



Vega Launch System

Final Preparation for Qualification Flight

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AIAA JPC 2011, San Diego (CA), 04/08/2011

European Space Agency



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The European Vehicle Family (1/2)



The launchers developed by ESA guarantee European access to space. Their development is an example of how space challenges European industry and provides precious expertise.

Ariane is one of the most successful launcher series in the world, soon to be complemented by Vega and Soyuz, launched from Europe's Spaceport in French Guiana.





The European Vehicle Family (2/2)





VEGA Launch Complex

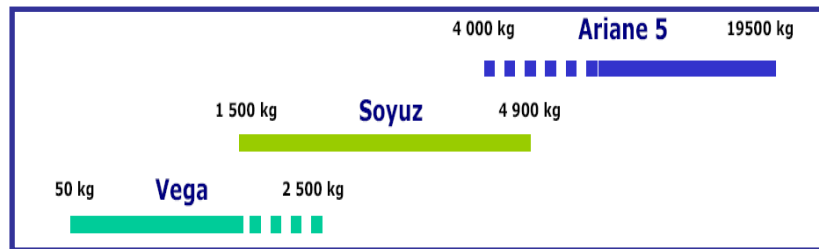




VEGA Launch System at a Glance



- Vega complements the European Space Agency family of launchers and targets the small payload in low Earth orbit
- Vega will guarantee European independent access to Space for many institutional satellites performing a wide range of missions (science, earth observation, exploration...).



VEGA Reference Mission capability:

1 500 kg at 700 km in circular polar orbit

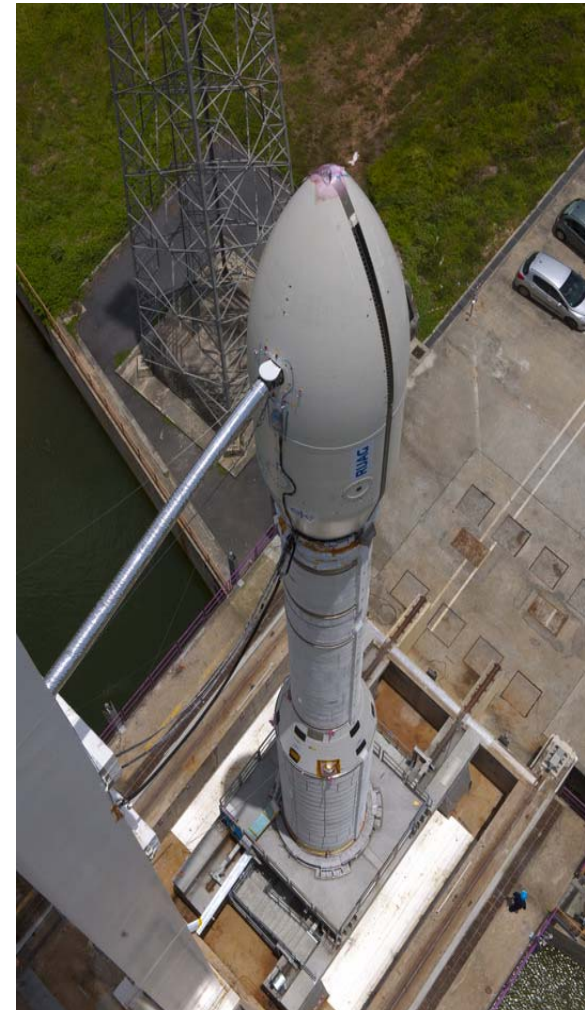
Flexibility: a wide mission range

From equatorial to polar & SSO orbit (5.2° - 102°)

From 300 km to 1 500 km altitude

From 300 kg to 2 500 kg

Design Reliability: 0.98





Program Management



Within ESA Launchers Directorate,

- The **VEGA Integrated Project Team (IPT)** has the overall responsibility for the development and qualification of the launch system (about 50 persons).

Three elements for one system:

The Launch Vehicle

The P80

The Ground Segment

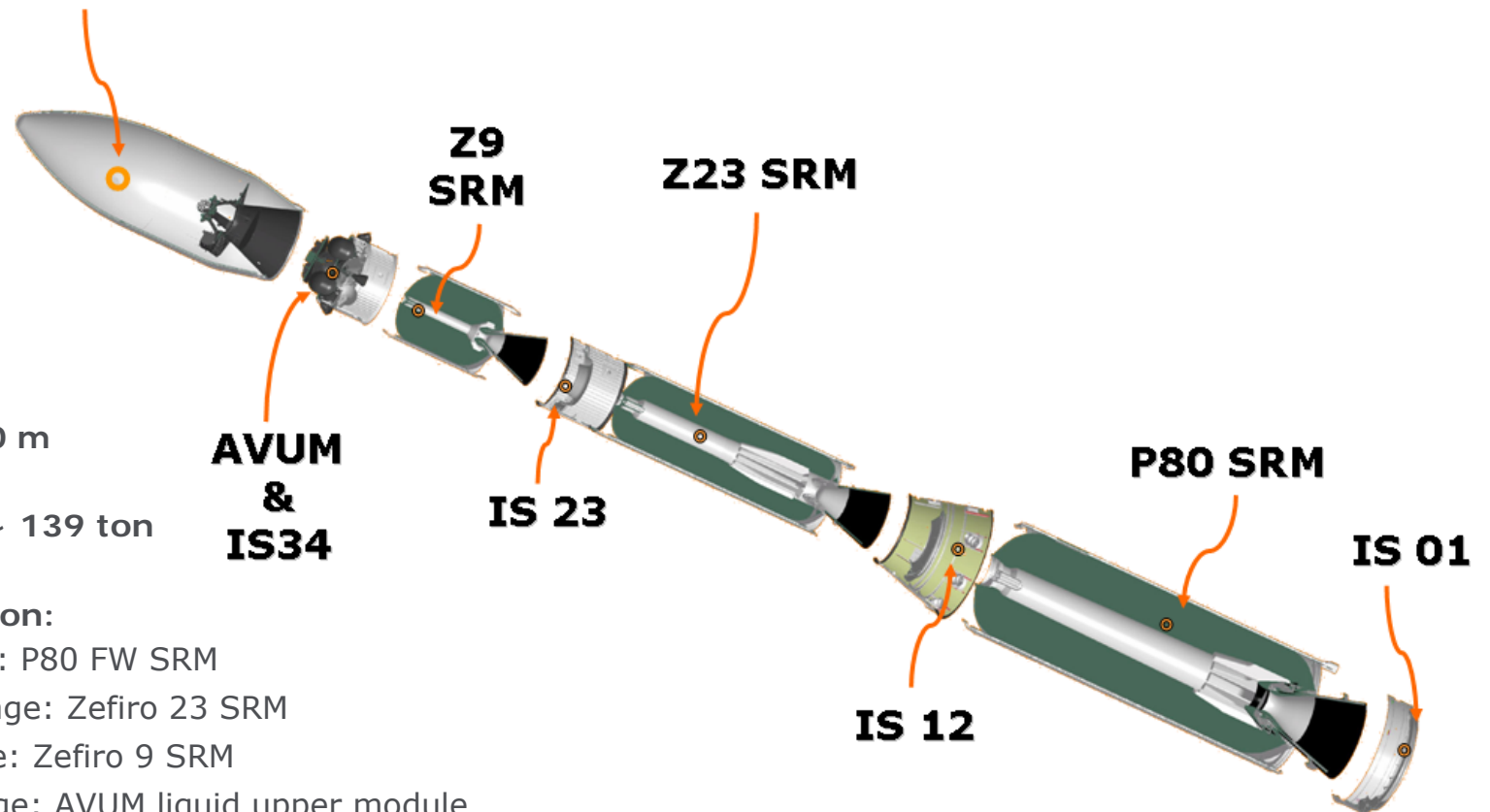
- The IPT, composed by ESA, ASI and CNES representatives is located in ESRIN, Frascati (VEGA vehicle & ground segment) and in CNES, Evry (P80)
- The IPT also receives the technical support (additional 40/50 persons) of the various agencies (ESA, ASI, CNES) and Arianespace.



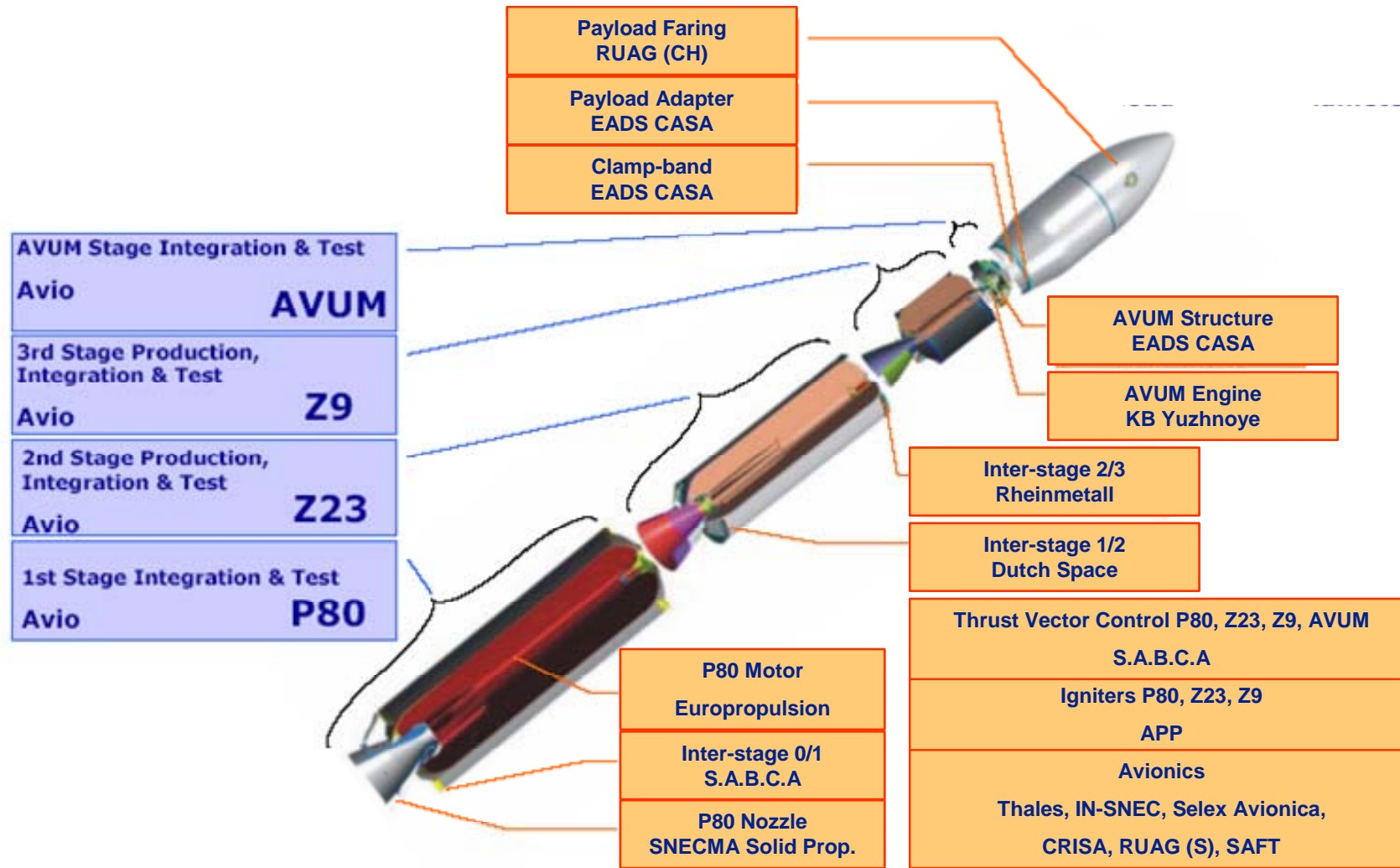


The Launch Vehicle

Payload Composite



- Overall Length: ~ 30 m
- LV mass at lift-off: ~ 139 ton
- VEGA LV Configuration:
 - First Stage: P80 FW SRM
 - Second Stage: Zefiro 23 SRM
 - Third Stage: Zefiro 9 SRM
 - Fourth Stage: AVUM liquid upper module
 - Upper Composite (payload adapter & fairing)





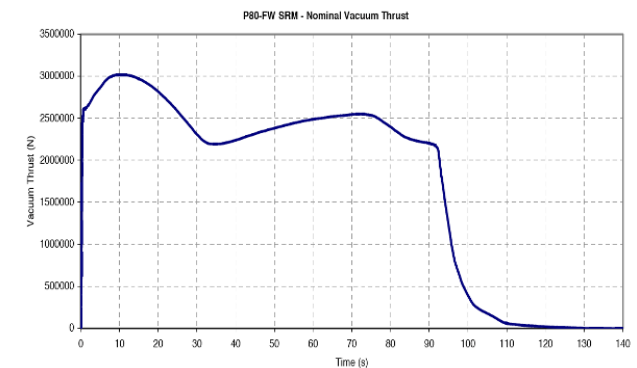
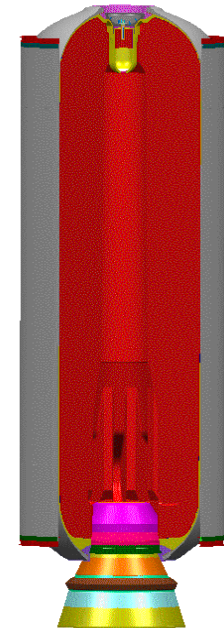
The 1st Stage (1/4)



Main subsystems

- Loaded motor case
- Igniter
- Nozzle
- Thrust Vector Control
- Rear skirt (IS 0/1)
- Inter-stage 1/2 skirt
- Avionic
 - Thrust Vector Control driving unit
 - Batteries
 - Safeguard subsystem

Length: 10.5 m **Ø :** 3.0 m
Combustion time: 107 s
Thrust (vacuum): 2980 kN
Max pressure: 95 bars
Propellant mass: 88383 kg
Inert mass: 7408 kg
Vacuum specific impulse: 279.5 s
Nozzle expansion ratio: 16
Nozzle deflection angle: +/- 6.5°

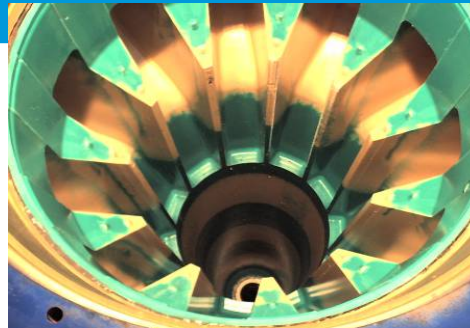




The 1st Stage (2/4) Subsystem Tests



P80 case hydroburst test



P80 casting test



P80 filament winding facility

Rear skirt
strength
test



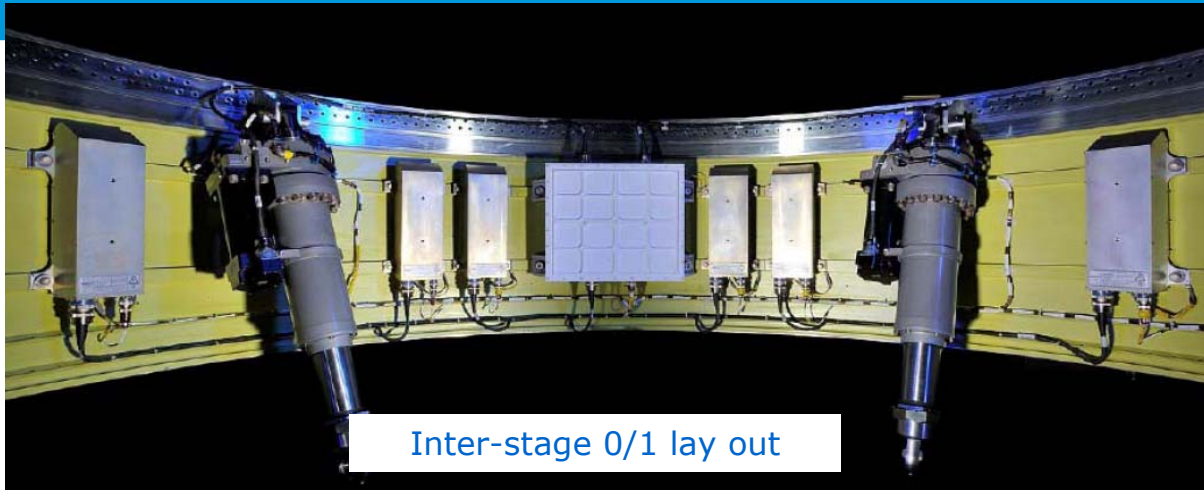
TVC subsystem test facility



P80 igniter test



The 1st Stage (3/4) P80 components



Inter-stage 0/1 lay out



Nozzle



Avio Colleferro P80 & Zefiro plant



Inter-stage 1/2



The 1st Stage (4/4) Static Firing Tests



Development firing test: 30 November 2006

Qualification firing test: 4 December 2007

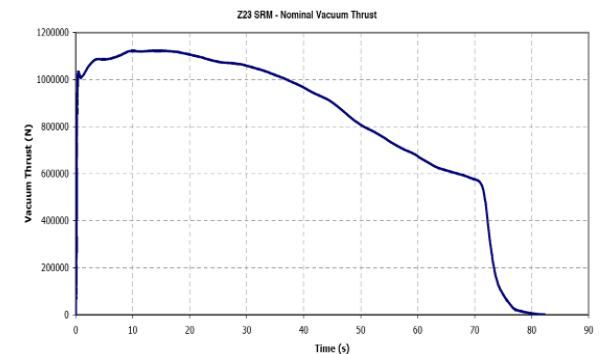
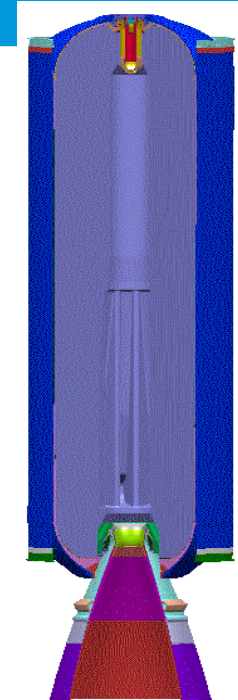
Stage qualification: June 2010



Main subsystems

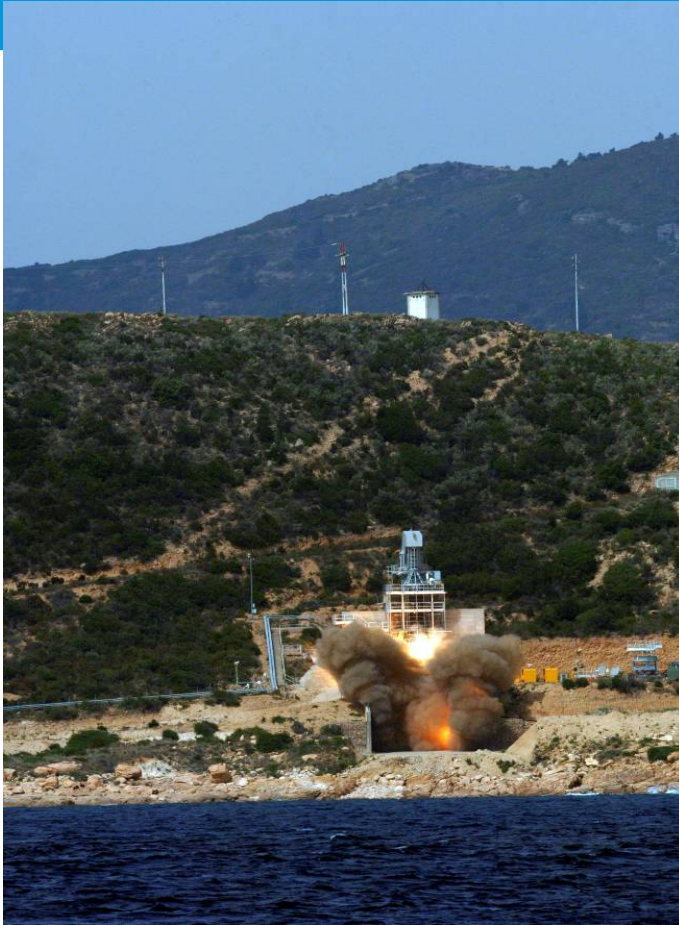
- Loaded motor case
- Igniter
- Nozzle
- Thrust Vector Control
- Avionic
 - Thrust Vector Control driving unit
 - Batteries
 - Safeguard subsystem

L: 8.9 m	Ø : 1.925 m
Combustion time:	71 s
Thrust (vacuum):	1200 kN
Max pressure:	95 bar
Propellant mass:	23900 kg
Inert mass:	1877 kg
Vacuum specific impulse:	289 s
Nozzle expansion ratio:	25
Nozzle deflection angle:	+/- 6.5°





The 2nd Stage (2/2)



Development firing test: 26-06-2006

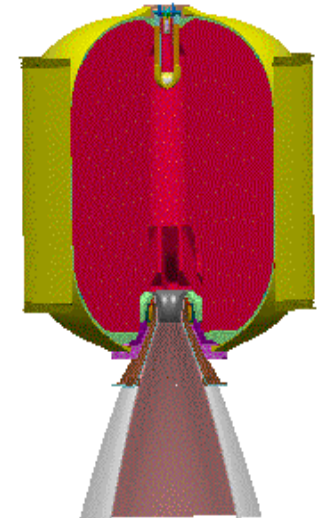
Qualification firing test: 23-03-2008

Stage qualification: December 2008

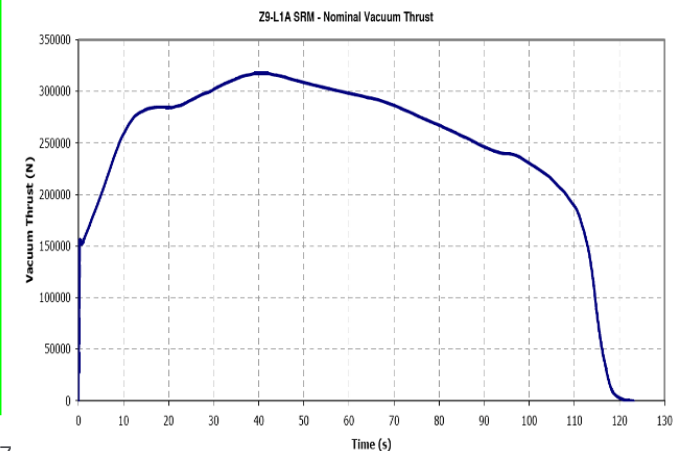


Main subsystems

- Loaded motor case
- Igniter
- Nozzle
- Inter-stage skirt 2/3
- Thrust Vector Control
- Avionic
 - Thrust Vector Control driving unit
 - Batteries
 - Safeguard subsystem



L: 4.12 m	Ø: 1.925 m
Combustion time:	117 s
Thrust (vacuum):	280 kN
Max pressure:	67 bar
Propellant mass:	10 115 kg
Inert mass:	833 kg
Vacuum specific impulse:	294 s
Nozzle expansion ratio:	56
Nozzle deflection angle:	+/- 6°





Inter-stage 2/3 vibration test



Inter-stage 2/3 strength test



Zefiro 9 actuator



Z9 Integrated Power Distribution Unit



Z9 nozzle with base cover



Safeguard Master Unit



TVC Li-Ion battery module



The 3rd Stage (3/3)



Z9 Development firing test: 19-12-2005

Z9 Qualification firing test: 27-03-2007 Nozzle failure

Z9 Qualification firing test 1 → 23 October 2008

Z9 Qualification firing test 2 → 28 April 2009

Z9 VERTA firing test → May 2010

Stage qualification: November 2009



Helium pressurised tanks (GHe):
88 litres @ 310 bar
Propellant tanks (NPO L - Russia)
UDMH: 2 x 142 litres
NTO: 2 x 142 litres
Max pressure: 36 bars

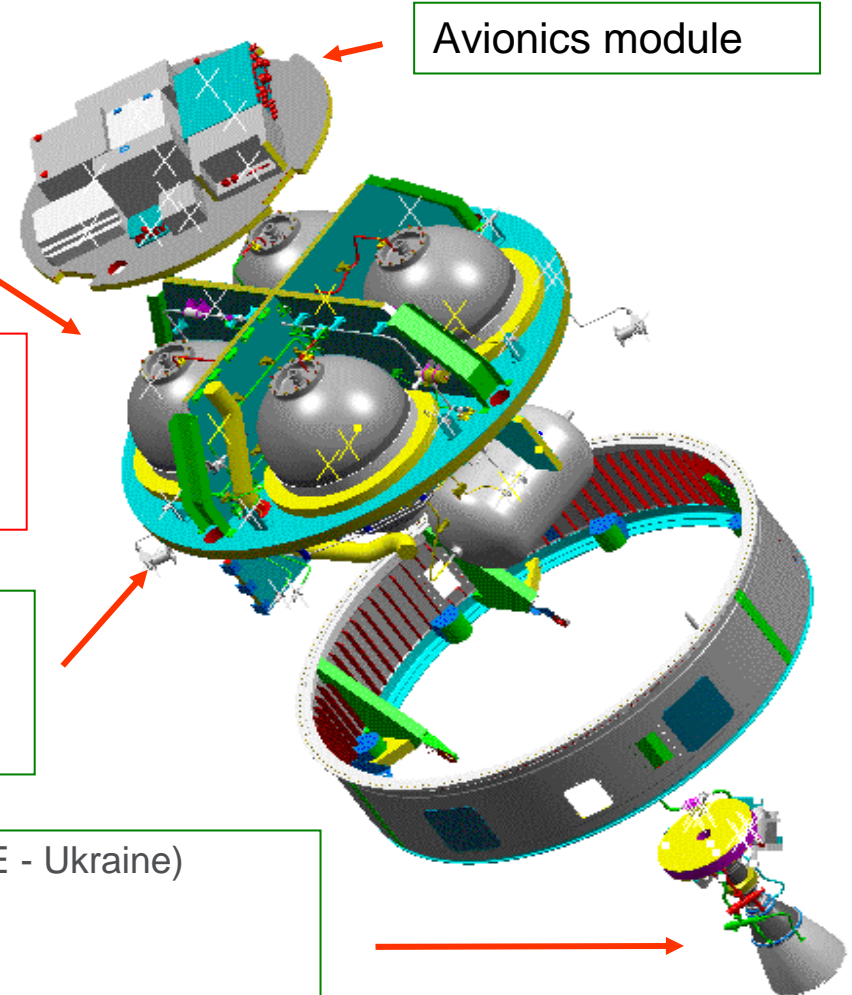
RACS: 2 x 3 thrusters (Aerojet)
Thrust: 240 N (each)
N₂H₄ tank: 39 kg @ 26 bar

Liquid Propulsion
module
(LPS + RACS)

Main engine: RD-869 (YUZHNOYE - Ukraine)

- Thrust: 2450 N
- Specific impulse: 315.5 s
- Restartable: 5 times

- **Gimbal displacement $\pm 10^\circ$**





The Fourth Stage: AVUM (2/3)

Main Engine Qualification

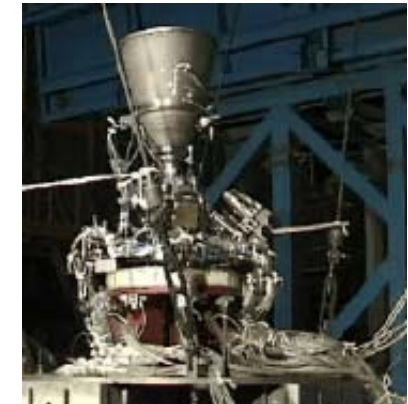


Stage vacuum firing tests

- Three Qualification engines tested
- 6000 s cumulated firing time
- More than 100 Ignition sequences (vacuum cold & hot, restarts)
- Stage firing test campaign
- Robustness tests (bubble injection)



Engine vacuum firing tests



Strength tests

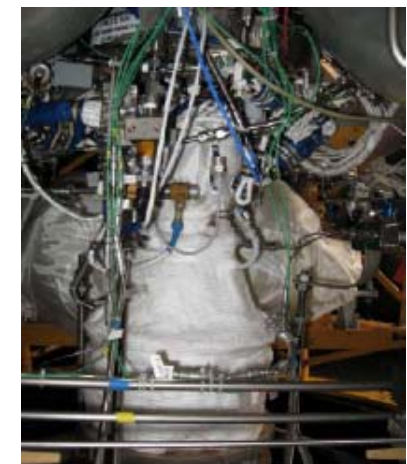
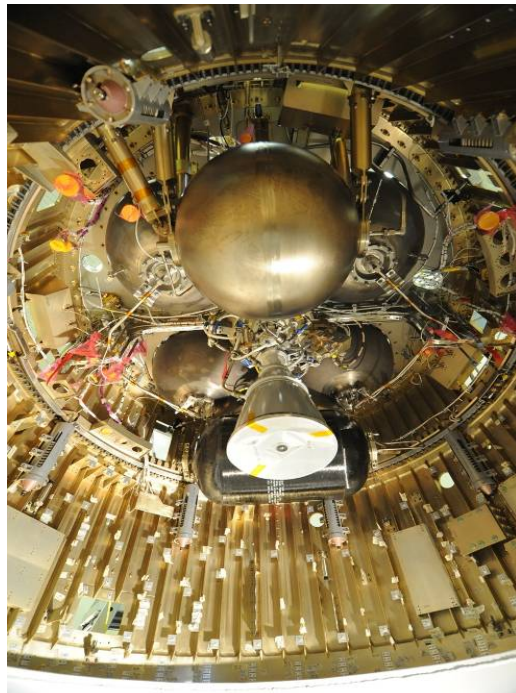


Figure 38: UCIFIRE hot restart configuration

Engine hot restart
firing tests



AVUM structure strength test



AVUM Lay out



AVUM on its integration stand



AVUM Engine

Stage qualification (structure & propulsion)
Feb 2010



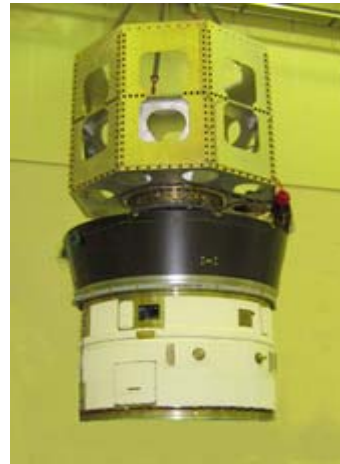
The Upper Composite



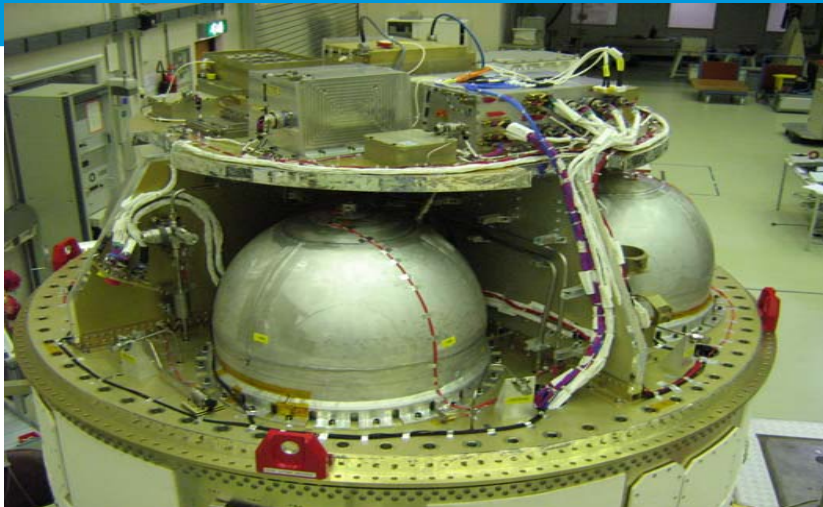
Fairing strength test

Fairing qualification Dec 2007

Adapter qualification Apr 2010



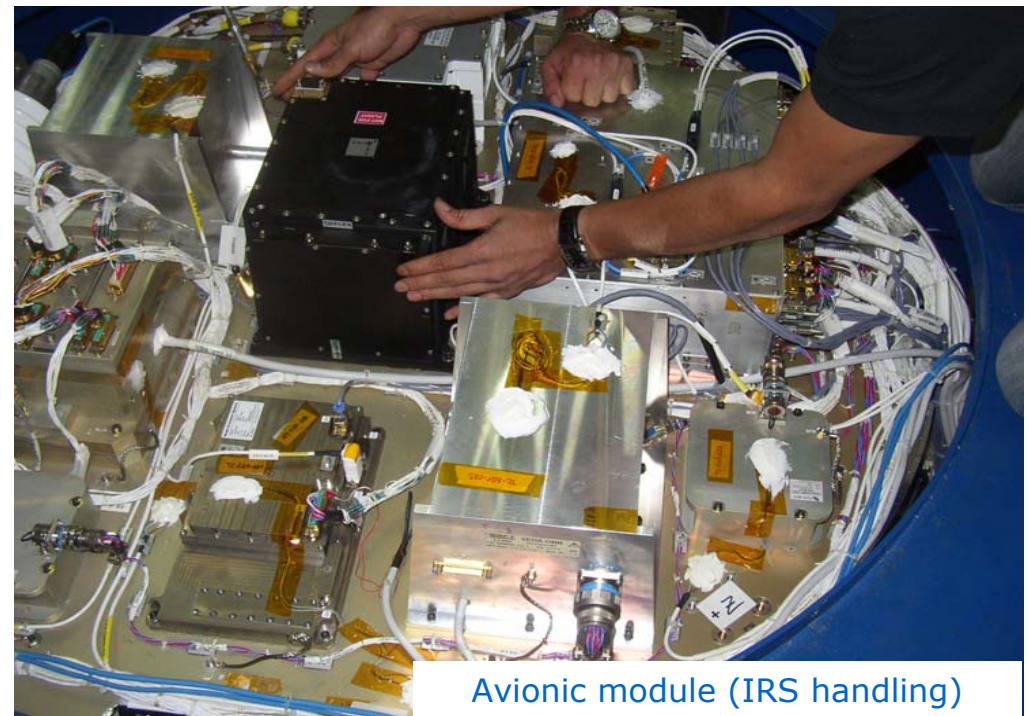
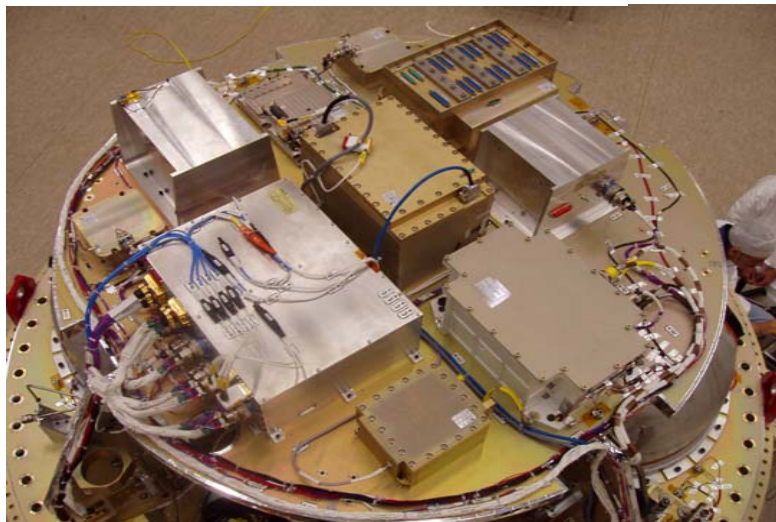
Adaptor strength test



AVUM and Avionic module lay out

Avionics functions are distributed among Hardware items and On-Board Software. They are split into the following three subsystems:

- The **GNC** - Guidance, Navigation and Control Subsystem
- The **SAS** - Safeguard Subsystem
- The **TMS** - Telemetry subsystem



Avionic module (IRS handling)



Any equipment is qualified

The overall functional qualification of the Electrical systems of the vehicle is performed on a dedicated test facility: the HardWare In the Loop test bench (HWIL)

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Figure 6 - 32 Destruction and pyro battery picture



The Vehicle System Tests



The system tests campaigns: from the stages and sub systems to the Launch Vehicle

Fundamental steps towards the Launch Vehicle qualification

Mechanical

- Upper Composite Mechanical Campaign
- Wind test tunnel, Scaled acoustic
- Vehicle modal characterisation
- Stages separations

Electrical

- Upper Composite Electro-Magnetic Compatibility Campaign
- HardWare In the Loop tests campaigns

All system test campaigns have been successfully completed



Upper Composite Mechanical Tests



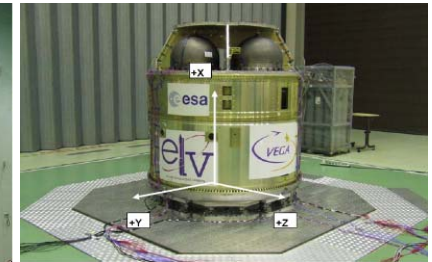
Composite integration in ESTEC



AVUM vibration test in ESTEC



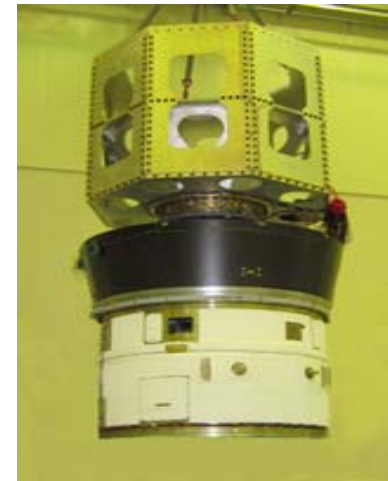
Acoustic test in ESTEC



Fairing boat tail separation test in INTA



AVUM separation test (INTA)





Mechanical System Tests



Inter-stage 1/2
Separation Test
ELV



Inter-stage 2/3
Separation Test ELV



Inter-stage $\frac{3}{4}$ Separation
Test
INTA



Acoustic scale
model
ONERA



Wind test tunnel
DLR



LV Modal
characterisation
IABG



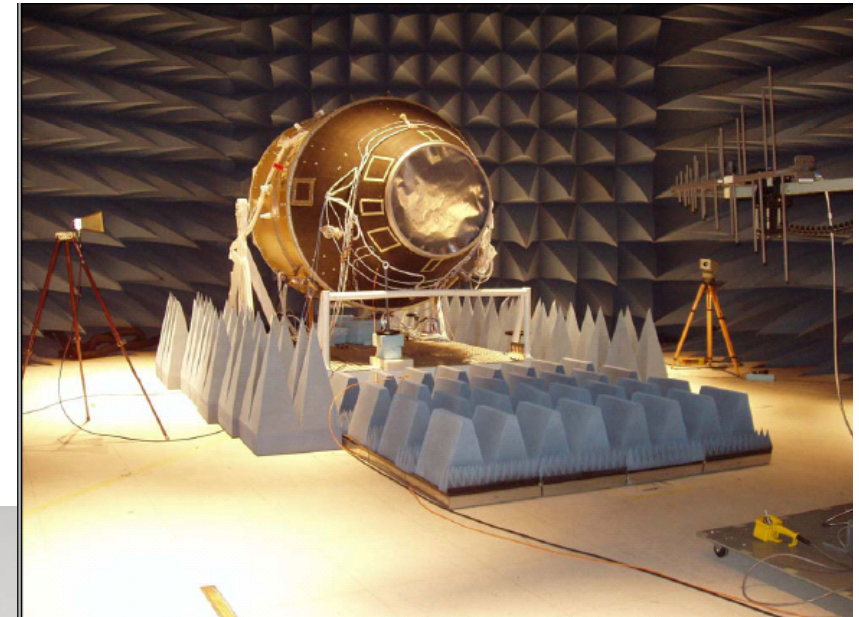
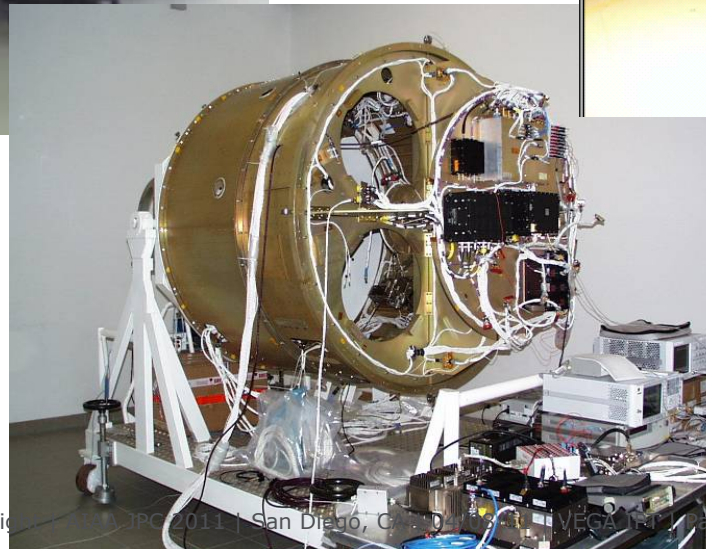
Upper Composite Electro-Magnetic Compatibility Tests



- AVIONICS tests campaigns



Conducted campaign (ELV)



Radiated campaign (INTA Spain)





Vehicle System Electrical Tests



HardWare In the Loop facility allows testing the whole electrical equipments and the flight program software of the Launch Vehicle

- The bench includes every Vehicle electrical equipment and actuator
- The facility allows testing failures and degraded modes. Erroneous signal may be injected to test FDIR functions and the robustness of the system.

HardWare In the Loop test campaign

→ **The backbone of the Electrical systems qualification**



✓ Thrust Vector Control loop performance



✓ Flight Program Software





The Ground Segment



Ground Segment Architecture



- VEGA Launch Vehicle is operated from a dedicated room in the Ariane 5 Launch Control Building
- The Ground Segment is divided in four main sub systems
 - Infrastructures and Mobile Gantry
 - Vega Control Bench (CCV)
 - Safety Control Bench (CCS)
 - Fluid systems (Air, N₂, He, N₂O₄, UDMH, N₂H₄, water)
- Safety Control Command is common with Ariane 5 (fire, toxic vapours, gas detection, surveillance)
- Sub systems are certified by the accredited organisms according to French regulation
- Same operational organisation as Ariane 5 (planning, operation sheets, procedure approval, safety supervision...)



Ground Segment Subsystems



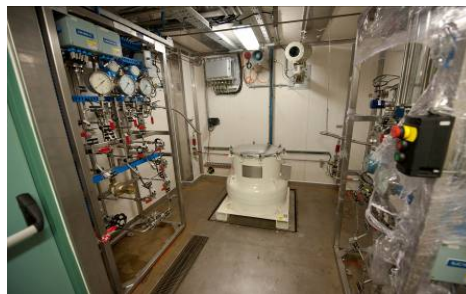
Vega control room in CDL 3



He - N₂ fluid panel



Vega control command bench



N₂O₄ Room



Mobile Gantry



The Vehicle/Ground Segment Combined Tests Campaign





The LV / GS Combined Tests



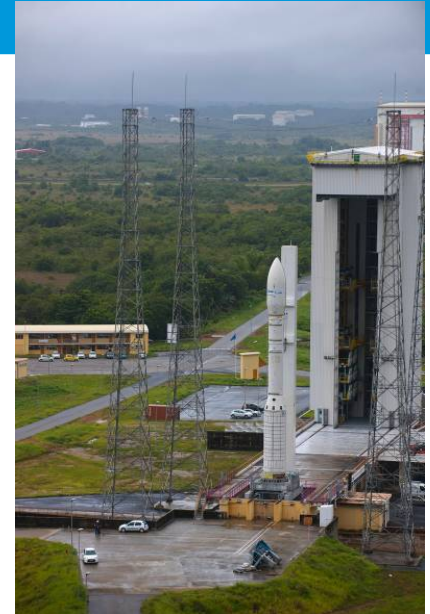
The Combined tests campaign is the last test campaign during which the Vehicle and the Ground Segment are operated together for the first time. The vehicle is representative in its definition and mass (Inert Static Vehicle)

LV Integration and LV/GS system mechanical tests

- ✓ Verification of vehicle integration and interfaces (including off nominal operations)
- ✓ Verification system behavior (anti vortex shedding, thermal)
- ✓ Verification of 4th stage propellant loading and downloading operations
- ✓ Verification of payload preparation, transfer and integration

LV Electrical controls and Control Bench automatic procedures for operational qualification

- ✓ Vega Electrical Simulator validation
- ✓ Pre Validation of Operational procedures in Europe
- ✓ Validation of Operational procedures in French Guiana with the Control Bench
- ✓ Launch Vehicle electrical integration and control (as part of AIT ops)
- ✓ Launch Chronology and Count Down Sequence





Combined Tests Status with Payload Composite



Combined test specimen is under preparation for the 4th stage (AVUM) propellant loading/downloading campaign.

Nest steps:

- Ground Segment Operational Readiness
- Qualification Launch Campaign



VEGA Reviews



- A process of reviews with the participation of independent experts has been put in place at unit levels, Launch Vehicle (LV) level, Ground Segment level and Launch System (LS) level:
 - **Conceptual Reviews – 1999**
 - **Preliminary Design Reviews (LV) – 2001**
 - **LV System Design Review – 2004**
 - **LS Critical Design Reviews – 2007**
 - **S/S Qualification Reviews – 2010**
 - **First Article Configuration Reviews – within 2nd Quarter 2011**
 - **LS Ground Qualification Review – September 2011**
 - **Operational Readiness Review – September 2011**
 - **Flight Readiness Review – October 2011**
 - **Launch Readiness Review: FRR + 49 Days**
 - **Flight Qualification Review – Launch + 6 months**



VEGA Development Status

Remaining Activities up to the Flight



- **Completion of the Launch System qualification**

- Roll & Attitude Control System qualification (July 2011)
- HWIL Test campaign completion & Flight Software Qualification (August 2011)
- Completion of the Combined Tests campaign (September 2011)
- Operational Readiness Review

Launch System Ground Qualification Review closeout → September 2011

- **Maiden flight launch campaign**

- Flight Readiness Review planned on middle October
- 49 days launch campaign
- Payload availability in Kourou on October

Launch slot starting middle December 2011



Maiden Flight



The qualification flight mission has been defined considering the passengers needs, the qualification objectives and the safety constraints.

Orbit: 1450 km circular End of mission parking orbit: 350 x 1450 km

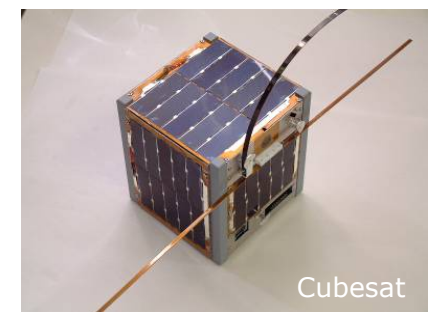
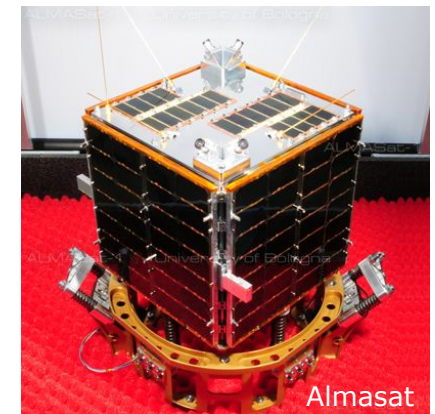
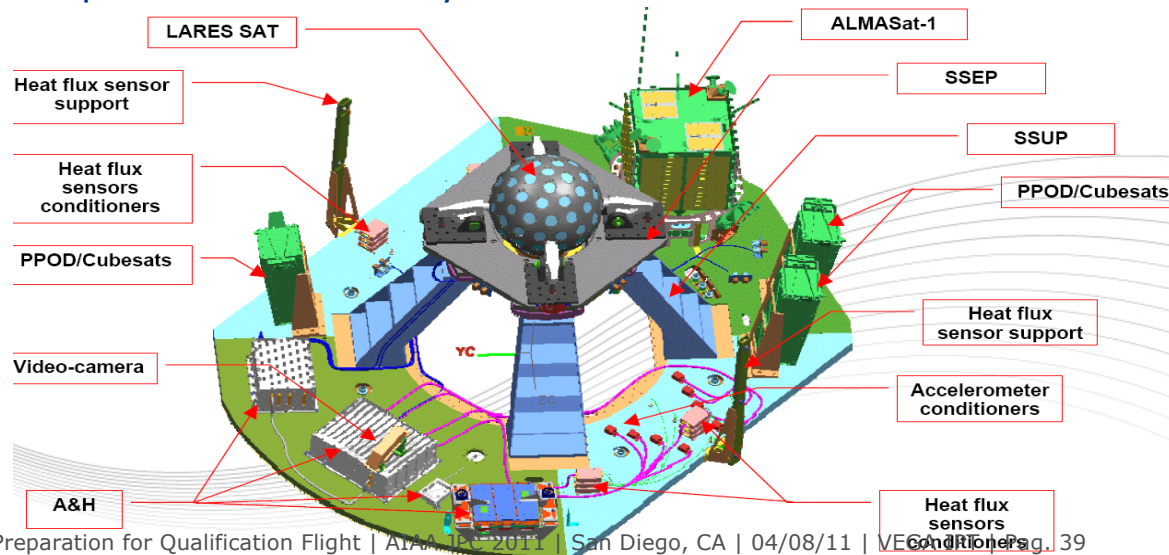
Inclination: 69°

Payloads total mass: 700 kg

The main passenger of the mission is the **LARES** (400 kg) developed by ASI (satellite laser ranging experiment).

Educational payloads (Almasat 1 & Cubesats) as secondary passengers.

The upper composite is extensively instrumented





Notes

THANK YOU

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