EUCASS 2013
Space Transportation Challenges

Antonio Fabrizi – Director of Launchers – ESA
M Flaminia Rossi – Head of Policy, Plans and Quality Management Dept. - LAU - ESA

Munich, 1 July 2013

Contents

The family of launchers operated from CSG

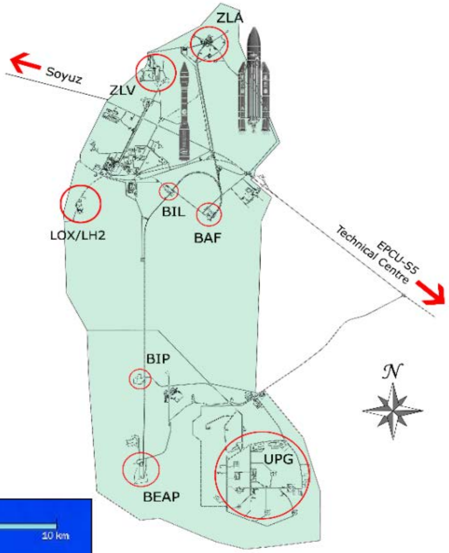
The family of launchers operated from CSG is providing European access to space for most of the institutional and commercial European missions in the short / medium term.

Ariane 5 ECA and ES
servicing the GTO, LEO and escape orbits and setting a standard for the delivery of heavy payloads

Soyuz at the CSG
providing access for mid-range payloads (operational from 2011)

Vega
Ensuring access for small payloads to LEO and SSO orbits (Operational from 2012)

The European Spaceport



Launch service market demand and offer evolution

Launch Service offer

GTO

- Heavy payload market dominated by Ariane 5 since end 2012 with high price levels for heavy payloads despite aggressive pricing strategy by Proton in early 2013, but
- competition becoming more fierce for payloads < 3.5t with aggressive pricing strategy by Falcon 9 in the commercial market backed by notably higher prices for captive missions, and
- dual and tandem launch options offered by Ariane, Proton, Falcon (incl. in-orbit-delivery solutions).

LEO

- New offer since 2012: Vega, Long March 2 but a number of new LVs should become available in the coming decade including Epsilon, Athena, Soyuz 2.1v, small Angara and additional Long March versions

Launch Service demand

GTO

Constant accessible annual demand: ~ 19 payloads per year (not exceeding 17-20 payloads p.a. on average beyond 2020)

- Average payload mass (and power) to continue increasing to 5.2 t by 2020 and increased competition for payloads <3.5 t

Non-GTO

In 2014-2020: Increased accessible annual demand : ~ 8 payloads p.a. (around 10 payloads beyond 2020)

Evolving demand due to electric propulsion

GTO satellites today

- Arianespace has launched about 50% of the accessible GTO payloads over the last 10 years
- The majority of the commercial payloads launched are communication satellites using chemical on-board propulsion systems and requiring injection into a standard GTO orbit

Electric propulsion status

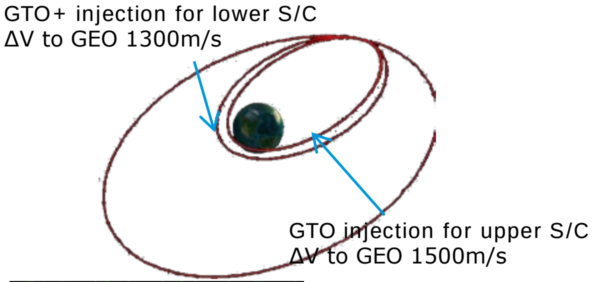
- Electric propulsion systems developed since the 1960s in US, Russia, Europe, first commercial platform using an ion engine for station keeping launched in the US in 1997
- Electric propulsion systems used today as a standard solution for station-keeping / attitude control on a number of commercial and institutional satellite platforms
- Maturity now deemed sufficient to use electrical propulsion systems as main thrusters on commercial satellite platforms including for orbit raising manoeuvres: first all-electric commercial platform contract signatures in 2012 for launch in 2015

Rationale for using electric propulsion

- Main driver in using electric on-board propulsion systems for satellite operators: **attempt to reduce cost per transponder or Gbps in orbit**
- **Using electric propulsion on board would allow customers to either lower their payload mass requirements or alternatively to increase the number of transponders on a single satellite**
- Satellite operators are increasingly taking into account electric propulsion satellites in their fleet planning. It is assumed that by 2020, up to 20% of satellites ordered may be using electric propulsion

Challenges from electric propulsion and implications on launch vehicle adaptation

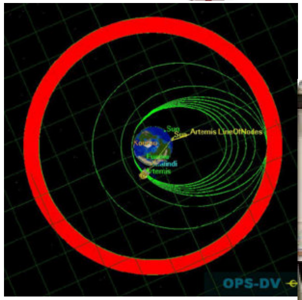
Up to now, standards for communication satellites (chemical propulsion) have been an injection to GTO followed by a few hours of transfer to orbit



Changes due to electric propulsion

Low thrust provided by electric propulsion systems could necessitate a change in orbit-raising approaches due to

- requirement of satellite operators not to exceed a max time of 6 months to orbit
- minimisation of transfer time through the van Allen belt
- need to reduce number (and cost) of ground stations during orbit transfer



Variable parameters include

- variations in injection orbit types
- in orbit raising strategies (possible combination of electric and chemical propulsion systems)

Evolutions of launch requirements

The changes raise a number of challenges for new launcher system developments, in particular in terms of **requirements' flexibility**

- Change in mass/volume ratio with increased volumes at identical mass requiring e.g. **fairing evolutions**
- **New satellite mass category emerging today around 2.5 t,** with possible mass increase in the future
- **Orbit injection requirement changes**
- Necessity to **pair big / heavy chemical satellites with big / light electric satellites** for dual launches

Challenges for future European launchers

Today, the operational European launchers are the most reliable on the worldwide market by:

- ✓ Ariane 5 launcher is an uncontested success for Europe and the space community with more than 50 successful flights in a row. The two first flights of Vega have been flawless successes.
- ✓ A stable and regular Ariane 5 exploitation, based on more than 30 years of experience
- ✓ The largest commercial order book, an important industrial workload
- ✓ A strong backing of both European Member States and European Space Industry

Given this positive status: Why not keep Ariane 5 as it is?
What is the motivation for change?

- Increase launch service competitiveness and reduce launch service price
- Respond to changing customers' needs, e.g. average satellite mass increasing but Electric Propulsion satellites can be lighter than current ones
- Request for service to multiple orbits
- Comply with anti debris policy/debris avoidance policy
- Reach an economically balances exploitation without public-funded accompaniment programmes addressing technical risks or contributing to fixed costs.

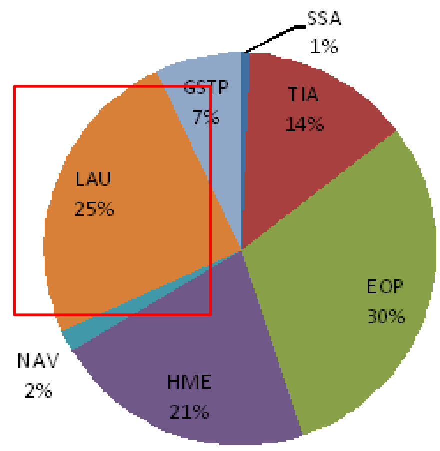
2012 Council at Ministerial level
Launchers development programmes

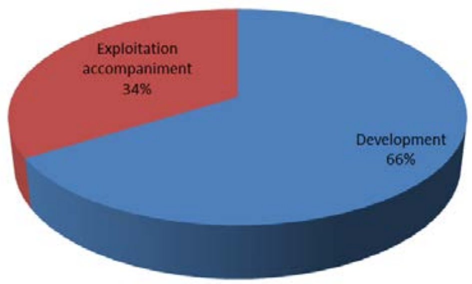
Launchers development programmes have been the main focus of the Council representing 25% of overall optional programme subscriptions

66% of actual subscriptions are for development programmes:

- **Adapted Ariane 5 ME and Ariane 6 activities** along a consolidated integrated logic:
  - Continued adaptation and development of Ariane 5 ME
  - Detailed definition study of Ariane 6 and implementation of phase A/B1 of Ariane 6
  - Common upper stage development activities, to be used both for adapted Ariane 5 ME and Ariane 6
- **Vega consolidation and evolution preparation**
- **Future Launcher Preparatory Programme Period 3** including activities continuation on
  - Cryogenic Upper Stage
  - FLPP Expander Demonstrator / Vinci engine
  - Development of High pressure regeneratively cooled nozzle Sandwich technology

CM12 decisions

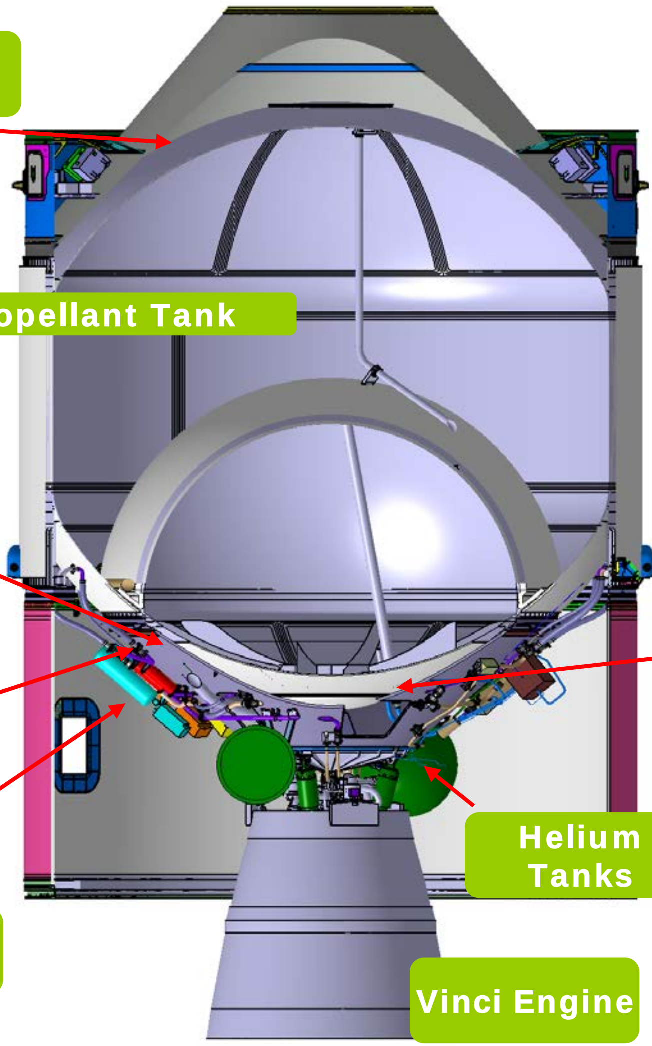




Launchers programmes

- Activities in the area of re-entry through in-flight demonstration of critical re-entry technologies for future space transportation with
  - the **Intermediate eXperimental Vehicle (IXV)** and its
  - follow-on **Programme for a Reusable In-orbit Demonstrator for Europe (PRIDE)**

aA5ME – A6
Upper Stage Commonalities



Functional Li-ion Batteries

Propellant Tank

Fluid Control Equipment

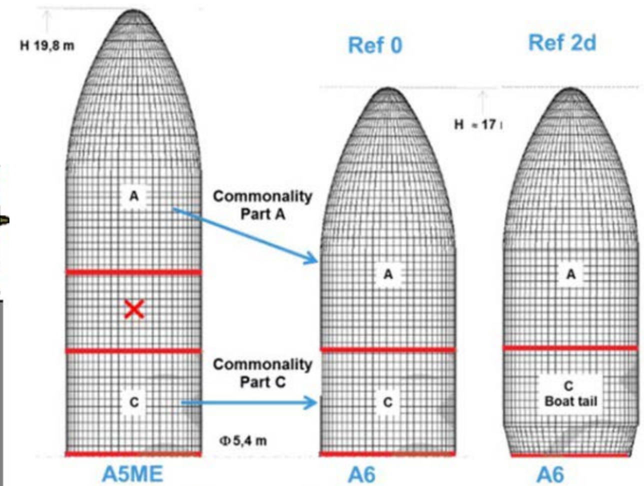
Propellant Lines

Thrust Vector Actuation System

Engine Thrust Frame

Helium Tanks

Vinci Engine

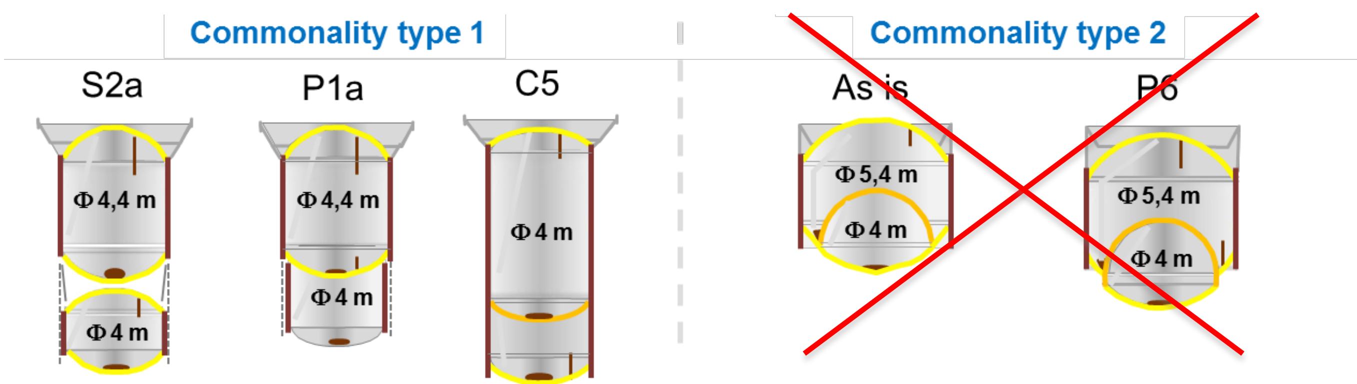


Payload Fairing

EGSE

aA5ME – A6
Upper Stage Propellant Tank Commonalities

- On the basis of a dedicated trade off, the re-use of the same adapted Ariane 5 ME propellant tank architecture has been discarded
- A family of tank concepts having diameter spanning between 4 and 4,4 m is being investigated for the Ariane 6 configuration detailed study, keeping as constraint the interface at Engine Thrust Frame level
- The selected concepts include both common bulkhead and separated LOx and LH2 tanks
- Ariane 6 tank's architecture enables large re-use of adapted Ariane 5 ME tank building blocks and a re-usability of the relevant manufacturing facilities

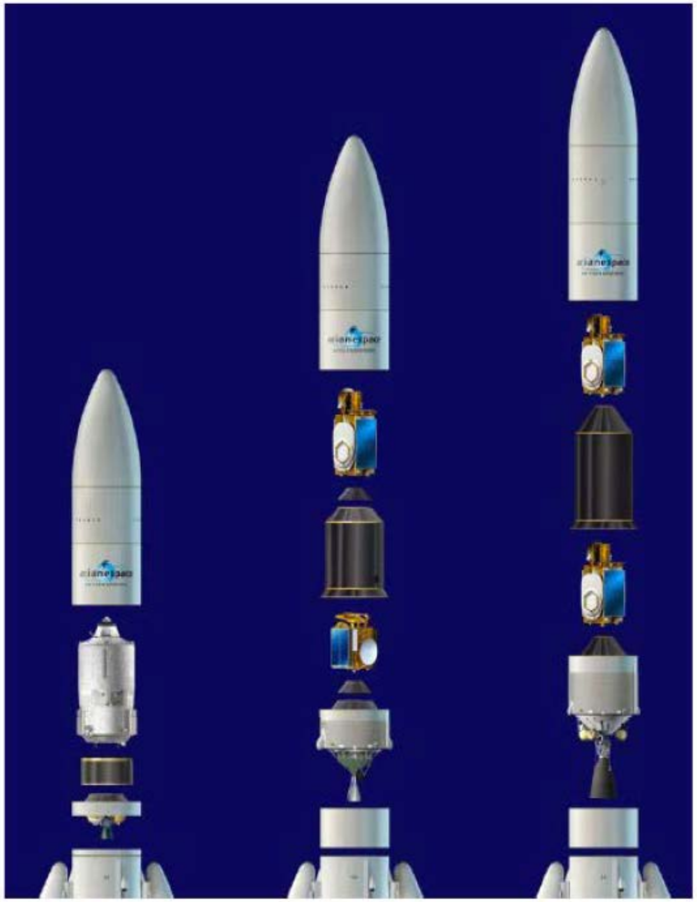


Adapted Ariane 5 ME

A5ME will answer to the challenges by

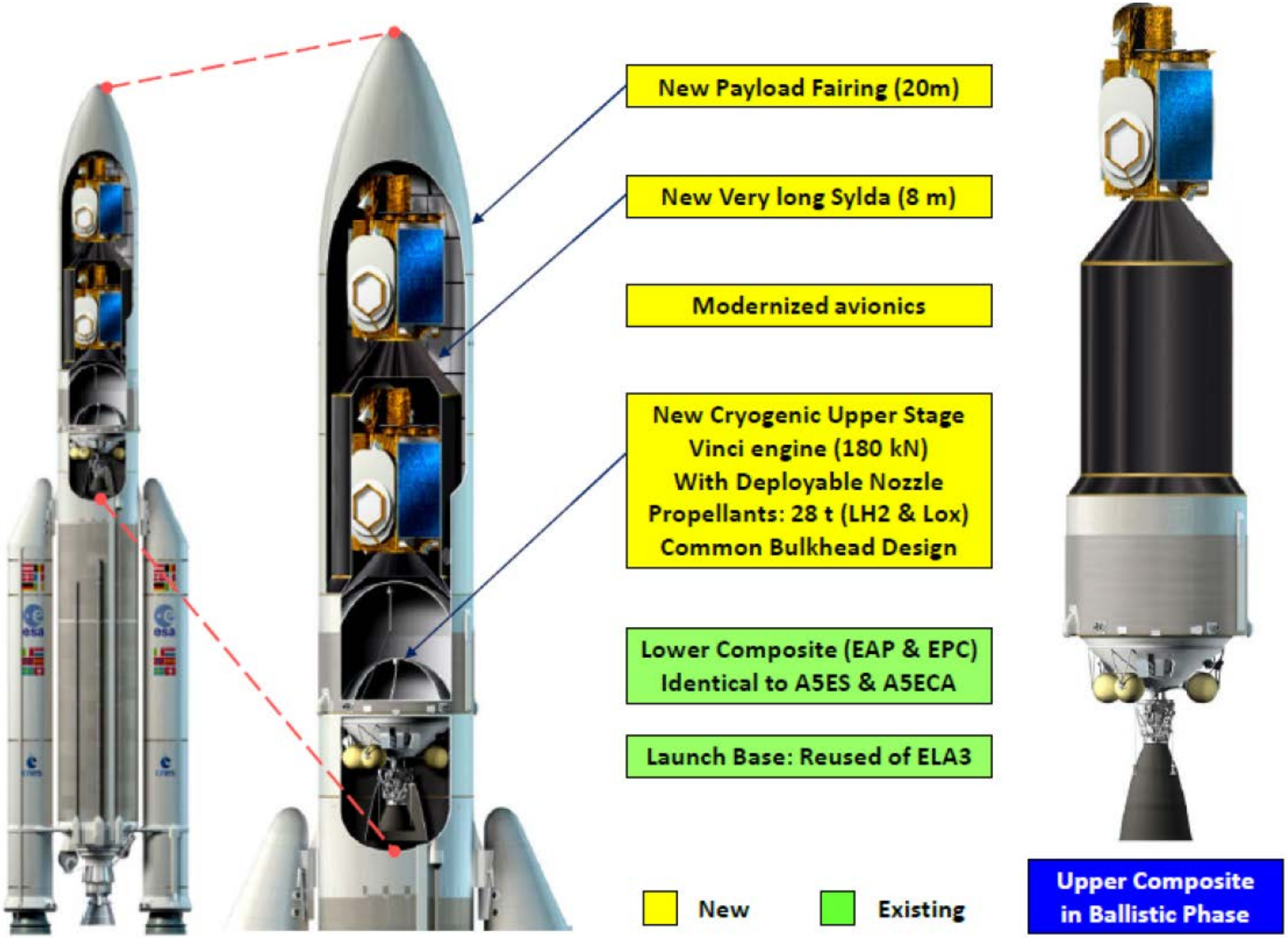
- Increased precision and performance >12t GTO and 20% lower costs per ton into orbit.
- More versatile, with a re-ignitable upper-stage based on the new Vinci engine, allowing the injection of satellites in a higher orbit and maximising the launcher's performance, thus reducing the payload's propulsion needs to reach the target GEO.
- Versatility will allow combinations and pairing of different types of institutional missions, such as Earth-escape, GTO-escape, GEO and Moon or Mars missions, with improved precision and performance.
- Capability for direct de-orbitation (GTO-DD) and/or injection into graveyard orbits will keep the space environment free of space debris.

Ariane-5 Upper Part Configurations

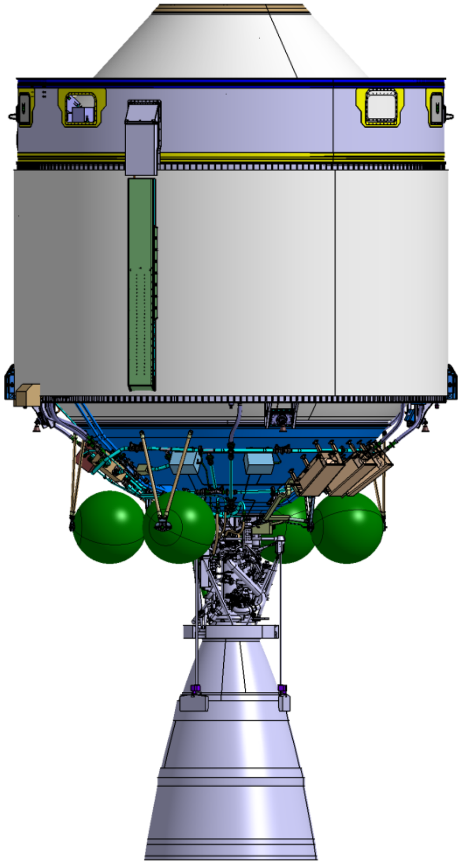


EPS / Aestus | ECA / HM7-B | ME / VINCI

Adapted Ariane 5 ME



Adapted Ariane 5 ME Stage characteristics



- Stage Height: 7900 mm
  (without deployed Vinci Nozzle)
- Stage Diameter: 5400 mm

- 28 tons Loaded Propellant Mass
- Vinci-Engine: 130 - 180 KN
- Boost duration: 790 s
- Number of Re-Ignitions: 1 main plus 2 re-Boosts

- LOX Tank Pressurization:
  Helium – stored within 300 litre and 400 bar vessels
- LH2 Tank Pressurization:
  GH2 heated by the Vinci engine

- Dry Mass after separation: 5970 kg (GTO DDO)

DDO = Direct De-orbitation

Ariane 6 requirements

Ariane 6 overarching objective is to be economically self-sustainable in a stabilised exploitation phase without public-funded exploitation support.

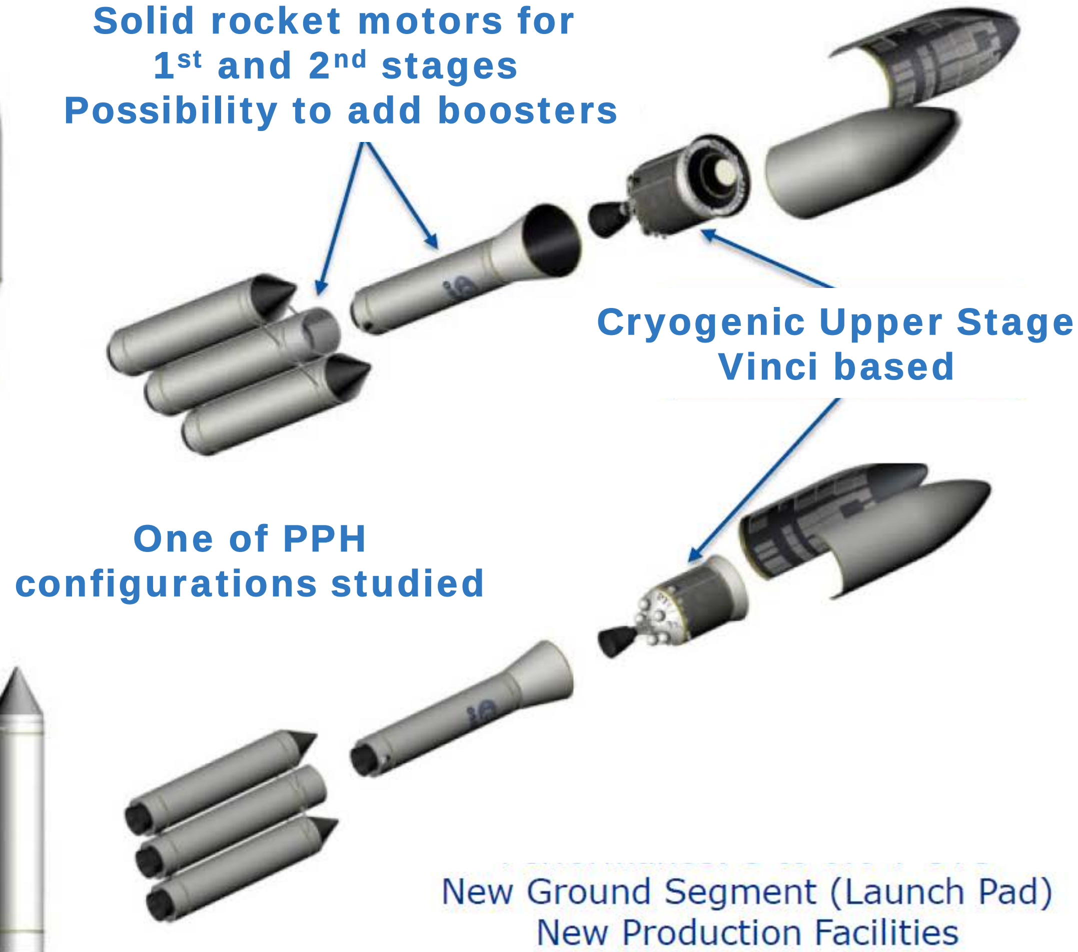
Ariane 6 shall be competitive with respect to other launch systems (such as Proton and Falcon 9 today).

The target date for the first flight of Ariane 6 is 2021. The system shall be fully operational by 2025 with an operational lifetime of at least 25 years.

- **Type of launch:** Single launch
- **Type of missions:**
  - GEO missions, either directly or through intermediate orbits, in particular GTO. This objective requires re-ignition capabilities;
  - LEO in particular Polar/SSO at different altitudes;
  - MEO or MTO missions;
  - LEO/orbital infrastructure servicing;
  - Escape and Lagrange points missions.
- **Design launch rate:** 12 launches/year
- **Performance:**
  - In GTO equivalent: 3 to 6.5 t, with 2 main segments (3-3.5 t and 6-6.5 t) and capacity for growth potential up to 8 t;
  - Polar/SSO : 4 t at 800 km altitude.
- **Reliability:** equivalent to or better than the design reliability of Ariane 5 ECA or the one of main competitors (such as Proton or Sea Launch).

Ariane 6 upper stage will allow for direct de-orbitation (GTO-DD) and/or injection into graveyard orbits to keep the space environment free of space debris

Ariane 6 PPH concept



Ariane 6 configuration

Following a selection starting from 12 PPH configurations three are now retained and further studied - with special focus on competitions to optimise exploitation costs - in preparation of the decisions to be taken at Council in 2014.

- 1st stage: composite monolithic P180 (∅ 3,7m)
- 2nd stage: P110 monolithic (∅ 3,7m)
- 3rd stage: H30 Vinci
- Boosters: B50 monolithic (∅ 1,8m)
- Launcher height: 50m

MC-2PH+Bz

- 1st stage: 3 P130-P135 monolithic (∅ 3,5m) Common Core Booster architecture
- 2nd stage: P130-P135 (identical to 1st stage SRM)
- 3rd stage: H32 Vinci
- Launcher height: 50m

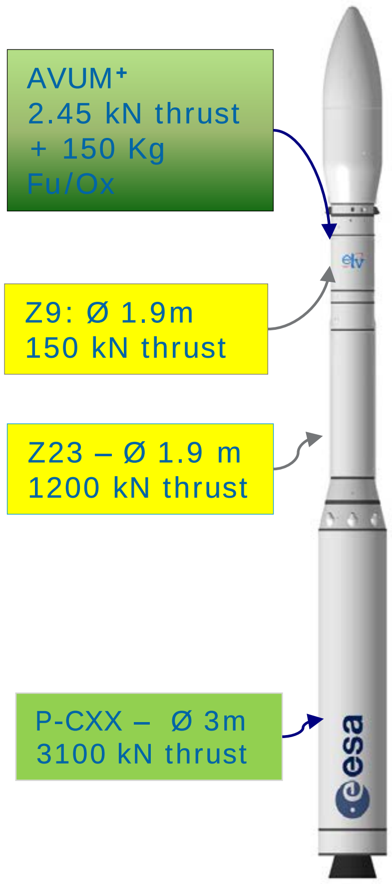
MC-MP-2PH+CCB

- 1st stage: 3 composite monolithic P130-P135 (∅3 ,5m) Cluster architecture
- 2nd stage: P130-P135 (identical to 1st stage SRM)
- 3rd stage: H32 Vinci
- Launcher height: 53m

MC-MP-2PH+CL

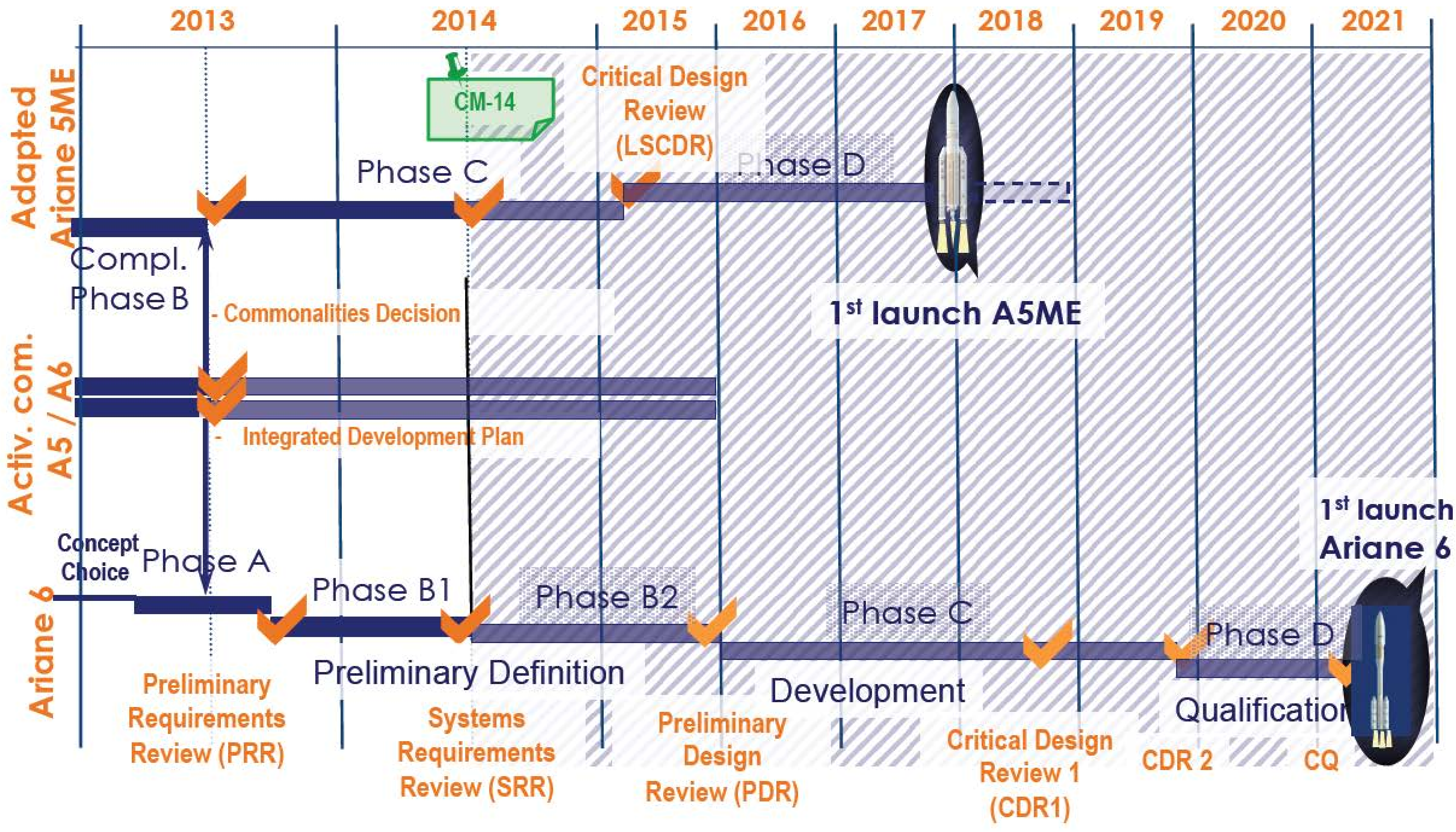
A6 and Vega possible synergies

- Commonalities and synergies between A6 and Vega C are identified and assessed in terms of:
  - solid propulsion (motor system, materials, technologies, processes, equipment/components);
  - TVC, Avionics, Pyrotechnics, others.
- Motor system: antagonistic requirements on the thrust slope between A6 and Vega must implies compromises (on both sides !)
- A6 motors in the class P130 present the largest commonalities/ synergies with the VECEP P-CXX: Insulated Motor Case, Liner, Loaded Motor Case, Nozzle and Igniter.



VEGA C

aA5ME and A6 preliminary integrated development plan



Conclusions

- ESA is continuing to support the exploitation of its successful family of launchers.
- The market and competition evolution requires to start now the development of the new launchers necessary to keep the current market share at acceptable economic conditions in the future.
- At 2012 Council at Ministerial level ESA Ministers agreed to start these development activities fixing a new milestone in 2014 to decide on their completion.
- ESA and industry are progressing according to plans to meet the 2014 appointment.

Thank you!

Would you like to know more?

www.esa.int