

Energy Infrastructure and the Defense Industrial Base

Annex

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This annex describes the methodology used in a March 2026 study, “Energy Infrastructure and the Defense Industrial Base.” It begins by providing the embodied energy and critical industrial facility sources and assumptions. It then provides the production rates for each weapons system, examines the study’s methodological limitations and their impact on the analysis, and offers a detailed description of each platform included in the modelling, including how each fits into the study’s three scenarios.

Table A-1 documents the embodied energy factors used in this analysis, their sources, and the research team’s key assumptions. Embodied energy represents the cumulative energy consumed in extracting, processing, and manufacturing materials from cradle to factory gate.

Critical Industrial Facility Location Data Sources and Limitations

Data on U.S. steel plant locations and capacity were drawn from the [Global Iron and Steel Plant Tracker](#). Titanium plant data was sourced from the [2021 USGS Mineral Yearbook](#). Aluminum plant locations and capacity were compiled from publicly available industry sources for the [Alcoa Warrick facility](#), the [Alcoa Massena facility](#), the [Century Aluminum Sebree facility](#), and the [Century Aluminum Mt. Holly facility](#). Semiconductor fabrication facility data was cross-referenced across [Wikipedia](#) and multiple [industry and government sources](#) to verify location and capacity. This category includes conventional silicon fabs producing logic, memory, and analog integrated circuits, as well as compound semiconductor facilities (GaAs, GaN, SiC), micro-electronical systems (MEMS) and photonics foundries, and specialty fabrication sites for optoelectronics, radio frequency filters, and quantum processors. Note that semiconductor facilities without publicly available production capacity data were assumed to have a conservative production estimate of 10,000 chips annually.

Table A-1: Material Embodied Energy (EE), Sources, and Assumptions

Material	Embodied Energy (MJ/kg)	Source & Assumptions
Steel	25.3	ICE Database v2.0 Steel with 39% recycled content; cradle-to-gate value from the Inventory of Carbon & Energy (University of Bath)
Aluminum	155	ICE Database v2.0 General aluminum with ~33% recycled content; UK form-mix cradle-to-gate value
Titanium	361	DOE Titanium Bandwidth Study (2017) Primary titanium production via Kroll process; cradle-to-gate energy intensity
Carbon fiber	286	Howarth et al. (2014) High end of reported virgin carbon fiber range (183-286 MJ/kg); conservative estimate for aerospace-grade material
Graphite epoxy	203	Derived from Howarth et al. (2014) 60% carbon fiber / 40% epoxy by mass; CF = 286 MJ/kg, epoxy = 78 MJ/kg; calculated: $0.6 \times 286 + 0.4 \times 78 = 203$ MJ/kg
Graphite BMI	203	Derived estimate from Howarth et al. (2014) Bismaleimide resin assumed similar to epoxy for energy intensity; same calculation as graphite epoxy
Carbon epoxy	172	DOE Quadrennial Technology Review (2015) 60/40 CF to epoxy mass fraction; using average values: CF = 235 MJ/kg, epoxy = 78 MJ/kg
Fiberglass epoxy	44.7	DOE Quadrennial Technology Review (2015) 60% fiberglass/40% epoxy; fiberglass = 13-32 MJ/kg (avg 22.5), epoxy = 76-80 MJ/kg (avg 78)
Composites (GFRP)	42	Howarth et al. (2014) Generic glass fiber reinforced polymer; 60% glass/40% polyester resin
Thermoset polymers	70.5	DOE Quadrennial Technology Review (2015) Polyester resin with embodied energy range of 63-78 MJ/kg; average value used

Material	Embodied Energy (MJ/kg)	Source & Assumptions
Electronics	748.8	Environmental Protection Agency (2018) Weighted average of electronics components (e.g., CPUs, LEDs, displays, notebooks); PCB-intensive systems proxy for military avionics
JP-10 fuel	7.8	GREET Model / ANL (2016) Well-to-pump energy for conventional jet fuel as proxy; WTP = 0.18 MJ/MJ x 43.2 MJ/kg = 7.8 MJ/kg
Explosives (RDX)	136	Costa et al. (2015) RDX process energy from plant inventory; electricity + boiler fuel inputs converted from kWh to MJ; lower-bound estimate
Solid rocket fuel	43	Electrolytic Production of Sodium Perchlorate, ICE Database v2.0 APCP propellant (70% AP / 15% Al / 15% binder); AP electrolysis = 12 MJ/kg, Al = 155 MJ/kg, binder = 70.5 MJ/kg
Plastic bonded explosive (PBX)	136	Proxy from RDX PBX assumed similar to RDX for process energy; may underestimate due to additional binder processing

Table A-2: Mobilization Scenario Rates by Defense System

System	Baseline Rate	Buildup Rate	War Rate
Arleigh Burke-class destroyer	1.5	3	5
Ford-class carrier	0.25	0.25	0.33
Constellation-class frigate	0	3	5
Virginia-class submarine (Virginia Payload Module)	1	2	3
Virginia-class submarine (non-Virginia Payload Module)	0.5	0	0
Columbia-class submarine	0.5	1	1
America-class landing helicopter assault	0.2	0.3	0.5
San Antonio-class landing platform, dock	0.5	0.7	1
F-35A Lightning II	156	250	500
F-15EX Eagle II	24	36	72
F/A-XX (Hornet replacement)	0	2	0
F-47 next-generation air superiority fighter	20	32	64
B-21 Raider	7	20	40
Modular Attack Surface Craft (MASC)	9	15	100
Collaborative Combat Aircraft (CCA)	120	300	1,500
Joint Air-to-Surface Standoff Missile (JASSM)	1,000	2,000	10,000
GBU-39 Small Diameter Bomb	3,200	9,500	30,000
Tomahawk Missile	55	1,000	1,815

Source: CSIS.

Defining Peer War

This analysis assumes that a war between the United States and China will be a protracted one. Due to the long lead times associated with most of the platforms analyzed here, only a war that lasts more than a year or two is likely to have any impact on the production of these **platforms**.

The war rate scenario lacks a strong empirical basis for forecasting: The modern era has not seen a war between great powers as powerful as the United States and China. Unsurprisingly, the U.S. government has released no documents detailing its planning assumptions for such a protracted war.

Nor are published wargame results much use. Despite the fact that some **wargames** publish loss and munitions expenditure rates, they mostly focus on the initial stages of the fighting between the United States and China rather than a protracted industrial war between the two countries. These **wargames** and similar models have demonstrated that munitions expenditure and losses have been enormous. However, expenditure of different types of munitions and platforms surge early in a conflict and then decline to reach varied usage rates as the conflict **protracts**. While both sides may want to produce enough platforms and munitions to allow usage rates comparable to the initial spasm of violence, the war in Ukraine **suggests** that reaching such a rate of production is extremely unlikely.

This study's solution was to look to history: specifically, World War II. A U.S. buildup on the scale of the World War II mobilization is **unlikely** today. However, it represents a useful scenario for testing the extent of demands that might be placed on the U.S. energy supply during a protracted war with China.

One major difference is the high complexity associated with modern systems relative to those used in World War II. To account for that difference, the research team used lower-complexity analogues when thinking about extrapolating from World War II-era production patterns. Assuming that the United States could possibly complete construction of 18 aircraft carriers in less than four years, as it did **during World War II**, would be ludicrous. Instead, we assumed that a World War II naval combatants more closely resembled a modern fighter aircraft in its production complexity and that production of such aircraft could be scaled at similar levels as U.S. large warship production in World War II.

Methodological Limitations

INHERENT UNCERTAINTY

The method used in this report involves many limitations. The first is the inherent uncertainty about the future. The U.S. Navy cannot predict what ships it will want to **build** (or that will be successfully commissioned) in even a few years. Nor have past efforts to predict losses or munitions expenditure rates seen much success. As such, the scenarios should not be considered predictions. Rather, they represent heuristic tools for thinking systematically about risk.

An inability to predict the future does not represent a major obstacle to this analysis, which is focused on identifying areas of fragility. Fragility is a **structural aspect** of complex systems that render them prone to failure. Fragile systems are characterized by overconcentration, internal homogeneity, and lack of redundancy. As a result, such systems are overly dependent on single points of failure and vulnerable to shocks. Scenario analysis allows analysts to target their search for such points of failure in a systematic way based on plausible shocks that could affect a system.

DATA AVAILABILITY

The second major limitation relates to data availability, the lack of which puts downward pressure on the estimates presented here. Most importantly, this report relied entirely on open sources, which required a variety of assumptions, described below.

The embodied energy analysis makes a large number of simplifying assumptions that systematically bias energy analysis downwards. Major weapons systems are enormously complex. For example, one F-35 contains more than 40,000 individual parts alone. Even if the details of these parts were unclassified, including all of the individual parts in an embodied energy analysis would impose unacceptable costs. Instead, we focus on the largest known components, which we assume are most likely to influence the energy demands of production. However, there may be highly energy-intensive materials involved in other subsystems of which we are not aware.

A more important source of bias is the lack of embodied energy data on military-grade components. Because the analysis uses embodied energy estimates from public databases, it almost certainly underestimates the embodied energy of military-grade components. Military-grade steel, for example, is produced to higher standards than civilian steel, especially the type of steel used for the highest-end systems, such as nuclear submarines. It seems reasonable to assume that the same will be true for most of the components included in the embodied energy analysis.

Another critical source of bias is the absence of data on energy use during assembly and production. Energy-intensive processes like high-precision machine tooling and nuclear welding are used in the manufacture of many of the weapons systems examined here, but the research team was unable to find reliable data on how much energy these processes used.

Although the government presumably has better data on some of these questions, data availability problems are not only the result of this project's exclusive use of open sources. According to a 2025 U.S. Government Accountability Office [report](#), the main government procurement database only provides visibility into first-tier suppliers or "prime contractors." Although the DOD is increasing its efforts to understand its own supply chain, these efforts are still limited relative to the enormous complexity of defense supply chains, which the department [estimates](#) involve more than 200,000 suppliers.

SCOPE CONDITIONS

A third source of downward pressure on this report's estimates is the fact that not every weapons system produced by the U.S. defense industry could possibly be included in this analysis. The resources required to analyze the dozens (if not hundreds) of vehicles, munitions, and other products used by the U.S. military would have quickly outstripped those available for this research. To keep the scope manageable, this analysis focused only on high-end combat aircraft, warships, and a few types of munitions deemed to be particularly important for war between the United States and China.

A fourth source of downward pressure is the focus on specific materials that interviews and initial desk research indicated were likely to constitute the largest energy demands either due to their high proportion of system composition (e.g., steel for warships) or their high embodied energy (e.g., semiconductors). This means that many potentially important materials were excluded from the analysis, such as the copper and silica glass [needed](#) for the miles of cables required for large warships. This scoping assumption means that the analysis is not capable of demonstrating what the most

vulnerable inputs are from an energy perspective, merely of pointing to key pressure points from among the assessed materials.

A final source of bias, which partially counteracts the downward biases identified above, is the fact that defense production is highly multinational. Many components and even some final products are made outside of the United States, which means they draw on a different energy supply than production that occurs within the United States. This has two implications for the analysis presented in this paper. The first is that the embodied energy calculated for the systems examined here is higher, potentially much higher, than the embodied energy of the components manufactured in the United States. The second is that the supply of energy for total defense production is much greater than the United States itself provides.

Systems Breakdown

WARSHIPS

The baseline scenario represents a continuation of current shipbuilding trends. Naval shipbuilding has stagnated for a variety of reasons, and this **scenario** assumes most of the problems remain unsolved over the next 10 years. The main source for the buildup scenario was the most recent **U.S. Navy Annual Long-Range Shipbuilding Plan**, which was released March 2024. During a war, production was assumed to less than double due to the extreme complexity of modern warship construction. This puts wartime warship production slightly over **Reagan-era buildup rates**.

Ford-Class Nuclear-Powered Aircraft Carrier (CVN)

Ford-class carriers are the world's largest warships. The **USS Gerald R. Ford** displaces about 100,000 tons fully loaded. This **analysis** assumes that the ship uses about 50,000 tons of steel, about half its displacement. It also assumes that the ship has about 96 tons of electronics in its **radar systems** and another 400 tons in **other combat electronics**.

Both the baseline and buildup scenario envisions an average delivery rate of 0.25 carriers per year per the **2024 shipbuilding plan**. The number of carriers in the U.S. fleet is set by Congress, and we assume that industry will be able to meet the goal of one carrier delivery every four years due to the extremely high-profile nature of the platform and **associated legal mandates**. We assume only a small increase in production to 0.33 per year in the war rate scenario due to the extreme complexity and size of a CVN.

Arleigh Burke-Class Destroyer (DDG)

The **Arleigh Burke Flight III** displaces about 10,000 tons, about half of which we assume is steel for the hull. We **model** several subsystems: the Mk 41 Vertical Launch System (190 tons of steel), the Mk 45 naval gun (21 tons of steel), and the Aegis system (50 tons of steel and 30 tons of electronics).

The baseline scenario assumes that the recent **historical trend** of one to two Arleigh Burke deliveries holds for an average rate of 1.5 ships constructed each year. The **2024 shipbuilding plan** envisioned beginning construction of the next-generation DDG(X) in FY 2032 while sustaining Arleigh Burke Flight III construction. Although the **plan** anticipates a seven-ship delivery of large surface combatants in 2035, the buildup scenario assumes a delivery rate of three per year, in line with the average delivery rate between 2030 and 2040. The war rate scenario assumes a five-ship annual production rate, two hulls under the maximum envisioned delivery year in the 2024 shipbuilding plan.

Constellation-Class Frigate (FFG)

The **Constellation-class frigate** was a small surface combatant that was still under construction during modelling. It displaces about 8,000 tons, about half of which we assume was steel for the hull. The Constellation was also set to have an Mk 41 VLS system (although the ship carried fewer cells than the *Arleigh Burke*-class, an Mk 110 naval gun (7.5 tons), and a variant of the Aegis system, which we assumed would have the same **specifications** of its cousin on the *Arleigh Burke*-class.

The **2024 shipbuilding plan** assumes a delivery rate of two FFGs per year throughout the first half of the 2030s, although it would quickly climb to three in the following years. However, the Navy canceled the **program** in late 2025. The Navy's plans for replacing the Constellation were not known at the time of modelling, so the buildup scenario uses three Constellations a year as an input based on **post-2035 delivery estimates**. Due to the recent change and the long lead times associated with first-in-class ships, we assume that the baseline scenario involves no FFG production. The war rate scenario assumes the same production rate as the *Arleigh Burke*: five ships per year.

Virginia-Class Nuclear-Powered Attack Submarine (SSN)

A **Virginia-class boat** displaces about 8,700 tons. Some newer boats are being built with an addition the Navy calls the **Virginia Payload Module** (VPM), which brings the displacement to 10,200 tons. We **assume** that about 60 percent of the displacement is steel. We **assume** that about 2 percent of the boat's displacement is combat electronics.

The baseline scenario assumes minor increases in the **annual production rate** to 1.5 boats per year. It assumes that one-third of delivered boats lack the VPM and that the remainder are VPM variants. The buildup scenario envisions **annual delivery** of two SSNs each year, both of which are VPM variants. The war rate scenario assumes production of three boats per year, all of which are VPM variants.

Columbia-Class Nuclear-Powered Ballistic Missile Submarine (SSBN)

A **Columbia-class boat** will displace nearly 21,000 tons. We **assume** that about 60 percent of the displacement is steel: 12,600 tons. We **assume** that about 2 percent of the boat's displacement is combat electronics: 420 tons.

No Columbias have yet been launched, so the baseline scenario takes a pessimistic view that the United States only produces one boat every two years (0.5 per year) to distinguish it from the buildup scenario, which envisions **annual delivery** of one SSBN each year. The war rate scenario assumes no further increase in SSBN production because they are not warfighting assets.

Amphibious Assault Ships

The scenarios included two types of amphibious assault ship: the *America*-class landing helicopter assault ship (LHA) and *San Antonio*-class amphibious transport dock (LPD). The **America-class** LHA displaces about 49,000 tons. This **analysis** assumes that the ship uses about 24,500 tons of steel, about half its displacement. It also **assumes** that the ship has about 250 tons in combat electronics. The **San Antonio-class** LPD displaces about 24,900 tons, and we made the same assumptions.

The baseline scenario assumes an average of 0.2 and 0.5 *America*-class and *San Antonio*-class ships produced each year. The buildup scenario assumed that the defense industry would complete one amphibious assault ship per year. These were divided between 0.3 LHAs and 0.7 LPDs each year. The

war rate scenario assumes a 50 percent increase due to the relatively low complexity compared with a Ford-class CVN.

Modular Attack Surface Craft (MASC)

This analysis assumes that U.S. unmanned surface combatants will closely resemble Blue Water Autonomy’s proposed “Liberty-class” unmanned ship. This proposed MASC displaces about 850 tons and can carry about 160 tons of containerized materiel—**probably** Mk 70 VLS systems.

Using the same assumptions as detailed above for other surface craft, we assume that about 50 percent of that displacement is its hull—which in this case is made of aluminum—and about 2 percent is combat electronics.

No MASCs were under serial production during the period of analysis, but **Navy force structure plans** suggest eventual procurement of “as many as several dozen MASCs.” The Navy’s **2024 shipbuilding plan** called for between 89 and 149 unmanned platforms by 2045. Assuming that 2035 would occur during a gradual ramp-up of production, we assumed a baseline scenario of nine MASCs per year and a buildup scenario of 15 MASCs per year in the mid-2030s. Both are in line with **Blue Water Autonomy’s predictions** regarding possible production rates.

To estimate production during a war rate buildup, we assumed that MASCs were **approximately** as difficult to produce (given changes in technology) as World War II-era submarines, which roughly quintupled by 1945 among Germany, the United Kingdom, and the United States. Assuming that the United States is on its way to achieving the maximum production rate predicted by Blue Water Autonomy (20 per year) when a war begins, we assume a wartime production rate of 100 MASCs per year in the mid-2030s—about five years into a war.

COMBAT AIRCRAFT

No counterpart to the Navy’s shipbuilding plan exists for combat aircraft, so we generally use think tank and industry statements to assess what a buildup rate could look like. For the war rate scenario, we generally assume that that production could be roughly doubled from a buildup already under way. The United States was able to accomplish this with large surface combatants in World War II, which were much more complex than the aircraft of the time. In addition, the United States lost between 90 and 744 combat aircraft in iterations of a **CSIS wargame** that covered one to three weeks of a U.S.-China war. We assume that at peak production the United States will be making strides toward replacing those losses and building air forces capable of ending the conflict, with war rate production of about 670 manned aircraft and 1,500 Collaborative Combat Aircraft (CCAs) per year. This is significantly greater than Reagan-era buildup **delivery rates** but plausible with a nationwide industrial mobilization. Unlike shipbuilding, the United States has a large aircraft industry, and production capacity can be shifted (albeit incompletely) between civilian and military production.

F-35 Lightning II

The F-35 Lightning II is the U.S. military’s most modern multirole fighter in operation. The U.S. government has **announced** that it will order more than 2,000 F-35s to replace the F-16 Fighting Falcon. Based on **Lockheed Martin data**, we assume that the airframe consists of approximately 40 percent aluminum, 13 percent graphite-epoxy, 21 percent graphite-BMI, and 15 percent titanium. The empty weight of an **F-35** is 29,300 lbs. Although the full weight of the airframe is less than the

full weight of the plane, we assume that the remaining parts have comparable proportions of these materials. In addition, we assume that the F-35's 6,422 lb. F135 **engine** is made entirely of titanium and that 7 percent of the airplane's weight consists of various types of electronics.

Lockheed Martin **currently produces** about 156 F-35s per year, although it is probably capable of increasing **production** to more than 190 planes **per year**. We therefore use 156 planes as the baseline rate. The DOD **plans** to eventually purchase 2,460 F-35s. Given that the U.S. military currently operates about 740 F-35s, procuring the remaining 1,720 in the next 10 years would be potentially manageable at rates barely over **current production**. A buildup scenario assumes that the DOD seeks to hit that target in seven years, requiring an eventual production rate of about 250 F-35s per year.

To estimate the war rate, we assume that modern fighter aircraft are approximately as difficult to produce as the most complex World War II-era surface combatants and submarines. Principal surface combatant and submarine commissionings **approximately** doubled from 1941 to 1942, so we assume a doubling of F-35 production from the buildup rate to about 500 per year would be plausible after a full wartime mobilization.

F-15EX Eagle II

We assume that the fighter's empty weight of 14,500 kg is distributed between aluminum, titanium, steel, and composites according to publicly available data on the F-15. We **assume** that its two engines are made entirely of titanium and that, like other fighter aircraft in the model, that 7 percent of its weight is made up of electronics.

Currently, Boeing is **increasing production** to a steady rate of about 24 F-15EXs each year, which we consider to be the baseline rate. The **Air Force** seems to consider 36 F-15EXs per year an achievable buildup rate. We make the same assumptions regarding war rate production as in the case of the F-35, for an annual rate of 72 aircraft.

F/A-XX

The **F/A-XX** is a still-notional replacement to the F/A-18 Hornet, the U.S. Navy's most numerous combat aircraft. Its specifications are still to be determined, so we assume that it is an F/A-18 with the airframe material percentages of an F-35. We assume that it will use two 2,450 lb. titanium engines and that, as is the case with all other fighters, 7 percent of its weight is electronics.

In the baseline scenario, we assume that the fighter has been deprioritized and is not in production in 2035. In the buildup scenario, we assume it is in early, low-rate production of about two per year. Finally, we assume that development of such an aircraft would be deprioritized in a war in order to produce proven aircraft like the F-35 or develop new types of airframes more suitable for quick mass production, leading to a war rate of zero.

B-21 Raider

The B-21 Raider is the next generation of U.S. bomber. It weighs roughly 70,000 lbs, and we **assume** it consists of 39 percent composite (like the B-2), 15 percent aluminum, 7 percent steel, 39 percent titanium (like the F-22), and 7 percent electronics (like all other modelled combat aircraft).

Although actual production targets for the B-21 remain classified, it is generally **assumed** to be about seven per year, which we adopt as the baseline. The **Mitchell Institute for Aerospace Studies**

recommends a much higher acquisition rate, which we assume to be a buildup rate. As with other extremely complex platforms, we assume that the United States can roughly double production of the B-21 for war rate production.

F-47 Next Generation Air Superiority Fighter

The **F-47** is the U.S. military's notional sixth-generation air superiority fighter. Almost nothing has been released about its specifications, so we assume it to be identical to the F-22.

The Air Force plans to replace the F-22 with the F-47, so we assume the baseline production rate to be about 20 per year—the same rate achieved by F-22 production at **full-rate production**. However, the **Mitchell Institute** has also suggested a higher F-47 acquisition target of 300 aircraft, so we assume a buildup rate of 32 fighters per year and a war rate production of 64 per year.

Collaborative Combat Aircraft (CCA)

CCAs are a generic term for what will likely become a variety of **unmanned combat aircraft** designed to fly as part of a formation with a manned aircraft. Since little information is publicly available, we assume the entire airframe to be made of carbon epoxy except the titanium engine. We assume that 10 percent of the aircraft's weight will be electronics to account for the **relatively high role** they will play in an autonomous system.

The U.S. Air Force **stated** under the Biden administration that it sought a CCA fleet of about 1,000 aircraft. To meet that goal in about 15 years implies a baseline rate of about 120 per year after several years of low-rate production. While it is difficult to separate marketing language from true production capability, **Anduril** and **General Atomics** both claim to be able to produce hundreds of CCAs each year. We therefore assume that in the buildup scenario, the producers are both able to achieve their goals and the Air Force wants many more CCAs, resulting in a rate of 300 per year. As is the case with the MASC, we assume that CCAs are roughly equivalent in complexity to World War II-era submarines, which implies a major **increase in production** to reach a war rate of about 1,500 per year.

LONG-RANGE PRECISION MUNITIONS

Due to the variety of long-range precision munitions in the U.S. arsenal, this **analysis** uses examples of relatively low- and high-end long-range munitions that might plausibly be used in a conflict with China.

GBU-39B Small Diameter Bomb (SDB)

The **SDB** is a 250 lb. GPS/inertial navigation system-guided glide bomb suitable for all-weather, around-the-clock operations. It is **produced** in two variants, one of which has a longer range but a much higher price tag. The warhead contains about 37 lbs. of high explosive, and we **assume** the remainder is a mix of steel and aluminum, plus 5 percent of its weight in electronics.

We assume the baseline production of SDB variants is about 3,200 (2,500 of the less-capable SDB and about 1,700 of the more advanced SDB II), the average of annual production across the lifetime of the **program**. We assume that buildup production would sustain the highest annual **production rate** for multiple years: 9,500 (about 30 percent of which are the more advanced SDB II). We assume that modern guided munitions are comparable in complexity to World War II-era combat aircraft. Using U.S. aircraft production as an analogue, we assume that the United States can increase its production from the base rate approximately ninefold to a war rate of about 30,000.

Joint Air-to-Surface Standoff Missile (JASSM) Family

The JASSM family includes three missiles: the JASSM, JASSM-Extended Range (JASSM-ER), and the Long-Range Anti-Ship Missile (LRASM). The JASSM is no longer in production, and the **JASSM-ER and LRASM** are sufficiently similar that we model them as one missile type. These missiles are likely to play a critical role in a **conflict with China**. The **JASSM** weighs about 2,250 lbs. and carries about 240 lbs. of plastic explosive. We **assume** that the remainder of the 1,000 lb. warhead is steel and that it has a 100 lb. titanium engine. We further assume that 5 percent of the remaining mass is electronics while the rest consists of aluminum and composites.

Despite lower historical rates of delivery, we assume that Lockheed Martin will achieve its stated goal of **producing** 1,100 JASSMs at baseline. We assume that production roughly doubles for a buildup, and that the United States eventually achieves a production rate of about 10,000 per year in a war rate production scenario in line with German combat aircraft production trends.

Tomahawk Missile

The Tomahawk uses a comparable warhead to the JASSM, so they are considered to be identical. The engine weight of the most recent production block remains classified, so we **assume** it to have a 141 lb. Williams F107 engine. We assume that the remainder of the Tomahawk, like the JASSM, consists of electronics, aluminum, and composites. Finally, it also has 600 lb. ARC/CSD solid-fuel booster, of which the booster itself weighs about 350 lbs., meaning that the rocket fuel **likely weighs** about 250 lbs.

Recent **reporting suggests** baseline Tomahawk production of about 60 missiles per year. The **producer's goal**, however, is to achieve a production rate of about 1,000 per year, which would represent a sizable buildup. We look at the **example** of U.S. aircraft production from 1936 to the height of the war as a model and assume that the United States will be producing a war rate of 1,815 Tomahawks about five years into a war with China. ■

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