ARIANE 6

Bruxelles 31 mai 2017
Ariane 1 development:
After the failure of the Europa launcher programme, France has proposed to its European partners the development of a substitute able to put in GTO 1500 Kg of payload. The aim was the autonomy of Europe in the access to space. The decision of Ariane 1 development was taken in 1973. The first flight was the 24th of December 1979. Qualification in 1981.

Ariane commercialisation:
Arianespace company was created in 1980 and the first real commercial contract was with Intelsat: 7th flight in 1983.
Arianespace organisation

shareholders

CNES

ESA

Suppliers

Satellite customer

Suppliers contracts

Stage 1

Stage 2

Stage 3

Propulsion 1

Propulsion 2
Very rapidly, it appears that the performance of Ariane 1 has to be increased to follow the evolution of the masses of telecom satellites.

In addition, to be more competitive front of the Space Shuttle pricing policy, Arianespace « invented » the dual launch, requiring double performances.

The US « all Shuttle policy » gave to Ariane a great chance and after the Challenger accident in 1986, Ariane launcher became the reference launcher for telecom satellites.
Why dual launch is competitive

Only two main parameters drive the performance of a launcher: the ejection speed of propellants and the ratio dry mass on propellant mass (structural index). This index is decreasing with the size of the launcher. When propellant masses are doubled, structure masses are far to be doubled, propulsion masses too and electronic masses are quite similar. Idem for costs. On the figure, you can read that the cost of a 5 tons launcher is 0.7 compared to Ariane 5 ECA which is a ten tons launcher.

40% savings for a dual launch
Ariane 5

To increase again the performance, a new concept of launcher was required. Ariane 5 started with the ES version (6 tons), storable upper stage re-ignitable. Then a second version (10 tons in GEO) was developed with a cryogenic upper stage but not re-ignitable (re-use of the HM7 engine).
**Telecom geostationary satellites**: today, the only commercial market; 20-25 satellites per year. Masses continuously increase, but limitation by dual sources of launchers (~6 tons). The electrical propulsion will be used to increase the payload mass and not decrease the mass at lift-off.

**Navigation satellites** (GPS, Galileo, Glonass, Beidou): constellations of around two dozens of satellites (600-1000 Kg). No apogee boost motor. Launcher upper stage re-ignitable. Launch with cluster of satellites. Only governmental.

**Mega constellations**: no experience today. Small masses (few hundreds of Kg). Launch with large clusters of satellites. Commercial approach if future is positive.

**Observation satellites**: masses dispersed (16 tons for Key Hole military satellites to hundreds of Kg). Tendency is for masses to decrease. Mainly a military or governmental market. No dual launch. Few export.

**Manned Stations** (ISS, Tiangong): cargo or manned vehicle as Orion, Dragon, Cygnus, HTV or Shenzhou (7 to 20 tons). Only governmental.
## Worldwide launcher competition

### 2015

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Global commercial market and market share 2016

- Governmental: 76% (65)
- Commercial:
  - SpaceX: 24% (21)
  - Arianespace: 38% (8)
  - ILS: 24% (5)
  - ULA: 19% (4)
  - Others: 10% (2)
  - Others: 10% (2)
Worldwide launcher competition

Russia

Difficult situation:
Proton flights fail frequently (loss of know how)
Soyuz remains monopolistic for the transfer to the ISS (until Orion?)
Soyuz is also fired from Guyana (until Ariane 6 enters the market?).
When Angara will be qualified?
Small launchers, derived from ballistic missiles, come to an end.
**Worldwide launcher competition**

**United States**
No real competition with classical launchers Atlas V and Delta 4 used nearly exclusively for governmental missions. The commercial competition was reactivated by Space X with a strong support of NASA. Falcon 9 launched small GEO telecom satellites in 2013 and 2014 for very attractive prices. Space X has also demonstrated the re-usability of the first stage, even it is difficult to assess the economical interest of this solution. They explain that their fully integrated industrial organisation is the key of costs reduction. They intend to develop a heavy version of Falcon which will exceed the performance of Ariane 5 and 6, Atlas and Delta. NASA support another company, Orbital-ATK but, to day, not competing on the commercial market.
China
A lot of launchers, named all Long March, but with a large set of performances, for all types of missions including manned flights.
A new family of launcher is under development: Long March 5, with better rationalisation.
The US ITAR policy prevents these launchers to be on the commercial market. Until when?
Some exports in their sphere of influence.

Japan
Japan has acquired its technological autonomy with the HII launcher.
But due to a very low rate of flights, HII costs remain high.
It seems that they want to be on the launcher market with the new HIII launcher. Japanese telecom satellites were good customers of Ariane!
Worldwide launcher competition

India
The Indian PSLV is a low cost launcher for LEO, appreciated by Cubesats. The GSLV is less popular, but will launch the domestic telecom satellites which were before customers of Ariane.

Other nations, even with some launcher at disposal are not really in the competition: South and North Korea, Iran, Israel, Brazil.
Rationale for Ariane 6

Ariane 5 is a reliable launcher, but is lacking flexibility. Answering to the telecom market in dual launch, it is unable to launch Earth observation satellites for reasonable prices. So, entered Vega and Soyuz (Guyana) in the European landscape, a small and a medium launcher. Exploitation of Ariane 5, at the market price, has shown to be constantly in deficit, forcing the member states of ESA to finance Arianespace. So, it was contradictory for the participating states to finance a launcher badly designed for their governmental missions! After the competition with Proton along the 2000 years, Space X is clearly a hard competitor with a strong support of NASA.

Europe is attached to be autonomous for its access to space, but is aware that its governmental market is not enough to make industrial a line of production of launchers. Europe must win a significant part of the commercial satellites market.
Rationale for Ariane 6

The solution:

**At technical level**, a family of launchers with maximum commonalities able to keep autonomy for any kind of mission, GEO, MEO, LEO.

Ariane 6 in two version and Vega.
Rationale for Ariane 6

At management level, a new organisation between ESA and industry to reinforce the competitiveness of the European offer:

- The system prime Airbus and the propulsion prime Safran propose to merge their activities in a single company (Space X example). It is Airbus Safran Launcher, now Arianegroup: ~8000 people; ~2 billions € of sales.
- This integrated prime will be in charge of commercialisation. It controls Arianespace by acquiring the shares of CNES. So it is the owner of Arianespace with 74% of the shares. Today, no change for the other suppliers.
- ESA will continue to fund the development of the new launchers, but will not pay for exploitation. However, it will guarantee the purchase of launchers for five satellites, each year.
ESA

Convention & guarantee

Arianegroup

Equipment supplier 1
Equipment supplier 2
Equipment supplier 3

Arianespace

Suppliers

26%

Satellite customer
Ariane 6 Challenges

Exploitation price
Institutional missions 70 M€
(even in single launch)

Reducer development budget
- Firm Fixed Price
- Industrial investment

Launcher design authority to industry
Reliability
Availability/timeliness
Flexibility/versatility:
Launch rate,
Spacecraft mass, volume, environment
Missions (perigee, plane)

Reduced development time
1\textsuperscript{st} flight before mid-2020
11±1 launches per year from 2023
A single launch vehicle for most commercial and institutional applications, from single-satellite launches to constellations

**Ariane 62** – 2 boosters
- Medium variant
- Non-geostationary missions SSO performance $>4.5t$
- One satellite to GTO

**Ariane 64** – 4 boosters
- Heavy variant
- Geostationary missions with dual launch capability
- GTO performance $>10.5t$ gross

**Utilization of existing components**
- Upper stage with new Vinci engine
- Core stage with Vulcain 2+ derived from Ariane 5 ECA
- New P120+ solid rocket motor common with Vega

**Increased production rates**
- 11 + 11 + 35 Per year
Ariane 6 architecture

- Lower stage “LLPM”
  - 150t LOX-LH2
  - 2/4 solid rocket boosters
    - “ESR”
    - 142t propellant – single segment
    - 350t thrust
- Upper stage “ULPM”
  - 30t LOX-LH2
  - Vinci re-ignitable engine
    - 18t thrust
- Dual launch system
  - SYLDA Ø 4.5m usable
- Fairing
  - 20m height
- Vulcain 2.1 engine
  - 137t thrust
Performances

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Performances comply with Space Law and preliminary close range constraints.
New processes and production means

- Simplification
- Reduced delays
- Quality
- Reliability
Innovation in technology and in production to optimize costs

New technologies
Opto – pyro, Avionics

New production processes
Additive Layer Manufacturing (3D printing)
Friction-Stir Welding (FSW)

Augmented reality

Standardization
Launcher System Qualification Logic

**Progressive Flight Domain Enlargement**

- **FM1 – July 16, 2020**
  - A62 atmospheric phase
  - Vinci ignition and re-ignition capability
  - APU capabilities
  - Mission GTO/GTO+ like

- **FM2 – January 2021**
  - ULPM high performances with longer duration of orbital phases (versatility)
  - Mission MEO

- **FM3 – April 2021**
  - Versatility in LEO with 3-boosts
  - Vinci mission
  - Long fairing

- **FM4 – July 2021**
  - A64 atmospheric phase
  - Dual launch capability

**System Tests**
- Qualified and industrialized FMs from serial number 1
- Combined Tests model production
- Combined Tests model AIT
- Hot Firing model production
- Cryogenic connection
- LLPM modal
- QM2 Integration
- ESR
- ULPM mechanical
- AIT Hot Firing tests
- Flight chronology
- Mission domain qualification
- FM1 flight preparation

**Avionics Function Validations**
- FM1 flight preparation
- Mission domain qualification
- Flight chronology
- AIT Hot Firing tests
- LLPM modal
- Cryogenic connection
- Combined Tests model AIT

**Avionics System Tests**
- Reduce flight introduction risks
- Benefit from in-flight measurements for models calibration and design margins assessment
2017 Next Steps

MG6.1 - Authorize manufacturing of Qualification Models
- March 27 - April 20
- Arianegroup with Partners

MG6.2 - Authorize manufacturing of Flight Model 1
- November
- Assess roadmap progress
- Exploitation concept finalized

Exploitation Readiness Key Point (ERKP)
- Review Q4 - GO/NOGO decision March 2018 latest
- Viability of exploitation business plan: adequacy to market (constellations, ...), exploitation costs, MQO
- Ariane 5 / Ariane 6 transition phase: process and cost
- Institutional launches: European preference and public order

Production contracts
Signatures in April 2018

A6 Marketing by Arianespace
Formal Kick-off this year.
First customers already interested