# Iran's Rocket and Missile Forces and Strategic Options

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# Executive Summary

Iran's rocket and missile forces serve a wide range of Iranian strategic objectives. Iran's forces range from relatively short-range artillery rockets that support its ground forces and limit the need for close air support to long-range missiles that can reach any target in the region and the development of booster systems that might give Iran the ability to strike at targets throughout Europe and even in the US.

They are steadily evolving. While the lethality of most current systems is limited by a reliance on conventional warheads, poor accuracy, and uncertain reliability; Iran is developing steadily improved guidance systems, attempting to improve the lethality of its conventional warheads, and has at least studied arming its missiles with nuclear warheads.

## Iran's Rockets and Shorter Range Missile Systems

Iran's family of artillery rockets and shorter-range missiles give Iran a wide mix of capabilities. Iran's shorter-range systems include a family of artillery rockets that supplement its tube artillery forces, and provide a major increase in area fire capability in terms of both range and volume of fire. They could also compensate in part for Iran's limited close air support capability, particularly in a defensive mode.

There are varying reports on Iran's holding of artillery rockets, but key types and their ranges include the Fajr 1-Type 63-BM-12 (8 kilometers), H-20 (unknown distance), Falaq 1 (10 kilometers), Oghab/Type 83 (34 -45 kilometers), Fajr 3 (43 kilometers), and Fajar 5 (75-80 kilometers). Iran's shorter-range artillery rockets may have limited military value -- given the lack of any near-term prospect of an outside invasion -- but Iran 's longer-range artillery rockets can be used in harassment fire and as weapons of intimidation against targets across the Iranian border in Iraq and Kuwait. The longest range systems could be used against targets in the other Southern Gulf states.

Iran's shorter-range missile systems include a wide variety of systems, and again reports vary sharply as to types, numbers, and performance. Iran sometimes announces missile programs, names, and ranges that are questionable, but its short-range ballistic missiles (SRBMs) seem to include the Naze'at (100–130 km), Zelzal family (Zelzal-1 (150 km), Zelzal-2 (210 km), Zelzal-3 (200–250 km), Fateh-110 (200–300 km), Shahab-1, Scud B (350 km) Shahab-2, Scud C, Hwasong-6 (750 km), and Qiam 1 (700–800 km).

To put these ranges in perspective, any system with a range of 200 kilometers can strike from a position on Iran's Gulf coast at a target on the Southern Gulf coast that is immediately across from it. Iran can also, however, disperse many of its shorter-range missiles away from positions directly opposite a target in the Southern Gulf and still fire from sites deliberately chosen to disperse its missiles. Iran's longer-range systems can be widely dispersed and still used against targets on the Southern Gulf Coast.

Such strikes would normally have serious limits. The limited lethality and accuracy of most of Iran's rockets and shorter-range ballistic missiles mean that most Iranian missiles cannot hit a point target and would not produce significant damage if fired into an area target. They lack advanced precision guidance systems or terminal homing capabilities that could make them more political weapons and sources of intimidation than effective war fighting systems – except for the systems Iran is beginning to equip with GPS guidance systems. Some experts feel, however, that less

accurate and reliable systems might be used in large volleys against key area targets, and that Iran is developing the capability to use GPS guidance for the larger and long-range systems – improvements that would greatly increase their lethality.

## The Broader Strategic Value of Iran's Short Range Rockets and Missiles

Iran has shown that even short-range artillery rockets can have a strategic impact and be used in irregular warfare and as an indirect form of power projection. Iran has played a major role in helping Hamas and the Palestinian Islamic Jihad create a major pool of steadily improving rockets that it can conceal, disperse and fire against Israel, and that Israel cannot easily seek out and destroy even in a land invasion.

Israel has responded with defensive systems like Iron Dome and is developing systems to deal with larger and longer-range rockets like David's Sling and improved versions of the Arrow. It has also steadily improved its IS&R capability and tactics and training to use air strikes and land raids to attack launch sites and missile storage facilities.

Israel, however, was not able to suppress the threat from Gaza in 2014. In spite of a massive air campaign and a land invasion, the IDF estimated that the Palestinians had fired some 3,000 out of 10,000 rockets they held before the fighting started, the IDF had destroyed a total of roughly 3,000-4,000 rockets in combat, and 3,000-4,000 remained. Moreover, the Palestinians had been steadily able to improve the range and payload of their rockets with outside aid during 2008-2014.

Iran and Syria have transferred far larger forces of rockets and guided missiles to the Hezbollah in Lebanon. Hezbollah claimed to have an inventory of 33,000 by 2006, fired some 3,970 rockets into Israel from southern Lebanon, killing 44 Israeli civilians and 118 soldiers.[1] US experts felt that Hezbollah had some 33,000 rockets and missiles as of July 2014. Israel's official estimate was some 40,000 largely short-range systems – and some Israeli experts put the total at 100,000, while sources like Iran tracker put the total at 40,000 to 50,000.[2]

Virtually all sources agree that the Hezbollah has significant holdings of rockets and missiles like the Zelzal 2 (Range of 100-300 kilometers, 600 kilogram warhead, solid fuel), possibly some Scud missiles, and 12 or more anti-ship guided missiles. There are also reports that Iran and Syria have transferred longer-range versions of the Iranian Zelzal like the Zelzal 2, and Syrian M300/M302 and M600, with GPS guidance to the Hezbollah, which would greatly increase Hezbollah capability to carry out lethal strikes against targets in Israel.[3]

Uzi Rubin, a key developer of Israel's missile defense program warned in January 2014 that, "The Iranians took the Zelzal 2 and turned it into a guided rocket. The third generation of it contains a homing sensor and a GPS. The Syrians can have this capability, too, to create a fully guided M-600 rocket with a GPS…Hezbollah will seek to import such guided weapons. [4]

Ehud Barak warned on March 25, 2014 that, "We will continue to see many more missiles, a lot more accuracy, and within five years the missile will reach a maximum level of accuracy that will allow them to choose which building in Israel to hit. These means will proliferate, and will be cheaper for terror organizations like Hezbollah and Hamas in Gaza…In the future we will see terrorism backed by science and technology…Somewhere in a small lab, hostile elements sit planning the future weapon of mass destruction. This is an unprecedented terrorism potential…We can't wait until the threat is realized, as the gap will be difficult to close."[5]

The end result is that Iran has the ability to put pressure on Israel from two fronts without taking direct responsibility for its actions or a high risk of retaliation, and transfer a relatively low-cost threat that forces Israel to purchase far more expensive missile defenses – with exchange ratios where Israeli's defensive missiles are far more costly than the systems held by Hamas and Hezbollah.

## Iran's Medium and Long-Range Missile Systems

Iran's medium and long-range missile systems include a wide range of medium-range ballistic missiles (MRBMs) that can cover the range from Iran to targets across the Gulf, and throughout the areas near Iran's borders. There is no clear dividing line that defines the military role of such medium-range systems from Iran's longer-range or intermediate-range ballistic missiles IRBMs) that Iran it can use to attack strategic area targets.

The end result is to give Iran a constantly evolving family of missiles that have the range to attack virtually any target in Israel, the Levant, the Gulf and Arabian Peninsula, Turkey, Pakistan and part of Central Asia, and targets in Southern Russia and Europe. These systems give Iran a longer-range strike capability that its aging air force largely lacks. Iran's combat aircraft have the potential range-payload to strike deep beyond the Gulf, but they lack the performance, numbers, and enablers to operate effectively in large numbers of sorties against the US and Southern Gulf mix of fighters, strike aircraft, enablers, and surface-to-air missiles.

Iran also announced fewer tests and specific details regarding its missile developments over the last few years. As this report makes clear, there also are many are conflicting reports about the names and range of such missiles, and conflicting unclassified reports about key aspects of individual missile systems.

The key uncertainties involved are:

- Iran's testing of missiles and rockets and their accuracy and reliability, the operational realism of such testing, and Iran's perceptions of its progress versus the reality. Limited tests under "white suit" conditions can produce a greatly exaggerated picture of capability, particularly if success is exaggerated to the political leadership.
- The warhead and fusing design, of Iran's rocket and missile forces and the real world lethality of unitary high explosive warheads under operational conditions, and of any cluster munitions Iran may have for such systems. A unitary conventional missile warhead that relies on a near surface burst can have only 30-60% of the lethality of a bomb with a similar payload because the closing velocity vectors much of the explosive force upwards.
- The relative accuracy of the missile and targeting systems relative to high value targets and the ability to launch or "volley" enough systems to compensate for limited accuracy against point and area targets.
- The strength and quality of US, Gulf, Israeli and other missile defenses.
- Iranian perceptions of the risk of counterstrikes by Gulf and Israeli air forces, and US and Israeli missiles.
- The actual political, psychological, and retaliatory behavior of targeted countries and their allies.

Nevertheless, a wide range of reports indicate that Iran's missiles and missile developments now include a mix of solid and liquid-fuels medium range ballistic missiles (MRBMs) with names and ranges like the Ghadr-110 (2,000–3,000 km), Shahab-3 (2,100 km) (Iran), Fajr-3 (2,500 km) Ashoura (2,000–2,500 km), and Sejjil (2,000–2,500 km). Far more controversially, they also may include developmental systems like the intermediate range ballistic missiles (IRBMs) like the Shahab-5 or Toqyān 1 (3000–5000 km) and the Shahab-6 or Toqyān 2)(3000–5000 km).[6]

Most are still systems that lack advanced guidance systems, do not seem to have had enough tests in their final configuration to establish a high level of reliability or an accuracy based on real-world tests, and have guidance systems present major problems in attacking point targets or high value parts of area targets without being armed with nuclear weapon. As a result, much of Iran's missile force is more a weapon of intimidation that a war fighting tool. Such missiles can, however, hit large area-sized targets, and disrupt military and economic operations, and civil life.

Yet, systems that relay on conventional warheads and lack high accuracy or terminal guidance still have military value. They present the constant risk of a lucky hit – which increase with multiple firings. The very fact Iran deploys such missiles forces states in the region to buy missile defenses, consider civil defense programs, and potentially halt petroleum exports and other economic activity from vulnerable area targets.

Accordingly, they partly compensate for the fact that Iran has not been able to compete with the US and its Arab neighbors in modernizing its airpower and surface-to-air missile defenses. They also help compensate for the fact that Iran's land and naval forces also face many limits in terms of modernization, equipment strength, and readiness, but Iran's missiles and rockets give it added strike capabilities at every level for land and naval tactical warfare to the ability to threaten states throughout the region with long range missiles.

Iran's longer-range missiles and space developments missiles have political and strategic value as well. The inability to predict how and when Iran will use them, how quickly they will evolve into more accurate and lethal systems, and know their operational impact until they are used gives them both deterrent value and makes them weapons of intimidation.

Iran gains strategic leverage from developmental programs that could someday enable it to launch missiles that can strike the US, as well as all of Europe and Russia. It is still unclear that Iran actually intends to deploy a real ICBM or IRBMs that can cover all of Europe and Russia. Iran is, however, developing boosters for what it claims are space purposes that create the potential to deploy a future ICBM.

Any Iranian long-range IRBM or ICBM would require an extraordinarily effective guidance system and level of reliability to have any real lethality with conventional warheads, even if it could be equipped with a functional GPS guidance platform. It would probably require nuclear warheads in order to compensate for critical problems in accuracy, reliability, and warhead lethality. Iran would also face problems in conducting anything approaching a suitable test program at the ranges involved. Iran can, however, still gain visibility and political leverage simply by assembling the components of an ICBM or a booster for a satellite launch vehicle. It can also potentially push the US into expensive additional investments in missile defense and preemptive strike capabilities.

While such systems are not a primary part of this analysis, Iran is also developing a family of cruise missiles, longer-range air-launched systems, and Unmanned Aerial Vehicles (UAVs) and Unmanned Combat Aerial Vehicles (UCAVs); that can supplement its ballistic missiles and provide better targeting and damage assessment data. It is also seeking to develop satellite reconnaissance, targeting, and damage assessment capabilities, developing better mobile missile launchers, experimenting with missile shelters and silos, and creating less vulnerable and more secure command and control systems using optical fibers and land lines.[7]

## The Near-Term Impact of the Iranian Missile Threat

Iran’s existing missile forces give it the capability to attack targets in the Gulf and near its border with conventionally armed long-range missiles and rockets, and Iran can attack targets in Israel, throughout the region, and beyond with its longest-range ballistic missiles. However, the short-term risks posed by Iran’s current conventionally armed rockets and missiles should not be exaggerated.

Most are relatively short-range systems, and have limited accuracy and lethality. They can be used as artillery, limited substitutes for air power, or as weapons of terror or intimidation. While Iran is deploying some systems with GPS guidance, most of Iran’s are not accurate and lethal enough to play a substantial role in a conventional war, despite Iran’s efforts to upgrade them.

The limited lethality of Iran’s current warheads, the severe limits to the accuracy of most currently deployed systems, and the uncertain reliability of Iran’s longer-range systems now combine to limit the impact of missile strikes to almost random hits somewhere in a large area. Even a lucky hit would only produce damage or casualties that would most probably be limited to those resulting from a single 1,000-pound unguided bomb.

Experts debate the extent to which Iran is developing missile systems with basic or advanced penetration aids, and the cumulative uncertainties in trying to estimate the effectiveness of current missile defense systems against Iran’s current missile capabilities making any modeling effort highly uncertain. Israel, the Arab Gulf states, and the US are, however, steadily improving their missile defenses and shifting from point defense to wide area defenses.

In the near-term, this combination of real-world limits to the lethality of Iran’s missiles and growing missile defenses sharply limits the military effectiveness of Iran’s rockets and missiles as long as they are armed with conventional warheads:

- Iran would need to use large numbers of shorter-range rockets as artillery to achieve a major impact on military area targets. The seriousness of such threats will depend in part on Iran’s ability to launch rockets and missiles in salvos and volleys, and in the ability to launch “stacked threats” of different types of weapons that complicate the use of missile defenses and suppressive strikes.
- While it is beginning to deploy shorter-range systems with GPS guidance, it would need to use volleys or salvos of short-range missiles and long-range rockets to have even a moderate probability of hitting a high value building or facility in military bases and civil area targets. These are tactics Iran has exercised, but may not yet implemented effectively.
- Iran use of MRBM and IRBM strikes could not be massed effectively in large numbers against longer-range area targets, and they will remain weapons of intimation that can be used largely psychological or “terror” purposes until they either acquire far better guidance and terminal homing capability and/or terminal homing.

Nevertheless, Iran is making a major effort to deploy more accurate missiles, and there are important indicators that it is developing nuclear warheads and seeking to give its systems penetration aids to counter missile defenses. No nearby state can disregard the fact that Iran can use conventionally armed missiles long-range rockets as terror weapons, and strike against large area targets like petroleum export facilities and cities. No state can disregard the fact that Iran might escalate to the use of such systems because of a conventional war in the Gulf, in reaction to any military threat to its ruling regime, as a response to covert action against the state, or as a method of resolving domestic fissures.

If one considers the full range of Iranian missiles, it is also clear that any assessment of its current military and strategic capabilities must include the entire Gulf, Israel, and US bases in the region.

Iran's can threaten every other regional state, including Turkey, Jordan, and Israel, and Iran has shown that it can develop additional threats by transferring longer-range or more precise rockets and missiles to "friendly" or "proxy" forces like the Hezbollah and Hamas or to new friendly state or non-state actors forces in countries like Yemen.

Finally, while no outside source has produce clear indications that Iran has stockpiled anything other than unitary and cluster conventional warheads, Iran is a declared chemical weapons state that has never declared its actual holdings. It is possible that it has chemical warheads, and such warheads could have a major impact in increasing the terror and intimidation effect of Iranian missile strikes even if their real world lethality is limited.

When it comes to assessing to overall military balance in the region, it is also important to note that Iran's rocket and missile forces blur the distinction between ground and air forces. The same is true of any distinction its sea and air-launched systems, and Iran's longer-range systems blur any distinction between missile and air power in both the offensive and defensive roles. There also is no clear separation between the impact of Iran's rocket and missile systems based solely on range. Like efforts to distinguish between "asymmetric" and "conventional" warfare, they are potentially useful in structuring an analysis but they have steadily less real world meaning in terms of both deterrence and warfare.

## Shaping the Future Threat: Nuclear Warheads vs. Precision Conventional Warheads

The Iranian missile threat may become far more serious in the future. Left to its own devices, Iran would probably deploy both nuclear-armed missile and highly accurate missiles with conventional warheads. Iran has powerful military incentives to deploy nuclear weapons, and Iran's missile forces give it the potential ability to develop a major nuclear strike force.

Such a nuclear force would greatly strengthen Iran's deterrent capabilities as well as its ability to exercise political leverage on its neighbors. It would increase the risk in any US or regional use of conventional weapons and air power to attack Iran, and to escalate to a serious conventional conflict in response to Iran's use of irregular warfare, and limited war in the Gulf or neighboring states.

It would also trigger a nuclear arms race in the region. Israel has already developed mature nuclear-armed missile forces and can probably pose as much of an existential threat to Iran as Iran could to Israel with any near-term nuclear-armed missile forces it could deploy. It seems certain, however, that Israel will seek to create and maintain an even greater nuclear "edge" over Iran – if it does not launch preventive war. The US has already offered its regional allies "extended deterrence" and the same kind of security guarantees it gave its NATO allies against Soviet technical nuclear forces. Saudi Arabia already has ballistic missiles of its own and might be able to acquire nuclear warheads from a country like Pakistan.

Short of some form of regional nuclear and missile arms control agreement, the end result could well mean a constant race to develop larger nuclear forces, warheads with larger nuclear warheads, missiles with more accuracy and penetration aids, better missile defenses, less vulnerable basing and deployment systems and the ability to launch-on-warning (LOW) or launch under attack (LUA). What Albert Wohlstetter once called the "delicate balance of terror" between the US and USSR and NATO and Warsaw Pact could become the "unstable balance of terror" in the Gulf and Middle East.

At the same time, Iran’s existing missile forces serve many other purposes and precision guided missiles could post a major new strategic threat, and Iran’s missile will become more lethal over the coming half-decade even if Iran does not get nuclear weapons.

Iran’s current missile already becoming somewhat more lethal as they are equipped with cluster munitions and better fusing -- although their lethality will still be limited by their range-payload limits, and a lack of accuracy if this was the only area of improvement. Even substantial volleys of missiles and rockets with better conventional warheads against area targets would still be limited in real world lethality, and would be more terror strikes than strikes capable of quickly hitting and destroying key point targets.

If Iran is to make a major advances in missile lethality without arming its missiles with nuclear warheads, it must make advances in one of three other areas: (1) it must either deploy missiles with precision guidance and terminal homing; or (2) deploy missiles with chemical or biological weapons, and enhancing command and control to launch semi-accurate volleys – potentially in “ stacked” arrays of different missiles from different launch sites.

Iran is already taking the first step in giving its conventionally armed missiles more accuracy. Iran is deploying short-range systems with GPS guidance and has said publicly that it is seeking to provide its missiles with precision guidance and/or terminal homing warheads, and with countermeasures to ballistic missile defenses. It already has deployed at least one missile with GPS guidance and begun to experiment with cruise missiles.

A number of sources indicate that its systems with greatly improved guidance include production of the Zelzal-2 as a guided rocket, and development of the Ya Ali land attack cruise missile, the Zelzal-3 ballistic missile, and the Raad-301 precision guided bomb. Iran has also claimed to have demonstrated that it has a near precision strike capability by attacking a simulated airfield -- although satellite photos of the target area indicate it simulated at least some of its accurate missile hits by using explosive devices at the scene.

A truly reliable precision strike capability would make Iran’s missiles capable of targeting key military, petroleum, power, and water facilities with enough accuracy to destroy them with a credible conventional payload. It would radically alter the lethality of Iran’s longer-range systems against high value military targets and civil targets like key oil product facilities and desalination plants - creating the equivalent of “weapons of mass effectiveness.” Iran would also run far less risk of catastrophic escalation in retaliation to either the threat of using its missiles, or carrying out limited strikes, if it could use missile forces with conventional warheads in strategic attacks rather than nuclear warheads.

There is no evidence as yet that Iran has such capabilities for most of its systems and no certainty that it can acquire them in the near future. Iran has, however, made claims that imply it already has such accuracy, and a number of Israeli experts believe it is developing such systems.

As for the second option, Iran does not seem to be arming it missile forces with other weapons of mass destruction. No key source has yet claimed that Iran is actively pursuing deploy chemical or biological warheads to give its missiles more lethality – although Iran did have short-range, chemically armed rockets in the past.

This option also needs to be kept in perspective. Chemical and biological missile warhead would have an immediate impact as terror weapons, but making them highly lethal is another story. It is easy to exaggerate the lethality of chemical missile warheads under real world operational

conditions. Dispersing a chemical agent effectively is a major challenge, and chemical cluster weapons present serious timing and height of burst problems. Mounting chemical and biological weapons on longer ranged ballistic missiles also requires to warhead to survive the harsh re-entry environment that could degrade the effectiveness of the weapon if it is not shielded properly. It might well take a substantial volley of shorter-range rocket to have a major effect, and such a strike could remove all limits to a conflict and might still produce limited damage to critical targets.

Biological weapons can theoretically be as - or more - lethal than fission nuclear weapons and Iran has all of the technology and manufacturing capability needed to make such weapon. Effective dispersal is, however, even more difficult than with chemical weapons, and developing and testing such a warhead presents serious technical problems, could only have its lethality fully validated by human or primate testing, and presents the political problem that such a threat might not be credible until Iran's capability was proven. Moreover, the very threat that Iran was arming its missiles with biological weapons could trigger massive preventive strikes and any use of such warheads would eliminate any barriers to counterstrikes with nuclear weapons.

## Missiles, Political and Psychological Warfighting, and Wars of Intimidation

Political aims are also at the heart of Iranian ballistic strategy. If Iran uses its current longer-range artillery rockets and missiles in combat, it can copy Saddam Hussein's strategy in using missile attacks during the Iran-Iraq War and the first Gulf War 1991. Missile forces also have political dimensions that help Iran fight "wars of intimidation" even in peacetime.

At a minimum, Iran's growing missile forces increase its deterrent and defensive ability to deter attack on Iran and compensate for its weaknesses in airpower. More broadly, Iran can use its missiles politically and strategically, and not simply to damage targets. Selective firings and "volleys" of conventionally armed, unguided long-range missiles and rockets can be used as political symbols or terror weapons.

As the exports of Iranian artillery rockets and shorter-range missiles have shown, Iran's missiles can have a growing political, strategic and psychological impact outside Iran. Current Iranian doctrine seems to stress building up the risk and reality of allied and proxy attacks around the world, Hamas and Hezbollah rocket and missile strikes already have had a major impact on Israel's military posture, and "third party" missile strikes may be a growing problem for the US and its Arab allies in the future.

Missile and long-range rocket attacks can also boost Iranian morale. In the face of limited, attrition-like conflict between Iran and the US and GCC, ballistic strikes provide Iran with the chance to show its public that it is prosecuting the war and inflicting casualties on the other side. Framed as retaliation for a combination of sabotage, assassination, sanctions, and potentially overt strikes, ballistic missiles demonstrate to the Iranian population that its government is capable of repaying the suffering it has undergone.

Iran might use its missiles to strike Israel after an Israeli preventive strike, or to strike at Israel in some other contingency where it felt the political symbolism inside Iran and the Arab and Islamic worlds were worth the cost. Iran could hope that conventional missile strikes on Israel would lead to limited Israeli retaliation, leading in turn to political pressure on Arab states to reduce ties to the US. Strikes on Arab states would bring the costs of war home to populations that are ill prepared for conflict, raising the penalties for Gulf publics that have rarely had to face the personal risks stemming from regional instability.

As was demonstrated during the “war of the cities” during the Iran-Iraq war, by the use of the Scud missile during the Afghan War, and by the Iraqi Scud attacks on Israel and Saudi Arabia during the Gulf War in 1991, missile strikes can have a powerful propaganda impact that vastly exceeds their actual warfighting effect - at least initially. There were reports during the Iran-Iraq War of civilians and officials fleeing Tehran. Iraqis, Israelis, Saudis, and Coalition forces also routinely took shelter during missile attacks, and the Israeli press report many cases of individuals that effectively panicked in 1991 - although perhaps more from fear that missiles might have chemical weapons than out of a fear of missiles or conventional warheads per se.

Even a few Iran missile strikes on either Israel or Saudi Arabia might also be seen by Arab states as a demonstration of Iran’s willingness and capability to escalate even further, and growing future ability to strike with far more effectiveness. Iran could pick on one or a few Arab states, and seek to divide Arab states from each other. Moreover, Iran can use even token or failed missile strikes for internal political propaganda purposes.

Iran might also use missile strikes as a counter to any US, Gulf, or other conventional air or cruise missile strikes on Iranian military, civil, or infrastructure targets. Such a response might be deliberate, or escalate out of an incident in the Gulf or some other form of military clash. There are no clear boundaries between conventional and irregular/asymmetric warfare, and no clear steps on the escalation ladder that deter the use of one form of force against another, or the level and mix of land-air-sea-missile force that will be used. Iran has historically been a relatively cautious power focusing on regime survival, but history is a clear warning that even the most cautious power can suddenly become locked into a massively escalating conflict.

Regardless of the current limits to the lethality of Iran’s missile forces, the psychological impact of Iran’s ability to launch a sudden, massive missile barrage on regional population centers and military installations should not be underestimated. Neither should the possibility of a lucky hit producing enough casualties or highly visible damage to have a lasting psychological impact - what might grimly be called the “World Trade Center effect.” Iran’s ability to launch a large volume of missiles over a period of days with little warning before the first round of launches gives Iran leverage and makes such missiles a weapon of intimidation. Even if - and perhaps especially if - they are never used, Iran’s missiles also have the capability to intimidate and leverage Iran’s neighbors, and to force the US and its regional allies to devote resources to missile defense.

At the same time, it should be noted that many of the political psychological effects of ineffective missile strikes, however, wore off relatively quickly. There were not enough missile firings to sustain a high degree of popular fear, and people were soon reported to be going to their roofs at night to “watch the show.” There is simply too much empty area in a given urban complex or large military base for largely random strikes to either produce critical damage or kill enough people to shock or intimidate the population. Limited by the number of TELs and static launching sites, Iran may be unable to continue a bombardment campaign for an extended period of time in the face of Arab or US airstrikes.

## Putting Iran’s Missile and Nuclear Programs in Perspective

It is difficult to predict how aggressive Iran would become in exploiting its nuclear capability if Iran did acquire nuclear-armed missiles. Iran has so far been cautious in initiating any use of force that might threaten the survival regime. Its best strategy would be to limit its use of nuclear missile forces to pressure, deter, and intimidate.

Iran is, however, clearly involved in an active competition with the US and with its Arab neighbors in an effort to win strategic influence and leverage. Iran faces US and Arab competition for influence and control over Iraq, the emerging threat of the Islamic State, and growing uncertainty over the future of its alliance with the Assad regime in Syria and the Hezbollah in Lebanon. Iran also still seems to see American influence behind all of these steadily growing pressures.

Iran has long sought to develop asymmetric military capabilities and forces that can challenge US encroachment in "its" region. Iran has threatened in the past to use such forces to "close" the Gulf, and has carried out major exercises targeted against the US and less directly at the GCC states. It has also described many of its exercise exercises as a response to Israeli or American threats and "aggression".

While Iran has normally been careful to avoid any major threats and military incidents, to avoid provocative military steps, and to limit the risk of military confrontation; it is not clear that Iran would show the same restraint in using its full range of asymmetric warfare capabilities if it could arm its missile forces with nuclear weapons or if its missile forces developed a precision strike capability. Iran might then be more willing to take risks in using its other irregular warfare capabilities to try to force more favorable compromises, persuade the Iranian people they do face real foreign enemies, show how serious the impact could be on the global economy, or simply punish other powers.

Military history is also a warning that restraint in peacetime does not necessarily last in a crisis or limited conflict. The history of war is not the history of rational bargainers. Tempers can grow short, given units can overreact, situations can be misunderstood, and one nation's view of how to escalate rarely matches another's once a crisis begins. Iran could escalate to major rocket and missile strikes because of miscalculations on both sides of a future clash or lower level conflict.

## The Mid and Longer Term Risk of an Iranian Nuclear Weapon and a Nuclear-Armed Missile Threat

There are many different estimates of Iran's nuclear programs, its intentions, and when it could build a stockpile of nuclear weapons. No one, however, can discount this threat. The US Director of National Intelligence, James R. Clapper, touched on this case in his Worldwide Threat Assessment for 2012 statement, and it is still far from clear that the P5+1 negotiations with Iran will change the validity of his judgments:[8]

> We judge Iran would likely choose missile delivery as its preferred method of delivering a nuclear weapon. Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile forces, many of which are inherently capable of carrying a nuclear payload.
>
> We judge Iran's nuclear decision-making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran's security, prestige, and influence, as well as the international political and security environment, when making decisions about its nuclear program.
>
> Iran's growing inventory of ballistic missiles and its acquisition and indigenous production of anti-ship cruise missiles (ASCM) provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces. Its ballistic missiles are inherently capable of delivering WMD, and, if so armed, would fit into this strategy.

Clapper was also reported to have said during his testimony that Iran might get a nuclear device in as short as a year under worst case conditions and arm a missile in as little as two more years. The reality seems more likely to be 4 to 7 years, but there is so little hard data on Iran's programs that any such judgments are highly uncertain.

At the same time, it must be stressed that Iran cannot deploy either nuclear-armed missiles or precision strike missiles in a military vacuum where its neighbors and the US do not respond. If Iran does go nuclear, this decision will impact on a region that is already involved in a nuclear arms race. The prospect of combined Iranian missile and nuclear threat has already posed risks that have affected every aspect of US, Arab, Israeli and other military competition with Iran for at least the last decade. This competition has increasingly focused them on responding with on options like preventive strikes, proliferation, and extended deterrence as Iran has made enough progress towards a nuclear weapons capability so that there is a real prospect that Iran could acquire nuclear weapons and arm its missiles and aircraft with nuclear weapons within the next three to five years.

Key nations like Israel have already reacted to the fact that a nuclear-armed Iran could destroy any military target or city in the region, and pose an "existential" threat to many states. The US, other powers, and the Gulf states have also to the fact that a regional war that even threatened to escalate to nuclear weapons could have a far more radical and lasting impact on the global economy, which gets some 20% of the world's oil supply through the Gulf.

Once again, few experts feel Iran's leaders would act irrationally or without regard to the risks, but once again, the history of war and diplomacy is the history of mistakes, miscalculations, and unintended conflicts. For all of the talk of a stable pattern of mutual assured destruction during the Cold War, it is important to remember the reality of what actually happened. The US went from no more than six nuclear weapons at the end of 1945 to a peak of over 31,000 in 1967, while the Soviet Union went from none before 1949 to a peak of nearly 41,000 in 1987.

These risks help explain why the US and other members of the P5+1 have pressed so hard to end the Iranian nuclear threat though negotiations. If these efforts fail, the choices become preventive strikes or deterring and containing a nuclear-armed Iranian missile force by military means. Missile defenses, proliferation, and extended deterrence are all issues that affect US and regional plans and actions.

Even the most successful efforts at deterrence, containment, and missile defense present risks of their own. The very risk of Iranian nuclear-armed missiles eventually becoming an Iranian reality led Israel to increase the range of its nuclear-armed missiles to cover all targets in Iran more than a decade ago. It has since led Israel to plan for, and exercise the option of, preventive strikes, and the US to openly declare that it has developed such a military option. It has also led the US and Israel to research and develop missile defenses, and the US to work with friendly Arab states to purchase new missile defenses.

The increasing Iranian missile threat has also helped lead to a steady increase in the long-range strike capabilities of rival states. Saudi Arabia first acquired long-range conventionally armed Chinese-made ballistic missiles in 2007 because of the threat from Iraq but it has retained and upgraded them because of the threat from Iran. The US and Gulf Arab countries have also increased the strike capabilities of their air forces, and US has shown that demonstrate it could make extensive use of conventionally armed cruise missiles.

Then U.S. Secretary of *State* Hilary *Clinton* offered friendly states in the Gulf region some form of “extended deterrence” in 2009, but the US has never clarified whether this would only apply to Iranian nuclear strikes, and would involve conventional or nuclear-armed systems. At the same time senior Saudi officials have said that the Kingdom has examined a nuclear option, and a number of experts have noted that Pakistan might be willing to sell Saudi Arabia both nuclear warheads and more advanced missiles.

## The Challenges if Iran has to Deploy a Nuclear-Armed Missile Force

The risks to Iran in deploying a nuclear armed missile forces are increased by the fact that an Iranian effort to create a survivable and effective nuclear-armed or precision strike missile forces would take years to deploy, and would present other kinds of challenges in the process. Iran cannot become a meaningful nuclear power overnight, and Iran does not exist in a “nuclear vacuum.”

Iran faces technical challenges in creating and deploying nuclear-armed missiles and in ensuring they would not be subject to preemption or counterforce nuclear strikes. Much would depend on the reliability of the missiles, and real-world accuracy could still be a problem. Moreover, Iran might well have a very limited stockpile of nuclear weapons for some years after it first began to deploy such weapons, and creating a survivable and effective force would pose problems of a different kind.

Long before Iran could deploy a meaningful nuclear-armed missile force, Iran’s efforts to acquire nuclear weapons could lead to US or Israeli preventive attacks on both its nuclear and missile facilities and forces. If the current P5+1 talks fail, President Obama and other senior US officials have made it clear that US policy sees Iran’s acquisition of nuclear weapons as “unacceptable.” Both Israel and the US have repeatedly stated that they are planning and ready for military options that could include preventive strikes on at least Iran’s nuclear facilities and, and that US strikes might cover a much wider range of missile facilities and other targets.

Such preventive strikes would present risks for the attacker as well as Iran They might trigger a direct military confrontation or conflict in the Gulf with little warning. They might also lead to at least symbolic Iranian missile strikes on US basing facilities, GCC targets or Israel. At the same time, it could lead to much more serious covert and proxy operations in Lebanon, Iraq, Afghanistan, the rest of the Gulf, and other areas.

Furthermore, unless preventive strikes were reinforced by a lasting regime of follow-on strikes, they could trigger a much stronger Iranian effort to actually acquire and deploy nuclear weapons and/or Iranian rejection of the Nuclear Non-Proliferation Treaty (NPT) and negotiations. The US, in contrast, might see it had no choice other than to maintain a military over-watch and restrike capability to ensure Iran could not carry out such a program and rebuild its nuclear capabilities or any other capabilities that were attacked.

A preventive war, however, is only part of the threat Iran will face. As has been touched upon earlier, Israel is a mature nuclear power that already has a thermonuclear-armed missile forces with considerable counterstrike capability. Israel’s ability to destroy Iranian cities and population centers already makes Israel an existing existential threat to Iran. At least initially, Iran could only secure is evolving forces by relying on launch-on-warning (LOW) or launch-under-attack (LUA). This, however, would push Israel into shaping a nuclear force posture designed to react to any Iranian use of nuclear forces – or even an Iranian threat – by launching an all-out nuclear attack

with a force posture that would almost be designed to lead both sides to miscalculation or over-reaction.

Any Iranian threat to use nuclear weapons against other regional targets might well lead to similar retaliation if the US should ever implement its offer of “extended deterrence.” Iran would also face the prospect that actually acquiring nuclear weapons might provoke a Gulf power like Saudi Arabia to seek nuclear-armed missiles from Pakistan, and any nuclear armed neighboring states would almost certainly respond to any nuclear attack in kind.

These risks will increase if Iran deploys missiles with weapons of mass destruction even if it does not use them. Iran faces the grim fact that its missiles can make a war far more damaging and lethal, cannot win either any arms race in which the US takes part, or any process of escalation that involves the US and Israel.

Iran’s actions have almost certainly already provoked Israel into developing the capability to target thermonuclear warheads on every major Iranian city, creating an “existential” threat to Iran long before Iran will pose one to Israel. Saudi Arabia and the GCC states may well have the option of turning to Pakistan for nuclear-armed missiles, and senior Saudi officials have said Saudi Arabia has examined nuclear options. The US has also officially offered its regional friends and allies “extended deterrence” of the kind it once provided to Europe during the Cold War - essentially confronting Iran with an open-ended threat of US retaliation.

Even if Iran does go nuclear as part of this aspect of its competition with the US and its Gulf neighbors, it is far from clear that it will not suffer more than any nation or nations it attacks. No one can downplay the psychological and political impact of even the threat of nuclear strikes, the deterrent impact it might have in limiting a response to Iran’s use of asymmetric warfare, or the risk of some “accident” or miscalculation. The worst moments in history rarely occurred because of accurate calculations by rational bargainers.

This is why success in the current negotiations between the P5+1 and Iran would probably be of significant strategic benefit to Iran. It would eliminate Iran’s nuclear option, but the end result could do more to ensure Iran’s overall security than Iranian nuclear-armed missiles. Once Iran tests a nuclear device or claims to have nuclear weapons, it will also enter a very different world of risks. Iran’s missiles will be seen by many Israelis as “existential” risks the moment Iran has – or even claims to have – nuclear weapons. It is Iran, however, that will face the most immediate threat from Israel of preventive war, preemption, or massive retaliatory

At the same time, the failure of such negotiations would have a negative impact on the US and its regional allies as well. The end result is that if the P5+1 negotiations – or some form of negotiations – fail, Israel, the US, and Arab states cannot choose between preventive war and containment. Unless Iran fundamentally changes its present course, the choice is between preventive strike and containment, or containment alone. Preventive strikes may be able to delay Iran for a given period of time, but if Iran seeks to rebuild it nuclear capabilities, Israel, the US, and the Arab countries will have to strengthen their missile and other defenses, develop great retaliatory capabilities and/or restrike every new Iranian effort to move towards nuclear weapons.

No amount of US or Gulf military containment effort can alter the fact that a nuclear arms race already exists between Israel and Iran - albeit one where only Israel now has a nuclear strike capability. The practical problem this raises for Iran - and for stabilizing this arms race - is that it will face a possible Israeli first strike option until it can secure its nuclear armed forces.

The end result could well be forces that initially push Iran towards a concealed or breakout deployment, followed by phase where it would have to launch on warning or under attack until it has a survivable force. Iran would then, however, have to compete with powers with far larger stockpiles and boosted and thermonuclear weapons until it can create a more sophisticated force of its own. This confronts Iran with the reality that it at least initially faces a high-risk arms race, and is then likely to become trapped in a steady race to increase its forces, find ways to secure them against counterforce strikes, find ways to compete in missile defense and still find itself confronting an escalating mix of Israeli, US, and Gulf nuclear and conventional strike capabilities superior to any force Iran can deploy.

## The Challenges if Iran Come to Deploy a Major Conventionally Armed Precision Strike Missile Force

The outside response is likely to be far less threatening if Iran succeeds in deploying precision strike missile systems with conventional warheads, but the end result would still be a regional arms race which Iran is unlikely to win. Once again, Iran cannot act in a vacuum. As full analysis shows, outside powers have a major advantage in overall air warfare capability, combat aircraft, and surface-to-air missiles. Iran's target base is at least as vulnerable as that of its Gulf neighbors. The Arab Gulf states already have missile defenses for many key targets, the US is deploying missile defense ships with wide area missile defense capability, and nations like the UAE and Qatar have already indicated that they may buy land-based wide area missile defenses like THAAD.

Unless Russia or China alter their polices to sell Iran virtually any advanced weapons technology it wants, the Arab Gulf states, Israel, and the US will have an overwhelming advantage in many areas of air and missile strike capability and missile and air defense. Every major Iranian improvement in its missile forces will trigger an overall set of counter efforts by the US and the other states in the region.

Iran may be able to gain some political leverage by exploiting the risk of a conflict, but it will progressively increase the probable damage to Iran if a conflict actually occurs. Iran will also then face a military situation where Israel retains a nuclear option and Iran does not. It seems unlikely that Israel would ever initiate the use of nuclear weapons against Iran in response to any probable scenario in a world where Iran did not deploy nuclear-armed forces, but Israel would be

## The Impact of Retaliatory Threats and Retaliation

Regardless of how or why Iran uses its missile and other delivery system, Iran cannot operate in an environment where there will be no response. As has been discussed earlier, Iran faces far superior air strike forces and air and missile defense forces.

Israel has a wide range of retaliatory and escalatory options, including nuclear-armed ballistic and sea-launched cruise missiles. Saudi Arabia already has long-range, conventionally armed Chinese missiles that can strike area targets in Iran, and the UAE has some SCUD-B missiles (likely equivalent to Shahab-1s). There are questions about the status, reliability, readiness, and accuracy of the Saudi and Emirati missiles, but these same questions apply to Iran's forces. This raises the specter of any missile "war of the cities" of the kind observed between Iran and Iraq.

Iran faces the risk of steadily more capable retaliation by US strike fighters and bombers with "stealth capability and by the best air forces of the Gulf as states like Saudi Arabia and the UAE acquire steadily better strike fighters with may be less likely to initially have a terror impact on

civilian populations, they provide a far more effective strike and targeting capability that Iran can do little to reduce. In the near-to-mid term, Iran's forces and critical infrastructure are is becoming more vulnerable to Southern Gulf air forces as they acquire missile defenses and become less vulnerable to Iranian missiles.

Any Iranian use of long-range missiles against another Gulf state also presents a serious escalatory risk to Iran. Even one such missile firing would effectively escalate to a level where the US would have no clear limits on its use of air and cruise missile power to strike at strategic targets in Iran. Iran's major cities are as vulnerable in terms of power, water, and fuel supplies as the cities of the southern Gulf, and Iran's refineries and certain key links in its ports and transport systems are highly vulnerable as well. Iran cannot possibly win a contest in escalation with its current conventional forces and conventionally armed missiles, and such a contest could spiral into an asymmetric or unconventional war that is costly and destructive for all sides.

Moreover, the first time Iran uses even a conventionally armed missiles, it may create conditions that lead to some form of US guarantees and "extended deterrence." The US has stated that it will not accept an Iran with nuclear weapons, but even if does, this scarcely offers Iran security or freedom from preemption and retaliation. Should Iranian nuclear efforts prompt Riyadh to develop its own nuclear program, as was mentioned previously, this would only increase the risks of escalation if Iran uses its ballistic missiles.

## Impact on Policy

The US and its regional allies need to recognize and decisively react to the fact that Iran's ballistic missile programs serve several strategic goals.

- One is a population and infrastructure-centric approach based on large numbers of SRBMs that can strike across the Gulf or into Iraq and Kuwait and provide a coercive edge in a dispute with Iran's Arab neighbors.
- These systems act as a substitute for advanced strike aircraft and may well exist in umbers that could saturate or exhaust missile defenses.
- They can be used to attack area and population targets and while they would have limited lethality, they could have a major political and psychological impact.
- They are systems that Iran can use to arm movements like Hezbollah and attack or threat a state like Israel indirectly.
- Iran's longer-range, conventionally-armed MRBM and IRBM forces can be used to intimidate Iran's neighbors and other states at much longer ranges, and
- Conventionally armed MRBM and IRBM forces can also conduct conventional attacks on area targets like population centers and infrastructure. They only exist in limited numbers and they too have limited lethality. They still, however, have value as weapons of political intimidation.
- Longer-range anti-ship cruise and ballistic missiles already supplement Iran's conventional and other asymmetric forces, while posing a different form of "stacked threat" to the flow of world oil exports at the strategic level.

These threats will remain limited until Iran acquires nuclear warheads and/or more lethal conventional warheads with terminal guidance. The prospect of salvos of conventional missiles already provides a serious threat. Even relatively large salvos of such weapons would be unlikely to have a major lethal impact even on large area targets, and even if they proved capable of saturating or penetrating missile defenses. However, they would largely have the effect of increasing the political or terror impact of strikes.

The practical question for US and allied policy is what level of missile threat can be tolerated and is safe to deter and contain.

An Iran armed with missiles with nuclear warheads and massive capability for asymmetric warfare would not need to match other states in advanced conventional arms, and would be seen as a dominant regional power unless Arab states also acquired nuclear weapons or a convincing commitment to extended deterrence from the US. Nuclear-armed Iranian missile forces could also cause massive damage to any area target and provide a far more effective deterrent against US, Israeli, and European interference in Iran's sphere of influence within the Gulf - and shield against attacks on Iran's asymmetric forces.

US declared policy is that no Iranian nuclear weapons capability will be tolerated. It is one thing, however, to threaten and another to act. It also is unlikely that an Israeli preventive strike could have lasting impact and a truly successful US strike would be a major attack, one requiring restrikes, and one that would probably require the support of the Arab Gulf states for the US to sustain its impact over time.

What is less clear is whether Iran's acquiring long-range missiles with true precision terminal guidance homing should or would be tolerated. While the current accuracy of its missiles so far does not permit it to threaten grievous damage to key targets, the US and its allies need to pay as much attention to future improvements in guidance systems and conventional payloads as Iran's efforts to deploy nuclear warheads.

Iran may not acquire a major force of missiles with sophisticated and enough accuracy and reliability to provide a conventional point target destruction capability for some years, but the current US and allied focus on Iran's nuclear programs may understate the priority the US and its allies should give to deploying the most advanced missile defenses and agreeing on some form of US extended deterrence.

Given the vulnerability of key Gulf water, petroleum, and infrastructure facilities, there is the prospect that such forces could become "weapons of mass effectiveness even against better missile defenses if fired in large salvos. Quantity imposes its own quality in warfare, and Iran's ballistic missile stocks are larger than the strategic anti-missile holdings of the GCC.[9] While the Gulf States are improving their missile defenses, given the need to have multiple interceptors for each attacking missile, Iran is likely to maintain an edge.

This means that the US and its allies should base their defense and deterrence on dealing with the combined prospect of an Iranian nuclear warhead and precision conventional strike capability until Iran has decisively given up its nuclear weapons efforts and then retain a decisive edge in retaliatory capability and missile and air defense.

The US and its regional allies need to cooperate in deciding what forms of preventive strike, counterstrike, or preventive attacks are needed. The risk Iran will acquire a precision conventional strike capability indicates that if the US does carry out a preventive strike on Iran's nuclear facilities, it should destroy as many of Iran's missiles and missile RDT&E and production facilities as possible. It also raises questions about whether such preventive attacks should be carried out against any Iranian deployed longer-range systems - particularly ones with ICBM-like ranges - even if Iran does not appear to be creating nuclear warheads.

As for containment, deterrence and retaliation, Iran has much to fear from both the US and its Arab neighbors. Iran appears unlikely to develop any ability to launch a meaningful strike against the

US in the near future. While its missile program has made significant strides, it still faces substantial challenges in building a force that could reach the United States. A true intercontinental ballistic missile would almost certainly require improved engines, more efficient multi-staging technique, advanced guidance systems, and larger and lighter construction components, all which would require development and testing. Until such a threat materializes, Iran will lack the ability to deter the US from supporting the Arab Gulf states, Israel, and is other neighbors.

This will make the US offer of extended deterrence an important asset to its Arab and other regional allies regardless of whether Iran chose to go nuclear or relies on precision conventional strikes. It also helps to keep the threat of US stealth and cruise missile attacks on Iran credible - attacks that could disable its power grid, communications, and key infrastructure, government and military facilities. Weapons of mass effectiveness work in two directions and the US now has such weapons and Iran does not.

Much will depend, however, on the willingness of Arab Gulf states to actively defend themselves, cooperate developing an integrated wide area capability to destroy incoming missiles. While the MTCR restricts what ballistic weapons the US can supply to Gulf States, there are no limits on anti-missile cooperation. Neither should there be any restrictions on supporting Gulf efforts to build up strike aircraft and ground attack munitions.

Strike aircraft allow Gulf States to retaliate individually and collectively to any Iranian missile strikes, targeting and crippling Iranian infrastructure in return for such strikes. The threat of Gulf air strikes on Iran may not match the impact of some formal US guarantee of extended deterrence or giving the GCC states their own missiles, but it could provide enough additional security to reduce the risk or impact of a steadily deepening arms race in the Gulf, provide a cheaper and more effectively ability to limit Iranian escalation potential, and limit the overall strategic and political advantages Iran can gains from its ballistic missile program.

# I. Iranian Politics and Their Impact on Iran’s Missiles and Nuclear Warhead Programs

It is important to understand the various political motivations that may ultimately decide the direction, design, and scale of Iran’s missile and rocket forces, and nuclear weapons and warhead programs. The rise of Shia clerics and the overthrow of the Shah in the 1979 revolution ushered in what has become one of the most dictatorial regimes in the modern era. Despite its autocratic structure, Iranian politics are as unpredictable as American politics, with each faction competing for power and influence.

While most political power constitutionally rests in the hands of the Supreme Leader, Ayatollah Ali Khamenei, there are limitations to his power, as was seen with the Presidential election of Hassan Rouhani in June 2013. This was the first election under Khamenei’s rule where he and his political faction did not interfere to influence the outcome of the election. Due to Khamenei altering the results of the 2009 election, which led to the reelection of Mahmoud Ahmadinejad, he stapled his legitimacy to Ahmadinejad’s.

The violent repression of the Green Movement in 2009, Ahmadinejad’s mismanagement of the economy, nuclear centrifugal proliferation, and an increasingly militant rhetoric and posture toward the West, and the implementation of crushing sanctions were attributed to Khamenei and his faction. Many experts feel this caused Khamenei to worry about the longevity of the Iranian Revolution and his rule, and kept him from ensuring the selection of a loyal and highly conservative president.

Other experts feel that factional struggles played a key role, and that political differences within the conservative faction led to its division between moderate, traditional, and radical sects, evidenced by the three different candidates the “conservative” faction pushed through the Guardian Council: Saeed Jalili, Mohsen Rezaee, and Mohammad Bagher Ghalibaf. Capitalizing on Khamenei’s temporary lack of political capital, and the conservative division, the “reformist” and “pragmatist” factions—led by former presidents Mohammad Khatami, and Akbar Hashemi Rafsanjani, respectively—formed an alliance and elected Hassan Rouhani by an overwhelming majority.

In much the same way, factional politics seem likely to affect Iran’s future nuclear, missile, and rocket programs. Iran’s nuclear program is seen as a symbol of national unity. Yet within this unity are factional divisions.[10] Each faction has a different plan for making Iran, a respected—or “normal”—state in the international community, which inevitably involves their nuclear, missile, and rocket programs.

Any effort to characterize even the current factions within Iran’s power structure are uncertain, but some experts feel that “reformists” such as Mohammad Khatami or Hassan Khomeini, seem to favor a peaceful nuclear program, but place a higher value on becoming a “normal” state in the international community. They believe good relations with the United States, the implementation of international norms and social justice initiatives, and making modest concessions on Iran’s nuclear program are the best way to achieve their goals. Therefore, reformists are more receptive to limiting their nuclear enrichment to very low levels and their ballistic missile capabilities and implementing reforms as long as they will be *accepted* into the international community as a

"normal" state. To this faction, the costs of maintaining a civil nuclear program do not outweigh the benefits.[11]

Some experts also feel that a "pragmatist" faction exists that varies from the reformists. Embodied by former President Rafsanjani and President Rouhani, such "pragmatists" reject full concessions of Iran's nuclear program to the United States and world powers, but believe in more flexible policies when it comes to their nuclear program and ballistic missiles. They reason that through flexibility with the West, Iran's most pressing needs can be met, and it can be politically and economically *integrated* into the international community.[12] This is the guiding principle of Rouhani's presidency.

These "pragmatists" value economic development, but see the sanctions as the main obstacle preventing such development. They reason that Iran must reasonably concede certain parts of their nuclear program in return for the P5+1 (The UN Security Council members and Germany) to lift sanctions, thereby allowing them access to the international banking and financial system, which they so desperately need.

Unlike the "reformists," they oppose major nuclear and missile concessions. They recognize their civilian need for nuclear energy, but they are also perceptive of Iranian national security threats if it obtains a nuclear weapon: the potential for Saudi proliferation,[13] Israeli military retaliation, and an unpredictable response from the United States. At the same time, however, they also recognize that Iran is a Shia dominant state amongst Sunni states that have sponsored enemy terrorist groups against Iran.

Their only stalwart ally in the region, Bashar al-Assad, a Shia Alawite is fighting a civil war and an insurgency, and the eastern part of his country is now being attacked by a coalition of Sunni-Arab and Western forces. Balancing the benefits of possession against absence is at the heart of the nuclear and missile debate, and may even lead the "pragmatists" to support a nuclear weapons and nuclear-armed missile program.

Finally, there is considerable public evidence that a "conservative" faction exists that has quite a different view of Iran's nuclear and missile programs. Broadly, "conservatives" view a nuclear weapon and nuclear-armed medium and long-range nuclear missile programs as a deterrent from foreign aggression and intervention, primarily from the United States. Like the "pragmatists" and reformists, they see their nuclear program as a means to an end.

Unlike the "pragmatists" and "reformists, some "conservatives" seem to see nuclear proliferation and nuclear-armed missile forces as a way for Iran to become a *respected* state among the international community. They reason that once they have a nuclear weapon, they will forever be recognized as a "great power," much like Pakistan and India were, and Iran will be treated like a "normal" state, if not better.

Divisions amongst the "conservatives" are worth recognizing because it is these different 'sub-factions' that will determine the direction of Iran's nuclear program if they make the key decisions shaping Iran's missile and nuclear warhead programs. Moderate "conservatives" favor proliferation for deterrence and defense. The traditional conservatives, like the Supreme Leader, seem likely to support the development of tactical nuclear weapons for the express purpose of repelling an invasion. Despite a 2010 fatwa forbidding the production, stockpiling, and use of weapons of mass destruction, Iran has a history of contradicting their ideology so long as the regime (the Islamic Republic) survives.[14]

Finally, there may be more radical "conservatives" that see the acquisition of nuclear weapons and nuclear-armed missile forces as a way to expand Iran's influence throughout the Gulf and Middle East, gain active leverage over neighboring states, act as a warfighting counter to US and Arab Gulf conventional military superiority, defend Shi'ite enclaves outside Iran, and take a more actively aggressive stand in using Iran irregular forces, arms transfers, and the Al Quds force throughout the Gulf and the region.

The uncertainties in such assessment will be obvious to any expert on Iran and there are no guarantees of how Iran will change in the future or even how the success or failure of any P5+1 agreement will change groups and motives in the near-term. These same uncertainties, however, are critical in shaping the focus throughout the rest of this analysis on Iran's current and developing capabilities, rather than trying to guess at the underlying realities behind the Iranian statements quoted throughout the analysis, trying to find a current Iranian doctrine or strategy in a climate of so much uncertainty, or trying to predict a single path in Iran's missile developments.

On the basis of technology alone, things are evolving so quickly, and with so many uncertainties about timing and future capability that Iran's leaders and factions will be forced to change their current intentions and positions. As has just been shown, leaders can change as well, along with the positions of Arab states, Israel, Turkey, and outside powers like the United States. And once again, history is a grim warning that pre-crisis plans and intentions often do not survive the initial phase of a crisis, and that arms race – particularly asymmetric arms races – lead to constant changes in force plans and actual deployments, as well as unstable patterns of escalation in actual war. These factions—the "conservatives," the "reformists," and the "pragmatists"—differ in their motivations for the Iranian nuclear warhead because each has its own interests and interpretations of the values of the Islamic Revolution and how to preserve them. Iran's nuclear warhead is a divisive issue, yet understanding these divisions will ultimately help better analyze what the Iranian warhead might look like, the direction and development of Iran's missile and rocket program, and how the two could be combined if a future Iranian leader so chooses.

# II. Setting The Stage: Iran's Missile and Rocket Programs and Their Impact on the Gulf and Regional Military Balance

Iran's missile and rocket programs are both an independent element of its overall military efforts and a key aspect of any Iranian nuclear weapons efforts. US, European, Gulf, and Israeli policymakers and experts all agree that Iran already possesses a large and growing rocket and missile force, and a growing number of missiles capable of hitting Israel and Europe. They agree that Iran has begun developing longer range and solid fuel missiles, and already possesses a sufficient number to pose an economic and psychological threat to Gulf States.

While Iran's artillery rocket program has a strategic impact that extends far beyond its borders, its missile programs have a far larger strategic impact. Iran has put a major share of its military resources into developing a family of short, medium and long-range missiles that present a broad range of threats within the Gulf region, the Middle East as a whole, and increasingly outside it. Iran has been developing ballistic missile capabilities based on Russian, North Korean, and Chinese technology or weapons systems since the early 1980s. Iran currently possesses the largest ballistic missile inventory in the Middle East, and the country's military and scientific establishments are working to increase the sophistication, scale, and reach of its missiles.[15]

## *The Evolving Mix of Iranian Rocket and Missile Forces*

There are many differences in estimates of the nature and scale of the Iranian effort, how Iran would use its present missile forces, the types and performance of the systems Iran deploys and is developing, Iran's goals in developing new systems, and the extent to which Iran's missile programs are tied to its search for nuclear weapons. These uncertainties are compounded by the fact that Iran continues to test new variants of many of its systems, and is in the process of adding upgrades to existing missiles. For example, it is actively pursuing more advanced GPS guidance systems and is modifying systems like the Fateh-110 to give it an anti-radiation seeking capability. The Hormuz 1 is the designation for the upgraded anti-radiation Fateh-110.

**Figure 1** draws on work by a range of unclassified sources to provide a rough overview of the number of Iran's major missiles and their key performance specifications. The differences between these sources on even the types of missiles in Iranian hands are clearly uncertain and the data on missile numbers even more so.

It is clear that Iran has built up massive stocks of artillery rockets and has large numbers of ballistic missiles that can attach maritime and other targets across the Gulf – especially in the upper Gulf near Kuwait and Iraq. At present, Iran's rockets and missiles lack the combination of accuracy and lethality to pose a major threat to coastal ports and critical energy facilities. [16]

Unclassified reports on the nature of Iran's holdings, and deployments of such weapons are uncertain, but reports by the IISS, Jane's/IHS and other sources indicate that Iran's shorter range rockets and missiles include the FROG 7 (70 kilometers, 250 rockets), Oghab rockets (35-45 kilometers, ), Nazeat/Iran-130 missiles (100-130 kilometers, 500-650 missiles), and Zelzal 1 (150 kilometers), Zelzal 1B (150 kilometers), Zelzal 2 (100-210 kilometers), and Zelzal 3 (200 kilometers.[17]

They also include more advanced solid-fuel Fateh 110 and A-110), the Tondar 69 (200 missiles), systems with a 210 kilometer range, the Chinese-made CCS-8 (M7/Project 8610) with a range of 150 kilometers and a 190 kilogram warhead, and a newer Qiam-1 tactical ballistic missile.[18] Jane's reports that the Qiam-1 missile is a finless system with a 700-850 kilometer range and warheads of 500 to 650 kilograms. Some sources indicate that these systems have some form of GPS guidance. Variants have been reported with names like the MDC-300 and MDC-600, although some reports seem to assume Iran has Syrian missiles.

Sources are equally conflicting in reporting on Iran's medium range ballistic missiles, with different listings of types, age, test data, range, accuracy, and warheads. They also differ on how much technology Iran has gotten from North Korea and the current level of cooperation. It is clear, however, that Iran has moved far beyond the point where it's dependent on imports or its own production of systems with ranges of around 300 kilometers or less like the Scud B SS-1c (Iranian Shahab-1, 300-350 kilometers, 25-300 missiles) and Scud C SS-1d (Iranian Shahab-2 (750 kilometers, 50-100 missiles).

Iran also has more capable systems that are deployed or have reached final development. They include the storable liquid fueled Shahab 3 (1,300 kilometers), Shahab 3A (1,500-1,800 kilometers), Ghadr-1 (1,800 kilometers), Shahab 3B (2,000-2,500 kilometers), and possible development/deployment of some form of Pakistan's solid-fueled Shahin-2 (200-250 missiles, 2,500 kilometers).

Iran has tested a solid fueled rocket called the Sejjil-2 or Sijjil-2, which Jane's indicates may have a range of some 2,000 kilometers with a 1,000 kilogram warhead. Jane's and the Wikileaks website also indicate that Iran may have acquired 19 North Korean Musudan IRBMs (aka Mirim, No-Dong, BM-25) based on the Russian R-27 (SS-N-6 Serb). IISS reporting doubts this, but such a system could have a range of up 2,500-4,000 kilometers.

The limited unclassified data on range in **Figure 1** -- along with far more speculative warhead and CEP data—seem to be based on nominal engineering models and estimates rather than actual test data. The full range of problems in these data are discussed in depth later in this report, but it is important to note that and CEP data apply only to 50% of the force and assume that the missile is perfectly reliable and targeting is perfect within a few meters. In the past, such data have been notoriously unreliable compared to data based on proven operational tests and use of the derived aim point method. Moreover, operational performance has often fallen far short of the result obtained even through large-scale test and evaluation.

As is explained later in more depth, CEP and other nominal accuracy should never be used as a valid indicator of real world performance. Given the real world operational accuracy of such systems, and the lethality of unitary or even advanced conventional warheads, most or all cannot be used effectively to attack a point target. They also have limited lethality even when fired into a large area target unless they hit a critical point out of sheer chance.

## *The Scale and Cost of the Iranian Rocket and Missile Effort*

There are no credible cost estimates of what Iran has spent or is spending on the various aspect of its missile program and forces, and few reliable unclassified data are available on the specifics of Iran's missile R&D, production, test and other effort. At the same time, it is clear that Iran has put major resources into these efforts for several decades and that they are national in scale.[19] The scale of Iran's effort is also reflected in the number of missile systems that Iran deploys.

Few reliable unclassified data are available on the specifics of Iran's missile R&D, production, tests and other efforts, but it is again clear that Iran has put major resources into these efforts for several decades and that they are national in scale.[20] The scale of Iran's effort is also reflected in the number of missile systems that Iran deploys. **Figure 2** again draws on work by Steven A. Hildreth of the Congressional Research Service, and by the Nuclear Threat Initiative, to provide a rough indication of the scale of Iran's missile effort in terms of key facilities.

***Figure 1: Major Iranian Missile Force: An Overview – Part One***

## Hildreth Estimate 2010

| | Shahab-1 | Shahab-2 | Shahab-3 | Ghadr-1 | Sejjil-2 | Khalij Fars | Fateh-110 | Zelzal-1/2/3 |
|---|---|---|---|---|---|---|---|---|
| Range (km) | 300-315 | 375-700 | 800-1300 | 1100-2500 | 1800+ | 300 | 200-400 | 125/200/ 150-400 |
| Payload (kg) | 1000 | 1000-730 | 1000 | 1000-750 | 1000 | 650 | 500 | 600 |
| CEP (m) | 450-1000 | 50-700 | 190-2500 | 1000 | Unknown | <50 | 100-300 | 100-3000 |
| Number in Service | 200-300 | 100-200 | 25-100 | 25-300 | Unknown | Unknown | Unknown; likely in hundreds | Unknown; likely in thousands |
| Launchers | 18 | 18 (same as Shahab-1) | 6-20 | 6-20 (same as Shahab-3) | Unknown | Unknown | Unknown | Unknown |
| Fuel | Liquid | Liquid | Liquid | Liquid | Solid | Solid | Solid | Solid |

Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service, December 6, 2012, 15.

## Israeli INSS Estimate 2013

| **Missile Type** | **Launcher Numbers** | **Missile Numbers** | **Comments** |
|---|---|---|---|
| SS-1 (Scud B) | 20 | 300 | - |
| SS-1 (Scud C) | 20 | 100 | - |
| Shehab 2 | - | - | Probably similar to Syrian Scud D |
| Shehab-3/3B, Ghadir | 10 | 300 | - |
| BM-25 | - | 18 | Operational Status unknown. |
| Tondar-69 (CSS 8) | 16 | - | - |
| Qiam-1 | - | - | Liquid fuel |
| Fateh-100 | - | - | - |
| Shehab 3B/Ghadir development | - | - | Includes new RV, believed in production. |
| Ashura/Sejjil | - | - | Solid propellant. |

Source: Institute for National Security Studies (INSS), "Iran-Strategic," *Middle East Military Forces*, February 1, 2013, 7, http://inss.web2.moonsite.co.il/uploadimages/SystemFiles/iran.pdf.

***Figure 1: Major Iranian Missile Performance Details: An Overview – Part Two***

## IHS Jane's 2013

### System Number Range (KM) Mission and Comments

| | | | |
|---|---|---|---|
| FROG 7 Rocket | 250 | | battlefield rocket |
| Oghab | 250 | | battlefield missile |
| Shahin-2 | 250 | | battlefield missile |
| Nazeat/Iran 130 | 500 | | battlefield missile |
| Fateh 110 | na | 200+ | ballistic missile |
| Fateh A-110 (Mersad) | na | 250 | ballistic missile |
| Fateh-110-D1 | na | 250 | ballistic missile |
| Tondar 69 | 200 | | ballistic missile |
| Shahab-1 (SS-1c 'Scud B') | 250 | 300 | ballistic missile, 1000 Kg warhead |
| Shahab-2 (SS-1d 'Scud C') | 50 | 500-600 | ballistic missile, 800 Kg warhead |
| Shahab-3 (No-dong 2) | 25 | | ballistic missile |
| Shahab 3A | na | 1,500-1,800 | uncertain variant |
| Ghadr 1 | na | 1,800 | uncertain variant |
| Shahab 3B | na | 2,000-2,500 | uncertain variant |
| Sejjil-2 | na | 2,000 | developmental, 1000 Kg warhead |
| BM-25 | 18? | | ballistic missile |
| Qiam 1 | na | 700 | ballistic missile |

Source: IHS Jane's, *Sentinel Series*, "Iran, Strategic Weapons," 2013, 6-9.

## IISS Estimate 2014

*Iranian Army holdings* of *Shahin*-1/*Shahin*-2; *Nazeat*; *Oghab*

*IRGC Holdings of:*

1 SRBM brigade with *Shahab*-1/2

- 18+ launchers: some *Fateh* 110; 12-18 *Shahab*-1/2 launchers (ε200–300 missiles)

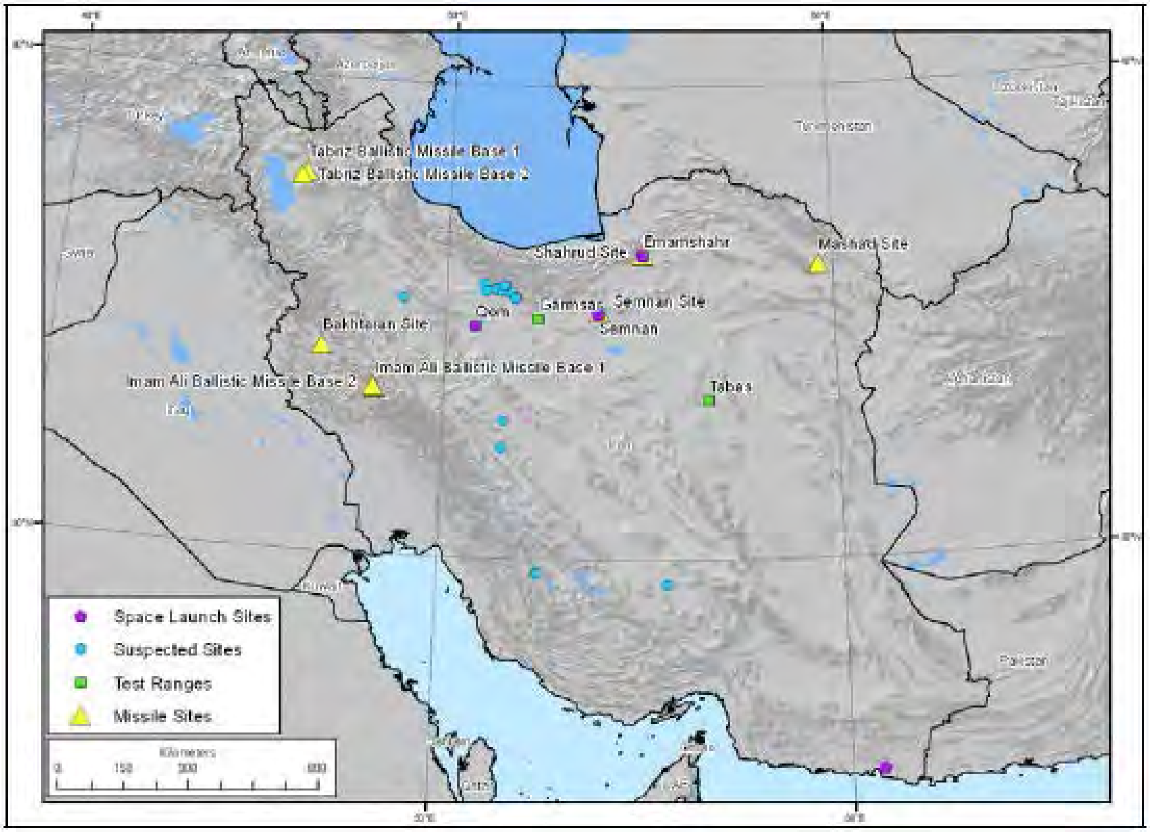
1 MRBM brigade with *Shahab*-3; *Ghadr*-1; *Sajjil-2* (in development)

- 12+ launchers: 12+ *Shahab*-3/*Ghadr*-1; some *Sajjil*-2

Some units with Short-range Zelzal surface-to-surface missiles

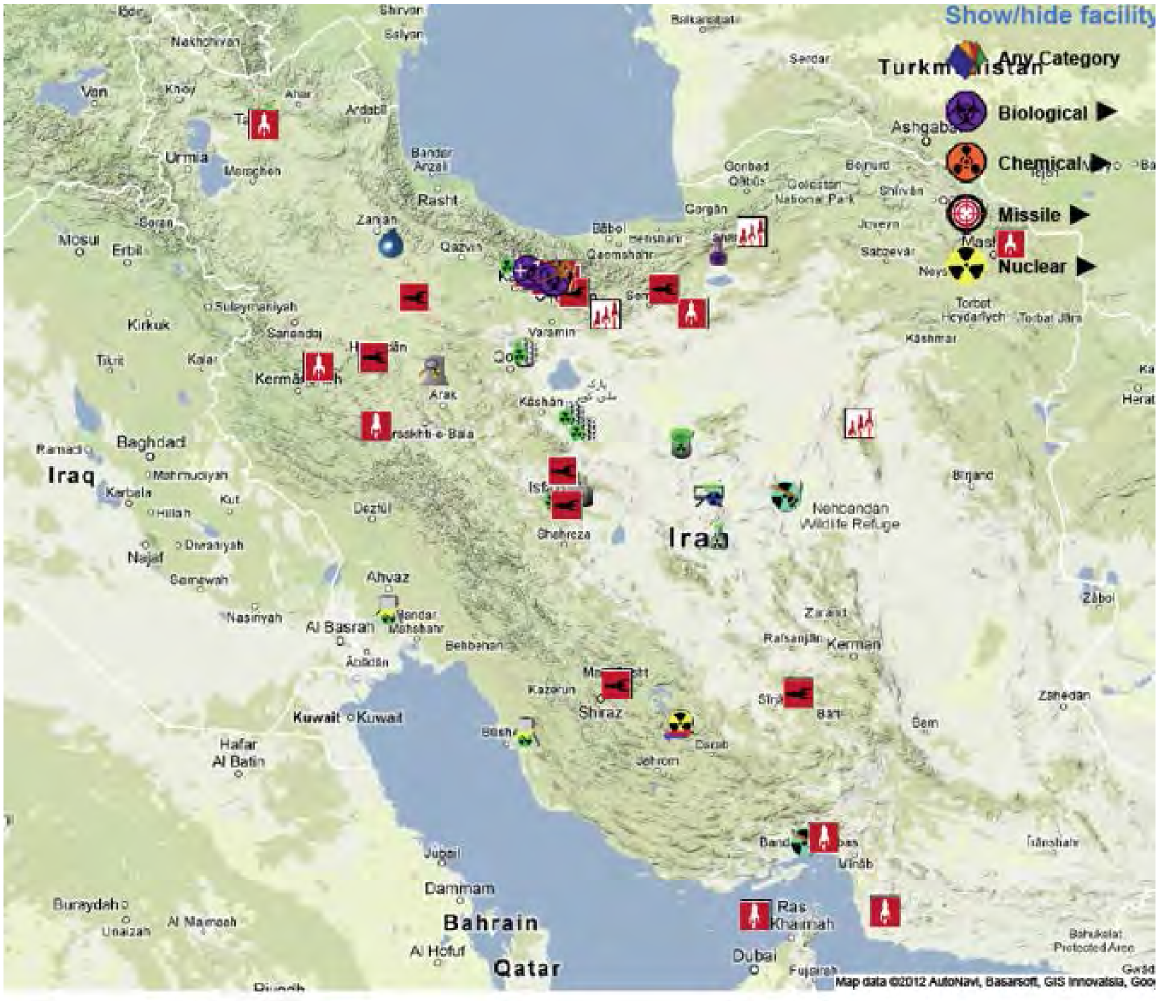
Source: IISS, "Iran," Military Balance, 2014, pp. 319-320.

***Figure 2: Iran's Ballistic Missile and Space Launch Facilities – Part I***




Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service, December 6, 2012, 15.

*Figure 2: Iran's Ballistic Missile and Space Launch Facilities – Part II*





Source: Source: NTI, September 2012, http://www.nti.org/gmap/?country=iran&layers.

## *Rockets and Missiles as Compensation for Iran’s Weaknesses in Conventional Warfare and as Tools in Asymmetric and Irregular Warfare*

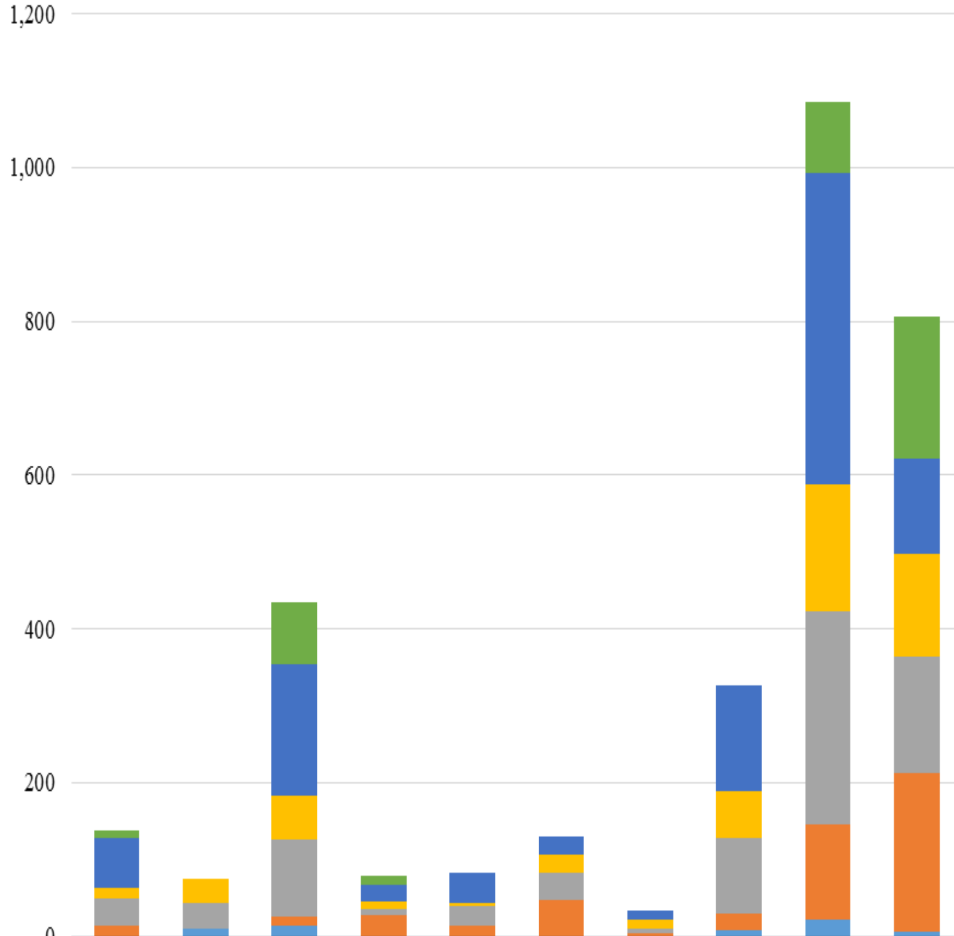
Iran has discussed ambitious programs to build up and modernize its conventional forces for years, and initially gave such program a major emphasis after its disastrous defeats in the final battles of the Iran-Iraq War – defeats that US estimates indicate cost it some 40-60% of its major inventory of land weapons. It has sought to import advanced combat aircraft and surface-to-air missiles from the former Soviet Union (FSU) and Russia and made repeated claims that it will – or is –producing advanced weapons systems on its own. The reality is, however, that its conventional forces remain far too weak to compete with the forces the US, the Gulf States, Britain, and France can deploy against Iran. This has made artillery rockets and missiles a key part of Iran’s deterrent and defense capabilities and of a broader Iran strategy to use irregular forces and asymmetric warfare as a substitute for conventional military power.

### The Air and Air Defense Balance

The weaknesses in Iran’s conventional forces include major limitations in the strength and modernization of key land force and major naval systems, but the key weaknesses that help explain Iran’s emphasis on missile forces lie in its lack of modern air power and surface-to-air missiles. Iran has not been able to obtain major imports of modern combat aircraft from the US and Europe since the fall of the Shah, or any of the modernization programs critical to upgrading its US-made aircraft. It has only had limited imports of surface-to-air missiles and has not had access to US and European upgrades and newer systems. It has sought advance combat aircraft and surface-to-air missiles from Russia but has had little more than token success, and its claims of producing substitutes have so far been little more than hollow propaganda.

**Figures 3 to Figure 8** show that the air balance in the region decisively favors the US and Southern Gulf states. The US and Arab Gulf states have a decisive advantage in air and surface-to-air missile quality and quantity, and the US can rapidly deploy a massive superiority in every aspect of air and cruise missile power including stealth aircraft, carrier and land-based forces, IS&R and C4I/battle management systems.

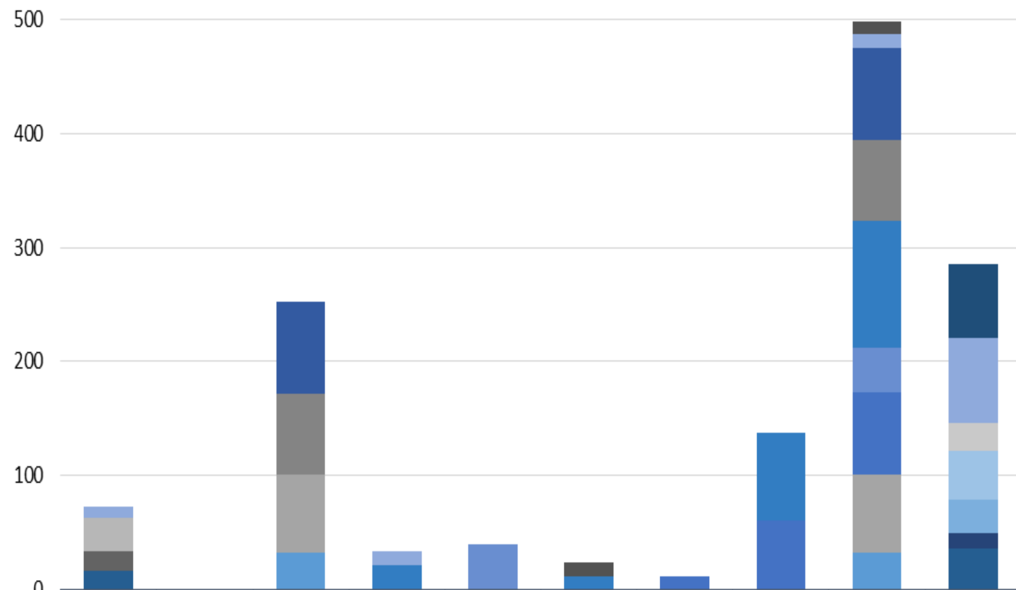
***Figure 3: Total Combat Air Strength without US and Other Allied Aircraft***




| | Yemen | Iraq | Saudi | Bahrain | Kuwait | Oman | Qatar | UAE | GCC Total | Iran |
|---|---|---|---|---|---|---|---|---|---|---|
| Fighter | 10 | 0 | 81 | 12 | 0 | 0 | 0 | 0 | 93 | 184 |
| Fighter/Grnd Attack | 65 | 0 | 172 | 21 | 39 | 24 | 12 | 138 | 406 | 124 |
| Transport | 13 | 32 | 56 | 10 | 3 | 23 | 12 | 60 | 164 | 134 |
| Training | 36 | 33 | 100 | 9 | 27 | 36 | 6 | 99 | 277 | 151 |
| Support Helicopters | 14 | 0 | 12 | 27 | 13 | 47 | 4 | 22 | 125 | 207 |
| ISR | 0 | 10 | 14 | 0 | 0 | 0 | 0 | 7 | 21 | 6 |

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014*, and IHS Jane's, *Sentinel Series*.

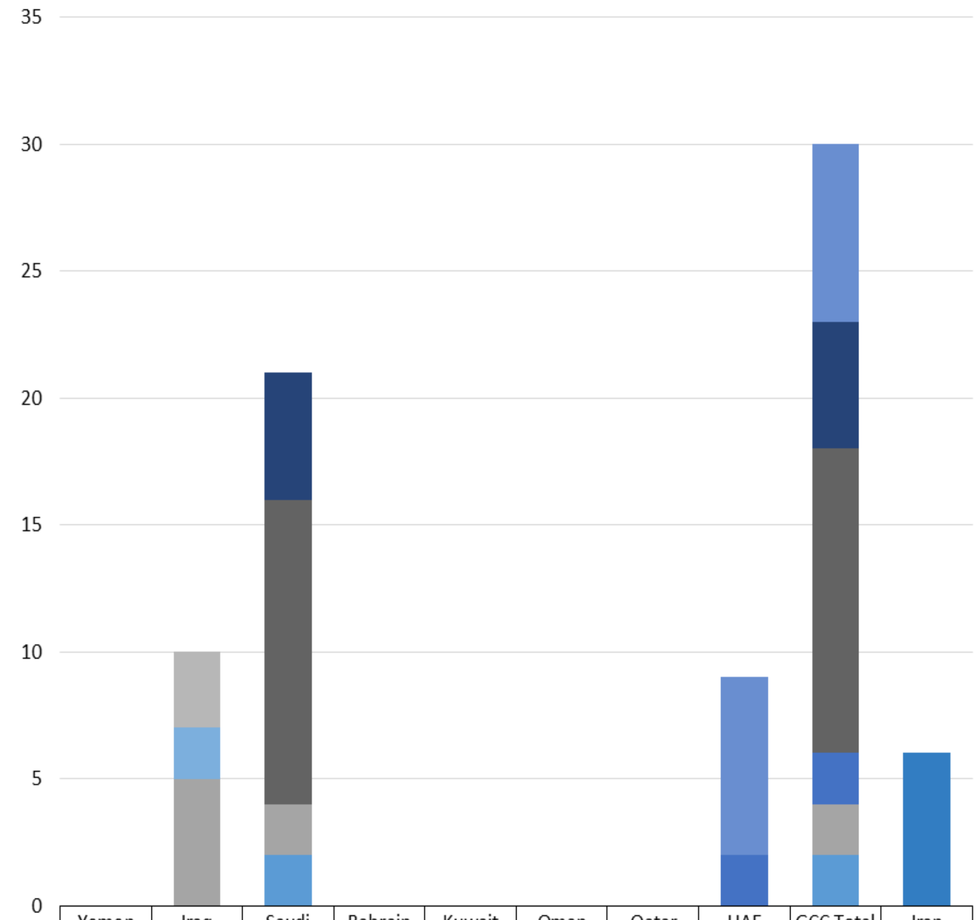
***Figure 4: Comparative "Modern" Fighter Strength without US and Other Allied Aircraft***




| | Yemen | Iraq | Saudi | Bahrain | Kuwait | Oman | Qatar | UAE | GCC Total | Iran |
|---|---|---|---|---|---|---|---|---|---|---|
| Jaguar B/S | | | | | | 12 | | | 12 | |
| F-4D/E | | | | | | | | | | 65 |
| F-5B/E/F | 10 | | | 12 | | | | | 12 | 75 |
| F-7 | | | | | | | | | | 24 |
| F-14 | | | | | | | | | | 43 |
| F-15C/D | | | 81 | | | | | | 81 | |
| F-15S | | | 71 | | | | | | 71 | |
| F-16 | | | | 21 | | 12 | | 78 | 111 | |
| F-18 | | | | | 39 | | | | 39 | |
| Su-20/22 | 29 | | | | | | | | | |
| Su-24 | | | | | | | | | | 30 |
| Su-25 | | | | | | | | | | 13 |
| MiG-21 | 18 | | | | | | | | | |
| Mig-29 | 16 | | | | | | | | | 36 |
| Mirage 2000 | | | | | | | 12 | 60 | 72 | |
| Tornado IDS | | | 69 | | | | | | 69 | |
| Typhoon-2 | | | 32 | | | | | | 32 | |

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014*, and IHS Jane's, *Sentinel Series.*

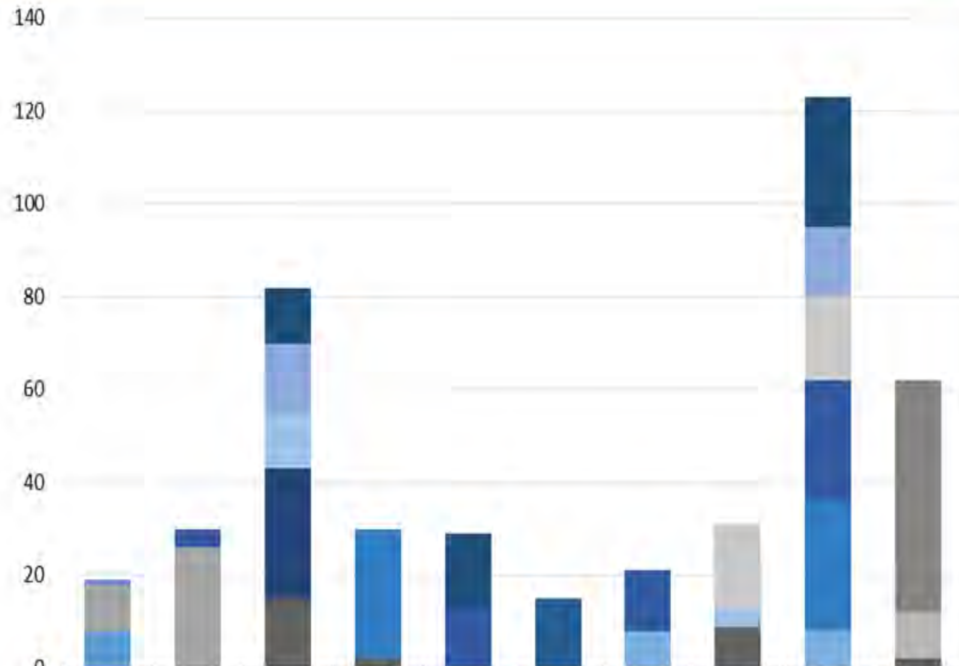
***Figure 5: Comparative Reconnaissance, Major Intelligence, & Air Control and Warning (AEW/ AWACS) Aircraft Strength without US and Other Allied Aircraft***




| | Yemen | Iraq | Saudi | Bahrain | Kuwait | Oman | Qatar | UAE | GCC Total | Iran |
|---|---|---|---|---|---|---|---|---|---|---|
| RF-4E | | | | | | | | | | 6 |
| Mirage 2000 RAD | | | | | | | | 7 | 7 | |
| Cessna 208B | | 3 | | | | | | | | |
| SB7L-360 | | 2 | | | | | | | | |
| E-3A | | | 5 | | | | | | 5 | |
| Tornado GR1A | | | 12 | | | | | | 12 | |
| RC-130 | | | | | | | | | | |
| Saab 340 | | | | | | | | 2 | 2 | |
| 350ER King Air | | 5 | 2 | | | | | | 2 | |
| RE-3A/B | | | 2 | | | | | | 2 | |

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014*, and IHS Jane's, *Sentinel Series*.

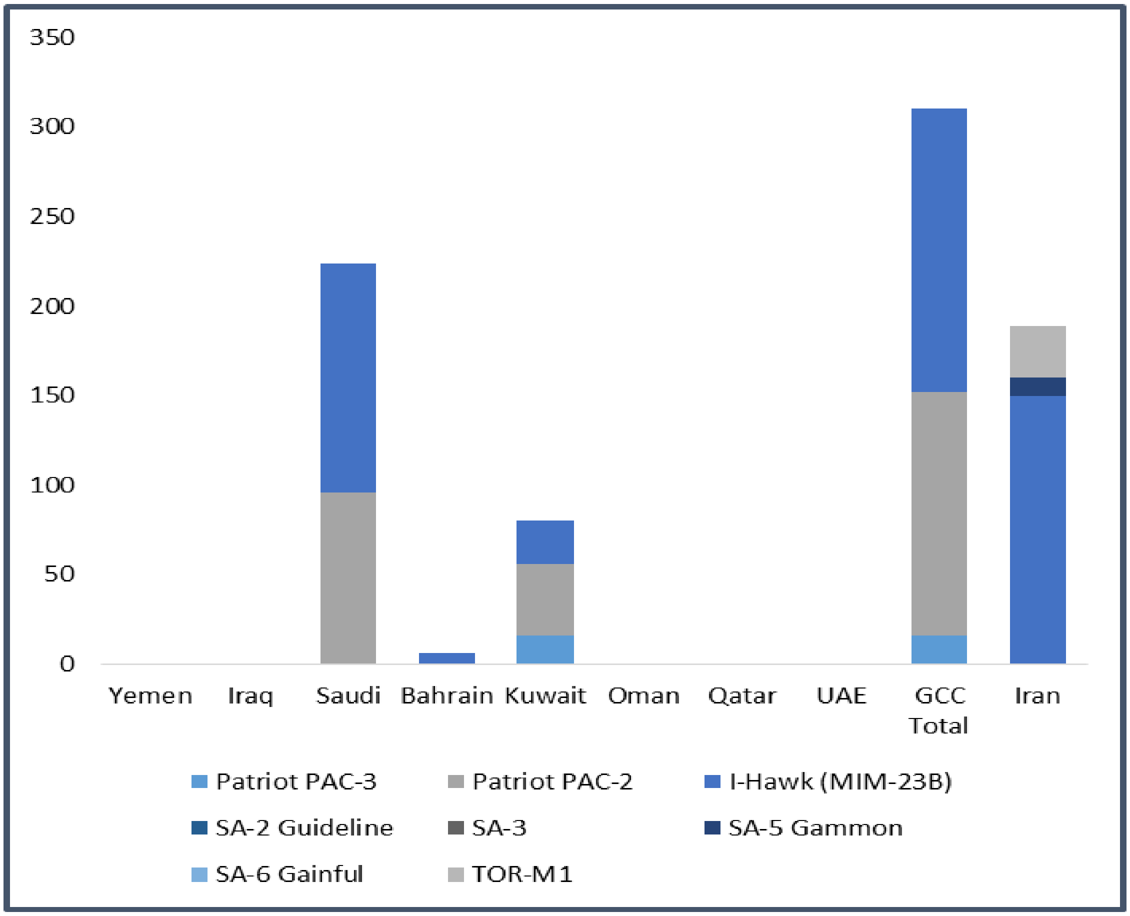
***Figure 6: Comparative Attack, Armed, and Naval Combat Helicopter Strength without US and Other Allied Aircraft***




| | Yemen | Iraq | Saudi | Bahrain | Kuwait | Oman | Qatar | UAE | GCC Total | Iran |
|---|---|---|---|---|---|---|---|---|---|---|
| AH-64 | | | 12 | | 16 | | | | 28 | |
| AS-565 | | | 15 | | | | | | 15 | |
| AS-550C3 | | | | | | | | 18 | 18 | |
| AS-365N | | | 12 | | | | | 4 | | |
| SA-341/342 HOT | | 4 | | | 13 | | 13 | | 26 | |
| AH-1J | | | | | | | | | 0 | 50 |
| AH-1E/F | | | | 28 | | | | | 28 | |
| KA-27 | 1 | | | | | | | | 0 | |
| SH-3D | | | | | | | | | 0 | 10 |
| Commando Mk3 | | | | | | | 8 | | 8 | |
| Bell 406CS | | | 28 | | | | | | | |
| Bell 412 | | | 15 | 2 | | | | 9 | | 2 |
| Mk-300 Super Lynx | | | | | | 15 | | | | |
| Mi-35 | | | | | | | | | 0 | |
| Mi-17 | 10 | 26 | | | | | | | 0 | |
| RH-53D | 8 | | | | | | | | 0 | |

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014,* and IHS Jane’s, *Sentinel Series*.

***Figure 7: Comparative Major Surface-to-Air and Ballistic Missile Defense Launcher Strength without US and Other Allied Forces***




| | Yemen | Iraq | Saudi | Bahrain | Kuwait | Oman | Qatar | UAE | GCC Total | Iran |
|---|---|---|---|---|---|---|---|---|---|---|
| Patriot PAC-3 | | | | | 16 | | | some | 16 | |
| Patriot PAC-2 | | | 96 | | 40 | | | | 136 | |
| I-Hawk (MIM-23B) | | | 128 | 6 | 24 | | | some | 158 | 150 |
| SA-2 Guideline | | | | | | | | | | |
| SA-3 | some | | | | | | | | | |
| SA-5 Gammon | | | | | | | | | | 10 |
| SA-6 Gainful | some | | | | | | | | | |
| TOR-M1 | | | | | | | | | | 29 |

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014*, and IHS Jane's, *Sentinel Series*.

***Figure 8: Iranian Reliance on Aging/Mediocre Air and Air Defense Systems***

## Air Forces

**FTR 184+:** 20 F-5B *Freedom Fighter*; 55+ F-5E *Tiger* II/F-5F *Tiger* II; 24 F-7M *Airguard*; 43 F-14 *Tomcat*; 36 MiG-29A/U/UB *Fulcrum*; up to 6 *Azarakhsh* reported

**FGA 111:** 65 F-4D/E *Phantom* II; 10 *Mirage* F-1E; 30 Su-24MK *Fencer* D; up to 6 *Saegheh* reported

**ATK 13:** 7 Su-25K *Frogfoot*; 3 Su-25T *Frogfoot*; 3 Su-25UBK *Frogfoot*

**ASW** 5 P-3MP *Orion*
**ISR:** 6+ RF-4E *Phantom II*

**TKR/TPT** B-707; ε2 B-747
**TPT 117:** Medium ε19 C-130E/H *Hercules*; Light 10 F-27 *Friendship*; 1 L-1329 *Jetstar*; 10 PC-6B *Turbo Porter*; 8 TB-21 *Trinidad*; 4 TB-200 *Tobago*; 3 *Turbo Commander* 680; 14 Y-7; 9 Y-12; PAX 11: 2 B-707; 1 B-747; 4 B-747F; 1 *Falcon* 20; 3 *Falcon* 50

**HELICOPTERS**
**MRH 32:** 30 Bell 214C (AB-214C); 2 Bell 412
**TPT 4+:** Heavy 2+ CH-47 *Chinook*; Light 2+: 2 Bell 206A *Jet Ranger* (AB-206A);

## Land Based Air Defenses

**Air Defense Force**

**SAM** 529+:
250 FM-80 (*Crotale*); 30 *Rapier*; 15 *Tigercat*; 150+ MIM-23B I-HAWK/*Shahin*; 45 S-75 *Dvina* (SA-2 *Guideline)*; 10 S-200 *Angara* (SA-5 *Gammon);* 29 9K331 *Tor*-M1 (SA-15 *Gauntlet)* (reported)

**MANPAD** FIM-92A *Stinger*; 9K32 *Strela*-2 (SA-7 *Grail*)‡

**Army**

**SP** 10+: HQ-7 (reported); 10 *Pantsyr* S-1E (SA-22 *Greyhound*)

**MANPAD** 9K36 *Strela*-3 (SA-14 *Gremlin*); 9K32 *Strela*-2 (SA-7 *Grail*)‡*; Misaq 1* (QW-1 *Vanguard*); *Misaq 2* (QW-11); *Igla-S* (SA-24 *Grinch* - reported); HN-54

Source: Adapted by Anthony H. Cordesman and Garrett Berntsen from IISS, *Military Balance, 2014,* and IHS Jane's, *Sentinel Series*.

## The Iranian Air Force: A Weak and Aging Force

Estimates do differ sharply regarding Iran's air strength and operational status. **Figure 9** shows a range of such assessment by leading authorities, however, and it is clear that the differences do not affect the overall character, age, and readiness of Iranian combat air forces.

The INSS and IHS Jane's both show major gaps between Iran's original holdings and current total inventory and its operational capabilities by type. The IISS indicated that Iran's actual ability to operate its aging air forces, however, was limited. It estimated that only about 60% of the US and French supported combat aircraft were operational and about 80% of the Russian and Chinese-supplied aircraft.

It is clear from these and other sources that there are equally serious problems in the readiness of Iran's large fleet of Western supplied transports, trainers and helicopters – and that this was true in all of its regular military services and the IRGC. Once again, the readiness of its Russian-supplied transports and other aircraft was higher, although readiness varied by type and even rough percentages of operational status were lacking.

While Southern Gulf air forces have limits, the Iranian air force (IRIAF) still lags far behind the capabilities of the GCC air forces and even further behind the combined capabilities of the GCC and US air forces. Iran lags badly behind the Gulf States in modernizing its air forces. Iran's most advanced fighters consist of a small number of export versions of the Su-24 and MiG-29, whose avionics lag far behind their Russian counterparts and date back to the early 1990s.

Iran's aircraft also suffer from limited access to required spare parts and upgrades, reducing Iran's effective airpower to roughly sixty percent of its existing planes; furthermore, while information on training is classified, Iran has made public far fewer air force exercises than missile and naval drills.

These limits to Iran's air force are particularly important as Iran has air bases that are only a few minutes flight time from critical targets in the Gulf and the coastal areas of the southern Gulf States. They are also important because Iran's weaknesses in air-to-air combat, and its weaknesses in surface-to-air missile defense which are described below, leave it highly vulnerable to any US or US and Gulf attack and vulnerable to a major preventive strike by Israel.

As for its structure and strength, the IRIAF is divided into three commands – Eastern, Southern, and Western, with the latter having the majority of active squadrons – with most of the advanced aircraft home-based in the interior of the country. Air command is split between the Iranian air force and the IRGC air force, with the former primarily controlling aircraft and the latter the caretakers of the strategic missile forces.

### *Figure 9: Comparative Estimates of Iranian Combat Aircraft – Part One*

## Israeli Institute of National Security Studies 2013 Estimate

| **Aircraft Type** | **Inventory** | **in Service** | **since** | **Supplier** | **Comments*** |
|---|---|---|---|---|---|
| *Fighters* | | | | | |
| F-5A/B/C | 50 | 42 | 1975 | US supplied, | obsolete |
| F-7 | 50 | 24 | 1987 | PRC supplied, | obsolete |
| Mirage F-1-E | 21 | 10 | 1991 | French supplied | obsolescent |
| F-4 D/E | 49 | 30 | 1968 | US | obsolescent |
| F-14A | 57 | 35 | 1972 | US, | obsolescent |
| MiG-29 | 34 | 24 | 1990 | Russian, | export version |
| Su-24 strike fighter | 22 | 22 | 1991 | Russian, | export version |
| Su-25 close support | 13 | 13 | 1991 | Russian, | upgraded |
| Saegheh | 12 | 12 | 2006 | Iranian made, | still developmental. |
| Azazakhsh | 6 | 6 | 2000 | Iranian made, | still developmental. |
| J-10 | 24 | NA | NA | | Possible buy from PRC. |
| Su-27 | - | - | - | | Possible buy from Russia. |
| *Surveillance and Recce* | | | | | |
| RC-130 | 2 | 2 | 1970 | Obsolete | but upgraded. |
| RF-4E | 6 | ? | 1974 | Obsolete | |
| *Attack Helicopters* | | | | | |
| AH-1J Cobra | 90 | 65 | 1976 | US supplied | badly worn and dated. |
| Shabaviz 2091/Toophan | ? | ? | ? | Iranian upgrade | status uncertain. |
| Shahed 285 | 10 | 10 | 2009 | Iranian upgrade | status uncertain. |
| *Maritime Patrol* | | | | | |
| PF-3 Orion | 2 | 2 | 1974 | US-supplied, | obsolete but upgraded. |
| CH-130HP | 5 | 5 | 1970 | US supplied, | obsolete. Also transport. |
| AN-140 Oghab | 1 | 1 | 2012 | | |
| Y12 | 7 | 7 | 2000 | Transport, | second mission uncertain. |
| Dornier DO-228 | 2 | 2 | ? | Transport, | second mission uncertain. |

* By authors of study, not INSS.

Source: Institute for National Security Studies, "Military Force-Iran," February 1, 2013, http://inss.web2.moonsite.co.il/uploadimages/SystemFiles/iran.pdf.

### *Figure 9: Comparative: Estimates of Iranian Combat Aircraft – Part Two*

## IHS Jane's 2013 Estimate

| **Aircraft Type** | **Original Deliveries** | **Operational** | **First Delivery** | **Supplier and background** |
|---|---|---|---|---|
| F-5B Smiorgh | 13 | 12 | n/a | US/iAMi supplied, F-5B converted from F-5A; at least 13 reported to have been completed |
| 5F-E II | 141 | 31 | 1974 | US supplied |
| F5-FII | 28 | 18 | 1974 | US supplied |
| F-7N | - | 30 | - | PRC supplied |
| FT-7N | - | 30 | - | PRC supplied |
| Mirage F-1EQ | na | 20 | 1991 | French supplied, Impounded Iraqi aircraft; in case of Mirage, at least six F1BQ two-seaters and 15 F1EQ single-seaters are believed to be operated |
| F-4 D | 32 | 5 | 1968 | US supplied |
| F-4E | 177 | 49 | 1971 | US supplied |
| RF-4E | 16 | 4 | 1971 | US supplied |
| F-14A | 79 | 44 | 1976 | US supplied, only about 35 maintained in operational status at any given time |
| MiG-29 | - | 48 | 1990 | Russian supplied, includes 21 impounded Iraqi aircraft; at least seven MiG-29UB 'Fulcrum B' two-seaters have been received; 35 to be overhauled and upgraded. |
| Su-24MK/Fencer D | 30 | 29 | 1991 | Russian supplied. Low estimate. Total includes 18 impounded Iraqi aircraft; more allegedly received from requirement for 100 ex-Russian aircraft; armed with Fajr-e-Darya AShMs; 24 to be overhauled and upgraded |
| Su-25 close support | 13 | 13 | 1991 | Russian supplied, Includes examples of the Su-25K, Su-25UBK and Su-25T versions, with at least five Su-25K/UBK being former Iraqi Air Force aircraft. |
| S-100 Saegheh | - | 3 | - | Iranian made fighter, still developmental. |
| IL-76 AEW | 2 | 0-2 | - | Total of 15 Il-76s acquired, including two ex-Iraqi aircraft modified for AEW mission. Of 13 pure transport aircraft, five were passed to Revolutionary Guards Corps, with only one Il-76TD reported active in 2011. |
| B-707-39JC Sigint | - | 2 | | Iranian conversions of B-707s to signals intelligence mission. |
| AH-1J Sea Cobra/Toufan | - | 45 | 1974 | US supplied attack helicopters. Refurbishments began in 1998. Ten upgraded 'Toufan' aircraft reportedly delivered in 2010 |
| *Maritime Patrol* | | | | |
| PF-3 Orion | | 6 | 4 | US-supplied, Obsolete but upgraded. To be replaced by version of Iran-140 Faraz |

Source: IHS Jane's, *Sentinel Series*, "Iran," 2013, 23, 12-13.

### *Figure 9: Comparative Estimates of Iranian Combat Aircraft – Part Three*

## International Institute of Strategic Studies 2014 Estimate

| Aircraft Type | Original Holding | In Service | Comments |
|---|---|---|---|
| *Fighters* | | | |
| F-5B | - | 20 | * |
| F5-E/F | - | 55+ | * |
| F-4D/EII | - | 65 | * |
| RF-4E | - | 6 | * |
| F-14 | - | 43 | * |
| Mirage F-1EQ | - | 10 | * |
| F-7M | - | 24 | ** |
| Mig-29A/U/UB | - | 30 | ** |
| Su-24MK | - | 30 | ** |
| Su-25K | - | 7 | ** |
| Su-25T | - | 3 | ** |
| Su-25UBK | - | 3 | ** |
| Saegheh | - | 6 | Iranian made |
| *Maritime Patrol* | | | |
| *P-3MP* | - | *5* | |
| *Attack Helicopter* | | | |
| AH-1J | - | 50 | |

*Only about 60% of the US and French supported combat aircraft are operational

**About 80% of the Russian and Chinese-supplied aircraft are operational.

Source: IISS, "Iran," *Military Balance, 2014*, pp. 319-321.

## The Uncertainties Affecting Iran's Aircraft and Modernization

Even allowing for Iranian efforts at updates and modifications, much of Iran's air force is something of a military museum. It is a tribute to Iran that it can keep so many of its US-supplied and older Russian and Chinese aircraft flying, but none of the Western-supplied aircraft in Iran's inventory have been modernized by the US since the fall of the Shah. Experts suggest, however, Iran has been relatively successful in maintenance, material and management -- enabling the IRIAF to continue flying despite an almost complete blockade on new parts.

Maintenance has been aided by the fact that Iran developed extensive illegal purchasing networks during the Iran-Iraq War and has maintained them ever since. It has kept many of its aircraft flying, although it is unclear that it can fly more than 60% of its 297-312 remaining combat aircraft at any given time.[21] There is no way on the basis of unclassified data to estimate its sortie generation rate over time, and it is unclear that Iran has ever stressed its air force to find out the answer. It does seem likely that its sortie generation rate over time would be a fraction of the rate that the US and better Southern Gulf air forces could generate.

A combination of cannibalization and re-engineered similar parts also enables Iran to maintain its systems. These efforts have been particularly successful with the F-4 and C-130, while the F-14 – which proved to be a maintenance problem for the US as well – remains far below operational capacity. Iran has been trying to get the SU-22, -24, and -25's that it obtained from Iraq in 1991 to full effectiveness. Experts claim this effort has been supported by parts and advice from Russian and Ukrainian companies, but such this aid is believed to have been sporadic and of limited utility.

Experts feel that Iran has proven unable to reverse-engineer the more advanced elements of American and Soviet aircraft, although Iran's reverse engineering skills have improved. Iran has made efforts to update many of its aircraft, but the need to reverse engineer and improvise has been a critical shortcoming. Their US-flown counterparts – especially the 44 F-14s and 65 F-4D aircraft still in Iranian service – are aircraft that never went through the long series of US Multi-Stage Improvement Programs (MSIPs) that corrected design problems, improved flight performance, improved sortie generation capability, and modernized their avionics and radars for air-to-air and air-to-ground/sea operations after 1979.

Iran has both obsolescent and modern air-to-air, air-to-ground, and air-to-ship weapons. Iran claims to have adapted its Hawk missiles to replace the Phoenix missiles on its F-14s and has aging AIM-9 Sidewinders and AIM-7 Sparrows. It also has more modern Russian made air-to-air missiles: The AA-8, AA-9, AA-10, and AA-11.[22]

Jane's-IHS reports that the air-to-surface precision weapons in active inventory that might be used against ships or targets affecting maritime exports include the Iranian made Satter 1 and Satter 2 air-to-ground missiles, aging or failed AGM-65 Mavericks, and Russian-made AS-10 "Karen" (Zvezda), AS-11 "Kilter" (Raduga), AS-12 "Kegler" (Zvezda), AS-14 "Kedge" (Vympel), and AS-16 "Kickback" (Radua). Iran also has a limited inventory of air-launch, anti-ship missiles: YJ-6 (CAS 1) CPMIEC, C-801C "Sardine" CPMIEC, (Iranian copy of MARTE/Sea Killer), and possible some active RIM-66 Standard made by Raytheon.

It is unclear, however, that Iran has the avionics and mix of capabilities to begin to compete with the modern combat aircraft in Southern Gulf forces and US fighters. Iran also has only limited airborne air control and warning assets that would probably not survive long in combat. As noted

above, Iran does claim to have modernized the avionics on some of its aircraft, and to have adapted its F-14s to carry the Hawk surface-to-air missile as a long-range air-to-air missile to compensate for the sabotage of the F-14s' capability to fire the Phoenix air-to-air missile and conduct beyond-visual-range air-to-air combat during the fall of the Shah. Iran also claims to have modified its F-4Ds to fire the C-700 or C-800 series anti-ship missiles as well as the systems listed earlier.

It is also unclear whether its aging US systems are really functional and how well they perform – if at all. It is also unclear how well Iran can target, manage precision strike operations, and maintain real or near real time maritime surveillance/IS&R/C4 and battle management capabilities for managing complex anti-ship air strikes. Comparable questions surround Iran's efforts to mount C-700 or C-800 missiles on its helicopters; although such efforts are believed to be more successful than their fixed-wing counterparts, it is unclear whether Iran in the short run will have a rotary-wing missile capability. There are reports that Iran has acquired FL-10 missiles – a cheaper version of the C-701 – and has been developing that as an air-launched cruise missile.

Similarly, it is doubtful Russia systematically modernized Iran's early export versions of the 30 Su-24 and 35 MiG-29 – which lack the radar and avionics performance of their counterparts in Russian service. More broadly, Iran's air forces rely heavily on conventional bombs in an era dominated by precision-guided attack weapons with considerable standoff capability. It is unclear whether this is a matter of weapons supply, avionics, doctrine, or training, but it does reflect a serious limit to Iran's offensive capabilities.

Iran has developed significant software skills and does produce some competent electronic warfare equipment. It is highly uncertain, however, that Iran can produce anything like the integrated capabilities necessary to systematically modernize its aircraft and make them competitive in either munitions delivery or electronic warfare. Iranian weapons modifications have likely produced incremental improvements in its weapons systems – for aircraft as well as other naval and land weapons – but there is a limit to how much piecemeal change will enable Iran to offset weapons platforms' old age. It is also unclear that Iran has anything like the test facilities to determine how effective its modifications would be against US air forces and ships, or against a properly trained modern Southern Gulf air force. There is no way to make such estimates without access to classified electronic order of battle and exercise data.

More broadly, Iran only has limited airborne AC&W and IS&R capability in peacetime, although it has an extensive network of land-based radars and an increasing number of short-to-long range unmanned aerial vehicles to provide airborne targeting, surveillance, and attack capability against maritime targets. It lacks the level of AC&W and IS&R capability it needs to sustain and protects its systems in the event of a significant attack.

Iran claims to have created electronic warfare aircraft by upgrading Ukrainian Antonov AN-140s and to have modernized the avionics on its 3 PF-3 Orion maritime patrol aircraft in its Naval Aviation forces. If Iran has been successful, its aging AN-140s could function as mini-AWACs in a crisis, and provide airborne radar for one coast. If Iran also made use of the relatively advanced radar in its F-14s, it could provide limited but functional airborne radar coverage in peacetime. Iran also has improved its land-based radar coverage, and claims to have a mix of unmanned combat aerial vehicles (UCAVs and UAVs) it can use to make up for some of the limitation in its aircraft – likely visual surveillance and reconnaissance.

The success of its AN-140 upgrade program is in doubt, however, after the 2006 crash of an Iran-140 that killed the Ukrainian and Russian scientists on board, along with the Iranian managers who

ran the program. Combined with Iran's ongoing difficulties in producing its own engines, this event also raised questions about Iran's indigenous airplane manufacturing capability.

Iran still has significant naval aviation forces, although their readiness and operational capabilities are limited by the age of many of its system and they do not have the kind of strike capabilities that makes Iran's artillery rocket and surface-to-surface missiles relevant. According to the IISS, these assets included 3 combat capable ASW 3 P-3F Orion MPA aircraft in 2013. Its fixed wing transport assets included 5 Do-228; 4 F-27 Friendship; 4 Turbo and Commander 680. It had 3 Falcon 20 ELINT aircraft. Its helicopter assets included m 10 SH-3D Sea King ASW aircraft, three RH-53D Sea Stallion mine warfare aircraft, and a large mix of transport aircraft included 5 Bell 205A (AB-205A); 2 Bell 206 Jet Ranger (AB-206); and 10 Bell 212 (AB-212).[23]

## Iranian Claims Air Modernization and Combat Capability

Iran's officers have made ambitious claims about Iranian capabilities. Moreover, Iran has sought more modern fighters from Russia, but past reports of sales have never materialized. As a result, Iran has sought to develop its own fighters, the most notable of which are the Saeqeh ("Thunderbolt") and the Azarakhsh ("Lightning"), both of which are based on the Northrop F-5. Iran also has made many claims to have modernized its fighters and their systems and munitions, although many such claims are clearly exaggerated:

- "A radar system special to detecting stealth aircraft, which has been developed by young and specialist (Iranian) forces despite conditions caused by (US-engineered) sanctions, will be used to counter stealth aircraft." –Brigadier General Farzad Esmayeeli, commander of Khatam ol-Anbia Air Defense Base, May 18, 2014, http://english.farsnews.com/newstext.aspx?nn=13930228000319

- "It is obvious that future wars will be in the sky with massive air and missile raids; therefore, the Air Force has adopted a new approach and focused all its internal power on building fighter jets in a self-driven, but organized way," –Brigadier General Hassan Shah Safi, Commander of the Iranian Air Force, February 10, 2014, http://english.farsnews.com/newstext.aspx?nn=13921121001075

- "Manufacturing this military aircraft will make us fully needless of purchasing jet fighters from abroad, specially for training purposes…We have taken very good measures in producing aircraft ammunition, long-range ammunition and smart missiles." –Brigadier General Aziz Nasirzadeh, Islamic Republic Air Force Chief Liaison Officer, February 3, 2014, http://english.farsnews.com/newstext.aspx?nn=13921114000429

- "An important feature of these drills was the deployment and test-firing of Qader and Nasr air-based cruise missiles that have recently been supplied to the Air Force." –Brigadier General Hossein Chitforoush, Spokesman of Mesbah Al-Hoda air drills, January 28, 2014, http://english.farsnews.com/newstext.aspx?nn=13921108000902

- "all flights by the jet fighters, jet bombers, heavy and semi-heavy cargo planes, tactical sea patrol and reconnaissance missions were conducted according to the schedule and timeline and all the missions for targeting and destroying moving objects in the air and also the ground targets on islands in the Southern parts of the Persian Gulf and the general combat zone have been accomplished successfully" –Brigadier General Hossein Chitforoush, Spokesman of Mesbah Al-Hoda air drills, January 28, 2014, http://english.farsnews.com/newstext.aspx?nn=13921108000902

- "Any violation against Iran's airspace, territorial waters, and land will receive a strong response by the Islamic Republic of Iran," Mohammad Saleh Jokar, Security and Foreign Policy Committee, Majlis, November 8, 2012. [24]

- "Defenders of the Islamic republic of Iran will receive a strong response by the Iranian Republic of Iran," Iranian Minister of Defense, Massoud Jazayeri, Deputy Commander of Iran's Armed Forces, November 8, 2012.[25]
- "Despite Western sanctions, Iran is not having problems procuring training jets. "Kowsar 88 and Azarakhsh training jets are among the projects that are underway… and the blueprints have been prepared, and we are witnessing very good progress in this field… Like the Saeqeh (Thunderbolt), these jets will come into operation soon." "General Manouchehr Yazdani, Commander of the Islamic Republic of Iran Air Force for Training, October 26, 2012, http://english.farsnews.com/newstext.php?nn=9107113742.
- "Zionists must expect hundreds of other drones in 25 different models with new flying systems that they won't know how to confront. He added that the infiltration of the UAV exposed only the smallest part of Hezbollah's power." Brigadier General Mohammad Reza Naqdi, October 22, 2012.
- "We can simultaneously fire numerous and countless missiles from different spots at one or several targets, which indicates our capability to perform convergent and parallel operations." Brigadier General Hossein Salami, Lieutenant Commander of the Islamic Revolution Guards Corps, September 27, 2012.

  http://english.farsnews.com/newstext.php?nn=9106242598
- "Sukhoi fighter jet has been optimized by the Army Air Force experts and now has the capability to hit and destroy targets with high precision in absolute darkness." – General Seyed Mohammed Alavi, Lieutenant Commander of the Iranian Air Force for Operations, April 25, 2011.
- "The production of hi-tech and advanced military tools, weapons and equipments [sic] displays Iran's might and power and proves that sanctions against the country have been futile.

  Iran has recently made good progress in the air industry and has succeeded in gaining the technical know-how for producing stealth aircraft and drones." – Brigadier General Ahmad Vahidi, Iranian Minister of Defense, October 7, 2011.
- "Now the Islamic Republic of Iran is not only independent in the area of defense industries production, but also exports strategic defensive items." – General Mostafa Mohammad Najjar, Iranian Defense Minister Brigadier, February 6, 2006.
- "One of the most important actions taken in these drills was increasing the range of the anti-radar missiles mounted on Sukhoi-24 fighters… they hit the specified targets successfully.

  The missiles enjoy a 100-percent precision capability, meaning that they can hit any target with a zero margin of error." – Brigadier General Hossein Chitforoush, Iranian Air Force Lieutenant Commander, September 15, 2011
- "The squadron is the first fighter squadron equipped with fighters [Saeqeh] and equipments made inside the country.

  The squadron is capable of detecting and confronting aggressive aircraft and enemy fighters." – General Seyed Mohammad Allavi, Lieutenant Commander of Army's Air Force for Operations, February 25, 2011.
- "By mass-production of home-made Saeqeh fighters, we move past all the gorges of designing and building of this fighter and we will strive to use more high-tech and updated models in our fleet in the future." – Brigadier General Hassan Shahsafi, Iranian Air Force Commander, September 9, 2009.[26]

There are obvious problems in taking many of Iran's claims seriously – both in terms of war fighting capability and missile performance. For example, Mohammad Saleh Jokar, a member of the Security and Foreign Policy Committee of Majlis, joined Iran's senior commanders in claiming in early November 2012 that the IRAF had driven a US Predator UAV out of Iranian air space and that, "Any violation against Iran's airspace, territorial waters, and land will receive a strong response by the Islamic Republic of Iran."[27]

The facts illustrate the degree to which Iranian claims can be unreal. In practice, it was two Su-25s in the IRGC air units that attempted to shoot down the predator over international waters, and

failed. The slow flying Predator did not "escape;" the Su-25s failed to hit it. [28] It is unclear whether the Su-25 pilots – flying an aircraft is designed as a tank killer and for land combat – knew it was still outside Iran's air space or were provoking an incident. What is clear is Iran makes many claims about its air, naval, land, and missile forces that are exaggerated or nothing more than propaganda and does so to cover up known problems and weaknesses.

More generally, the IISS Military Balance for 2014 indicates that Iran has a total of 334 combat aircraft in inventory.[29] These include more than 75 F-5s and F-5IIs, 43 F-14s, 65 F-4D/Es, more than 6 RF-4E, and 5 P-3MP Orions. This is a total of at least 194 aging US aircraft supplied more than 30 years ago when the Shah was still in power – some 58% of Iran's air force. Iraq has 24 low quality F-7Ms and 10 Mirage F-1Es it got from Iraq in 1991. This raises the total of aging, obsolete aircraft to 228 or 68%.

So far Iran has only deployed six of its Azarakhsh (a design that seems to have been derived by reverse engineering the US fighters in Iranian service), and up to six Saegheh Iranian made-fighters (a design Iran claims is superior to the F-18 but seems to be an upgraded version of the F-5F.)

Iran's combat aircraft imports since the fall of the Shah consist of 36 early export versions of the MiG-29 fighter, 30 early export versions of the SU-24MK, and 7 Su-25 anti-tank attack aircraft. None compare to first line US, British, or French combat aircraft. None compare to Saudi holdings like 81 F-15C/Ds, 71 F-15S, 80 Tornados, and 24 Typhoons – a total of 256 more capable aircraft than any in the Iranian inventory. None compare to a smaller Gulf air force like the UAE, which has 139 modern fighters: 54 F-16E Block 60, 25 F-16F Block 60, 16 *Mirage* 2000-9DAD; 44 *Mirage* 2000-9EAD, and 7 *Mirage* 2000 RAD.

## *Iran's Uncertain Surface-to-Air Missile Forces*

Iran's surface-to-air missile forces are another key weakness that gives Iran a strong incentive to pursue missile programs. As **Figure 7** and **Figure 8** have shown, most of Iran's inventory of surface-to-air missiles dates back to the time of the Shah or consists of Russian and Chinese designs that were originally developed at the time of the Vietnam War.

Iran did not have a functioning, integrated land-based air defense system at the time the Shah fell. It had most of the sensors and command and control systems for a medium to high-altitude system, but not the software and technical support necessary to make the system function. Iran has since integrated many of the elements of such a system using Russian, Chinese, US, European, and Iranian-designed and made equipment. It has also created sheltered and hardened command centers and buried data links for some systems. It has integrated its systems using optical fiber netting in the West and parts of the South, but its integration and netting efforts are weaker in the East and North.

Iran has since developed its own short-range systems, tried to upgrade its Hawk and other surface-to-air missiles, and produced its own version of the short-range French Crotale called the Ya Zahra. Iran still, however, has not demonstrated that it has the design and manufacturing capability to create a truly modern system, one that is immune to electronic warfare and can function without becoming tactically vulnerable to anti-radiation weapons and other forms of active "suppression of enemy air defense" (SEAD) systems. Iran's network also faces US and GCC aircraft with considerably higher performance and decoy abilities than the planes they were designed to target, limiting their value even without electronic warfare.

## Iran’s Current Systems

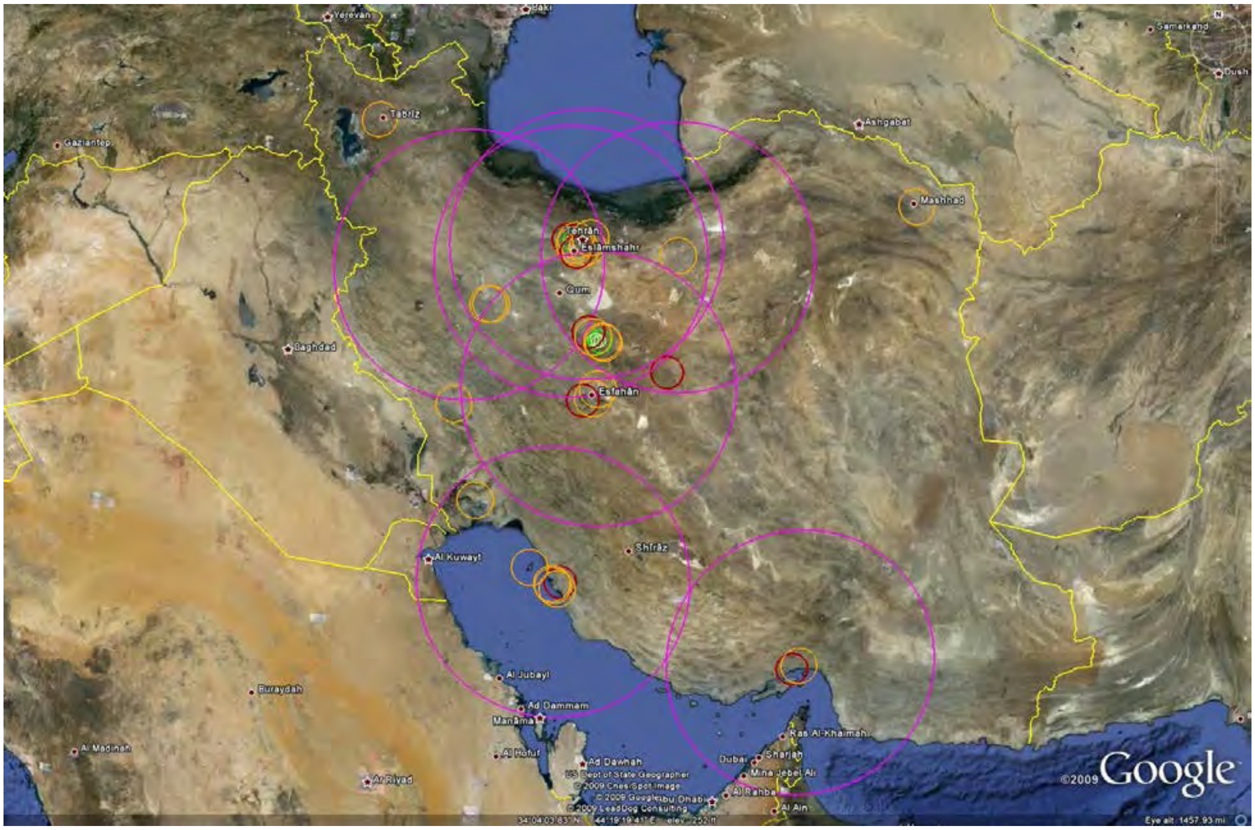
Unclassified sources differ over the details of Iran’s surface-to-air missile forces. Sean O’Connor reported 41 strategic SAM sites were active in a report originally dated January 2010 and updated in April 2012 with limited changes.[30] O’Connor indicated that there were 22 Hawk sites with coverage focused on key cities and Iran’s main oil facility and port along the Gulf.[31] He reported seven Chinese-made HQ-2 (an SA-2 clone) sites were active in 2010, but that the system was not a key part of Iran’s forces.

O’Connor also reported that there were seven SA-5/S-200 sites providing long-range medium to high altitude coverage of key cities, the border with Iraq, and the Gulf. O’Connor felt that these were some of the most critical aspects of Iran’s land-based air defenses,

> The four northernmost sites are positioned to defend the northern border and the region surrounding the capital of Tehran. A fifth site is situated to defend facilities in and around Esfahan in central Iran, including the Natanz nuclear facility. The last two sites are situated at Bandar Abbas and Bushehr and provide coverage over the Straits of Hormuz and the northern half of the Persian Gulf, respectively.
>
> The northern four S-200 sites, as well as the southern two sites, are well positioned to provide air defense outside Iran’s borders to deter any inbound aggressor from approaching the ADIZ [Air Defense Identification Zone]. The central site near Esfahan is a curiosity, however. The southern and western portions of the coverage area are limited due to the presence of a good deal of mountainous terrain, in some cases 10,000 feet or more higher than the terrain where Esfahan is located. This also affects the remaining six sites, but they are affected to a lesser degree due to the fact that they are positioned to defend outwards towards the border and beyond, not likely intended to defend against targets operating deep within Iranian airspace.
>
> The Esfahan site, in direct contrast, is apparently situated to defend a central portion of the nation, and as such is limited in its effectiveness by the aforementioned terrain considerations. The curiosity lies in positioning a long-range SAM system in such a fashion to apparently purposely limit its effectiveness. This can be overlooked to a small degree, as the S-200 is not necessarily a choice system when it comes to engaging low-altitude targets, but the terrain in the area would seem to greatly reduce the effectiveness of the Esfahan site. The radar horizon is the key issue here, as each piece of terrain situated higher than the engagement radar will carve a significant portion out of the system’s field of view and limit its ability to provide widespread coverage.
>
> Iranian S-200 sites appear to be purposely limited in their composition. Each site consists, unusually, of one 5N62 (SQUARE PAIR) engagement radar and two launch rails.

If O’Connor’s map is accurate (**Figure 10** and **Figure 11**), it further suggests that Iran’s plant in Fordo had a high priority in Iran’s nuclear weapons program. For all intents and purposes, Fordo is located in Qom, Iran. If O’Connor’s maps are correct, Qom is protected by five of Iran’s seven SA-5/S200 sites. Tehran, the capital, is protected by four; Arak is protected by five; Natanz is protected by five; Parchin military complex is protected by five; Bushehr, a nuclear power facility, is protected by one; and Basra, also a nuclear power facility, is protected by none. For Iran to claim that Fordo is used for the peaceful production of isotopes to treat cancer suggests that their placement of S-200s has nothing to do with their nuclear enrichment. The pattern above, however, suggests otherwise, contributing to the doubt behind Iran’s stated intentions.

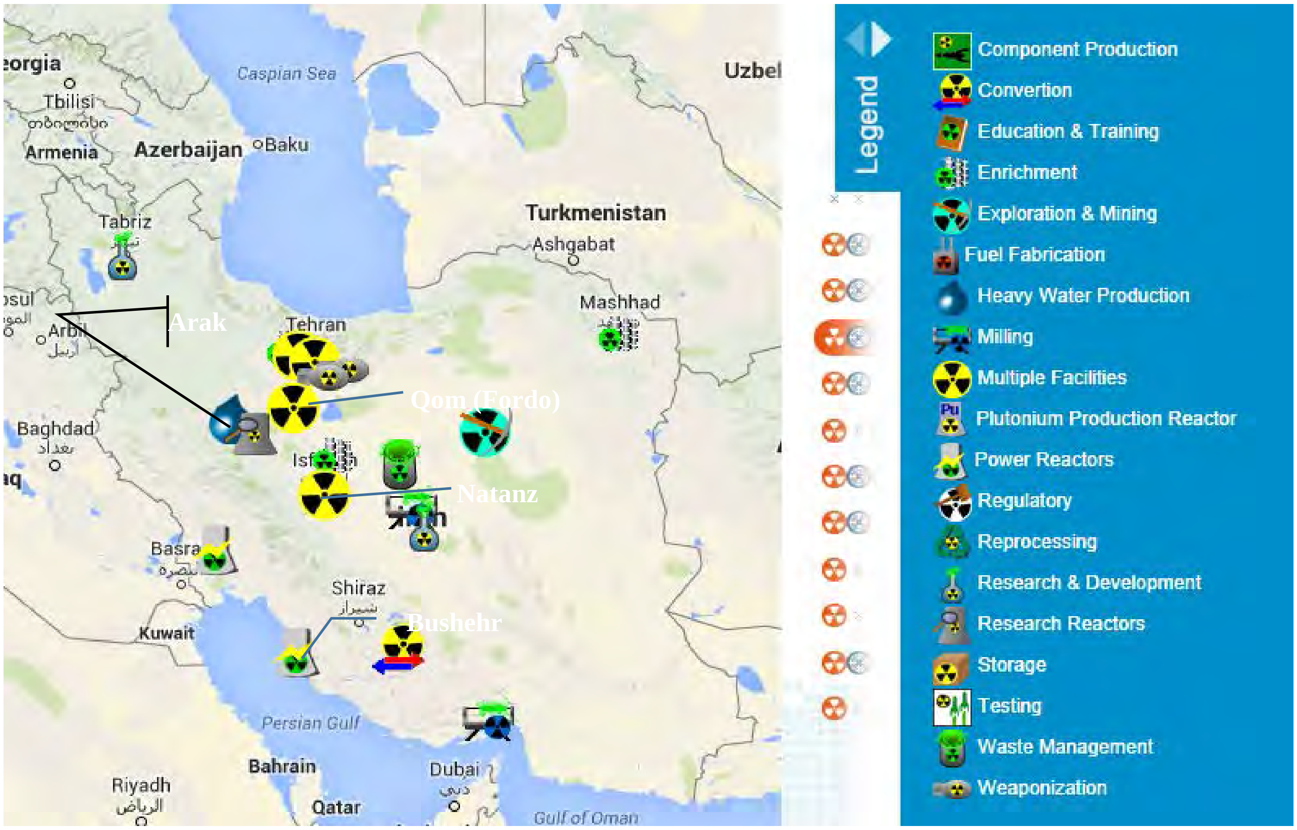
### *Figure 10: Iran’s SAM Coverage*




Legend: HQ-2 Sites are red; HAWK sites are orange; S-200 sites are purple; 2K12 sites are bright green, and Tor-M1E sites are faded green.

Source: Sean O’Connor, “Iranian Strategic SAM Deployment,” January 4, 2010, http://geimint.blogspot.com/2007/09/iranian-sam-network.html.

***Figure 11: Iran Facilities Map***




Source: Nuclear Threat Initiative, “Interactive Iran Facilities Map,” December 14, 2013, http://www.nti.org/gmap/nuclear_iran.html?/.

O’Connor reported that there are some 31 unoccupied, prepared SAM sites that are either HQ-2 or HAWK sites, and could be used to disperse Iran’s forces and reduce their vulnerability to SEAD attacks. He also notes, however, that,[32]

> It is possible that Iran simply does not feel that a robust SAM network is necessary. Given the aforementioned terrain constraints in some areas of the nation, as well as the lack of a large number of what may be regarded by the Iranian government as potential critical targets inside of Iran, the Persian nation may have simply taken a minimalist posture, relying on the S-200 for long-range defense and the other systems as point defense weapons to defend Iran’s critical military and political infrastructure.
>
> A…reason for the lack of deployed SAM systems could be that the shorter-ranged HQ-2 and HAWK systems are no longer viewed as being effective enough to warrant widespread use. HQ-2 sites are currently 33% occupied, with HAWK sites being approximately 50% occupied, perhaps signifying more faith in the HAWK system but still demonstrating a potential overall trend of perceived non-reliability. Iran does have reason to suspect the reliability of the HAWK SAM system against a Western opponent, as the missile was an American product and has been in widespread use throughout the West for decades. The HQ-2, however, should be regarded as potentially more reliable, as it is not a standard (and widely exploited) S-75 but rather a Chinese-produced weapon with which the West should have a lesser degree of technical familiarity insofar as electronic performance, if not physical performance, is concerned.
>
> A high ratio of unoccupied sites could be due to financial reasons (lack of operating funds may have resulted in a number of batteries placed in storage) or simple attrition (they may have been expended or destroyed in the Iran-Iraq War), of course, but those facets of the equation cannot be examined through imagery analysis alone. It should be mentioned that one possible source of attrition for the HQ-2 system is the conversion of

> many missiles to Tondar-69 SSMs to complement CSS-8 SSMs (HQ-2 derivatives) obtained from China. Many batteries may also be out of service for modification to Sayyad-1 standard, which represents a modification of the HQ-2 design with some indigenous components.

The Israeli Institute for National Security Studies (INSS) reported in 2013 that Iran's medium and heavy surface-to-air missile forces included some 15 batteries of Iranian upgraded IHawk MIM23Bs, which Iran called Mersads or Shahins. It also included some 109 batteries of Iranian upgraded SA-2s, which Iran called Sayyads, and which Iran may have placed under the IRGC. There were four batteries of SA-5s or S-200s, which Iran also claimed to have upgraded or be further upgrading.

The INSS estimated that Iran had a range of light to very short range missiles that included 24 HQ-7/ FM-80 (YaZahra) launchers, which were part of the Skyguard air defense system, ADS; 30 Rapier launchers that were being upgraded; 50 RBS 70 launchers, and 15 Tigercat launchers, plus manportable surface-to-air missiles. [33] According to IISS's 2014 *Military Balance*, Iran had 30 *Rapiers* and over 250 *Crotale* missiles, The *Rapier* and *Crotale* are mobile systems that provide additional point-defense. They are French in origin and the original versions are dated. Several Gulf states use one or both systems, and both GCC and American pilots are familiar with countermeasures. Iran is reported, however, to be producing an improved version of the Crotale called the *Ya Zahra*, and to be improving its *Rapiers.*

IHS Jane's estimated in 2013 that Iran's Army had 120 operational MIM-23 Hawk missile launchers. It reported that Iran had air defense headquarters near Bandar Abbas, Tehran, Esfahan and Iran's centrifuge facility at Natanz. It stated that Hawks were deployed at each headquarters site, in the Bushehr area, and probably at other locations, and that there were "at least 19 prepared but unoccupied sites for the HQ-2 and/or HAWK."[34]

It reported that the Air Defense Force that Iran had established in 2009 had three S-200 Angara (SA-5 'Gammon') sites. One defending the northern border area and greater Tehran, one defending Tehran one defending the Esfahan area, a site at Bandar Abbas defending the area around the Strait of Hormuz, and a site at Bushehr covering the upper Gulf. As is discussed in more depth shortly, Iran claimed In November 2010 that these S200s had been upgraded to something approaching the capability of the S300, were operated by the IRGC, and sites had six single rail launchers and an independent fire control radar. Later reports claimed further improvement s in 2011. [35]

IHS Jane's also stated that Air Defense force might have acquired SA-6 missiles from Romania in 2003, and had acquired 29 Tor-M1 (SA-15 'Gauntlet') surface-to-air missiles from Russia in 2006. It said that Iran had developed, manufactured and deployed a system called the Shahab Thaqeb, which had a four-wheeled trailer and closely resembled the Crotale *R440.* It estimated that. Iran's had five Rapier squadrons with 30 fire units, 5-10 Chinese FM-80 launchers, 10-15 Tigercat fire units and some RBS-70s. [36]

It reported that the Army operated 10 Pantsyr-S1 96K6 SA-22 Greyhound fire units, an unknown number of FM-80 / Crotale/Shahab Thaqeb fire units, possible holdings of an unknown number of Chinese-made FM-90 fire units. It also said that he Army also operated Strela-2M / 9K32M SA-7b Grail, Strela-3 (SA-14 'Gremlin'), Igla-S (SA-24 'Grinch'), Misagh-1, and Misagh-2 manportable surface-to-air missiles. [37]

The IISS estimate in the 2014 edition of the *Military Balance* estimated that Iran had 16 battalions with 150 MIM-23B I-HAWK/Shahin missiles, and unstated numbers of S-200 Angara (SA-5 Gammon); Volkhov (SA-2 Guideline); 9K331, and Tor-M1 (SA-15 Gauntlet) missiles and fire

units. Its shorter-range air defense missiles included five squadrons with FM-80 (Crotale); and unstated numbers of Rapier; Tigercat; S-75M, and manportable surface-to-air missiles.[38]

## Iran's Newer Systems

While sources differ, it is clear that Iran has several relatively modern systems that lack all of the capabilities of the Patriot and S300/S400 series, but are more modern and capable. Iran has succeeded in turning to Russia to augment its largely obsolescent holdings of modern short-range air defense (SHORAD) systems. It has acquired some 6 batteries and 29-32 Tor-M1 (SA-15 Gauntlet) launchers, and evidently 10 Pantsyr S-1E (SA-22 Greyhound). [39] These are capable short-range systems and can be used for point defense against cruise missiles and some precision-guided weapons – although there are no unclassified data on actual capability versus manufacturer claims. Iran also has acquired more modern manportable surface-to-air missiles.

The Russian TOR-M1 – also known as the SA-15 Gauntlet or 9K330 -- is mounted on a tracked vehicle with a modern radar and support electronics, but has very short-range (1-15 kilometers), can only hit low-to-medium altitude targets (0.01 to 10,000 meters), and is designed for point defense rather than broad air defense coverage. There is also some uncertainty as to whether Russia delivered the most modern version with all of the capabilities of its own updated TOR-M2E/M1-1, and M1V systems.[40]

Iran also has acquired an unknown number of Ra'ad SA-17/SA-6 batteries, some of which seem to have upgraded 9M317 missiles.[41] It also seems to have SA-17 fire units and command equipment. [42] The Ra'ad is both a land-mobile system and naval defense system

The IRGC displayed what it claimed was a new, domestically designed Ra'ad medium-range air-to-surface missile system during its annual military parade in September 2012. It said that the system was designed to hit US aircraft, could be equipped with 'Taer' (Bird) missiles, and could trace and hit targets 50 kilometers in distance and 75,000 feet in altitude: "The system has been built in a bid to confront US aircraft and can hit targets 50km in distance and 75,000 feet in altitude."[43]

The Ra'ad is believed to have been developed from the Russian SA-11 and SA-17 with some outside assistance. Iranian-published information on the Ra'ad gives it performance superior to that of the SA-11 – itself an outdated Soviet mobile medium-range SAM – with a 50 kilometer versus 30 kilometer range and a 22,000 meter versus 14,000 meter ceiling.[44]

At least some Ra'ad may be of Russian origin. Russia is believed to have delivered SA-17s to Syria in 2013, provoking an Israeli air strike on a convoy delivering such missiles. As noted earlier, IHS Jane's issue is reports that Iran has upgraded SA-6s or other SA-17 equivalents that it calls the Ra'ad. If Jane's is correct, Iran has or is acquiring the he SA-17 Grizzly 9A317E BUK-M2. This is a Russian mobile medium-range surface-to-air missile system that is an upgraded version of the SA-11 or Buk-M1.

If Iran has a fully modern version of this system, and has begun to fully integrate it into its land-based air defenses, this would be an important upgrade. The SA-17 has much better capability against electronic countermeasures and some capability against naval and land targets than most of Iran's systems. It has a more modern target-acquisition radar, a battle management station, self-propelled firing vehicles, illumination and guidance radar, loader-launcher vehicles, and can be mounted either on tracked or wheeled chassis. According to unclassified reports, it can track targets at ranges of up to 140 kilometers, and track and engage aircraft, helicopters, cruise missiles, and

UAVs/UCAVs altitudes of 30 to 24,000 meters, has a maximum range of 40-50 kilometers, and a battery or battalion can simultaneously engage up to 24 targets at different altitudes and directions. [45]

Given Iran's history of exaggerating accomplishments and overstating the technical specifications of its weapons, however, it is impossible to determine from conflicting unclassified reports whether the Ra'ad is actually a modified SA-11 or SA-17 (which would mean Iran will be restricted to upgrading prior imports), an SA-11 or SA-17 clone with a new name, an upgraded and indigenously produced system, or an entirely new system only cosmetically similar to the Buk-M2. Some experts feel that Iran may also have developed a new missile designed to be the companion of the new long-range Bavar-373 SAM, adopting the Soviet tactic of pairing strategic and medium range systems for mutual protection.

## Modernization of Current Systems, Upgrades and Tactics

Iran has no current ability to buy the surface-to-air missiles and other components of the fully modern national system it needs from any Western supplier.[46] Iran has, however, made some creative upgrades of its overall land-based air defense system, and has obtained some more modern Russian shorter-range missiles and radars, and a mix of European, Russian, and Chinese electronic warfare and command and control systems as well as used optical fibers and pother land links to reduce the vulnerability of its associated $C^4$I/battle management systems.

Iran's older surface-to-air missiles forces retain important military capabilities in spite of their limits, and several its older systems have been modernized to some degree. The most import case is its IHawks. It is not clear from unclassified sources how many of the improvements the US has made to the IHawk in its MSIP and other programs over the years have leaked into Iranian hands, although it is certain that Iran has conducted a major covert espionage and purchasing effort.

Iran success in this is important because the Hawk is one of its most important current systems, and is a US-made system and one where the US has unique knowledge of its vulnerabilities over any given generation. The IHawk is still a capable system when fully modernized, but it does still have serious limits and some tactical and countermeasure vulnerabilities that US and US-allied forces are well aware of. It would be substantially less of a threat, however, if Iran is limited to uncertain mix of indigenous technical upgrades.

It is unclear how much Iran has modernized its other surface-to-air missile systems, and overall land-based air defense system, but it has had extensive Russian and Chinese technical aid, and seems to have steadily modernized its older Russian and Chinese supported systems over time. While the US developed effective countermeasures to most older Russian and Chinese systems during the Vietnam War, potential upgrades to their electronics could enable Iran to better engage US and Arab fighters, and even key enablers like the AWACS and EW/ECM aircraft under some conditions. Their ranges, combined with Iran's ability to create overlapping fields of fire, could also complicate any air-defense suppression efforts.

Iran has modernized its radars and dedicated $C^4$I systems. It seems to have both more modern radars and to have netted some 24 early warning radar sites, although some may not be active. [47]

They cover Iran's borders, particularly its Gulf coast and border with Iraq, with internal sites near Tehran, Natanz, Arak, and Isfahan. The strength of the network varies depending on the threat Iran perceives emanating from each direction, with what experts consider the best equipment in the

west, a capable system in the south, and weaker to nonexistent network coverage in the east and north.

Iran has shown in exercising these systems that it now operates a much better netted mix of radars and has linked them to its air force and surface-to-air missile units, but it is unclear how survivable, effective, and electronic warfare-resistant these systems are. The quality of their electronic warfare capabilities, systems integration, survivability, and ability to handle complex operations in real time is difficult to estimate with unclassified data but seems to be moderate to good in some areas for low intensity operations and poor to mediocre in complex, intense operations.

Iran has developed the ability to domestically manufacture high-frequency radars, including very-high frequency or ultra-high frequency surveillance radars. Such systems are believed to have a limited ability to track stealth aircraft under optimal conditions. While Iran has likely been unable to test its radar against actual American B-2s, F-22s, and F-35 flying stealth profiles, further improvements in radar production and signal processing could erode America's technological edge.[48]

Iran has also received some assistance from Russian and Chinese experts in modifying its overall command and control network, and perhaps in improving the performance of individual SAM systems as well. Like other alleged cases of external support, it is difficult to determine the scope and nature of this assistance, in particular whether the aid is coming at an individual, corporate, or state level.

Experts feel, however, that such external support has so far only provided incremental improvements and has not allowed Iran to overhaul its entire air defense network. Much of the outside expertise has allegedly been involved in improving guidance packages on current SAMs, replacing tracking systems that are already well-known to US and GCC pilots. It has also assisted in the maintenance of older weapons, prolonging the life of some systems that are over three decades old, and have also helped Iran develop the ability to domestically construct radars. Iran needs more modern systems than it has yet received, and will face serious challenges purchasing or domestically developing the integrated air defense network it needs to complement individual weapons.

While key aspects of Iran's progress cannot be determined from unclassified sources, it is clear that Iran has put a major effort into creating a system that minimizes vulnerability to a technologically superior opponent, focusing on multiple analog systems and human watchers connected by resilient communications channels. Instead of focusing on advanced systems that provide both real-time targeting information and a tempting target for air and cyber-attacks, Iran has adapted its $C^4I$ around survivability and attrition.

Iran has also modernized its tactics and paid close attention to the lesson of the Vietnam War, Balkans conflict, Gulf War in 1991, Iraq War in 2003, and other uses of land-based air defenses. At best, however, Iran faces major challenges in compensating for the age and gaps in its systems, their lack of real-world missile defense capability, having to create a patchwork system without the benefit of the technology base of a modern power, and the combat experience of states that have used such systems in the last decade.

Pop-up emitter and remote sensor tactics can help defeat modern countermeasures, but such systems are inherently far more vulnerable than IHawks, particularly when they are not part of a

layered, integrated system with a low-altitude surface-to-air missile like the SA-3 and the mobile SA-6 system or its far more capable Russian successors.

## The Ongoing Struggle to Fully Modernize Iran's Surface-to-Air Missile and Surface-Based Missile Defenses

Iran still badly needs a more modern and fully integrated mix of short and long-range, modern surface-to-air and missile systems, sensors, and electronic warfare capabilities that can cover the country and replace its aging Russian, US, and Chinese-supplied 1970s vintage systems. As a result, Iran has long realized it needs to obtain modern long-range surface-to-air missiles like the Russian S-300 or S-400, as well as many shorter-range systems and other components of a modern nation-wide system as it can obtain.

### *The S300/S400*

Russia and China are now Iran's only potential sources for the import of the modern long-range surface-to-air weapons it needs, and Iran has shown in the past it is well aware that it would take major deliveries of a new integrated air defense system based around the S-300 or S-400 surface-to-air missiles to begin addressing Iran's strategic vulnerabilities to an aerial campaign.

So far, however, neither Russia nor China has proved willing to sell the Russian version or Chinese modified version of such systems. Russia is reported to have cancelled a 2007 deal to deliver modern S-300PMU1 (SA-20 Gargoyle) long range SAMs. The deal was cancelled by decree of Russian President Dmitry Medvedev in 2010 as a part of a joint effort with the US and UN to pressure Iran to halt its nuclear enrichment and suspected nuclear weapons programs.

Iran responded by filing a $4 billion lawsuit against Russia in the international arbitration court in Geneva. Russia then attempted to ease its tensions with Iran by the offering far less capable substitutes; first the Tor-M and more recently the Antei-2500.[49] Both the Tor-M and Antei-2500, however, a far more limited and shorter-range systems mounted on mobile vehicles, with independent radar, computer, and firing systems. Although a future shift in Russian policy – or Chinese sale of its version of the S-300 might alter the situation, Iran now has no source of imports to close critical gap in Iran's conventional capabilities that reinforces its weakness in airpower.

### *The Bavar 373, Ra'ad, and S-200 Upgrades*

Iran has claimed it is compensating for its inability to buy the S300/S400 by building its own equivalent of S-300/S-400 called the Bavar 373, but such claims seem exaggerated:[50] In 2011 – after Russia publicly refused to sell it the S-300 – Iran claims that it was developing a far more advanced system called the Bavar-373 (Belief). It claimed this system would include Iran's own version of the Russian S-300 surface-to-air missile system, that the Bavar 373 missile would be far more advanced than the Russian S-300, and that it would be mobile, with four missiles loaded on each mobile truck launcher, and able to undertake a cold launch like the Tor-M1.[51]

Brigadier General Farzad Esmaili, said to reporters in Tehran on the National Day of Air Defense on September 3, 2012, that the Bavar-373 (Belief-373) system was "30 per cent complete" and that Iran could execute the project without foreign assistance. Esmaili went on to say that he hoped the system would be finished by the end of the Iranian year, which would be March 2013, or by March 2014, and would be a "*powerful rival*" for the Russian surface-to-air system. Iran would

deploy up to three different types of missiles, with "*higher capabilities than the S-300 in detecting, identifying and destroying targets*." [52]

Other Iranian statements made similar claims:

- "We are through with developing the threat-detection capability of the system and its sensitive parts have been manufactured in Iran. We have no problem for supplying the missiles needed for this system. With this powerful system in our hand, we would not think of S-300 anymore. Bavar 373 system is an important and completely indigenous achievement that can be a powerful rival for S-300." – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 3, 2012.[53]
- "Manufacturing Bavar (Belief) 373 Missile System is in progress and all production needs have been supplied domestically. This project will soon enter its final stage (of production) and it will be much more advanced than the S-300 missile system."
- "The flaws and defects of the (Russian) S-300 system have been removed in the indigenous version of the system and its conceptual designing has finished." – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 22, 2011.
- "It is now several years that our defense industries researchers and experts have been designing a system whose capabilities are way beyond the S-300 missile system."
- "The system has been designed based on our own operational needs." – Colonel Mohammad Hossein Shamkhali, Deputy Commander of Khatam ol-Anbia Air Defense Base for Research and Self-Sufficiency Jihad, September 22, 2011.
- Defense minister Ahmad Vahidi told Iranian media at Sept. 22. 2010 that they will develop a similar domestic system by themselves: "We have planned to build a long-range air defense missile system similar to S-300. By God's grace and by the Iranian engineers' efforts, we will reach self-sufficiency in this regard."
- "If they do not deliver S-300 defensive system to us, we have replacements and we can supply our operational requirements through innovative techniques and different designs." – General Hassan Mansourian, Deputy Commander of Khatam ol-Anbia Air Defense Base for Coordination, July 6, 2010.[54]

To put such statements in context, Iran has made many claims about other types of weapons systems and military technology systems it later did not deploy, only deployed in token numbers, or deployed in forms that lacked anything like the capability claimed – such as a radar less version of a supposed SA-6 clone.

It is far from clear Iran has the production base required to build a robust air defense network. Moreover, anecdotal unclassified reporting indicates that Iran lacks effective test and evaluation methods and has politicized its technology to the point it sometimes believes its own rhetoric. Exaggerated claims are a sin common to all weapons developers and military powers, but there are signs that Iran sins more than most.

Open source intelligence suggests that Iran has only been able to deploy limited upgrades of its Soviet-era SA-5/S-200 medium to high altitude long-range surface-to-air missiles. The PO Almaz S-200 Angara/Vega/Dubna (Russian Ангара\Вега\Дубна), is called the SA-5 or Gammon by NATO. Iran has tested what seem to be upgraded versions of the SA-5/S-200 have been tested since 2008, but there are few unclassified data to support ambitious and probably grossly exaggerated Iranian claims for either the upgrades to the SA-5/S-200.[55]

While the upgraded system may be more effective than the old SA-5/S-200, it is unlikely to pose a significant threat to American or Israeli aircraft as a long-range air-denial weapon. For example, Brigadier General Farzad Esmaeili, commander of the Khatam-ol-Anbiya (also Khatam al-Anbia) Air Defense Base, said in September 2012 that, "With the changes being made to this system by

our experts, the S-200 will be able to deal with threats at medium altitudes in addition to (threats) at high altitudes."[56]

General Esmaeili announced that Iran was upgrading the S-200 long-range surface-to-air missile system, and stated that, "By making our systems mobile, we are aiming to increase the agility of the defense system," and went on to tout the system's increased reaction time and precision. [57] He further noted that the upgraded missile system would have a new name because "the system will undergo systemic and structural modifications,"[58] highlighting the apparent technological and tactical improvements to the system. According to a Jane's report in July 2013, however, such upgrades were actually limited to developing S-200 mobility and a quicker response time against enemy aircraft. [59]

More recent Iranian statements about different improvements in its air defense missile systems are no more convincing. In November 2013, Iran's Minister of Defense, Hossein Dehqan, announced that Iran was producing still another new line of surface-to-air missiles called the Sayyad-2 (Hunter-2) which was an upgraded version of an earlier Sayyad-1, and that could intercept "*"different kinds of cruise missiles, bombers, drones, helicopters and targets with small radar cross-section and high speed and maneuverability within its operational range. This system was said to be able to attack* medium-altitude targets with greater precision, range and defensive power, to be equipped with a 200-kilogram warhead, and to have a speed of 1,200 meters per second.[60]

Then, in September 2014, the head of Iran's air defense forces, General Farzad Esmaili claimed that Iran now successfully test fired another S300-like system called the Talash-3, or Endeavor-3 missile. He said this was a missile that could "shoot down any hostile target," even at high altitudes. He also said Iran had begun to deploy two new two radar systems — the Arash-2, which could detect miniature drones at a distance of 150 kilometers (93 miles), and the Kayhan, which could detect cruise missiles and drones.[61]

As is discussed in this analysis, Iran's problems also go far beyond air defense. Iran faces steadily improving US, Gulf, and Israeli missile defenses that include the Israeli Arrow series, US ship borne systems, PAC-3 land-based systems, and orders for the THAAD wide area missile defense system. So far, Russia and China have refused to sell such systems, although Russia has used its ability to make such systems for sale as political leverage in the past. Iran has claimed that its new versions of an S300-like surface-to-air missile do have missile defense capability, but it is far from clear such claims are realistic and no clear test evidence has yet been shown to exist.

At the same time, there is little reliable unclassified data on the kind of tactics, weapons, and countermeasures the US, Israel, and more advanced Gulf air forces could use to bypass, suppress, or destroy such systems. If Iran can deploy them in an effective force, they might well be a significant threat to even a concentrated and well planned US or Arab Gulf air campaign.

## Iran's Strengths and Weaknesses in Fighting a Significant Air War

Rockets and missiles do more than compensate for the Iran's lack of air strength and modernization. They give Iran credibility in being able to suddenly launch attacks from highly disperse sites and in ways that require far less training and readiness than air forces. There are few meaningful data on IRIAF's real world warfighting capabilities. Like all the elements of the IRGC and other Iranian military forces, the Iranian Air Force does seem heavily dependent on conscripts

and short-service personnel, and to have encountered problems in terms of its military politics and leadership.

Iran did a consistently poor job of managing large-scale air operations in the Iran-Iraq War. It has since done much to improve its training and exercise, joint warfare capability, readiness, sustainability, IS&R, and overall command structure. Like the other elements of Iran's forces, however, it would now have to go to war with forces that have not had any real military combat experience since the end of the Iran-Iraq War in 1988 – over a quarter of a century.

While the IRIAF has focused on improving its training regime and making simulations more realistic, nevertheless it lacks the material, number of experienced trainers, and, above all, accurate training equipment and drills to prepare its pilots for high-speed and large-scale combat operations.[62]

The regional tendency to emphasize aircraft numbers over sustainability is an issue. One reason that Arab air forces lost so decisively to Israel in past wars is that they could not generate anything like the surge sortie numbers – or sustained sortie numbers – that Israel could. Numbers of aircraft are never the critical measure of air strength. The issue is how many are operational at the start of a conflict, how well aircraft can be repaired or made ready in combat, and how many sorties can be generated over time (estimates suggest that Iran would have difficulty generating even one sortie every two days for its F-14s, while US aircraft are expected to undertake 2-3 sorties per day during intense air operations)[63].

Current Iranian exercises, command and control, technology, and vulnerabilities to outside attack or suppression do indicate Iran might still have critical problems in managing large air operations. Iran's lack of modern technology for integrating operations and creating the most advanced situational awareness possible could be critical. Iran's newer defense concept – relying on decentralized forces that are relatively unaffected by command and control strikes – is likely to be far less effective in aerial warfare, where small forces have a much harder time hiding and launching irregular attacks without warning. Iran's air force also conducts few joint exercises with its Army, IRGC, or Navy and those it does conduct are fixed set piece exercises with guaranteed success – a form of exercise training that can do more harm than good.

Basic pilot skills seem good, but this is not the same as having had advanced combat training – particularly using the kind of large-scale air operations training used by the US and some of its Gulf allies. Nevertheless, Iran's pilots do seem to be relatively well trained subject to the limitations of their aircraft and flying hours. In past Middle East wars that pitted Western against Soviet and/or indigenous aircraft, the Israeli and Western pilots possessed a marked edge in their individual and group training as well as in technology and $C^4$ISR. While Iran does not appear to have conducted mass drills with its fighters and strike aircraft, its personnel are generally believed to be competent individual pilots, suggesting that despite inferior equipment they may inflict serious casualties on Arab air forces.

The Iranian air force does, however, face a wide range of operational limits and problems and many could affect its performance in an a sea-air-missile conflict affecting some aspect of maritime time traffic in the Gulf-Indian Ocean-red Sea area.

- Iran would need weeks of strategic warning to surge its air force to maximum defensive readiness and/or conduct a major combat operation.

- The level of real world capability Iran's air force has developed for attacks on shipping, opposing naval forces, precision attacks on ports and offshore facilities, and key export facilities and critical infrastructure is unclear.
- The operational effectiveness of Iran's ability to use precision guided air-to-ground and air-to ship missiles is limited by the age and avionics capability of many of its aircraft and the effectiveness of its efforts to modernize its aircraft and adapt them to new missiles is unclear.
- The full state of the operational effectiveness of its maritime surveillance aircraft and UAVs is unclear. The real-world operational ability to use them to remotely target longer-range anti-ship missiles is also unclear.
- Iran's joint warfare capabilities seem to be limited in spite of exercises and training designed to improve them.
- Iran's acquisition of fighter and surface-to-air missile forces make it vulnerable to outside air attack and limits its capability in air-to-air combat.
- Even if Iran's air force does not come under large-scale attack, Iran's sortie rate could drop precipitously as it did at the beginning of the Iran-Iraq War – a factor that crippled it in competing with an incompetent and terribly led Iraqi Air Force.
- Iran could carry out a series of surprise strikes against Southern Gulf and Iraq targets, but not sustain either a long, intense air offensive or a long, intense air defense screen.
- Iran lacks the air strength to defend the entire country, although enough warning capability will probably survive attack and suppression to provide some coverage of its coast and western border, and its defense capabilities will improve with the depth of enemy penetration into Iranian air space.
- Iran will face serious limits in electronic warfare and countering jamming and electronic intelligence (ELINT) operations from any US or US-led force.
- Iran's limited air control and warning environment will be vulnerable to jamming, spoofing, and a variety of anti-radiation weapons.
- Iran's land and air-based IS&R systems are of limited capabilities, vulnerable, and sometimes relatively easy to suppress.
- Iran will have a major disadvantage in air-to-air missile combat and especially in beyond visual range air-to-air combat.
- Iran will not be able to penetrate a properly maintained US or Southern Gulf air defense system supported by AWACS aircraft
- Iran will be vulnerable to stealth systems like the B-2 and F-22, as well as the F-35 as it deploys. It will have very limited air to air defense capability against well-planned, well flown low altitude missions flown by cruise missiles, the B-1, and modern US and Southern Gulf strike fighters – with the possible exception of point defenses using its Russian supplied short-range Tor-M1 surface-to-air missiles.
- Iran will have problems in using its anti-ship and any other cruise missiles requiring a remote target system or airborne radar, and UCAVs/UAVs if US forces are present with modern electronic warfare and jamming capabilities, and in operating its maritime and intelligence aircraft both in the face of jamming and the threat from fighters.
- Iran would have serious problems in screening its critical targets. These not only include its nuclear facilities, but its missile facilities, major production facilities, refineries and fuel storage and distribution system, electrical grid, water purification facilities, and other key targets. A precision strategic bombing campaign could cripple much of Iran's economy and military production capability in a matter of days.
- Iran could engage in raids and limited air efforts, but would probably lose the ability to operate aircraft in numbers over the Gulf and southern Iran in a matter of days. It could not use its air force in numbers in sustained, survivable sorties to defend its ports, larger surface ships, or southern bases.

- Iran has so far been unable to construct precision munitions, weakening the IRIAF's ability to effectively target GCC forces or infrastructure.
- Limited tanker and air refueling assets that restrict Iran to maintaining continuous combat air patrols over only a small number of sites – key areas like Tehran.

The comments do apply more to sustained levels of combat over time -- where the US is present or Southern Gulf air forces are prepared, properly trained, and made interoperable by either US support or reforms that are still very much a matter of discussion rather than implementation. Iran could pose an important surge threat to maritime traffic or conduct sporadic raids and attacks that used airpower – alone or in combination with naval/marine/missile/IRGC forces -- in a war of attrition that affected maritime traffic throughout the Gulf and the region but was so low in intensity and so sporadic that it did not produce escalation to the kind of major conflict that would defeat Iran.

Experts indicate that Iran's military literature and training methods show that Iran is aware of the deficiencies in its air force, and has been seeking to remedy them through a combination of technological and doctrinal adjustments. With an eye for the ability of Western and Israeli forces to conduct devastating first strikes, the Iranian air force has sought to disperse its aircraft and provide independent command control systems, allowing small units to continue to fight even if a first strike badly damages the $C^4I$ system. Recognizing its own aircraft have limited ranges and effectiveness, newer training exercises have stressed in-flight refueling, strike missions at critical infrastructure, deployment of air-to-ground missiles, and advanced air-to-air combat.

Experts also confirm that Iran has carefully studied the tactics, technology, and the high tempo of US operations– including the Gulf wars, campaigns in the Balkans, and Operation Enduring Freedom – and carefully observes US air power tactics and management. These observations not only provide Iran with a blueprint for how a US/GCC air campaign against it might play out, but may have enabled more realistic and effective drills for its own air force.

There is only limited unclassified data on the quality of the enablers Iran needs -- its real world IS&R, $C^4I$, electronic warfare, and refueling capabilities. Experts do report Iran has sought to upgrade its radar systems with technology that has a higher chance of detecting stealth aircraft, potentially enabling it to diminish one of the US's primary advantages. Iran has also reportedly acquired an older F-16 fighter from Venezuela; while a single model is unlikely to allow it to produce its own advanced fighter aircraft, the transfer would enable Iran to better understand the avionics and capabilities of its potential foes.

Iran officially unveiled two systems in September 2014 that would enhance command and control for Iran's air defenses: the FIC2 and the Hadi. Brigadier General Farzed Esmaili described the FIC as a system that "receives and processes information from Iran's automated air traffic control center and sends it to air defense command-and-control bases."[64] He described the Hadi as a "data transfer system to share information" across Iran's integrated air defense network. It could transfer "radar information to a distance of over 100km and it acts through the optical fiber systems and enjoys GPS radar, detection radar and height-specifying radar systems, and can receive information form command and control systems.[65]

Experts also feel, however, that such Iranian systems are only likely to be effective in peacetime, could be quickly suppressed or destroyed in combat, and Iran is forced to plan for the rapid shift in its system to distributed and local control, and target of opportunity operations by individual fire units. Iran lacks survivable IS&R capability to support air operations, has only two to three

fully operational P-3s whose lack of full-scale modernization limits their wartime capability. It relies on aging Russian aircraft for much of its AC&W capability, relies largely on modified Cessnas and other small aircraft for maritime surveillance, but has no survivable "enablers" for air warfare. It is gradually developing a family of UAVs and UCAVs to provide better IS&R/battle management/targeting capability but these now are limited in capability and poorly netted, and lack effective over-the-horizon targeting capability.

Experts also report that Iran has been developing its own human-centric data gathering system that is designed to operate in the face of overwhelming US electronic superiority. Iran uses manned stations and small ships like the Dhows that ply the Gulf and Strait to watch commercial and military traffic in the region, and try to create an intelligence network that could provide targeting data during a war. This passive network, while slower and less accurate than modern digital (or even analog) systems, may prove resilient enough to help support the style of warfare Iran expects the US to wage. Iran has also made efforts to blend its human assets and analog electronic systems, creating a hybrid command and control design that can coordinate stacks of missiles and packs of fast missile boats, theoretically even in the face of decapitating air strikes.

In short, the Iranian Air force has serious limits in carrying out or supporting attacks that affect the flow of maritime traffic, but should be not discounted. An untested capability does not necessarily equal a lack of capability. The Iranian Air Force is operational in the Gulf and the Gulf of Oman, and no one can predict the way in which any air combat might emerge between Iran, its Arab neighbors, and the US.

## The US, Southern Gulf, and Iran's Capability for Air Combat

Missiles also give Iran a "deep strike" capability that Iran's air force may not be able to deliver in combat. While **Figure 12** shows that Iran's air force does have the range to strike maritime traffic, ports, offshore facilities, and petroleum export targets in the Gulf, its offensive capability is unlikely to survive in any protracted air battle. The Iranian air force will also be limited by its inexperience with large-scale operations and the actual use of many of its upgrades and munitions in combat. Iran's aircraft will also be range-limited in penetrating deep into Saudi Arabia. Iran is unable to strike targets all across the Gulf without secure refueling, while all of Iran is vulnerable to tanker-supported Arab or US strike aircraft. While Iranian air forces could conceivably benefit by launching a surprise attack or the elimination of Arab radar by their own missile forces, advanced radar systems and long-range missiles (IHAWK and Patriots) would still probably seriously degrade any Iranian operation.

These limits to Iran's capabilities must, however, be kept in perspective. Although Iran's air assets fall far short in quality relative to those of its steadily modernizing Gulf neighbors, the Southern Gulf states do have some special vulnerabilities which could be exploited if the US does not provide overall battle management and IS&R capability.

As other CSIS Burke Chair studies show, however, the Southern Gulf states have talked for years about interoperability and integrated air operations and air defense systems, but made far too little progress. There are many areas where their systems and stocks are not interoperable, readiness and training levels vary sharply by country, and so do preparedness and reliability. (See *The Gulf Military Balance: Volume III: The Gulf and the Arabian Peninsula*: http://csis.org/files/publication/120228_Iran_Ch_VI_Gulf_State.pdf, September 5, 2013.)

Furthermore, Iran has improved the “passive defense” of its air and surface-to-air missile units – camouflage, aircraft dispersal, and hardened shelters – in an effort to reduce losses from American and Arab Gulf attacks. While American and GCC forces have only a limited number of launching points, Iranian aircraft, due to the size and variety of large airports in Iran, will face a much simpler time in surviving on the ground; degradation of airfields will hinder the GCC and American sortie rate much more than the Iranian rate.

Much now depends on the extent to which the Southern Gulf states cooperate effectively with the US. The Southern Gulf states need the US and the US needs them. The US cannot fight large-scale air war in the Gulf using carriers and ship-based cruise missile alone – although these provide extremely powerful strike and defense capabilities for more limited engagements. It needs effective support from its Gulf allies who now must be trained and equipped to advantage of the full range of US-enablers like the E-3C AWACS, electronic intelligence and warfare aircraft – and ideally create integration battler management. IS&R, training, and support facilities and capabilities of their own. The US also needs protection from local land-based air defense and fighters, and access to Gulf air bases for support/arming/recovery to efficiently fight a major air or air/sea conflict.

Finally, air power cannot be separated from missile power. Iran can use both types of forces at the same time, and the US and regional powers might find it harder to deconflict air and missile defenses and check Iranian airpower under such conditions.

***Figure 12: Range of Iranian Airpower***


Source: Abdullah Toukan, April 29, 2014.

## *Asymmetric Warfare and Wars of Intimidation*

Iran's rocket missile capabilities also interact with Iran's far broader efforts to develop a mix of asymmetric forces and irregular warfare capabilities. Iran has shown that it can use transfers of such weapons to build-up allied or proxy forces like Hamas and the Hezbollah. It can also either use, or threaten to use, such systems if the US or neighboring states use or threaten to use their superior air and cruise missile strike capabilities against Iran if it supports internal threats or conducts lower level asymmetric attacks with its other asymmetric forces like its steadily increasing naval capabilities for asymmetric warfare.

Iran does not have to make active use of its longer-range artillery rockets or its missile forces if these provide a convincing threat that leads potential attacker to avoid attacks on Iran or higher levels of escalation. From an Iranian viewpoint, the best possible way to use military force is in "wars of intimidation." These do not involve Iranian losses in combat, the military risks inherent in Iran's actually attacking at any level of force, and allow Iran to manipulate its range of threats from very low-level action like using its Quds force to try to destabilize the internal situation in Gulf states to threats on critical energy export facilities like Ras Tanura or infrastructure facilities like desalination plants.

### *Using Asymmetric Forces to Compensate for Conventional Weakness*

Iran's developing missile capabilities are key reasons to stress that Iran's weaknesses in conventional forces need to be kept in careful perspective. Iran has spent two decades building up capabilities for asymmetric and irregular warfare. The end result is still a mix of Iranian forces the US can counter relatively quickly with the large-scale use of its own forces, combined with a

strong ability to escalate against targets within Iran. Still, any such escalation means a major war, and a full-scale use of force by the US would dramatically raise tensions in the Gulf and further poison long-term relations with Iran.

Iran has already developed a mix of *conventional* and *asymmetric* missile, land, air, and naval capabilities that can threaten its neighbors, challenge the US, and affect other parts of the Middle East and Asia. Iran may also be able to use state and non-state actors as proxies to threaten and manipulate a range of neighboring states, including Afghanistan, Iraq, and Israel. These forces are the key military elements of Iranian strategic competition and are steadily increasing in size and capability.

Accordingly Iran's asymmetric warfare capabilities may still give it a powerful capability to intimidate its neighbors and pose a higher risk to the US than a similarly sized, symmetrically oriented military., It would be far harder for the US to defeat Iran in a limited war of attrition or any other conflict where the US is unable to act decisively, overwhelmingly, and disproportionately in striking Iranian forces and targets (either for political reasons or because of a lack of support from the Arab Gulf state).

## Ongoing Developments in Iran's Growing Mix of Asymmetric Warfare Forces

Iran continues to improve the capabilities and training of its conventional forces for asymmetric warfare in recent years and to build up specialized elements within its force structure. As of 2012, some of the key recent developments in Iran's growing asymmetric capabilities included:

- The development of the *Karrar* and *R'ad* UCAVs in early 2010, both of which have a range in excess of 1000 km and can destroy targets with guided munitions.[66]
- The installation of a "Coastal Defense Missile" system along the country's 1,500 mile coastline, a move deemed the "appropriate strategy" to protect the country from attack.[67]
- The development of the *Khalij Fars* ("Persian Gulf") anti-ship ballistic missile.[68]
- The introduction of new high-speed combat boats armed with guided missiles and torpedoes such as the Seraj-1 and the Zalfaqar.[69]
- The introduction of the Bavar-2 flying boat, which is equipped with night vision and armed with machine guns and rockets.[70]
- The introduction of high mobility all-terrain vehicles such as the ATV-500 Jaguar and the Kaviran.[71][72]
- Increasing use of SDVs ("Swimmer Delivery Vehicle"), which can be used for inserting special forces elements or laying mines covertly.
- Further development and deployment of midget submarines capable of laying mines and potentially firing torpedos in the shallow, ASW-unfriendly Stratis of Hormuz.
- Several ongoing tests, including a C-700 series anti-ship cruise missile testing in the northern Arabian Gulf and a helicopter-launched anti-ship cruise missile.
- Development of satellite navigation-guided Fateh-110 missiles, and other precision-guided variants
- Testing of the solid propellant Badr-313 short-range ballistic missile , based on the Fateh-110 and possible field deployment in 2015.

Unlike Iran's conventional forces and its nuclear and missile efforts, the range of Iranian asymmetric options and forces is too wide to easily charterize or catalog. The core aspects of Iran's

growing capabilities for asymmetrtic warfare are below**,** but as the following analysis of its missiles show, this is only part of the story.

## The Limits to Iran's Missile/Asymmetric Capabilities

Iran does face serious risks in relying on such capabilities, however, as the following potential list of Iranian targets shows:

- Critical dependence on refineries with high cost, long lead facilities and on imports of product.
- Minimal power grid that can be crippled or destroyed selectively on a regional or national basis.
- Gas production and distribution facilities needed by Iran's domestic economy.
- Key bridges, tunnels, overpasses and mountain routes for road and rail traffic.
- Gulf tanker loading facilities, oil storage and tanker terminals – for mining or direct attack.
- Key military production facilities
- Command and control centers.
- Communications grids.
- Airfield and air bases.
- IRGC land, air, and naval facilities.
- Coastal naval bases and port facilities.

The US and Arab Gulf states can still do far more damage to Iran by escalating than Iran can do to them. At a political level, threats can simply provoke counter-threats or lead to threatened states seeing Iran as more of a threat and mobilizing their own populations against Iran. At a military level, they can lead to an accelerated military build-up by other regional states, US deployment of additional forces, US commitments to extended deterrence, and Arab Gulf states acquiring more of their own missiles and even nuclear weapons.

## Linkages to Iran's Nuclear and Ballistic Missile Programs

One key question is how much Iran's overall mix of asymmetric warfare capabilities would be if Iran either had nuclear-armed missiles or long-range precision strike capability with conventional warheads. From a strategic perspective, Iran's asymmetric capabilities interact with its nuclear weapons development efforts to compensate for the limitations to its conventional forces. "Going nuclear" provides a level of intimidation that Iran can use both to heighten the power and deterrent capabilities of its asymmetric forces and to deter conventional responses to its use of asymmetric warfare:

- Even the search for nuclear power is enough to have a major effect on competition and perceptions.
- Development of long-range missiles adds to Iran's credibility and pressures Iran's competitors.
- Crossing the nuclear threshold in terms of acquiring a "bomb in the basement" option, creating ambiguity and hence a form of deterrence.
- Threats to Israel legitimize the capabilities that tacitly threaten Arab states. Support of Hamas and Hezbollah increases legitimacy in Arab eyes – at least Arab publics.
- Many future options: stockpile low enriched material and disperse centrifuges, plutonium reactors, underground tests, actual production, arm missiles, breakout arming of missiles.

As is discussed later, Iran could also obtain many of the same benefits from successfully developing a precision strike capability for its missile forces. Much of the target base around Iran is critical dependent on high value energy export facilities, and on critical infrastructure like major electric plants and desalination plants.

# III. Iran's Artillery Rocket Programs

Iran has a growing range of artillery rockets – some with considerable range. These systems have been proven in part by their use by the Hezbollah and Hamas, and are deployed in large enough numbers to be fired in volleys. They could be used against Iraq and Kuwait, and some could be fired across the Gulf. They are deployed in both Iranian army and IRGC forces.

## *The Impact on Iran's Land Force Capabilities*

Iran has made efforts to reduce the divisions and tensions between its regular army and the Revolutionary Guards since 2003. It has reduced the degree of separation between the forces by combining them at the general staff level and running joint exercises and practiced defensive operations where its regular forces first fight an invading enemy with support from the IRGC, and then disperse and join the IRGC in an asymmetric, sustained, national campaign to reverse initial successes by the invader.

At the same time, Iranian ground forces have serious limitations and military quantity is only as effective as its quality. Until recently, the IRIA has not carried out large-scale joint warfare drills that would prepare it for formal conventional war except for ones that dealt with the unrealistic prospect of some form of US invasion. Iranian combined arms maneuver capability is limited by both equipment and training, and Iran has not organized to sustain combat operations much beyond Iran's borders. Iran does not practice realistic amphibious warfare beyond small operations or raids in the Gulf, and has limited lift capability and little capability to protect it.

Iran does hold large exercises and combined air-Army-IRGC exercises like the week long "Modafe'an-e Aseman-e Velayat 4," (Defenders of Velayat Skies 4) exercise it held in November 2012.[73] It, however, tends to exaggerate their size and progress. The Commander of Khatam al-Anbia Air Defense Base Brigadier General Farzad Esmayeeli briefed the media on the latter exercise and claimed the exercise would be carried out in an area of more than 850,000 square kilometers, and "display the full strength and preparedness of Iran's air defense forces to defend the Islamic Republic's eastern borders."[74] In practice, however, the preparations for the exercise seemed to be for little more than a command post exercise.

This is typical of Iranian exercises that often claim very large numbers and very demanding scenarios, but are far smaller in practice, show little inter-service cooperation beyond set piece activities with guaranteed success, and show little ability to innovate or go on the offensive.

The effectiveness of IRIA $C^4$IS&R systems is unclear, but many systems seem dated and their level of integration seems limited. Like the other elements of Iran's military forces and the IRGC, the army is heavily dependent on conscripts, and has encountered problems in terms of its military politics and leadership as the IRGC has become the dominant political element of Iran's forces and moved close to Iran's Supreme Leader.

Like the rest of Iran's forces, the Army would also have to go to war with forces that have not had any real military combat experience since the end of the Iran-Iraq War in 1988 – a period of nearly a quarter of a century. While Iran has sent some volunteer cadres to Syria, neither its Army nor IRGC have been engaged them in large-scale combat. This not only means it has no cadres with combat experience, but that it plans to use them to fight a very different kind of war than Iran has ever fought before.

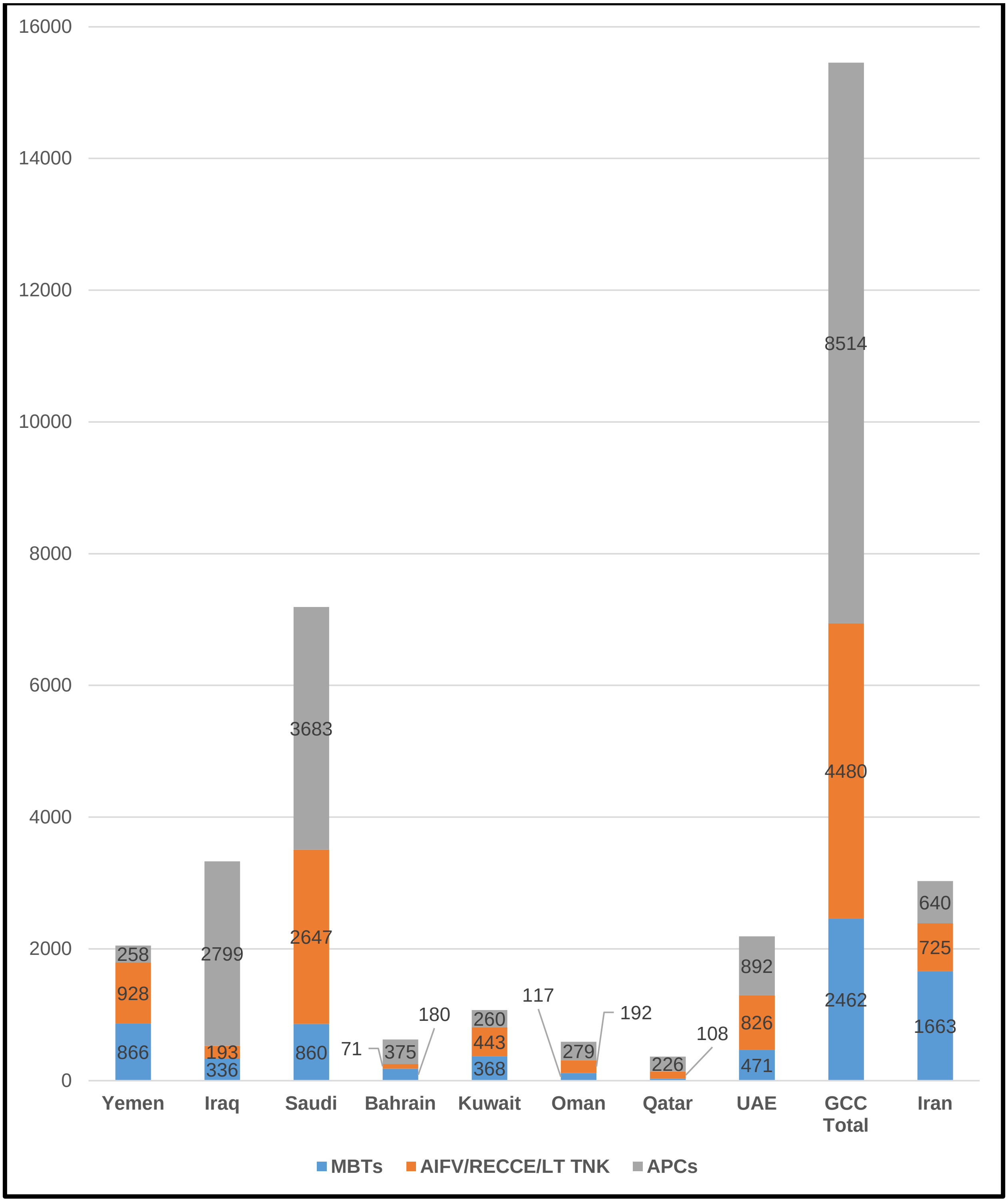
The GCC states have the potential edge in the quality of their armor, artillery, and mobility. The US can deploy several brigades' worth of heavy or light ground forces with some of the most advanced weaponry available; and air superiority gives the US and GCC states a major advantage in an era of joint air-land and precision day-night warfare.

**Figure 13 Part One and Figure 13 Part Two** show, Iran's land forces are still well equipped enough to have significant self-defense capability and present a serious threat to countries near its border. Iran has more than 1,660 main battle tanks, but none come close to the US M-1A1 or M-1A2, or most recent European and Russian designs. Only about 630 are relatively new and not combat worn. Iran is just beginning to renew its holding of other armored vehicles.

It has a vast pool of over 8,500 effective towed artillery weapons and multiple rocket launchers, but less than 300 self-propelled weapons that have high maneuver capability and many are worn out. All of its 50 AH-1J attack helicopters date back to the time of the Shah, as do most of its transport and utility helicopters.

At the same time, however, the vast majority of Iran's major land weapons are aging, of low to moderate capability, and require modernization. Many are worn as a result of the Iran-Iraq War, and both US experts and the various editions of the IISS *Military Balance* between 1989 and 2014 indicate Iran's land forces have never fully recovered from the loss of at least 40% of their major land weapons during the climactic battles of that war. Iran's ground forces have also focused largely on defense and deterrence of a ground invasion, and only a few units seem to be equipped and trained for longer-range maneuver and sustained offensives at any distance from Iran's borders.

***Figure 13: Comparative Major Weapons in Iranian and Gulf Land Forces – Part One: Armor (Graph)***

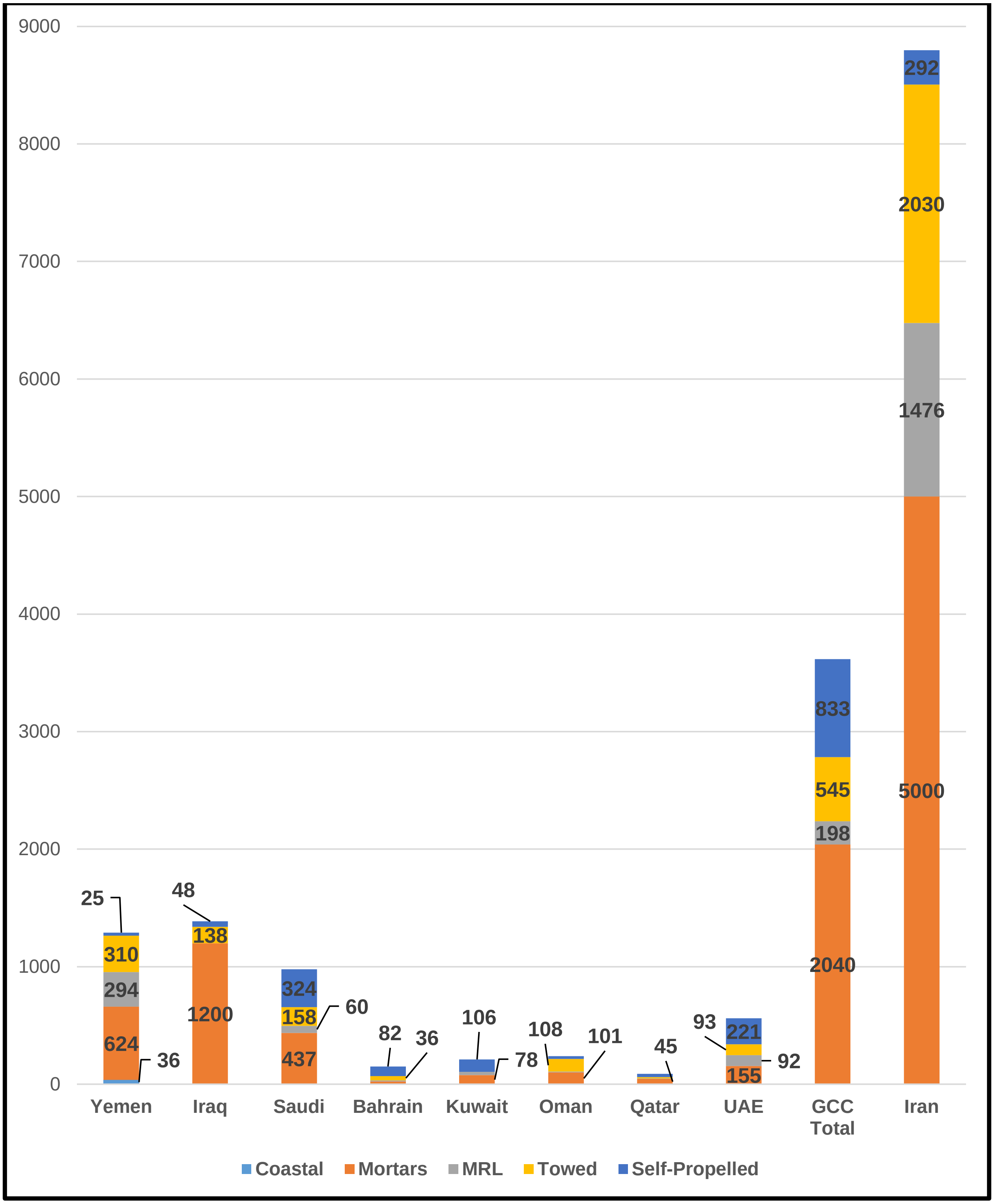



Source: Adapted from the IISS, Military Balance, 2013.

***Figure 13: Comparative Major Weapons in Iranian and Gulf Land Forces – Part Two: Armor (Table)***

| | **Yemen** | **Iraq** | **Saudi** | **Bahrain** | **Kuwait** | **Oman** | **Qatar** | **UAE** | **GCC Total** | **Iran** |
|---|---|---|---|---|---|---|---|---|---|---|
| MBTs | 866 | 336 | 860 | 180 | 368 | 117 | 30 | 471 | 2462 | 1900 |
| AIFV/RECCE/LT TNK | 928 | 193 | 2647 | 71 | 443 | 192 | 108 | 826 | 4480 | 725 |
| APCs | 258 | 2799 | 3683 | 375 | 260 | 279 | 226 | 892 | 8514 | 640 |

***Figure 14: Comparative Major Weapons in Iranian and Gulf Land Forces – Part One: Artillery (Graph)***




Source: Adapted from the IISS, Military Balance, 2013.

***Figure 14: Comparative Major Weapons in Iranian and Gulf Land Forces – Part Two: Artillery (Table)***

| | **Yemen** | **Iraq** | **Saudi** | **Bahrain** | **Kuwait** | **Oman** | **Qatar** | **UAE** | **GCC Total** | **Iran** |
|---|---|---|---|---|---|---|---|---|---|---|
| Coastal | 36 | | | | | | | | | |
| Mortars | 624 | 1200 | 437 | 24 | 78 | 101 | 45 | 155 | 2040 | 5000 |
| MRL | 294 | | 60 | 9 | 27 | 6 | 4 | 92 | 198 | 1476 |
| Towed | 310 | 138 | 158 | 36 | | 108 | 12 | 93 | 545 | 2030 |
| Self-Propelled | 25 | 48 | 324 | 82 | 106 | 24 | 28 | 221 | 833 | 292 |

## *The Tactical Impact of Iran's Artillery Rockets*

Iran's artillery rockets can help Iran's ground forces by providing a major surge in short-range fire against area targets, and suppressive and harassment and interdiction fire. They do, however, have only moderate mobility and cross country capability, and it takes substantial transport and supply capability to deliver heavy rates of fire for the systems using multiple rocket launchers.

### Range and Warhead Capability

**Figure 14 Part One and Figure 14 Part 2** provide a rough estimate of Iran's short and medium range artillery rockets. It reflects uncertain and often deeply conflicting unclassified reports. It is clear, however, that Iran's shorter-range artillery rockets not only can add to Iran's tube artillery capability, but act as a partial substitute for close air support in fire against area targets.

As is the case for virtually every aspect of Iran's military programs, the data in Figure 12 are uncertain, and sources differ over the scale of Iran's efforts.

An IHS-Jane's estimate which seems to date to 2012, listed the following holdings of multiple rocket launcher (MRL) artillery rockets:

- 100 holdings of 107mm NORINCO launcher or fire units.
- 600 fire units in service of 107mm HASEB or Fadjr 1 launchers.
- 170 holdings of 122mm BM-21 launcher or fire units, with 100 in service.
- 75 holdings of 122mm Arash launcher or fire units, with 50 in service.
- An unknown number of Iranian Aerospace Industries (AIO)-made 240m Fadjr 3 units.
- An unknown number of Iranian Aerospace Industries (AIO)-made 330mm Fadjr 3 units.
- An unknown number of Iranian Aerospace Industries (AIO)-made 330mm Shahin-1 and Shahin-2 units.

An early 2013 estimate by the Israeli Institute for National Security Studies (INSS) credits Iran with producing 310mm Fajer (Fadjr-5), Falaq, 355mm Nazeat, 333mm Shahin-2 and 610mm Zelzal-2 rockets. The INSS also reports Iranian production of launchers and rounds for 107 mm Type-63 (100 launcher) 122mm (150 launchers), 160mm, 230mm Oghab, and 240mm Fadjr-3 multiple artillery rockets (MRLs). [75] Finally, the INSS credits Iran with assembly and production of Scud C, Shehab-2, Shehab3, Qiam and Kosar liquid fueled ballistic missiles (with Chinese, North Korean, Russian and possibly also Pakistani support), and Fateh-110 and Tondar-69 solid-fuel ballistic missiles.[76]

The 2014 edition of the IISS Military Balance reports Iran has having a total artillery force of 5,000 mortars, 292+ self-propelled tube weapons, 2,030 towed tube weapons, and 1,476 multiple rocket launchers. The IISS estimates that these artillery rockets include:

- 1,300 107mm MRL launchers: 700 Type-63 600 HASEB and some Fadjir-1 launchers.
- 157 122mm launchers: 7 BM-11; 100 BM-21; and 50 *Arash*/*Hadid*/*Noor*,
- 19 240mm launchers: ε10 *Fadjr* 3;and 9 M-1985, and,
- An unstated number of 330mm *Fadjr* 5 launchers.[77]

The longer-range artillery rockets are to some extent a legacy of Iran's efforts to catch up with Iraq's superior ballistic missile launch capabilities during the Iran-Iraq War, and superior ability

to hit Iranian area targets during its” war of the cities.” Unclassified data provide the following estimates of the key longer-range systems involved:

- **Haseb** - The Haseb is a short-range 107mm rocket that can be fired from a 12-tube launcher. This is a variant the Chinese Type 63 107mm rocket. The rocket carries an 8kg warhead to a maximum range of 9 km. [78]
- **Falaq** - The Falaq rockets are short-range, large-caliber rockets. They are unguided and spin-stabilized. The Falaq-1 is a 240mm rocket with a range of 10 km, carrying a 50kg warhead. The Falaq-2 is a 333mm rocket with a range of 10.8km, carrying a 117kg warhead. Both variants of the Falaq can be launched from trucks or boats. The Falaq has been used in the Syrian Civil War.[79]
- **Arash family/Noor** – The Arash family of 122mm rockets consist of three types of rockets, the Arash-1, -2, and -3. Estimates of the maximum ranges for these rockets are 21.5km, 30km, and 18km, respectively, with longer-range rockets having longer lengths. All three rockets have 18.3kg warheads and can be considered BM-21 analogs. Noor, which is the name of an Iranian anti-ship cruise missile, is also an alternate name for the Arash-3.[80]
- **Oghab** – The Oghab is a 230mm unguided, solid-fuel rocket with a range of 34-45 km. The warhead is 70kg. The Oghab is derived from the Chinese Type 83 rocket.[81]
- **Fajr** - The Fajr is a family of truck launched artillery rockets. The Fajr-1 is a 107mm rocket with a 7.9kg warhead and 8.3km range. The Fajr-3 240mm rocket has a range of about 43km and a 45kg warhead. They can be launched from a truck equipped with 12 launch tubes. The Fajr-5 333mm rocket has a range of 75km and a 90kg warhead. They can be launched from a truck equipped with 4 launch tubes. Iran has exported Fajr-5 rockets to Hamas, which has used them against Israel.
- **Nazeat** – The Nazeat rocket family is based of the Russian FROG rockets. The latest variant is the Nazeat 10. The Nazeat 10 has been described by Iranian media as a “middle range ballistic missile with a range of about 100 kilometers.”[82] The largest variant of the Nazeat 10, the Nazeat-10H is a 455mm rocket. It carried a 230kg warhead to a purported 140km maximum range at a CEP of 5% of its range.

  In May 2014, IHS Jane’s reported on a new variant the Nazeat 10 that featured small nozzles behind the warhead section that were pointed towards the rear of the missile and laterally to the missiles long axis. It’s possible that these small nozzles are part of rockets designed to spin the missile and separate the warhead from the rest of the missile. Other spin-stabilized rockets, like the Zelzal, fire these types of rockets to spin the missile and improve accuracy. Removing the warhead from the rocket body would decrease the effects of drag IHS Jane’s also stated that this could be a system similar some rockets employed by the BM-30 MRL system, where the warhead is separated from the rocket body and a parachute is deployed to guide the warhead on a vertical trajectory to the target.[83]
- **Zelzal 2 -** The Zelzal 2 is a 610mm rocket with 250km range, and appears similar to the Russian FROG-7 system. The missile is unguided and spin-stabilized by firing small rockets, which are pointed laterally to the missiles long axis, immediately after launch. In May 2014, a variant of the Zelzal with 30 17kg submunitions was unveiled as an IRGC exhibition. Launchers that can carry two and three missile at once have been seen.[84]

They have enough range to pose a potential threat to area targets like military bases, urban facilities, and critical infrastructure. They are also inaccurate, however, that they can only have a reasonable change of scoring a serious hit on a critical building or other target if used in salvos or volleys. Iranian doctrine calls for such attacks, and some are mounted on multiple launch racks, but it is unclear that Iran can coordinate such attacks effectively.

The longer-range systems with heavier payloads still have limited real-world lethality with unified HE warheads even if they hit near a target, and it is unclear that their lethality would sharply increase against anything other than exposed infantry or populations with cluster warheads.

Opinions are divided on the potential extent and military value of Iran's efforts to deploy cluster warheads, but Iran seems to have them for some systems. Iran's Minister of Defense, Hossein Dehghan, declared on March 4, 2014, that the Iranian Qadr H1 and Qiam had cluster munition warheads, "These missiles are able to hit and destroy enemy targets with precision, and they meet a variety of the armed forces' needs…The weapons have strengthened Iran's deterrence power and military might."[85]

Several US experts feel, that Iran's current conventional cluster warhead designs have limited effectiveness and certainly lack the increase area of lethality necessary to begin to compensate for missile inaccuracy. They also feel that Iran does not deploy chemical cluster warheads, and that efforts to upgrade accuracy leave accuracy at the moderate levels common in other competent unguided rocket designs.

This does not mean that Iran's longer-range artillery rockets do not have military value. Like inaccurate missile strikes, the political and psychological impact of rocket strikes could be significant even if they did little damage. Attacks could disrupt military and civilian operations, workers may refuse to work, and aircraft and ships may refuse to enter ports. Rockets could also be used as part of "stack threats" and launched in ways designed to saturate or exhaust missile defense, potentially allowing more effective ballistic missiles to penetrate and reach a target.

### *Figure 15: Iranian Short and Medium Range Artillery Rockets*

| Type | Max. Range (KM) | Diameter (MM) | Warhead (KG) | Comment |
|---|---|---|---|---|
| Arash<br>BM-11<br>BM-21 | 20-45 | 122 | 18 | Vehicle mounted or towed MRL.<br>Made DIO. Arash has range of<br>20.5 KM. Other vary by type and age. |
| Fajr-3 | 45 | 240 | 90 (45 HE) | MRL launched system. Vehicle mounted<br>In Iranian Army artillery |
| Fajr-5<br>(Faqr-5?) | 75-80 | 333 | 175 (90 HE)<br>May be CW<br>version | MRL launched system. Vehicle mounted<br>In Iranian Army artillery.<br>North Korean design origin.<br>Reports of a single round version with<br>rage of 190 KM, and radar guided<br>antiship version. |
| Haseb-1<br>(Fajr 1)<br>Type 63 | 8-9 | 107 (106.7) | 8 | MRL launched system. Towed.<br>In Iranian Army artillery. PRC design |
| Mushak-120<br>Zelzal-1<br>Zelzal 1A | 100-215<br>130<br>160 | 450-601 | 500-600 | Cited as mobile, or in fixed sites of 3,<br>TEL launched artillery rocket. Status uncertain,<br>some reports is follow-on to FROG and<br>larger than Nazeat. Some reports are 1A,2,3,<br>and 3B versions. |
| Nazeat-4 | 70 | | 550 | Russian FROG 9M21 Luna. Status unclear. |
| Nazeat-5 | 90 | | | Single launcher FROG (LUNA A) development |
| Nazeat-6-H | 105 | 355 | 850 | Single launcher FROG (LUNA A) development |
| Nazeat-10-H | 140 | 450 | 250 | Single launcher FROG (LUNA A) development.<br>New version may have separable<br>parachuted fragmentation warhead.<br>Claim CEP=5% of range.<br>Some reports of PRC design aid. |
| Noor | 18 | 122 | 18 | MRL 3-tube launch system. In Iranian Army<br>artillery. Sometimes<br>listed Iranian copy of C-802 anti-ship missile |
| Oghab | 34-45 | 230 | 70 | Development form PRC Type-83.<br>Triple rail launched system.<br>In Iranian Army and IRGC artillery.<br>Very inaccurate. CEP in excess of 500 meters.<br>Some 260-270 fired in Iran-Iraq War. |
| Shahin-1 | 13 | 333 | 190 | Short-range heavy artillery rocket |
| Shahin-2 | 20 | 333 | 190 | Short-range heavy artillery rocket |
| Zelzal-2<br>Mushak-200 | 100-210 | 610 | 500-600 | Uncertain developmental system with<br>various names, Some reports is copy of,<br>derived from FROG-7 |

Note: None is guided. All are fin guided. Most systems are spin stabilized.

Source: IHS-Jane's, Global Security, and FAS, "Iranian Artillery Rockets," http://www.fas.org/man/dod-101/sys/land/row/mrl-iran.html.

Iran's Defense Industries Organization (DIO), which produces many of Iran's weapons, released a document that described some of their artillery rockets. Some of their figures differ from other figures describing their weapons. Below is a

| Name | Range | Caliber | Warhead weight |
|---|---|---|---|
| Short range Arash | 12km | 122mm | 19kg |
| Standard Arash | 21km | 122mm | 19kg |
| Long range Arash | 40km | 122mm | 22kg |
| Fajr 1 | 8.3km | 107mm | 7.9kg |
| Fajr 2 | 23km | 240mm | 85kg |
| Fajr 3 | 43km | 240mm | 85km |
| Fajr 5 | 75km | 333mm | 175kg |
| Two stage Fajr 5 | 180km | 561mm (1st stage)/333mm | 175kg |
| Falagh 1 | 10km | 240mm | 50kg |
| Falagh 2 | 10.8km | 333mm | 117kg |

## Targeting and Battle Damage Assessment Capability

Iran seems to have only limited targeting and battle damage assessment capabilities to make effective use of its artillery rockets, but any such judgment has important uncertainties. Iran's active forces do have artillery radars and computers, although the level of equipment and its quality is unclear, as is the level and type of training. Such systems generally become progressively less accurate with distance, however, and are useful only for counterbattery purposes and limited at best to ranges under 40 kilometers.

It is unclear how well Iranian forces can target its longer-range artillery systems on mobile targets, and how well they can set up strikes on fixed targets in the field. It seems likely that the Iranian forces involved would have accurate GPS systems to locate at least the larger and longer range launchers and that all active forces will now have GPS devices.

Iran may have catalogued the GPS coordinates of all potential fixed area targets in Iran and nearby. Anyone can gather GPS target data on a site they can enter or bracket with GPS devices, and security is marginal for critical infrastructure and even many secure facilities since any worker that can enter the facility can normally carry in a GPS device – something that applies to gathering target data at far longer ranges and generally to palaces, critical infrastructure facilities, and many military bases and facilities throughout the entire region.

Iran would not need military satellite capability or air or unmanned aerial vehicle reconnaissance data to get area fire targeting data on fixed facilities for its long-range rockets or missiles. Commercial satellite data would be adequate. It seems doubtful in any case that Iran could use its limit fixed wing air reconnaissance assets for such missions. Iran is, however, making steadily greater use of unmanned aerial vehicles (UAVs) like the Ababil, Fotros, and Yasir (Yaseer, Yasser, Yassir), as well as unmanned combat aerial vehicles (UCAVs) like the Ra'ad 85 and Shahed (Witness)-129.[86]

Iran has made ambitious claims about its UAV and UCAV programs that it is not possible to verify. For example, a report in Defense News indicates that Maj. Gen. Mohammad-Ali Jafari of Iran's IRGC claimed on September 27, 2013 that the deployment of the Shahed-129 showed Iran's industrial sector had self-sufficiency in the production of UAVs and UCAVs. He claimed "smart and precise" targeting capabilities for the Shahed 129 which was stated to have been produced and developed by the Aerospace Division of the IRGC, and which Iran claimed it had achieved a "successful reverse engineering technology" that gave Iran the capability to its own version of the US CIA's RQ-170 Sentinel stealth UAV that Iran had found near the town of Kashmar.[87]

Iran made the Shahed 129 a symbol of its advances in UAVs and UCAVs and claimed it could carry up to eight weapons, remain airborne for 24 hours, and had an operational radius of 1,700 kilometers. Iran's Press TV said that Brig. Gen. Amir-Ali Hajizadeh, the commander of the IRGC's Aerospace Division, stated that the,"Shahed-129 can easily track and identify… anyone targeting the Islamic Republic of Iran's sustainable security and can fire missiles at them upon orders from commanders." It was unclear that the system was really operational, however, or had an effective set of command-communications links and command and control system, or could even be fully operational at ranges of 200 kilometers. [88]

Iran also released new data on its Yasir UAV, and *Defense News* reported that Israeli experts said it seemed to be a copy of the US-produced Scan Eagle. Iran released new images of a ship-based, catapult-launched version of the Yasir on September 28, and that the system was capable of flying up to eight hours at some 15,000 feet, with a range of up to 200 kilometers.

Iran's semi-official FARS news agency quoted Brig. Gen. Ahmad Reza Pourdastan, commander of Iranian Army Ground Forces, as stating that "Yasir is capable of identifying targets with its very powerful camera and reporting back to base." Iran's Tasnim News Agency quoted Pourdastan as announcing production of the Ra'ad-85, an "advanced suicide drone" for attacking enemy helicopters and ground targets. Pourdastan also stated that the Ra'ad-(Thunder) 85 as akin to "a mobile bomb, capable of destroying fixed and mobile targets." [89]

Iran's UAVs could provide real time targeting and battle damage assessment data to Iran's fire units and tactical commanders, but it is not clear how many such systems have been deployed, who they have been deployed to, what the capabilities of such systems are, or what level of training and capability Iranian forces have.

## Command and Control

It is not clear how Iran structures its command and control for its artillery rockets. Its shorter range multiple rocket systems seem to be integrated into the regular artillery forces of its army, navy, and the IRGC. All of its longer-range rockets and ballistic missiles seem to be under the command of the IRGC.

Iran does have dedicated command vehicles such as the Basir and Rasoul for its larger artillery rockets with microwave communications with line of sight ranges of 30 KM at 32 MB/s and a dedicated command link. Some have optical fiber links. There are evidently separate longer-range target groups.[90]

Brigadier General Ahmed Reza Pourdastan gave an interview in March 2013 where he made some vague claims about Iran's progress in command and control equipment.[91,92]

> In regards to the subject of C4I you mention, the technology that, in recent decades, has entered the armies of the world, is not unique to our army. In the context of the army ground forces, the situation is very good.

> Today I can communicate with the bases of my subordinates in audio and visual, and we practice this regularly. This relationship is such that we can even see each other, and exchange maps and information. We have the capacities to suit the operation and are improving is.

## *The Broader Strategic Value of Iran's Artillery Rockets*

Iran has shown that even its shortest-range rocket designs can have a strategic impact and can be used in irregular warfare and as an indirect form of power projection. Iran exports many of its artillery rockets and has modified some of its longer-range systems – such as the Fajr-5 – so they can be smuggled in parts into other countries or through the tunnels from Egypt to Gaza. Some seem to transit through the Sudan and Iran may be sending components to Gaza so Hamas and the PIJ can assemble the rest of the system.[93]

Iran has played a major role in helping Hamas and the Palestinian Islamic Jihad create a major pool of steadily improving rockets that it can conceal, disperse and fire against Israel, and that Israel cannot easily seek out and destroy even in a land invasion. Key portions of a separate Burke chair study by Aram Nerguizian of the security situation in the Levant provides some detailed insights into these developments and the weapons involved.

> Hamas and Hezbollah have actively sought to acquire, expand and modernize their holdings of surface-to-surface rocket and missile holdings. Surface-to-surface systems – especially when equipped with even limited guidance systems – served to bolster each group's domestic credentials within the Palestinian territories and Lebanon, enhanced each group's relative deterrence vis-à-vis Israel and increased the costs to Israel and its allies in their quest to either eliminate threats both before launch and in-flight.
>
> Hamas steadily developed its holdings of short-range rockets over time, aided in part by smuggling from Sinai via an underground network of tunnels, with some open source estimates placing the Palestinian militant group's 2014 holdings at some 10,000 rockets.[94] However, Israeli security measures – including the separation barrier between Israel and the West Bank – have limited supplies to Hamas and other Palestinian groups.
>
> …Israel's 2012 attacks against Hamas and other militant targets during "Operation Pillar of Defense" reduced the group's rocket holding as a result of targeted strikes by the IAF and the launching of some 1,500 rockets by Palestinian militants in attack against Israel. Despite effort to set back Palestinian rocket and missile capabilities, Hamas's holdings immediately after the 2012 conflict of longer range rockets may still have included dozens of 122-mm *Grad* or similar rockets, 230-mm *Oghabs*, and as many as 50 modified 240-mm *Fajr-3* rockets that had the potential to strike Tel Aviv or Israeli nuclear facilities in the Negev.[95]
>
> Beyond the state of Hamas' post-2012 rocket and missile holdings, the Palestinian militant group also appeared to have made effective use of its tunnel network linking the Gaza Strip to smugglers in Sinai, and Hamas' relatively favorable ties with the Muslim Brotherhood linked government of Mohamed Morsi, to rebuild some of its holdings over the 2012 to 2014 period.[96] As of August 5, 2014, Israeli defense sources reported that Palestinian militants had fired more than 3,700 rockets and missiles.[97]
>
> One other way that Hamas could have built up its holdings was through limited local production. While Iran had publically stated that it supplied the militant group with the 333 mm *Fajr-5* and the 240 mm *Fajr-3* in the past, it may also have transferred some assembly or production capabilities. There is some preliminary reporting that Hamas and other Palestinian factions may now have the capability and the resources to build their own *Fajr-5* rockets.[98]
>
> This may have partly reflected the impact of degrading security in Sinai and the impact of a less secure Egyptian-Gaza frontier on Iran's ability to send aid to its allies in Gaza. Some of these trends may have reversed in light of both a relative decline in relations between Hamas and Iran over the Syria conflict and the fact that the Sisi government was far less tolerant of both Hamas and Iran's efforts to support its regional allies.

Beyond *Fajr*-type rockets, Hamas may have also bolstered its ability to produce some of its own rockets – which could have become a necessity if ties to Iran were strained. In 2013, the IDF asserted that Hamas was producing many of its own longer-range rocket systems. This was reported to include the M-75 rocket.

A locally built and designed system named after Ahmad Ibrahim al-Muqadimah – a Hamas leader killed by the IDF in 2003 – the M-75 was a 200 mm rocket with a nominal range of 75 km. However, a great deal of skepticism surrounded claims the group could produce its own rockets, especially given the improvised nature of many of the rockets used by Hamas with nominal ranges not exceeding 15 km.[99]

While Hamas did much to expand its holdings of surface-to-surface systems with Iranian support, no regional sub-national group – let alone most regional states – could compete with the scope and scale of Hezbollah’s rocket and missile holdings. Prior to Israel’s withdrawal from South Lebanon in 2000, Hezbollah’s longest-range rocket system was the tried and testing 122 mm *Katyusha* with an operation range of some 20 km. By the time of the 2006 Israel-Hezbollah conflict, Israeli estimates placed Hezbollah rocket holdings at some 13,000 to 14,000 rockets – most of which were short range and unguided with limited numbers of rockets with ranges up to 200 km. By mid-2013, Hezbollah’s holdings grew to include at least 60,000 to 80,000 rockets, including increasingly capable short-range ballistic missile systems that afforded Hezbollah the ability to launch from well north of its traditional South Lebanon AOR.[100]

**….**Various reports indicate that Iranian and Syrian transfers that build the Hezbollah’s growing holdings of guided and unguided short range and tactical missiles became a steadily more important aspect of the asymmetric balance, and one where Iranian competition with the US and Israel had an important impact.

- Some reports indicated that Hezbollah’s one of largest rocket system was the 610 mm *Zelzal-2*. Weighing some 3,400 kg and capable of delivering a 500 kg warhead in excess of 200 km, the system’s lethality and utility were limited by its lack of electronic guidance systems. While the Shi’a militant group did not use its *Zelzal* rockets during the 2006 war, it was widely believed to have vastly expanded its holdings of both short and medium range unguided rockets to deter future conflict or to inflict psychological costs on the Israeli population in any future war.

- Hezbollah also expanded its holdings of guided rocket systems. The “Fatah” A-110, a guided version of the *Zelzal-2*, or the Syrian made M600, a *Fatah* A-110 clone, presented more of a threat to Israel’s interior. Equipped with inertial guidance systems and able to deliver a 500 kg payload to a range of 250 km within a circular error probability (CEP) of 100 m, these systems could allow Hezbollah to threaten as far south as Tel Aviv from the Northern Bekaa. While there were competing and unconfirmed reports surrounding whether or not Hezbollah had them in inventory, the group was generally believed to have limited holdings of both systems by 2014.

- Reports surfaced in early 2010 that Syria may have transferred Russian R-17 *Scud-B* ballistic missiles to Hezbollah. 11.25 m long and weighting some 5,900 kg, the guided liquid fuel rocket is able to deliver a 985 kg warhead over a range of 300 km.

  While the *Scud-B* had superior range to Hezbollah other holdings of unguided medium range rockets, its much larger CEP of 450 m was significantly inferior to the *Fatah* A-110’s CEP of 100 m. In July 2011, reports surfaced that Syria transferred some ten *Scud-D* to Hezbollah.[101]

  *Scud*-type missiles were unwieldy systems for an organization that emphasized stealth, mobility and rapid deployments for multiple fires. They could not be taken apart for easy or inconspicuous transportation. Furthermore, the complexity and volatility of the missile’s propulsion system would require dedicated facilities in addition to highly trained personnel.

  There was continued skepticism surrounding the transfer of *Scud-B* or *Scud-D* to Hezbollah and as of 2014, there were no releases of aerial observation of any *Scud* transfers across the Lebanese-Syrian border. Unlike solid-propellant rockets like the *Zelzal-2*, even a modified/stealthy *Scud* transporter/erector/launcher (TEL) would present a clear target for overhead reconnaissance.[102] US defense sources also indicated that while a transfer was not ruled out, there were increasing indications that Hezbollah personnel trained on *Scud* type systems in Syria rather than in the wake of a transfer to Lebanon.

> Ultimately, *Scud*-type liquid fueled rockets could present more of a liability than an asset to Hezbollah's overall missile capability. Furthermore, given Hezbollah's existing inventory of guided and unguided systems, the potential acquisition of *Scud-B* or *Scud-D* had a popular psychological impact in Israel, rather than actually impacting the overall regional balance.
>
> - While Hezbollah continued to consolidate its arsenal of short-range 107 mm and 122 mm rockets meant to harass IDF ground forces in any future war, it may also have developed a use for systems otherwise considered irrelevant in the asymmetric balance. These included relying on multiple teams using large numbers of 106 mm recoilless rifle rounds to swarm and overwhelm the IDF's *Trophy* active protection system currently equipped on Israeli *Merkava* MBTs. *Jane's* went on to report that if assisted by sighting guns, this low-tech anti-tank (AT) solution could successfully hit Israeli armor out to a range of 1,000 m.[103] Such tactics could have been part of Hezbollah's own lessons learned as it tried to build an edge in the asymmetric balance with Israel.
>
> While counter-terror, counter-insurgency and counter-intelligence threats from groups like ISIS in ungoverned and under-governed spaces in Levant persisted in 2014, the threat that any sub-national armed group could make effective use of longer-range surface to surface missiles remained limited.
>
> **…**This growing mix of short-range and longer-range rockets – and ATGMs/MANPADs – did not threaten Israel's "edge" in military technology in 2014. The systems involved were too lacking in accuracy and lethality. Hamas's holding in particular appeared to lack real-world lethality and included far too large a mix of improvised and locally built or modified systems to be effective against Israel.
>
> However, Hamas and Hezbollah rocket holdings posed enough of a future risk for Israel to make major efforts to field newer defensive counter-fire systems. These included a wide range of new systems to defend against different types of threats: the *Trophy* active protection system (APS) for Israeli armor, the *Iron Dome* defensive systems for shorter range rockets mortars, the *David's Sling* for longer-range rockets, the *Arrow II* high altitude anti-missile system, and the *Arrow III* wide area theater counter-ballistic missile defense system. It also prompted the IDF to further decentralize its supply and logistics infrastructure to protect ammunition and equipment in the event of a future wars.
>
> The combination of systems that included *Iron Dome*, *David's Sling*, and *Arrow II* and *Arrow III* probably did much to limit Iranian, Syrian, and any non-state actor's capability to leverage the asymmetric balance in their favor. However, only a lasting peace, supported by both Israelis and Palestinians and backed by the US and other regional players could be a truly effective security option in the long term, or halt Iran's efforts to constantly gain advantage in the Levant, leverage its ties to Palestinian militants and foil US interests. Furthermore – and as the next sections will show – there were always going to be unexpected limits in terms of just how much any anti-missile system could shape the optics of Israeli asymmetric victory.

Israel has responded with defensive systems like Iron Dome and is developing systems to deal with larger and longer-range rockets like David's Sling and improved versions of the Arrow. It has also steadily improved its IS&R capability and tactics and training to use air strikes and land raids to attack launch sites and missile storage facilities.

As **Figure 16 Part One and Figure 16 Part 2** show, however, Israel has not been able to suppress the threat from Gaza. In spite of a massive air campaign and a land invasion, the IDF estimated that in 2014, the Palestinians had fired over 3,000 out of 10,000 rockets they held before the fighting started, the IDF had destroyed a total of roughly 3,000-4,000 rockets in combat, and 3,000-4,000 remained, Moreover, the Palestinians had been steadily able to improve the range and payload of their rockets with outside aid during 2008-2014.

The end result is that Iran has the ability to put pressure on Israel from two fronts without taking direct responsibility for its actions or a high risk of retaliation, and transfer a relatively low-cost threat that forces Israel to purchase far more expensive missile defenses – with exchange ratios where Israeli's defensive missiles are far more costly than the systems held by Hamas and Hezbollah.

Iran and Syria have been even more successful in transferring rockets and guided missiles to the Hezbollah in Lebanon. The Hezbollah claimed to have an inventory of 33,000 by 2006, and the Hezbollah fired some 3,970 rockets into Israel from southern Lebanon, killing 44 Israeli civilians and 118 soldiers.[104]

There are many competing estimates of more current Hezbollah holdings of short to medium range rocket and missile holdings like the Qassam-1/2/3, al-Quds 1/2/3, Saraya 1/2, and Yasir 1 – which are supplemented in short-range attacks by its holdings of 120mm, 82mm, and 60mm mortars.[105]

In 2013, Hezbollah's holdings were estimated to include at least 60,000 to 80,000 rockets, including increasingly capable short-range ballistic missile systems that gave Hezbollah the ability to launch from well north of its traditional South Lebanon area of responsibility.[106] Meanwhile, US experts felt the Hezbollah had some 33,000 rockets and missiles as of July 2014. Israel's official estimate was some 40,000 largely short-range systems – and some Israeli experts put the total at 100,000. Other sources like Iran Tracker put the total at 40,000 to 50,000.[107]

Virtually all sources agree that the Hezbollah has significant holdings of rockets and missiles like the Zelzal 2 (Range of 100-300 kilometers, 600 kilogram warhead, solid fuel), possibly some Scud missiles, and 12 or more anti-ship guided missiles. There are also what seem to be reliable reports that Iran has transferred longer- range versions of the Zelzal, and Syrian M600, with GPS guidance to the Hezbollah, which would greatly increase Hezbollah capability to carry out lethal strikes against targets in Israel.[108]

The Israeli INSS provides a December 2013 estimate that does not show numbers in its on-line military balance data for Lebanon, but credits the Hezbollah with holdings of 122 BM-21 MRL rockets, 220 mm Syrian made MRL rockets, 240mm Fadjr-3,rockets, 302mm Khaibar Syrian made rockets, 333mm Falaq rockets, and 333mm Fadjr-5 rockets (possibly under IRGC control). It also reports Hezbollah holdings of M600 / Fatah-110, 610mm Zelzal-2, and Scud B ballistic missiles, all possibly under IRGC control.[109] There are no reliable estimates of which systems have been transferred by Iran and which by Syria.

While such claims are exaggerated, Brig-Gen. Amir Ali Hajizadeh – the Commander of the IRGC's Aerospace Force – said in an interview in September 2014 that, "Based on our information, Hezbollah's power has so much increased in recent years that they can attack any target in any part of the occupied territories with a high precision capability and with a very low margin of error…(Hezbollah) Based on our information, Hezbollah's power has so much increased in recent years that they can attack any target in any part of the occupied territories with a high precision capability and with a very low margin of error."[110]

***Figure 16: An Initial Assessment of "Operation Protective Edge": Going beyond Air Power & Iron Dome's in 2014 – Part One***

## Trends in the Rocket Wars in the Gaza

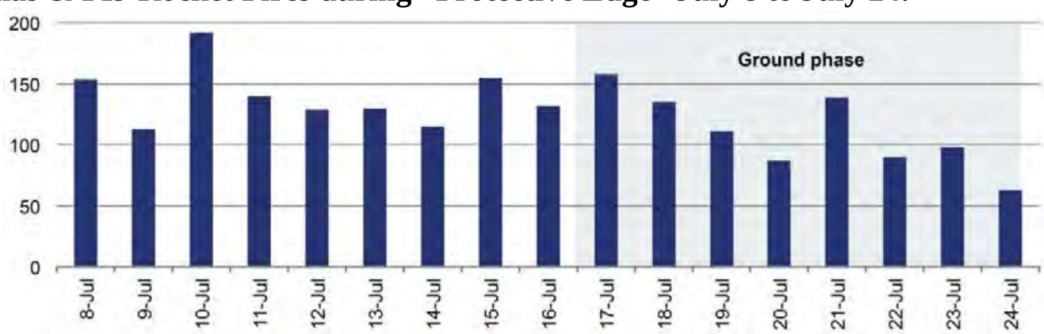
**Year Duration Rockets Fired Cumulative Deaths**
**Day 1 Last Day 1 Last Day**
**Israelis Palestinians Israelis Palestinians**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2008 | 23 Days | 105 | 916 | 1 | 341 | 13 | 1,369 |
| 2012 | 8 Days | 50 | 845 | 0 | 6 | 5 | 167 |
| 2014 | 24 days* | 156 | 2,719 | 0 | 19 | 64 | 1,408 |

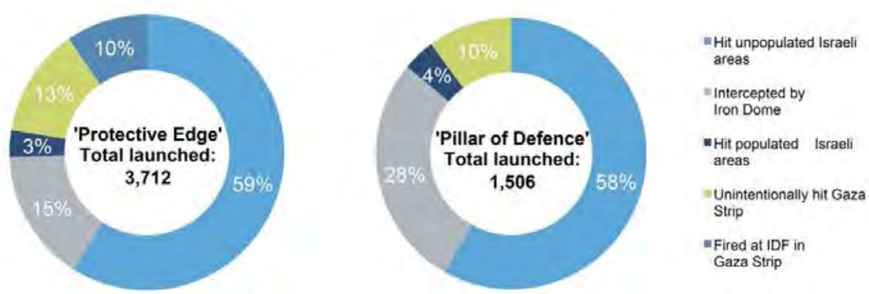
* Duration before an uncertain ceasefire on July 31, 2014, and before some further exchanges. The IDF now talks about a 50 day war.

Source: Jeremy Ashkenas, Archies Tse, and Karen Yourish, "In Gaza, a Pattern of Conflict," *New York Times*, July 31, 2014, http://www.nytimes.com/interactive/2014/07/31/world/middleeast/in-gaza-a-pattern-of-conflict.html. The *Times*' data sources were B'tselem, Israel Defense Forces, Israel Ministry of Foreign Affairs, Israel Security Agency, Palestinian Ministry of Health. Israeli deaths and rocket attacks for 2008-9 and 2012 conflicts were based on archived press releases that were published by the Israeli government. Rocket data for the 2008-9 and 2014 conflicts are total rockets launched from Gaza to Israel. Rocket data for 2012 includes only rockets that hit Israel. Palestinian deaths for 2014 are based on the daily reports from the Palestinian Ministry of Health.

## Hamas & PIJ Rocket Fires during "Protective Edge" July 8 to July 24:




## An Initial Comparison of Rocket Fire in 2012 and 2014:

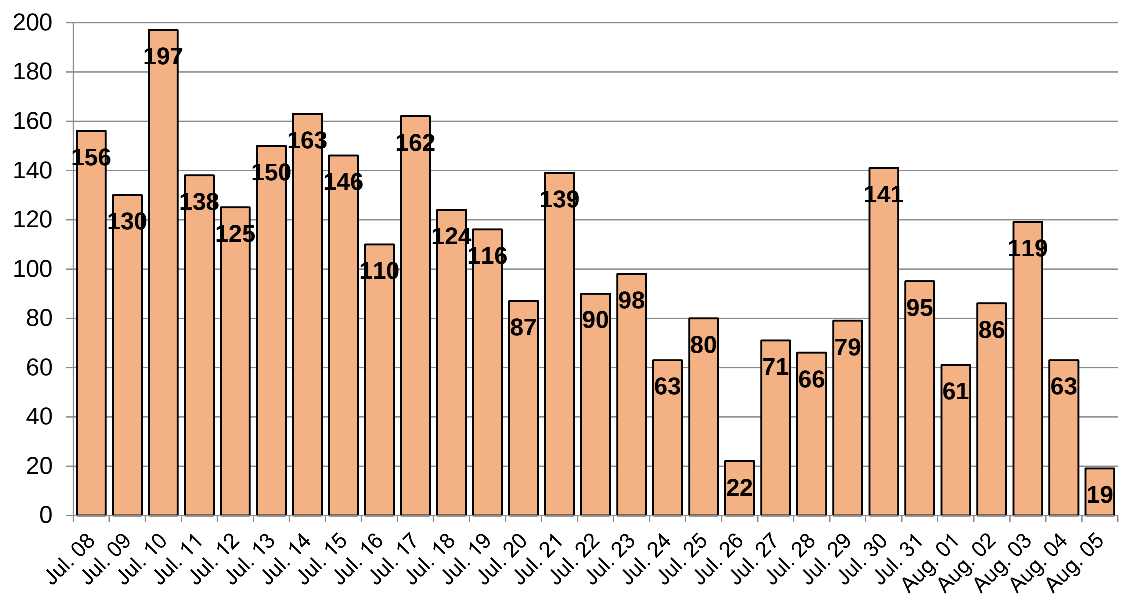



Note: "PIJ" stands for Palestinian Islamic Jihad. All data for 2014 was preliminary in light of ongoing conflict as of August 16, 2014. Some variation in final numbers across sources is to be expected.

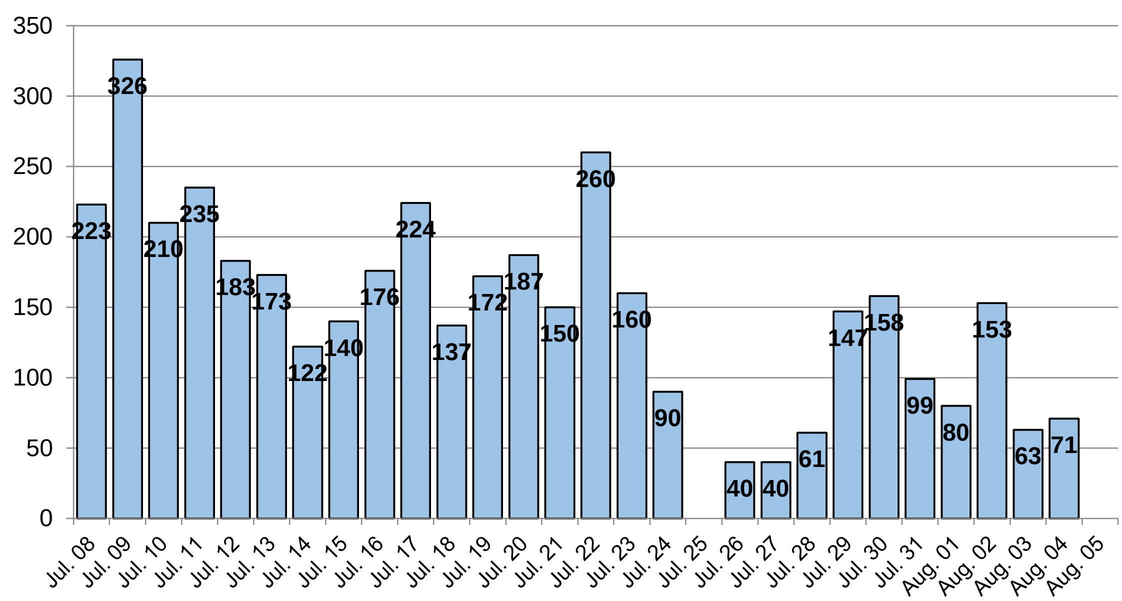
Source: Adapted by Aram Nerguizian from data provided to IHS *Jane's*; see Jeremy Binnie, "IDF detail the damage inflicted on Gaza militants," *Jane's Defense Weekly*, August 7, 2014.

***Figure 16: An Initial Assessment of "Operation Protective Edge": Palestinian Rocket Fire and IDF Strike Rates in 2014 – Part II***

**Palestinian Rocket Fires against Israel July 8 to August 5:**




**Israeli Military Air and Artillery Strikes in Gaza July 8 to August 5:**




Note: data presented reflects Israel Defense Forces estimates.

Source: Adapted by Aram Nerguizian from data provided in Karen Yourish & Josh Keller, "The Toll in Gaza and Israel, Day by Day," *New York Times*, August 8, 2014.

# IV. Iran's Shorter Range Missiles

Iran's development of short-range ballistic missiles (SRBMs) was originally driven by its need to match Iraq's missile capabilities during the Iran-Iraq War, but has since has served several purposes. Iran's research served a dual purpose. The research, production, maintenance, and upgrading of the shorter range weapons that Iran had acquired from abroad helped Iran to build its knowledge of the critical components of ballistic missiles, underpinning its research on longer-range ballistic missiles. Without the experience garnered through these r systems, Iranian scientists would have faced severe challenges constructing medium two-stage missiles as the Sejjil-2.

Iran's current shorter-range missiles are notably less lethal, versatile, and effective than US and Arab Gulf strike aircraft. They have limited individual lethality, accuracy, and range. However, they allow Iran to strike at area targets without exposing its aircraft to air-to-air combat or surface-to-air missiles, and dispersed launchers/fire units or groups of launchers/fire units are hard to target and attack.

Like Iran's artillery rockets, however, Iran's shorter-range missiles serve an immediate purpose in Iran's conventional military strategy. Their relatively short range and imprecise targeting can be partially compensated for by firing salvos or volleys. In the event of a ground war, they can supplement Iran's artillery holdings, with the mobile missiles hidden and used for hit-and-run strikes.

They also serve as deterrent weapons and weapons of intimidation. Missile strikes that hit sensitive areas can have a major political, psychological, and disruptive effect even if they produce little or no damage. Coupled to "stacked threats" of multiple systems, they can also be used to force missile defenses to exhaust their interceptor missiles or penetrate through missile defenses – particularly missile defenses that only provide point defense of sensitive areas.

Finally, if Iran's short-range missile force can be successfully upgraded to the point where its missiles are accurate and reliable enough to attack fixed-point targets with conventional warhead and/or Iran has enough nuclear warheads to deploy on shorter-range systems, it will improve radically in military capability, lethality, and the ability to intimidate and deter. Some of these advantages will occur even if the system does not really have the necessary accuracy and reliability. Iran can potentially gain an advantage simply by claiming such capability, reporting a few successful tests, or providing false media reports and data. Neighboring states must then decide how accurate any contrary intelligence may be and how many risks to take.

Improving missile lethality also tends to reverse the missile and air defense cost equation. Less accurate systems do not pose enough of a threat for missile defense systems to engage unless the missile is clearly headed towards a key target area. A more accurate missile will require missile defenses to engage with every strike, and advanced interceptors generally are very expensive and more costly than shorter-range surface-to-surface missiles. The defending state must also maintain both land-based missile and air defenses, and de-conflict them with its air defense aircraft to avoid attacking its airborne air defense assets.

At the same time, there is a major inherent risk in such a force posture. Its success depends heavily on relative perceived value and risk in Iran versus its neighbors and the US. If Iran's opponent continue to have more lethal air, ballistic, and cruise missile attack capabilities – and superior air and missile defenses – Iran can easily become trapped in an "escalation contest" it cannot win. It

can also see a limited conflict escalate in ways it has never intended, and trigger a process of counter-value or strategic attacks on Iran that could do immense damage even with precision guided- conventional weapons.

There are two critical problems in any "escalation contest" that occur almost regardless of its nature, and are easy to ignore in simple scenario models and game theory. The first is that threats become actions, or actions become steadily more serious in ways that were never intended and the "law of untended consequences" comes to dominate both the fighting and the outcome of a conflict. The second is the real-world ease with which a conflict can climb the escalation ladder, and turn an initial tactical gain into a serious strategic loss or liability.

## *Iranian Statements about its Shorter Range Missile Programs*

Despite the similarities to the U.S. military, very little has emerged in terms of the decision making processes of the IRGC. In fact, of the few things that are known include the Commanding Officers, and what they head.

All of Iran's ballistic missiles, for example, seem to be under the command of the Aerospace Force of its Islamic IRGC. This force operates in parallel with the Iranian Air Force and has its own light combat aircraft, transports, and helicopters. US experts feel it not only operates Iran's ballistic missiles, but plays a critical role in their development, test and evaluation, and production; and in the development of both improved conventional warheads and any nuclear warhead designs.[111]

Its officers, along with other Iranian officials and spokesmen, clearly understand the propaganda value of Iran's missile programs, and the value of publicizing and exaggerating their capabilities. They have often announced technical progress that almost certainly did not exist, created deliberate confusion over the different types of missiles Iran deploys, exaggerated or faked test results, and implied a willingness to escalate and take risks that is almost certainly design to enhance deterrent and intimidation effects rather than reflect Iran's real world risk assessments and caution.

This makes it difficult to interpret Iranian statements, and tie them to any real world plans and doctrine. As is discussed later in this analysis, Iran has also cut back on some of its public statements about actual tests and exercise in recent years. This may be explained by (a) a growing emphasis on secrecy, (b) the desired to be less provocative at a time the P5+1 negotiations are underway over nuclear weapons and which also address missile capabilities and warheads, (c) a desire to be less provocative in stimulating an Arab and US response in terms of airpower, missiles, and missile defenses, (d) real-world problems in creating more advanced missiles, and (e) all or some of the above.

Iranian officers and officials have not placed as much public emphasis on Iran's short-range missile forces as on its longer-range forces, but they do provide comments that provide some insights:

- "We did not send any weapons into Gaza, but declare with pride and dignity that we did provide the technology to produce Fajr-5 missiles, and now they have built a large number of missiles that are in their possession. We never hesitate to transfer knowledge and technology to all oppressed Muslims." - Major General Mohammad Ali Jafari, Commander of the Islamic Revolution Guards Corps, November, 21, 2012. http://www.irandailybrief.com/2012/11/28/revolutionary-guards-commander-iran-did-not-send-weapons-into-gaza-but-provided-the-technology-for-the-production-of-fajr-5-rockets-to-the-palestinian-authority/
- "We can simultaneously fire numerous and countless missiles from different spots at one or several targets, which indicates our capability to perform convergent and parallel operations." - Brigadier General Hossein

Salami, Lieutenant Commander of the Islamic Revolution Guards Corps, September 7, 2012. http://english.farsnews.com/newstext.php?nn=9106242598

- The fourth generation of the Fateh 110 missile, with a range of more than 300 kilometers, was successfully tested by the Aerospace Organization of the Defense Ministry...[the missile can target] enemy deployment areas, command centers, missile sites, ammunition depots, radar and other targets with 100% precision." - General Ahmad Vahidi, Iranian Defense Minister, August 7, 2012. http://www.irandailybrief.com/2012/08/07/dm-new-generation-of-fateh-110-can-destroy-enemy-concentration-points-command-centers-missile-sites-ammunition-depots/
- "In our strategic planning, we have set out a radius we call the preventive/deterrent radius that covers all the strategic interests of the enemy in the region, and we will therefore be able to control the arena of conflict at any level. The IRGC navy's cruise missiles have the highest capabilities in terms of accuracy, range, and radar evasion, and these are missiles that can be fired at different ranges and from different launchers with great precision." - Hussein Salami, Acting Commander of the IRGC, June 25, 2012. http://www.irandailybrief.com/2012/06/25/interview-with-hussein-salami-in-honor-of-irgc-day/
- "Our missiles have tactically offensive and strategically deterrent and defensive features… Our fingers are still kept on the trigger, but the number of these triggers has increased." - Brigadier General Hossein Salami, Lieutenant Commander of the IRGC, June 28, 2011. http://english.farsnews.com/newstext.php?nn=9004074141
- "As the enemy's threats will likely come from the sea, air, and by missiles, the Revolutionary Guard has been equipped to neutralize the enemy's advanced technology." - Mohammed Ali Jafari, commander of the IRGC on a new anti-ship ballistic missile that Iran has allegedly developed, February 7, 2011. http://www.google.com/hostednews/afp/article/ALeqM5hfIrLpGsCvEg1YS5ANA8bTP939NA?docId=CNG.30a945d880fb0c467a82e584423dac3f.281
- "The operational capabilities of the missile unit of the IRGC Aerospace Force will be remarkably enhanced." - Iranian Minister of Defense Ahmad Vahidi regarding the new indigenously produced Fateh-110 ballistic missile, September 21, 2010. http://www.dsrc.ir/En/news/view.aspx?nid=4636

Some Iranian statements are exaggerated, but even these statements show that Iran views its ballistic missiles as a critical component of its national defense, and stresses that an effective ballistic missile program provides the country with increased strategic and asymmetric capabilities. Iranian officials regularly refer to their conventionally armed missile forces as an effective deterrent to attack, and the Iranian leadership is not shy about its country's advancements concerning ballistic missile technology. High-ranking officials in Iran's political and military establishments regularly boast of their country's progress in this field.

## *Key Aspects of the Short Range Missile Force*

A RAND analysis issued in 2012 summarized the threat posed by Iran's missile systems and the broad improvements Iran was likely to seek in the near future, in ways that are still applicable today:

> Iran's short- and intermediate-range conventional ballistic missiles confront the United States and its allies with the threat of retaliatory strikes against key regional targets in the event of a conflict. However, given the relatively limited capabilities of Iran's conventional missile program, particularly the relative inaccuracy of the SCUD-based models, and even the Shahab-3 and its variants, these systems are likely to play two operational roles. First, these missiles may be launched against large U.S. bases—including Ali Al Salem in Kuwait, Al-Udeid in Qatar, AL-Dhafra in the UAE, and perhaps Incirlik in Turkey—in order to disrupt U.S. air operations….Additionally, Iran's missiles may be utilized in a punitive counter-value campaign against population centers in the region, and perhaps oil production infrastructure in Saudi Arabia and the Gulf States, to intimidate opposing regimes and perhaps limit cooperation with U.S. forces.

> …The limited technical capabilities of the Iranian missile systems, particularly their relative inaccuracy and reliance on primitive conventional warheads, are unlikely to provide Iran with a capacity to execute a highly coordinated first-strike against high-value U.S. and allied military targets in the region…While a preventive or preemptive missile strike launched in the midst of an intense diplomatic crisis cannot be ruled out, the inherent technical limitations of these missiles undermine their military effectiveness and would seem to make their employment as anything other than retaliatory weapons improbable.
>
> U.S. forward bases and installations will be at far greater risk of damage or destruction from nuclear-armed, intermediate-range missiles. However, without a significant enhancement of Iranian air defense capabilities, fighter aircraft, or both, the United States would still be expected to achieve air superiority in a conflict and able to strike high-value targets, including Iranian missile forces, even if responding from European bases or U.S. aircraft carriers.[112]

The most significant elements of Iran's current short-range ballistic missile forces seem to consist of the following systems: Fateh-110C single stage, solid propellant rocket with a 250-275 km range; Fateh-110 SRBMs with a 280-300 km range, and variants in development with a range greater than 500 kms; Zelzal-3B SRBM with a 250-260 km range; Zelzal-3 SRBM with a 200 km range, including guided versions that integrate satellite navigation with accuracy of less than 20 meters;

Iran's more capable short range missiles include the Shahab 1 liquid propelled SRBM with a 300 km range; Shahab 2 liquid propelled SRBM with a 500 km range, with possible development of system upgrades; and Qiam-1 liquid propelled SRBM with a 750 km range and separating payload. They will evidently include the Badr-313 solid propellant SRBM with a 475 km range (based on the Fateh-110), due for field deployment in 2015

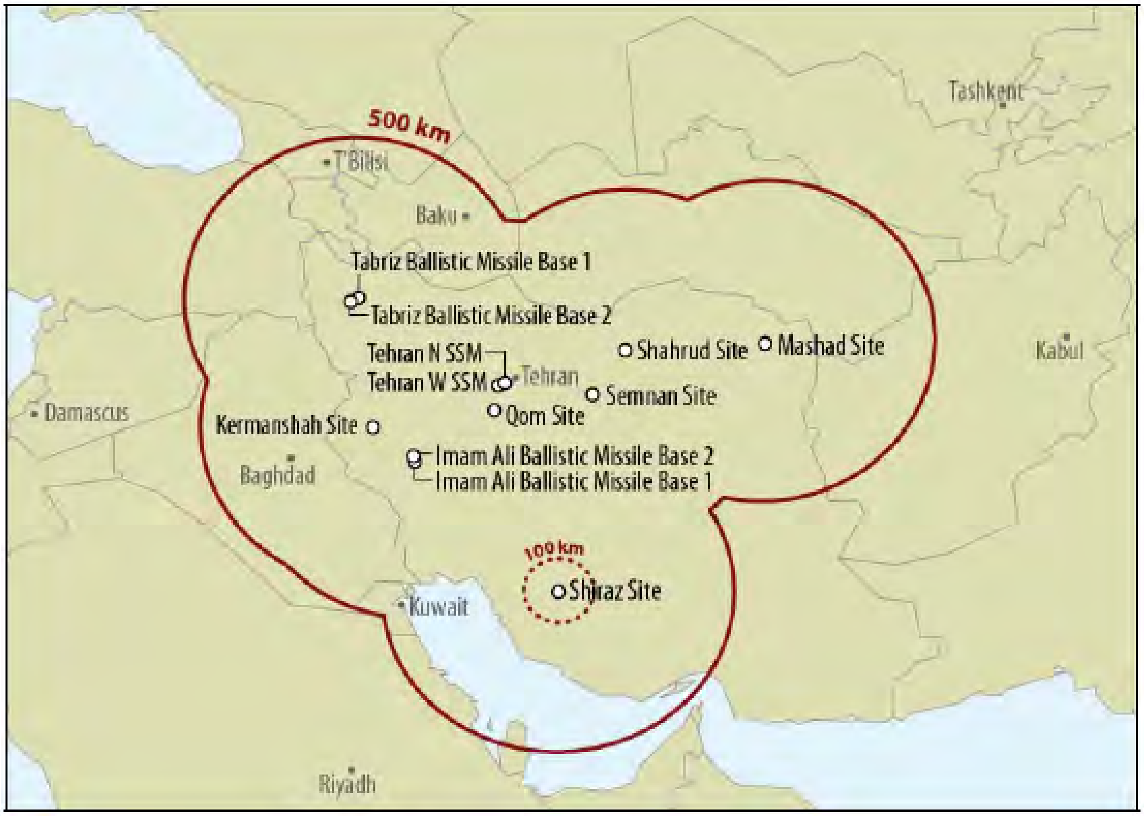
Work by Steven A. Hildreth warns that, "A precise, public accounting of Iran's SRBM force is not available. Official U.S. sources often cite the figure of "hundreds of SRBMs" with perhaps 50-100 launchers (a launcher can be reused to fire additional missiles). There is no further breakdown of these numbers.[113] Hildreth also provides a rough map of the location of these forces that is shown in **Figure 17**, and states that, [114]

> Other good public sources cite figures of perhaps 200-300 Shahab-1 and Shahab-2 SRBMs (with as few as 18-20 launchers or up to around 50 launchers). ..These latter sources cite additional, different named SRBMs in Iran's inventory, which this report does not attempt to deconflict. This section provides a brief overview of Iran's SRBM missiles and programs.
>
> Finally, imagery obtained through the Library of Congress shows what appear to be a number of short-range missile bunkers in western Iran around Kermanshah and what a SRBM missile base might look like.

According to other US experts, there are good estimates of some parts of Iran's missile force. For instance, at the Al Ghadir Missile Command of the IRGC Aerospace Force, the IRGC maintains the following SRBMs, in approximate quantities: 175 CSS-8; 500 Fateh-110; 600 Shahab 1 and 2; and 175 Qiam-1.

Iran has also shown that its shorter-range rockets and missiles can be valuable as exports to proxies as its artillery rockets. As is discussed later, reports indicate that Iran has supplied them to Syria and the Hezbollah. The range limitations of such weapons become far less important once they are deployed in the Levant. Zelzals and Fateh-110s are able to reach Tel Aviv and Jerusalem from Lebanon. Such exports not only serve to distract Israel and provide Iran with credibility on the Arab street, but also further Hezbollah's and other allies' dependence on Iran.

***Figure 17: Iranian SRBM Sites and Ranges***




Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service, December 6, 2012, 16.

## The Performance of Individual Shorter Range Missiles

For all the uncertainties in the data, Iran's older shorter-range missile systems are among the best-understood elements of the Iranian ballistic stockpile. Many of these missiles are based on systems that saw service in the Iran-Iraq War, and many have been repeatedly fired and tested since then. What is not clear is how far Iran has gone in upgrading their performance (given its tendency to exaggerate all of its weapons performance claims) and how many missiles and rockets of each type it actually has.

Recent unclassified reporting does, however, still provide a considerable amount of detail on Iran's short-range missile systems, and indicate what Iran's goals may be in their updates.

### *Zelzal (Earthquake)*

The Zelzal program is not an SRBM program in the classic sense. As the previous chapter has shown, the Zelzals began as artillery rockets like the Nazeat and other Iranian short-range solid-fuel artillery programs during the Iran-Iraq war. These weapons, for the most part, were limited to less than 100 km, with only the Nazeat going 150 km (at the cost of 90 kg warhead). The Zelzal artillery rockets seem to be designed limited North Korean Chinese support.

Describing the system is difficult because the Zelzal name has been surfaced in at least three distinct iterations – most of which are artillery rockets and not short-range ballistic missiles. They also had improvements in accuracy that did not involve on-board guidance. According to various

reports, some later Zelzal artillery rockets were spin-stabilized, with external rockets firing shortly after launch to reduce deviations in accuracy. Unclassified sources provide a wide range of different data on each variant.

Typical descriptions of the Zelzal class missiles are summarized below:

- The Zelzal 1 is a solid fueled-artillery rocket that seems to be a modification of the old Russian FROG artillery rocket, and has a range of 100-160 KM and a 500-600 kilogram (1,200 pound) warhead.[115] Its CEP is no better that 0.5 to 1 kilometer depending on range. The original system was designed primarily to carry a nuclear warhead. Reports of chemical and cluster warheads are not confirmed.

- The Zelzal 2 is a somewhat longer-range, and has a maximum range of 300 KM. It too seems to have a 600-kilogram (1,200 pound) warhead.[116] Its CEP too is no better that 0.5 to 1 kilometer depending on range. The original system was designed primarily to carry a nuclear warhead. Reports of chemical and cluster warheads are not confirmed.

- The Zelzal 3 is sometimes used as a name for the Shahab 3, which is a much longer range MRBM based on the North Korean No Dong. If the Zelzal 3 is actually deployed as a fully functioning system SRBM, it is an extended range version of the basic Zelzal design with a range of 150-400 kilometers. According to *Missile Threat*, the Zelzal-3 capable of reaching 400 km only with additional propellant strapped on (an as-yet unconfirmed capability). Its CEP is estimated to be several kilometers; although Iran has made claims that indicate it has some form of GPS guidance and the CEP of its newest upgrade could have been cut to 50-100 meters. The Zelzal-3B battlefield rocket has also been converted to a SRBM by adding a guidance, navigation, and control section, similar to that of the Fateh-110.

Since the shorter-range version of the Zelzal has been in production roughly since 1998, some sources assume that Iran has built hundreds of Zelzals, but there are no credible estimates in the public domain. Given the large number extant and their relative cheapness, Iran has reportedly attempted to improve their accuracy.

The IRGC has claimed, however, that it had developed a strap-on guidance kit that reduces the CEP to 50 m, which – if actually enough--makes the system a viable military precision option.[117] So far, there has been no independent confirmation of this increase in ability, and given Iran's tendency to issue exaggerated public pronouncements, it is unlikely Iran has so dramatically increased the Zelzal's precision. But gradual improvements in accuracy have led some, such as former Israel Defense Minister Ehud Barak, to believe that Iran will eventually have missiles accurate enough change the strategic picture. Barak stated that he believed Hezbollah and Hamas, who receive Iranian rockets, would eventually have missiles that would be accurate enough to target individual buildings. He added that the third generation of the Zelzal rocket contained "a homing sensor and a GPS. The Syrians can have this capability, too, to create a fully guided M-600 rocket with a GPS."[118]

Zelzals are reported to carry a 600 kg warhead. According to Missile Threat, their ranges are estimated at 125 km, 200 km, and 150-400 km, respectively, with the Zelzal-3 capable of reaching 400 km only with additional propellant strapped on (an as-yet unconfirmed capability). Its CEP is estimated to be several kilometers; although Iran's newest upgrade may have cut it to 50-100 m. A Zelzal with a cluster warhead containing 30 17kg submunitions was unveiled at an IRGC-ASF exhibition in May 2014.[119]

It should be noted that all estimates of artillery rockets and missile CEPs are based on the theoretical accuracy of the rocket or the missile guidance platform and not any tests of actual missile performance under operational conditions. By definition, CEP also only applies to where 50% of the systems fired land - with no estimate of the distribution of where the strikes the strikes

from the other 50% of the other missiles fired. It only applies to a missile or rocket that functions perfectly from launch-to flight-to impact, with perfect launch coordinates, set up, and operation, and with perfectly located targets.

### *Fateh-110 (Conqueror)*

Iran's basic Fateh-110 missile was developed as an improved version of the Zelzal, with additional guidance from an onboard set of gyroscopes. Instead of relying on spin-stabilization, the Fateh-110 used a set of instruments and fins to maintain a preprogrammed angle during the launch phase. While not a true precision system - the missile still is subject to uncorrected changes of direction during unpowered flight - it does provide a more precise weapon.

Iran seems to have had Chinese support in designing and producing the system. Missile threat reports that, "In 2006 the US Department of the Treasury accused Great Wall Industry, a Chinese Corporation and its partners for playing a lead role in the development of the Fateh missile system."

Unfortunately, little is known about the operational accuracy and deployed numbers of this system. The system is believed to have entered full-scale production in 2004, with several hundred emplaced on mobile launchers. It is believed to have entered test production in 2002, full production in 2004, and gone through at least two modifications, with newer varieties using inertial guidance and capable of carrying slightly larger warheads over marginally longer distances. At least 10 tests have been reported, but no details are available, and most to have been from fixed sites and conducted unit by technical teams rather than under operational conditions, but some video coverage exists of tests using TEL launchers.

Estimates place the range of Fateh 110 variants at between 200 and 400 km - with the third generation the longest-ranged of the three - and a warhead payload of around 500 kg for all variants. Some sources report chemical and cluster warheads, and some form of cluster warhead option seems to exist. [120] Iran reported the development of an improved system in 2010, and made claims that implied it might have electro-optical terminal or GPS guidance. This is unconfirmed. The newest guidance system is reported to give it a CEP of 100-300 meters. Experts believe the system is significantly less accurate in reality.

Hildreth provides the following estimate: [121]

> The Fateh-110 is a solid-fuel, road-mobile battlefield or tactical ballistic missile with a range of about 200 km. Its development probably started around 1995 and its first test flight reported in 2001. There may be three versions of the Fateh-110 in service; one is apparently called the Khalij-Fars….An upgraded version of the Fateh-110 reportedly was tested in early August 2012. Iran claimed it was the fourth generation of the Fateh, and equipped with a new guidance system capable of striking targets up to 300 km away with high accuracy.63 Experts such as Elleman find the Iranian assertion dubious; the missile has a maximum range of only 200-250 km, and claims of high accuracy are questionable.

The IRGC also provided a display of a new submunition warhead on what may have been a Fateh-110, but Jane's reports that the missile was labeled as the Zelzal Barshi. The Zelzal heavy rocket was the original artillery rocket that was developed into the Fateh-110 by adding a guidance unit with canards between its warhead and motor. 'Barshi' is the Persian word for rain and is used by the IRGC to describe cluster munitions. The display was also interesting because it may have later led to Iranian claims that it had MIRV'd missiles which are described in later chapters. The display includes a cross section which showed 30 submunitions with pointed noses and cylindrical bodies

and that the Fars News Agency stated each bomblets, weighed 17 kg (collectively weighing 510 kg).[122]

Jane's also reported that, "The IRGC created more confusion by labeling a smaller-diameter missile with guidance canards like those on the Fateh-110 as a Fajr-5: the name of Iran's 333 mm unguided rocket. This raises the possibility that Iran is developing a guided version of the Fajr-5 as it did with the Zelzal. The missile would be rail launched as the canards do not retract to fit inside the tube used with the unguided version."[123]

### *Hormuz-1 and Hormuz-2*

Iran did announce that it was developing two new versions of the Fateh-110 on February 10, 2014. These may have improved guidance and possibly GPS guidance. The details, however, are unclear. [124] The Hormuz 1 and Hormuz 2 were unveiled at a May 2014 IRGC-ASF exhibition that highlighted the IRGC-ASF's technological achievements.

The Hormuz-1 has been reported as having an anti-radiation capability to attack radars. IHS-Jane's has reported that the commander of the IRGC Aerospace Force, Brigadier General Amir Ali Hajizadeh, stated in announcing the new system that the Hormuz-1 was an anti-radiation variant and Iranian the television broadcast a segment showing the Supreme Leader watching a video of a test in which a missile destroyed a target with a radar antenna, which Brigadier General Amir Ali Hajizadeh that stated that, "The missile destroyed a 20 ft. [6 m] container at a distance of 300 km during test fire." Iran had previously claimed that it had deployed anti-ship version of the Fateh-110 called the Khalij Fars, but this uses electro-optical/infrared (EO/IR) terminal guidance.[125]

Hajizadeh also stated that the Hormuz-2 was an anti-ship missile, but Jane's indicates that photos showed that it too had, "what appeared to be a radio frequency-transparent radome and not a window on its nose for EO/IR guidance. This raises the possibility that it uses active or passive radar terminal guidance. The latter is more likely as the missile would be less vulnerable to electronic countermeasures, but that would make it essentially the same as the Hormuz-1."[126]

Little to no information about the Hormuz 1 and Hormuz 2 has been released since the May IRGC-ASF exhibition.

### *Khalij Fars (and Guided Ballistic Missiles)*

Iran claims that it has developed a modification of the Fateh-110 called the Khalij Fars, and developed a long-range, passive radar covering a 1,100km-radius. It says this missile has a speed of Mach 3, a range of up to 300 kilometers, a 650 kilogram explosive warhead, missile defense countermeasures, and an anti-ship homing warhead.[127] The distinguishing feature of the Khalij Fars is the electro-optical seeker on the tip of the missile. The Khalij Fars is reported to have entered service in early 2011, although Iran claims it was finished in 2008. It is also reported to have a CEP in the hundreds of meters, although the CEP accuracy of the guidance platform is not a reliable or meaningful indication of actual missile performance.[128] [129] The Iranians claim that they had improved accuracy to a "maximum margin of error of 8.5 meters" in 2013.[130] In a March 2014 ceremony, the missile was officially delivered to the military. The US Department of Defense mentioned that anti-ship ballistic missiles were being quietly fielded, the first corroboration of Iranian claims that the missile was in service.[131]

### *Shahab-1 (Meteor 1)*

The Shahab-1 is the Iranian version of the SCUD-B missile, a weapon designed by the Soviet Union in the 1960s and later exported to over 20 countries. It was used by Iran and Iraq in the War of the Cities during the Iran-Iraq War, and was used to target Coalition bases and Israeli cities during the first Persian Gulf War. Designed as a tactical nuclear missile, it has since become the most widely copied ballistic missile, with its ease of construction and launch making up for deficiencies in accuracy.

There is broad agreement on some details of the system's performance. According to a Joint Threat Analysis produced by Dr. Postol, with a 1000 kg warhead the Shahab-1 has a range of approximately 315 km. This agrees with the Federation of America Scientists' (FAS)[132] assessment that its range is 285 to 330 km, similar to the US Department of Defenses' estimate of 185 mi (300 km). Both Missile Threat [133] and FAS give the Shahab-1 a CEP[134] of 450 m; IISS gives 450 as its best-case number, but suggests 1000 m is more likely.[135] The system is liquid-fueled, and requires approximately one hour to fuel and to prepare for launch (and can only be kept in a launch-ready state for a limited period of time).

Experience from the Gulf War and other conflicts demonstrate that these missiles are far too inaccurate to be used to hit point targets. The roughly 90 SCUD-Bs fired by Iraq caused approximately 30 direct casualties, most of which were caused by the missile strike on the US base at Dhahran. While terror-induced strokes and heart attacks increased the total, barring considerable luck or improvements in accuracy, this weapon armed with a conventional warhead has limited military utility. Even a best case scenario could require several hundred Shahab-1 strikes to hit a single point target with lethal accuracy.

Iran's force numbers are uncertain. According to a 1995 Jane's Intelligence Review - *Special* Report No. 6 Iran had 15 transport-erector-launchers (TEL) and 250-300 Shahab-1 missiles, along with the capacity to manufacture more. It is not clear how the force has evolved over time. Assertions that Iran can manufacture all the components of Shahab-1 engines are disputed by IISS in a recent briefing, which agrees that Iran only possesses approximately 200-300 Shahab-1.[136] The UN Panel of Experts on Iran Sanctions supports either interpretation, stating:

> "With assistance from the Democratic People's Republic of Korea, Iran has likely established Shahab missile assembly facilities, which can produce these missiles using imported components.
>
> Iran claims that it produces Shahab 1 and 2 missiles indigenously, for both domestic use and export. Its production of the Shahab 3 however requires some imported components including guidance systems, liquid-propellant engines and telemetry equipment. Experts also note that the performance of the Shahab 1, for example, mirrors closely its Soviet-era Scud counterpart, indicating that it may continue to rely upon imported engines and critical components. Iran currently is not said to possess a fully indigenous liquid-propellant engine production line."[137]

It is interesting to note that Iran fired a Shahab 1 from a ship in the Caspian in 1988 - presenting the possibility it could use a ship like a freighter or tanker to fire such a system from a distance off the coast of Israel or the US.[138]

### *Shahab-2*

The Shahab-2 is the Iranian designation for Iran's version of the SCUD-C. The SCUD-C was developed by the Soviet Union as a longer-range version of SCUD-B, using more fuel, a more efficient design, and potentially a smaller warhead. Widely exported, like the SCUD-B it was allegedly obtained by Iran from North Korea, and is liquid fueled and road-mobile.

There is much less agreement on the exact nature performance of this system than on the Shahab-1/Scud-B, and much of the data that exists are based on a nominal warhead rather than an actual payload. According to Dr. Postol's analysis, the Shahab-2, armed with a 1000 kg warhead, has a range of approximately 375 km, while the 2010 DOD report gives 310 mi (500 km) and FAS and Missile Threat estimates 500-700 km. Dr. Elleman from IISS suggests that its range is 500 km when armed with a 730 kg warhead. Appraisals of the Shahab-2's accuracy diverge by an order of magnitude, with FAS estimating the CEP at 50 meters and Shifrinson and Priebe citing 700 m.[139]

The number of active Shahab-2 missiles and TELs is unclear and estimates vary widely. FAS states that Iran's total Shahab-1 and 2 holdings are between 200 and 450 missiles (which, given FAS estimates for Shahab-1 holdings, leaves Iran with between 0 and 200 Shahab-2),[140] with a March 2006 Air Force report placing the aggregate number of TELs at under 100. Missile Threat states that Iran purchased between 150 and 200 SCUD-Cs from North Korea by 1994; after testing and possible reverse engineering, it suggests Iran has between 300 and 400 Shahab-1 and 2 today.[141] The latest Jane's data, from 2013, estimates that Iran has only 50 Shahab 2's.[142]

***Qiam***

Less is known about a system called the Qiam. Hildreth mentions the possibility that Iran has a more modern and finless variant of the Shahab 2 called the Qiam that could be used in multiple vertical or "box" launchers. The Qiam can carry a 650kg payload to a range of 700km, which is similar to the Shahab 2's range and payload.[143] Hildreth notes, however, that,[144]

> The only reported test of this ballistic missile in the media was in August 2010. A UN Report said a Member State "assessed the Qiam to be based on the Shahab-2, with a range between 500 and1,000 kilometers. Some experts have raised questions about the missile's lack of apparent testing…"Missiles are known to require extensive flight testing before they can be fully operational."…The status of the Qiam is unclear. According to a Hezbollah (Lebanese) media source, the Qiam 1 was delivered to the Aerospace Force of the IRGC in late May 2010.61 Iran's Islamic Republic
>
> News Agency quoted Defense Minister BG Vahdi as saying the Qiam is harder to detect than older models and that mass production of the Qiam missile, the country's first missile without stabilizer fins, demonstrates Iran's self-sufficiency in producing various types of missiles. Gen. Vahdi added that the Qiam's design reduces the possibility of being detected by enemy anti-missile systems and the omission of its fins increases the missile's speed enabling it to hit its targets with high precision. According to the same Hezbollah source, IRGC Commander Mohammed Ali Jafari, told reporters earlier in 2010 "these new missiles enjoy supersonic speed and cannot be tracked or intercepted by the enemy."[1]

While the lack of fins is the most distinguishing feature of the Qiam, the Union of Concerned Scientists noted small protrusions on the front of the missile, similar to the guidance antennas of the Chinese DF-2A missile.[145]

> The improved guidance system may rely on ground controls rather than relying on an internal guidance system in the missile. For example, ground radars can track the flight of the missile and a ground station can radio guidance maneuvers to the missile. This could increase the accuracy of the missile during boost phase and allow the active control needed to remove the fins, although it might not be necessary for that. This kind of guidance can be done for short-range missiles since the boost phase remains within the range of the radar, and this is what was done on a number of early, short-range missiles.

Iran began "mass production" of the Qiam in May 2011 and delivered a first "significant" back to the IRGC-ASF.[146] Later, in March 2014, a ceremony was held "to mark the delivery of Ghadr, Qiam, Fateh-110, and Khalij Fars ballistic missiles to operational units."[147] Defense Minister Hossein Dehghan stated at the ceremony that the Qiam was equipped with "multiple

warheads," which most likely refers to a cluster warhead, not multiple re-entry vehicles. Work on the missile has continued, including the likely testing of new ballistic missile defense countermeasure using booster fragments to complicate the detection of reentry vehicles. Since the booster fragments and the reentry vehicle are released at the same time and travel together in a mixed or cluttered environment, interceptors have a more difficult time with target discrimination. According to recent analysis, the Qiam-1 is a liquid propelled missile with a separating payload. [148] One source estimates that there are an estimated 175 Qiam-1 airframes, and the fielding of upgrades is believed to have taken place for the first time in 2014.

## Military Potential and Effectiveness

Iran's shorter-range missile programs are an integral part of both its conventional and asymmetric strategies. They help compensate for the Islamic Republic's weakness in conventional airpower, and it also gives Iran other forms of war fighting capabilities that greatly complicate US and Gulf Arab missile defenses, and gives Iran a way of arming the Hezbollah and working with Syria in ways that threaten Israel.

At the same time, limitations in range, accuracy, and lethality limit the effectiveness of most of Iran's current SRBMs in conventional combat. Experts believe Iran is at least 5-10 years away from giving broad elements of its SRBM ballistic missiles forces GPS, advanced INS, or other forms of precision guidance.

This means Iran faces serious problems in using its SRBMs to achieve significant lethality with conventional warheads because most of its missiles have older or limited guidance systems that mean the missile lack the reliability, accuracy, and warhead lethality to have a significant probability of attacking high value point targets. Systems that lack reliable and highly accurate levels of operational accuracy – which requires very advanced use of GPS or the most advanced possible inertial navigation systems to produce actual hits with less than a few hundred meters of the target – do not have the warhead lethality to hit and destroy a critical building, facility, or area with even the best fusing and most lethal unitary warhead designs.

Moreover, while Iran's beyond visual range and targeting capability is improving and it can covertly survey GPS coordinates for most targets in the region, it still remains limited. It also seems to only have uncertain, over-the-horizon targeting and damage assessment capabilities to survive in intense combat.

Nevertheless, SRBMs represents a significant deterrent, and give Iran added ability to try to intimidate its neighbors. Strikes in sensitive areas like military bases and facilities, ports and airports, urban areas, and critical infrastructure can have a major disruptive impact even if they produce little critical damage and only limited casualties. They can also use to threaten and disrupt petroleum operations and exports if Iran tried to "close the Gulf" by naval means - small-boat harassment or mine warfare – but striking at ports and key petroleum area facilities, power plants, or desalination plants.

This, and the possibility Iran will deploy far more accurate, effective and reliable SRBMs and longer-range missile forces -- is another reason for the Gulf states to acquire more effective wide area missile defenses and create integrated missile defense capabilities. As Iran's SRBMs and longer-range missile forces become more precise, they will increase the Islamic Republic's ability target all of the critical infrastructure and the war-making capabilities of its Gulf and other regional opponents.

Such developments do, however, seem likely to push both the Gulf States and the US towards wide area missile defense. There already are too many airfields, depots, ports, and staging points for Iran to close them all, and improvements in missile defense will continue to reduce the number of expected surviving missiles.

### *Attacks across the Gulf*

The fact that Iran’s SRBMs have limited range needs to be kept in careful perspective. The Gulf is only 300 km wide at its widest point, and only 50 km wide at the Strait of Hormuz. With maximum ranges in 200-400 km range, the Zelzal and Fateh-110 have limited utility in attacking land target across the Gulf, particularly since the accuracy of such missiles is poor and deteriorates further at long ranges.

To put these ranges in perspective, any system with a range of 200 kilometers can strike from a position on Iran’s Gulf coast at a target on the Southern Gulf coast that is immediately across from it. Iran can, however, widely disperse many of its shorter-range missiles and still fire from sites deliberately chosen to disperse its missiles. Iran’s short-range ballistic missiles (SRBMs) include a number of systems with such ranges: the Naze’at (100–130 km), Zelzal family (Zelzal-1 (150 km), Zelzal-2 (210 km), Zelzal-3 (200–250 km)), Fateh-110 (200–300 km), Shahab-1, Scud B (350 km), Shahab-2, Scud C, Hwasong-6 (750 km), and Qiam 1 (700–800 km).

**Figure 18** shows some typical ranges from city to city that give a rough idea of how broadly Iran’s systems can be dispersed and still used against targets on the Southern Gulf Coast. It should be emphasized, however, that range is only one parameter of performance. As noted earlier, the limited lethality and accuracy of most of Iran’s shorter-range ballistic missiles is a major problem.

### *Figure 18: Distances From Launch sites in Iran to Gulf Targets*

| Location in Iran | Target in Gulf | Range in Kilometers |
|---|---|---|
| Chabahar (Port East of Strait of Hormuz) | Muscat, Oman | 309 |
| | Masira Island, Oman | 590 |
| | Diego Garcia (British Indian Ocean) | 3,779 |
| Bandar-e-Abbas (Port Opposite Strait of Hormuz) | Khasab, Oman | 115 |
| | Dubai, UAE | 250 |
| | Ras al Kaimah, UAE | 225 |
| | Abu Dhabi, UAE | 380 |
| | Muscat, Oman | 500 |
| | Tel Aviv, Israel | 2,150 |
| | Haifa, Israel | |
| Kangan (Mid Gulf) | Doha, Qatar | 230 |
| | Manama, UAE | 185 |
| | Ras al Kaimah, UAE | 449 |
| Bushehr (Central Gulf) | Jubail, Saudi Arabia | 120-125 |
| | Ras Tanura, Saudi Arabia | 230-235 |
| | Dammam/Al Khobar, Saudi Arabia | 115 |
| | Doha, Qatar | 290 |
| | Manama. UAE | 225 |
| Borazjan (Eastern-Central Iranian coast) | Ras Tanura, Saudi Arabia | 350 |
| | Riyadh, Saudi Arabia | 715 |
| Kharg Island (Eastern-Central Iranian coast) | Jubail, Saudi Arabia | 230 |
| | Ras Tanura, Saudi Arabia | 335 |
| | Manama, UAE | 335 |
| Abadan (Far East in Iran near Gulf Coast) | Kuwait City, Kuwait | 115 |
| | Hafr al Batin, Saudi Arabia | 320 |
| | Ras Tanura, Saudi Arabia | 481 |
| | Jubail, Saudi Arabia | 360 |
| | Basra, Iraq | 45 |
| | Tel Aviv, Israel | 1,305 |

Source: World Atlas, http://www.worldatlas.com/travelaids/flight_distance.htm.

#### *Volley or Salvo Fire*

While experts feel the bulk of Iran's SRBM and longer-range systems may be upgraded to precision guidance over time, open source evidence suggests that current Iranian doctrine now calls for many existing SRBM and longer-range systems to be fired in volleys. Such volleys would still have limited real-world lethality in striking point targets, but they could have a major impact in terms of psychological and political warfare if used against Arab Gulf area targets and US, British, and French forces and basing facilities.

Moreover, short-range land-based missiles are relatively cheap, mobile, easy-to-use systems that can be used independent of any central command. Unlike longer-range missiles - particularly those emplaced in silos - aiming and firing these weapons is done on the initiative of lower-echelon commanders. Accordingly, they could be valuable in both political intimidation and deterrence. Well dispersed mobile missile forces are hard to target and destroy, and the destruction of Iranian command and control facilities would not eliminate missile-launching capabilities, although it

could weaken their effectiveness in a major attack because their lack of precision and the need for massed volleys demands a coordinated $C^3I$.

It is unclear from unclassified reporting whether recent ground-war exercises in Iran have realistically simulated the launch of large numbers of systems like Zelzals and Fateh-110s, and whether the IRGC intends create the necessary kind of command and control for salvo or volley fire. As **Figure 18** has shown, however, SRBMs could play a significant role in any Iranian effort to threaten or actually attack Iraq, Kuwait, as well as the Gulf littoral, if Iran is building a real-world salvo or volley capability.

All the Gulf States have a substantial portion of their petroleum infrastructure located on the Gulf coast. The vast majority of GCC oil fields are located on or near the Gulf, with most major infrastructure - for production, refining, and transportation - within 100 km of the coast.

Iran has already shown during the Iran-Iraq War that it could launch such missiles against targets in Iraq. Iran, for instance, has stated that with the spread of ISIL, it is prepared to attack ISIL targets by launching Fateh-110 and Zelzal 3B from its Kermanshah Garrison.

All of populated Kuwait lies within SRBM range, and must send its tankers to ports close to Iran. Kuwait's vulnerability was demonstrated during the Tanker War, when Kuwait was the first Gulf state to request US assistance in securing its oil exports, and despite new Patriot missiles Iran likely views Kuwait as the most vulnerable state. Iraq has greater strategic depth than any GCC state, but it lacks either anti-missile systems or the retaliatory capability to deter Iranian missile strikes. In any military or diplomatic confrontation, Iran could use or threaten to use its short-range systems, for which Iraq has no proportional response.

The other GCC states (excepting Bahrain) have some strategic depth, but all have their key facilities cluster along the Gulf coast and most concentrate them into large-scale facilities that are attractive area targets. Iran's longer-range versions are able to target Gulf coastal cities, and key Gulf infrastructure, given Iran's presumed large stocks. Iran can also fire SRBMs and long-range artillery rockets in volleys – possibly along with longer-range missiles - potentially complicating, saturating, or exhausting the reload capability of missile defenses. It is uncertain whether a combination of the offensive strike and missile defense capabilities of the US and Gulf States could fully protect this region from multiple volleys. This is particularly critical given Iran's islands in the Gulf, which allow it to emplace missiles closer to the coastline of GCC states' coastline.[149]

Saudi Arabia has three desalination plants on the Gulf, including the intake stations for Riyadh, and Qatar, Bahrain, and the United Arab Emirates all rely on desalination for 99%, 30% (with wastewater reuse - and its attendant vulnerable infrastructure - making up another 30%), and 40% of their water, respectively. All of these are large, unhardened complexes, and might require on the order of 50-75 missiles to damage them with 50% confidence (more to ensure the damage is serious).

Key parts of the UAE like Dubai would be within range of Zelzal-2s and Fateh-110s. If Iran could base missiles off its islands in the Gulf, it would be able to target all the petroleum and desalination facilities that provide roughly a quarter of the UAE's GDP, along with a portion of Saudi Arabia's northeastern oil fields. While launchers on Gulf islands would be vulnerable to airstrikes, they provide Iran with the possibility of at least one volley of direct attacks on its Gulf neighbors. The UAE's territory would be vulnerable to such attack. However, even if Iran did not emplace SRBMs missiles on its islands. Moreover, if Iran put is mobile launchers inland, they would be more likely

to survive and launch additional volleys of strikes, meaning the Emirates may face the most sustained missile campaign should hostilities break out.

Current Iranian SRBMs like the Zelzal and Fateh-110s do not pose a major threat to US forces in the region. Their reach is too short to penetrate deeply beyond the littoral, and only US bases in Kuwait, the port facilities and headquarters building in Bahrain, the al Dhafra air base, and some positions in Saudi Arabia would be vulnerable to missiles launched from Iran's Gulf islands. The same is true for many GCC military bases - despite their relative lack of strategic depth (except in the case of Saudi Arabia). Many bases are too distant from mainland Iran to be vulnerable to multiple volleys of missile fire from Iran's more numerous SRBMs like Zelzals and Fateh-110s.

Such salvo or volley attacks might never destroy critical or long lead components but could have a major impact on the attitudes of the population in urban areas. They could also disrupt operations or damage less critical military and infrastructure facilities long enough to have a political impact, and hit a truly critical target by luck in the process.

It should be noted that these limitations are even more serious for attacks with upgraded Fajr-5 rockets. There have been aerodynamic improvements, but they do not pose a serious threat to US and GCC targets in the region. Iran's current missile designs are also reported to make use of cluster munitions and better fusing -- although their lethality would still be sharply limited by range-payload limits, and a lack of accuracy if this was the only area of improvement. [150] Even substantial volleys of missiles and rockets with better conventional warheads against area targets would still be limited in real world lethality, and would be more terror strikes than strikes capable of quickly hitting and destroying key point targets.

### *The Impact of Precision Guidance*

Iran's SRBMs may become substantially more lethal if reports that Iran is now deploying an increasing number of systems with GPS guidance prove to be true, and *if such systems actually prove to be reliable and accurate enough to seriously damage point targets*. As the US showed in the first Gulf War in 1991 and in its initial invasion of Iraq in 2003, missiles and bombs with accurate GPS guidance and unitary conventional warheads can hit and destroy key fixed facilities with great effectiveness.

It is not yet clear when (and possibly if) Iran can acquire truly operational systems that can make use of GPS levels of accuracy, but there are numerous reports that Iran is improving the accuracy of its SRBMs and other ballistic missiles, and US intelligence experts do confirm that it has an active program to develop or modify missiles with GPS guidance. A number of sources indicate that Iran is already producing systems with greatly improved guidance. These include the production of the Zelzal-2 as a guided rocket, and development of the Ya Ali land attack cruise missile, the Zelzal-3 ballistic missile, and the Raad-301 precision guided bomb.

Iran has also claimed to have demonstrated that it has a near precision strike capability by attacking a simulated airfield -- although satellite photos of the target area indicate it simulated at least some of its accurate missile hits by using explosive devices panted at the scene. There are also reports that it is converting M-600 long-range rockets into SRBMs with guidance, navigation, and control, similar to the Fateh-110s.

As a result, Iran's missile and rocket forces could become steadily more lethal over the coming half-decade even if Iran does not get nuclear weapons. A truly reliable precision strike capability would make Iran's SRBMs and other missiles capable of targeting and destroying key military,

petroleum, power, and water facilities with enough accuracy to destroy them with a credible conventional payload.

Unless Iran's neighbors and the US deploy truly effective missile defenses, this would radically alter the lethality of Iran's missiles against high value military targets and civil targets like key oil product facilities and desalination plants – potentially creating the equivalent of "weapons of mass effectiveness." Iran would also run far less risk of catastrophic escalation in retaliation to either the threat of using its missiles, or actually carrying out missile strikes, if it could use missile forces with conventional warheads in strategic attacks rather than nuclear warheads.

### *Radar Correlators*

One needs to be careful, however, to not confuse the high level of accuracy or CEP that can be achieved by GPS platforms and the best inertial guidance systems, with how Iran's missiles will actually perform in combat. The details of expert assessments of such Iranian capabilities remain classified, but a summary description of this guidance system in WIKIPEDIA illustrates the issues involved,[151]

> Iran lacks both the technology and incentive to use some guidance systems. For example, the active radar guidance system used in earlier precision guidance ballistic missiles like the Pershing II was based on comparing live radar video return to restored reference scenes of the target area and determining the warhead/RV position errors with respect to its trajectory and target location. These position errors were used to correct and update the missiles' inertial guidance system, which in turn sent commands to the vane control system on the missile fins to guide the warhead/RV to the target.
>
> At a predetermined altitude, the radar unit was activated to provide altitude update data and begin scanning the target area. The analog radar video return was digitized into two-bit pixels by the correlator unit and was formatted into a 128 by 128 array. The target reference scene data, loaded prior to launch via the ground and missile data links, were also encoded as two-bit pixels and placed in reference memory formatted in a 256 by 256 array. The reference scene resolution necessary to correspond to the decreasing altitude of the RV was effected by placing four reference data arrays in memory, each representing a given altitude band. This correlation process was performed several times during each of four altitude bands and continued to update the inertial guidance system until just before the impact.
>
> If for some reason the correlator system failed to operate or if the correlation data quality was determined to be faulty, the inertial guidance system continued to operate and guided the RV to the target area with inertial accuracy only. Goodyear also developed the Reference Scene Generation Facility—a truck mounted shelter containing the equipment required to program the missile targeting. Radar maps of target areas were stored on disk, then specific targeting data.

US experts state privately, however, that this system worked far better in theory than in practice, and that modern inertial guidance and GPS guidance are far more reliable. Accordingly, it seems doubtful that Iran will attempt to deploy such a guidance system even if it finds it can acquire all of the necessary technology and components.

The accuracy of different weapons like missiles with optical seekers, GPS guided air-to-surface ordnance, and launch platforms like unmanned aerial vehicles (UCAVs) does not apply to weapons with the complexity, range, speed, apogees, reentry issues, and design limitations of ballistic missiles. The TERCOM systems used by some cruise missiles require relatively slow overflights, a variable flight path that is adjusted to ensure there are high contrast radar features to make TERCOM work, and still have serious limitations and reliability issues unless linked to GPS systems – which have generally proved to be superior.

Once again, an unclassified report in WIKIPEDIA highlights some of the key issues:[152]

> TERCOM for “terrain contour matching”, uses altitude maps of the strip of land from the launch site to the target, and compares them with information from a radar altimeter on board. More sophisticated TERCOM systems allow the missile to fly a complex route over a full 3D map, instead of flying directly to the target. TERCOM is the typical system for cruise missile guidance, but is being supplanted by GPS systems and by DSMAC, Digital Scene-Matching Area Correlator, which employs a camera to view an area of land, digitizes the view, and compares it to stored scenes in an onboard computer to guide the missile to its target.
>
> DSMAC is reputed to be so lacking in robustness that destruction of prominent buildings marked in the system’s internal map (such as by a preceding cruise missile) upsets its navigation

### *INS and GPS*

Inertial navigation systems (INS) and global position system (GPS) guidance are a very different story. The very best INS guidance systems have extraordinary precision. They use extremely sensitive on-board measurement devices to calculate the location of the missile due to the acceleration put on it after leaving a known position. Many of the initial systems were mechanical systems were not very accurate, and some required some sort of external adjustment to allow them to hit targets even the size of a city.[153]

The most modern systems now use solid-state ring laser gyros that are *potentially* accurate to within meters, and do not require additional inputs. This kind of solid state INS reached the point in the AIRS system in the MX missile where it offered a theoretical accuracy under 100meters at intercontinental ranges assuming a perfectly round earth. Developing countries can obtain a far less accurate version relatively easily because civilian aircraft now use inertial guidance that are based on the ring laser gyroscopes. Such technology, however, is less accurate than the earlier mechanical systems found in ICBMs.

Nuclear powers also still deploy inertial guidance as initial guidance and guidance for their reentry vehicles of strategic missiles, because it INS does not need an external signal and cannot be jammed as GPS and radar can, because accuracy is less important for boosted and thermonuclear nuclear warheads.

GPS guidance potentially can be jammed or misled by a false signal. It is also affected to some degree by atmospheric effects, sky blockage, and receiver quality. At the same time, it relies on a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the from an unobstructed line of sight to four or more GPS satellites whose signal the missile and RV can access during almost all of the missile’s flight.

A GPS receiver embedded in a missile is also relatively easy to make immune to acceleration and vibration, and is less sensitive to minor oddities in the earth’s shape. This also helps explain why other nuclear powers and major missile powers are developing their own systems: They include the Russian Global Navigation Satellite System (GLONASS), the planned European Union Galileo positioning system, India’s Indian Regional Navigation Satellite System, and the Chinese Beidou Navigation Satellite System.

GPS accuracy can be very exact and has steadily improved over time. A civilian norm exists of 7.8 meters with 95% confidence. Accuracy of three meters is common in some commercial equipment. Iran would not have access to the US military PPS system, but it is unclear this now matters. Moreover, the most advanced systems now use a combination of INS and GPS.

### *Theory versus Reality*

Accordingly, some experts feel Iran will be able to deploy SRBMs, MRBMs, and IRBMs with CEPs within 0.1% for every 1 kilometer, which would mean that that means the CEP would be close to 1000 meters over a range of 1,000 km. This may be possible over time, but practical test and evaluation as well as US combat experience warns that the error budget of things that can degrade operational accuracy in a real world missile is far greater than the accuracy of the guidance platform would suggest. Moreover, CEP applies to 50% of a perfectly located and launched missile that operate perfectly in flight to reach a perfectly located target.

Given the age, uncertain character, and other problems that affect Iran's SRBMs and missiles, any estimate of real world accuracy has to be based on real world testing of the same configuration of a missile under real world launch conditions and in numbers that are statistically relevant.

History is also a warning that engineering estimates of systems that are not fully tested are almost as useful as engineering estimates of future cost – with the difference that cost estimates are far too low and performance estimate are far too high. While one can always enjoy the fantasy until one tries to make it real, the only way to develop an objective picture of the operational error budget in a ballistic missile is to test a statistically meaningful number of systems under operational conditions, and usually to correct for systematic efforts in even the most accurate guidance platforms be seeing where a warhead actually lands versus its air point. No meaningful unclassified data exist on any Iranian missiles that meet these tests, and it is unclear that Iran has ever run enough tests of its own under real world conditions with the same missile configuration (sometimes called the derived aim point method) to have accurate estimates of its own.

## Targeting and Battle Damage Assessment Capability

Once again, it is unclear how well Iranian forces could target such systems, but all missile forces will have secure command and control links, military grade GPS devices, and almost certainly have a range of preset deployment locations, mobility plans, and targets.

As noted earlier in the discussion of artillery rockets, Iran may have catalogued the GPS coordinates of all potential fixed area targets in Iran and nearby. Anyone can gather GPS target data on a site they can enter or bracket with GPS devices, and security is marginal for critical infrastructure and many secure facilities since any worker that can enter the facility can normally carry in a GPS device – something that applies to gathering target data at far longer ranges and generally to palaces, critical infrastructure facilities, and many military bases and facilities throughout the entire region. There also are devices that can calculate the GPS aim point of a given part of a building or facility at a considerable distance where any unsecured line of sight exists to the target

Iran would not need military satellite capability or air or unmanned aerial vehicle reconnaissance data to get area fire targeting data on fixed facilities for its long-range rockets or missiles. Commercial satellite data would be adequate. It seems doubtful in any case that Iran could use its limit fixed wing air reconnaissance assets for such missions. Iran is, however, making steadily greater use of unmanned aerial vehicles (UAVs) like the Ababil, Fotros, and Yasser, as well as unmanned combat aerial vehicles (UCAVs) like the Ra'ad 85 and Shahed-129.[154]

Iran has made ambitious claims about its UAV and UCAV programs that it is not possible to verify. However, Iran's UAVs could probably provide real time targeting and battle damage assessment

data to Iran's fire units and tactical commanders, but it is not clear how many such systems have been deployed, who they have been deployed to, what the capabilities of such systems are, or what level of training and capability Iranian forces have.

One also needs to be extremely careful about Iranian claims. As is discussed throughout this report. Iran fully understand the value of missiles as political and propaganda weapons. It has used Photoshop to exaggerate the number and character of the missile launches it has shown on television. It also and seems to have superimposed a diagram of an air base over a cluster of close missile hits to claim it could conduct accurate strikes against major military base, while setting off additional explosions to look like craters.[155]

## Command and Control

The command and control of virtually all missile operations is under the control of the Iranian Revolutionary Guard Corps (IRGC). This is both a result of the time when the Ayatollah Khomeini and his supporters were distrustful of the Shah's former military and their loyalties, and of the fact that many of the former leaders of the IRGC role are now key supporters of the Supreme Leader and the IRGC itself is seen as responsive to the Supreme Leader and not any of the more moderate officials around the President and in the rest of the Iranian government.

The Islamic Revolutionary Guard Corps (IRGC) Air Force also seems to have broad authority over the development and production of Iran's missiles by its Defense Industries Organization, as well as planning doctrine, targeting, employment, and operations from short-range systems like the Fateh-110 short-range ballistic missile to the Ashura medium-range ballistic missile, and all longer-range systems. This IRGC command is various known as the IRGC Missile Command, Islamic Revolutionary Guard Corps Missile Command, and IRGC-Air Force Missile Command. According to some reports, is part of a larger air-missile element of the IRGC whose name was changed from IRGC Air Force to IRGC Aerospace Force in October 2009.[156]

There do not seem to be credible unclassified details on the command and control structure, IS&R (intelligence, surveillance, and reconnaissance), $C^4I$/battle management systems, tactics and doctrine, and development plans for Iran's missile forces. The readiness and operational skill levels of these elements of Iranian forces also are unknown, but seem to have high priority within Iran's forces.

It seems likely that any launches and strikes for military purposes would require the direct authorization of the Supreme Leader. But Iran may have contingency plans for targeting and launch in the event that leadership is killed, incapacitated, or can no longer communicate for a predetermined period.

# V. Iran's Medium and Long-Range Missile Programs

Iran's evolving medium and long range missile programs present the most serious threat in terms of Iran's efforts to improve its overall strike capability, as well as in Iran's potential ability to use nuclear weapons to change the regional balance.

Iran's medium and long-range missile systems include a wide range of missiles that can cover the range from Iran to target across the Gulf. These systems give Iran a longer-range strike capability that its aging air force largely lacks. Iran's combat aircraft have the potential range-payload to strike deep beyond the Gulf, but they lack the performance, numbers, and enablers to operate effectively in large numbers of sorties against the US and Southern Gulf mix of fighters, strike aircraft, enablers, and surface-to-air missiles.

Iran's longer-range missiles have also done far more to capture world attention than its rockets, shorter-range ballistic missiles, cruise missiles, unmanned combat aerial vehicles, or drones. This is partly because their range allows Iran to attack targets throughout the region in spite of the limits to its airpower, and its growing ability to attack targets in Europe and Russia. It is also because they have the highest range-payload capability of any Iranian systems, the greatest capability to carry a nuclear warhead, the highest reentry speeds, and ability carry penetration aids to defeat missile defenses.

At the same time, the error budget in missile performance and accuracy still tends to increase steadily with missile range and complexity and Iran's current systems are substantially less accurate than Iran's shorter-range systems and even less likely to be effective with a conventional warhead. This raises key questions about Iran's true motives in developing such systems, even allowing for the fact it is seeking more accurate and reliable designs. While Iran has claimed it can give such missile enough accuracy and reliability to use conventional weapons against point targets, this is far from clear.

These technical realities also make a May 2014 statement by Iran's Supreme Leader Ayatollah Ali Khamenei that any effort to link such missiles to Iran's nuclear programs are ""stupid and idiotic," and that Iran would go to the mass production of such missiles, deeply disturbing. It is hard not to see such a statement as a deliberate lie, given the fact that IAEA reports that Iran has had nuclear warhead programs. New reports in 2014 by the U.N. Panel of Experts, and the fact the statement was timed to occur one day before nuclear negotiations were to resume in Vienna, reveal Iran's true actions. This is why the P5+1 have made Iran's missile programs a key issue the nuclear weapons negotiations with Iran.[157]

The summary of the UN Panel of Experts report noted that,[158] [159]

> The Panel investigated more than two dozen cases during this mandate involving alleged violations of resolution 1929 (2010) and prior resolutions. The majority of incidents concern the attempted procurement of dual-use items. Most of those items, with some exceptions, fall below established control thresholds. Their identification remains a challenge to the implementation of Security Council sanctions intended to target Iranian procurement of goods and materials for prohibited activities. On the basis of the cases investigated by the Panel and information made available by States, it is increasingly difficult for authorities to identify links between below-threshold items and prohibited end users or end uses in the Islamic Republic of Iran. This may be a function of more sophisticated procurement strategies on the part of the Islamic Republic of Iran, which has developed methods of concealing procurement, while expanding prohibited activities. Such methods can also be used by the Islamic Republic of Iran to procure and finance legitimate trade, which further complicates the efforts of States to identify illicit procurement.

> The Islamic Republic of Iran has continued to engage in ballistic missile activities. It is reported to have conducted a number of ballistic missile test launches over the past year, which are a violation of paragraph 9 of resolution 1929 (2010). It is also developing its launch capabilities: a new launch site near the city of Shahrud was identified. At the same time, the Islamic Republic of Iran decided to forgo its 2013 Great Prophet military exercises, during which numerous ballistic missiles have traditionally been launched.

Reuters reported in covering Khomeini's statement that,[160]

> The new report by the U.N. Panel of Experts, seen by Reuters, said Iran's overall attempts to illicitly procure materials for its banned nuclear and missile programs appear to have slowed down as it pursues negotiations with world powers that it hopes will bring an end to sanctions….But the same report makes clear that, apart from holding off on test-firing one type of rocket, Iran shows no sign of putting the brakes on the expansion of its missile program…"Iran is continuing development of its ballistic missile and space programs," the experts said. "A new missile launch site 40 km (25 miles) from the city of Shahrud was identified in August 2013. A larger launch complex is assessed to be close to completion at the Imam Khomeini Space Center at Semnan for ballistic missiles and satellite launch vehicles."…The report also cited what it described as the June 2013 opening of the Imam Sadeq Observation and Monitoring Center for monitoring space objects, including satellites.

As is discussed in more detail later, the full 49-page Panel of Experts report stated that, "Analysis of Iran's ballistic missile program remains a challenge. With the exception of several launches, periodic displays of hardware and one recent revelation of a new ballistic launch facility, the program is opaque and not subject to the same level of transparency that Iran's nuclear activities are under IAEA safeguards." The report also revealed that the procurement for the missile program continues, with no apparent changes in the type of materials Iran seeks: "Among the most important items Iran is reportedly seeking are metals as well as components for guidance systems and fuel," the panel report said. "Similarities between Iran's ballistic missiles and space programs can make it difficult for states to distinguish the end-uses of procured items." [161] [162]

The Panel reported that it was unclear why Iran appears not to have test-fired a Sejil, Iran's longest-range, solid-fuelled ballistic missile, since 2011. This might be due to satisfaction with its performance, an inability to procure components or ingredients for solid fuel, or a shift to other missiles considered to be of higher priority, according to the report. "Iran may also have decided to suspend further testing which could be interpreted as inconsistent with the spirit of the (six power) negotiations," the experts assessed. Nevertheless, the panel said that proof Iran is continuing to develop the Sejil came from a 2013 parade of Sejil launchers. [163] [164] The issue then became caught up in the growing tensions between the US and Russia, the US put the missile issue high on the agenda during the negotiations in Vienna, Russia said it was not an issue.[165] [166]

## *US Assessments of Iran's Medium and Long Range Missile Programs*

There is no clear dividing line in terms of the military role of Iran's medium range-range systems from Iran's longer range rockets and shorter-range missiles, or from its longer-range missiles,. Iran has, however, developed an evolving family of longer-range missiles that can attack virtually any target in Israel, the Levant, the Gulf and Arabian Peninsula, Turkey, Pakistan and part of Central Asia, as well as targets in Southern Russia and Europe.

As the following analysis shows, Iran seems to deliberately issue false or confusing reports about its longer range missile programs. Iran's key medium and longer-range missiles and missile developments do, however, clearly include a mix of solid and liquid-fueled medium range ballistic missiles (MRBMs) with names and ranges like the Ghadr-110 (2,000–3,000 km), Shahab-3

(2,100 km) (Iran), Fajr-3 (2,500 km) Ashoura (2,000–2,500 km), and Sejjil (2,000–2,500 km). More controversially, they also may include developmental systems like the intermediate range ballistic missiles (IRBMs) like the Shahab-5 or Toqyān 1 (3000–5000 km) and the Shahab-6 or Toqyān 2 (3000–5000 km).

The US has long seen these Iranian medium and long-range missile programs as a growing threat. The Department of Defense has made it clear in its annual reports on the Iranian threat that it took Iran's missile capabilities very seriously. Its 2010 report made it clear that Iran's focus on missiles was now some three decades old, and included a mix of tactical and short to medium range conventional systems, as well as serving as potential platforms for nuclear warheads,[167]

> Over the past two decades, Iran has placed a significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and coalition forces in the Middle East and to project power in the region. Iran actively began acquisition and production programs in the 1980s during the Iran-Iraq war to address its inability to counter Iraqi missile attacks. In developing and expanding its missile program, Iran has received assistance from North Korea and China. At present, Iran is assessed to have the largest deployed ballistic missile force in the Middle East with approximately 1000 missiles that range from 90-1200 miles. To demonstrate its missile capabilities; Iran has conducted a total of four highly publicized exercises ("Noble Prophet"), since 2006.
>
> Short-range ballistic missiles provide Tehran with an effective mobile capability to strike coalition forces in the region. Iran continues to improve the survivability of these systems through technological advances, such as solid propellant and the use of antimissile defense tactics.
>
> Iran has also developed medium-range ballistic missiles to target Israel and continues to increase the range, lethality, and accuracy of these systems. For example, the Shahab 3, based on the North Korean No Dong, can reach all of Israel. The Ashura or "Sejil" is an indigenous, two-stage missile that is in development. It uses solid-propellant technology, which reduces the launch preparation time and footprint.
>
> …Coastal defense cruise missiles (CDCMs) are an important layer in Iran's defense of or denial of access to the Gulf and Strait of Hormuz. Iran can attack targeted ships with anti-ship cruise missiles (ASCMs) from its own shores, islands, and oil platforms using relatively small mobile launchers.
>
> The C801/802 is Iran's primary CDCM, first imported from China in 1995. The C801/802 is capable of engaging targets at a range of six nautical miles, and has greater accuracy, a lower cruising altitude, and a faster set-up time than the Seersucker missile Iran used during the Iran-Iraq War. The C801/802 allows Iran to target any point within the Strait of Hormuz and much of the Persian1 Gulf and Gulf of Oman. Iran has also worked with China to develop shorter-range missiles, including the C701, for deployment in narrow geographic environments.
>
> Iran can readily deploy its mobile CDCM launchers anywhere along its coast. These systems have auto control and radar homing guidance systems, and some can target using a remote air link. Mobile CDCMs, combined with multiple rocket launchers (MRLs), coastal artillery, and ballistic missiles, Iran hopes to overwhelm enemy air defenses.

The 2012 report focused on Iran's ballistic missile program and stated that, [168]

> …Regular Iranian ballistic missile training occurs throughout the country. Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe - including an extend range version of the Shahab 3 and a 2,000-kilometer range medium range ballistic missile, the Ashura. Beyond steady growth in missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems by improving accuracy and developing new submunition payloads. [169]
>
> Regular Iranian ballistic missile training continues throughout the country. Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe, including an extended-range variant of the Shahab-3 and a 2,000-km medium-range ballistic missile, the Ashura.

> Beyond steady growth in its missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems with accuracy improvements and new submunition payloads.
>
> Iran's missile force consists chiefly of mobile missile launchers that are not tethered to specific physical launch positions.
>
> Iran may be technically capable of flight-testing an intercontinental ballistic missile by 2015.
>
> During the last 20 years, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region.
>
> In 2011, Iran launched several missiles during the Noble Prophet 6 exercise, including a multiple missile salvo.
>
> Short-range ballistic missiles provide Tehran with an effective mobile capability to strike partner forces in the region. Iran continues to improve the survivability of these systems against missile defenses.
>
> It is also developing and claims to have deployed short-range ballistic missiles with seekers that enable the missile to identify and maneuver toward ships during flight. This technology also may be capable of striking land-based targets.
>
>> Iran also has developed medium-range ballistic missiles to target Israel and continues to increase the range, lethality, and accuracy of these systems.
>>
>> Since 2008, Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies.

A review by *Defense Update* of the unclassified portions of the 2013 report stated that,[170]

> An unclassified portion of the "Annual Report on Military Power of Iran," dated January 2013 and made available by the Pentagon today, also states that Iran is continuing to develop both the "technological capabilities applicable to nuclear weapons" and "ballistic missiles that could be adapted to deliver nuclear weapons." In December 2012 US sources were skeptical about Iran's ability to reach such milestone by 2015. Tehran encountered a major obstacle in 2011, after an explosion killed 21 people during a test, among the casualties was Hasan Tehrani Moghaddam, who was in charge of the country's missile program.
>
> …In two years' time, Iran could flight-test an intercontinental ballistic missile capable of striking the United States, given "sufficient foreign assistance", is provided to Tehran. The new assessment reiterated a longstanding estimate of the U.S. intelligence community. Iran could test such a missile by 2015 with assistance from nations like North Korea, China or Russia. Pyongyang is already in the process of developing the KN-08, an extended range ballistic missile that can reach the US West Coast.
>
> The missile's range could be extended to provide the missile an intercontinental strike capability. Pyongyang and Tehran have been collaborating and exchanging technologies regarding ballistic missiles and nuclear weapons for many years; both countries are seeking to match the two technologies to acquire nuclear weapons delivery capabilities. U.S. experts agree that North Korea and Iran could be capable of developing and testing few ICBM class missiles based on liquid propellants, but doubt they could acquire solid-propelled weapons in the near future. The lengthy pre-flight procedures required for fuelling liquid-propelled missiles means that such weapons cannot be mass-fired without warning, as the shorter range missiles could, therefore, providing the defender time to respond, employ missile defense or conduct preemptive attack.
>
> In the past Iran was reportedly working on 'Project Koussar', a ballistic missile capable of reaching targets at ranges of 4000 – 5000 km. These missiles, sometime referred to as Shahab 5 and Shahab 6 were believed to be based on different propulsion used on the Shahab 3. Some sources indicated the Iranians were relying on the RD-216 originally developed for the SS-5 IRBM and also used to with the Kosmos SL8 satellite launcher.
> James Clapper, the director of national intelligence, told the Senate Select Committee on Intelligence last month that "we do not know if Iran will eventually decide to build nuclear weapons." The U.S. government's 17 intelligence agencies, according to Clapper, "judge Iran would likely choose a ballistic missile as its preferred method of delivering a nuclear weapon, if one is ever fielded," he said in the U.S. intelligence

> community's annual worldwide threat assessment. These missiles are capable of delivering a weapon of mass destruction, he said.
>
> "In addition, Iran has demonstrated an ability to launch small satellites, and we grow increasingly concerned that these technical steps — along with a regime hostile toward the United States and our allies — provide Tehran with the means and motivation to develop larger space-launch vehicles and longer-range missiles, including an intercontinental ballistic missile," according to Clapper.
>
> … The Defense Department adds that Iran "continues to develop technological capabilities applicable to nuclear weapons" and is "proceeding with uranium enrichment and heavy-water nuclear reactor activities in violation of multiple U.N. Security Council resolutions." Iran "also continues to develop ballistic missiles that could be adapted to deliver nuclear weapons," it states. Despite "increased pressure resulting from sanctions" imposed by the United Nations, there "has been no change to Iran's national security and military strategies over the last year," according to the report.

The US Director of National Intelligence, James R. Clapper, summarized Iran's capabilities as follows in his 2013 report to Congress:[171]

> We assess **Iran** is developing nuclear capabilities to enhance its security, prestige, and regional influence and give it the ability to develop nuclear weapons, should a decision be made to do so. We do not know if Iran will eventually decide to build nuclear weapons.
>
> Tehran has developed technical expertise in a number of areas—including uranium enrichment, nuclear reactors, and ballistic missiles—from which it could draw if it decided to build missile-deliverable nuclear weapons. These technical advancements strengthen our assessment that Iran has the scientific, technical, and industrial capacity to eventually produce nuclear weapons. This makes the central issue its political will to do so.
>
> Of particular note, Iran has made progress during the past year that better positions it to produce weapons-grade uranium (WGU) using its declared facilities and uranium stockpiles, should it choose to do so. Despite this progress, we assess Iran could not divert safeguarded material and produce a weapon-worth of WGU before this activity is discovered.
>
> We judge Iran's nuclear decision making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran's security, prestige and influence, as well as the international political and security environment, when making decisions about its nuclear program. In this context, we judge that Iran is trying to balance conflicting objectives. It wants to advance its nuclear and missile capabilities and avoid severe repercussions—such as a military strike or regime threatening sanctions.
>
> We judge Iran would likely choose a ballistic missile as its preferred method of delivering a nuclear weapon, if one is ever fielded. Iran's ballistic missiles are capable of delivering WMD. In addition, Iran has demonstrated an ability to launch small satellites, and we grow increasingly concerned that these technical steps—along with a regime hostile toward the United States and our allies—provide Tehran with the means and motivation to develop larger space-launch vehicles and longer-range missiles, including an intercontinental ballistic missile (ICBM).
>
> Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile arsenal. Iran's growing ballistic missile inventory and its domestic production of anti-ship cruise missiles (ASCM) and development of its first long-range land attack cruise missile provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces.

Clapper's comments were similar in his 2014 report, but reflected the fact that Iran was now engaged in the P5+1 negotiations: [172]

> We continue to assess that **Iran's** overarching strategic goals of enhancing its security, prestige, and regional influence have led it to pursue capabilities to meet its civilian goals and give it the ability to build missile-deliverable nuclear weapons, if it chooses to do so. At the same time, Iran's perceived need for economic

> relief has led it to make concessions on its nuclear program through the 24 November 2013 Joint Plan of Action with the P5+1 countries and the European Union (EU). In this context, we judge that
>
> Iran is trying to balance conflicting objectives. It wants to improve its nuclear and missile capabilities while avoiding severe repercussions—such as a military strike or regime-threatening sanctions. We do not know if Iran will eventually decide to build nuclear weapons.
>
> Tehran has made technical progress in a number of areas—including uranium enrichment, nuclear reactors, and ballistic missiles—from which it could draw if it decided to build missile-deliverable nuclear weapons. These technical advancements strengthen our assessment that Iran has the scientific, technical, and industrial capacity to eventually produce nuclear weapons. This makes the central issue its political will to do so.
>
> Of particular note, Iran has made progress during the past year by installing additional centrifuges at the Fuel Enrichment Plant, developing advanced centrifuge designs, and stockpiling more low-enriched uranium hexafluoride (LEUF6). These improvements have better positioned Iran to produce weapons grade uranium (WGU) using its declared facilities and uranium stockpiles, if it chooses to do so. Despite this progress, we assess that Iran would not be able to divert safeguarded material and produce enough WGU for a weapon before such activity would be discovered. Iran has also continued to work toward starting up the IR-40 Heavy Water Research Reactor near Arak.
>
> We judge that Iran would choose a ballistic missile as its preferred method of delivering nuclear weapons, if Iran ever builds these weapons. Iran's ballistic missiles are inherently capable of delivering WMD, and Iran already has the largest inventory of ballistic missiles in the Middle East. Iran's progress on space launch vehicles—along with its desire to deter the United States and its allies—provides Tehran with the means and motivation to develop longer-range missiles, including an intercontinental ballistic missile (ICBM).
>
> We assess that if Iran fully implements the Joint Plan, it will temporarily halt the expansion of its enrichment program, eliminate its production and stockpile of 20-percent enriched uranium in a form suitable for further enrichment, and provide additional transparency into its existing and planned nuclear facilities. This transparency would provide earlier warning of a breakout using these facilities.

Lieutenant General Michael T. Flynn, the Director of the Defense Intelligence Agency, noted in his annual threat assessment for 2014 that,[173]

> … Iran has threatened to temporarily impede international ship traffic transiting through the Strait of Hormuz if it is attacked or in response to further sanctions on its oil exports. Additionally, Iran has threatened to launch missiles against U.S. targets and our regional allies in response to an attack. Tehran could also employ its terrorist surrogates. However, it is unlikely to initiate or intentionally provoke a conflict or launch a preemptive attack.
>
> … Iran is laboring to modernize its air and air defense forces under the weight of international sanctions. Each year, Iran unveils what it claims are state-of-the-art, Iranian-made systems, including SAMs, radars, unmanned aerial vehicles, and it did so again in 2013. It continues to seek an advanced long-range surface-to-air missile system.
>
> Iran can strike targets throughout the region and into Eastern Europe. In addition to its growing missile and rocket inventories, Iran is seeking to enhance lethality and effectiveness of existing systems with improvements in accuracy and warhead designs. Iran is developing the Khalij Fars, an anti-ship ballistic missile that could threaten maritime activity throughout the Persian Gulf and Strait of Hormuz. Iran's Simorgh space launch vehicle shows the country's intent to develop intercontinental ballistic missile (ICBM) technology.

IAEA and a host of outside sources make it clear that US intelligence services and the Department of Defense are correct in stressing the importance of missiles to Iran and that missiles are Iran's most likely platforms for the delivery of nuclear weapons. Their conventional capabilities, and US and Arab Gulf capabilities to deter and defend against their use in regional asymmetric and conventional warfare, are just as important.

There are, however, key uncertainties in a wide range of critical details. There is no agreement on the reliability and accuracy of Iran's missiles under operational conditions. There is no agreement as to when Iran may acquire missiles with homing warheads and the kind of terminal guidance that can hit point targets effectively with conventional warheads. There is no agreement on Iran's ability to deploy systems with countermeasures to missile defenses. Finally, there is no agreement on the extent to which Iran has mastered all of the design and production techniques for advanced ballistic missiles, and can now modernize and refine its force without importing additional equipment and technology.

## *Iranian Statements about its Medium and Longer-Range Missile Programs*

Iran has its own views of its medium and long-range missile capabilities. While Iran continues to deny it is seeking nuclear weapons, it stresses its long-range missile threat and has made missile test firings a major part of its televised military exercises.

Remarks made by high-ranking Iranian figures, and public missile firings, and even parades, are revealing. They are a direct indication of the Iranian regime's continued willingness to improve its ballistic missile arsenal as a component of its asymmetric warfare capabilities and a deterrent against the US and regional US allies. Given Iran's foreign policy objectives, conventional shortcomings, and an ever-expanding missile program, it is clear that Iran uses its missile program to try to improve its strategic standing and assert itself in the region.

Iran's military leaders routinely emphasize the importance of Iran's medium and long-range missile programs. This is clear from even brief excerpts from statements made during a single month in 2011. During the Great Prophet 6 war games in late June 2011, the commander of the IRGC's Aerospace Division, Brigadier General Amir Ali Hajizadeh, stated that,

> "We feel to be threatened by no county [sic] but the US and the Zionist regime and the ranges of our missile [sic] have been designed based on the distances between us and the US bases in the region and the Zionist regime."[174]

On June 28, 2011, Lieutenant Commander of the IRGC, Brigadier General Hossein Salami, also referred to the deterrent that Iran perceives in its missile forces:

> "Our missiles have tactically offensive and strategically deterrent and defensive features…Our fingers are still kept on the trigger, but the number of these triggers has increased."[175]

Later, on July 9, 2011, General Hajizadeh stated the following about the war games:

> "Those who are hostile to the Islamic Republic of Iran definitely have the right to be concerned about the drills, but we didn't hear any feeling of concern from the side of regional countries since our moves and actions have always been in pursuit of defensive goals.
>
> We are entitled to the right to growingly strengthen ourselves to protect the Islamic Iran and we naturally increase our power on a daily basis until we acquire full (power of) deterrence."[176]

These excerpts are typical of a consistent pattern of ambitious statements about Iran's missile capabilities:

- "Our ballistic missiles are capable of destroying moving targets with pinpoint precision." – Hossein Salami, Second-in-Command of the IRGC, June 1, 2014, http://www.presstv.com/detail/2014/06/01/365055/iran-boosts-ballistic-missile-precision/

- “The guidance systems of (the missiles delivered to the IRGC) today enjoy the capability of striking the targets with full precision and they have a margin of error below 5 meters.” – Hossein Dehqan, Iranian Defense Minister, March 5, 2014, http://www.algemeiner.com/2014/03/05/iranian-defense-minister-boasts-of-ballistic-missile-precision-margin-of-error-below-5-meters/

- “The inaccuracy of (our) ballistic long-range missiles in hitting targets is so minimal that we can pinpoint targets. The accuracy of surface-to-surface missiles is now two meters, while at some stage in the past it was 200 meters. We strive to reach zero inaccuracy.” – Hossein Dehqhan, Iranian Defense Minister, December 9, 2013, http://www.armytimes.com/article/20131209/NEWS08/312090014/Iran-says-improves-

- “Iran has now reached to a point of progress that can target 2,000 enemy bases within a range of 2,000km…We don’t need missiles with over 2000km but we have the technology to build them…Israel is our longest-range target.” - General Morteza Qorbani, senior advisor to the General Staff of the Iranian Armed Forces, January 7, 2013. http://english.farsnews.com/newstext.php?nn=9107133861

- “We can simultaneously fire numerous and countless missiles from different spots at one or several targets, which indicates our capability to perform convergent and parallel operations.” - Brigadier General Hossein Salami, Lieutenant Commander of the Islamic Revolution Guards Corps, September 7, 2012. http://english.farsnews.com/newstext.php?nn=9106242598

- “The (Russian-made S-200) system has been optimized for improved detection and electronic warfare… Two new types of missiles will be mounted on the system.” Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 7, 2012. http://www.irandailybrief.com/2012/09/06/iran-has-optimized-the-capabilities-of-the-russian-made-s-200-air-defense-systems/

- “We are through with developing the threat-detection capability of the system and its sensitive parts have been manufactured in Iran…We have no problem for supplying the missiles needed for this system…With this powerful system in our hand, we would not think of S-300 anymore…Bavar 373 system is an important and completely indigenous achievement that can be a powerful rival for S-300.” - Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 3, 2012. http://english.farsnews.com/newstext.php?nn=9106061552

- “In our strategic planning, we have set out a radius we call the preventive/deterrent radius that covers all the strategic interests of the enemy in the region, and we will therefore be able to control the arena of conflict at any level. The IRGC navy’s cruise missiles have the highest capabilities in terms of accuracy, range, and radar evasion, and these are missiles that can be fired at different ranges and from different launchers with great precision.” - Hussein Salami, Acting Commander of the IRGC, June 25, 2012. http://www.irandailybrief.com/2012/06/25/interview-with-hussein-salami-in-honor-of-irgc-day/

- “Our missiles have tactically offensive and strategically deterrent and defensive features… Our fingers are still kept on the trigger, but the number of these triggers has increased.” - Brigadier General Hossein Salami, Lieutenant Commander of the IRGC, June 28, 2011. http://english.farsnews.com/newstext.php?nn=9004074141

- “We feel to be threatened by no county but the US and the Zionist regime and the ranges of our missile have been designed based on the distances between us and the US bases in the region and the Zionist regime.” - Brigadier General Amir Ali Hajizadeh, commander of the IRGC’s Aerospace Division, June 28, 2011. http://english.farsnews.com/newstext.php?nn=9004074047

- “The mass production of the Qiyam missile, the first without stabilizer fins, shows the Islamic Republic of Iran’s self-sufficiency in producing various types of missiles.” - Iranian Defense Minister Ahmad Vahidi, May 22, 2011. http://www.presstv.ir/detail/181167.html

- “As the enemy’s threats will likely come from the sea, air, and by missiles, the Revolutionary Guard has been equipped to neutralize the enemy’s advanced technology.” - Mohammed Ali Jafari, commander of the IRGC on a new anti-ship ballistic missile that Iran has allegedly developed, February 7, 2011.

http://www.google.com/hostednews/afp/article/ALeqM5hfIrLpGsCvEg1YS5ANA8bTP939NA?docId=CNG.30a945d880fb0c467a82e584423dac3f.281

- "Those who are hostile to the Islamic Republic of Iran definitely have the right to be concerned about the drills, but we didn't hear any feeling of concern from the side of the regional countries since our moves and actions have always been in pursuit of defensive goals…We are entitled to the right to growingly strengthen ourselves to protect the Islamic Iran and we naturally increase our power on a daily basis until we acquire full (power of) deterrence." - General Amir Ali Hajizadeh, commander of the IRGC's Aerospace Division in reference to Iran's most recent missile tests, July 9, 2011. http://english.farsnews.com/newstext.php?nn=9004183678

Such statements need to be kept in context. Iran regularly exaggerates the progress of all its rocket and missile programs from precision-guided heavy rockets -- which Iran asserts are the basis of its development of GPS-guided ballistic missiles -- to successful ballistic missile tests involving the hitting of moving targets, to laser-guided missiles, missiles with multiple reentry vehicles such as the Ghadr H, and even "battlefield tested" supersonic anti-ship cruise missiles and long-range missiles on helicopters. Propaganda is viewed in the IRGC, MODAFL, and throughout Iran's security establishment, as much a part of Iran's missile program as the missiles themselves.

Iran's use of military propaganda often focuses on Iran's longer-range missiles. For example, FARS announced shortly after Iran and the P5+1 reached an agreement on nuclear weapons in November 2013, that Brigadier General Hossein Salami, the lieutenant commander of Iran's elite Islamic Revolutionary Guard Corps (IRGC), had stated that,

> "Iran is among the only three world countries enjoying an indigenous ballistic missile technology…Many countries may have access to cruise missiles technology, but when it comes to ballistic missiles, I am confident that only the U.S. and the [former] Soviet Union could master this technology, and now we can announce that we own this technology as well". [177]

Brigadier General Hossein Salami also claimed that Iran was also developing other advanced systems, "While we did not have any knowledge about drones, we have developed and acquired drones that travel 2,000 kilometers, conduct their operations, and then land in our desirable regions." At nearly the same time, General Ramezan Sharif, Head of the IRGC's Public Relations Department, stated that, "The U.S. has double-standards towards social issues of nations and the language that Americans understands is the language of force…U.S. power is growing weaker every year…The pillars of the U.S. strength have become seriously shaky in the world, especially in the Middle-East."[178]

For all their occasional hype, such statements show that Iran views its ballistic missiles as a critical component of its national defense, and stresses that an effective ballistic missile program provides the country with increased strategic and asymmetric capabilities. Iranian officials regularly refer to their conventionally armed missile forces as an effective deterrent to attack, and the Iranian leadership is not shy about its country's advancements concerning ballistic missile technology. High-ranking officials in Iran's political and military establishments regularly boast of their country's progress in this field.

Ballistic missiles have been prominently displayed at parades and public functions, with video footage of drills given prominent showing on public TV. The Iranian government has made a concerted effort to link the missile effort with the state, turning the space/missile program into a national issue. This effort has the effect of not only rallying the public around further research and development efforts in ballistics, but also demonstrating to the West that putting the lid back on the program will be nearly impossible due to domestic concerns.

## *Key Uncertainties in Making an Assessment*

It is not easy to provide a clear picture of any aspect of Iran's diverse and constantly changing programs, although the key trends in Iran's overall programs do not change as often as systems names and performance specifications. Iran has clearly learned the advantages of using weapons developments, tests, and exercises as a form of propaganda. These are strategic communications that enhance its ability to deter and intimidate. It has also become clear that truth is not only the first casualty of war, but the first casualty of effective strategic communications in peace time.

### A Range of Estimates

Then result is that Iran has added a "fog of missiles" to the "fog of war," However, while the end result is that much of the unclassified data are uncertain or based on conflicting nominal estimates, the following figures provide snapshots of different maps of the estimate range of longer-range Iranian missiles, and are certainly correct in showing a steady increase in real-world capabilities:

**Figure 19** provides an outline picture of some of Iran's missile systems.

**Figure 20** provides tables summarizing CRS and IISS and other estimates of the names, fuel types, estimated ranges, and likely payloads of the missiles in Iran's arsenal, and a table describing Iran's current missiles

**Figure 21** shows a map with a 2005 estimate of the ranges of Iran's ballistic missiles.

**Figure 22** provides relatively conservative 2012 estimate of the range of Iran's missile forces. According to the BPC's estimate, Iranian missiles could potentially strike Athens, Bucharest, or Moscow.

**Figure 23** shows a 2012 estimate that highlights the importance of different Iranian launch sites.

**Figure 24** provides a 2014 estimate of Iran's missile ranges by Dr. Abdullah Toukan.

**Figure 25** graphs estimates of the range-payload capabilities of Iran's MRBMs and IRBMs.

### A Matching Range of Uncertainties

It is all too clear from a comparison of such estimates that even a limited selection of unclassified sources does not provide a reliable basis for estimating how effective Iran's medium and longer-range systems really are. In some cases, even Iran may not have reliable data because it simply has not conducted enough tests of the same system in the same configuration.

While the performance of shorter-range systems like unmodified versions of the Scud B is based on a well-established and largely public record, this is not true of many aspects of the capabilities of Iran's longer-range and more developmental missile programs. Many aspects of Iran's missile programs change on an opportunistic basis. Iran has not conducted extensive, realistic missile tests at full operational ranges and carried through to strikes on target with the same configuration of its modified or Iranian-produced missiles to make reliable estimates of their war fighting capability.

A Council on Foreign Relations report on Iran's ballistic missile program notes that:

> Defense analysts say despite Iran's public pronouncements and frequently publicized test firings, assessments of Iranian hardware are largely speculative. Indeed, many Western reports offer contradictory findings, with different missile names, ranges, inventory numbers, and other characteristics for even the most commonly cited systems. The Federation of American Scientists, an advocacy group that promotes disarmament, for instance, estimates the maximum range of the liquid-fueled workhorse of the Iranian arsenal, the Shahab-3 medium-range missile, at 1,500 kilometers, while Missile Treat.com, a project of the conservative Claremont Institute, puts the maximum range at 2,500 kilometers.[179]

Some performance data are based on data drawn from comparable foreign systems - SCUD-B for Shahab-1, SCUD-C for Shahab-2, and Nodong for Shahab-3 - but these estimates often do not take into account any further upgrades Iran may have made of missiles, or the impact over time of local weather, age, and maintenance by unfamiliar technicians on their electronics, guidance systems, and propulsion. These problems are complicated by the fact that Iran has a tendency to introduce similar missiles under different names, exaggerate missile performance, exaggerate the number of missiles used in tests, and actively doctor reports of firings and their results.

## Unrealistic Accuracy Estimates

As is the case with Iran’s shorter range missile systems, most of the unclassified data on the structure of Iran’s missile forces and the technical performance of its longer range missiles rely heavily on engineering estimates and guesstimates about deployed force numbers, force structure, command and control, and readiness. Such estimates also tend to reflect ideal rather than operational conditions. Launching a weapon from a sanitized testing facility may bear only limited little relation to what may happen in the field under the stress and confusion of battle. While factors such as storage conditions, improper fueling, and local engineering will affect the range and maximum payload, mistakes by the launching crew - as well as mechanical defects - are also likely to reduce the accuracy of the weapon.

Iran has not conducted anything like the number of tests needed to establish reliability or accuracy using a derived aim point rather than a theoretical engineering estimate of CEP. This lack of large-scale testing eliminates Iran’s ability to calibrate the accuracy of its systems using valid real world statistical test results versus an estimate based on a few tests and design data. It also means Iran faces problems in compensating for the earth’s rotation and irregularities in its shape.

A number of past tests ended in the missile being destroyed before it hit a land target. While Iranian scientists can compare the actual flight path to the expected route - an option not available to foreigners - they lose out on data about the missile’s final approach to its target. Iranian engineers have also faced difficulty addressing natural factors, as flights over the Indian Ocean have encountered weather and geological complications that have restricted useful test data.

US experts indicate that Iran has rarely fired its longer-range missiles at their maximum claimed range. Although two Shahab 3s were fired into the Indian Ocean the launches were evidently more a test of range than a part of a well-structured effort to determine accuracy. Iran also tends to fire off its older missiles, rather than its latest inventory. Experts indicate, for example, that Iran’s newer, longer-range versions of the Shahab 3 seem to be much improved over its earliest deployed versions.

Much of the technical literature on Iranian systems has serious limitations in that it uses standard specifications for nominal warhead weights that have nothing to do with the actual warhead on a real world missile. Many unclassified range estimates use a nominal 1,000 or similar kilogram payload that bears no relation to the actual payload. This casts serious doubt on both the range-payload data and the ability to make an estimate of warhead lethality. **Figure 25** illustrates this point by showing estimated range-payload charts, and the trade-off between warhead size and distance, but these projections are based on technical models and guesstimates about some of the input data, and not hard test data.

## Nominal Warheads Are Not Real Warheads

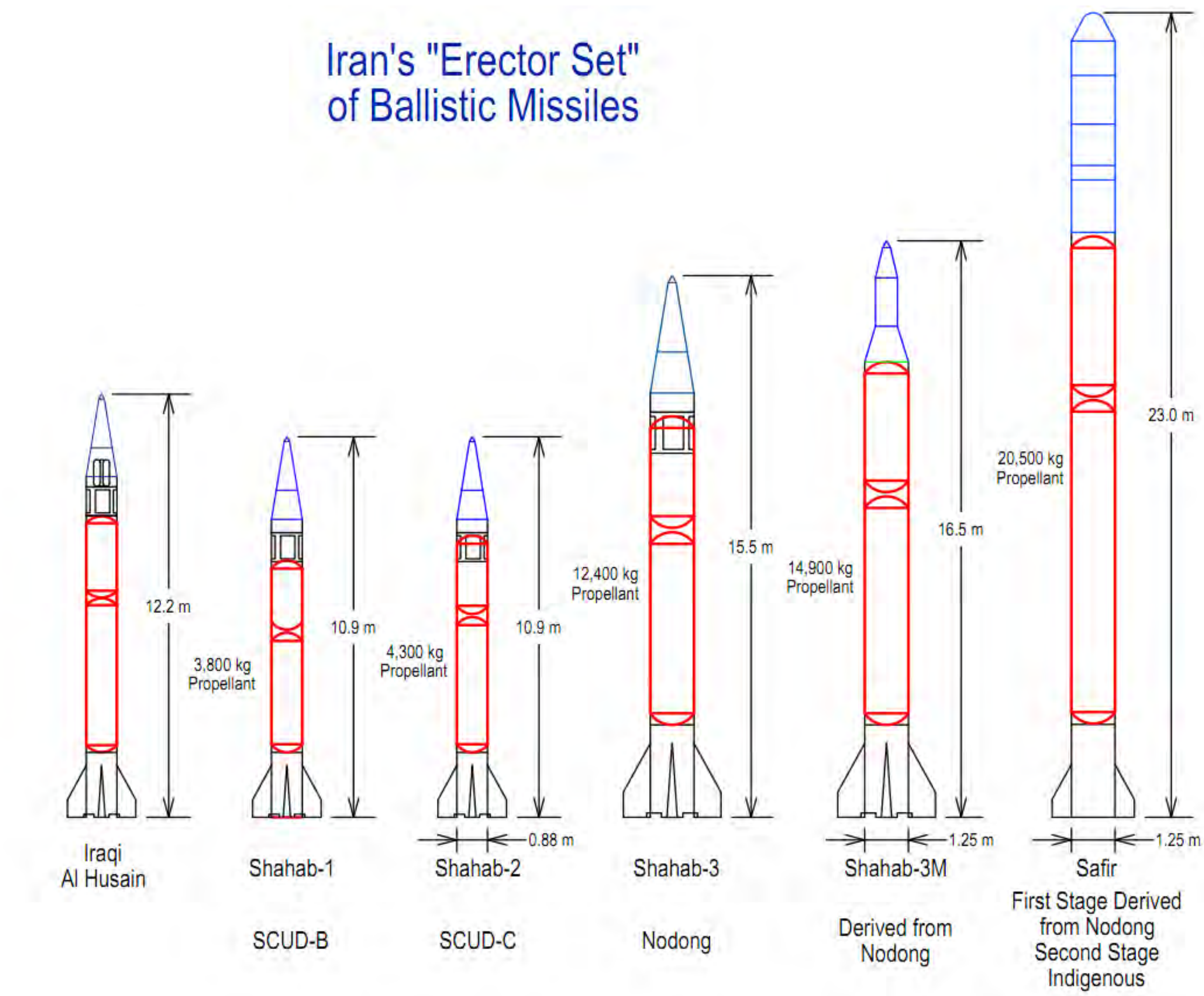
Most warhead specifications also imply Iran is launching missiles with unitary warheads - which would generally limit the lethality of missile warheads to about one-third of the impact of a bomb with similar weight of explosive because of the upward vectoring of the explosion as the missile hits at high velocities. They feel Iran does not have chemical warheads for such missiles or effective submunitions. However, it is unclear if there are a reliable unclassified sources on the details of Iranian developments in submunitions and missile accuracy, both of which could increase lethality.

These data problems are particularly important in light of events like the Qiam launches in July 2012, where Iran claimed to have demonstrated both a superior warhead and improved guidance systems, but may actually have changed very little. Experts say on background that they have not seen evidence that Iran has deployed stocks of advanced or highly effective high explosive or chemical munitions, guided or homing submunitions, or effective fusing and dispersal systems. Iran may have used submunitions during the testing of a Shahab 3 missile in January 2014 that ended with in-flight failure. A submunitions test the following month was deemed successful by Iran but Iran did not provide any details.

Finally, Iran keeps changing other key aspects of its longer-range systems like warhead shape as it moves towards long range systems with payloads large enough to either hold a CBRN weapon or a far more sophisticated conventional warhead. This affects range-payload, accuracy and stability, and warhead lethality but Iran rarely provides details.

It is scarcely surprising under these conditions that that unclassified reports are often contradictory and provide a very limited understanding of new classes of Iranian missiles. For instance, Iran has touted the positive development of its modified Fateh-110, in which it installed an anti-radiation seeker, alleging that it provided an all-weather strike capability that made it useful for targeting specific radar-emitting land-based and maritime targets. Iranian press has reported that the modifications add to the improvements in guidance and accuracy to its short-range arsenal that may or may not have been made.

***Figure 19: Iran's "Erector Set" of Ballistic Missiles***




Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential," JTA, May 6, 2009.

## *Figure 20: Elements of Iran's Longer Range Ballistic Missile Arsenal – Part One*

| | |
|---|---|
| **Shahab-3 ("Meteor")** | 800-1.300km range. The Defense Department report of April 2010, cited earlier, has the missiles as "deployed." Still, several of its tests (July 1998, July 2000, and September 2000) reportedly were unsuccessful or partially successful, and US experts say the missile is not completely reliable. Iran tested several of the missiles on September 28, 2009, in advance of the October 1 meeting with the P5+1.[180]<br><br>IHS Jane's and Missile Threat mention two variants of the Shahab 3, the Shahab 3A with 1500-1800 km range, and the Shahab-3B with 2000-2500km range. Regardless of whether or not these variants actually exist or are deployed, a longer range missile will require the overall weight of the missile to be reduced if a stronger propellant cannot be obtained. Reducing the size of the warhead is an obvious way to lighten the missile. |
| **Shahab-3 Variant** | 1,500-1,800km range. The April 2010 Defense Department report has the liquid fueled Shahab-3 "variant" as "possibly deployed." This is a single stage, liquid-propelled MRBM. Iran is thought to have 45 mobile launchers and 10-12 fixed launchers, as well as approximately 650 airframes. A variant of the Shahab-3 is known as the Emad. It is essentially a Shahab-3, but with a maneuvering reentry vehicle to improve system accuracy and complicate missile defense. |
| **Sejjil** | A two-stage, solid fuel missile, called the Sejjil, is considered "not" deployed by the Defense Department. The Sejjil is alternatively called the "Ashoura." The Ashoura was actually renamed the Sejjil, but Western sources still use the old designator on occasion. These missiles potentially put large portions of the Near East and Southeastern Europe in range, including US bases in Turkey. It is thought to have a range of 2,000 km, with 10-12 mobile launchers and 24 airframes. As of 2014, further production of the Sejjil remained uncertain. The Sejjil-2 MRBM is the follow-on model of the Sejjil missile that may have accuracy improvements, though information is not available in open sources. It is unclear if Iran has field tested the Sejjil-2. |
| **Ghadr (Qadr/Ghadir)** | Naming conventions for the Ghadr missile are very confusing. Sources have made reference to at least five Ghadr missile variants. The Ghadr-101, the -110, the Ghadr F, and the Ghadr H. The Ghadr F may have been renamed the Ghadr H, and the Ghadr-1, Ghadr-101, and Ghadr-110 may actually be the same missile.<br><br>There is also debate on the types of fuel used by the Ghadr "family." Missile Threat describes the Ghadr as having a liquid first stage and a solid second stage. Another source translated a placard at an Iranian military exhibition that described the Ghadr F as a liquid fuel missile.[181] Most sources agree that the Ghadr missile is derived from the Shahab 3 and is an MRBM.<br><br>Missile Threat and IHS Jane's both describe the Ghadr as having a range of about 1800-1900 km and a triconic warhead. This could be the upper stage of the Ghaem ICBM. On March 5, 2014, Iranian media reported on a ceremony where the IRGC accepted a mass delivery of Ghadr H missiles along with Qiam SRBMs, as well as Fateh-110-D SRBMs and Khalij Fars ASBMs. [182]<br><br>***The UN Panel of Experts report issued in June 2014 reported that, "One State recently informed the Panel that the Islamic Republic of Iran tested Ghadr 1 missiles on two occasions over the past year, in November 2013 and January 2014. The Panel has no additional information in this regard.[183] |

**Other Missiles**

On September 6, 2002, Iran said it successfully tested a 200-mile range “Fateh-110” missile (solid propellant), and Iran said in late September 2002 that it had begun production. Iran also possesses a few hundred short-range ballistic missiles, including the *Shahab-1* (Scud-B), the *Shahab-2* (Scud-C), and the *Tondar-69* (CSS-8). In January 2009, Iran claimed to have tested a new air-to-air missile. On March 7, 2010, Iran claimed it was now producing short-range cruise missiles that it claimed are highly accurate and can destroy heavy targets. At a February 8, 2011 press conference, IRGC chief Mohammed Ali Jafari announced that Iran had developed the Khalij Fars (“Persian Gulf”), a “smart” anti-ship ballistic missile based on the Fateh-110 that is allegedly able to hit high-value targets throughout the Gulf. The missile can be identified by the electro-optical seeker at the tip of the nosecone. There is also a missile known as the Emad-1 MRBM, with 1700km range, 500m accuracy, and 750kg payload. It is a variation of the Shahab-3 MRBM. It is Iran’s first maneuvering reentry vehicle equipped system (to improve accuracy), liquid propelled, equipped with SATNAV, and reported to be slated for deployment sometime after 2016. To date, there are no indications testing has occurred. Note: The CEP is a dramatic increase over the Shahab-3’s CEP of approx. 2,000m.

**Space Vehicle**

Iran’s space launch vehicle (SLV) program first came to light in 1998 with a modified Shahab-3. At that time, not much was known about the program, especially since it was hidden from public view for several years. In 2004, Iran established the Iranian Space Agency with the purpose of supporting “all the space activities for peaceful application and technology under the leadership of Iran’s president.”[184] Furthermore, its goals are to “define and implementation of space research policy aiming peaceful purposes, manufacturing, lunching and using indigenous satellite, and increasing the partnership with private and corporative sector.”[185] It wasn’t until 2007 until Iran launched their first SLV, the Kavoshgar, which the regime hailed as a success.[186]

Despite the stated intentions and goals, the launch of the Kavoshgar and Iran’s SLV program in general are thought to be covers for further development of Iran’s ballistic missile capabilities.[187] Iran’s capabilities are extensive. In February 2008, Iran claimed to have launched a probe into space, suggesting its missile technology might be improving to the point where an Iranian ICBM is realistic. Following an August 2008 failure, in early February 2009, Iran successfully launched a small, low-earth satellite on a Safir-2 rocket (range about 155 miles). The Pentagon said the launch was “clearly a concern of ours” because “there are dual-use capabilities here which could be applied toward the development of long-range missiles.” Additionally, Iran has embarked on an ambitious satellite launch program since early-mid 2011. The Safir SLV is a two-stage, liquid propelled rocket designed to place 50-75 kg satellites into low earth orbit at approximately 475-500 km. To date, there are indications that Iran has conducted approximately 9 tests of the Safir SLV since an initial failure in 2008, though Iran is unwilling to publicly acknowledge failures as failures. Of the 9 launches, 6 have been successful and three have failed. Iran is also working on the Simorgh SLV. Iran could employ the Simorgh as a ballistic missile, allowing its booster to reach ICBM ranges. However, Iran still requires a reentry vehicle capable of surviving ICBM ranges. Much work remains to be done including completion of the launch site, possibly in 2014, likely in 2015 and additional engine tests. Iranian press has indicated that Iran plans to launch 3 satellites using the Simorgh from March 2015 to March 2016.[188] A UN Security Council report states that the expansion of Semnan Space Center may accommodate Simorgh SLV, and that the Simorgh project will “intensify” once the Semnan construction is complete.[189]

A lack of credible, open source information about Iran’s SLV capabilities makes it hard to gauge the threat it poses to peace and security. A larger rocket under development, the Qoqnoos (Phoenix), has been mentioned by Iranian officials. However, official details about the rocket are unknown. Similarly, it is speculated that Iran has the capability to launch a “manned suborbital mission by 2016 and the rollout of SLVs capable of setting satellites into 36,000km of

geosynchronous orbit."[190] In other words, Iran seeks to place geostationary satellites, most likely used as communication satellites for weather forecasting, satellite radio, and other similar purposes. The reason this information is unknown is due to Iran's "long history of announcing satellite launch targets that it then fails to meet."[191]

Regardless, such type of technological development in Iran's rocket booster capabilities is worrisome. After all, if Iran could launch a rocket carrying a communications satellite, what is to prevent it from launching a rocket with a different payload, like a nuclear warhead?

**Warheads** A *Wall Street Journal* report of September 14, 2005, said that US intelligence believes Iran is working to adapt the Shahab-3 to deliver a nuclear warhead. Subsequent press reports say that US intelligence captured an Iranian computer in mid-2004 showing plans to construct a nuclear warhead for the Shahab. The IAEA's report in 2011 noted Iranian efforts to develop and/or procure components needed for the construction of a nuclear warhead. Some of these include explosive bridgewire detonators, neutron emitters, radiation detection and measuring equipment, high speed electronic switches, and spark gaps.

Sources: Updated in part by the authors and based on Kenneth Katzman, "Iran: US Concerns and Policy Responses," Congressional Research Service, February 14, 2011; Iranian reporting; IAEA "Implementation of the NPT Safeguards Agreement and relevant provisions of Security Council resolutions in the Islamic Republic of Iran," November 8, 2011.

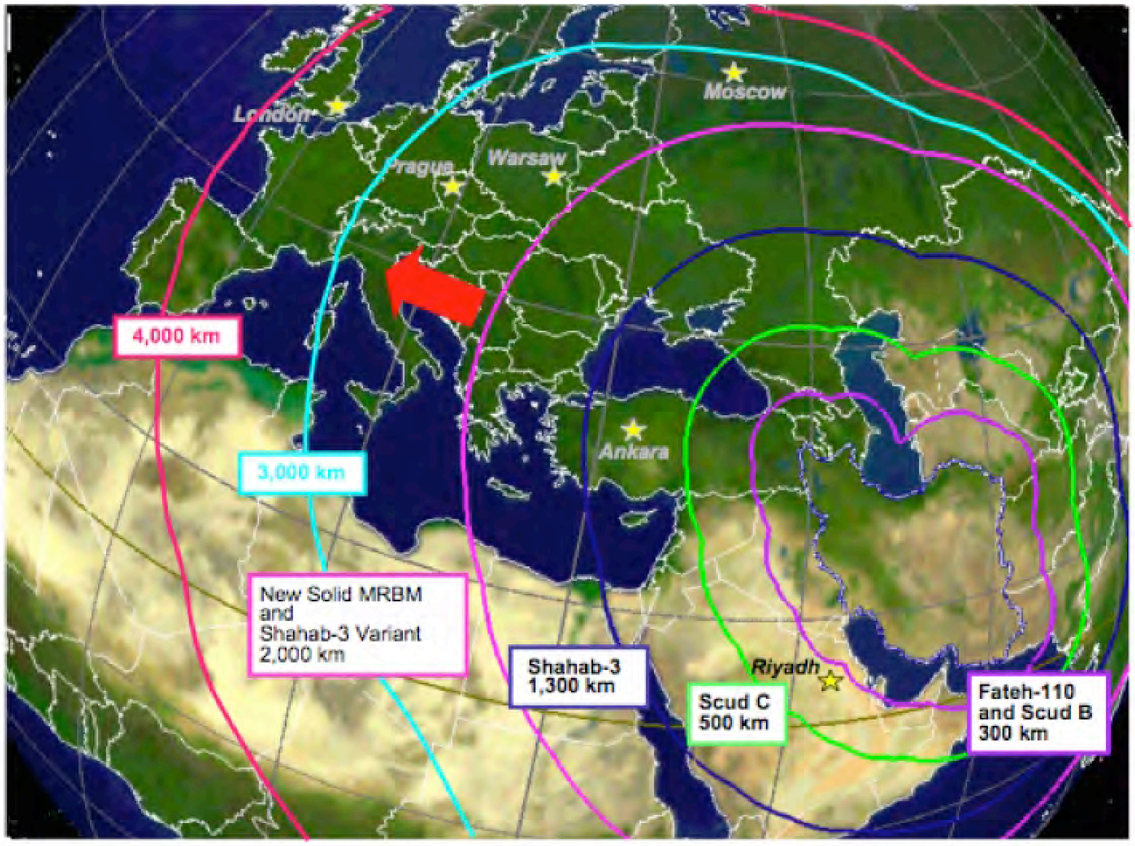
***Figure 20: Possible Elements of Iran's Longer Range Ballistic Missile Arsenal – Part Two***

| **Missile** | **Translation** | **Fuel Type** | **Estimated Range** | **Payload** |
|---|---|---|---|---|
| Fajr-3 | *Dawn-3* | Solid | 45 km | 45 kg |
| Fajr-5 | *Dawn-5* | Solid | 75 km | 90 kg |
| Fateh-110 | *Victorious* | Solid | 20 km | 500 kg |
| Ghadr-1 | *Powerful-1* | Liquid | 1600 km | 750 kg |
| Iran-130/Nazeat | *Removal* | Solid | 90-120 km | 150 kg |
| Kh-55 | | Liquid | 2500-3000 km | 400-450 kg |
| Nazeat-6 | *Removal-6* | Solid | 100 km | 150 kg |
| Nazeat-10 | *Removal-10* | Solid | 140-150 km | 250 kg |
| Oghab | *Eagle* | Solid | 40 km | 70 kg |
| Sajjil-2 | *Baked Clay-2* | Solid | 2200-2400 km | 750 kg |
| Shahab-1 | *Meteor-1* | Liquid | 300 km | 1000 kg |
| Shahab-2 | *Meteor-2* | Liquid | 500 km | 730 kg |
| Shahab-3 | *Meteor-3* | Liquid | 800-1000 km | 760-1100 kg |
| Shahin-1 | *Hawk-1* | Solid | 13 km | |
| Shahin-2 | *Hawk-2* | Solid | 20 km | |
| Zelzal-1 | *Earthquake-1* | Solid | 125 km | 600 kg |
| Zelzal-2 | *Earthquake-2* | Solid | 200 km | 600 kg |

Source: 2010 IISS Iran's Ballistic Missile Capabilities: A Net Assessment.

Note: This table does not include other missiles, such as the Qiam-1 SRBM, the Khorramshahr MRBM, or the Badr-313 SRBM.

***Figure 21: Estimated Range of Iranian Long-Range Missile Forces – NASIC, March 2005***

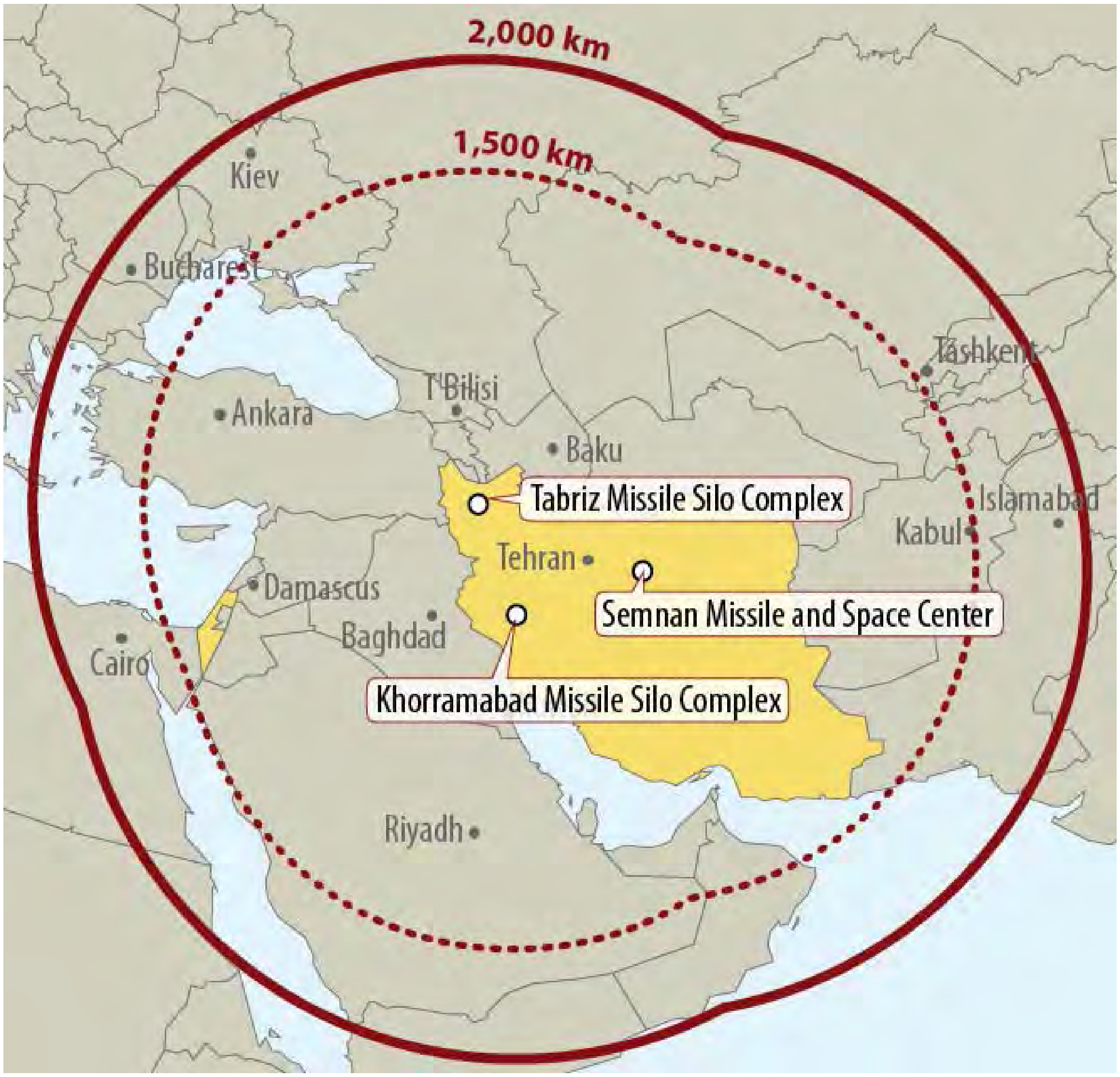



Source: NASIC, B&CM Threat 2006, Jacoby Testimony, March 2005.

***Figure 22: Estimated Range of Iranian Long-Range Missile Force – BPC, February 2012***

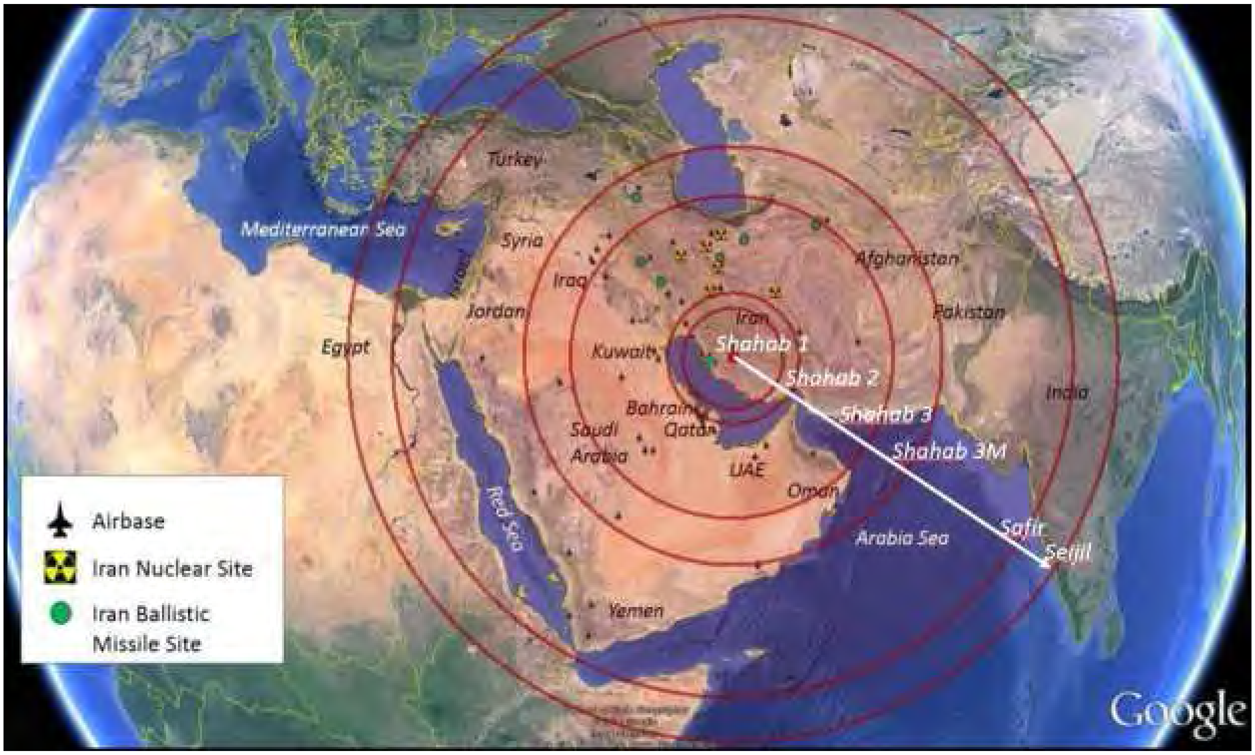

Source: Bipartisan Policy Center, “Meeting the Challenge: Stopping the Clock,” February 2012. http://www.bipartisanpolicy.org/sites/default/files/BPC%20Iran%20Report.pdf.

***Figure 23: Estimated Range of Iranian Long-Range Missile Forces – CRS, December 2012***



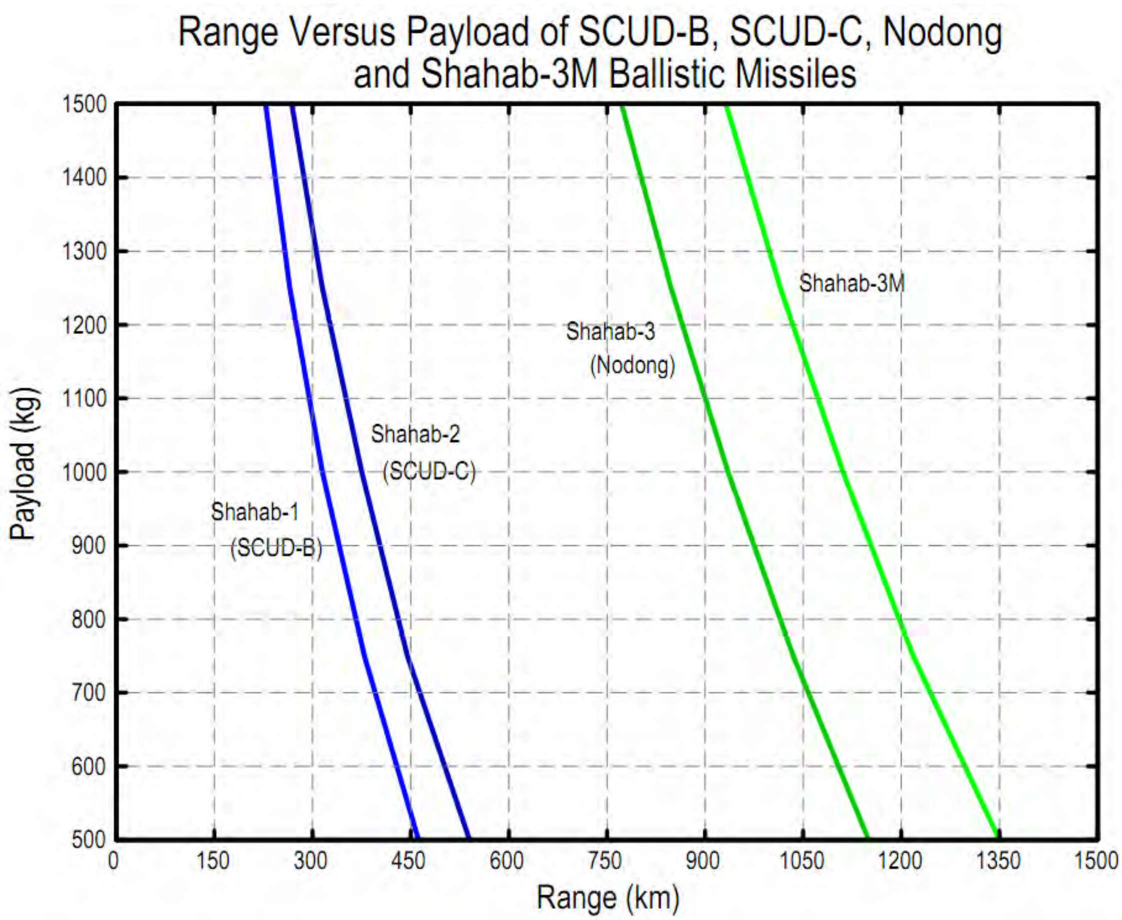

Source: Steven A. Hildreth, *Iran's Ballistic Missile and Space Launch Programs*, Congressional Research Service, December 6, 2012.

***Figure 24: Estimated Range of Iranian Long-Range Missile Forces – Abdullah Toukan, September 2014***



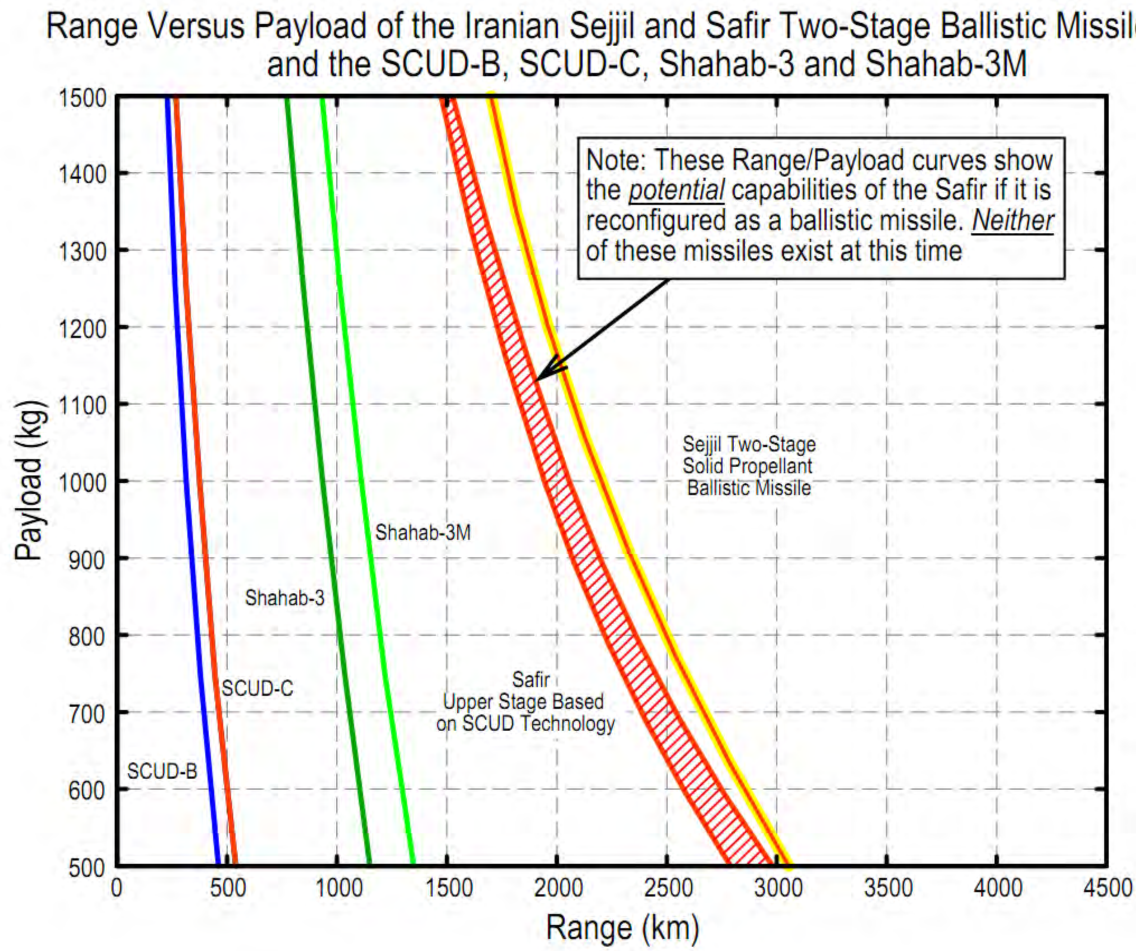

Source: Abdullah Toucan, September 9, 2014.

***Figure 25: Range-Payload Relationship for Active Iranian Missiles – Part I***




Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential," JTA, May 6, 2009.

***Figure 25: Range-Payload Relationship for Active Iranian Missiles – Part II***




Source: Theodore Postol, *A Technical Assessment of Iran's Ballistic Missile Program*, from "Technical Addendum to the Joint Threat Assessment on the Iran's Nuclear and Missile Potential," JTA, May 6, 2009.

## *Assessing Iran's Individual Longer Range MRBMs and IRBMs*

As **Figures 20** to **Figure 25** have shown, Iran possesses two major categories of longer-range ballistic missiles. The first category includes Iran's medium-range ballistic missiles (MRBMs), such as the Shahab-3, its longer- range variants, the Sejjil, and other systems. There is a great deal of reporting on individual systems. Reliable data and estimates are often lacking. As is the case with many of its major weapons development efforts, Iran has made longer-range missile development programs a propaganda issue.

### *Shahab-3*

The Shahab-3 is based on the North Korean Nodong-1, has a range of roughly 1,000 km, and can potentially reach targets throughout the Middle East. Iran's other MRBMs can reach up to 2000 km.[192] The original Shahab-3 has since been upgraded by Tehran to increase its range and potentially the versatility of its warhead. These versions - which may include the Shahab-3A, Shahab-3B, Shahab-4, and Ghadr-1 - may all be similar versions of the same missile. They may be incremental improvements of which only the latest has entered production, or distinct weapons for different missions.

Despite the similarity in nomenclature, the Shahab-3 is a very different weapon than the Shahab-1 and 2. Although liquid-fueled and road-mobile, the Shahab-3 is derived from the North Korean Nodong, which some experts believe is derived from Soviet submarine-launched ballistic missiles. Designed as a medium-range ballistic missile, its exterior is essentially a SCUD-B that has been stretched by a factor of 1.4 in every dimension, with an advanced engine based off the Soviet SS-N-4 SLBM.[193] Its increased range, greater payload capacity, and Iran's sizeable holdings of the Shahab-3 make it the most formidable ballistic missile class currently deployed by Iran for Middle East operations.

Sources contain differing or contradictory information, and often use a nominal payload and optimal guidance data, rather than real-world performance. The result is that this weapon is less dangerous in a war zone than the statistics would suggest.

According to Dr. Postol, a Shahab-3 with a 1000 kg warhead has a range of 930 km, while the 2010 DOD report and FAS suggest 800 mi (1290 km), Missile Threat estimates 800 to 1300 km, and Dr. Elleman, for a 1000 kg warhead, gives the range as 800-1000 km.

Missile Threat recognizes these problems in what seems to be one of the most accurate summaries of the variants in the Shahab 3 program:

> The lack of reliable information, especially when combined with the confusing list of alternate names, has made the separate specifications for the Shahab 3 variants almost impossible to sort out. Photos have confirmed the existence of variants and observing test launches of externally modified Shahab 3 missiles, but which project/missile name belongs to each specific modification is less clear.
>
> Based upon known tests and photographs, the Shahab 3 has undergone the following modifications:
>
> - Size reduction of rear fins.
> - Material replacement of fuselage (aluminum in place of steel) to reduce weight.
> - Overall reduction of warhead mass.
> - Lengthening of airframe to allow for longer fuel tanks (and additional fuel).
> - Replacement of navigation and guidance systems.

- Redesign of the RV/warhead unit, giving the nose cone a "baby bottle" shape that allows for a higher re-entry velocity and possibly an airburst detonation (necessary for EMP).

> Known and supposed modifications have led experts to suggest that the newer missiles have a range of 1,500 to 1,800 km**…**Some sources suggest that later versions are capable of reaching 2,500 km**…**Of course, the additional range bears a heavy cost on payload, and most experts place the maximum payload of Shahab 3 variants around 800 kg**…**Given RV design requirements, an 800 kg payload could be expected to carry a 500 kg warhead. The combination of reduced fuselage weight and increased fuel capacity provide the Shahab 3 variants with about the same launch weight as the original Shahab 3. The increased fuel may increase overall launch weight by as much as 1,000 kg, but the extra ten seconds or so of burn-time give the missile a significantly increased range…
>
> The original Shahab 3 had a separating RV-unit that gave the missile a standard, conical nose cone. The Shahab 3 variants employ a modified RV that gives the missiles a baby bottle-shaped nose cone. More exactly, the RV consists of a small cone attached to a cylinder that connects to the body of the missile (the single stage engine) with metal skirting.
>
> The new design is probably capable of faster re-entry speeds, thus making it more difficult to target with anti-ballistic missile systems. The changed design may also make it possible for the warhead to detonate high above a target….Though an airburst detonation may improve a ballistic missile's ability to disburse chemical or biological weapons, its most effective use is with a nuclear warhead. A nuclear warhead, when detonated high in the atmosphere, creates an EMP that is potentially more devastating than a conventionally employed nuclear warhead.
>
> Some reports have suggested that the newest variants of the Shahab 3 employ solid fuel…Such a modification would represent a great improvement to the overall Shahab 3 program and an incredible development in Iranian missile technology. Solid fuel allows missiles to be stored and transported while fully fueled and ready to launch; thus the missiles can be quickly and easily launched. Less secure launch locations - on the border of Iran and Iraq, for example - also become more feasible as the decreased launch time lessens the time that a launch crew is vulnerable to enemy fire. Since a solid-fuelled missile requires no pre-launch fueling, the size of a launch crew is also greatly reduced, as fuelling vehicles and fire-safety equipment are no longer necessary.
>
> The Shahab 3 missiles were tested in July 2002, August 2002, and July 2003 may have been Shahab 3 variants. Since that time, Shahab 3 variants have been tested in August 2004, September 2004, October 2004, January 2006, March 2006 (possible), May 2006, and November 2006…It is believed that the earliest Shahab 3 variants reached operational status in 2007. The Iranian space program, which appears to use Shahab 3 missiles or Shahab 3 technology, tested rockets in February 2007 (probably a failure), February 2008, and August 2008. In February 2009, Iran successfully placed a satellite in space aboard the Safir-1. Though the space program represents significant advances in the Iranian program, the rocket used in the 2009 launch is not capable of delivering a warhead at ICBM range (unlike the Russian rocket used to put Sputnik in space). [194]

Hildreth describes the Shahab 3 and possible variants as follows: [195]

> The Shahab-3 is a ballistic missile imported from the DPRK and based on the No-dong 1. Iran may have "purchased a production line for these missiles in the early 1990s and is now manufacturing them rapidly," according to one expert….The Shahab-3 has been given various names by Iran and others over time. There reportedly have been several different versions of this liquid-fueled missile flight tested with various other modifications made to it, perhaps providing the Shahab-3 with ranges varying from about 800 – 1,000 km.
>
> **…**Because the range of the Shahab-3 lies at the low end of an MRBM, Iran has sought to develop, test and deploy a much longer-range ballistic missile…. It has sought to do this with both liquid-fueled missile programs based off the Shahab-3, such as the Ghadr-1 or Kadr (or Kadr F), and a separate solid-fuel missile such as the Sejil or Ashura.
>
> Iran first pursued a number of efforts to extend the range of the Shahab-3 with mixed test results. One expert wrote that "there are indications that perhaps as many as one-half of them [Shahab-3 tests] failed."71 Some have variously referred to this as an extended range or modified Shahab-3 Ghadar-1. Range estimates for this missile vary widely, from 1,000 km to 2,000 km. Such range differences could in large part be explained in

> terms of ranges associated with payloads of different weights.
>
> This missile reportedly carries a smaller payload than the Shahab-3, includes a lighter airframe for greater distances, and has "an improved guidance system and uses a triconic aeroshell geometry that provides greater aerodynamic stability."…The Ghadar-1 design, "almost certainly includes a separating warhead," could provide the capacity "to carry airburst warheads, or warheads containing submunition packages."… It was reported in 2006 that some Western intelligence experts believed Iran had been able to modify the nose cone or reentry vehicle (RV) of the Shahab-3 with Russian and Chinese assistance. An identical RV was twice displayed on No Dong missiles in North Korean parades, so it may have been designed by North Korea.
>
> One source says that "instead of the single cone normally attached to this type of missile, the new Shahab has three cones, or a triconic, warhead. A triconic warhead allows the missile to accommodate a nuclear device and this type of warhead is normally found only in nuclear weapons."…But others have suggested the triconic RV may be less suitable for a nuclear payload than the previous conical RV associated with the older Shahab 3, and may instead be designed for higher accuracy that may indicate a nonnuclear mission. But none of this has been officially confirmed in Iran. U.S. and other intelligence reports indicate that Iran apparently has not made the decision to develop a nuclear weapon, but developments such as these cause concern among many decision makers and observers.

Tests of the Shahab have often been announced with little real data on its performance or purpose. There are exceptions: Arms Control Today reported in June 2013 that Iranian Defense Minister Ali Shamkhani stated on May 26 that Iran had successfully completed a fourth test of the Shahab-3 medium-range ballistic missile in mid-May 2013. The IRNA report also quoted Shamkhani as stating that Iran would continue its missile program "in order to promote the power and precision of the Shahab-3 missile," and that the tests were carried out "to upgrade the missile and are not regarded as a new production or step toward increasing its range." He added that despite the test's success, Iran "is not intending to build new missiles under the names of Shahab-4 or Shahab-5, as claimed by the Americans." However, Shamkhani had previously called for development of a Shahab-4 with space-launch potential and has mentioned plans for a longer-range Shahab-5 missile.[196]

*Arms Control Today* reported that. "With a range of 1,300 kilometers when equipped with a 700-kilogram payload, the liquid-fueled, road-mobile Shahab-3 can potentially target all of Israel with weapons of mass destruction…." A US State Department spokesman had said earlier on May 16th, 2013, that the administration continues to have "serious concerns" about the missile program, and that the United States viewed "Iran's efforts to further develop its missile capabilities, including flight testing of missiles, as a threat to the region and to U.S. interests" and said that Washington will "continue to actively pursue extensive efforts to stop the proliferation of missile technology and equipment to Iran."

Reports of tests of the Shahab 3 continued through 2013, although little is known about the exact nature of such tests. Syrian news showed launches of the Shahab-1, 2, and 3 on February 23, 2013.[197] Other sources reported new tests of the Shahab 3 and Ghadir 1 in May and November 2013, but did not provide clear details.

The uncertainties in the unclassified data on the Shahab's performance and that of its possible variants illustrate both the difficulties in dealing with a key Iranian system and the broader problems in analyzing the Iranian missile effort. There have been too few tests for Iran to have a credible picture of accuracy and reliability based on empirical data and derived aim points. The Shahab has been in development since well before 1998, when it was first shown in public. It only

had four tests before it was declared reading for deployment in November 2004 – none of which have been described reliably in unclassified literature.

Since that time, Iran has only conducted a limited number of tests and firings that have become public. The images of the Shahab also show steady changes in configuration that may have led to the development of more accurate Shahab 3B with enhanced penetration capability. Other reports of Shahab variants that go as high as a “Shahab 6.” Iran claimed in 2006 that these included cluster warheads with over 1,000 (1,400?) submunitions.

Unclassified sources make it clear that Iran has made progress in developing the capability to fire “volleys” of missile in a short period of time – although it has only done so in exercises where it could prepare for such firings long in advance. Similarly, there is unclassified imagery showing an Iranian attack on a mock-up of a US air base where missiles and or rockets hit the base with reasonable accuracy. However, some sources indicate that the “hits” may have been faked with preset explosives and that the hits would still have not been accurate enough to do serious damage.

Similarly, Iran has suddenly fired “tests” of the Shahabs that were a political response to missile tests by Israel without any clear technical purpose. Although Iran has made many claims about improved missile performance, some are known to be false, including TV images of multiple firings that turned out to be faked.

Perhaps the most reliable perspective is the one the Department of Defense provided in the unclassified version of its 2012 report to Congress on the Iranian threat. It stated that Iran’s missile and rockets had become more accurate, and some had submunitions.[198]

> Iran continues to develop ballistic missiles that can range regional adversaries, Israel, and Eastern Europe, including an extended-range variant of the Shahab-3 and a 2,000-krn medium-range ballistic missile, the Ashura.
>
> Beyond steady growth in its missile and rocket inventories, Iran has boosted the lethality and effectiveness of existing systems by improving accuracy and developing new submunition payloads.
>
> During the last two decades, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region.
>
> With sufficient foreign assistance, Iran may be technically capable of flight-testing an intercontinental ballistic missile by 2015.

US experts later made it clear, that these improvements did not give Iran anything like a precision strike capability, or the capability to carry out anything like the attacks Iranian officials and officers describe.

Iranian officers have made claims a far more advanced a precision strike capability, although these have not been clearly tied to the Shahab 3 or any specific type of Iranian missile. After the series of tests in July 2012, Iranian state media reported that,[199]

> “Within 10 minutes, a considerable number of missiles were fired at a single target. The achievement, called high firing density, makes it impossible for anti-missile systems to intercept and destroy them. In the end, the target is definitely hit”

An AP report following the July 2012 tests quoted Ismaeil Kowsari, a former Revolutionary Guard commander and member of the Majlis, as saying that, [200]

> “Our missiles are more accurate and lethal than ever…These achievements send clear signals to the West that Iran is a formidable force, making enemies think twice before making any decision to attack us.

At the same time, some Iranian claims reached the point of absurdity, such as those of General Amir Ali Hajizadeh, the head of IRGC's Aerospace Division. Hajizadeh claimed in July 2012 that Israel would "disappear from the Earth" if it attacked Iran. He also "warned that 35 American military bases in the Middle East are within Iran's missile range and would be destroyed within seconds after any U.S. attack on Iran." [201]

The quantitative unclassified estimates of the Shahab's accuracy are even more suspect. They reinforce and illustrate the general problems in assessing Iran's progress and capabilities. The FAS reports the Shahab's CEP as 190 meters, noting that Iran appears to have improved the accuracy over the past few years). Shifrinson and Priebe place the CEP between 1850 and 2500 m, and Global Security cites a Jane's Report that the CEP was 3 km for a series of tests in 2000. These latter estimates seem more likely to be accurate, and it should be noted that CEP only delineates the accuracy of 50% of the missiles, and does not take targeting and reliability factors into account.

There is no agreement on estimates of the number of Shahab-3 missiles. FAS believes that Iran has 20 Shahab-3 launchers, while Global Security estimates that Iran 300 Shahab-3 and Ghadir-1 missiles. Missile Threat says that Iran may have begun production of 12-15 missiles each year as early as 1998 (an assertion Dr. Elleman disagrees with[202]), potentially giving Iran 25-100 Shahab-3 in operation today, while Shifrinson and Priebe only estimate the number as being greater than 30. From other sources, it appears that Iran has approximately 650 Shahab-3 missiles with roughly 60 mobile launchers and 10-12 fixed launchers located at the IRGC's Al Ghadir Missile Command. IHS Jane's estimates that Iran has 25 Shahab-3's but it does not make clear whether it is referring to missiles or TELs.[203] IISS estimates the numbers of TELs at 6, while other sources provide no information. Iran does have silos that are capable of launching Shahab-3, although the number of operational sites is unknown.

### *Ghadr-1/F/H*

The Ghadr-1 - also called the Shahab-3B, the Shahab-3M, and the Shahab-4 - seems to be an indigenously improved version of the Shahab-3. Technical data are harder to establish for these weapons due to Iran's tendency to ascribe new names to the same weapons system, wide ranges in estimates on technical specifications for new launches, and deliberately obfuscation of technical details of some of its most important weapons programs. Although the variants of the Shahab-3 will be termed Ghadr-1 throughout this chapter, this weapon (or, more accurately, system of weapons) is closely related to the Shahab-3 and at this time should be treated as a similar missile. At least three variants of Ghadr missile have been seen: Ghadr-1, Ghadr-F, and Ghadr-H. According to Norbert Brugge, Ghadr-1 missiles could be distinguished by cable ducts that extended to the cone of the warhead. He also noted that the Ghadr-F was later renamed Ghadr-H and can be distinguished by cable ducts which stop short of the warhead cone, unlike the Ghadir-1. The Ghadir-F/H is also about 40cm longer than the Ghadir-1.[204] There have been conflicting reports about what kind of propulsion the Ghadir uses. *Missile Threat* noted that some reports described the Ghadir as a liquid first-stage and solid second-stage missile.[205] A defense exhibition in Iran displayed a missile with a placard describing it as a Ghadir-F missile with liquid propulsion.[206]

The Ghadir-1 is primarily distinguished from its predecessor by a longer body and a reshaped warhead. The elongated body uses the additional thrust from the SS-N-4's engines to carry more fuel, increasing the systems' range. The results of design changes in the nosecone are less certain.

While technical analysis estimates that the triconic shape will improve the stability of the reentry vehicle with a higher payload, reducing the CEP,[207] it is unclear whether the improved design will allow Iran to upgrade the type of warhead (i.e. facilitate the usage of cluster munitions or a CBRN device). [208] Missile Threat also suggests that Shahab-3 variants incorporate changes in fin design, lighter materials in construction of the body, and an overhaul of the navigation system, overall increasing the range and slightly boosting the accuracy.

According to Dr. Postol, armed with a 1000 kg warhead, the Ghadir-1 has a range of 1100 km. The 2010 DOD report proposes a maximum range of 1200+ mi (1930+ km), while Missile Threat estimates between 1500 and 2500 km and Dr. Elleman suggests 1600 km with a 750 kg warhead. The Arms Control Center suggests a similar range of 1100-1600 km. CEP is estimated to be slightly improved from the Shahab-3 original, with Missile Threat estimating 1000 m. No other unclassified estimates are available at this time.

There are no meaningful estimates of Ghadir-1 stockpiles either. Global Security's estimate of 300 and Missile Threat's estimate of 25-100 Shahab-3 and Ghadr-1 seem to be little more than guesstimates. A September 2013 military parade included 12 Sejjil and 18 Ghadir missiles, but this is hardly a definitive measure of missile stockpiles. Missile Threat does, however, provide an interesting summary of the Ghadir 1's possible history and the uncertainties surrounding it:

> The Ghadr-1 appears to be an improved variant of the Shahab-3A, also referred to as the Ghadr-101 and the Ghadr-110. There are mixed reports regarding the new missile. In 2004, it was believed to have a liquid-fuel first stage and a solid-fuel second stage…According to *Jane's Strategic Weapon Systems*, this would allow it to have a range of 1950 km. The length is thought to be 15.86 m, with a launch weight of about 19,000 kg. If reports regarding the Ghadr-1 accuracy are correct, then it would be a significant improvement of the Shahab 3 (2,500 CEP). A December 2008 report noted a CEP of 300 for the Ghadr-1. Reports also indicate the possibility that Ghadr could be designed to carry a nuclear payload. This possibility is raised with uncertainty as the Ghadr appears to be comparable to the Shahab system, whose apparent goal is to obtain such a payload.
>
> The Ghadr-1 is also believed to have a higher maneuverability than the Shahab-3. While some sources believe that it is the same missile as the Shahab 4, the higher maneuverability as well as the 30-minute set-up time, provide sufficient evidence to consider this a separate missile. Additionally, sources from 2007 report that the Ghadr 1 may have a significantly shorter stated range than originally projected in 2004. It remains classified as an MRBM and is now considered distinct from its shorter range, Shahab-3, and longer-range, Shahab-4, counterparts. Sources also indicate that the Ghadr-1 is being manufactured entirely in Iran at the top-secret Hemmat Missile Industries Complex….An article from December 2007, though, cites interaction between the German Intelligence agencies and Iranian nationals within German borders. The report states that on more than one occasion Iranian nationals have been held in conjunction with the smuggling of "dual use goods." These items are usually converted for their secondary use, military needs, in Iran after their transit from Germany. Reports indicate that these dual use goods were used in the development of the Ghadr-1 missile system…
>
> In December of 2004 the National Council of Resistance of Iran claimed ongoing research and ground testing of the Ghadr-1….In March 2006, the Paris-based Iranian opposition group, the National Council of Resistance of Iran (NCRI), claimed that Iran had ramped up its development of the Ghadr-1, allegedly 70 percent complete at the time. The NCRI added that the new missile was expected to be entirely complete in one year's time….Reports from October 2007 indicate that Teheran unveiled the Ghadr whose shape was very similar to that of the Shahab-3 MRBM…[209]

*Missile Threat* is also careful to qualify reports of a Shahab 4:

> The Shahab 4 has been mentioned in many media and intelligence reports over the last ten years. Unfortunately, those reports have frequently been contradictory and their sum does not provide a clear picture of the Shahab 4 missile project. The program, in fact, may not actually exist. Assuming that the missile is in development, it would probably borrow from the technologies of the Shahab 3 while improving performance

> characteristics to allow for greater range, a heavier payload, and increased accuracy.
>
> Though Iranian missile development has progressed dramatically in the last 15 years, many experts believe that the Shahab 4 borrows from foreign missile design. In keeping with the North Korea-Pakistan-Iran missile relationship, some speculate that the Shahab 4 is based off of the North Korean No Dong 2 or Taepo Dong 1 missiles or the Pakistani Hatf 5A. Other sources suggest that the Shahab 4 is based on defunct Russian technology from the SS-4 or SS-N-6….
>
> The No Dong 2 and the Hatf 5A are obvious comparisons with the Shahab 4. The Shahab 3 was based upon the same technology as the No Dong 1 and the Hatf 5, so it makes some sense that the improved versions of those missiles would form the basis of the newer Shahab missile. Of course, Iran has already greatly improved upon the Shahab 3, as discussed in the Shahab 3 variants entry. If the Shahab 4 is based upon the No Dong 2 and Hatf 5A, then it is probably one of the many Shahab 3 variants and not a separate project. Given the tendency of Iranian officials to name and rename projects, this conclusion is likely accurate.
>
> The SS-4 was 22.8 m long with a diameter of 1.65 m and a launch weight of 42,000 kg. Its 1,600 kg payload contained a single separating warhead. It used a single-stage liquid propellant engine and an inertial guidance system. The SS-4 had a range of 2,000 km (1,243 miles) and an abysmal accuracy of 2,400 m CEP. Depending on the similarity between the Shahab 4 and the SS-4, these figures may not be relevant. It is believed that the Shahab 4 will have an accuracy of between 2,500 and 3,500 m CEP and a range of between 2,000 and 3,000 km (1,243 to 1,864 miles)…
>
> The Soviet SS-N-6 bears similar specifications to the SS-4 and the projected specifications for Shahab 4, but with increased accuracy (1,000m CEP), greater range (2,500-4,000 km), and a lighter payload (1,200kg). Originally submarine launched, the SS-N-6 is believed to have been modified by North Korean, and finally adjusted and assembled by Iran for use as a land-based missile. At the fall of the Soviet Union, many of these SLBMs remained in operational condition. Reports indicate that one or more of these weapons made their way to North Korea before North Korea delivered some of these missiles to Iran…
>
> In 2003 Iran announced that it would close the Shahab 4 program in favor of an SLV program (Satellite Launch Vehicle)**...**Since that time, Iran has had some success with a domestic space program that has successfully put a small satellite into orbit. Regardless of the space program, however, talk of a Shahab 4 has not completely quieted and many believe that a missile with this designator is still in development. The Shahab 3 and its variants can hardly meet many conceivable range and payload objectives, so it seems reasonable to expect that a new missile is in development.
>
> If the Shahab 4′s reported range of 2,000 km range is correct, the missile will have the capability to target all of Israel, as well as Turkey, much of India, and US forces stationed in Iraq, Afghanistan, or the Persian Gulf. The missile could substantially increase the political and military leverage held by the Iranian government, especially if Iran develops a nuclear warhead.
>
> An additional threat is the possibility that Iran will give or sell its missile technology to rogue nations or terrorist organizations antagonistic toward the U.S. At present, Iran's missiles are stored and operated in underground sites under the complete control of the Islamic Revolutionary Guard Corps, which enjoys little outside supervision within Iran. General Mahmud Chahar Baghi of the IRGC stated in 2008 that any act of Israeli aggression would be retorted by the launching of 11,000 missiles within the first minute…
>
> The Iranian missile program has been shrouded in secrecy, deception, and the unknown. Iran obtains weapons of various design and origin, and frequently retains a single name and reclassifies its physical missile assets, which adds to the confusion. According to Defense Minister Najjar, when asked about the testing of the Shahab 4, "Names and titles are not important in this regard. The important point, though, is that we are proceeding according to our defense doctrine"…At present the future of the Iranian missile program is uncertain, but the existence of these missiles proves that ballistic missiles are no longer the purview of first world nations. If the US and its allies are to remain safe, they must deploy missile defense systems capable of undermining the effectiveness of these now ubiquitous offensive system[210]

Hildreth writes,[211]

> Various reports of a Shahab-4 surfaced in the 1990s and those missile designations are still used or mentioned on occasion. It appears, however, that whatever was intended originally, any "Shahab-4"missile effort likely

> led to the development of the extended-range Shahab-3 MRBMs or the Ghadr-1.
>
> In the late 1990s and early 2000s, other reports said Iran was developing a solid- or liquid-fueled, two- or three-stage MRBM or space launch vehicle. It is possible they once had a designation ofShahab-5 and Shahab-6, which continues to cause some confusion today. But, more likely these programs led to other ballistic missile and space launch programs in Iran today. One may have become or led to the Ashura/Sejil and the other may have become or led to the Safir space launch vehicle…When asked in a lengthy and seemingly rather open interview in 2006 about Iranian military exercises (‘Great Prophet’ IV) and Iranian ballistic missiles, then IRGC Commander Gen. Safavi said, “I’d prefer not to answer,” whether there were Shahab-4 and Shahab-5 missiles.

It is likely that the functional operational accuracy of all the Shahab-3 variants - as distinguished from their technical CEP - is over a thousand meters, meaning that its conventional significance is limited. While Iranian sources regularly talk about the precision of the system, Iranian officials generally call all missiles “precise” or “accurate,” and there are no hard data to suggest that the guidance packages have been substantially improved.

In March 2014, the IRGC-ASF held a ceremony to mark the delivery of Ghadr’s into “operational units.”[212]

### *Sejjil-2/Ashura*[213]

Iran is also developing additional MRBMs - most importantly the Sejjil. These systems could form the backbone of a strategic missile force that would allow Iran to conduct more effective strikes against population centers and area targets throughout the region, and deliver CBN weapons on distant targets. Future development in the MRBM/IRBM (Intermediate Range Ballistic Missiles) field is likely to be concentrated in solid-fueled designs.[214]

The Sejjil-2 (also called the Ashura, Ashoura, Sajil) ballistic missile was first tested on May 20, 2009, and represented Iran’s first solid-propellant two-stage ballistic missile. Built with two identical stages, the sole distinction being that the second has less fuel, the missile is very different from the Safir, the recently tested liquid fueled two-stage satellite launcher. With an estimated range of 2000 to 2200 km, this MRBM allows Iran to target Israel.

This new class was reportedly developed by Shahid Bagheri Industrial Group (SBIG) under the Sanam Industrial Group (Department 140), which is a subsidiary of the Defense Industries Organization (DIO) of Iran, with expertise developed in work on both solid- and liquid-fueled missiles.[215] Unconfirmed sources suggest that the warhead closed more quickly than that of the Shahab and had a special coating to reduce detection by the radar of missile defense systems. Iran reported other launches in 2010 and 2011, but with little detail.[216]

Little is known about the technical details of this weapon. Some sources - including Jane’s Defense Weekly - suggest the system has at least rudimentary inertial guidance, with advanced guidance systems (IISS suggests steering vanes and controlled thrust termination) that give it greater accuracy than the Shahab systems, but its CEP is unknown. Its range is subject to wide estimates (although all observers place it above 1800 km, and most above 2000 km). As a solid-fuel missile, Iran has the option to allow several to remain ready to fly at all times. Given the absence of unclassified estimates for the number of missiles, the number of TELs, the existence of missile silos (although some are known to exist), or improvements in the warhead that would make the weapon tactically relevant, it is difficult to assess what impact this missile will have on future competition in the Gulf.

Hildreth describes the system as follows:[217]

> The Sejil is a solid-fueled ground-mobile ballistic missile that Iran says has a range about 2,000 km according to official U.S. sources. Both Postol and Elleman state a 2,200 km range. Some in Israel and elsewhere believe the missile might have a range up to 2,500 km.
>
> The Ashura was announced by Iran in November 2007. This announcement was accompanied either by an unsuccessful test of the solid propellant motors or the Ashura missile itself depending on whether an Israeli or Russian account, respectively, was accurate.
>
> Subsequently renamed the Sejil, it was flight tested successfully in November 2008, reportedly at about 800 km. Additional tests of the Sejil or a modified and apparently more capable version of it (Sejil 2) took place in May, September and December 2009. From the progress shown in the Sejil solid-fuel rocket program, Elleman concludes that "Iran is at a minimum in the process of mastering the technology."…Many consider the Sejil 2 a nuclear capable ballistic missile as its payload capacity could accommodate a first generation nuclear warhead. Some have suggested that the MRBM silos near Tabriz and Khorramabad might be intended for the Sejil 2. Many believe the missile is the same regardless of the naming designation (i.e., Sejil, Sejjil 2, or Ashura).

Some US and Israel experts now believe at least some Sejjil-2s are in the field. The IISS did not, however, treat the system as fully operational in it May 2012 report,

> "Iran is also developing a new medium-range, solid-propellant missile, the *Sajjil*-2, potentially capable of delivering a 750kg warhead to a range of about 2,200km. Iran is the only country to have developed a missile of this reach without first having developed nuclear weapons. The solid-fuelled system offers many strategic advantages, including being less vulnerable to pre-emption thanks to its shorter launch-preparation time. The *Sajjil*-2, which was successfully flight-tested for the first time in November 2008, is still two to three years of flight testing away from becoming an operational system that can be deployed to military units. Iran has yet to demonstrate that the missile's individual stages perform consistently and reliably under a variety of operational conditions. If deemed necessary, this new missile could conceivably be used for combat in late 2010 or early 2011. However, the history of solid-propellant missile programs elsewhere suggests an initial deployment of the *Sajjil*-2 in 2012 or later is more likely."[218]

Missile Threat described the Sejjiil-2 as follows in 2012:

> Development of the Sejil missile likely began in the late 1990s, but the program can hardly be understood apart from other Iranian missile programs whose development began much earlier. Most importantly, Iran began development on the Zelzal missiles in 1994 or 1995. The production of the Zelzal missiles required Iran to develop the domestic ability to produce composite solid propellant in fairly large quantities. The technology and equipment used in Zelzal fuel production has almost definitely been used for the Sejil missile project. It is believed that China aided Iran in the improvement of their solid-propellant production ability for the Zelzal missiles; it seems likely that China has also aided Iran in the production of fuel for the Sejil missile.
>
> At the same time that Iran was developing composite solid-propellant fuel, they were working with the North Korean No Dong 1 missile design to produce the Shahab 3. The Shahab 3 design was used by Iranian engineers to produce a number of domestic missile technologies - a major advance from earlier Shahab designs, which relied almost entirely on Russian and North Korean technology. The Shahab 3 variants have provided a number of advantages over the original North Korean design and proved that Iranian engineers can domestically design and produce improved warheads and SLVs. The Sejil missile, internally quite different from the Shahab 3 missile (solid propellants require very different motors and internal design), probably borrows from a number of Shahab 3 technologies. At the very least, it is believed that the RV/nose cone design that first appeared in Shahab 3 variants has been used on the Sejil missile.
>
> Though the missile has a similar size, weight, payload, and range to the Shahab 3 variants, the fact that it is fuelled by solid propellants is a huge improvement over the Shahab design. Solid propellants allow for a near-immediate launch time, leaving the missile much less vulnerable during launch. Because solid-propellant missiles do not have to be fuelled immediately prior to launch, they are also much more easily transported. On the other hand, solid propellant missiles have particular performance characteristics that

> make them more difficult to guide and control. How Iranian engineers have overcome these hurdles is unknown, but it seems likely that they have modified Shahab guidance systems and/or received considerable foreign assistance.
>
> The Sejil missile has a length of 17.6 m, a diameter of 1.25 m, and an overall launch weight of 23,600 kg. It carries a payload of 500 to 1,000 kg. Presumably the missile will carry HE warheads until Iran gains nuclear warheads. The missile’s maximum range is about 2,000 km, though these figures are based upon a missile fuselage with the weight and performance characteristics of aeronautical-grade steel. Supposing that Iran had the technology to produce missiles built of maraging steel, titanium, or composite material, the missile would potentially be lighter and have an extended range upwards of 2,400 km.
>
> The first test launch occurred in 2008 and the missile reportedly flew 800km. A second launch was conducted in May 2009 to test improved guidance and navigation systems. Four other flight tests have occurred since 2009, with the sixth test flying approximately 1,900 km into the Indian ocean…
>
> The Sejil missile appears to be a unique Iranian design. Though some speculation has tied the missile to the Chinese DF-11 and DF-15, the size and specifications of the missile suggest that the Iranian missile is unique. Unlike earlier Iranian systems, the missile also does not appear to be a copy of a previously released North Korean missile. Of course, it is highly likely that the missile project has made significant gains through foreign assistance. Because the design is new, Iran will probably have to subject it to a great deal of testing before putting the missile into regular operation. Assuming that the Sejil project moves at about the same speed as foreign missile development projects, Iran will probably not declare the missile operational until at least 2012…
>
> The Sejil missile system may be operational, but regardless, Iran continues to make improvements. There may be multiple versions of the Sejil system. In 2009, Iran referred to the test launch as the Sejil 2. An unconfirmed report stated that a Sejil 3 may be in development. The Sejil 3 would reportedly have three stages, a maximum range of 4,000 km, and a launch weight of 38,000 kg…[219]

There is also a controversy over the extent to which Iran may have carried out Shahab 3 and Sejil tests capable of carrying a nuclear warhead. Once again, Hildreth provides an excellent summary of the issues involved as of 2012,[220]

> In comments to the British parliament in June 2011, British Foreign Minister William Hague said Iran had conducted three secret tests of ballistic missiles capable of carrying nuclear weapons in contravention of UN Security Council Resolution 1929…An Iranian spokesman denied the British allegations, saying that none of the missiles tested by Iran has a nuclear capability….Britain apparently reported these tests to the UN, but had not previously made them public.
>
> Although it received little media attention at the time, a report by a Panel of Experts at the UN became public the month before Hague’s speech in London. According to AP the UN report said Iran launched a liquid-fueled Shahab-3 missile with a range of about 800 kilometers, and one or two solid-fueled Sejil 1 missiles with a range of about 2,000 kilometers. AP further said the UK believed these missile tests showed that Iran’s leaders wanted to avoid scrutiny over “the real extent of their weapons programs.”
>
> This unpublished May 2011 report…was not circulated because it had not been approved by the UN Security Council, apparently for political reasons—China and Russia opposed its release according to UN sources. Nonetheless, the news it shed on previously undisclosed Iranian MRBM tests was highly significant. Specifically, the report mentioned the launch of the Sejil/Ashura in October 2010 and a Sejil and Shahab-3 test in February 2011.
>
> …By early July 2011, Iran conceded the two February tests. Reuters reported that Iran state television admitted test-firing two long-range missiles from the “Semnan province into the mouth of the Indian Ocean” about 1,900 kilometers away sometime between January 21 and February 19, 2011.BG Hajizadeh, head of the IRGC’s Aerospace Division, said U.S. spy planes were operating in the area where the missiles hit, but it was “interesting that they [the United States] did not report it.”
>
> …Jane’s said these medium-range missile tests were likely the Sejil-2 or the Shahab-3. The fact that there was neither public announcement by Iran at the time of these launches, nor any public condemnation from the United States or from any other any other nation represented a notable departure from the past. Three key

questions are thus raised. First, what might account for this change in Iranian policy that normally publicizes or televises missile tests? There are several conceivable explanations:

- One or more of the tests might have failed and Iran did not want that known. This could explain what happened with the first launch, but evidence is that the February flights were successful, or
- Iran may have tested to a new, untried range for which it did not want international attention. Only after media reports and the leaked UN draft report did Iran concede the longer range tests into the Indian Ocean; or
- Iran may have decided for whatever reason that it no longer wanted to publicly demonstrate its MRBM capabilities, perhaps over concern regarding UNSCR 1929. But in "Great Prophet" 7 Iran said it had flown a 2,000 kilometer missile, which should be noted was not independently verified. And Iran had declared two other Sejil launches and a Shahab-3 test in 2009, after UNSCR 1929 passed earlier that year. Also, just because Iran did not publicly announce or show these tests does not mean they cannot be verified by others. A second key question is why neither the United States nor any other nation at the time chose to criticize Iran for those tests, which to many seemingly violates UNSCR 1929. Possible reasons might include:
- The United States might have wanted to forge a consensus behind closed doors for additional sanctions and worried that public attention to the tests might make it harder to bring in Russian or Chinese support, or both. U.S. Permanent Representative to the UN Susan Rice complained about Iran's noncompliance with UNSCR 1929 in June 2011 and referred to the draft Panel of Experts as containing "troubling findings, including significant evidence about several reported violations" of UN sanctions related to Iran, but implied some Member States were holding up public release…Some have noted that the Final Report released in June 2012did not mention the three tests from the unpublished earlier Final Report in May 2011. This was for no other reason than the missile launches occurred in a different mandated reporting period.
- Due to the sensitive, ongoing talks with Russia over the U.S. European Phased Adaptive Approach (EPAA), there may have been some reticence within parts of the U.S. Government to "shove this" into the Russian face. Keeping an announcement of these Iranian tests out of the public debate may have been seen as having a greater policy priority in order to facilitate an agreement with Moscow.

The UN Panel of Experts report issued in June 2014 stated that,[221]

> The Sejil (Ashura) is the Islamic Republic of Iran's longest-range solid-fuelled ballistic missile. Its last reported test was carried out in 2011; experts have suggested a number of possible explanations for the absence of subsequent tests. There may be difficulties procuring missile components or securing a reliable supply of ingredients for solid fuel, hence a decision not to deplete a limited store of missiles with tests.
>
> Another possibility is that the Islamic Republic of Iran has decided to prioritize resources to more established missiles such as the Shahab series. It cannot be excluded that the Islamic Republic of Iran is satisfied with the Sejil's performance and feels no further tests are necessary. It may also have decided to suspend further testing which could be interpreted as inconsistent with the spirit of the E3+3 negotiations. The Panel has no information about the number of operational Sejil missiles in the Islamic Republic of Iran's arsenal; the missile is assessed by experts to require further testing.
>
> One indication that development of the Sejil is continuing is the display of 20 Sejil transporter erector launcher vehicles (TEL) at a 2013 military parade for the first time Transporter erector launcher vehicles enhance the mobility of missiles while decreasing their vulnerability. One expert noted that "The number of TELs at Iran's disposal is strategically crucial as the more ballistic missiles it can launch in a single wave, the greater its chance of overwhelming defensive systems".

As is the case in so many other aspects of the data on Iran's forces, unclassified data are limited and contradictory both regarding the missile and its operational status. Some experts do believe, however, that if the Sejjil-2 has not yet been deployed in missile brigades like the Shahab-1 and Shahab-2, there are operational missiles that could be married with warheads and used in case of a conflict.

Iran's development of the Sejjil-2 also reflects a broader trend among ballistic weapons states to gradually emphasize solid-fueled missiles over their liquid-fueled counterparts. Although liquid missiles are generally easier to develop and manufacture at smaller scales, their high maintenance cost and vulnerability to first-strike attacks limits their usefulness. While liquid-fueled systems are still useful for space flight, and despite the tendency for solid fuels to exhibit higher variance between missiles, all major nuclear powers rely on solid-fueled rockets to deliver their weapons.

Solid fuel system development does require improved technology in both casting the fuel and building the engine, and refinements in each are necessary to develop efficient and long-range weapons. Even so, it seems probable that the Sejjil-2 is mostly or wholly produced indigenously. Iran has spent considerable time and capital developing its solid fuel program, starting with domestic production of unguided artillery rockets and gradually building up. Unlike its liquid fuel rockets and fuel production, Iran potentially has developed a sufficient store of local knowledge and construction expertise to develop and manufacture this weapon. While many of its systems are still undeveloped by Western standards (particularly regarding guidance and thrust production), if Iran were able to build the entire missile domestically, upgrading may be easier than for its liquid-fueled missiles.[222]

***BM-25***

Some estimates may include systems Iran has never actually deployed. In 2010, there were allegations that Iran has received the BM-25/SS-N-26/R-27 missile from North Korea. The SS-N-26 was a liquid-fueled Soviet SLBM with an advanced engine and guidance system. These reports were partly substantiated by the appearance of R-27 steering rockets on the side of the Safir SLV.[223]

Despite this, there is little evidence that Iran actually possesses a working copy of the BM-25. These weapons transfers are alleged to have taken place in 2005. Since then, Iran has not demonstrated a working model of any ballistic missile similar to the BM-25. When launching its Safir, it used an underpowered engine that forced it to launch a small satellite to a very low orbit. Using a BM-25 engine would have increased the payload capacity and orbital height. While it seems likely Iran does have access to some BM-25 technology, their regular tests and development of other missiles, particularly using underpowered engines, suggests that Iran does not have a working version of this weapon.[224]

Hildreth seems to provide the most authoritative picture of the controversies over this system: [225]

> The issue of whether Iran received at some point some number of Soviet-era R-27 SLBMs (submarine launched ballistic missiles) or components remains unsettled, controversial and persistent. Early on, the German press named this missile the BM-25 when they referred to the Iranian version, and others have referred to this as the Musadan when used in the context of North Korean involvement. The pedigree of this system is far from trivial and its reported design or redesign remains obscure. No official public U.S. assessment or word of this was found.
>
> This issue, therefore, has been largely been a debate among technical experts and observers who track Iranian missile programs. Whether Iran acquired these missiles or their rocket motors in whole or part, or received other technical assistance regarding these missiles or their component parts is important. If accurate, acquiring this capability or technical knowledge might enable Iran to build more powerful and longer range ballistic missiles.
>
> Some experts lend credence to assessments that Iran may have some number of these missiles or their components. Uzi Rubin stated that "Iran has acquired eighteen BM25 land-mobile missiles with launchers from North Korea, which can strike targets in Europe. In the past, the BM-25 has been produced in two

> models: one with a range of 2,500 km and the second with a range of 3,500 km."…Similarly, according to an unpublished May 2011 UN Panel of Experts Report, two Member States shared the assessment that "Iran received a shipment of 19 BM-25 missiles from the DPRK in semi-knock down and complete knock down kits….Schmucker and Schiller acknowledge that the BM-25 is "seen as an operational part of the North Korean and Iranian missile arsenals, though it was never actually launched," but that its display in a 2007 DPRK military parade turned out to be a different, very short-range missile.
>
> The *Washington Post* reported in 2010, citing U.S. cables, that Iran had obtained 19 of the BM- 25 or Musadan missiles from North Korea. The document reportedly summarized a meeting of U.S. and Russian technical experts and officials, where the Russians claim the BM-25 might not even exist and U.S. officials acknowledge never seeing the missile in Iran. It turns out that the U.S. delegation reportedly relied heavily on a 2005 article from a conservative leaning German tabloid called Bild Zeitung quoting German intelligence sources that Iran had purchased 18 (not 19) BM-25 kits made up of missile components for the BM-25 from North Korea. One technical expert was quoted in the *Post* article as saying "the U.S. side does not firmly say we have evidence that the BM-25 is in Iran."
>
> This missile has not been seen publicly in Iran and has not been tested. Some were reportedly shown in North Korea, but subsequently discounted as mock-ups. Some analysts have reported the BM-25 might be capable of reaching 3,500 km. It is reputedly based on a Soviet-era submarine launched ballistic missile known as the R-27 in Russia and the SS-N-6 in the West. Experts such as Michael Elleman believe that although it is "highly improbable that complete or disassembled R-27 missiles were exported by Russia, it is possible that individual components of the missile may have been smuggled out of the country..."
>
> Other missile experts such as Ted Postol of MIT argue that the evidence suggests that an unknown quantity of Soviet-era naval ballistic missile parts were shipped to North Korea without the approval or knowledge of the central government during the collapse of the 1990s. Russia never acknowledged this transfer, Postol and Elleman said, because it would tarnish Russia's reputation as a country that claims to have never sold technology that could be used in an intercontinental ballistic missile...

## Stacked Threats and Basing on Mobile Launchers and in Silos

As is the case with its shorter range systems, Iran reduces the vulnerability of its missile systems, and potentially increases their effectiveness, through improved mobility and dispersal, the use of shelters and silos, and by using arrays of "stacked threats" that deploy several different types of missiles in a given attack area. This combination of measures complicates missile defense since Iran will try to saturate a given capability with lower-range missiles and then fire longer-range systems. This makes it harder to use strike fighters to suppress the missile threat to a given area, and raises the possibility that Iran could lead a given defender to exhaust its holdings of missile interceptors by firing its lower quality systems first.

Iran has both mobile launchers and missile silos. Iran announced its silos publically by showing video on Press TV in late June 2011. It did so as part of an exercise called "Great Prophet 6" and claimed they would allow it to launch missiles more quickly and reliably. These silos seem to have been built near Tabriz and Khorramabad in northwest Iran, but this is uncertain and other silos may well exist.[226]

The same video showed mobile launchers for the Shahab-3, and press reports indicated that the silos had $C^4$I links linked to a missile control center - presumably commanded by the IRGC Aerospace Force. The *New York Times* quoted the commander of the Guards' Aerospace Force, Amir Ali Hajizadeh, as stating that the silos were a crucial asset in Iran's standoff with the West, and as saying that as a result, "we are certain that we can confront unequal enemies and defend the Islamic Republic of Iran."

*The New York Times* reported that another Guards officer had said on state television that, "only few countries in the world possess the technology to construct underground missile silos. The technology required for that is no less complicated than building the missile itself." It reported that Iran claimed its designs were original and not copied from North Korea.[227]

Iran's Fars news service stated separately that,[228]

> The silos are a part of the swift reaction unit of the [IRGC] missile brigade; missiles are stored vertically, ready to be launched against pre-determined targets," Fars News Agency quoted the IRGC spokesman in charge of the drills, General Asghar Qelich-Khani, as saying on Monday.
>
> Qelich-Khani said the country has been using domestically-built missile silos for fifteen years and added that the newer generation silos are operational from a launch control center located far from the launch pads.
>
> The main advantage of missile silos is the reduced launch time as the weapons need not be moved or aligned prior to launch.
>
> On Sunday, Commander of the Aerospace Division of the IRGC Brigadier General Amir Ali Hajizadeh short-, medium- and long-range missiles, namely Khalij Fars (Persian Gulf), Sejjil (Baked Clay), Fateh (Conqueror), Qiam (Rising), Shahab-1 and Shahab-2 missiles would be fired during the war games.
>
> Hajizadeh stressed that Great Prophet 6 maneuver has completely defensive objectives and will be staged with the message of "peace and friendship."
>
> IRGC's naval, air and ground forces staged the Great Prophet 5 military drill in the Persian Gulf in April 2010.

Hildreth describes these silo developments in ways that again highlight the difficulties in separating Iranian claims and hints from any clear picture of reality:[229]

> During the June 2011 "Great Prophet" military exercises, Iranian military leaders publicly revealed for the first time the existence of a secret network of what they characterized as 'underground missile silos'. These structures are distinctly different that those that have been built by the United States, Russia and China. The Shahab-3 is housed in a chamber that has a vertical tunnel that the missile flies through. Both the chamber and the tunnel are large relative to the missile diameter. This creates a very large volume that the rocket exhaust gases can expand into, greatly reducing the challenges associated with flying out of the types of ballistic missile silos built by the United States, Russia and China.
>
> Iran's IRGC Aerospace Forces Commander BG Amir Ali Hajizadeh told state media that the Guard had the capability to "attack all American facilities in the region by these [Shahab 3] missiles."…In a televised segment another military official said that Iran had been building this network for the past 15 years. ..In June 2012, the UN said these missile silos, "which have been reported for a number of years, have not been confirmed to be operational…."
>
> …It was not until 2008, however, that more specific claims about silo construction, hardened sites, locations, and imagery, began to surface in public…Two different blogs, gemint.com and arms controlwonk.com, wrote about the same time in early 2008 of a possible silo missile base near Tabriz
>
> If the Iranian military official was quoted correctly, it would mean that work would have started on these silos around 1996. In fact, perhaps the first public account of Iranian interest in such came in 1993 when then Iranian Defense Minister Foruzandeh led an economic delegation to the DPRK and may have discussed the possibility of joint production of the Nodong missile and construction of underground missile shelters at 18 sites across Iran.
>
> Construction may have been underway by 1998 when Israeli Prime Minister Netanyahu said Iran is "building an enormous infrastructure [including] hardened missiles silos," which can house Iranian ballistic missiles and protect them against U.S. or Israeli preemptive strikes.
>
> …The next time there was any apparent mention of Iranian missile silos came in 2006. Former head of Israel's missile defense agency and missile engineer Uzi Rubin wrote that, "there are indications they

> [Iranians] are now constructing fixed silo-like hardened sites to make their missiles even more survivable." Rubin mentioned this in the context of Iran's MRBMs.
>
> …Based on these previous assessments and using imagery obtained through the Library of Congress, this report locates what appear to be those missile silos in northwest Iran near Tabriz. …Imagery obtained through the Library of Congress dated around 2000 and examining additional imagery dated about once every year or two at this location shows what appears to be gradual construction of the second silo site referenced by O'Connor. This second silo pair may have been completed by 2011 from looking at that imagery…
>
> Since then, only a few other experts have mentioned these silos until the Iranian videos and interviews in June 2011. To date, there does not appear to have been any official U.S. public assessment or acknowledgment of these silos. It is unclear what the absence of any such assessment might mean.

To the extent such silos are operational, they offer the potential advantage of allowing Iran to emplace substantially larger missiles as it develops them. While its current MRBMs are fully road-mobile - both the Sejjil and the Shahab-3 and its variants can be launched from movable transporter-erector-launchers - later missiles may be in the range of 40-80 tons (from around 20 for the Sejjil) and hence will not be able to use current TELs. Mobile launchers are generally considered to be more secure than missiles in silos, so constructing them now only makes sense if Iran seeks to streamline construction techniques for later use.

While silos might be a vulnerability in a conflict with the US in the near future, more advanced designs could serve as the home of any future Iranian ICBM force if Iran had sufficient numbers to make a first strike uncertain. They also present added risks from any missile system if Iran chooses to act on the basis of launch on warning or launch under attack.

Some recent reports indicate that Iran has approximately 4-6 active missiles for every TEL (this ratio does not hold for Sejjils), with Iran expected to build more launchers as it produces additional missiles to avoid bottlenecks in its firing rate. In a conflict in which Iran seeks to use its SRBMs, MRBMs, and IRBMs, it will likely rely exclusively on mobile TELs to avoid US and GCC airstrikes and maintain its missile deterrent.

## *Iran's Possible Search for an ICBM*

As the US intelligence warnings cited earlier have shown, there have been reports that Iran is developing an ICBM with ranges greater than 5000 kilometers (3,400 miles). It is unclear whether these reports are based on uncertain earlier intelligence reports of North Korean missile sales, or the fact Iran is creating its own boosters that could be used for this mission, or whether some earlier reports that Iran could develop an ICBM in a few years are still current.

The major uncertainties involved are illustrated by an IHS Jane's report issued in 2013,[230]

> US diplomats believed that Iran received 19 Musudan IRBMs from North Korea, according to confidential US State Department cables released by the Wikileaks website, the New York Times reported in late 2010. While the Musudan's estimated range of 2,500 km to 4,000 km means Iran could use it to strike European cities including Berlin, Moscow and Rome, experts have played down the significance of the news. The Musudan, also known as the Mirim or No Dong B by the US and BM-25 by Israel, is believed to be based on the Russian R-27 (SS-N-6 'Serb'), with which it shares a distinctive triconic nose shape. It is believed to be about 12.5 m long, with a body diameter of 1.5 m and a launch weight of 19,000 kg. Iran was originally thought to have bought 18 Musudan missile sets from North Korea in 2005. However, a December 2009 report said that some components for these missiles had been intercepted in July 2009 by the United Arab Emirates.
>
> According to the leaked US State Department cable, dated 24 February 2010, US officials told Russian officials they believed that a shipment of complete systems had taken place and that Iran had received 19,

not 18, Musudan missiles. A report published by the International Institute for Strategic Studies (IISS) in May 2010 was skeptical that Tehran had received the Musudans, saying that a missile resembling it "has not been openly displayed or flight-tested by Iran". It added: "The BM- 25's public absence ... is difficult to explain when one considers the other missile and space-launch activities observed since 2005". While the leaked cable was helpful in illustrating recent US thinking over Iran's missile development, Tehran's indigenous missile programs are widely believed to have outpaced those of North Korea.

If Iran has had such transfers, it is possible that it could have a missile that could reach the US in a few years, although earlier estimates of 2015 seem impossible. At the same time, Iran will probably develop the capability to launch warheads at such ranges on its own. Iran has been developing and testing rocket motor technology and multi-stage boosters since 2008 that *could* serve this purpose. Iran launched its first satellite, the Omid (Hope), in February 2009, and its second in June 2011. These seem to have used a Safir solid-fuel rocket booster with limited payload capability.[231] Iran had another launch fail in October 2011, but did launch another small satellite in February 2012.

## The Space Path to ICBMs?

The NTI reports that Iran announced in February 2010 that it had, "created a new satellite launch vehicle (SLV), the Simorgh" in February 2010. The NTI report indicates that this was a larger, "'a 27-meter-long, multi-stage, liquid-fuel missile with a thrust of 143 metric tons.' The Simorgh is designed to carry a 60kg (132lb) satellite into low earth orbit (LEO) and could be enhanced to carry a 700kg satellite."[232]

Iran successfully launched a second satellite, dubbed Rassad (Observation), into orbit in June 2011. Its mission was to take images of the Earth and transmit them along with telemetry information to ground stations. It launched a Navid-e Elm-o Sanat (Harbinger of Science and Industry) satellite into orbit in February 2012. The records made by the telecom, measurement and scientific satellite could be used in a wide range of fields.[233]

Iran's current satellite launch vehicle, the Safir, may lack the thrust and/or structural integrity to carry any type of warhead. The Simorgh, assuming that it is derived from the North Korean Unha,[234] would similarly face difficulties carrying a military payload. While it would probably only take a few years to fully weaponize such a system, the testing necessary to guarantee its structural integrity and accuracy would provide the US with sufficient warning to react.

Hamid Fazeli, the Director of the Iran Space Agency (ISA) announced on February 2, 2013 that Iran would launch indigenous satellites into space.[235] Fazeli said that Iran had launched a Kavoshgar Pishgam (Pioneer Discoverer) satellite carrying a monkey on January 28th. He added that the Nahid, Qaem, and Fajr satellites would be launched into orbit within the next few days and that that Iran planned to launch a satellite called the Sharifsat by the end of the current Iranian calendar year (March 20, 2013). He also said that a Tolou satellite would be launched into orbit in the near future.

Iran claimed that they were planning to launch at least 6 satellites into orbit in 2014, beginning the following Iranian calendar year (March 2015-March 2016).[236]

- Fajr – A "monitoring" and "reconnaissance" satellite that will be placed in a 400km elliptical orbit. The satellite was developed by the "Salran electronic and communication company."

- Tadbir – A 50 kg satellite developed by the Iran University of Science and Technology and the Space Research Center. It is an upgrade of the Elm-o Sanat satellite. Tadbir has "has higher precision in taking photos compared to its predecessor, and its interactive computer system enables 16 users to send and receive

> information in any geological position. It is equipped with the Global Position System (GPS) and can be tracked anytime from a ground station."

- Sharif Sat – A 50 kg satellite developed by the Sharif University of Technology to be placed in Low Earth Orbit.
- Zafar – A "monitoring" satellite that will be placed in geostationary orbit. "The satellite will reportedly have a lifespan of one year and six months, and will capture images and transmit them to stations on earth."
- Tolou – A satellite designed to carry out "remote sensing and topography missions." The satellite will be placed in a 500km orbit.
- AUT Sat – A "monitoring and telecommunications satellite" developed by Amir Kabir University of Technology. The satellite weighs 100 kg and has an expected lifespan of two years.

The Zafar, Tolou, and AUT Sat are planned to be placed in orbit by the Simorgh SLV. The Fajr and Sharif Sat will be launched by the Safir.

Iran continues to receive foreign assistance for its space and satellite programs. *Russia Today*, a news organization owned by Russian state owned media group RIA Novosti, reported that Russia and Iran signed a "secret deal on wide cooperation in space exploration, ranging from training Iranian cosmonauts in Russia to possible production of Earth observation and telecommunication satellites for Iran."[237]

Some experts feel these "space" efforts could allow Iran to develop an ICBM capability as early as 2015-2020. In February 2012, Israel's Finance Minister, Yuval Steinitz, stated that Iran could develop an ICBM that could reach the East Coast of the US within the next two to three years,[238]

> "They (the Iranians) are working now and investing a lot of billions of dollars in order to develop intercontinental ballistic missiles…And we estimate that in two to three years they will have the first intercontinental ballistic missiles that can reach the East Coast of America. So their aim is to put a direct nuclear ballistic threat…to Europe and to the United States of America."

## How Soon and What Real World Capabilities?

Given what is known about Iran's ballistic missile technology, however, these claims probably represent a worst case for any date before 2018-2022. US intelligence sources have not yet announced that Iran has a full-scale ICBM program at present. The Secretary of Defense stated in his April 2012 report to Congress that,[239]

> "Since 2008, Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies.
>
> …During the last two decades, Iran has placed significant emphasis on developing and fielding ballistic missiles to counter perceived threats from Israel and Coalition forces in the Middle East and to project power in the region. With sufficient foreign assistance, Iran may be technically able of flight-testing and intercontinental ballistic missile by 2015."

Without a major test effort, it seems unlikely that Iran will reach the level of guidance or re-entry technology necessary to reliably strike at even city-sized targets on the East Coast of the US, or anywhere else at similar range with an ICBM in less than 4-10 years.[240] It would also need to have nuclear warheads to achieve any effect other than a random conventional explosion unless it can make more progress in conventional precision strike capability at extremely long ranges than now seems likely. The longer time frame seems more likely and Iran would then need a nuclear or extremely effective biological warhead to do serious damage.

Hildreth summarizes what still seems to be the current view of US experts as follows:[241]

> In 1999, the U.S. intelligence community assessed that at some point the United States would probably face ICBM threats from Iran…This remains the official U.S. position. More specifically, the 1999 assessment warned that “Iran could test an ICBM in the last half of the next decade using Russian technology and assistance” (emphasis in the original). A similar report was issued in 2001….Such a test did not occur in this time frame, but in 2010 the DIA assessed that, by 2015: “Iran’s Ballistic Missile and Space Launch Programs with sufficient foreign assistance, Iran could develop and test an intercontinental ballistic missile (ICBM) capable of reaching the United States. In late 2008 and early 2009, Iran launched the Safir, a multi-stage space launch vehicle (SLV), demonstrating progress in some technologies relevant to ICBMs. Iran displayed its next generation SLV, the Simorgh, in February 2010. The Simorgh is much larger than the Safir and shows progress in booster design that could be applicable to an ICBM design.”
>
> The 2012 annual report on Iran’s military power to Congress (April 2012) restated that, “Iran has launched multistage space launch vehicles that could serve as a test bed for developing long-range ballistic missile technologies.”
>
> These assessments are often interpreted as stating that Iran will have nuclear-tipped ICBMs capable of striking the United States by 2015, but the unclassified intelligence statements continue to place various caveats on potential capability to test at some date. These assessments focus only on the ability to test an ICBM and do not make any judgments about the ability of Iran to successfully deliver a nuclear warhead at ICBM range.
>
> These intelligence statements serve as the official U.S. basis for assessing the Iranian ICBM threat to the United States and to its friends and allies. These assessments drive U.S. military efforts designed to respond to such threats, such as the U.S. BMD program in general and the U.S. missile defense system in Europe specifically, as well as U.S. diplomatic and other efforts such as sanctions to dissuade or slow down Iranian long-range ballistic missile programs…However, they do not offer a probability assessment for such technological assistance being available.
>
> These assessments do not mean that currently universal agreement exists within the U.S. intelligence community on the issue of an Iranian ICBM. According to these same unclassified statements, some within the intelligence community argued that an Iranian ICBM test was likely before 2010 (which did not happen), and very likely before 2015. Other U.S. officials believed, however, that there is “less than an even chance” for such a test before 2015. Furthermore, U.S. assessments are also conditional in that an Iranian ICBM capability would have to rely on access to foreign technology, from, for example, North Korea or Russia.
>
> …Finally, some argue that an Iranian ICBM could be developed out of the Iranian space program under which a space-launch vehicle might be converted into an ICBM program. In the 1990s, some argued that Iran could have developed and tested such a space launch vehicle by 2010. Iran successfully demonstrated a space launch capability in 2009 with the launch of a low-earth orbit satellite, but the IC has not assessed that Iran has conducted an ICBM test or acquired an ICBM capability.

The IISS and other expert sources agreed with this assessment as of November 2013, and development and testing of an effective ICBM system is highly visible process.[242] Static burn tests for solid fuel motors are nearly impossible to conceal, and satellite-based detectors would likely be able to determine that Iran is experimenting with far more powerful engines. Additional flight tests would be necessary to determine whether the entire missile flies correctly and can carry a warhead. All these trials would allow the US to monitor progress in Iran’s missile development, potentially triggering preventive strikes or allowing it to improve missile defenses before a crisis.

Furthermore, development and testing of such a system is an onerous and highly visible process. Static burn tests for solid fuel motors are nearly impossible to conceal, and satellite-based detectors would likely be able to determine that Iran is experimenting with far more powerful engines. Additional flight tests would be necessary to determine whether the entire missile flies correctly and can carry a warhead. All these trials would allow the US to monitor progress in Iran’s missile development, potentially triggering preventive strikes or allowing it to improve missile defenses before a crisis.

## *Targeting and Battle Damage Assessment Capability*

As noted in the discussion of Iran's shorter range systems, it is unclear how well Iranian forces could target such systems, but all missile forces will have secure command and control links, military grade GPS devices, and almost certainly have a range of preset deployment locations, mobility plans, and targets.

Iran may have catalogued the GPS coordinates of all potential fixed area targets in Iran and nearby. Anyone can gather GPS target data on a site they can enter or bracket with GPS devices, and security is marginal for critical infrastructure and even many secure facilities since any worker that can enter the facility can normally carry in a GPS device – something that applies to gathering target data at far longer ranges and generally to palaces, critical infrastructure facilities, and many military bases and facilities throughout the entire region.

Iran would not need military satellite capability or air or unmanned aerial vehicle reconnaissance data to get area fire targeting data on fixed facilities for its long-range rockets or missiles. Commercial satellite data would be adequate. It seems doubtful in any case that Iran could use its limit fixed wing air reconnaissance assets for such missions. Iran is, however, making steadily greater use of unmanned aerial vehicles (UAVs) like the Ababil, Fotros, and Yasir, as well as unmanned combat aerial vehicles (UCAVs) like the Ra'ad 85 and Shahed-129.[243]

## *Command and Control*

As discussed earlier, there are few credible unclassified details regarding Iran's missile command and control systems. The Islamic Revolutionary Guard Corps (IRGC) Aerospace Command seems to have command and control authority over the industrial development of Iran's missiles by its Defense Industries Organization. Deployment and operation all almost all ballistic missile systems, from short-range systems like the Fateh-110 ballistic missile to the Sejjil medium-range ballistic missile, fall under the command and control of the IRGC Aerospace Command.

This IRGC command is also known as the IRGC Missile Command, Islamic Revolutionary Guard Corps Missile Command, and IRGC-Air Force Missile Command. According to some reports, its name was changed from IRGC Air Force to IRGC Aerospace Force in October 2009.[244]

There do not seem to be credible unclassified details on the command and control structure, IS&R (intelligence, surveillance, and reconnaissance), $C^4$I/battle management systems, tactics and doctrine, and development plans for Iran's missile forces. The readiness and operational skill levels of these elements of Iranian forces also are unknown, but seem to have high priority within Iran's forces.

It seems likely that any launches and strikes for military purposes would require the direct authorization of the Supreme Leader, but Iran may have contingency plans for targeting and launch if the leadership is killed, incapacitated, or can no longer communicate for a predetermined period.

# VI. Assessing Warfighting Capabilities of Iran's Current and Future Medium and Longer-Range Ballistic Missile Force

For all of the reasons discussed earlier, the warfighting impact of Iran's medium and long-range missile capabilities should not be exaggerated. Nevertheless, Iran already has operational missiles that are mobile and in silos with ranges of 1,500 to 2,500 km. From these launching sites, Iran can strike at targets throughout the Middle East, Turkey, and southeast Europe.[245] It is steadily developing missiles with greater ranges and payloads and developing a booster that could be used for an ICBM Moreover, both Israeli and US experts feel Iran is improving the accuracy of its missiles, is arming them with submunitions that can achieve better lethality with conventional and chemical munitions, and is developing at least limited countermeasures to missile defenses.

At the same time, this progress raises additional uncertainties about Iran's current and future force issue that anyone assessing the warfighting capabilities of Iran's missile programs must consider:

- The operational readiness and capability of both Iran's operators and missiles remain uncertain. Almost all launches seem to be "white suit" launches prepared by technical expert with long warning and time to both check out and ready the system. There is no way to know what real world combat preparation time and readiness really is. Iran stated that its July 2012 Great Prophet VII exercise was more realistic, but there is as yet no way to verify this claim.
- Many systems are destroyed in flight during the test. This deprives Iran as well as outside observers of the ability to know what ordinary operators and forces can do. It is unclear whether these premature detonations are accidental, ordered by Iran to avoid providing information to observers, or necessary to prevent the missile from landing in Iran.
- Declassified sources mention efforts reduce vulnerability to missile defenses but give no details.
- Iran seems to be seeking some form of GPS guidance and terminal homing capability, but it is far from clear what progress it has made - if any. A truly precision-guided missile would be far more lethal with even a conventional warhead.
- The possible use of volleys to compensate for accuracy and reliability exists, but it is unclear if any test data really demonstrate whether Iran has a serious capability at more than short ranges. Volleys are likely to be limited by the number of TELs, which is currently believed to be around twenty - although that number may have risen sharply in the last two years as Iran expanded other aspects of its missile program.
- There are no meaningful unclassified reports on the details of Iran's warning systems, command, control, computer, intelligence, surveillance, and reconnaissance systems (C4IS&R), command structures, or operational doctrine.
- There are no useful data on Iranian target doctrine, targeting capability, and damage assessment capability.
- Iran does have long-range Russian cruise missiles it can reverse engineer, could convert combat aircraft in high payload unmanned combat aerial vehicles (UCAVs), and used medium-range UCAVs during the Israeli-Hezbollah War in 2006. It is unclear, however, whether Iran is moving forward in long-range, high payload cruise missiles and UCAVs. Constructing engines and guidance systems for these, while not as challenging as for ballistic missiles, is still likely to slow down Iranian efforts to develop additional long-range delivery systems.
- While it is an outlier, much depends on the warhead and if Iran goes nuclear, on how quickly it can achieve reliable fission weapons, move on to boosted weapons, and then to thermonuclear weapons.

While data are lacking in many of these areas, the following analysis addresses several of the key challenges affecting Iran's warfighting capability.

## *The Accuracy and Reliability Challenge*

Iranian statements often exaggerate the accuracy of Iran's missiles. A recent example occurred in November 2013, when Brigadier General Hossein Salami, the Lieutenant Commander of the Islamic Revolution Guards Corps (IRGC) said Iran was one of three countries in the world that had an indigenous ballistic missile technology. "Many countries may have access to cruise missiles technology, but when it comes to ballistic missiles, I am confident that only the US and the (former) Soviet Union could master this technology, and now we can announce that we own this technology as well."[246]

According to a report by FNA on November 26, 2013, he said in ceremony on November 12, 20123 that that the precision targeting of IRGC's ballistic missiles had been improved to have a margin of error near zero: "Our situation has improved now because our ballistic missiles margin of error (in precision targeting) is near zero now." General Salami spoke ceremony in Tehran commemorating the "martyrs" killed in a blast at an IRGC base on November 12, 2011. They included General Hassan Tehrani Moqaddam who was in charge of the IRGC's Arms and Military Equipment Self-Sufficiency Program. [247]

General Salami pointed to the role played by Major General Tehrani Moqaddam, in the design and production of high-precision ballistic missiles, and said, "Due to such attempts the precision of Iran's ballistic missiles has approached (a) zero (margin of error) and our ballistic missiles target moving vessels on the sea and they operate against (enemies') command and control centers…Martyr Tehrani Moqaddam led us to self-sufficiency in area of ground-to-ground missiles and his ideas resulted in the development of an innovative missile power for Iran." [248]

Although Iran boasts a large arsenal of conventionally armed missiles of varying ranges and payloads, their seeming lack of terminal guidance and advanced warheads sharply reduces their military effectiveness. Without the accuracy necessary for conventionally armed missiles to be effective against point or high value targets, they can be used as tools of terror and intimidation and to strike at targets throughout the region with little, if any, warning.

It is unclear that Iran has the warfighting ability in the short run to translate its current medium and long-range missile forces into anything more than limited "terror" weapons. While Iran is improving its guidance technology, its short- and medium-range missiles remain blanket weapons systems that can hit a broad area but not a key point target - and then only if they are properly targeted and fired, and function reliably.

As **Figure 26** shows, the destruction of even a small point target with Shahab-1 could require over 100 missiles, far too many for any practical military role. This number is smaller for a substantial target such as an airfield or radar center, but such military targets - which generally have built-in redundancies - would require substantial numbers of missiles to disable.

Iran's longer-range systems have had too little consistent testing to produce accurate engineering estimates of their reliable circular errors of probability (CEPs) under deployed and operational conditions. As such, they are assumed to have CEPs similar to Shahab-1 and -2 and their military value is believed to be minor, as Iran lacks the numbers of Sejjil-2 and Ghadr-1 to launch sustained volleys.

As is the case with Iran's shorter-range systems, it is important to understand the difference between *theoretical* CEP and accuracy based on a statistically large-enough sample to establish a reliable *operational* estimate. CEP is defined as the level of accuracy that *should* occur if the system is perfectly aimed, launches under ideal circumstances, and every aspect of the design functions as exactly as it should. It then estimates the radius of the circle that half the rockets of missiles will land within as determined by the technology of the guidance platform. It is not a practical measurement in the sense it does not normally include any input from statistically relevant tests and evaluations that establishes the real-world reliability of the system.

Iran is well aware of these problems in most of its existing systems. To date, Iran has relied heavily on spin stabilization and steering vanes at the exhaust point of its missiles; the former at best achieves error of roughly 1.5% distance traveled, while the latter reduces missile range. Iran is still developing advanced inertial guidance and GPS systems missiles (the Khalij Fars may have some inertial tracking), and so far has had limited experience in perfecting the use of steering fins, gimbaled thrust, and Vernier engines to adjust the course of its missile rockets in flight, experience in steering systems, but Iran has made no public demonstrations in this regard. [249]

US experts feel that Iran is making progress, but has not conducted realistic enough tests of even its current ballistic systems to provide enough data to calculate their accuracy and reliability using their existing guidance systems, particularly under field conditions. Moreover, missiles rarely achieve anything like their stated CEP in practice. As a result, barring the success of Iran's modernization and accuracy upgrades, many of Iran's medium and longer--range systems will be lucky to hit within 500 to 1,000 meters distance of their target even if they function perfectly.

Some Israeli experts have warned that truly accurate conventionally armed missiles could sharply increase the effectiveness of Iran's missile forces, but they too are cautious about Iranian progress to date. Dr. Uzi Rubin, who created and directed the Defense Ministry's Israel Missile Defense Organization and the Arrow program ballistic missile defense program, warned in January 2014 that Iran had some 400 missiles it could potentially arm with nuclear warheads, and was designing missiles with GPS guidance and homing warheads.

He said at a conference on missile defense, held by Israel's Institute for National Security Studies (INSS), that,[250]

> Iran possesses over 400 ballistic missiles that can reach Israel, with warheads of 750 kilograms. Syria possesses 200 to 300… That's the bad news. The worse news is that these rockets are being turned into smart rockets. The Iranians took the Zelzal 2 and turned it into a guided rocket. The third generation of it contains a homing sensor and a GPS. The Syrians can have this capability too, to create a fully guided M-600 rocket with GPS. Hezbollah probably has these… That (missile strikes) would change the skyline of Tel Aviv.
>
> …This is not a tactical threat, it's not harassment. This is a strategic threat. Even worse news is coming; ballistic missiles are becoming smart… We are talking about escalating a war to quicken it, and end it within three days. They are talking about doing the same. This threat can degrade the IDF's ground capabilities… It can paralyze Israel's war economy. And of course, it can inflict massive casualties. …I'm not talking about Dresden, but Coventry, perhaps."

Rubin was talking about a possible future, however, and not the present. He stated in a March 2014 briefing at a conference held by the Royal United Services Institute that there were indicators that Iran still faced major problems and had slowed down its missile and space programs:[251]

- No announced test of either liquid or solid propellant long-range missile from February 2011 to February 2014 – a three year hiatus.

- No “Great Prophet” exercise – usually featuring numerous ballistic missile launches – since July 2012, more than a year and a half ago.
- No announced space launches since February 2012, two years ago.
- Some analysts attribute this lull (in space launches) to the sanctions that presumably starved the programs from materials, components, and money.
- However, there is ample evidence to the contrary.

Rubin went on to provide satellite pictures of failed space launches in May 2012, February 2013, October 2013. He noted that these failures came after one failure in late 2008, and successes in 2009, 2011, and in early 2012. He also noted that development of the Sejjil 2 solid fuel missile was “conspicuous in its absence.”

At the same time, Rubin highlighted the same kind of uncertainties that have been addressed throughout this analysis. He warned that Iran’s programs might be considerably more robust than more open source reporting indicated. He reported that Iran had unveiled a Shahab 3 launcher production line in May 2013, a new major missile launch facility near Sharud to supplement its facility near Semnan in August 2013, and had claimed to test a cluster warhead for its Shahab 3s in February 2014. It also unveiled massive underground missile storage facilities in March 2014, a finless test of the Shahab 2, and claimed to show a new extended range version of the Shahab 3 called the Ghadr F, with a 1,947 kilometer range.[252]

He concluded by warning that Iran might have been ceasing to publically report on the improvements taking place in the range, accuracy, and lethality of its missiles because of sanctions and the P5+1 talks and shifting to a covert program: [253]

- The Shahab program goes on; this is evident from the busy production line of its launchers and the large storage facilities.
- The full-scale production of Qiam 1 hints of more flight tests than the single disclosed test.
- The construction of a second large flight test facility indicates an accelerated flight test program.
- The space program may actually be speeding up.
- The perceived “lull” is not due to sanction induced shortages, but to a combination of technical difficulties and policy decisions:
  - The Sejjil solid propellant IRBM may still be recovering from a snag or is being deemphasized to allay European concerns.
  - The unsuccessful space launches remain unannounced.
  - Ballistic missile tests are concealed.
  - A new policy of opacity and toning down of rhetoric as part of a wider diplomatic effort to end the sanctions.

The UN Panel of Experts report issued in 2014 highlights such possibilities. It noted that Iran was expanding its missile launch facilities, which may help Iran increase reliability:[254] [255]

> The Islamic Republic of Iran is continuing development of its ballistic missile and space programs. A new missile launch site 40 km from the city of Shahrud was identified in August 2013.12 A larger launch complex is assessed to be close to completion at the Imam Khomeini Space Centre at Semnan for ballistic missiles and satellite launch vehicles….The Islamic Republic of Iran announced on 9 June 2013 the opening of the Imam Sadeq Observation and Monitoring Centre for monitoring space objects, in particular satellites.

> …A larger launch complex assessed to be close to completion at the Imam Khomeini Space Centre at Semnan for ballistic missiles and satellite launch vehicles.
>
> According to published reports and experts consulted by the Panel, the Islamic Republic of Iran has continued to expand its rocket launch capabilities at the Semnan Space Centre to accommodate larger missiles and space launch vehicles, including possibly the Simorgh 3 space launch vehicle…. Some experts have suggested that as the launch site construction is finished work on the Simorgh project will intensify.
>
> A new missile launch site 40 km from the city of Shahrud was identified in August 2013. IHS Jane's published analysis of satellite imagery of this, suggesting that the new launch facility is capable of testing long-range ballistic missiles. Analysts stated that, "This site could be a facility for launching satellites into orbit. However, Iran is already building at least one other site for this purpose and, looking at the satellite imagery we have got, we believe that this facility is most likely used for testing ballistic missiles." This assessment is based on a number of factors, including the site's current lack of a liquid fuel storage facility, the orientation of the launch pad (150 degrees north), and the location and arrangement of buildings.
>
> In February 2014, the Islamic Republic of Iran displayed two satellites developed by Malek Ashtar University. A modification of the Navid satellite, the Tadbir and Khalij-e-Fars satellites are reportedly intended to support secure wireless communication.39 One State recently informed the Panel of a Safir space launch vehicle launched in March 2014. This has not been reported in open sources and the Panel has no additional information regarding the launch at this time.
>
> The Panel continues to receive limited information regarding procurement efforts by the Islamic Republic of Iran for its ballistic missile-related activities. According to one State, there is no change in procurement patterns for missiles.
>
> Among the most important items the country is reportedly seeking are metals, as well as components for guidance systems and fuel. Similarities between the Islamic Republic of Iran's ballistic missile and space programs can make it difficult for States to distinguish the end uses of procured items.

IHS Jane's noted that, "The location of the site and angle of the launch pad allow missiles to be fired on a trajectory in which individual rocket stages would land within Iranian territory and the re-entry vehicle land in the Indian Ocean. The Islamic Republic of Iran would thus be able to maximize the gathering of telemetry information.[256]

UN Security Council reports from 2013 and 2014 also highlighted Iran's attempts to procure assets and technology that Iran still probably cannot reliably produce at home:

> On 11 April 2013, France reported that it received an export license request for a fiber-optic gyroscope for a third country declared as the end user. The authorities of that third country interdicted the shipment once it became clear that an intermediary intended to re-export the goods to the Islamic Republic of Iran. The goods were then returned to France. The Panel is currently investigating additional reported seizures that allegedly implicate the Islamic Republic of Iran in procurement on behalf of its ballistic missile program, including aluminum rods, steel bars, vibration measuring devices, a fiber-optic gyrocompass and specialized metals. [257]
>
> On 29 April 2013, the United States reported a violation involving the transfer of specialized metals to several entities in the Islamic Republic of Iran associated with the ballistic missile program, including entities designated under resolution 1929 (2010) and previous resolutions.[258]

The 2014 UNSC report stated that it was possible that these technological constraints contributed to the drop in testing of one of Iran's most advanced missiles, the Sejjil. It also noted that it was possible that Iran was simply satisfied with the Sejjil's performance:[259]

> The Sejil (Ashura) is the Islamic Republic of Iran's longest-range solid-fuelled ballistic missile. Its last reported test was carried out in 2011; experts have suggested a number of possible explanations for the absence of subsequent tests. There may be difficulties procuring missile components or securing a reliable supply of ingredients for solid fuel, hence a decision not to deplete a limited store of missiles with tests. Another possibility is that the Islamic Republic of Iran has decided to prioritize resources to more established missiles such as the Shahab series. It cannot be excluded that the Islamic Republic of Iran is satisfied with

> the Sejil's performance and feels no further tests are necessary. It may also have decided to suspend further testing which could be interpreted as inconsistent with the spirit of the E3+3 negotiations. The Panel has no information about the number of operational Sejil missiles in the Islamic Republic of Iran's arsenal; the missile is assessed by experts to require further testing.

At the same time, reporting by the Bulletin of the Atomic Scientists notes Iran's technological constraints and dependence on technology imports:[260]

> The solid-fueled missile program, however, has not seen as much recent activity. The Sajjil-2 missile, which has a maximum range believed to be around 2,200 kilometers, has been under development since around 2000. When it enters service, it will probably be Iran's most technologically advanced and capable missile, but it has not been tested since February 2011. Recent analysis has pointed to technology-based sanctions, especially constraints on the availability of solid propellant and constituent elements such as fine metal powders, as the reason for the hiatus (International Institute for Strategic Studies, 2012). For the development and manufacture of larger solid-fueled ballistic missiles, a supply of consistently high-quality ingredients is vital. Meanwhile, the development of shorter-range solid-fueled missiles, less demanding both in terms of propellant ingredients and technical expertise, has continued with the test of the Fateh-110 conducted in August 2012 (Fars News Agency, 2012b).
>
> Iran appears to be dependent on imports of individual components of a strap-down navigation and guidance system for ballistic missiles (International Institute for Strategic Studies, 2010: 98).

Even if Iran is able to improve its inertial navigation systems or develop reliable GPS guidance, both of which were mentioned earlier, the increase in accuracy of ballistic missiles may not be large enough to produce a high level of operational lethality, according to the US Institute of Peace:[261]

> Iran is also unlikely to be able to improve the accuracy of its short-range missiles for at least the next five to ten years. The addition of more sophisticated inertial guidance units — or Global Positioning System (GPS) receivers — could improve accuracy by only 25 percent if properly incorporated into a Shahab or Fateh-110 missile, and then thoroughly tested. To further enhance its accuracy, Iran would have to develop the capacity to terminate missile thrust precisely or add correction systems for the post-boost phase. But adding these mechanisms would also require flight testing likely to take four years or longer.

As **Figures 26 and Figure 27** show, trying to destroy hardened targets using missiles with a CEP over 200 meters (note that most reports for Iranian missiles place their best-case CEP at 450 meters) requires over a hundred missiles to achieve even a 50% chance of destruction. Even to destroy a soft target with 50% confidence would require at least 11 missiles. Doubling the CEP - to 400 meters, or the maximum efficiency Iran is expected to reach - would still require over 40 ideally performing missiles for even a single soft, point target.

These technical difficulties push Iran to develop nuclear warheads, cluster warheads, or more missiles with far more conventional warheads to compensate for its systems' weaknesses. Iran is likely to concentrate its R&D on three aspects of its missile program - improving accuracy, increasing production, and developing warheads that are more effective. The first and last will make each individual missile more effective, allowing Iran to reduce the number of missiles needed; increasing production improves accuracy and reliability by swamping defensive systems and increasing the odds of a single hit.

Iran has made progress in all three. With the triconic warhead replacing the old conical nosecone, Iran has improved the maximum payload and stability of its warheads. Based on data from a laptop obtained by US intelligence in 2004, Iran also has developed an altitude device for the Ghadir-1 that would let it detonate at 600 m. Assuming that this upgrade is successful, the safety, arming,

and fusing system would allow the triconic warheads to operate for both cluster warheads and unconventional munitions.[262]

While developing a new warhead section is a challenging engineering task, it is far simpler than the establishment of domestic facilities for producing rocket engines, guidance and control systems, high-quality fuel, and low-weight, high-caliber missiles. Iran has striven to develop a domestic capacity, as these Iranian speeches highlight:

- "Our missiles can be launched from boats with speeds of over 30 knots, and these missiles include Zafar, Nasr, Nour and Qader...The tactical use (and goals) of these missiles can vary in accordance with the type of threat." - General Mehdi Farah, Deputy Defense Minister and Head of Iran's Aerospace Organization, October 19, 2012. http://www.irandailybrief.com/2012/10/19/deputy-defense-minister-iranian-speedboats-capable-of-launching-cruise-missiles/
- "Our cruise missiles can completely respond to any kind of threat…Nasr, Qader, Nour, Zafar and Fateh anti-ship cruise missiles can hit every enemy target…[Iran] feels no shortage in missile fields." - Brigadier General Ahmad Vahidi, Iranian Defense Minister, October 6, 2012. http://english.farsnews.com/newstext.php?nn=9107110952
- "The Islamic Iran's progress in different fields of aerospace and missile industries is endless and Iran is self-sufficient today in producing missiles in different sizes and needs no one. The youths of this land are able to manufacture missiles and are manufacturing them." - Vice President for Parliamentary Affairs Seyed Mohammad Reza Mir-Tajaddini, October 10, 2012. http://english.farsnews.com/newstext.php?nn=9007160864
- "Different kinds of cruise missiles that are currently in our possession are for marine targets, and Nasr, Qader, Nour, and Zafar missiles as well as Fateh ballistic missile are able to repel any threat…Iran has no shortage in the missile field... - Brigadier General Ahmad Vahidi, October 6, 2012. http://www.presstv.ir/detail/2012/10/06/265261/iran-missiles-will-answer-threats/
- He said that Iran has reached self-sufficiency in the missile industry and added we can target every base of the enemy in the region from any spot with the desired precision and degree of power.[263]
- "We intend to reach the point where our aerial defense ability will be so efficient from the operational perspective that it will destroy and disrupt all the enemy's military plans. Regarding anti-missile defense shields such as the Iron Dome, it must be understood that these systems can give limited coverage, to a certain height and range, and therefore all these plans are just psychological warfare. They know full well that they are very vulnerable from the technical and operational perspective, and they cannot remain protected from a multi-missile attack by Iran's accurate, destructive missiles." - Mohammad Eslami, Deputy Defense Minister for Industry and Research, August 27, 2012. http://www.irandailybrief.com/2012/08/27/iran-to-expand-range-of-cruise-missiles-distancing-enemy-miles-from-maritime-borders/

Tehran has also been experimenting with new engines, suggesting that it has either learned how to vastly improve its old engines or started to develop new motors. Each rocket test renders the engine inoperable, which has been a major impediment to upgrading and testing Iran's old, restricted stock of Kh-55 cruise missiles and, potentially, Shahab-3 and Ghadr-1 MRBMs.

Iran has also had problems at a key test site. An explosion at the Bid Kaneh missile test site on November 12, 2011 is believed by the Institute for Science and International Security (ISIS) to have occurred during the testing of a new engine.[264] The presence of Major General Hassan Moghaddam (head of the "self-sufficiency section" of the IRGC missile center) suggests that the event was significant for the development of Iran's missile program. While the explosion has since been blamed on both careless maintenance by untrained technicians and sabotage, the presence of

such a high-ranking official so close to a missile suggests that a failure of the engine test would have been significant.

Evidence that Iran has developed at least a limited ability to construct its own engines comes from recent tests and exercises carried out by the IRGC. During the Great Prophet 3 drill, in July 2008, Iran reportedly fired nine ballistic missiles.[265] By Great Prophet 7, carried out in July 2012, Iran was reportedly able to fire "dozens" of missiles.[266] Although the uptick in tensions at the time may have led Iran to expend additional missiles, this also suggests that Iran either has a sufficient number of ballistic weapons stockpiled that it can afford to fire several dozen, or is capable of rebuilding its stocks through domestic manufacture.

Between the Great Prophet 3 and Great Prophet 7 exercises, according to the 2010 DOD report on Iran's military,[267] Iran had amassed an arsenal of 1000 missiles with ranges between 90 and 1200 miles. There are no sources that estimate how much the missile force has grown since then. IISS also suggests that Iran has, using the expertise gained in its artillery rocket program, developed far greater knowledge about solid fuels than liquid fuels.[268] This suggests that while Iran's stocks of Shahab-1, -2, and -3 may remain dependent on imports, longer-range systems such as the Sejjil-2 may be fully locally sourced and hence present in greater numbers as tensions in the Gulf escalate.

There is as of yet no solid evidence as to whether Iran has mastered the casting of missile fuels. This technical challenge is critical to the establishment of an indigenous missile program, and the expertise entailed normally requires both training by outside experts and considerable personal experience.

While many sources suggest that Iran is receiving help on its missile program from North Korea (with some possible assistance from Chinese and/or Russian scientists[269]), other experts question how dependent Iran is on North Korea versus North Korea (and Syria) acquiring technology from Iran. They feel North Korean rocket scientists do not have experience mixing fuels that are more effective than those currently in use by Iran.

Some feel that if Iran is to develop better fuels, it will have to obtain convince another ballistic missile state to violate the Missile Technology Control Regime (MCTR) and provide it with techniques, steal them via industrial espionage, or gradually develop the expertise locally. Iranian efforts to smuggle in aluminum powder suggests that while it may have mastered the production process for some solid rocket fuels, it is not yet self-sufficient in producing the precursor ingredients domestically.[270]

Iranian improvements in accuracy are less evident than increases in engine knowledge and warhead capacity. The existence of steering vanes on the Sejjil-2, along with reports of tungsten powder smuggled from China, implies Iran may have learned how to craft an inefficient but useful guidance system for an IRBM.[271] The steering fins on the Khalij Fars may provide a higher degree of accuracy, albeit for a slower and shorter-range system - if the video is accurate, they permit a relatively slow ballistic missile to hit within a few dozen meters of its target.

Research related to improving missile guidance continues to appear in Iranian universities and scientific journals. Research in ring laser gyroscopes, sensor fusion between gyroscopes and accelerometers, improvement of inertial navigation through redundant sensors, MEMS (microelectromechanical systems) gyroscopes.[272] These development could help Iranian missiles to miniaturize guidance systems, hit moving targets, and improve accuracy in general.

Satellite imagery and video footage of an attack on a simulated airbase during the Great Prophet 7 exercises would appear to shed light on Iran’s ballistic missile accuracy. Iran fired several types of missiles during this exercise, include Shahab-1/-2/-3, Fateh-110, Tondar 69, and Zelzal rockets. According to impact craters, nearly all the missile fell within 2km of the center of the 6 $km^2$ base, with one missile hitting the runway. The report continued:[273]

> “While it is impossible to definitively link the craters to the different types of missiles, the general level of accuracy would mean that, in a conflict between Iran and the United States, the majority would have to be engaged by missile defense systems. The Patriot Advanced Capability-3 (PAC-3) and ship-borne systems are currently deployed in the Gulf, with the Terminal High Altitude Area Defense (THAAD) system expected to arrive in the future. Even the missiles that fell more than 3 km away from the center of the base would have to be intercepted if they were suspected of carrying chemical warfare agents.”

Corresponding footage of the exercise also exists, where explosions appear in and around the simulated airbase.[274] However, Iran has conducted very scripted and pre-determined training exercises before. Iran has even doctored photos using Photoshop in order to exaggerate the scale of its missile drills.[275] The footage is not clear at all and it is impossible to determine how realistic the exercise was through the satellite imagery and video footage. While the value of this exercise in describing actual Iranian missile accuracy is dubious, it does provide an interesting open-source reference. There is little satellite imagery and corresponding footage like this in open sources.

In addition to the accuracy of the weapons, the tactical relevance of ballistic missiles is compromised without an effective over-the-horizon targeting capability. While no such capacity is needed for engaging fixed points - infrastructure, established military bases, cities - it is fundamental for engaging mobile forces, naval vessels, and troop concentrations. If Iran wants to turn its ballistic program into a viable military threat, it will have to develop sensor platforms and integrate those into its ballistic command and control.

Iran has built several long range radar systems in order to improve detection of missiles and aircraft. While these radars are not designed to provide long range targeting information for ballistic missiles, the development of these radars may shed light on the pace of Iranian technological progress in long range radars. If vital components of these radar systems are imported, it would suggest that Iranian development in radar technology is still reliant on foreign assistance.

One such system is the Ghadir surveillance radar, which was officially unveiled in June 2014. The Ghadir resembles Russia Rezonans-NE system.[276] It is a large stationary structure consisting buildings surrounded by four large radar arrays Brigadier General Farzed Esmaili claimed that “Ghadir can stand [up] well against electronic warfare systems, and there is a very small chance [of] their discovery and destruction by anti-radar missiles.” The radar was describes as being able to “trace” targets more than 1000 km away and up to 300 km high, and could “detect incoming missiles in depth and before they approach Iran’s borders.”[277] Brigadier General Amir Ali Hajizedeh added that it could even identify radar-evading aircraft and low-altitude satellites.[278] Although officially unveiled only recently, the Ghadir radar appears to have been operational since 2012 after 8-10 months of construction.

The Sepehr system is a “space radar system” that detect targets at a range of about 3000 km. Brigadier General Farzad Esmayeeli added that Iran was developing the capability to detect and track satellites by building radar systems that are “connected in phased arrangements.”

Esmayeeli also mentioned that Iran was designing and building passive phased array radars under the “Soundless Project,” which aimed to detect stealth targets and cruise missiles.[279]

Regarding Iran’s ability to overcome these accuracy hurdles, the Great Prophet 7 exercise in 2012 also saw the introduction of a new ballistic missile, the Qiam. While little is known about the technical specifications of the weapon, two details stand out. First is its improved warhead, which is mounted on a body that appears very similar to a Shahab-2. Like the new reentry vehicle for the Ghadir-1, it is triconic, implying that Iran has found a way to improve the payload for its older missiles. Second, the absence of steering fins suggests that Iran has improved its internal guidance systems to a more efficient (non-steering fin or steering vane) technology.

While there are no public testing data on how this upgrade impacts accuracy, it has the potential to reduce CEP and create a missile that could potentially, after additional refinements, pose a military threat.[280] These improvements suggest that Iran has begun to develop the domestic capacity to improve its existing missile stocks, expertise that may be used to reverse-engineer and locally produce missiles already in its inventory.

It is important to note that Iran has been conducting the Great Prophet series of exercises since March-April 2006 and that its claims of success in these exercises have become progressively greater. This is illustrated by summaries of Great Prophet 4 to Great Prophet 7 developed by Steven Hildreth,[281]

> **Great Prophet 4** (September 2009): Iran conducted military and missile exercises from September 27 - 28, 2009 in which it reportedly launched the Shahab-3 MRBM and the new solid-fueled Sejil-2 MRBM…An Iranian military official, Abdullah Araqi, was quoted as saying “Iranian missiles are able to target any place that threatens Iran.”…Another source said the “optimized Shahab-3” missile has a range of 1,300 – 2,000 kilometers and that the Sejil was launched for the first time in military maneuvers from the central province of Semnan where Iran’s space program is located.
>
> The IRGC’s Air Force Commander said the main aim of the exercise was to evaluate the “technical developments recently achieved in surface-to-surface missiles ... including simultaneous ... and successive” missile launches….Also reported were launches specifically of Shahab-1 and 2 SRBMs, and Fateh, Tondar, Zelzal, and various other tactical ballistic missiles…Iran claimed to have also tested a “multiple missile launcher for the first time.”
>
> **Great Prophet 5 (April 2010):** Iran conducted war games on April 22 – 25, 2010, reportedly firing five tactical sea-to-sea and shore-to-sea missiles at a single target simultaneously from different locations…The Deputy Head of Iran’s Armed Forces Headquarters, BG Massoud Jazayeri, said Iran “is designing defense operations to strengthen deterrent power of its forces and give a crushing response to any aggression. “But it does not appear that any short or medium-range ballistic missiles were launched in this exercise.
>
> **Great Prophet 6 (June 2011):** Iran conducted military exercises June 27-July 6, 2011 and reportedly launched 14 ballistic missiles, including Shahab-1 and Shahab-2 SRBMs and Zelzal and Fateh-110 tactical ballistic missiles. At least one Qiam SRBM, or an upgraded Shahab-3 or Ghadr (or Kadr), or a Sejil MRBM…was reportedly launched, depending on which source is cited. Reports said some missiles were aimed at targets at sea and perhaps as many as nine of the missiles were fired simultaneously…The Department of Defense subsequently confirmed that this exercise included a multiple missile salvo of some unspecified number.
>
> Iran also unveiled the existence of a network of underground missile silos for the first time, which
>
> IRGC spokesman Asghar Qelich-Khani said were “part of the swift reaction unit of [Iran’s] missile brigade; missiles are stored vertically.”…*The New York Times* added that Iranian officials showed an underground launching pad or silo for what they called the Shahab-3 MRBM. The televised reports also showed a large metal roof opening atop the silo to allow the firing of the missile….Iran claimed the silos were built indigenously, but Israel was reported as saying the silos were built with DPRK assistance.

> One account of a tour of the silo complex also showed reported footage of a missile launch from a silo…which at least one analyst said looked like the launch of a DPRK missile from its silo. Although Iran kept the location of the silos a secret, others, such as *Jane's Defence Weekly*, said Iran's hidden silos were near Tabriz and Khorramabad. IRGC deputy commander BG Hossein Salami further added, "our missiles have aggressive, tactical, strategically deterrent and defensive features, of course we will not initiate any operation but our responses will be purely aggressive."
>
> …The Washington Post reported a Shahab-3 was fired at targets at sea and added that Iranian television quoted Iranian military officials saying that Iran "began building a network of such silos across the nation 15 years ago."
>
> **Great Prophet 7 (July 2012):** Iran held military exercises and missile launches July 1-3, 2012. Iran reported that it fired from different locations tens of Shahab-1 and Shahab-2 SRBMs, Shahab-3 MRBMs and Fateh, Qiam, Persian Gulf, and Zelzal tactical ballistic missiles simultaneously at a mock air base in Iran's Lut desert in southeastern Iran.
>
> IRGC Aerospace Force Commander BG Amir Ali Hajizadeh said "these maneuvers send a message to the adventurous nations that the IRGC is standing up to bullies alongside the determined and unified Iranian nation, and will decisively respond to any trouble they cause." Iran's FARS news agency further said these exercises "underline Tehran's threat to strike U.S. military bases in the neighboring countries—in Afghanistan, Bahrain, Kuwait and Saudi Arabia—if it comes under attack by Israel or the United States."
>
> The Associated Press (AP) reported from Iranian sources that the missile tests demonstrated improved accuracy where 90% of the missiles hit their targets. Additionally, AP reported that Iran said it fired a considerable number of missiles against a single target (mock air base) making it "impossible for anti-missile systems to intercept and destroy them." Iran warned that 35 U.S. military bases in the Middle East are within Iran's missile range and would "be destroyed within seconds after any attack on Iran."…Another source said Iran claimed it had launched a missile capable of reaching targets 2,000 km away, but only fired to a range of 1,300 km. and repeated many of the things said here of July 2012 test launches. There was no reported official U.S. response as to the accuracy of the claims made by Iran about their Great Prophet 7 exercises.
>
> **Great Prophet 8 (February 2013)** was held in Eastern Iran and it involved a mix of land. Air, and asymmetric warfare activity including activity in the cities of Kerman and Sirjan, but there were no new announcements of major missile activity.

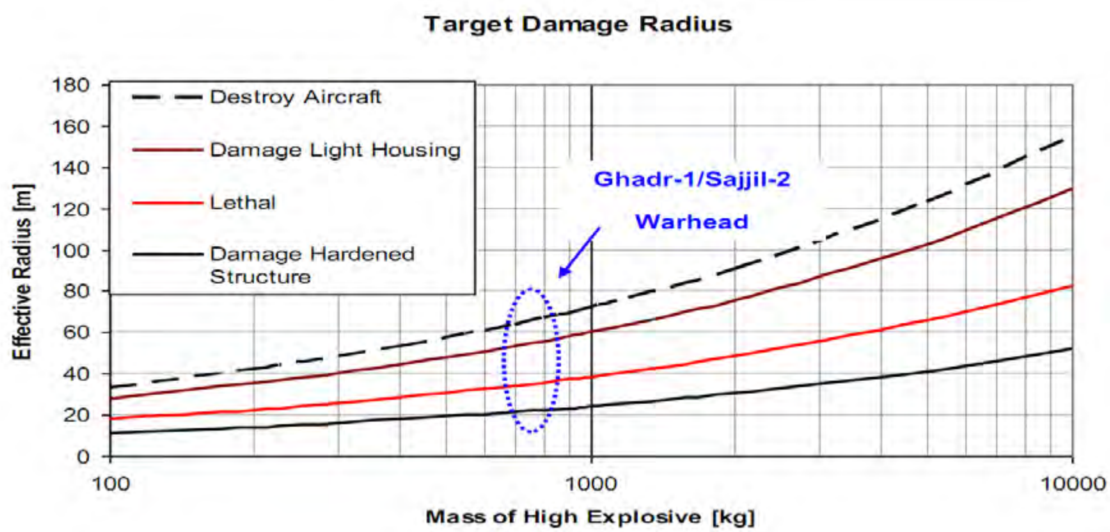
There is no unclassified way to validate the claims Iran makes during its exercises, and US and other experts indicate there is evidence that they have sometimes exaggerated claims relating to accuracy and reliability in conducting successful multiple launches, and physical faked imagery on their level of accuracy in striking area targets like air bases.[282] At the same time, any current exaggerations and delays in Iranian efforts to produce and test new missiles does not mean that the Iranian ballistics program cannot achieve high levels of accuracy and reliability or evolve to the point where missiles have highly accurate terminal guidance.

According to various experts, new missile systems routinely take 4-6 years; while Iran's jump from the Zelzal to the Sejjil has taken twice as long, this effort has helped Iran reduce its industrial deficit, and it now has a much higher level of ballistic know-how than it did during the 1990s. While failures are costly, in terms of time, money, and, occasionally, people, they have also helped Iran build a far better platform for continuing its missile research. While strongly hindered by sanctions and the general low level of industrial technology in the Iranian economy, Iran likely has enough indigenous experience to continue developing and improving its ballistic missiles, even in the face of international pressure and efforts to prevent it from importing missile technology.

In summary, it does seem likely that Iran's ballistic weapons will grow steadily more accurate over time as its missile technology keeps evolving along with Iran's design and manufacturing skills. The pace and character of that improvement, however, is almost impossible to estimate without more empirical data. The kind of warnings experts like Rubin have given do not seem to apply to

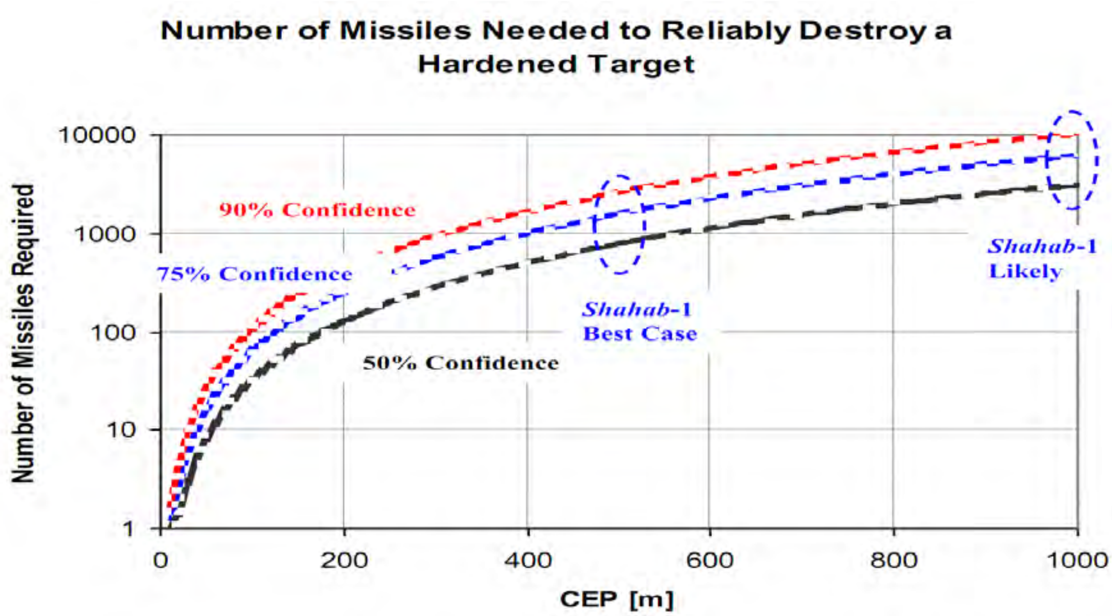
Iran’s current forces or those it can develop in the near term. What is probably an unrealistic “worst case” today, however, can become a reality in the future. Given the lead times in halting Iran’s efforts, or creating effective deterrents and defenses, this makes it as important to take Iran’s future capabilities for precision conventional missile warfare just as seriously as its future capabilities for nuclear-armed missiles.

***Figure 26: Estimate of Sejjil Lethality against Soft Targets***




Source: Michael Elleman, "Iran's Ballistic Missile Capabilities: Assessing the Threat to Civilian Infrastructure," April 24, 2012, http://www.fleminggulf.com/cms/uploads/conference/downloads/IISS.pdf.

***Figure 27: Estimate of Shahab-1 Lethality against a Hardened Target***




Source: Michael Elleman, "Iran's Ballistic Missile Capabilities: Assessing the Threat to Civilian Infrastructure," April 24, 2012, http://www.fleminggulf.com/cms/uploads/conference/downloads/IISS.pdf.

## *The Range-Payload Challenge*

Many of the data on Iran's missiles use computer models to guess the range of Iran's missiles by assuming a nominal payload on 750 to 1,000 kilograms. These models normally have at least an uncertainty of +/- 30%, even assuming such a normal payload. In the real world, the actual payload determines missile performance, which may be much heavier or lighter than the nominal payload. Missiles that use conventional or CBR warheads, or early nuclear designs, may well have much higher payloads than the nominal 750 or 1,000-kilogram warhead. They may also require less stable warhead shapes and increase reentry and stability problems, further reducing the accuracy of the system.

This is one reason any Iranian long-range ballistic missile program is likely to incorporate significant testing before Iran attempts to use it. Different warheads have slightly different centers of mass, which, while not noticeable during short-range testing, can have a dramatic effect on a missile over several thousand kilometers of flight. Even with advanced in-flight steering systems, the warheads must be tested for stability, forcing Iran to use either advanced warheads or very close analogues if it wishes to install CBRN weapons on its missiles.

Iran also is confronted with the difficulty of building missiles out of more advanced materials than it currently has available. Lighter, stronger components such as maraging or flow-formed steel, titanium, or composite materials would reduce missile weight and extend range. But at this time, Iran does not have the technical know-how to produce these components. Doing so would also allow it to reduce structural integrity concerns, removing one constraint on warhead weight.

Iran's recent missile test over the Indian Ocean was likely a trial for a system with an improved range-payload. Although it is unknown whether the missile was solid- or liquid-fueled or derived from a Shahab-3 or Sejjil-2, the test shows that Iran believes it can no longer gain sufficient range-payload data from land-overflight tests within Iran itself. Due to insufficient open source information, it is unknown what data Western and Iranian military planners gathered from this test.

## *The Warhead Lethality Challenge*

A high explosive warhead on a long-range missile presents design problems that limit its lethality compared to bombs, air launched missiles, and cruises missiles. Unless it is almost perfectly fused and designed, or uses cluster munitions that are explosively disseminated at exactly the right altitude and are designed and fused so they are actually lethal against the target type being struck, the damage tends to be limited by the fact that due to warhead design and high reentry speeds the explosion of a unitary warhead is deflected upwards as the warhead hits the earth - vectoring much of its explosive effective where it will do far less damage.

As a result, the damage is significantly less than that caused by a bomb or artillery shell of the same general size. As has been stated earlier, Iran has said it possesses cluster munitions on some of its systems. But the presence, character, and effectiveness of such warheads is uncertain from unclassified data and it is not clear that Iran could have conducted enough suitable tests of its longer range systems to have reliable data.

Unless these submunitions are armed with chemical, radiological, or biological agents, they present the problem that each additional submunition imposes extra non-explosive weight on the missile, reducing its effective payload. Further, on an inaccurate missile, the submunitions are still likely to miss the target area. While they increase the chance that a submunition will strike

something of value, they are unlikely on their own to cause significant damage. The submunitions that Iran can deploy are also of limited value. While some advanced types can seek out individual tanks and penetrate their thin armor at the top, Iran is more likely to use grenades with an altimeter, meaning they can only injure light structures and individuals.

The lethality of conventional cluster munitions could be substantially higher where shorter-range missiles or rocket could be fired in volley and line of sight observations are possible. But it is one thing to use cluster munitions with a precision-guided air launched bomb or missile, or unguided cluster munitions against exposed infantry, and quite another to fire them almost at random. Until Iran acquires medium to long-range missiles with precise terminal guidance and/or truly effective warheads using some form of weapon of mass destruction, the lethality of its missiles will be sharply limited.

These conditions do not apply if a missile warhead has reliable and accurate terminal homing of the kind the US deployed on the Pershing II, the level of accuracy of US cruise missiles, or has truly accurate missiles that can actually achieve operational results equal to the most accurate GPS guidance platforms. Even then, however, the probable lethality will at best be that of a single bomb of the same size, and it is far from clear that the terminal guidance of a ballistic missile will really achieve the same accuracy as a cruise missile or precision guided bomb. The problems imposed by range, far greater levels of acceleration, and reentry buffeting are simply too great.

Iran does, however, continue to make ambitious claims. In December 2013, Brigadier Hossein Dehghan, Iran's Minister of Defense, claimed that Iran had used lasers –evidently meaning the most advanced GPS guidance systems – to make its long-range missiles able to strike with two meters versus an earlier 200 meters: "{The inaccuracy of (our) ballistic long-range missiles in hitting targets is so minimal that we can pinpoint targets. The accuracy of surface-to-surface missiles is now two meters, while at some stage in the past it was 200 meters. We strive to reach zero inaccuracy."[283]

On February 10, 2014, the Iranian Ministry of Defense announced that they had tested a new missile named the Barani.[284] It is reported to have said that this was part of a "new generation of long-range ballistic missiles carrying multiple re-entry vehicle [MRV] payloads, "and the Fars News Agency quoted Defence Minister Brigadier General Hossein Dehghan as saying that it also would have advanced penetration aid to counter missile defenses: "Evading enemy's anti-missile defense systems, the capability of destroying massive targets and destroying multiple targets are specifications of this missile." [285]

This missile was purportedly equipped with multiple re-entry vehicles. However, MIRV technology is out of Iran's reach. The payload for this missile, if it truly exists, is more likely a cluster warhead. An Iranian TV segment showed a Shahab-3 intermediate-range ballistic missile (IRBM) launch, and then cut to a computer-generated clip of two ballistic missiles each releasing around 30 re-entry vehicles in space. In all likelihood, the "test" was nothing more than an exercise in deception and propaganda.[286]

The UN Panel of Experts report issued in June 2014 reported that, [287]

> On 10 February 2014, the Islamic Republic of Iran test-fired the Barani, described by the Ministry of Defence as "a new generation of long-range ballistic missiles capable of carrying multiple re-entry vehicle payloads"… Experts identified it as a variant of the Shahab (Ghadr 1) and questioned its alleged multiple re-entry vehicle capability, suggesting instead that it carried sub-munitions. The Islamic Republic of Iran reportedly first announced this capability in 2006. Aside from the Barani, the Islamic Republic of Iran

announced no tests of new ballistic missiles.

Iran also announced another new missile called the Bina at the same time, which Iran's Fars News Service said was both air launched and rail-based.[288] Hossein Dehqhan was reported to have said the Bina had fragmentation warhead, and used laser guidance in an air-launched mode – which would require the aircraft or someone on the ground to illuminate the target continuously during the tracking phase. According to some reports, it is an Iranian copy or upgrade of the US Maverick air to ground missile with a semi-active laser seeker and not a suitable system ground launch. There is a limited possibility it might be fired at line-of-sight ranges or be able to acquire a laser illuminated target at longer ranges. Photos of the missile on an Su-25 attack fighter strongly suggest this and show it is a short-range system and not capable of approaching even the ranges of an SRBM. It is possible that such a system could work at short ranges, but this is very far from either some new form of laser homing or correlation or a cluster warhead for a longer-range missile. [289]

Another potential example of a cluster munition weapon was seen in the IRGC-ASF "Exhibition of Achievement" in May 2014, where a Zelzal rocket had its warhead exposed to reveal several submunitions.[290] But this missile has not been seen outside the exhibition.

## *The CBR Warhead Challenge*

Many conditions that affect missiles with conventional warheads do not apply if a missile is armed with a nuclear warhead or a truly effective chemical or biological weapon. Once again, however, even nuclear weapons need to be part of a warhead with a reliable height of burst to reach maximum, predictable effectiveness. The conditions are far more challenging for chemical and biological weapons (CBW). The closing velocities of missile warheads are so great that getting the correct height for a broad, effective dissemination of chemical agents, particularly in varying local conditions, is a major engineering challenge.

As the fighting in the Syrian civil war has shown, any use of chemical weapons can also trigger a global reaction and local military response that greatly exceeds its military value. The US and other outside states reacted far more severely to token chemical warfare casualties than massive conventional casualties regardless of the fact that chemical weapons are no more horrific in their effects than many fragmentation wounds.

Any sort of CBRN weapon also needs extensive live testing on an areas basis to ensure its accuracy and efficacy, and there is no evidence to date that Iran has done such tests. Moreover, chemical and biological agents inside the re-entry vehicle would need to be shielded to a point where internal temperatures are low enough to prevent heat from affecting the lethality of the payload.

This is equally true of biological agents, some of which are also extremely sensitive to sunlight. CBW warheads are much easier to design in the computer than to make work in the field, particularly given the error-prone fusing and proximity equipment Iran likely has access to. Biological agents have become progressively easier to make with commercial food processing and pharmaceutical equipment, as has the genetic modification of such agents. It is much more difficult, however, to determine their lethality, infectivity area effects, symptoms and detection, and treatments and countermeasures. These are not casual issues because any use of such weapons could trigger world condemnation and a massive escalatory response. Moreover, Iran would not risk the spread of any infectious agent. In many ways, the potential to create and deploy such

weapons is a safer and more productive way to use them, and a "bio in the basement" is better "than a bio in the hand."

Designing chemical and radiological warheads that can achieve anything like the potential lethality of the agents they carry under operational conditions is extremely difficult. Under many real world conditions, they would have more of an area denial, psychological, or panic impact than actual lethality. Chemical weapons and all but the most advanced radiological weapons have lethalities several orders of magnitude less lethal than nuclear weapons and the most lethal biological weapons.

During the Iraqi SCUD strikes against Israel in 1991, even the threat of chemical weapons was sufficient to badly impair civilian life for a few weeks. The psychological and political impact of these weapons, particularly on populations that have no exposure to military operations, is hard to estimate but is likely to be severe. Even a prepared military may take some casualties from CBR attacks, and are forced to use bulky and time-consuming equipment to avoid fatal contamination. These problems are particularly acute for biological weapons, which only need a few successful initial contaminations to cause mass casualties.

Biological warheads also present critical problems for missile warhead design, and again, the theoretical lethality of the agent is no indication of operational lethality. Moreover, short of extensive testing against live humans under realistic urban or combat conditions, real world lethality is extremely difficult to predict. Animal testing can help with some biological agents, but many can only be used against humans. Past testing warns that selective use of agents against animals under simulated operational conditions cannot be scaled up or reliability predict lethality.

Nevertheless, chemical, biological, or radiological (CBR) warheads would provide a much more effective deterrent to attack and provide Tehran with the ability to strike at major population centers. Given such payloads, even a small number of missiles armed with CBRN warheads that bypassed US and Arab Gulf defenses and countermeasures could potentially cause serious to massive casualties. But much would still depend on the ability to design truly effective chemical and radiological submunitions, solving the problem of dispersing effective biological weapons, or having truly reliable nuclear warheads.

Under worst-case conditions, such weapons could still do considerable damage to the militaries, economies, and critical infrastructure of regional countries. These capabilities, in combination with the deterrent and the psychological impact they would produce, would have a profound impact on the strategic balance between Iran and the US and its Arab Gulf allies.

## *External Dimensions of Iran's Missile Program*

Starting from a low industrial base and with no prior experience in ballistic missile production, Iran was forced to rely on other states' support during the early years of its missile program. Iran obtained most of its ballistic equipment and expertise from North Korea. There are unconfirmed reports that China and Russia assisted as well. As Iran's missile program has matured to the point that Tehran can build its own missiles, Iran has begun exporting its short-range systems, enabling its proxies throughout the region to leverage Iranian systems.[291]

Most public sources identify the Shahab-1, Shahab-2, and Shahab-3 as imported SCUD-B, SCUD-C, and Nodong North Korean missiles. North Korea exported these weapons as fully developed systems, allowing Iran to rapidly develop a SCUD missile force in the late 1980s and Shahab-3

missiles in the mid-1990s. Pyongyang also permitted Iranian engineers to visit North Korean production facilities, training them in the basics of missile design and production.

However, North Korea also suffered from a low technological base for missile production. As Dr. Elleman reports,[292] it is likely that North Korea's liquid fueled missile program still depends on Russian-manufactured engines and critical components. It is likely that North Korea's relative inexperience and lack of sophisticated systems, and consequent inability to teach Iranian scientists, helped retard the growth of the Iranian ballistic missile program.

Unconfirmed reports[293] suggest that under these circumstances Iran accessed Chinese expertise in overcoming major technical roadblocks. Although Iran likely preferred to resolve problems on its own and build indigenous know-how, it probably turned to China for help in addressing some intractable problems, probably relating to solid-fuel and engine production. It is also possible that the reports of a Chinese presence at missile tests were either false or simply reflected Beijing's interest in Tehran's missile development, rather than a sustained commitment to building Iran's missile program. Examples of Russia's involvement are even more fragmented, with the strongest evidence consisting of unconfirmed reports of Russian individuals working with Iranian ballistics engineers. Iran is also clearly using Russian technology, but given the proliferation of Russian ballistic systems in the aftermath of the Cold War, this does not point to direct support by the Russian government.

The only nation whose support at the state level for Iran's ballistic program has been confirmed is North Korea.[294] The DPRK has provided complete missiles, metrics on missile testing, training, and possibly joint research and development, enabling Tehran to quickly build-up its missile stock and study a more advanced missile program at close range. This expertise likely enabled Iran to begin refurbishing and repairing missiles domestically by the 1990, gradually advancing to assembling the missiles domestically with imported parts.[295]

This aid was partially limited by the poor quality of support from Pyongyang. While Iran used North Korean engines to power its first and second generation of liquid-fueled missiles, early tests often encountered significant problems in achieving the degree of reliability that Iran hoped to reach. It is unknown whether North Korea has improved the quality of its exports (in effect, having used Iranian and Pakistani missile launches as extended tests for its own ballistic program) or whether Iran has learned how to check and repair faulty components that it imports.

Open source information suggests that Iran has begun proliferating its weapons to allies and proxies throughout the region. Iran was possibly a transshipment point for North Korean exports to Syria, and likely provided support for Syria's establishment of its own assembly, maintenance, and repair facilities for its SCUDs. Iran also exported Fateh-110 missiles to Syria, possibly supplying entire production facilities to allow Syria to develop its own domestic missile capacity.[296]

Iran has also provided material support for Hezbollah and other proxy groups around the Middle East. It appears likely that Iran provided Zelzal rockets to Hezbollah during the early 2000s, in addition to shorter range rockets and military material.[297] Israel claimed that during its 2006 campaign against Hezbollah, it destroyed the majority of these imported missiles in bunkers, preventing Hezbollah from firing them during the conflict. Unconfirmed reports suggest that Hezbollah has or had as many as 220 Zelzal missiles, although the number operable today - between years of wear and tear and Israeli raids - is unknown.

Iranian exports to the heart of the Middle East are believed to travel two routes. Some weapons are air-shipped over Iraq to Syria and Hezbollah, a route that has only been available since the fall of Saddam. Most proliferation, however, travels by water, allowing foreign intelligence agencies the opportunity to track and occasionally interdict these shipments.[298] Despite this, Iran has continued to supply Hezbollah and Syria with missile systems, as this integration of ballistic technology and proxy war forms an integral component in Iran's extension of its strategic reach in the Middle East.

Currently, Iran's ballistic program appears to be making a transition from net importer to net exporter of ballistic technology. While it still may be importing some components from North Korea - likely engines - Iran either has already made or has attempted to make the switch to self-sufficiency. For solid fuel, Iran appears to be self-sufficient for its smaller missiles (Zelzal and Fateh-110), and maybe self-sufficient for the larger Sejjil-2 as well. Open sources indicate that it still may be working with China in advancing solid-fuel technology, but it is already sufficiently advanced to help Syria assemble and perhaps produce its own first-generation solid-fuel rockets.

# VII. Cruise Missiles

Iran has a long history of acquiring a range of unmanned shorter-range cruise missile systems it can use in land-attack, sea-based attached, and air-launched missions. These are large tactical systems that supplement its conventional warfighting capabilities or improve its short-range air and naval precision strike capability.

The majority of Iran's cruise missiles are anti-ship missiles. Iran's anti-ship missile (AShM) arsenal represents a key part of its asymmetric anti-access/area denial (A2/AD) strategy. An A2/AD strategy is particularly effective in the Persian Gulf, Straits of Hormuz, and Gulf of Oman because of the relatively confined spaces of these bodies of water. The wide variety of platforms from which Iran can launch AShM's presents a "360 degree threat."[299] In addition to coastal, ship, and fixed wing platforms, Iran recently integrated AShM's onto helicopters and aims to develop submarine launched missiles.

Surface vessels that can fire AShM's are a crucial part of Iran's asymmetric strategy. Part of this strategy calls for swarms of small vessels to attack larger enemy vessels. Although it is difficult to ascertain the current operational readiness of Iran's surface fleet, a 2009 report by the US Office of Naval Intelligence stated that approximately half of the IRIN's missile-armed surface combatants were in "very poor material condition, limiting their readiness and operational endurance."[300] To make up for this, coast-launched AShM's can be used in conjunction with small-boat swarm attacks in order to saturate enemy vessel defenses. AShM's based on coastal platforms are small, mobile, and can be disguised as civilian vehicles, making destruction of these platforms difficult.[301]

While Iran's shorter range AShM's, like the Nasr and Kowsar, are rocket powered, longer range AShM's are air breathing, making them cruise missiles. Iran's anti-ship cruise missiles (ASCM) include the C-802, Noor, Qader, and Ra'ad. Noor and Qader are both based on the C-802, which was imported from China. The Noor has a maximum range of 120km and the Qader has a maximum range of 200km.

These missiles are found on Iran's frigates, corvettes, and fixed wing aircraft. The Qader was claimed to have been integrated onto helicopters at the same time the same claim was made with Nasr. While the Mi-17 was specified as the platform for the Noor, no specific helicopter was given as the platform for the Qader.[302] Considering that the Qader is slightly larger than the Noor, but similar in the sense that it is also a C-802 derivative, the Mi-17 is likely the helicopter platform for the Qader. The Ra'ad, which is a modified HY-2, is Iran's longest range ASCM with a stated range of 360km.

The newest anti-ship missile was unveiled August 2014, the Nasr-e-Basir. It was described as having "high-operational capabilities with its silent and smart features." Pictures of a missile with the name Nasr-e-Basir written on the side show a short missile that lacks a scoop air inlet like the ones found on some of Iran's longer range anti-ship missiles.[303] This suggests that this is a shorter range, rocket-powered anti-ship missile.

## *Possible Ongoing Development efforts*

US intelligence reports have indicated, however, Iran is developing longer-range cruise missiles with a land attack capability. According to various reports, some of dubious veracity, it has had

access to as many as three advanced cruise missiles that could pose a significant threat to US forces in the region, with one capable of carrying nuclear payloads. These three systems may include the Kh-55 or AS-15A, the SS-N-22 Sunburn, and the SS-N-26. All three were developed by the Soviet Union in the 1980s, the latter two to combat Aegis-equipped ships; if they have been properly maintained and are used correctly, in the confined waters of the Gulf they represent a threat to US ships.[304]

## Kh-55

Twelve Kh-55 missiles may have been transferred to Iran by Ukraine in 2001.[305] Although the weapon was designed to carry a nuclear warhead, as a conventional weapon it could carry 410 kg of explosive, enough to do substantial damage to a naval vessel. With a maximum speed of Mach .8, a range of 2500 km, and inertial navigation and terrain matching guidance giving it a CEP of 25 m, it is slower but more accurate than any of Iran's ballistic missiles.

The Kh-55 was designed as air-launched cruise missiles, and while Iran may have adapted them for ground launch, so far there have been no public demonstrations of these missiles. The system was designed as a ground-attack system and is unlikely to be effective against moving vessels unless Iran has upgraded its seeker system. Given Iran's difficulty fabricating parts for its ballistic missile program, and the need to develop suitable power plants and guidance packages, Iran is unlikely to have reverse-engineered this or any other cruise missile. There are no indications that Iran has test-fired a Kh-55 or any cruise missile with similar characteristics in recent drills.

If Iran could eventually make use of these systems or reverse engineer them, they could represent a serious threat. Their range would allow Iran to target Israel, the entire Gulf, and Southeastern Europe from bases well within Iran. While the missile was originally armed with nuclear weapons, it is unlikely that Iran would be able to develop a 410 kg nuclear device in the near future (see below). The Kh-55's main danger comes from precision and long range. Although far more accurate than any ballistic missile currently in Iran's inventory, its relatively small payload (410 kg vs. 1000 kg for most SRBMs) and vulnerability to anti-missile weapons limits its effectiveness in hitting hardened and defended targets.

## SS-N-22

There are unconfirmed reports that Iran received eight SS-N-22 Sunburns from Russia early in the 1990s.[306] The Sunburn is larger and heavier than the Kh-55, with a maximum speed of Mach 2.5 at high altitudes and 2.1 at low altitudes. It carries a 300-320 kg warhead and has a maximum range of 160 km. Its guidance package uses inertial navigation and data links for launch and mid-course flight, with the final approach controlled by the missile's radar. This weapon was designed to be a carrier-killer for Soviet bombers, and for its time would likely have been highly effective against US anti-missile defenses. It is unknown if Iran has managed to improve on these weapons or has only been able to refurbish its current stock, and with the exception of a 2006 image of a Sunburn-like missile being fired from an Iranian frigate, there are no public data on their current status.

## SS-N-26

The SS-N-26 was designed to be a lighter, cheaper version of the SS-N-22. While some reports claim that it was publicly displayed in 1993, it is unknown if Iran has received any shipments of this missile. It has a longer range than the Sunburn but carries a lighter payload - 300 km vs. 160

km and 250 kg vs. 300-320 kg. It can be launched from submarines, surface ships, aircraft, and land batteries. If Iran actually has any, they are likely stationed on mobile launchers around the Strait of Hormuz. With the exception of a passing reference in *Missile Threat*, however, there is no indication that Iran has access to these weapons and intelligence experts do not feel they are a current threat.

In addition to these cruise missiles, Iran also has several hundred C-801, C-802, and SSC-3 missiles. These weapons have shorter ranges (50 km, 120 km, and 80 km), slower speeds (Mach .85, .85, and .9), and generally smaller warheads (165 kg, 165 kg, and 513 kg). All three carry some form of inertial guidance or autopilot combined with radar for the attack phase. All are based on designs that date from the 1960s or 1970s, although the Chinese production runs that Iran likely had access to from the 1980s and 1990s.

Iran does claim to have upgraded its speedboats and patrol craft to launch more advanced cruise missiles.[307] Observers of recent naval exercises have not publicly verified such claims. The mounting of the C-700 and C-800 series of weapons on small vessels is confirmed, however, and presents a real threat. It is also one where US and allied navies and air forces must attack the moment such a missile launch becomes likely in order to minimize the threat of a successful strike on a US or allied ship.

## HY-4/C-601/FL-4 Silkworm[308]

Iran also may have the Chinese HY-4 (C-601, Fl-4 Silkworm; NATO designation CSSC-7 Sadsack), although reports in this regard are unconfirmed. The HY-4 has a range of 135-150 km, a maximum speed of Mach .8, and a 513 kg warhead. It is a lighter version of the HY-2 Silkworm (2,000 kilograms versus 3,000 kilograms) with a turbojet sustainer with solid-fuel booster, a speed of Mach 0.8. There are reports that turbojet has had power and reliability problems.

According to Global Security, it has an, "autopilot for mid-course guidance and a J-band (10-20 GHz) monopulse active radar seeker for the terminal phase. A radio altimeter allows the cruise height to be adjusted between 70 and 200 m and the terminal phase involves a high angle dive attack. It is equipped with a 500 kg warhead, which is probably semi-armor-piercing."

It is normally air-launched, but a version is available that can be ship-launched, While it seems to be longer-range maximum range than the C-801, C-802, or SSC-3, none pose the same level of risk to military vessels that the SS-N-22 and SS-N-26 do. China is reported to have developed a longer-range version with an up to 300-kilometer range, but not to have put it into production.

## Indigenous Land-Attack Cruise Missile

Iran also has claimed it was going to deploy a new long-range land attack missile. The *New Straits Times* reported on April 1, 2013 (http://www.nst.com.my/latest/iran-to-unveil-new-cruise-missile-1.141722) that,

> Iranian Deputy Defense Minister Mehdi Farahi announced that a new domestically manufactured cruise missile with a range of 2,000 kilometers will be unveiled in the near future, Iran's Mehr News Agency (MNA) reported. Farahi also said that the cruise missile, named the Meshkat (Lantern), can be launched from land-based and sea-based missile systems, adding that the missile can also be fired by fighter jets.
>
> In addition, he said that Iran has built or is building 14 types of cruise missiles, including Zafar, Nasr, Qader, and Ghadir missiles. Elsewhere in his remarks, Farahi said that in the field of missile technology, the Defense Ministry has focused its efforts on increasing the precision, radar-evading capability, and operational range of domestically manufactured ballistic missiles.

> On the United States plan to build missile defense shields in the region, he said, “They are making some efforts and some claims, most of which are false, exaggerated, and have no basis in fact.” He also said, “We hope that no incident will take place, but if a conflict occurs, they will see that their claims are ineffective.”

This would be a far more ambitious cruise missile strike system that Iran has announced to date. The Zafar missile is a short-range anti-ship cruise missile designed for mounting on speed boats and small craft. The Noor seems to be a larger anti-ship cruise missile with a range of 130 to 1270 kilometers.

The Qader has variously been reported as an upgrade to the Shahab 3, as an unpowered electro-optically guided 2,000 pound glide-bomb, as a cruise missile with a range of up to 200 kilometers that can be used against ships and land targets, and as identical to the Meshkat - illustrating the problems in charactering Iran’s forces using unclassified sources.

One problem that helps create much of this confusion is poor translation and transliteration of Farsi into English and Roman lettering. For instance, while poor transliteration may lead one to believe that the same name is being used to designate a 200km anti-ship cruise missile and a ballistic missile derived from the Shahab 3, a proper translation from the Farsi reveals that the anti-ship cruise missiles English name is “Capable” and the ballistic missiles name is “Intensity.” Unfortunately for those who do not understand Farsi, those two Farsi words sound similar.

A land attack capable attack version of the Qader anti-ship cruise missile called does seem to be the same system that the US Director of National intelligence identified as a new land attack capability in April 2013. However, a similarly named Ghadir has been reported as a smaller anti-ship cruise missile that can also be used against land targets, and the same name is used for midget submarines.

Iran may not have been able to activate its KH-55s as operational systems, or reverse engineer them, but it does seem to be developing the capability to produce and deploy long range cruise missiles. The key point is that Iran has not shown it has been able to activate its KH-55s or reverse engineer them, but does seem to have developed enough long-range cruise missile technology and production capability to deploy such systems in the future.

During the IRGC-ASF exhibition in May 2014, the IRGC unveiled the “Ya Ali” land attack cruise missile, which has a reported range of 700km. IHS Jane’s notes that it is similar to the Chinese YJ-62 (export designation C-602) and may use a version of the Tolou turbojet that is already in use with Iran’s long range anti-ship cruise missiles. The wings do not retract into the missile body, suggesting that the missile cannot be launched from a container.[309] Little is known about the Ya Ali and it does not appear to have been shown outside of the May 2014 IRGC exhibition.

### *Other Cruise Missile Developments*

It is clear that that Iran is continuing to develop some new cruise missiles, although most of its public focus is on naval systems. Tasnim news agency reported that Rear Admiral Habibollah Sayyari, the Commander of the Iranian Navy, stated in late November 2013 that Iran planned to new cruise missiles during military exercises in January 2014. He stated the Velayat-92 exercises would be Iran’s largest yet, and would be held in northern part of the Indian Ocean and neutral waters, Tasnim news agency reported, “The newest cruise missiles will be tested during these exercises, aside from that, we will also test new weapons.” He also talked about new unmanned aerial vehicles (UAV) and said that Iran would demonstrate a new phased array radar named “Asr.”[310]

These statements came days after Iran had reached its nuclear agreement with the P5+1, but were tied to National Navy Day in Iran which occurs on November 28th, and celebrates Operation Morvarid of 1980, an Iranian Navy victory in the Iran-Iraq war. Sayyari also said that new military vessels and aircraft were planned to enter service, that the Navy would step up manufacture of the Sahand destroyer and that a 28th fleet of warships, comprised of Alborz and Bandar Abbas warships, along with the Younes/Kilo-class submarine, had been sent on a 70-day mission to in the Indian Ocean and would go to the Gulf of Aden and the Red Sea, and would dock in a number of ports in India, Sri Lanka, and Oman. [311]

## *To Cruise Missile or Not to Cruise Missile: Making Hard Choices*

One key question for Iran will be whether it chooses to pursue land-attack cruise missiles, ballistic missiles, or UCAVs, and the relative weight of effort it gives to each program. It is easy for Iran to announce a wide mix of programs, produce a few prototypes, and use the result for propaganda purposes. An effective war fighting forces, however, requires a careful investment strategy, hard choices by system, large enough forces to be effective, and a stable structure for command, deployment, support and training.

# VIII. Unmanned Aerial Vehicles (UAVs) and Unmanned Combat Aerial Vehicles (UCAVs)

As has been discussed earlier – and in more detail in the section on artillery rockets -- Iran has built UAVs with targeting and damage assessment capability. It also, however, is building UCAVs capable of carrying air-to-surface missiles or explosives – in effect, slower-moving but better controlled and potentially stealthier cruise missiles. Hezbollah used early versions of such systems in 2006.

Iran's early UCAVs seem to have had limited all-weather capability.[312] They provided only limited value in strike missions, even in the restricted strategic space of the Gulf. It is important to stress, however, that Iran has repeatedly declared that it is developing far more sophisticated and longer-ranged UAV and UCAV systems, including its own copies of "stealth" drones that it can use for targeting and damage assessment purposes, and to supplement Iran's ballistic and cruise missile strike capability.

## *Iran's UAVs and UCAVs*

There are no reliable details as to the nature and scale of such Iranian programs, but **Figure 28** shows a range of such projects. Iran has also issued many statements about its UAV and UCAV capability,

- "We are producing 20 types of UAVs inside the country, which are classified in the three categories of long, short and mid-range and altitude…We hope to soon unveil new strategic drones which can fly up to 30,000 feet in altitude and 24 hours of nonstop flight." - Deputy Defense Minister for Industrial and Research Affairs Mohammad Eslami, April 6, 2013.[313]
- "These military progresses by the Armed Forces of the Islamic Republic of Iran reinforce the country's capability of defending Iran's boundaries…Offensive drones with the missile-launching capability have great deterrent effects on enemies' threats and aggressions." - Parliament's National Security and Foreign Policy Commission Evaz Heidarpour, February 11, 2013.[314]
- "We are among the leading countries in the development of drones tasked with reconnaissance, surveillance and of course other military missions and I state very powerfully that the drone, Scan Eagle, is lagging behind our national drone technologies…Scan Eagle had been in our possession before and we have even copied it in production." - Defense Minister Brigadier General Ahmad Vahidi, December 19, 2013.[315]
- "Iran enjoys a very high speed in (acquiring and developing) knowledge and we are now at a good stage with regard to defense tools, equipments, and particularly know how… As regards aircraft and drones, all of our forces and all organizations of the Iranian Armed Forces have been equipped with this weapon and in different classes and types of defense…Our ground, naval and air divisions are using this weapon (drone) and we think that the higher Iran's defensive power and capability in this ground grows, the more it will contribute to our deterrence." - Deputy Chief of Staff of the Iranian Armed Forces for Basij and Defense Culture Brigadier General Massoud Jazzayeri, December 10, 2012.[316]
- "As regards UAV capability, our country stands at international levels, but we still want to expand it," Managing-Director of the Iranian Aviation Industries Organization (IAIO) Manouchehr Manteqi, December 10, 2012. [317]
- "Although the West and those who consider themselves as superpowers do not believe, the mass-production of Iranian drones will be started in the not far future, and then those who imagine to be superpowers should bow to the Islamic Republic of Iran…The West should recognize that we are serious

in our will and determination to expand and advance our technologies, the defense technologies in particular, and Iran's announcements are not diplomatic posture." – MP in the Iranian Parliament, Nasrallah Pejmanfar, December 8, 2012.[318]

- "Definitely, the drone which recently flew over the occupied lands (Israel) and astonished the world was not the product of Iran's latest technology…The Islamic Republic of Iran is now in possession of Unmanned Aerial Vehicles (UAVs) with much more advanced technology than that of the drone which was flown in the sky of the occupied territories by Hezbollah forces." - Defense Minister Brigadier General Ahmad Vahidi, October, 28, 2012.[319]

The most dramatic Iranian claims in terms of technology apply to the RQ-170 variant, a UAV that Iran claims has the stealth features of US designs. A mock up looking identical to a US UAV that it captured or salvaged has been seen in Iranian media several times. Iran did claim that its version was armed, however, and some experts felt it was nothing more than a model that was a fiberglass copy of the US system.[320]

## *UCAVs versus Ballistic and Cruise Missiles*

The statements, coupled to the fact that Iran has already demonstrated that it has armed UAVs and the Hezbollah has used such systems in combat against Israel, raise important questions about Iran's future programs. Iran needs ballistic missiles to deliver nuclear warheads, but UCAVs have become a steadily cheaper and effective way to deliver precision conventional strikes.

They are far cheaper to develop and produce than either ballistic or cruise missiles, they can now rely on GPS guidance and do not need expensive and challenging high technology options like TERCOM, they are easy to disperse, and they can be tailored to produce families of systems with different range payloads and stealth features for far less cost than a combat aircraft. They also produce less of an escalatory challenge than ballistic or cruise missiles, and fly at altitudes that effectively bypass missile defenses.

### *Figure 28: Illustrative Iranian UAV Projects /Assets*

| Name | Translation | Date of usage | Weapons, payload | Range (km) and Ceiling (ft.) | Specifications | Purpose |
|---|---|---|---|---|---|---|
| Fotros (Petros) | “Peter,” “Fallen Angel” | November 2013-Present | Air to surface missiles; hellfire missile derivative[321]; anti-tank missiles | R: 2,000<br>C: 25,000 | Can remain aloft for 16-30 hours; ceiling of 25k feet. Able to cover much of the Middle East, including Israel | Reconnaissance, and missile strikes[322] |
| Ababil and variants (B, S, T, II, III, and V) | “Swallow” | 1986-present | The Ababil-T variant is armed with an explosive warhead. Its use, however, ensures total destruction of the UAV.[323] | R: 100-150<br>C: 5,000-14,000[324] | Pneumatic or rocket boosters[325] | The primary purpose of the Ababil series is ISR. Historically, Iran deployed this family of UAVs during the Iran-Iraq War, and has provided some to the Iraqi government for ISR missions against ISIL.[326] |
| Mohajer Series (1-4) | “Immigrant” | Late 1980s-present | RPGs | R: 150<br>C: 15,000[327] | Max Speed: 120mph; Launched off rail and assisted by rocket booster. | ISR; Used in Syrian Civil war by Assad; a variation was used by Hezbollah in 2006 war with Israel. The most recent variation is said to be able to generate maps for military and civilian purposes[328] |
| Karrar | “Striker” | August 2010-Present | Can carry a single bomb or two anti-ship missiles | R: 970-1000<br>C: 40,000 (est.) | Turbojet-propelled | Long-range reconnaissance and attack; Based on the BQM-126 target drone[329] |

| | | | | | | |
|---|---|---|---|---|---|---|
| Yasir (Yaseer) | "Expedient" | 2009 | Electro-optical or infrared camera. | C: 16,000 | Reverse engineered U.S. Scan Eagle.[330, 331] Able to operate 16 hours. | ISR |
| H-110 Sarir | "Throne" | 2013-Present | Air to air missiles | *Unknown | Speculative stealth capabilities | ISR and combat |
| Hazem series | | 2012-Present | Can be equipped with missiles | Short, medium, and long range | Stealth; not originally designed for carrying missiles, but the Hazem 3 may be equipped with them; rocket propelled | Bombing and reconnaissance [332] |
| Shahed 129 | "Witness" | Sept. 2012-present | 8 bombs or smart missiles | R: 1,700m<br>C: 24000 | 24 hour non-stop flight capability; similar to U.S. Predator and Reaper drones | Combat |
| Hamaseh | "Epic" | May 2013-present | Missiles and rockets | High altitude and range[333] | HALE (High Altitude Long Endurance); Purported stealth capabilities, but structurally impossible. | Reconnaissance and combat |
| Ra'ad 85 | "Thunder," "Thunder Bolt" | Sept. 2013-present | | R: 100<br>C: | Suicide drone "capable of destroying fixed and mobile targets"[334] | |
| Nazer | "Observer" | | | | Small chopper drone; | Reconnaissance and border patrol (drug trafficking) |
| Sadeq[335] | "Sincere" | Sept. 2014-present | Air-to-air missiles | | Sent aloft by launcher; | |
| RQ-170 variant | "Sentinel" | May 2014-present | | | Stealth; copy of U.S. made system. | |

*R/S: Reconnaissance / Surveillance; **ISR: Intelligence / Surveillance / Reconnaissance.

## *Iran's UAV/UCAV Strategy*

While it is important to know Iran's exact UAV and UCAV arsenal and each UAVs and UCAVs capabilities, it is equally important to try to understand the reasoning behind Iran's need for UAVs and UCAVs and its strategy for deployment, and the play in intelligence and surveillance as well as strike systems.

1979 Revolution was significant for many reasons, but – as has been noted throughout this report -- several have had a major impact on Iran's strategic thinking and military priorities. In Iranian domestic politics, the Revolution ousted the oppressive Shah, emboldened Iranians to take their future in their own hands, and empowered the clergy, allowing them to rise to power. Internationally, the Revolution and the hostage crisis that followed hurt Iran's image and reputation, causing states across the globe to become very cautious about Iran. One significance that is often overlooked, however, is the anti-Americanism behind the Revolution. The Revolution was as much of a rejection of the Shah as it was of the United States.[336]

The most relevant of these foreign policy principles in conceptualizing Iran's UAV/UCAV program) is Iran's attempts to balance against and counter the United States, which Iran views as an existential threat.

Immediately after the Revolution, Ayatollah Khomeini rejected the West and the United States, drawing upon widespread anti-American sentiment. It is important to note this sentiment drew from the American and British coup that overthrew Iran's democratically elected government in 1953 and reinstalled the oppressive Shah, as well as a photo that was leaked of Iran's interim Prime Minister meeting with President Carter's National Security Advisor, Zbigniew Brzezinski in Algiers in 1979.

The meeting between the two officials infuriated Iranians—so much so that they seized the US Embassy in Tehran, beginning the Hostage Crisis—and rallied them behind Khomeini to support Khomeini's government. Finally, the failure of Operation Eagle-Claw, was the event that allowed Khomeini to further consolidate power and portray the U.S as an existential threat to Iran.[337]

The Iran-Iraq War, official Iranian foreign policy anti-American. Saddam Hussein Iran, many Iranians—especially the clergy—believed the U.S. was funding Iraq. Iran's foreign policy became more pragmatic after Khomeini died, this only lasted until Mahmoud Ahmadinejad became President, and the level of mistrust of and hostility towards the United States has never really subsided. When the U.S. fought insurgents in Iraq during the 2003-2011 campaign, Iran militant groups to fight against U.S. forces. Furthermore, during the Presidency of Mahmoud Ahmadinejad, Iran increased its nuclear enrichment activities, resisting U.S. and international pressure to refrain from further development of Iran's nuclear program.

In spite of the P5+1 negotiations, Iran's Supreme Leader has encouraged the development of a "economy of resistance," demonstrating his lack of faith in the negotiations, instead of trying to work with the P5+1 so that Iran can further integrate itself in the international banking system. The Supreme Leader has also indicated that even if the negotiations are successful, Iran will not broadly engage with the U.S. because it will not "benefit" Iran.[338]

Given this anti-Americanism and Iran's fear (or paranoia) of U.S aggression to their UAV/UCAV program, it becomes easier to determine Iran's UAV/UCAV strategy capabilities so that it can "partially redress the imbalance in surveillance capabilities [with the United States]"[339] and defend

itself against U.S. incursion. Put simply, because the U.S. has UAVs/UCAVs, Iran must have them to make up for surveillance imbalances and to protect itself.

This concept of protecting itself has allowed Iran to use their drones on various battlefields in the Middle East, most notably in Lebanon and Israel, and in Syria. While the U.S. may be perceived as Iran's most significant existential and imminent threat, Iran has regional threats and interests it must address and protect.

In October 2012, for example, Hezbollah claimed that it sent a drone into Israel that was designed in Iran;[340] and in September 2014, Hezbollah claimed to use a drone to bomb a building in Syria, occupied by Al Qaeda's al-Nusra Front.[341] While Hezbollah claims to be able to manufacture UAVs/UCAVs, only a few nations in the world have the technical capabilities to do so.[342] In fact, what is more likely is that Iran is supplying both Hezbollah and the Assad regime with drones to use for surveillance and combat in order to protect Iran's few allies in the region and interests abroad.

# IX. The Missile Defense Challenge

As **Figure 29** shows, missile defense poses a growing challenge to both the US and its allies, and to Iran – particularly as Iran uses short and medium rockets and missiles to extend the strike range of its land, air, and sea forces, and to compensate for the weaknesses in its air forces. The US and its allies must deal with the current threat posed by Iranian artillery rockets and missiles, and the future threats of increasing accuracy, terminal guidance, increased reliability, targeting capability, and layers of different type of fire units in sufficient numbers for volleys to overcome defenses and make up for limits on accuracy and lethality.

Some analyses of the Shahab 3 already indicate that Iran has taken serious steps to reduce the vulnerability of its missiles to missile defenses – although much of the following analysis of the Shahab is speculative and based on uncertain data,[343]

> …the Shahab-3B differs from the basic production variant. It has improvements to its guidance system and warhead, a few small changes on the missile body, and a new re-entry vehicle whose terminal guidance system and rocket-nozzle steering method are completely different from the Shahab-3A’s spin-stabilized re-entry vehicle.
>
> The new re-entry vehicle uses a triconic aeroshell geometry (or ‘baby bottle’ design) that improves the overall lift to drag ratio for the re-entry vehicle. This allows greater range maneuverability that can result in better precision. The triconic design also reduces the overall size of the warhead from an estimated 1 metric ton (2,200 lb.) to 700 kg (1,500 lb.).
>
> The rocket-nozzle control system allows the missile to change its trajectory several times during re-entry and even terminal phase, effectively preventing interceptor guidance via trajectory prediction by early warning radar - a method nearly all long range ABM systems use. As a high-speed ballistic missile and pre-mission fueling capability, the Shahab-3 has an extremely short launch/impact time ratio. This means that the INS/gyroscope guidance would also remain relatively accurate until impact (important, given the fact that the gyroscopes tend to lose accuracy with longer flights). The CEP is estimated to be at 30–50 meters (98–160 ft.) or less.[9] However, the accuracy of the missile is largely speculative and cannot be confidently predicted for wartime situations.[10]
>
> These improvements would greatly increase the Shahab-3B’s survivability against ABM systems such as Israel’s Arrow 2 missile as well as being used for precision attacks against high value targets such as command, control and communications centers

Iran, in turn, must deal with the fact that the US, the Southern Gulf States, and other US allies are steadily improving their missile defenses. The US has long agreed to provide the Gulf States and Israel with data that warns them of missile launches and the missile’s target. Most Gulf States have greatly improved versions of the Patriot missile defense system that can defend against Iran’s Shahab-1 and Shahab-2s, and have some capability against high-speed closures from larger missiles like the Sejjil-2 and Shahab-3.

Moreover, Qatar and the UAE have purchased the THAAD wide area theater missile defense system, and the US is deploying advanced missile defense ships to the Gulf and the Eastern Mediterranean

Missiles defenses are a key option for both the US and its allies, and for Iran. At present, the US, Israel, Turkey, and the Arab Gulf states have the advantage for containment, deterrence, and defense. Much depends, however, on whether Russia or China will sell Iran more advanced missile defense systems.

## *US, Israeli, and Arab Gulf Systems*

As has already been noted, the US has made it clear that it will rely on a combination of missile defense and deterrence whether or not Iran does deploy nuclear-armed aircraft and missiles. The

U.S. has continued to work with its allies to create missile defense forces in the Gulf, has supported Israel's missile defense programs, and has laid the ground for missile defense in Europe.

## US Missile Defense Forces and Developments

The full performance capabilities of all US missile defense systems are classified, but it is clear that a modified SM-3 destroyed a US satellite at an altitude of 130 nautical miles (240 kilometers), and some sources put its maximum, range at 114-230 miles.[344] The US has begun to deploy advanced missile defense destroyers in the Gulf and will upgrade to the Standard SM-6 beginning in 2015. The new US strategy announced in January 2012 calls for four advanced guided missile defense destroyers - with wide area ballistic missile defense coverage - to be based in Rota, Spain that can be used to defend Europe and Israel.

Other key missile defense assets in the region include US Navy Aegis anti-ballistic missile cruisers stationed in the Gulf, and advanced versions of the MIM-104 Patriot surface-to-air missile system that Bahrain, Egypt, Israel, Jordan, Kuwait, and Saudi Arabia have acquired from the US.

The US Missile Defense Agency (MDA) describes US shipborne missile defense capabilities with the SM-3 missile as follows:[345]

> Aegis Ballistic Missile Defense (BMD) is the sea-based component of the Missile Defense Agency's Ballistic Missile Defense System (BMDS). Aegis BMD builds upon the Aegis Weapon System, Standard Missile, Navy and joint forces' Command, Control and Communication systems. The Commander, Operational Test and Evaluation Force, formally found Aegis BMD to be operationally effective and suitable. The Navy embraces BMD as a core mission. In recognition of its scalability, Aegis BMD/SM-3 system is a keystone in the Phased Adaptive Approach (PAA) for missile defense in Europe.

*Regional Defense – Aegis BMD Engagement Capability*

- Defeats short- to intermediate-range, unitary and separating, midcourse-phase, ballistic missile threats with the Standard Missile-3 (SM-3), as well as short-range ballistic missiles in the terminal phase with the SM-2.
- Flight tests are conducted by Fleet warships. Each test increases the operational realism and complexity of targets and scenarios and is witnessed by Navy and Defense Department testing evaluators.

*Homeland Defense – Aegis BMD Long Range Surveillance and Track*

- Aegis BMD ships on Ballistic Missile Defense patrol, detect and track ballistic missiles of all ranges – including Intercontinental Ballistic Missiles and report track data to the missile defense system. This capability shares tracking data to cue other missile defense sensors and provides fire control data to Ground-based Midcourse Defense interceptors located at Fort Greely, Alaska and Vandenberg Air Force Base, Calif. and other elements of the BMDS including land-based firing units (Terminal High Altitude Area Defense, Patriot) and other Navy BMD ships.

*Deployment*

- As of November 2012, there are 26 Aegis BMD combatants (5 cruisers [CGs] and 21 destroyers [DDGs]) in the U.S. Navy. Of the 26 ships, 16 are assigned to the Pacific Fleet and 10 to the Atlantic Fleet. In response to the increasing demand for Aegis BMD capability from the Combatant Commanders, the MDA and Navy are working together to increase the number of Aegis BMD capable ships. Such efforts consist of upgrading Aegis DDGs to the BMD capability, incorporating Aegis BMD into the Aegis Modernization Program and new construction of Aegis BMD DDGs.

*International Efforts*

- Aegis BMD is the first missile defense capability produced by the MDA that has been purchased by a military ally. Japan's four KONGO Class Destroyers have been upgraded with BMD operational capabilities.

- SM-3 Cooperative Development Program is the joint U.S.-Japan development of a 21-inch diameter variant of the SM-3 missile, designated SM-3 Block IIA, to defeat longer range ballistic missiles. Deployment begins in 2018.

*Future Capabilities*

- Engagement of longer range ballistic missiles.
- Improving existing early intercept capability.
- Enhanced terminal capability against short and medium range ballistic missiles.
- Aegis Ashore.
- Increased number of ships and missiles.
- More maritime ally involvement

Given time, the US can also rush additional surface-to-air missile defense units into the Gulf or other friendly regional states, and the US Army will be able to deploy THAAD or SM-6 wide area missile defenses once it acquires and integrates such systems into its forces.[346]

## The GCC States

The Gulf states, in turn, are expanding and improving their surface-to-air missile forces and acquiring at least limited anti-missile defense capabilities. Most have – or will acquire – the PAC 3 version of the Patriot system, which has a greatly improved anti-missile defense capability as well as greatly upgraded air defense capabilities.[347] As **Figure 30** shows, the US has continued to push for missile defense forces in the Gulf, to support Israel's missile defense programs, and lay the ground for missile defense in Europe.

The Southern Gulf States have upgraded most of their Patriot systems to the PAC 3 version that has far better missile defense capabilities. The UAE and Qatar are seeking to purchase wide area BMD systems like THAAD, and the GCC is studying the creation of a broader wide area BMD system.

The PAC 3 is designed only for the missile defense role and is far more maneuverable than the previous Patriot missile series, including the PAC 2 GEM – which has greatly improved missile defense capability relative to earlier Patriots and can also be used for air defense. The PAC 3 has a more advanced hit-to-kill warhead, and has a much greater range and an advanced Ka-Band seeker that can detect and home in on the missile warhead. It is smaller and 16 can be loaded on a launcher versus only four PAC 2. Unclassified estimates give the PAC-3 a maximum ballistic missile intercept range of 15 kilometers and the improved PAC-3 MSE a range of 22 kilometers.

The US Missile Defense Agency (MDA) states that the PAC 3:[348]

- Provides simultaneous air and missile defense capabilities as the Lower Tier element in defense of U.S. deployed forces and allies.
- Works with THAAD to provide an integrated, overlapping defense against missile threats in the terminal phase of flight. Jointly, these systems engage the threat by forming a multi-tier theater defense against adversary missile threats using peer-to-peer engagement coordination, early warning track data, and battle management situational awareness.
- Contributes to the entire system's situational awareness by transmitting precision cueing data to other theater elements while simultaneously protecting system assets against short-range ballistic missiles, large-caliber rockets, and air-breathing threats.

- …provides detection, track, and engagement of short-range ballistic missiles and cruise missiles. These engagements are further enhanced by networked remote sensors that supply early warning data to increase the probability of success.
- …has added Upper-Tier Debris Mitigation capability to mitigate the excessive radar load and potential missile waste caused by debris from upper-tier intercepts.

Qatar and the UAE have requested permission from the United States to buy the THAAD system. Qatar has asked to purchase two fire units, 12 launchers, 150 interceptors, and associated radar units, spare parts, and training. The UAE requested 48 interceptors, nine launchers, and associated spare parts and training.[349] Qatar has requested the sale of two THAAD units with 12 launchers, 150 missiles, plus parts, training, and logistic support at a potential cost of $6.5 billion. Possible arms transfer plans are being briefed to other Gulf states.[350]

THAAD has a range greater than 200 kilometers and a speed of over Mach 8.24 or 2.8 km/s. It began deployment in the US Army in 2012. It is an advanced missile defense system capable of shooting down a ballistic missile both inside and just outside the atmosphere and is designed to defend against asymmetric ballistic missile threats. It uses hit-to-kill technology whereby kinetic energy destroys the incoming warhead, and its high altitude intercept reduce the effects of enemy weapons of mass destruction before they reach the ground. The system has four major components:[351]

- **Launcher**: Truck mounted, highly mobile, able to be stored; interceptors can be fired and rapidly reloaded. **Interceptors**: Eight per launcher.
- **Radar**: Army Navy/Transportable Radar Surveillance (AN/TPY-2) – Largest air-transportable X-band Radar in the world searches, tracks, and discriminates objects and provides updated tracking data to the interceptor.
- **Fire Control**: Communication and data-management backbone; links THAAD components together; links THAAD to external Command and Control nodes and to the entire BMDS; plans and executes intercept solutions.

According to its manufacturer, THAAD,[352] "can accept cues from Aegis, satellites, and other external sensors to further extend the battle space and defended area coverage, and operates in concert with the lower-tier Patriot/PAC-3 system to provide increased levels of effectiveness.

The main remaining problem with GCC forces is the lack of true integration and interoperability. This is particularly critical in case of air and missile defenses, where the short flight times over the Gulf, concentration of key targets in the Gulf or near the coast, risk of Iran penetrating through the "edges" of national air defense systems, and problems in deconflicting air and surface-based defense systems all combine to create a clear need for a truly integrated air and missile defense system. While the failure to create such a system is the fault of the leaders of the GCC states, and not their militaries, it does significantly degrade the real-world capability of this aspect of Gulf forces. While a shared common air picture, based on a fiber-optic communication system, has been developed for use by the Gulf states, it is not suitable for missile defense.[353]

Once again, however, Iran cannot compete with the GCC states in this aspect of military capability, much less the combined capabilities of GCC and US forces. Most GCC states also have a wide range of relatively advanced short-range vehicle mounted and man-portable surface-to-air missile systems or SHORADs.

## Turkey

In September, 2011 the US and Turkey reached an agreement whereby a missile defense radar site will be constructed only 435 miles from the Turkey-Iran border.[354] While Iran's missiles have not been stated as the exclusive target of the system, it will greatly enable the US' ability to detect and intercept an Iranian missile launch.

This radar station is an element of the larger US-driven European Phased Adaptive Approach to missile defense, which is comprised of four phases:[355]

> Phase one: the construction of the aforementioned radar system in Turkey as well as the stationing of three Aegis anti-ballistic missile cruisers in the eastern Mediterranean.
>
> Phase two: the deployment of a ballistic missile defense interceptor site at Deveselu Air Base in Romania scheduled for 2015.
>
> Phase three: the installation of a land-based interceptor site in Poland and the deployment of a more advanced Standard Missile-3 (SM-3) interceptor scheduled for 2018.
>
> Phase four: the deployment of more advanced SM-3 interceptors in 2020 to enhance the ability to counter MRBMs and potential future ICBMs missile threats to the US from the Middle East through the deployment of more advanced SM-3 interceptors.

## Israel

As for Israel, it first deployed its Arrow missile defense system in 2000, and has integrated them with its Patriot defense systems. It has deployed two Arrow batteries. Their complement of missiles and fire units is not clear, but each fire unit holds six Arrow missiles, and Israel may be deploying a third battery.

Israel has upgraded its system to use the Arrow 2, Mod 4, with US financial and technical assistance. It tested the system in intercepts at altitudes as high as 40 and 60 kilometers, at speeds of up to Mach 9, and at ranges of 90-135 kilometers. The Arrow 2 is designed for intercepts above the stratosphere, in order to ensure that the effects of hitting nuclear, chemical, and biological weapons do not affect the Israeli populations. It uses a blast-fragmentation warhead, rather than hit-to-kill. Israel is developing an Arrow 2, Mod 5 to integrate lower altitude missile defense into a layered missile defense using its new Arrow 3.

Israel plans to deploy the Arrow 3 system in 2014 to provide a full exoatmospheric interception capability. The full details of the system are not available, but it is designed to intercept far outside Israeli territory and eliminate the risk of a nuclear, chemical, and biological weapon affecting the territory where the warhead is intercepted and destroyed.

These Israeli defenses inevitably affect the Gulf since they limit Iran's ability to pose a real world threat to Israel along with Israel's nuclear-armed missile forces. Israel is also developing two other systems, however, which may provide a model for upgrading mid-term Gulf missile defenses.

The Israel Iron Dome or Iron Cap system is a mobile system that – like the Arrow – is partially US-funded under the United States–Israel Missile Defense Cooperation and Support Act (H.R. 5327). It is designed to defend against mortars, short-range artillery rockets and missiles firing from ranges of 4 to 70 kilometers, as well as VSHORAD Missiles System (up to 10 kilometers, and discriminate against those that would hit key populated or infrastructure targets. The system has four major components: Mobile detection and tracking radar - multi-mission radar (MMR);

battle management and control unit, sensors, and mobile missile firing unit (MFU) with 20 "TAMIR" interceptors.

Its manufacturer, Rafael, is seeking to expand the system to defend against firings up to 250 km and allow it to simultaneously intercept rockets and missiles come from different directions. Iron dome is also capable of anti-aircraft operations against targets flying up to 10,000 meters. It was used extensively against rockets being fired from the Gaza in 2012, and Israel claimed it achieved about 90% success against the rockets that would have hit population centers out of some 400 fired during this period.[356]

The second system is David's Sling or Magic Wand – a system in joint development by Raytheon and Rafael. It is a possible replacement for the IHawks in the IDF, and is an anti-ballistic and anti-cruise missile system with a range of 40 to 300 kilometers. It will use a larger, two-stage missile "Stunner" missile with both radar and electro-optical nose-cone sensors. It is in the final development stage and is due to be deployed in 2013 or 2014.[357]

While it is unlikely that Arab Gulf states will ever buy Israeli systems, they might buy similar systems made in the US. More importantly, Israel's shorter range systems illustrate what may be the shape of things to come in the Gulf as Iran makes more long-range artillery rockets and missiles that can fire across the Gulf or directly into neighboring states like Iraq and Kuwait.

The US and Gulf states may also adapt the missile and rocket suppression tactics that the Israeli air force first developed to use against Hezbollah rockets during the war between Israel and the Hezbollah in 2006.[358] Israel developed a mix of sensors and on-call strike fighter equipped with precision guided missiles that were often able to take out rocket launchers after their first firing. These tactics have grown steadily more sophisticated since that time, and Israel has shown that missile defense can be combined with anti-missile offense in ways the US and Arab Gulf air forces are well equipped to adopt.

## Iran

As has been discussed in Chapter I, Iran currently has no missile defense capabilities, and Russia and China are Iran's only potential sources of direct sales of missile defense systems. Iran has shown in the past it is well aware that it would take major deliveries of a new integrated air defense system based around the S-300 or S-400 surface-to-air missiles to begin addressing Iran's strategic vulnerabilities to an aerial campaign. So far, however, neither Russia nor China has proved willing to sell the Russian version or Chinese modified version of such systems.

Russia halted the sale of modern S-300PMU1 (SA-20 Gargoyle) long range SAMs in 2010, and has since refused since then to reopen the deal. Although a future shift in Russian policy – or Chinese sale of its version – represents a potential risk, this leaves a critical gap in Iran's conventional capabilities that reinforces its weakness in airpower.

Iran has claimed it is compensating by upgrading its S-200 missile series and by building its own equivalent of S-300/S-400 called the Bavar 373, but its claims to date seem to be sharply exaggerated:[359]

- "With the changes being made to this system by our experts, the S-200 will be able to deal with threats at medium altitudes in addition to (threats) at high altitudes." Brigadier General Farzad Esmaeili, commander of the Khatam-ol-Anbiya Air Defense Base, announced in late September s announced that Iran is upgrading the S-200 long-range surface-to-air missile system.

> He also said that after the upgrade of the missile system, it will be renamed because the system will undergo systemic and structural modifications and will be used as a medium-to-high altitude missile system. He stated this would eliminate the need to use medium-altitude missile systems, such as the Ra'ad (Thunder) air defense system, in the areas where the upgraded S-200 will be deployed.
>
> Esmaeili also said on September 7, 2012 Iran was building a missile system more advanced than the Russian S-300 missile system, and that missile system, named the Bavar 373 (Belief 373), would replace the need for the S-300 missile system. Tehran Times, September 28, 2012.
>
> http://tehrantimes.com/politics/101865-iran-upgrading-s-200-air-defense-system.

- The IRGC displayed its new, domestically designed Ra'ad air medium ranged air to surface missile system during the annual military parade on Friday, which it said was designed to hit US aircraft, and which it said can be equipped with 'Taer' (Bird) missiles, which can trace and hit targets 50km in distance and 75,000 feet in altitude. "The system has been built in a bid to confront US aircraft and can hit targets 50km in distance and 75,000 feet in altitude," Commander of the IRGC Aerospace Force Brigadier General Amir Ali Hajizadeh. September 21, 2012.

Open source intelligence suggests that Iran has only deployed limited upgrades of its Soviet-era SA-5/S-200 medium to high altitude long-rage surface-to-air missiles. The NPO Almaz S-200 Angara/Vega/Dubna (Russian Ангара\Вега\Дубна), is called the SA-5 or Gammon by NATO. Upgraded versions of the SA-5/S-200s have been tested since 2008, but there are few unclassified data to support ambitious, and probably grossly exaggerated, Iranian claims for either upgrading the SA-5/S-200 or building its own versions of the S-300/S-400.[360] While the upgraded system may be more effective than the old SA-5/S-200, it is unlikely to pose a significant threat to American or Israeli aircraft as a long-range air-denial weapon.

As for the developmental Bavar-373 (Belief-373) system, Brigadier General Farzad Esmaili, a commander of the Iranian army's air defense force said to reporters in Tehran on the National Day of Air Defense on September 3, 2012. He stated that the said the system was "30 per cent complete" and that Iran could execute the project without foreign assistance.

> "We are through with developing the threat-detection capability of the system, and its sensitive parts have been manufactured in Iran….we have no problem with supplying the missiles needed for this system."

Esmaili went on to say that he hoped the system would be finished by the end of the Iranian year, which would be March 2013, or by March 2014, and would be a "*powerful rival*" to the Russian surface-to-air system. Iran would deploy up to three different types of missiles, with "*higher capabilities than the S-300 in detecting, identifying and destroying targets*."

Other Iranian officers and officials have made similar claims:

- "We are through with developing the threat-detection capability of the system and its sensitive parts have been manufactured in Iran. We have no problem for supplying the missiles needed for this system.

  With this powerful system in our hand, we would not think of S-300 anymore.

  Bavar 373 system is an important and completely indigenous achievement that can be a powerful rival for S-300." – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 3, 2012.

- "Manufacturing Bavar (Belief) 373 Missile System is in progress and all production needs have been supplied domestically.

  This project will soon enter its final stage (of production) and it will be much more advanced than the S-300 missile system.

The flaws and defects of the (Russian) S-300 system have been removed in the indigenous version of the system and its conceptual designing has finished." – Brigadier General Farzad Esmayeeli, Commander of Khatam ol-Anbia Air Defense Base, September 22, 2011.

- "It is now several years that our defense industries researchers and experts have been designing a system whose capabilities are way beyond the S-300 missile system.

  The system has been designed based on our own operational needs." – Colonel Mohammad Hossein Shamkhali, Deputy Commander of Khatam ol-Anbia Air Defense Base for Research and Self-Sufficiency Jihad, September 22, 2011.

- Defense minister Ahmad Vahidi told Iranian media at Sept. 22. 2010 that they will develop a similar domestic system by themselves: "We have planned to build a long-range air defense missile system similar to S-300. By God's grace and by the Iranian engineers' efforts, we will reach self-sufficiency in this regard."

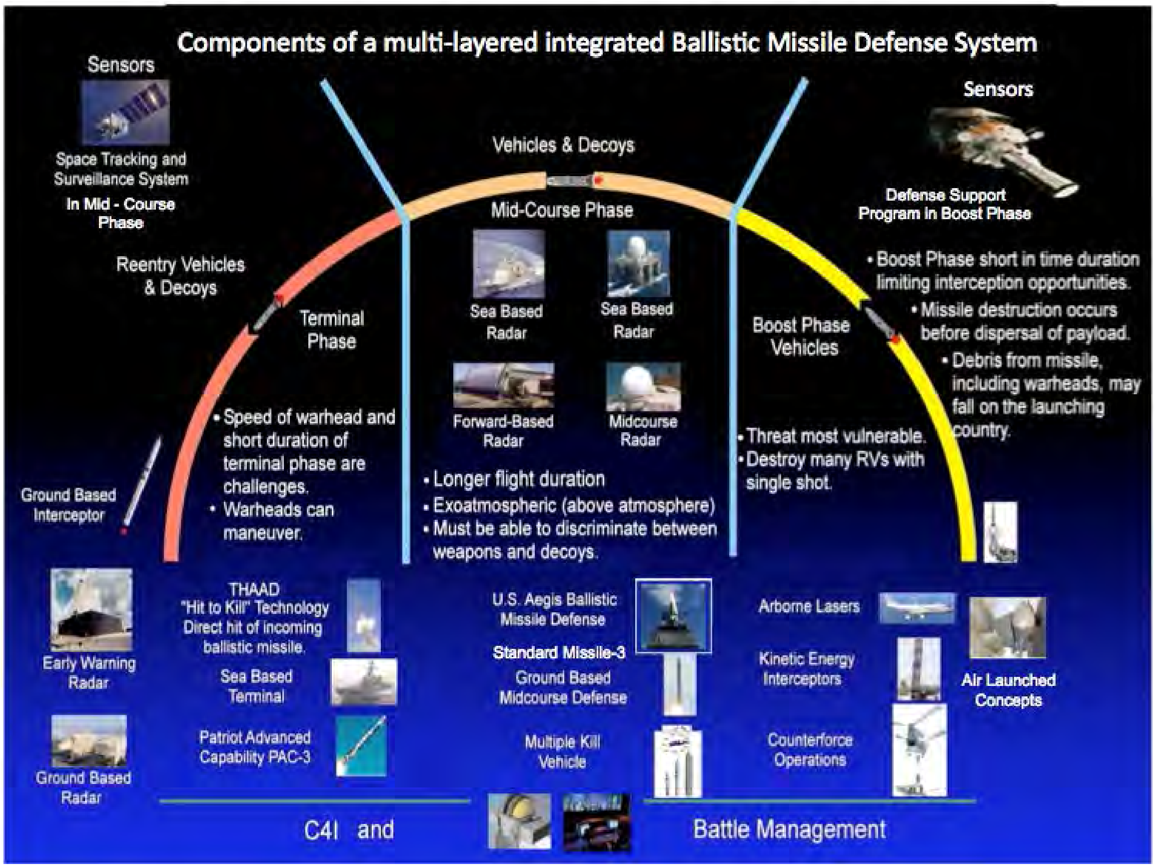
- "If they do not deliver S-300 defensive system to us, we have replacements and we can supply our operational requirements through innovative techniques and different designs." – General Hassan Mansourian, Deputy Commander of Khatam ol-Anbia Air Defense Base for Coordination, July 6, 2010.[361]

To put such statements in context, Iran has made many claims for systems it later did not deploy, only deployed in token numbers, or deployed in forms that lacked anything like the capability claimed – such as a radarless version of a supposed SA-6 clone. It is far from clear Iran has the production base required to build a robust air defense network. Moreover, anecdotal unclassified reporting indicates that Iran lacks effective test and evaluation methods and has politicized its technology to the point that it sometimes believes its own rhetoric. Exaggerated claims are a sin common to all weapons developers and military powers, but there are signs that Iran sins more than most.

*Figure 29: Missile Defenses and a Missile War in the Gulf*


Source: Abdullah Toukan.

***Figure 30: Gulf Integrated Missile Defenses***




Source: Abdullah Toukan.

## *The Impact of Missile Defenses on Iran’s Warfighting Capabilities*

It is clear that missile defense technology is becoming a key aspect of rocket, ballistic missile, and cruise missile warfare and can have a major impact on Iran’s capabilities. Just as giving Iran’s conventionally armed missiles terminal guidance or sufficient accuracy for small volleys to be used in precision strikes can be fundamental game changers, missile defense can radically alter the impact of rockets and missiles on containment, deterrence and warfighting at every level of combat. Missile defenses also create a highly uncertain duel in terms of future warfighting since real world exchange outcomes between missiles and missile defense systems are unproven in major combat, involve systems with limited real world testing, and involve weapons and technology that is constantly evolving.

At the same time, all of the rocket and missile defenses that have just been discussed present the problem that they are vulnerable to some degree to countermeasures ranging from tactics as simple as oversaturation of the defensive system to highly sophisticated penetration technology. A few practical example illustrate this further dimension of missile warfare.

If, as some Israeli and US experts report, Iran is using relatively simply technologies to make the path of its warheads less predictable to missile defenses, this may have some effectiveness in both reducing the area coverage of missile defenses and their effectiveness even if the warhead is closer to the missile launcher. At the same time, such developments can increase the risk that the warhead will miss its target or tumble in ways that can affect its reliability.

Iran is also claiming to develop missiles with a limited radar cross-section, reducing the reaction time available to anti-missile systems. Like other Iranian claims about improvements in its weapons systems, such an assertion may lack merit and should be treated cautiously. Given Iran’s difficulties in producing indigenous rockets and the significant trouble it has had constructing missiles with a range over 2000 km, reliable integration of effective countermeasures is still likely some years away.

Test, evaluation, simulation, and limited exchanges in actual combat are all useful in sources of data for building understanding of could happen in a potential exchange between Iran’s missiles and missile defenses. There still, however, is no clear way to estimate real world defense capabilities since there have been no operational cases of sufficient scale to show the relative effectiveness of the improvement in missile defenses versus Iran’s missiles. Real-world success of Iran’s efforts to improve its missile countermeasures to missile defenses is both classified and untested against Gulf and US missile defenses. While the US has had the opportunity to test its missile defenses against SCUD missiles similar to Iran’s Shahab-1 and Shahab-2 weapons, Iran’s modifications to these and its use of newer models renders the statistical relevance of these models insignificant.

No system is likely to be “leak proof,” or free from vulnerability to saturation or the exhaustion of its stocks of anti-missile missiles - and any exchange would now be one between missiles and anti-missile which both have unproven and unpredictable performance - but Iran’s missile threat grows steadily less credible as these missile defenses improve. Moreover, it is one thing to be threatened by the risk that one nuclear-armed missile gets through to a key target area, and quite another to face the risk a few far less lethal missiles get through.

Conventional or even CB-armed missiles will become steadily less credible as “terror” or psychological weapons as missile defenses improve. However, limited salvos and volleys of Iranian missiles, attacks with “stacks” of different missile systems, and attacks with steadily improved accuracy will further challenge missile defenses. Sheer numbers could overwhelm a nascent anti-missile system, and any leakers, even if highly inaccurate, would still have a propaganda or psychological impact.

If worst case estimates are right that Iran estimated possess nearly 1,000 rockets and missiles that could be fired across the Gulf (including shorter range Fateh-110s and Zelzals), defending states would require a massive investment in anti-missile missiles to reduce the number of successful attacks to an acceptable level.

Furthermore, as Iran arms its missiles with more effective conventional warheads, deploys missiles with accurate and reliable terminal guidance, and/or develops long-range cruise missiles with such capabilities - this will also change such war fighting calculations. Key export, power, desalination, and military targets could then become targets or hostages even with extensive missile defenses – particularly if the Southern Gulf states continue to fail to integrate their missile defenses. Iran could target any gaps in effective coverage, target the missile defenses with the fewest reloads and area coverage, and target isolated defenses of more forward targets where stack attacks would do most to saturate any missile defenses.

Similarly, even the credible threat - much less use of - CBRN warheads might dramatically upset the regional balance. Such capabilities would provide Iran with a much more solid deterrent, and a greater capability to exercise a bolder and more aggressive regional foreign policy. Nuclear warheads could also potentially produce enough EMP coverage with airburst on the perimeter of missile defense coverage to seriously compromise both air defense and missile defense radar capabilities.

# X. Impact on Deterrence and Warfighting

There is no way to separate Iran’s artillery rocket, ballistic missile, cruise missile, and UCAV forces into neat categories. The previous analysis has shown that there is no clear separation based on range, lethality target, tactical employment, and strategic impact – any more than there is a clear separation of missile power from land, air, and seapower. Like efforts to distinguish between “asymmetric” and “conventional” warfare, all of these assets are potentially useful in structuring an analysis but they have steadily less real- world meaning in terms of both deterrence and warfare.

Iran’s missiles do pose their greatest potential threat as nuclear-armed, long-range systems, but Iran’s existing missile forces serve many other purposes and precision guided missiles could post a major new strategic threat. At the same time, Iran’s missile and rocket forces will become more lethal over the coming half-decade even if Iran does not get nuclear weapons.

## *Missiles, Political and Psychological Warfighting, and Wars of Intimidation*

Iran’s efforts to use missile forces to achieve its political aims without fighting are likely to remain the heart of Iranian strategy. At a minimum, Iran’s growing longer-range artillery rockets, missile, and UCAV forces increase its deterrent and defensive ability to deter attack on Iran and compensate for its weaknesses in airpower. They also are forms of political and strategic leverage, even if they are never used, as well as weapons exports to third parties that can serve Iran’s strategic interests. Missile forces can help Iran fight “wars of intimidation” in peacetime.

If Iran does use its current longer-range artillery rockets, missiles, and UCAVs in combat, it does not need to escalate to all-out warfare. It can copy some aspects of Saddam Hussein’s strategy in using missile attacks during the Iran-Iraq War and the first Gulf War 1991. Iran can use its missiles politically and strategically, and not simply to damage targets. Selective firings and “volleys” of conventionally armed, unguided long-range missiles and rockets can be used as political symbols or terror weapons.

Iran might, for example, use missiles with conventional warheads to strike at Israel after an Israeli preventive strike, or to strike at Israel in some other contingency where it felt the political symbolism inside Iran and the Arab and Islamic worlds were worth the cost. Iran could hope that its strikes on Israel would put political pressure on Arab states to reduce ties to the US. Strikes on Arab states would bring the costs of war home to populations that are ill prepared for conflict, raising the penalties for Gulf publics that have rarely had to face the personal risks stemming from regional instability.

Even a few ineffective missile strikes on Israel might be seen by Arab populations as a demonstration of Iran’s willingness and capability to escalate even further, or growing future ability to strike with far more effectiveness. Iran could also pick on one or a few Arab states, and seek to divide Arab states from each other. Moreover, Iran can use even token or failed missile strikes for internal political propaganda purposes.

More broadly, Iran may launch token or limited strikes on its other neighbors. This was demonstrated during the “war of the cities” of the Iran-Iraq war, by the use of the Scud missiles during the Afghan War, and by the Iraqi Scud attacks on Israel and Saudi Arabia during the Gulf War in 1991. Missile strikes can have a powerful propaganda impact that vastly exceeds their

actual warfighting effect - at least initially. There were reports during the Iran-Iraq War of civilians and officials fleeing Tehran. Iraqis, Israelis, Saudis, and Coalition forces also routinely took shelter during missile attacks, and the Israeli press reported many cases of individuals that effectively panicked in 1991 - although perhaps more from fear that missiles might have chemical weapons than out of a fear of missiles or conventional warheads per se.

Regardless of the current limits to the lethality of Iran’s missile forces, the psychological impact of Iran’s ability to launch a sudden, massive missile barrage on regional population centers and military installations should not be underestimated. Neither should the possibility of a lucky hit producing enough casualties or highly visible damage to have a lasting psychological impact - what might grimly be called the “World Trade Center effect.”

Iran’s ability to launch a large volume of missiles over a period of days with little warning before the first round of launches gives Iran leverage and makes such missiles a weapon of intimidation. Even if - and perhaps especially if - they are never used, Iran’s missiles also have the capability to intimidate and leverage Iran’s neighbors, and to force the US and its regional allies to devote resources to missile defense. Iran does not seem, by its number of TELs and static launching sites, to be able to sustain a large missile campaign, but may be able to continue a low level bombardment campaign for an extended period of time in the face of Arab or US airstrikes.

At the same time, it should be noted that many of the political psychological effects of ineffective Iraqi missile strikes during the Iran-Iraq War wore off relatively quickly. There were not enough missile firings to sustain a high degree of popular fear, and people were soon reported to be going to their roofs at night to “watch the show.” There is simply too much empty area in a given urban complex or large military base for largely random strikes to either produce critical damage or kill enough people to shock or intimidate the population.

The strategic value of rocket, missile, and UAV/UCAV exports will continue. As the exports of Iranian artillery rockets and shorter-range missiles has shown, Iran’s missiles may also have a growing political, strategic and psychological impact outside Iran. Current Iranian doctrine seems to stress building up the risk and reality of allied and proxy attacks around the world. Hamas and Hezbollah rocket and missile strikes already have had a major impact on Israel’s military posture, which demonstrates this doctrine. “Third party” missile strikes may be a growing problem for the US and its Arab allies in the future.

Even limited missile and long-range rocket attacks can also boost Iranian morale. In the face of limited, attrition-like conflict between Iran and the US and GCC, ballistic strikes provide Iran with the chance to show its public that it is prosecuting the war and inflicting casualties on the other side. Framed as retaliation for a combination of sabotage, assassination, sanctions, and potentially overt strikes, ballistic missiles demonstrate to the Iranian population that its government is capable of repaying the suffering it has undergone.

## *Putting Iran's Missile and Nuclear Programs in Perspective*

The nuclear dimension of the Iran missile program is a different story. It is difficult to predict how aggressive Iran would become in trying to politically exploit its nuclear capability if Iran did acquire nuclear-armed missiles. Iran has so far been cautious in initiating any use of force that might threaten the survival of the regime. Its best strategy would be to limit its use of nuclear missile forces to efforts pressure, deter, and intimidate.

Iran is, however, clearly involved in an active competition with the US and with its Arab neighbors in an effort to win strategic influence and leverage. Iran faces US and Arab competition for influence and control over Iraq, the emerging threat of the Islamic State, and growing uncertainty over the future of its alliance with the Assad regime in Syria and the Hezbollah in Lebanon. Iran still seems to see American influence behind all of these steadily growing pressures.

Nuclear-armed missiles are also a way to deter or discourage any outside escalation in response to Iran's use of its lower levels of asymmetric warfare capability. Iran has long sought to develop asymmetric/irregular military capabilities and forces that can challenge US encroachment in "its" region. Iran has threatened in the past to use such forces to "close" the Gulf, and has carried out major exercises targeted against the US and less directly at the GCC states. It has also described many of its exercise exercises as a response to Israeli or American threats and "aggression".

Military history is also a warning that restraint in peacetime does not necessarily last in a crisis or limited conflict. The history of war is not the history of rational bargainers. Tempers can grow short, given units can overreact, situations can be misunderstood, and once a crisis begins, one nation's view of how to escalate rarely matches another's. Iran could escalate to major rocket and missile strikes because of miscalculations on both sides of a future clash or lower level conflict.

While Iran has normally been careful to avoid any major threats and military incidents, avoid provocative military steps, and limit the risk of military confrontation, it is not clear that Iran would show the same restraint in using its full range of asymmetric warfare capabilities if it could arm its missile forces with nuclear weapons or if its missile forces developed a precision strike capability. Iran might then be more willing to take risks in using its other irregular warfare capabilities to try to force more favorable compromises, persuade the Iranian people they do face real foreign enemies, show how serious their impact could be on the global economy, or simply punish other powers.

There is also room for miscommunication that leads to escalation. The IRGC's effort to decentralize its command and control in order to increase resiliency in the event of a large first strike on Iran may make miscommunication more likely.[362]

## *The Mid and Longer Term Risk of an Iranian Nuclear Weapon and a Nuclear-Armed Missile Threat*

There are many different estimates of Iran's nuclear programs, its intentions, and when it could build a stockpile of nuclear weapons. No one, however, can currently discount this threat. The US Director of National Intelligence, James R. Clapper, touched on this case in his Worldwide Threat Assessment for 2012 statement, and it is still far from clear that the P5+1 negotiations with Iran will change the validity of his judgments:[363]

> We judge Iran would likely choose missile delivery as its preferred method of delivering a nuclear weapon.

> Iran already has the largest inventory of ballistic missiles in the Middle East, and it is expanding the scale, reach, and sophistication of its ballistic missile forces, many of which are inherently capable of carrying a nuclear payload.
>
> We judge Iran's nuclear decision-making is guided by a cost-benefit approach, which offers the international community opportunities to influence Tehran. Iranian leaders undoubtedly consider Iran's security, prestige, and influence, as well as the international political and security environment, when making decisions about its nuclear program.
>
> Iran's growing inventory of ballistic missiles and its acquisition and indigenous production of anti-ship cruise missiles (ASCM) provide capabilities to enhance its power projection. Tehran views its conventionally armed missiles as an integral part of its strategy to deter—and if necessary retaliate against—forces in the region, including US forces. Its ballistic missiles are inherently capable of delivering WMD, and, if so armed, would fit into this strategy.

Clapper was also reported to have said during his testimony that Iran might get a nuclear device in as short as a year under worst case conditions, and arm a missile in as little as two more years. The reality seems more likely to be 4 to 7 years, but there is so little hard data on Iran's programs that any such judgments are highly uncertain.

## Timing and Design Issues

If Iran does go nuclear, most of its longer-range missiles can carry an implosion nuclear weapon. Work by Dr. Abdullah Toukan indicates that the range-payload capability of the Shahab 2 is marginal, but that more capable systems like the Shahab 3, Shahab 3M, Safir, and Sejjil all have enough range payload so that a relatively large implosion warhead could still be launched at ranges over 2,000 kilometers and a more efficient design could reach 3,000 kilometers.

The most definitive source regarding Iran's attempts to create and design a nuclear warhead for its missiles is the International Atomic Energy Agency (IAEA). The IAEA reported in November 201l that Iran seems to have conducted engineering studies as to how to integrate a spherical payload using a nuclear implosion device into the reentry vehicle of the Shahab-3 missile. The following excerpts from the military annex to that report remain the most authoritative data on the key aspects of Iran's program and missile warhead development, and are essential information to anyone trying to assess Iran's efforts: [364]

> The Agency has been provided with information by Member States which indicates that the activities referred to in Sections C.2 to C.12 were, at least for some significant period of time, managed through a program structure, assisted by advisory bodies, and that, owing to the importance of these efforts, senior Iranian figures featured within this command structure. From analysis of this information and information provided by Iran, and through its own endeavors, the Agency has been able to construct what it believes to be a good understanding of activities undertaken by Iran prior to the end of 2003. The Agency's ability to construct an equally good understanding of activities in Iran after the end of 2003 is reduced, due to the more limited information available to the Agency. For ease of reference, the figure below depicts, in summary form, what the Agency understands of the program structure, and administrative changes in that structure over the years. Attachment 1 to this Annex provides further details, derived from that information, about the organizational arrangements and projects within that program structure.
>
> …According to the Agency's assessment of the information contained in that documentation, the green salt project (identified as Project 5.13) was part of a larger project (identified as Project 5) to provide a source of uranium suitable for use in an undisclosed enrichment program. The product of this program would be converted into metal for use in the new warhead that was the subject of the missile re-entry vehicle studies (identified as Project 111). As of May 2008, the Agency was not in a position to demonstrate to Iran the connection between Project 5 and Project 111. However, subsequently, the Agency was shown documents which established a connection between Project 5 and Project 111, and hence a link between nuclear material and a new payload development program.

…In addition, throughout the entire timeline, instances of procurement and attempted procurement by individuals associated with the AMAD Plan of equipment, materials and services which, although having other civilian applications, would be useful in the development of a nuclear explosive device, have either been uncovered by the Agency itself or been made known to it.32 Among such equipment, materials and services are: high speed electronic switches and spark gaps (useful for triggering and firing detonators); high speed cameras (useful in experimental diagnostics); neutron sources (useful for calibrating neutron measuring equipment); radiation detection and measuring equipment (useful in a nuclear material production environment); and training courses on topics relevant to nuclear explosives development (such as neutron cross section calculations and shock wave interactions/hydrodynamics).

…The uranium metal document is known to have been available to the clandestine nuclear supply network that provided Iran with assistance in developing its centrifuge enrichment capability, and is also known to be part of a larger package of information which includes elements of a nuclear explosive design. A similar package of information, which surfaced in 2003, was provided by the same network to Libya…The information in the Libyan package, which was first reviewed by Agency experts in January 2004, included details on the design and construction of, and the manufacture of components for, a nuclear explosive device

…The development of safe, fast-acting detonators, and equipment suitable for firing the detonators, is an integral part of a program to develop an implosion type nuclear device. Included among the alleged studies documentation are a number of documents relating to the development by Iran, during the period 2002–2003, of fast functioning detonators, known as "exploding bridge wire detonators" or "EBWs" as safe alternatives to the type of detonator described for use in the nuclear device design referred to in above.

In 2008, Iran told the Agency that it had developed EBWs for civil and conventional military applications and had achieved a simultaneity of about one microsecond when firing two to three detonators together, and provided the Agency with a copy of a paper relating to EBW development work presented by two Iranian researchers at a conference held in Iran in 2005. A similar paper was published by the two researchers at an international conference later in 2005.

… Both papers indicate that suitable high voltage firing equipment had been acquired or developed by Iran. Also in 2008, Iran told the Agency that, before the period 2002–2004, it had already achieved EBW technology. Iran also provided the Agency with a short undated document in Farsi, understood to be the specifications for a detonator development program, and a document from a foreign source showing an example of a civilian application in which detonators are fired simultaneously. However, Iran has not explained to the Agency its own need or application for such detonators.

The Agency recognizes that there exist non-nuclear applications, albeit few, for detonators like EBWs, and of equipment suitable for firing multiple detonators with a high level of simultaneity. Notwithstanding, given their possible application in a nuclear explosive device, and the fact that there are limited civilian and conventional military applications for such technology, Iran's development of such detonators and equipment is a matter of concern, particularly in connection with the possible use of the multipoint initiation system referred to below Detonators provide point source initiation of explosives, generating a naturally diverging detonation wave. In an implosion type nuclear explosive device, an additional component, known as a multipoint initiation system, can be used to reshape the detonation wave into a converging smooth implosion to ensure uniform compression of the core fissile material to supercritical density.

….The Agency has shared with Iran information provided by a Member State which indicates that Iran has had access to information on the design concept of a multipoint initiation system that can be used to able to confirm independently that such a design concept exists and the country of origin of that design concept. Furthermore, the Agency has been informed by nuclear-weapon States that the specific multipoint initiation concept is used in some known nuclear explosive devices. In its 117 page submission to the Agency in May 2008, Iran stated that the subject was not understandable to Iran and that Iran had not conducted any activities of the type referred to in the document.

Information provided to the Agency by the same Member State referred to in the previous paragraph describes the multipoint initiation concept referred to above as being used by Iran in at least one large scale experiment in 2003 to initiate a high explosive charge in the form of a hemispherical shell.

According to that information, during that experiment, the internal hemispherical curved surface of the high explosive charge was monitored using a large number of optical fiber cables, and the light output of the

explosive upon detonation was recorded with a high speed streak camera. It should be noted that the dimensions of the initiation system and the explosives used with it were consistent with the dimensions for the new payload which, according to the alleged studies documentation, were given to the engineers who were studying how to integrate the new payload into the chamber of the Shahab 3 missile re-entry vehicle (Project 111) (see Section C.11 below). Further information provided to the Agency by the same Member State indicates that the large scale high explosive experiments were conducted by Iran in the region of Marivan.

The Agency has strong indications that the development by Iran of the high explosives initiation system, and its development of the high speed diagnostic configuration used to monitor related experiments, were assisted by the work of a foreign expert who was not only knowledgeable in these technologies, but who, a Member State has informed the Agency, worked for much of his career with this technology in the nuclear weapon program of the country of his origin. The Agency has reviewed publications by this foreign expert and has met with him. The Agency has been able to verify through three separate routes, including the expert himself, that this person was in Iran from about 1996 to about 2002, ostensibly to assist Iran in the development of a facility and techniques for making ultra-dispersed diamonds ("UDDs" or "nanodiamonds"), where he also lectured on explosion physics and its applications.

Furthermore, the Agency has received information from two Member States that, after 2003, Iran engaged in experimental research involving a scaled down version of the hemispherical initiation system and high explosive charge referred to in paragraph 43 above, albeit in connection with non-nuclear applications. This work, together with other studies made known to the Agency in which the same initiation system is used in cylindrical geometry, could also be relevant to improving and optimizing the multipoint initiation design concept relevant to nuclear applications.

The Agency's concern about the activities described in this Section derives from the fact that a multipoint initiation system, such as that described above, can be used in a nuclear explosive device. However, Iran has not been willing to engage in discussion of this topic with the Agency.

…One necessary step in a nuclear weapon development program is determining whether a theoretical design of an implosion device, the behavior of which can be studied through computer simulations, will work in practice. To that end, high explosive tests referred to as "hydrodynamic experiments" are conducted in which fissile and nuclear components may be replaced with surrogate materials…

Information which the Agency has been provided by Member States, some of which the Agency has been able to examine directly, indicates that Iran has manufactured simulated nuclear explosive components using high density materials such as tungsten. These components were said to have incorporated small central cavities suitable for the insertion of capsules such as those described in Section C.9 below. The end use of such components remains unclear, although they can be linked to other information received by the Agency concerning experiments involving the use of high speed diagnostic equipment, including flash X ray, to monitor the symmetry of the compressive shock of the simulated core of a nuclear device.

Other information which the Agency has been provided by Member States indicates that Iran constructed a large explosives containment vessel in which to conduct hydrodynamic experiments. The explosives vessel, or chamber, is said to have been put in place at Parchin in 2000. A building was constructed at that time around a large cylindrical object at a location at the Parchin military complex. A large earth berm was subsequently constructed between the building containing the cylinder and a neighboring building, indicating the probable use of high explosives in the chamber. The Agency has obtained commercial satellite images that are consistent with this information. From independent evidence, including a publication by the foreign expert referred to in paragraph 44 above, the Agency has been able to confirm the date of construction of the cylinder and some of its design features (such as its dimensions), and that it was designed to contain the detonation of up to 70 kilograms of high explosives, which would be suitable for carrying out the type of experiments described in paragraph 43 above.

As a result of information the Agency obtained from a Member State in the early 2000s alleging that Iran was conducting high explosive testing, possibly in association with nuclear materials, at the Parchin military complex, the Agency was permitted by Iran to visit the site twice in 2005. From satellite imagery available at that time, the Agency identified a number of areas of interest, none of which, however, included the

location now believed to contain the building which houses the explosives chamber mentioned above; consequently, the Agency's visits did not uncover anything of relevance.

Hydrodynamic experiments such as those described above, which involve high explosives in conjunction with nuclear material or nuclear material surrogates, are strong indicators of possible weapon development. In addition, the use of surrogate material, and/or confinement provided by a chamber of the type indicated above, could be used to prevent contamination of the site with nuclear material. It remains for Iran to explain the rationale behind these activities.

…Information provided to the Agency by two Member States relating to modeling studies alleged to have been conducted in 2008 and 2009 by Iran is of particular concern to the Agency. According to that information, the studies involved the modeling of spherical geometries, consisting of components of the core of an HEU nuclear device subjected to shock compression, for their neutronic behavior at high density, and a determination of the subsequent nuclear explosive yield. The information also identifies models said to have been used in those studies and the results of these calculations, which the Agency has seen. The application of such studies to anything other than a nuclear explosive is unclear to the Agency. It is therefore essential that Iran engage with the Agency and provide an explanation.

The Agency obtained information in 2005 from a Member State indicating that, in 1997, representatives from Iran had met with officials from an institute in a nuclear-weapon State to request training courses in the fields of neutron cross section calculations using computer codes employing Monte Carlo methodology, and shock wave interactions with metals. In a letter dated 14 May 2008, Iran advised the Agency that there was nothing to support this information.

The Agency has also been provided with information by a Member State indicating that, in 2005, arrangements were made in Iran for setting up projects within SADAT centers (see Section C.1 and Attachment 1), inter alia, to establish a databank for "equation of state" information42 and a hydrodynamics calculation center. The Agency has also been provided with information from a different Member State that, in 2005, a senior official in SADAT solicited assistance from Shahid Behesti University in connection with complex calculations relating to the state of criticality of a solid sphere of uranium being compressed by high explosives.

…Research by the Agency into scientific literature published over the past decade has revealed that Iranian workers, in particular groups of researchers at Shahid Behesti University and Amir Kabir University, have published papers relating to the generation, measurement and modeling of neutron transport…The Agency has also found, through open source research, other Iranian publications which relate to the application of detonation shock dynamics to the modeling of detonation in high explosives, and the use of hydrodynamic codes in the modeling of jet formation with shaped (hollow) charges. Such studies are commonly used in reactor physics or conventional ordnance research44, but also have applications in the development of nuclear explosives.

… The Agency has information from a Member State that Iran has undertaken work to manufacture small capsules suitable for use as containers of a component containing nuclear material. The Agency was also informed by a different Member State that Iran may also have experimented with such components in order to assess their performance in generating neutrons. Such components, if placed in the center of a nuclear core of an implosion type nuclear device and compressed, could produce a burst of neutrons suitable for initiating a fission chain reaction. The location where the experiments were conducted was said to have been cleaned of contamination after the experiments had taken place. The design of the capsule, and the material associated with it, are consistent with the device design information that the clandestine nuclear supply network allegedly provided to Iran.

The Agency also has information from a Member State that work in this technical area may have continued in Iran after 2004, and that Iran embarked on a four year program, from around 2006 onwards, on the further validation of the design of this neutron source, including through the use of a nonnuclear material to avoid contamination.… Given the importance of neutron generation and transport, and their effect on geometries containing fissile materials in the context of an implosion device, Iran needs to explain to the Agency its objectives and capabilities in this field.

The alleged studies documentation contains extensive information regarding work which is alleged to have

> been conducted by Iran during the period 2002 to 2003 under what was known as Project 111. From that information, the project appears to have consisted of a structured and comprehensive program of engineering studies to examine how to integrate a new spherical payload into the existing payload chamber that would be mounted in the re-entry vehicle of the Shahab 3 missile.
>
> According to that documentation, using a number of commercially available computer codes, Iran conducted computer modeling studies of at least 14 progressive design iterations of the payload chamber and its contents to examine how they would stand up to the various stresses that would be encountered on being launched and travelling on a ballistic trajectory to a target. It should be noted that the masses and dimensions of components identified in information provided to the Agency by Member States that Iran is alleged to have been developing (see paragraphs 43 and 48 above) correspond to those assessed to have been used in Project 111 engineering studies on the new payload chamber.
>
> During these studies, prototype components were allegedly manufactured at workshops known to exist in Iran but which Iran refused the Agency permission to visit. The six engineering groups said to have worked under Project 111 produced many technical reports, which comprise a substantial part of the alleged studies documentation. The Agency has studied these reports extensively and finds that they are both internally consistent and consistent with other supporting information related to Project 111.
>
> The alleged studies documentation also shows that, as part of the activities undertaken within Project 111, consideration was being given to subjecting the prototype payload and its chamber to engineering stress tests to see how well they would stand up in practice to simulated launch and flight stresses (so-called "environmental testing"). This work would have complemented the engineering modeling simulation studies referred to in paragraph 60 above. According to the information reflected in the alleged studies documentation, within Project 111, some, albeit limited, preparations were also being undertaken to enable the assembly of manufactured components.
>
> Iran has denied conducting the engineering studies, claiming that the documentation which the Agency has is in electronic format and so could have been manipulated, and that it would have been easy to fabricate.45 However, the quantity of the documentation, and the scope and contents of the work covered in the documentation, are sufficiently comprehensive and complex that, in the Agency's view, it is not likely to have been the result of forgery or fabrication. While the activities described as those of Project 111 may be relevant to the development of a non-nuclear payload, they are highly relevant to a nuclear weapon program.
>
> …The alleged studies documentation indicates that, as part of the studies carried out by the engineering groups under Project 111 to integrate the new payload into the re-entry vehicle of the Shahab 3 missile, additional work was conducted on the development of a prototype firing system that would enable the payload to explode both in the air above a target, or upon impact of the re-entry vehicle with the ground. Iran was shown this information, which, in its 117 page submission …it dismissed as being "an animation game".
>
> The Agency, in conjunction with experts from Member States other than those that had provided the information in question, carried out an assessment of the possible nature of the new payload. As a result of that assessment, it was concluded that any payload option other than nuclear which could also be expected to have an airburst option (such as chemical weapons) could be ruled out. Iran was asked to comment on this assessment and agreed in the course of a meeting with the Agency which took place in Tehran in May 2008 that, if the information upon which it was based were true, it would constitute a program for the development of a nuclear weapon...

The IAEA made it clear that Iran had still not addressed these issues in September 2014, in spite of the P5+1 negotiations. The Director General's report of September 5, 2014, noted that:[365]

> Previous reports by the Director General have identified outstanding issues related to possible military dimensions to Iran's nuclear program and actions required of Iran to resolve these…The Agency remains concerned about the possible existence in Iran of undisclosed nuclear relate activities involving military related organizations, including activities related to the development of a nuclear payload for a missile. Iran is required to cooperate fully with the Agency on all outstanding issues, particularly those which give rise to

concerns about the possible military dimensions to Iran's nuclear program, including by providing access without delay to all sites, equipment, persons and documents requested by the Agency.

.. .The Annex to the Director General's November 2011 report (GOV/2011/65) provided a detailed analysis of the information available to the Agency at that time, indicating that Iran has carried out activities that are relevant to the development of a nuclear explosive device. This information is assessed by the Agency to be, overall, credible…. The Agency has obtained more information since November 2011 that has further corroborated the analysis contained in that Annex.

…In February 2012, Iran dismissed the Agency's concerns, largely on the grounds that Iran considered them to be based on unfounded allegations… In a letter to the Agency dated 28 August 2014, Iran stated that "most of the issues" in the Annex to GOV/2011/65 were "mere allegations and do not merit consideration".

… As indicated above (para. 9), one of the seven practical measures agreed in the second step of the Framework for Cooperation on 20 May 2014 was the provision by Iran of "information and explanations for the Agency to assess Iran's stated need or application for the development of Exploding Bridge Wire detonators"… In this regard, as indicated in the Director General's previous report, Iran provided the Agency with information and explanations in April 2014 and additional information and explanations in May 2014, including showing documents, to substantiate its stated need for the development of EBW detonators and their application. At a technical meeting in Tehran on 16 August 2014, the Agency asked for additional clarifications, certain of which Iran provided. …During the technical meetings on 16 and 17 August 2014, the Agency and Iran also held discussions on the practical measures relating to the initiation of high explosives and to neutron transport calculations. As indicated above (para. 15), at the technical meeting in Tehran on 31 August 2014, the Agency and Iran began discussions on these two practical measures and agreed that another meeting would be convened.

… Since the Director General's previous report, at a particular location at the Parchin site, the Agency has observed through satellite imagery ongoing construction activity that appears to show the removal/replacement or refurbishment of the site's two main buildings' external wall structures. One of these buildings has also had a section of its roof removed and replaced. Observations of deposits of material and/or debris, and equipment suggest that construction activity has expanded to two other site buildings. These activities are likely to have further undermined the Agency's ability to conduct effective verification….It remains important for Iran to provide answers to the Agency's questions…and access to the particular location in question.

…As indicated in the Director General's previous report and as reiterated by the Director General following his meetings in Tehran on 17 August 2014, the Agency needs to be able to conduct a "system" assessment of the outstanding issues contained in the Annex to GOV/2011/65. This will involve considering and acquiring an understanding of each issue in turn, and then integrating all of the issues into a "system" and assessing that system as a whole.

… Contrary to the relevant resolutions of the Board of Governors and the Security Council, Iran is not implementing its Additional Protocol. The Agency will not be in a position to provide credible assurance about the absence of undeclared nuclear material and activities in Iran unless and until Iran provides the necessary cooperation with the Agency, including by implementing its Additional Protocol.

## What Nuclear Warhead Design and When?

Even actual nuclear weapons designers cannot agree on just how difficult it now is to design and manufacture a reliable and deployable nuclear weapon. Reports that Iran may have received significant design data from a number of sources, and reports by the IEA that Iran has been working on the design and key components for fission weapons for years, do not mean that Iran has detailed design data of the kind that allows it to produce an effective implosion weapon. Neither does it mean that it can easily move to develop a family of different weapons ranging from small nuclear weapons to boosted weapons that can be deployed on missiles or as relative light bombs.

North Korea's uncertain tests of fission devices -- which seem to have involved devices far too large for warhead weaponization -- show that getting large yields from a test device remains a major challenge. For new proliferators, India and Pakistan have both made spurious claims about the yields of their tests to disguise what seem to have been at least partial design failures. Even the simpler forms gun devices can present significant problems in terms of reliability and yield.

The US and Iran's neighbors may choose to assume that Iran could rapidly deploy a functioning nuclear weapon once it has sufficient fissile material, but such assumptions can exaggerate Iran's military capabilities, and it is unclear what kind of assumptions are actually correct. Bomb design also involves serious safety and reliability issues, as well as the need to be able to predict yield, the ability to operate in spite of the stress of a missile or air launch, and the ability of fuzing systems to trigger the weapon at the desired height of burst.

It is difficult, however, to go from standard fission implosion weapons to boosted weapons that have much higher yields, potentially raising the explosive force from a purely fissile 20-kiloton weapon to boosted weapons with yield of 100 kilotons or more. These involve key design issues, which include the problems involved in handling tritium and deuterium or solid lithium deuteride-tritide, and the fact that such designs are normally associated with plutonium weapons, not the uranium-based weapons that Iran would construct if it were successful in building a weapon.

Much of the unclassified analysis of how soon Iran could get a weapon is tied to weapons and warhead design issues. Many tacitly assume that Iran could assemble a gun device or even nuclear missile warheads without any practical testing or even a fissile event. They also fail to state the assumptions made regarding the amount of material needed per weapon, and the major uncertainties involved.

Such estimates also tend to focus on one estimate of the necessary fissile material without noting the uncertainties in any nominal estimate or the variation by weapons design. Unclassified estimates made in an article on nuclear weapons design by the Federation of American Scientists illustrate the scale of the uncertainties involved -- as well as some of the reasons effective weapons design is so difficult and uncertain without actual testing:[366]

> The minimum mass of fissile material that can sustain a nuclear chain reaction is called a critical mass and depends on the density, shape, and type of fissile material, as well as the effectiveness of any surrounding material (called a reflector or tamper) at reflecting neutrons back into the fissioning mass. Critical masses in spherical geometry for weapon-grade materials are as follows:

| | Uranium-235 | Plutonium-239 |
|---|---|---|
| Bare sphere: | 56 kg | 11 kg |
| Thick Tamper: | 15 kg | 5 kg |

> The critical mass of compressed fissile material decreases as the inverse square of the density achieved. Since critical mass decreases rapidly as density increases, the implosion technique can make do with substantially less nuclear material than the gun-assembly method. The "Fat Man" atomic bomb that destroyed Nagasaki in 1945 used 6.2 kilograms of plutonium and produced an explosive yield of 21-23 kilotons [a 1987 reassessment of the Japanese bombings placed the yield at 21 Kt]. Until January 1994, the Department of Energy (DOE) estimated that 8 kilograms would typically be needed to make a small nuclear weapon. Subsequently, however, DOE reduced the estimate of the amount of plutonium needed to 4 kilograms. Some US scientists believe that 1 kilogram of plutonium will suffice.

> ….In the gun device, two pieces of fissionable material, each less than a critical mass, are brought together very rapidly to form a single supercritical one. This gun-type assembly may be achieved in a tubular device in which a high explosive is used to blow one subcritical piece of fissionable material from one end of the tube into another subcritical piece held at the opposite end of the tube.

> Manhattan Project scientists were so confident in the performance of the “Little Boy” uranium bomb that the device was not even tested before it was used. This 15-kt weapon was airdropped on 06 August 1945 at Hiroshima, Japan. The device contained 64.1 kg of highly enriched uranium, with an average enrichment of 80%. The six bombs built by the Republic of South Africa were gun-assembled and used 50kg of uranium enriched to between 80 percent and 93 percent in the isotope U-235.
>
> Compared with the implosion approach, this method assembles the masses relatively slowly and at normal densities; it is practical only with highly enriched uranium. If plutonium -— even weapon-grade -- were used in a gun-assembly design, neutrons released from spontaneous fission of its even-numbered isotopes would likely trigger the nuclear chain reaction too soon, resulting in a “fizzle” of dramatically reduced yield.
>
> ...Because of the short time interval between spontaneous neutron emissions (and, therefore, the large number of background neutrons) found in plutonium because of the decay by spontaneous fission of the isotope Pu-240, Manhattan Project scientists devised the implosion method of assembly in which high explosives are arranged to form an imploding shock wave which compresses the fissile material to supercriticality.
>
> The core of fissile material that is formed into a super-critical mass by chemical high explosives (HE) or propellants. When the high explosive is detonated, an inwardly directed implosion wave is produced. This wave compresses the sphere of fissionable material. The decrease in surface to volume ratio of this compressed mass plus its increased density is then such as to make the mass supercritical. The HE is exploded by detonators timed electronically by a fuzing system, which may use altitude sensors or other means of control.
>
> The nuclear chain-reaction is normally started by an initiator that injects a burst of neutrons into the fissile core at an appropriate moment. The timing of the initiation of the chain reaction is important and must be carefully designed for the weapon to have a predictable yield. A neutron generator emits a burst of neutrons to initiate the chain reaction at the proper moment —- near the point of maximum compression in an implosion design or of full assembly in the gun-barrel design.
>
> A surrounding tamper may help keep the nuclear material assembled for a longer time before it blows itself apart, thus increasing the yield. The tamper often doubles as a neutron reflector.
>
> Implosion systems can be built using either Pu-239 or U-235 but the gun assembly only works for uranium. Implosion weapons are more difficult to build than gun weapons, but they are also more efficient, requiring less SNM and producing larger yields. Iraq attempted to build an implosion bomb using U-235. In contrast, North Korea chose to use 239 Pu produced in a nuclear reactor.
>
> To fission more of a given amount of fissile material, a small amount of material that can undergo fusion, deuterium and tritium (D-T) gas, can be placed inside the core of a fission device. Here, just as the fission chain reaction gets underway, the D-T gas undergoes fusion, releasing an intense burst of high-energy neutrons (along with a small amount of fusion energy as well) that fissions the surrounding material more completely. This approach, called boosting, is used in most modem nuclear weapons to maintain their yields while greatly decreasing their overall size and weight.

There are many different weapons designs Iran might choose from, many different levels of fissile material requirements, and many different levels of associated risk. Iran might take the risks of producing weapons without actual testing by trusting foreign design data and ignoring key safety and reliability issues. It is also possible that Iran might claim it has nuclear weapons without actually producing them or concluding that it has them in a truly usable form. However, Iran has been cautious in the past about taking any steps than threatened the existence of its regime. It seems equally or more possible that Iran would never seriously weaponize without either full design details or some form of underground or other active testing.

As noted earlier, the IEA has reported that Iran has had many elements of an R&D and test program that examines the behavior of every other aspect of weapons performance by setting off bomb designs without fissile material and examining the result. The now dismantled facility Iran created at Parchin might well have been designed for the purpose of non-fissile testing on an entire weapons assembly.

A September 2014 report by the Institute for Science and International Security (ISIS) notes that activity at the Parchin facility has started again, raising concerns about Iran's suspected effort to develop a nuclear weapon:[367]

> Recent Digital Globe satellite imagery dated August 12, 2014 shows that some activity continues at the Parchin site. As figure 1 shows, new construction material or debris, as well as new dirt or water runoff, appear in front of three buildings in the southern part of the site. Also, light vegetation appears to be growing at the center of the site, including on the protective berm, and the construction material or debris previously identified in front of the suspected test building remains. Finally, the dirt or water runoff and some of the possible construction material that appeared in previous imagery is no longer present in front of the large building in the northern part of the site.
>
> A May 2014 ISIS Imagery Brief showed several signs of external activity at the site. ISIS noted that possible building material and debris appeared in front of two main buildings at the site. Two trucks or containers had been removed from the area surrounding the suspected high explosives test building, while a larger object, possibly a truck or large container, appeared slightly north of it. Dirt or water runoff was visible in front of the northern building and three vehicles were clearly visible at the south entrance.
>
> Previously, a February 2014 ISIS Imagery Brief confirmed IAEA reporting of possible building material and debris appearing at the site. All of this activity followed a period of lull at the site (second half of 2013) in which commercial satellite imagery showed no significant visible alterations.

Some experts feel that Iran might also seek to obtain additional design validation data in the future by using subcritical radioactive material in such a test program, a speculation some other experts discount on the grounds it might not produce a reliable indication of full scale fissile event performance.

This makes obtaining accurate estimates of how much design data Iran actually has a critical issue. The UN Panel of Experts report issued in June 2014 did, however, confirm earlier IAEA reports and stated that,[368]

> There remain areas of concern regarding the Islamic Republic of Iran's nuclear program and its possible military dimensions. In its report of 20 February 2014, IAEA referred to its 2011 analysis of allegations that the Islamic Republic of Iran has carried out activities relevant to the development of a nuclear explosive device.
>
> Among the issues identified by IAEA in 2011 are concerns about "alleged studies" regarding "how to integrate a new spherical payload into the existing payload chamber which would be mounted in the re-entry vehicle of the Shahab 3 missile".
>
> …IAEA recently noted that information regarding the Islamic Republic of Iran's development of a nuclear explosive device "is assessed by the Agency to be, overall, credible" and despite the country's insistence that the claims are unfounded, "the Agency has obtained more information since November 2011 that has further corroborated the analysis contained in [the annex to the Director-General's report of November 2011]"… It is not known whether the additional information addresses the integration of a nuclear payload on a delivery vehicle.

Work by Michael Eisenstadt notes that,[369]

> Iran's weapons design choices will also be influenced by the kind of foreign assistance it has received in the past, and could receive in the future. This includes a Chinese weapons design that it may have received from the AQ Khan network (reportedly a smaller, more advanced design than that the latter provided to Libya); useful insights it might have gleaned from flawed plans for a firing set that the CIA allegedly provided Iran in order to sabotage and delay its weapons program (i.e., Operation Merlin); and assistance it may have received in designing the initiation and conventional explosives system for a nuclear weapon from the Russian scientist Vyacheslav Danilenko. In light of this history, it would be prudent to assume that Iran's

> future weapons design efforts will continue to benefit from foreign assistance, despite best efforts by the U.S. and others to prevent it.

The Institute for Science and International Security has summarized Vyacheslav Danilenko's contributions to the Iranian nuclear program, and gave some technical details regarding one aspect of Iran's nuclear weapons development. The technical details in the report give a sense of the progress that Iran was able to make with external assistance:[370]

> The IAEA obtained additional information that adds credibility to the conclusion that Danilenko used his technical and practical knowledge and expertise to provide assistance to Iran's program to develop a suitable initiation system for a nuclear explosive device. The IAEA assessed that a monitoring, or diagnostic, technique described in one of his papers had a remarkable similarity to one that the IAEA saw in material from a member state about a hemispherical initiation and explosives system developed in Iran (see below). This system is also described in the IAEA safeguards report as a multipoint initiation system used to start the detonation of a nuclear explosive.
>
> The IAEA also obtained from member states details of the design, development, and possible testing of what is called in IAEA information the R265 shock generator system, which is a round multipoint initiation system that would fit inside the payload chamber of the Shahab 3 missile tri-conic nose cone. This device involves a hemispherical aluminum shell with an inside radius of 265 mm and wall thickness of 10 mm thick. Outer channels are cut into the outer surface of the shell, each channel one by one millimeter, and contain explosive material. Each channel terminates in a cylindrical hole, 5 mm in diameter, that is drilled though the shell and contains an explosive pellet. The geometrical pattern formed by channels and holes is arranged in quadrants on the outer hemispheric surface which allows a single central point of initiation and the simultaneous detonation of explosives in all the holes on the hemisphere. This in turn allows the simultaneous initiation of all the high explosives under the shell by one exploding bridgewire (EBW). If properly prepared, the R265 constitutes the outer part of an explosively driven implosion system for a nuclear device. The outer radius of the R265 system is 275 millimeters, or a diameter of 550 millimeters, less than the estimated diameter of about 600 millimeters available inside the payload chamber of a Shahab 3 (or the Sejjil-2 missile).

No credible unclassified data currently exist to show just how much outside warhead design data that Iran has received, and this highlights a much broader limit to any unclassified analysis. How much is actually known at the classified level about Iran's access to serious design data, test program, and test options is obviously uncertain. What, if anything, this says about Iran's plans and intentions is another issue. If – as seems likely – Iran has been slowly advancing a nuclear weapons program since the time of the Shah, how much have the US and other intelligence communities learned that they have not made public? Intelligence does need to protect key sources and sensitive methods, but it often uses security to conceal the fact that its analysis is almost all method and "guesstimate" and no source.

This uncertainty regarding public versus unclassified knowledge is also critical to any real world success in implementing a P5+1 agreement or dealing with its failure. Any effort to both halt and characterize Iran's programs will, after all, be part of an ongoing duel with Iranian efforts to conceal as much as possible. No unclassified analysis can really address this aspect of Iran's missile programs. No one can do more than speculate as to what, if anything, Iran has been able to conceal that is not known to either outside intelligence agencies or analysts of the Iranian program.

## Using Untested or Unreliable Weapons and Weapons at a Time a Nation Has Limited Weapons Stockpiles

There are other important issues regarding accuracy, yield, and predictability that a nascent nuclear power like Iran must consider. Iran has been firing its shorter and medium range missiles for years. Some still have uncertain accuracy and reliability. Some are well proven, and Iran has begun to

deploy strap on GPS guidance systems and other improvements in accuracy that make strikes against given target points far more reliable.

There are serious inherent uncertainties, however, in the testing and development of other Iranian missiles that raise serious questions about Iranian claims regarding accuracy and reliability. These are not minor issues during a period when Iran may only have a few warheads of comparatively limited yield.

Iran would run major risks in launching missiles whose flight had to be aborted or if a missile failed on launch. It could potentially fire at one target and see most of the damage from a fission weapon with a yield under 20 kilotons largely miss even area targets. It can plan to use air bursts to largely eliminate fall out and see fusing fail and get a burst at an altitude with serious fall out effects.

Aircraft nuclear delivery systems are potentially more precise, but aircraft run a greater risk of defensive intercept. Iran also has not flown meaningful combat missions since 1988 – more than a quarter of a century ago. In both cases, most Iranian deliveries would also probably be tracked on radar to the point where there would be no doubt about the source of a strike.

The risks in using an untested or partially tested gun device would be far more limited than is the case with an implosion weapon. However, the high weight of a gun device – particularly in the most reliable form of an untested design -- presents further problems. These are problems that have led experts to consider it either being placed in a ship or built into a larger passenger aircraft. Both approaches would have some advantages.

A ship could carry it to a known point in a port, and a passenger or cargo aircraft might potentially deliver a surprise suicide attack on any specific point in its flight path. Depending on the distance from shore, a bomb in a ship would produce a mixture of rain out and fall out, and displace water as well as crater nearby port facilities. A passenger or cargo aircraft could detonate a bomb either at airburst altitudes or near the ground.

They also offer at least some form of cover or false flag deniability. It is unlikely that a post-strike analysis would fail to detect the fact the weapon was Iranian, or that Iran's motives in attacking would not immediately lead it to be singled out as the attacker; evidence might be less direct in the latter case. There might be enough doubt to prevent a decisive reaction.

In short, one needs to be very careful about scenarios that depend heavily on the willingness to risk an extremely small stockpile of untested or unreliable weapons. They are certainly possible, but scenarios which involve strikes with highly predictable results, and which attempt to send anything more than the simplest and crudest military signals, are not.

At least for some years, even if Iran can acquire a limited nuclear inventory, it could face sharp limits on its actual use. At a minimum, assessments of its strike capabilities need to explicitly consider the impact of such uncertainties on Iran's force structure and employment plans.

## Safety, Reliability, and Predictability

Iran must weigh the value of any concealment efforts, and a rush to early production, against the need for nuclear safety, reliability, and predictable yield. The US, for example, requires all nuclear weapons forces and programs to meet four key tests:[371]

- Prevent nuclear weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear yield.

- Prevent deliberate pre-arming, arming, launching, or releasing of nuclear weapons, except upon execution of emergency war orders or when directed by competent authority.
- Prevent inadvertent pre -arming, arming, launching, or releasing of nuclear weapons in all normal and credible abnormal environments.
- Ensure adequate security of nuclear weapons.

What is not clear is how well Iran can mix such requirements with the need for secrecy, and what safeguards it would enforce in the "saving" of a nuclear weapon. The FAS reports that current US weapons are "designed to a goal of less than a 1 in a 1 million chance of the weapon delivering more than 4 pounds of nuclear yield if the high explosives were detonated at the single most critical possible point. Other nations have adopted different safety criteria and have achieved their safety goals in other ways." [372] Other countries have also set different standards in the arming, fuzing, and controls for firing nuclear weapons – decisions Iran will have to make both to protect itself and to either signal other powers or give priority to concealment.

## The Dangers of Nuclear Success

At the same time, Iran cannot deploy either nuclear-armed missiles or precision strike missiles in a military vacuum where its neighbors and the US do not respond. If Iran does go nuclear, this decision will impact on a region that is already involved in a nuclear arms race. The prospect of combined Iranian missile and nuclear threat has already posed risks that have affected every aspect of US, Arab, Israeli and other military competition with Iran for at least the last decade. This competition has increasingly focused them on responding with options like preventive strikes, proliferation, and extended deterrence. Iran has made enough progress towards a nuclear weapons capability so that there is a real prospect that Iran could acquire nuclear weapons and arm its missiles and aircraft with nuclear weapons within the next three to five years. Regardless of the accuracy of this timeframe, the focus on the above options has sharpened as the Iranian nuclear program has progressed.

Key nations like Israel have already reacted to the fact that a nuclear-armed Iran could destroy any military target or city in the region, and pose an "existential" threat to many states. The US, other powers, and the Gulf states have to also face the fact that a regional war that even threatens to escalate to nuclear weapons, could have a far more radical and lasting impact on the global economy, which gets some 20% of the world's oil supply through the Gulf.

Few experts feel Iran's leaders would act irrationally or without regard to the risks. But once again, the history of war and diplomacy is the history of mistakes, miscalculations, and unintended conflicts. For all of the talk of a stable pattern of mutually assured destruction during the Cold War, it is important to remember the reality of what actually happened. The US went from no more than six nuclear weapons at the end of 1945 to a peak of over 31,000 in 1967, while the Soviet Union went from none before 1949 to a peak of nearly 41,000 in 1987.

These risks help explain why the US and other members of the P5+1 have pressed so hard to end the Iranian nuclear threat though negotiations. If these efforts fail, the choices become preventive strikes or deterring and containing a nuclear-armed Iranian missile force by military means. Missile defenses, proliferation, and extended deterrence are all issues that affect US and regional plans and actions.

Even the most successful efforts at deterrence, containment, and missile defense present risks of their own. The very risk of Iranian nuclear-armed missiles eventually becoming a reality led Israel

to increase the range of its nuclear-armed missiles to cover all targets in Iran more than a decade ago. It has since led Israel to plan for, and exercise the option of, preventive strikes, and the US to openly declare that it has developed such a military option. It has also led the US and Israel to research and develop missile defenses, and the US to work with friendly Arab states to purchase new missile defenses.

The increasing Iranian missile threat has also helped lead to a steady increase in the long-range strike capabilities of rival states. Saudi Arabia first acquired long-range conventionally armed Chinese-made ballistic missiles in 2007 because of the threat from Iraq but it has retained and upgraded them because of the threat from Iran. The US and Gulf Arab countries have also increased the strike capabilities of their air forces, and US has demonstrated it could make extensive use of conventionally armed cruise missiles.

Then U.S. Secretary of State Hilary Clinton offered friendly states in the Gulf region some form of “extended deterrence” in 2009, but the US has never clarified whether this would only apply to Iranian nuclear strikes, or whether this would involve conventional or nuclear-armed systems. At the same time senior Saudi officials have said that the Kingdom has examined a nuclear option, and a number of experts have noted that Pakistan might be willing to sell Saudi Arabia both nuclear warheads and more advanced missiles.

## The Vulnerability Windows as a Nuclear Force Evolves

The risks to Iran in deploying a nuclear armed missile forces are increased by the fact that an Iranian effort to create a survivable and effective nuclear-armed or precision strike missile forces would take years to deploy. Creating such a force would present other kinds of challenges in the process. Iran cannot become a meaningful nuclear power overnight, and Iran does not exist in a “nuclear vacuum.”

Iran faces technical challenges in creating and deploying nuclear-armed missiles and in ensuring they would not be subject to preemption or counterforce nuclear strikes. Much would depend on the reliability of the missiles, and real-world accuracy could still be a problem. Moreover, Iran might well have a very limited stockpile of nuclear weapons for some years after it first began to deploy such weapons, and creating a survivable and effective force would pose problems of a different kind.

Long before Iran could deploy a meaningful nuclear-armed missile force, Iran’s efforts to acquire nuclear weapons could lead to preventive attacks on both its nuclear and missile facilities and forces. If the current P5+1 talks fail, President Obama and other senior US officials have made it clear that US policy sees Iran’s acquisition of nuclear weapons as “unacceptable.” Both Israel and the US have repeatedly stated that they are planning for and are ready for military options that could include preventive strikes on at least Iran’s nuclear facilities. They have raised the possibility that US strikes might cover a much wider range of missile facilities and other targets.

Such preventive strikes would present risks for the attacker as well as Iran. They might trigger a direct military confrontation or conflict in the Gulf with little warning. They might also lead to at least symbolic Iranian missile strikes on US basing facilities, GCC targets, or Israel. At the same time, it could lead to much more serious covert and proxy operations in Lebanon, Iraq, Afghanistan, the rest of the Gulf, and other areas.

Furthermore, unless preventive strikes were reinforced by a lasting regime of follow-on strikes, they could trigger a much stronger Iranian effort to actually acquire and deploy nuclear weapons, Iranian rejection of the Nuclear Non-Proliferation Treaty (NPT), and rejection of negotiations. The US, in contrast, might perceive that it has no choice other than to maintain a military over watch and restrike capability to ensure Iran could not carry out such a program and rebuild its nuclear capabilities or any other capabilities that were attacked.

A preventive war, is only part of the threat Iran will face. Israel is a mature nuclear power that already has thermonuclear-armed missile forces with considerable counterstrike capability. Israel's ability to destroy Iranian cities and population centers makes Israel an extant existential threat to Iran. At least initially, Iran could only secure its evolving forces by relying on launch-on-warning or launch-under-attack. This, however, would push Israel into shaping a nuclear force posture designed to react to any Iranian use of nuclear forces – or even an Iranian threat – by launching an all-out nuclear attack with a force posture that would almost be designed to lead both sides to miscalculation or over-reaction.

Any Iranian threat to use nuclear weapons against other regional targets might well to lead to similar retaliation if the US should ever implement its offer of "extended deterrence." Iran would also face the prospect that actually acquiring nuclear weapons might provoke a Gulf power like Saudi Arabia to seek nuclear-armed missiles from Pakistan, and any nuclear armed neighboring states would almost certainly respond to any nuclear attack in kind.

These risks will increase if Iran deploys missiles with weapons of mass destruction, even if it does not use them. Iran faces the grim fact that its missiles can make a war far more damaging and lethal to itself, and that it cannot win either any arms race in which the US takes part, or any process of escalation that involves the US and Israel.

## Iran and Israel: Who Would Have the Existential Threat?

Iran's actions have almost certainly already provoked Israel into developing the capability to target thermonuclear warheads on every major Iranian city, creating an "existential" threat to Iran long before Iran will pose one to Israel. Saudi Arabia and the GCC states may well have the option of turning to Pakistan for nuclear-armed missiles, and senior Saudi officials have said Saudi Arabia has examined nuclear options. The US has also officially offered its regional friends and allies "extended deterrence" of the kind it once provided to Europe during the Cold War - essentially confronting Iran with an open-ended threat of US retaliation.

Even if Iran does go nuclear as part of this aspect of its competition with the US and its Gulf neighbors, it is far from clear that it will not suffer more than any nation or nations it attacks. No one can downplay the psychological and political impact of even the threat of nuclear strikes, the deterrent impact it might have in limiting a response to Iran's use of asymmetric warfare, or the risk of some "accident" or miscalculation. The worst moments in history rarely occurred because of accurate calculations by rational bargainers.

This is why success in the current negotiations between the P5+1 and Iran would probably be of significant strategic benefit to Iran. It would eliminate Iran's nuclear option, but the end result could do more to ensure Iran's overall security than Iranian nuclear armed missiles. Once Iran tests a nuclear device or claims to have nuclear weapons, it will also enter a very different world of risks. Iran's missiles will then be seen by many Israelis as "existential" risks the moment Iran has

– or even claims to have – a nuclear weapons. It is Iran, however, that will face the most immediate threat from Israel of preventive war, preemption, or massive retaliatory.

While any effort to model a nuclear exchange in detail lies for beyond the scope of this analysis, even a few images show the risks Iran would run, even if one disregards fall out and its impact on the long-term death rate from a nuclear exchange:

- **Figure 31** shows the comparative range of key Israeli and Iranian missiles in a strike on the opposing state.
- **Figure 32** shows the difference in lethality between the kind of fission weapons Iran can initially deploy and the kind of fusion/boosted weapon that Israel already possesses.
- **Figure 33** shows Israel's vulnerability by key city, but several include large Arab and Muslim populations.
- **Figure 34** shows Iran's vulnerability by key city.
- **Figure 35** shows Iran's ethnic vulnerability as a "Persian" nation.

It is important to note that Israel might also have an advantage in nuclear counterforce strikes until Iran could deploy enough dispersed or sheltered nuclear-armed missiles, unless Iran chose a launch-on warning or launch under attack posture. Since Iran might have little other choice early in its nuclear force deployments, this again highlights the risks in an Israeli-Iranian nuclear arms race. Such strikes, however, do assume Israel has sufficient nuclear weapons and missile accuracy to conduct such strikes, which seems uncertain.

What is somewhat more likely is that Israel might launch nuclear armed missile strikes on Iran's nuclear facilities either if the P5+1 talks fail, or if Iran crosses a critical threshold like testing a nuclear device in an actual high yield nuclear event. Israel certainly has the level of accuracy and nuclear yield capability to carry out such strikes on all of Iran's major nuclear facilities. However, they would have to be multiple ground bursts on each target and the impact in terms of direct damage and fallout could extend far beyond the Iranian nuclear site.

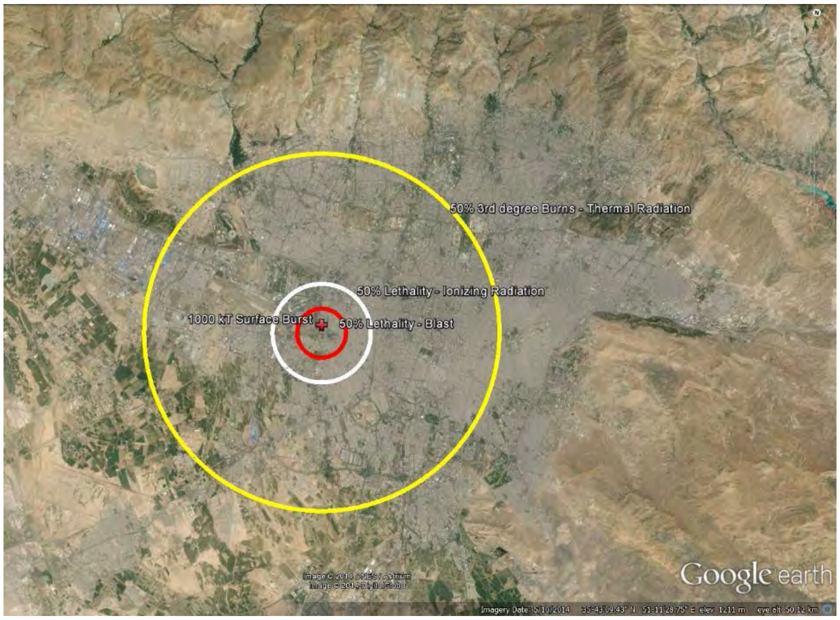
The question of who would "win" a nuclear exchange and exactly how to define existential seems horrifyingly irrelevant. Moreover, as Henry Kissinger once said, "The act of committing suicide is not an adequate deterrent to being murdered."

***Figure 31: Comparative Range Coverage of Israeli Jericho-2 and Iranian Shahb-3***

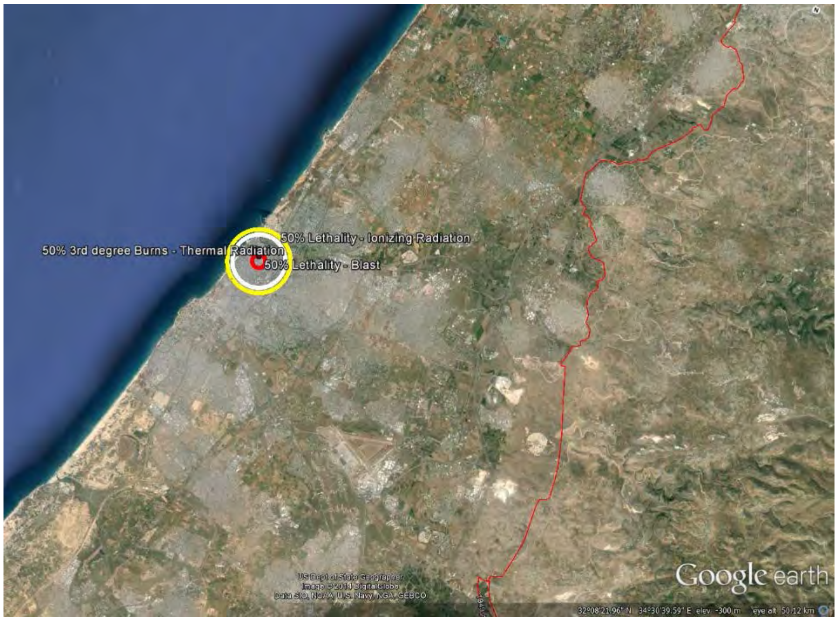

Source: Abdullah Toukan.

## *Figure 32: Lethality of Iranian Fission vs. Israeli Fusion Weapons – Part One: Comparative Destructive Effect*

**Israeli Strike on Tehran with One Megaton Fusion Weapon**




**Iranian Strike on Tel Aviv with 20 Kiloton Fission Weapon**



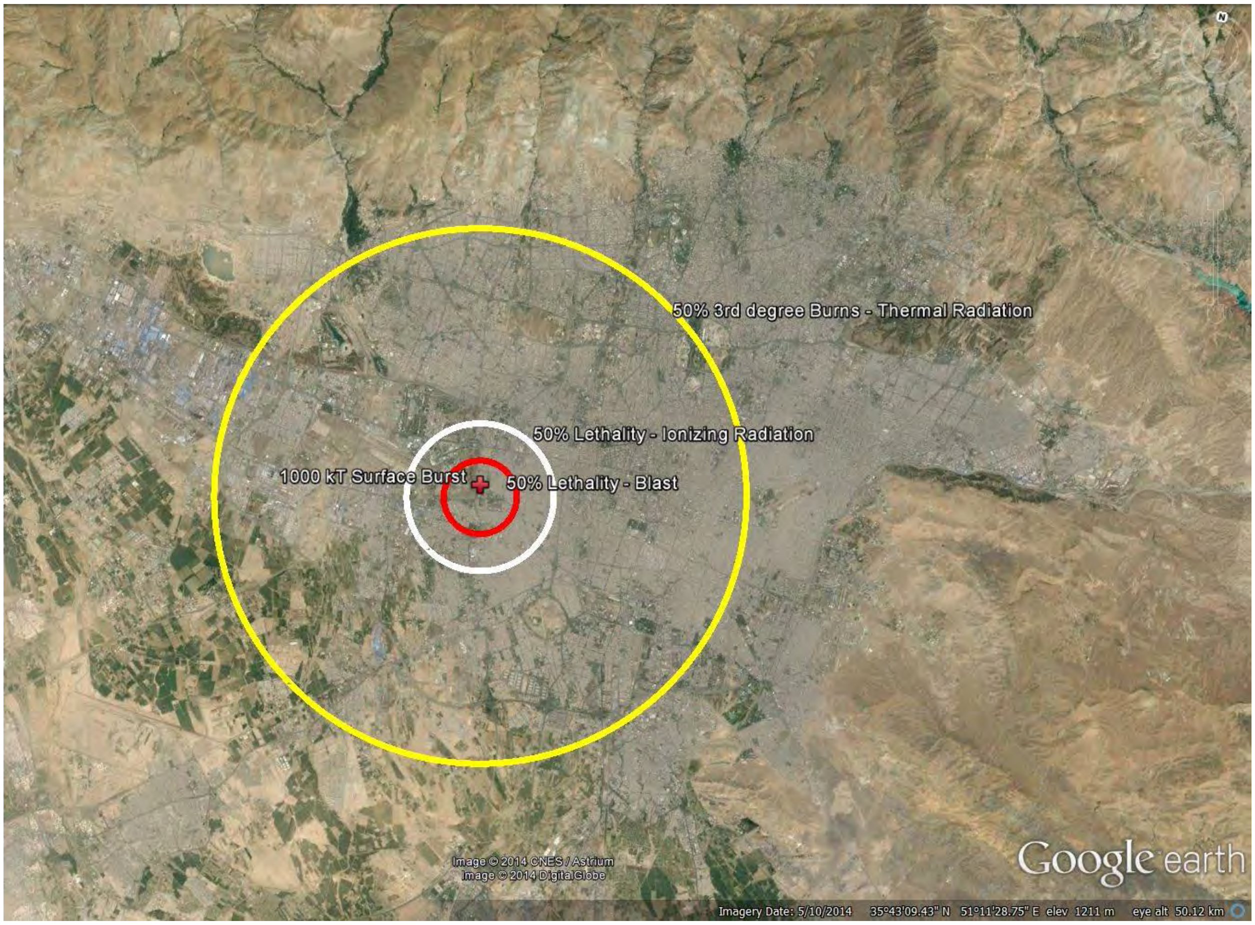
### *Figure 32: Lethality of Iranian Fission vs. Israeli Fusion Weapons – Part Two: Expanded View of Impact on Teheran*

**Israeli Strike on Tehran with One Megaton Fusion Weapon**

**Population: 8.3 million urban, 14 million wider area**

**Urban Area: 730 km$^2$ (280 sq. mi)**

**Wider Area: 1,274 km$^2$ (492 sq. mi)**



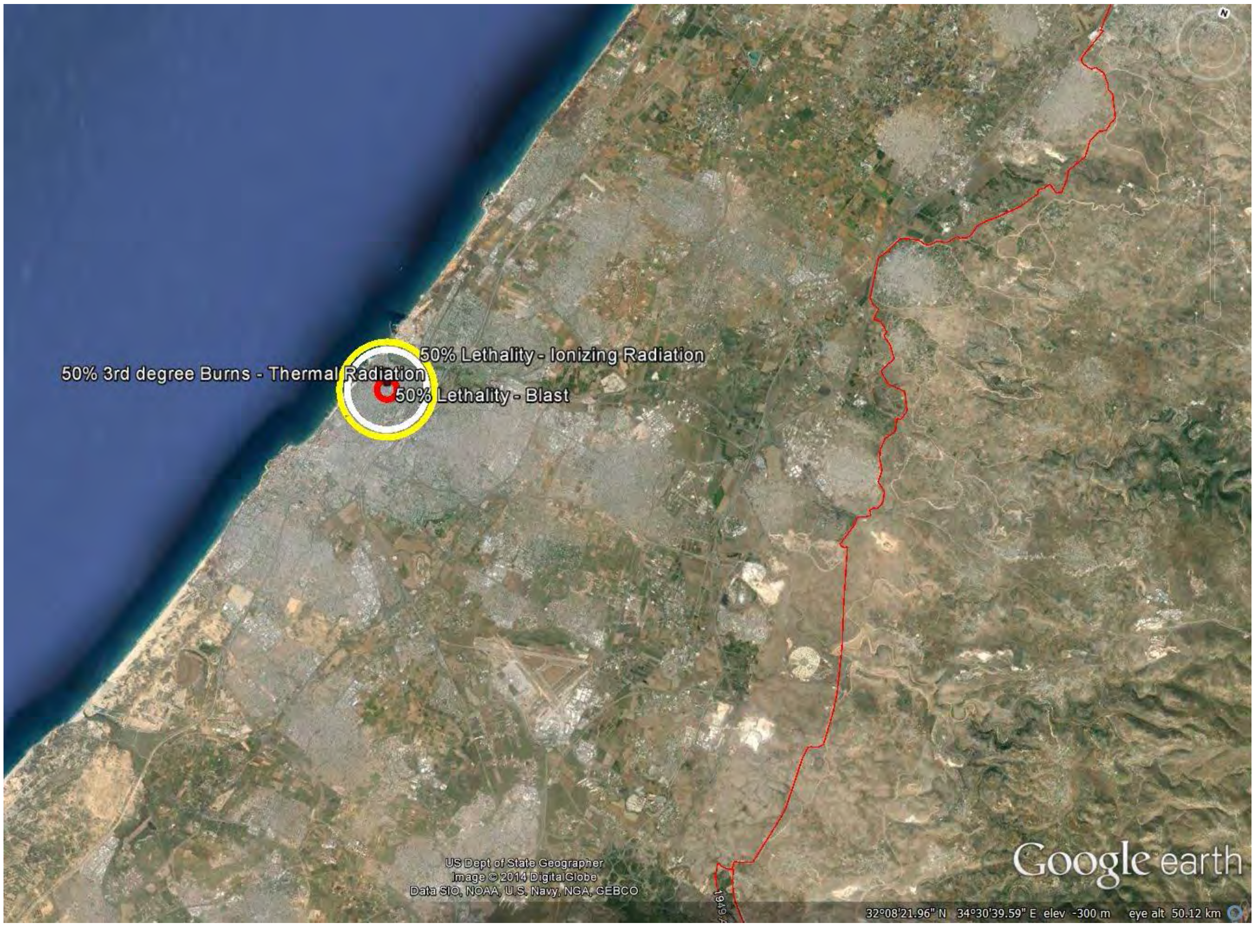

Source: Based on estimates by Abdullah Toukan.

## *Figure 32: Lethality of Iranian Fission vs. Israeli Fusion Weapons – Part Three: Expanded View of Impact on Tel Aviv*

**Iranian Strike on Tel Aviv with 20 Kiloton Fission Weapon**

**Population: 410,000+**

**Area: 52 km² (20 sq. mi)**




Source: Based on estimates by Abdullah Toukan.

### *Figure 33: Key Urban Targets in Israel*

**Israel: Population of 7,822,000 in mid-2014. Jewish 75.1%, Muslim 17.4%, Christian 2%, Druze 1.6%, other 3.9% (2012 est.)**

| Rank | Name | District | Pop. |
|---|---|---|---|
| 1 | Jerusalem | Jerusalem | 796,200* |
| 2 | Tel Aviv | Tel Aviv | 404,500 |
| 3 | Haifa | Haifa | 269,300 |
| 4 | Rishon LeZion | Central | 231,700 |
| 5 | Ashdod | Southern | 211,400 |
| 6 | Petah Tikva | Central | 210,800 |
| 7 | Beersheba | Southern | 195,800 |
| 8 | Netanya | Central | 188,200 |
| 9 | Holon | Tel Aviv | 182,000 |
| 10 | Bnei Brak | Tel Aviv | 161,100 |

This number includes occupied East Jerusalem and West Bank areas.

Source: CIA, "Israel," *World Factbook*, https://www.cia.gov/library/publications/the-world-factbook/geos/is.html, accessed September 7, 2014; Wikipedia; and "Population, by Population Group, Religion, Age, Sex and Type of Locality," *Statistical Abstract of Israel*, Israel Central Bureau of Statistics, September 11, 2012, http://www.cbs.gov.il/reader/shnaton/templ_shnaton_e.html?num_tab=st02_11x&CYear=2012.

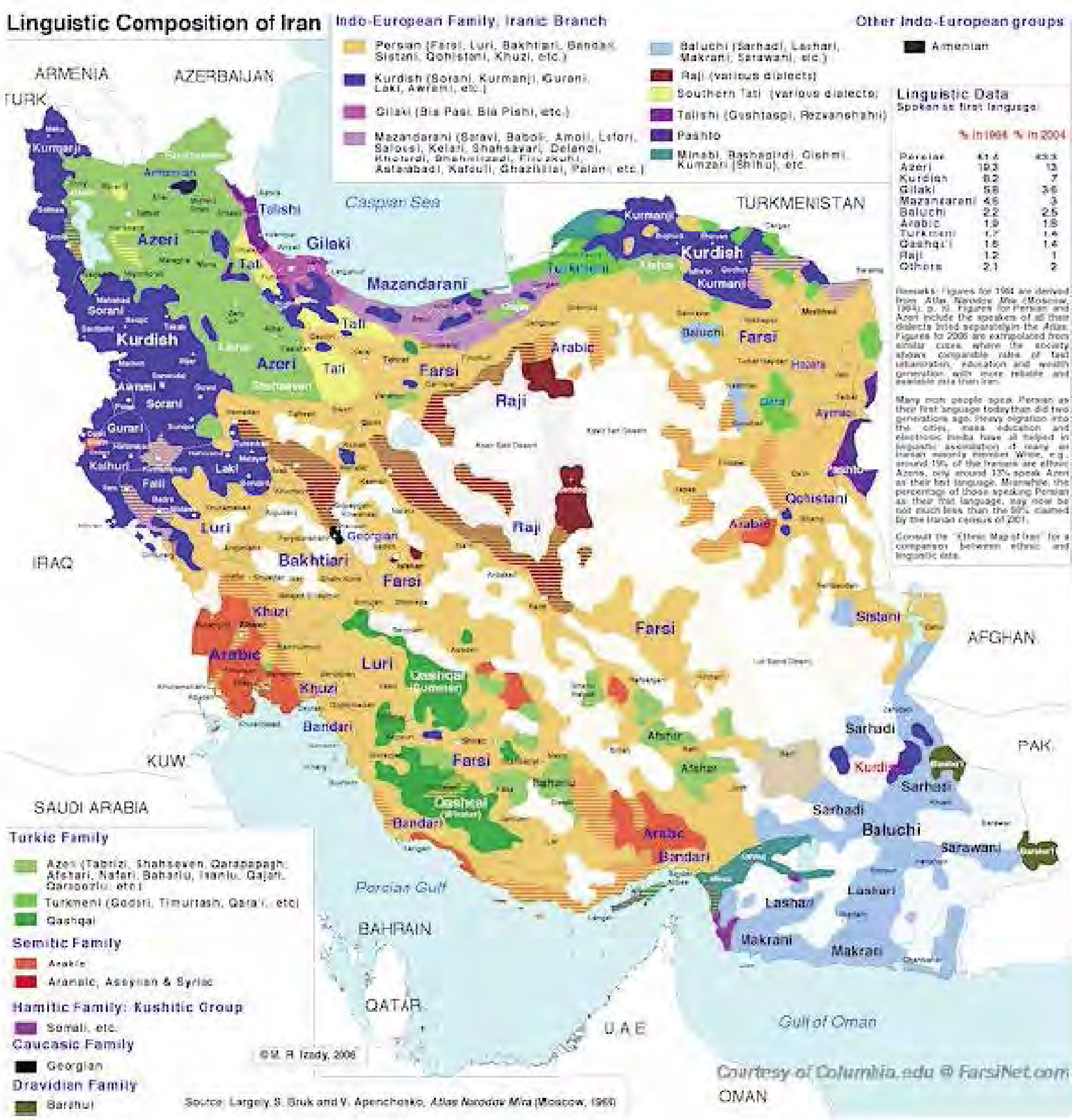
***Figure 34: Key Urban Targets in Iran***

**Iran: Population 80,841,000 in mid-2014; Persian 61%, Azeri 16%, Kurd 10%, Lur 6%, Baloch 2%, Arab 2%, Turkmen and Turkic tribes 2%, other 1%.**

| Rank by City | | |
|---|---|---|
| 1. | Tehran (Tehran Province) | 12,765,238 (conurbation and commuter towns included) (8,088,287 in the city itself) |
| 2. | Mashad (Razavi Khorasan) | 2,868,350 (includes suburban population) (2,410,800 in the city itself) |
| 3. | Isfahan (Isfahan Province) | 3,430,353 (including its metropolitan area and the population living within the Isfahan conurbation) (1,602,110 in the city itself) |
| 4. | Tabriz (East Azarbaijan) | 1,597,319 (city proper and main suburbs) (1,378,935 in the city itself) |
| 5. | Karaj (Alborz Province) | 1,377,450 |
| 6. | Shiraz (Fars Province) | 1,204,882 |

Source: CIA, “Israel,” *World Factbook*, https://www.cia.gov/library/publications/the-world-factbook/geos/ir.html, accessed September 7, 2014; and Wikipedia, “Demographics of Iran,” accessed September 7, 2014, http://en.wikipedia.org/wiki/Demographics_of_Iran#cite_note-Statistical_Center_of_Iran-24.

***Figure 35: Iran's Ethnic and Sectarian Vulnerability to Nuclear Attack***




Source: Farsi – Persian Language, Farsi - Persian Language, http://www.farsinet.com/farsi/.

## Deterrence, Containment, Defense, and Retaliation

If Iran develops a nuclear missile, the resulting arms race would also have a powerful impact on the actions of the US and other regional states. If the P5+1 negotiations – or some form of negotiations – fail, Israel, the US, and Arab states will have to choose between preventive strikes and containment, or containment alone.

Preventive strikes may be able to delay Iran for a given period of time, but if Iran seeks to rebuild it nuclear capabilities, Israel, the US, and Arab will have to strengthen their missile and other defenses, develop great retaliatory capabilities, and/or restrike every new Iranian effort to move towards nuclear weapons.

No amount of US or Gulf military containment effort can alter the fact that a nuclear arms race already exists between Israel and Iran, albeit one where only Israel now has a nuclear strike capability. The practical problem this raises for Iran - and for stabilizing this arms race - is that it will face a possible Israeli first strike option until it can secure its nuclear armed forces.

The end result could well be forces that play out over a period of years or decades that initially push Iran towards a concealed or breakout deployment, followed by phase where it would have to launch on warning or under attack until it has a survivable force. Iran would then, however, have to compete with powers with far larger stockpiles and boosted and thermonuclear weapons until it can create a more sophisticated force of its own.

This confronts Iran with the reality that it at least faces a high-risk arms race, and is likely to become trapped in a steady race to increase its forces, find ways to secure them against counterforce strikes, find ways to compete in missile defense, and still find itself confronting an escalating mix of Israeli, US, and Gulf nuclear and conventional strike capabilities superior to any force Iran can deploy.

# *The Challenges if Iran Deploys a Precision Strike Conventionally Armed Missile Force*

The outside response is likely to be far less threatening if Iran succeeds in deploying precision strike missile and UCAV systems with conventional warheads, but the end result would still be a regional arms race which Iran is unlikely to win. Once again, Iran cannot act in a vacuum. Regardless of how or why Iran tries uses its missile forces and other delivery systems, it cannot operate in an environment where there will be no response.

## Conventional Retaliatory Threats

Israel has a wide range of retaliatory and escalatory options, including nuclear-armed ballistic and sea-launched cruise missiles. Saudi Arabia already has long-range, conventionally armed Chinese missiles that can strike area targets in Iran, and the UAE has some SCUD-B missiles (likely equivalent to Shahab-1s). There are questions about the status, reliability, readiness, and accuracy of the Saudi and Emirati missiles, but these same questions apply to Iran's forces. This raises the specter of any missile "war of the cities" of the kind observed between Iran and Iraq.

As has been discussed earlier, Iran faces far superior air strike forces and air and missile defense forces. As a result, Iran faces the risk of steadily more capable retaliation by US strike fighters and bombers with stealth capability. Iran also faces retaliation by the best air forces of the Gulf as states like Saudi Arabia and the UAE acquire steadily better strike fighters. Strike fighters may be

less likely to initially have a terror impact on civilian populations, but they provide a far more effective strike and targeting capability that Iran can do little to reduce. In the near-to-mid-term, Iran's forces and critical infrastructure are becoming more vulnerable to Southern Gulf air forces as they acquire missile defenses and become less vulnerable to Iranian missiles.

Iran's target base is at least as vulnerable as that of its Gulf neighbors:[373]

- Highly populated, state dominated, corrupt economy with high military spending and major state interference.
- Halting all oil exports critical to Iran. EIA reports that,
    - Pre-sanctions, Iran exported approximately 2.2 million bbl/d of crude oil. Iranian Heavy Crude Oil is Iran's largest crude export followed by Iranian Light. In 2011, Iran's net oil export revenues amounted to approximately $95 billion. Oil exports provide half of Iran's government revenues, while crude oil and its derivatives account for nearly 80 percent of Iran's total exports.
    - Kharg Island, the site of the vast majority of Iran's exports, has a crude storage capacity of 20.2 million barrels of oil and a loading capacity of 5 million bbl/d. Lavan Island is the second-largest terminal with capacity to store 5 million barrels and loading capacity of 200,000 bbl/d. Other important terminals include Kish Island, Abadan, Bandar Mahshar, and Neka (which helps facilitate imports from the Caspian region).
    - Iran is the second-largest oil consuming country in the Middle East, second only to Saudi Arabia. Iranian domestic oil demand is mainly for diesel and gasoline. Total oil consumption was approximately 1.8 million bbl/d in 2010, about 10 percent higher than the year before. Iran has limited refinery capacity for the production of light fuels, and consequently imports a sizeable share of its gasoline supply (Imports 300,000 bbl. of gasoline per day.). Iran's total refinery capacity in January 2011 was about 1.5 million bbl/d, with its nine refineries operated by the National Iranian Oil Refining and Distribution Company (NIORDC), a NIOC subsidiary.
- Refineries and gas distribution critical to economy. Are highly vulnerable.
    - Natural gas accounts for 54 percent of Iran's total domestic energy consumption.
- Key aspects of transportation and power grid are highly vulnerable. Today's precision strike assets allow to know out key, repairable links or create long term incapacity. They have become "weapons of mass effectiveness."
    - EIA reports some power plants are running as low as 10 percent of their nameplate capacity as Iran's electricity infrastructure is largely in a state of dilapidation and rolling blackouts become endemic in summer months. The amount of generation lost in distribution is a central indicator of the disrepair of the electricity network, with upwards of 19 percent of total generation lost during transmission.
- Limited and vulnerable air defenses with only one modern and very short-range air and cruise missile defense system. Will remain vulnerable to stealth, cruise missiles, and corridor suppression of enemy air defenses unless can get fully modern mix of radars, C4I/BM assets, and S-300/400 equivalent.
- Needs imports of food and product.
- Rail system vulnerable. Can use smart mines on all ports.
- Naval embargo presents issues in maritime law, but can halt all Iranian traffic, "inspect" all incoming shipping.
- "No fly zone" would affect operations, especially if include helicopters. Warning could affect civil aviation.

The Arab Gulf states already have missile defenses for many key targets, the US is deploying missile defense ships with wide area missile defense capability, and nations like the UAE and

Qatar have already indicated that they may buy land-based wide area missile defenses like THAAD.

Unless Russia or China alter their polices to sell Iran virtually any advanced weapons technology it wants, the Arab Gulf states, Israel, and the US will have an overwhelming advantage in many areas of air and missile strike capability and missile and air defense. Every major Iranian improvement in its missile forces will trigger an overall set of counter efforts by the US and the other states in the region.

Iran may be able to gain some political leverage by exploiting the risk of a conflict, but it will progressively increase the probable damage to Iran if a conflict actually occurs. Iran will also then face a military situation where Israel retains a nuclear option and Iran does not.

### Rushing Up the Escalation Ladder in Peace and War?

Any Iranian use of long-range missiles against another Gulf state also presents a serious escalatory risk to Iran. Even one such missile firing would effectively escalate to a level where the US would have no clear limits on its use of air and cruise missile power to strike at strategic targets in Iran. Iran's major cities are as vulnerable in terms of power, water, and fuel supplies as the cities of the southern Gulf. Iran's refineries and key links in its ports and transport systems are highly vulnerable as well. Iran cannot possibly win a contest in escalation with its current conventional forces and conventionally armed missiles, and such a contest could spiral into an asymmetric or unconventional war that is costly and destructive for all sides.

Moreover, the first time Iran uses even a conventionally armed missile, it may create conditions that lead to some form of US guarantees and "extended deterrence." The US has stated that it will not accept an Iran with nuclear weapons. But even if does, this scarcely offers Iran security or freedom from preemption and retaliation. Should Iranian nuclear efforts prompt Riyadh to develop its own nuclear program, as was mentioned previously, this would only increase the risks of escalation if Iran uses its ballistic missiles.

## *Impact on Policy*

The US and its regional allies need to recognize and decisively react to the fact that Iran's ballistic missile programs serve several strategic goals.

- One is a population and infrastructure-centric approach based on large numbers of SRBMs that can strike across the Gulf or into Iraq and Kuwait and provide a coercive edge in a dispute with Iran's Arab neighbors.
- These systems act as a substitute for advanced strike aircraft and may well exist in numbers that could saturate or exhaust missile defenses.
- They can be used to attack area and population targets. While they would have limited lethality, they could have a major political and psychological impact.
- They are systems that Iran can use to arm movements like Hezbollah and attack or threaten a state like Israel indirectly.
- Iran's longer-range, conventionally armed MRBM and IRBM forces can be used to intimidate Iran's neighbors and other states at much longer ranges, and
- Conventionally armed MRBM and IRBM forces can also conduct conventional attacks on area targets like population centers and infrastructure. They only exist in limited numbers and they too have limited lethality. They still, however, have value as weapons of political intimidation.

- Longer-range anti-ship cruise and ballistic missiles already supplement Iran's conventional and other asymmetric forces, while posing a different form of "stacked threat" to the flow of world oil exports at the strategic level.

These threats will remain limited until Iran acquires nuclear warheads and/or more lethal conventional warheads with terminal guidance. The prospect of salvos of conventional missiles already provides a serious threat. Even relatively large salvos of such weapons would be unlikely to have a major lethal impact even on large area targets, even if they proved capable of saturating or penetrating missile defenses. However, they would largely have the effective of increasing the political or terror impact of strikes.

The practical question for US and allied policy is what level of missile threat can be tolerated and is safe to deter and contain. There seems to be a current consensus that a nuclear-armed force cannot be tolerated and would lead to preventive strikes. Nuclear-armed missile forces could do massive damage to any area target and provide a far more effective deterrent against US, Israeli, and European interference in Iran's sphere of influence within the Gulf, and shield against attacks on Iran's asymmetric forces.

An Iran armed with missiles with nuclear warheads and massive capability for asymmetric warfare would not need to match other states in advanced conventional arms and would be seen as a dominant regional power, unless Arab states also acquired nuclear weapons or a convincing commitment to extended deterrence from the US.

US declared policy is that no Iranian nuclear weapons capability will be tolerated. It is one thing, however, to threaten and another to act. It also is unlikely that an Israeli preventive strike could have lasting impact. A truly successful US strike would be a major attack, one that would require restrikes, and would probably require the support of the Arab Gulf states for the US to sustain its impact over time.

What is less clear is whether Iran's acquiring long-range missiles with true precision terminal guidance homing should or would be tolerated. While the current accuracy of its missiles so far does not permit it to threaten grievous damage to key targets, the US and its allies need to pay as much attention to future improvements in guidance systems and conventional payloads as Iran's efforts to deploy nuclear warheads.

Iran may not have a major force of missiles with sophisticated and reliable terminal homing capability or point target destruction capability for some years, but the current US and allied focus on Iran's nuclear programs may understate the future limits to containment and deterrence. It may also understate the priority the US and its allies should give to deploying the most advanced missile defenses and agreeing on some form of US extended deterrence.

Given the vulnerability of key Gulf water, petroleum, and infrastructure facilities, there is the prospect that such forces could become "weapons of mass effectiveness even against better missile defenses if fired in large salvos. Quantity imposes its own quality in warfare, and Iran's ballistic missile stocks are larger than the strategic anti-missile holdings of the GCC."[374] While the Gulf States are improving their missile defenses, given the need to have multiple interceptors for each attacking missile, Iran is likely to maintain an edge.

This means that the US and its allies should base their defense and deterrence on dealing with the combined prospect of an Iranian nuclear warhead and precision conventional strike capability until

Iran has decisively given up its nuclear weapons efforts, and then retain a decisive edge in retaliatory capability and missile and air defense.

The US and its regional allies need to cooperate in deciding what forms of preventive strike, counterstrike, or preventive attacks are needed. The risk that Iran will acquire a precision conventional strike capability indicates that if the US does carry out a preventive strike on Iran's nuclear facilities, it should destroy as many of Iran's missiles and missile RDT&E and production facilities as possible. It also raises questions about whether such preventive attacks should be carried out against any of Iran's deployed longer-range systems - particularly ones with ICBM-like ranges - even if Iran does not appear to be creating nuclear warheads.

As for containment, deterrence and retaliation, Iran has much to fear from both the US and its Arab neighbors. Iran appears unlikely to develop any ability to launch a meaningful strike against the US in the near future. While its missile program has made significant strides, it still faces substantial challenges in building a force that could reach the United States. A true intercontinental ballistic missile would almost certainly require improved engines, more efficient multi-staging techniques, advanced guidance systems, and larger and lighter construction components, all which would require development and testing. Until such a threat materializes, Iran will lack the ability to deter the US from supporting the Arab Gulf states, Israel, and is other neighbors.

This will make the US offer of extended deterrence an important asset to its Arab allies regardless of whether Iran chose to go nuclear or rely on precision conventional strikes. It also helps to keep the threat of US stealth and cruise missile attacks on Iran credible, attacks that could disable its power grid, communications, and key infrastructure, government and military facilities. Weapons of mass effectiveness work in two directions; the US has such weapons and Iran does not.

Much will depend, on the willingness of Arab Gulf states to actively defend themselves, and cooperate on developing an integrated wide area capability to destroy incoming missiles. While the MTCR restricts what ballistic weapons the US can supply to Gulf States, there are no limits on anti-missile cooperation. Neither should there be any restrictions on supporting Gulf efforts to build up strike aircraft and ground attack munitions.

Strike aircraft allow Gulf States to retaliate individually and collectively to any Iranian missile strikes, targeting and crippling Iranian infrastructure in return for such strikes. The threat of Gulf air strikes on Iran may not match the impact of some formal US guarantee of extended deterrence or giving the GCC states their own missiles, but it could provide enough additional security to reduce the risk or impact of a steadily deepening arms race in the Gulf, provide a cheaper and more effectively ability to limit Iranian escalation potential, and limit the overall strategic and political advantages Iran can gain from its ballistic missile program.

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