SAFRAN

an international

Technology Leader

Presentation to CSIS forum

November 12th, 2009, Washington DC

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SAFRAN : a long history in rocket propulsion …

1960- 1996
SEPR 844 – 1.5 t
Nitric Acid / Kerosen

1951 → 1954

VERONIQUE - 4 t
Nitric Acid / Kerosene

1959 → 1975

VERONIQUE AGI
VERONIQUE 61/
Nitric Acid / Turpentine

1965 → 1967

VESTA - 17 t
Nitric Acid / Turpentine

French national programs

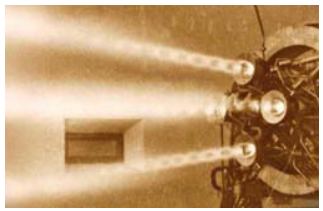
1965 → 1967
1st French Satellite

EMERAUDE - 28
DIAMANT A
Nitric Acid / Turpentine

1966 → 1971

CORALIE - 27 t
PA 1
UDMH

1967
HM4 1st H2/O2 engine test



1970 → 1975

L17 - 35 t
DIAMANT B – BP4
N2O4 / UDMH

1979

ARIANE 1
N2O4 / UDMH
H2/O2

EUROPA

European programs

… and in cooperation

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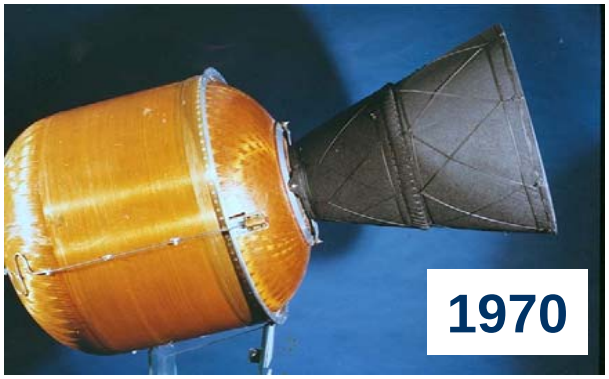
SAFRAN Carbon-Carbon - a successful spin-off story



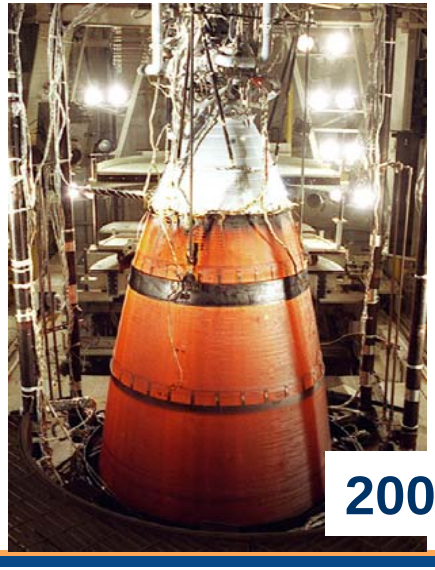
From ballistic missiles

To brakes

More efficient and cost effective technologies for propulsion

Worldwide leadership Of C-C brakes

Messier-Bugatti
Groupe SAFRAN



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SAFRAN Ceramic Matrix Composite - a new story

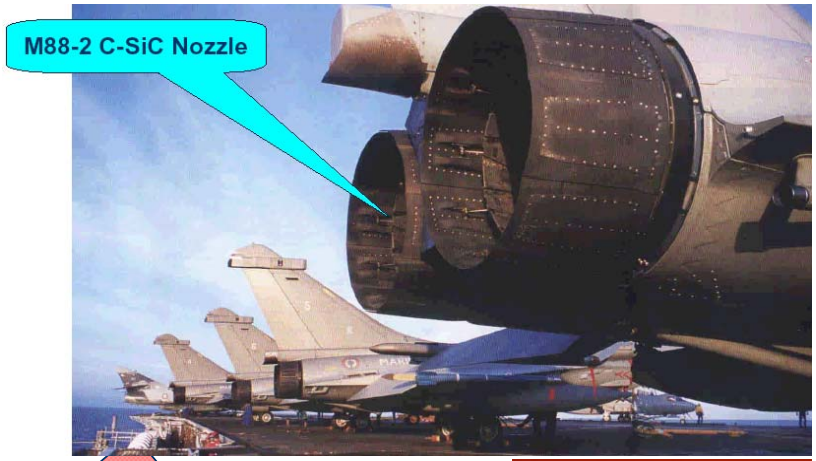
1988

HERMES :
the reason for CMC

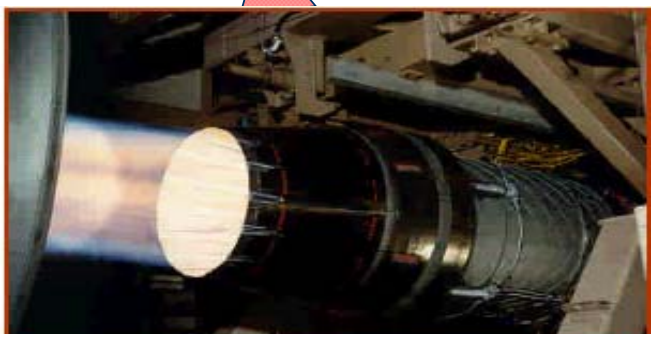
LCTS
creation

1995 : CMC

for M88 engine



2002 : 2nd generation
Self healing matrix



2005 : new applications

2020 : la clef du moteur vert

Life duration of F100 nozzle flaps x 4

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Ceramic Matrix Composite (CMC)

- **CMC mixer Tested on CFM56-5C**
  - 100lbs weight reduction
  - 750 C cycles demonstrated

- **COMBUSTOR: weight, lower Nox…**
  - Component tested

Ceramic matrix composites have 1/3 the density of nickel-based alloys

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What CFM is :

- **World's most** successful **aviation joint venture**

  … 30 aircraft applications … >20,000 engines delivered

- **World's largest aircraft** engine manufacturer

  … powering 55% of all aircraft ordered '96 – '08

- **Agreement renewed through the** year 2040

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CFM started on a shared vision, a common goal and…

Gerhard Neumann René Ravaud

… a personal relationship

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… and strong political support

Richard Nixon

Georges Pompidou

Reykjavík, Iceland, June 1973

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CFM, A 3-DECADE SUCCESS STORY

Boeing 737-300, -400 and -500 (Classic)

Airbus A340

Boeing 737-600, -700, -800 and -900 (Next Generation)

Boeing KC-135R, C-135FR, E3, KE-3 and E-6

CFM56

Airbus A318, A319, A320 and A321

Boeing 737 MMA

CFM International: 50% Snecma - 50% GE

- Leader on the 100+ pax A/C market with a 50% market share
- +20,000 engines delivered
- +7,000 aircraft flying
- 480 airlines

CFM agreement renewed until 2040

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SAFRAN IN ROCKET PROPULSION

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Safran leads large liquid engines development and production in Europe

Marotta
Supports

Snecma
Generator
Hydrogen turbopump
LEO, LEH
Generator valves

Snecma Propulsion Solide
Sensors

Avio
Oxygen turbopump

Microtecnica
Electrovalve unit

Volvo Aero
Oxygen turbine
Hydrogen turbine
Nozzle

MT Aerospace
Bearing, thermal protection

Astrium
Chamber

Techspace Aero
Purge valves
Hot gas valves
Chamber valves

APP
Starter, igniters

Vibro-meter
Sensors

Auxitrol
Sensors

Meggitt
Ducting & flexible components

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Europe objectives in Space

- The Lisbon treaty gives EU a responsability on space matters

- The 15th of October J.M. Barroso, president of the European Commission, has reaffirmed Europe objectives in space during the conference on European Space Policy:

  - « Four priorities were identified: climate change, security, innovation and exploration »
  - « First we must guarantee the success of our flagship projects Galileo and GMES »
  - « Second we must develop a strong, space-based capacity to deal with climate change »
  - « Third we need more security in space and from space »
  - « Space exploration is essential to expand human knowledge and to stimulate innovation »
  - « We must also reinforce support for bottom-up space research, which is the breeding ground for a growing knowledge society… »

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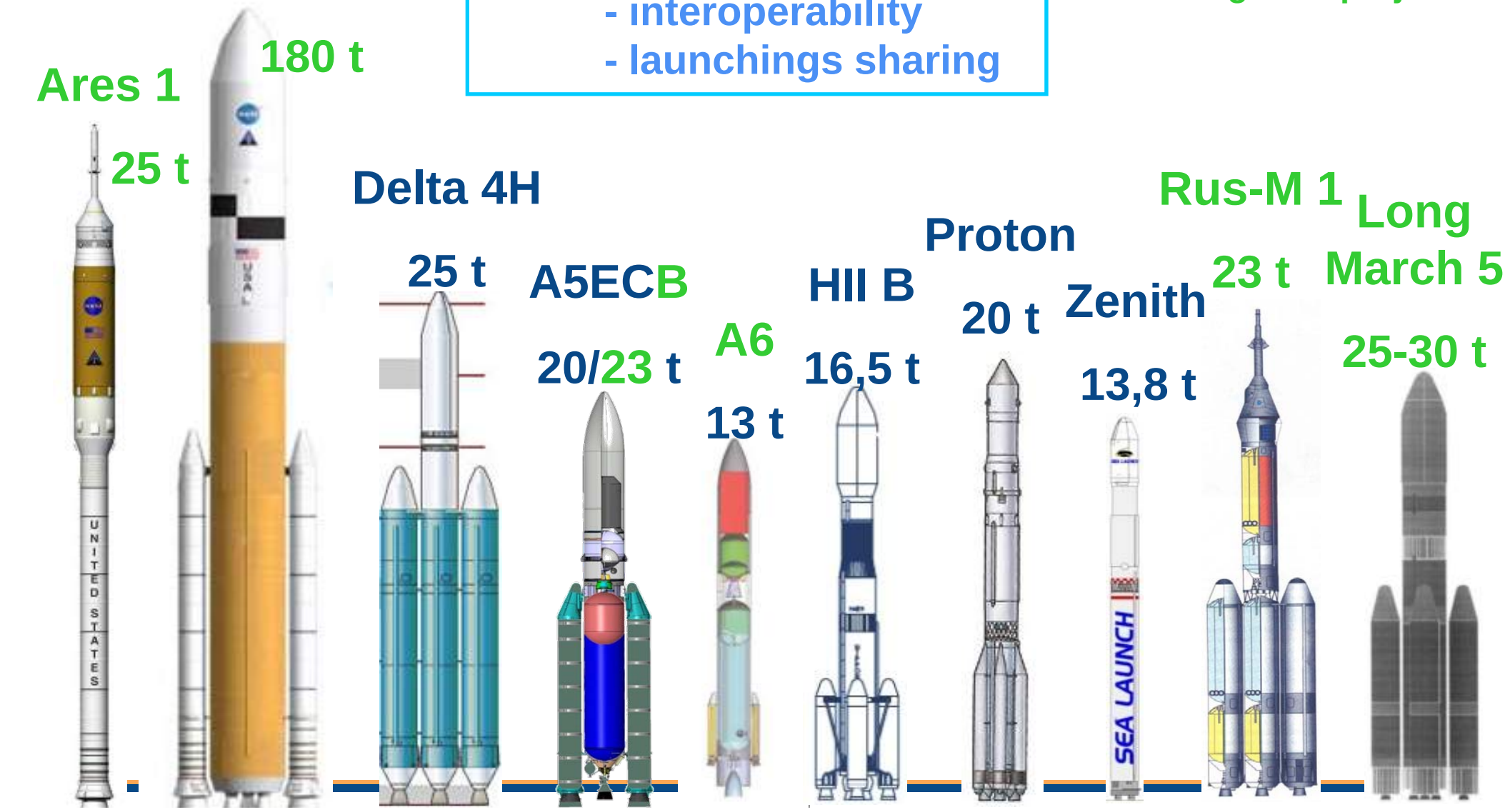
World medium/heavy launchers panorama

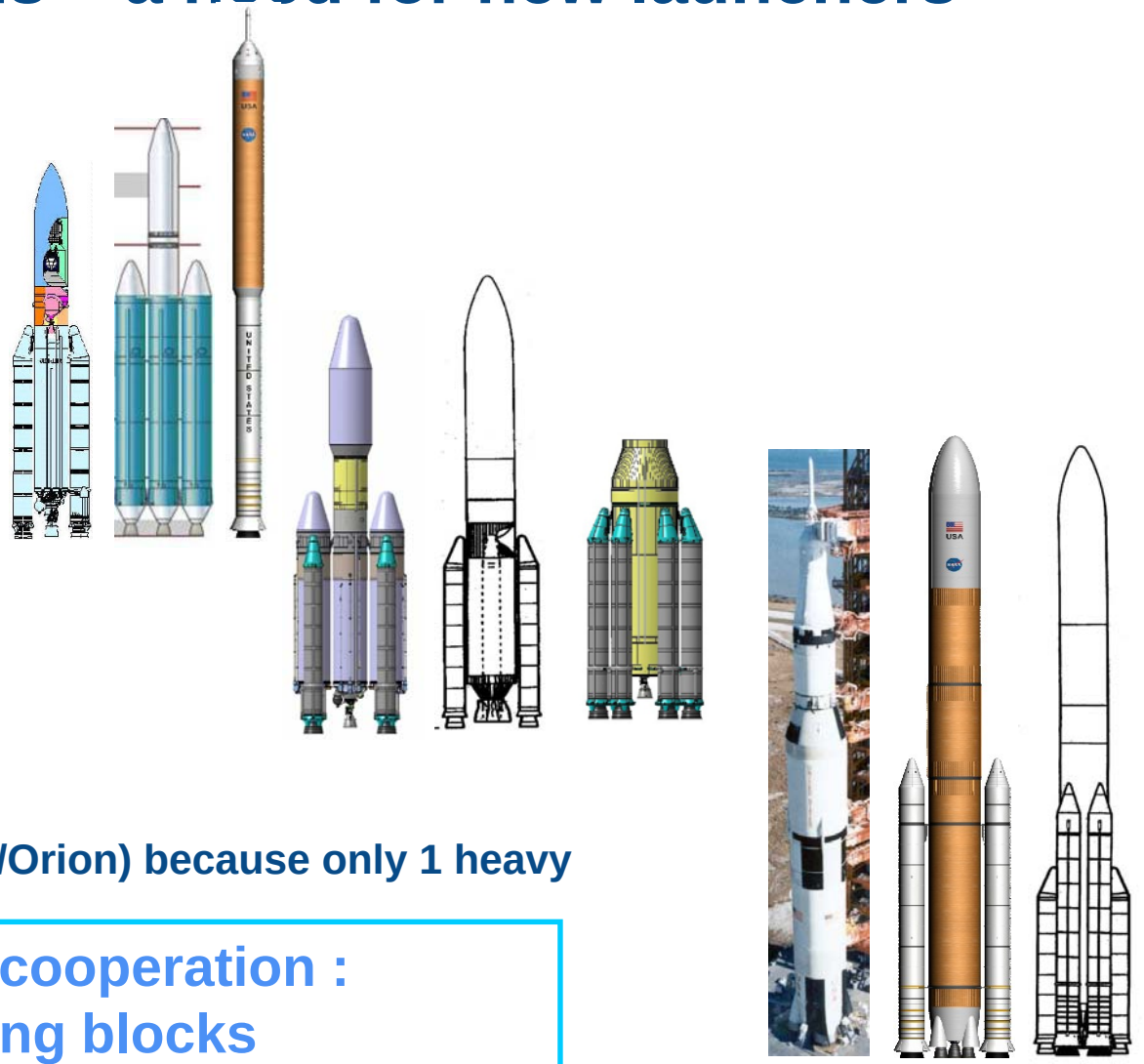
International cooperation:
- interoperability
- launchings sharing

LEO payloads
in green: projects



Exploration missions – a need for new launchers

- **Heavy robotic missions**
  - 20-30 t LEO
  - Compatible human flight in LEO
- **Lunar human missions**
  - 70-80 t LEO
  - Implies 2 launches
- **Mars human missions**
  - 150 t LEO
  - Implies 5 to 7 launches
  - Easier lunar missions (Apollo, Ares/Orion) because only 1 heavy launch



International cooperation :
- building blocks
- responsibilities sharing

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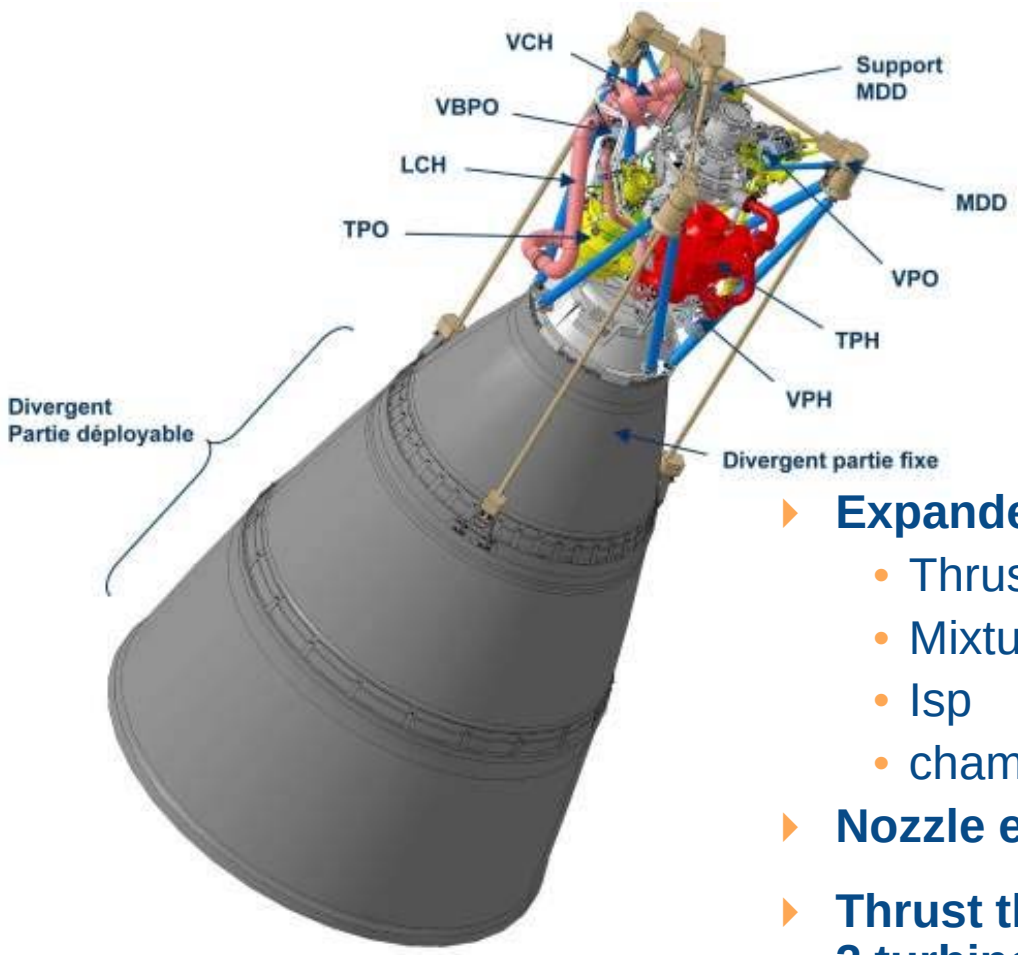
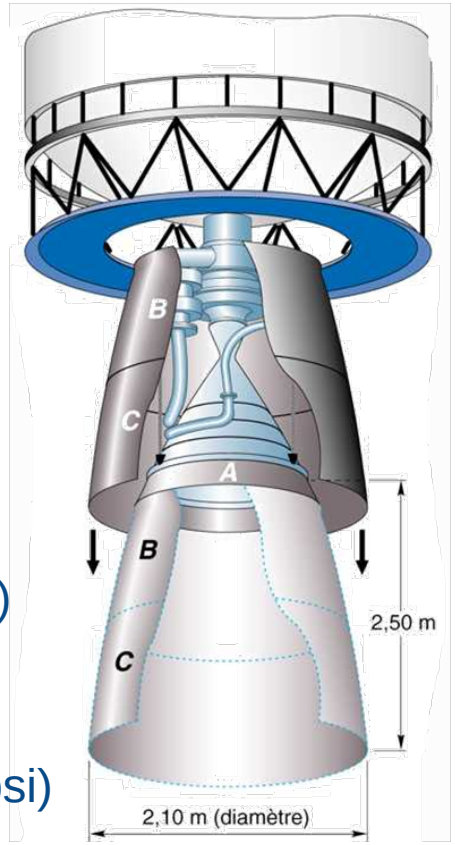
Vinci engine – a relevant building block





- **Expander cycle**
  - Thrust 180 kN (40kLbs)
  - Mixture ratio 5.7 / 5.9
  - Isp ≥ 464 s
  - chamber press. 60 bar (900 psi)
- **Nozzle extension till 240 to 1**
- **Thrust throttling and mixture ratio trimming with 2 turbine by pass valves**
- **Multiple ignitions : up to 5 firings in flight**

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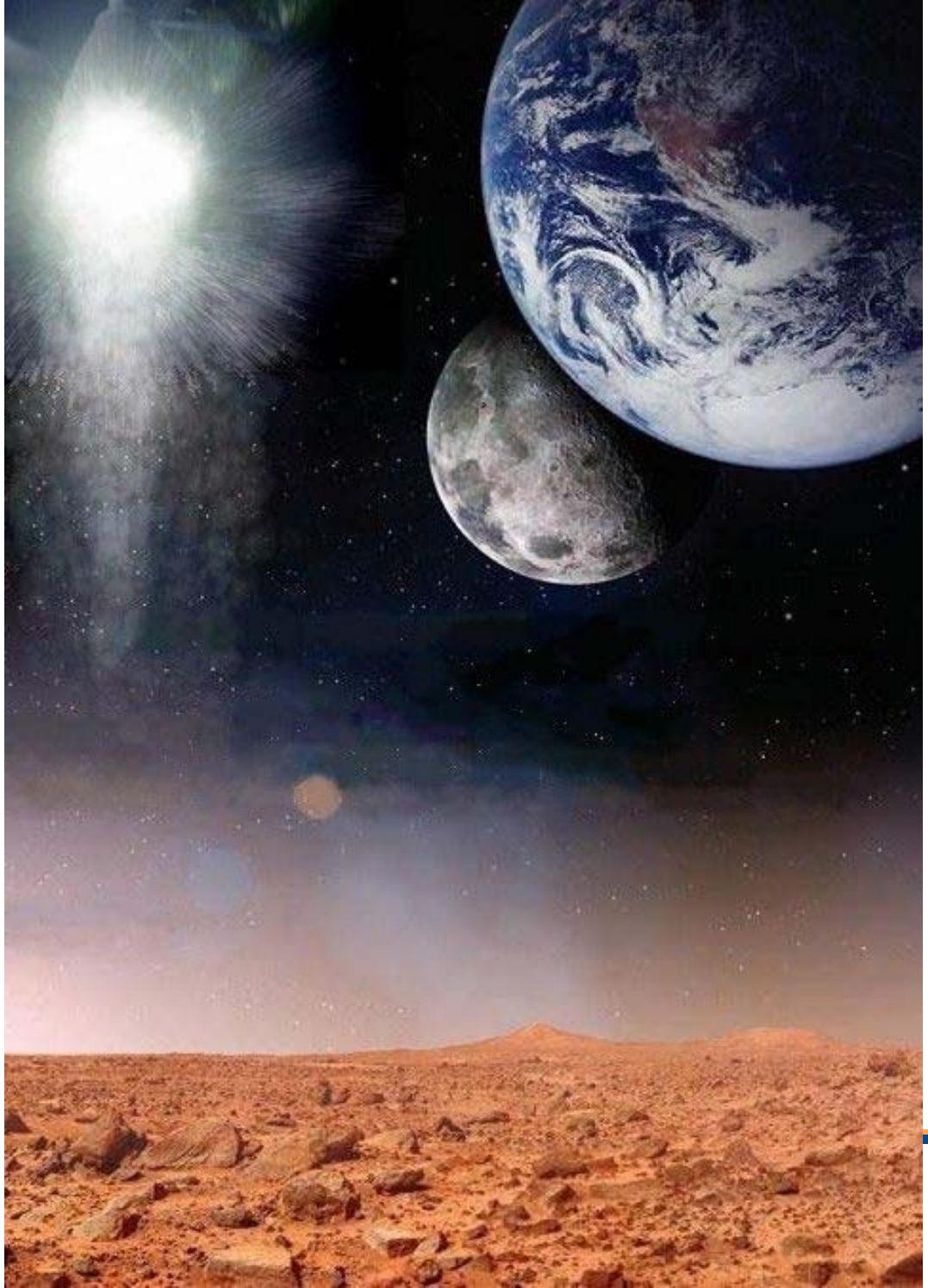

Sending and supporting humans on other celestial bodies are activities at some tens of billions per year

International cooperation will provide affordability and stability in these programs

Industry is able to act in this environment

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