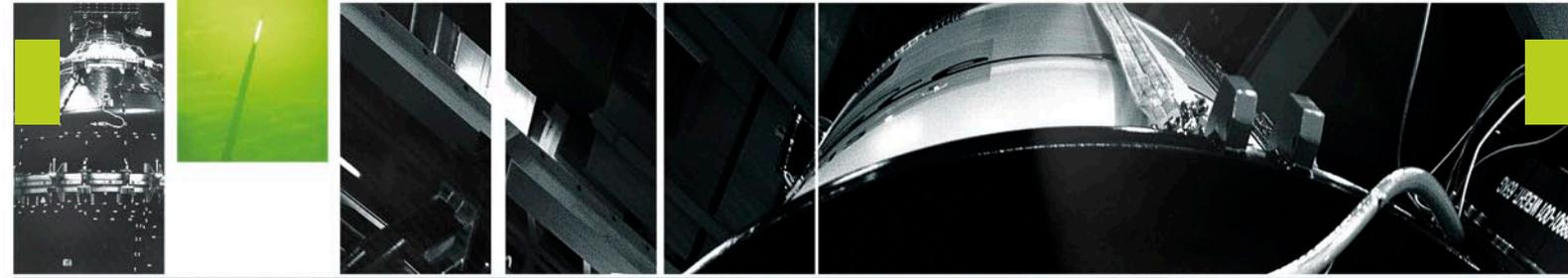


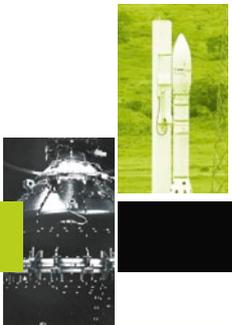
December  
2015



# VV 06

## LISA Pathfinder





# VV 06

## LISA Pathfinder



### VEGA'S SIXTH LAUNCH WILL ORBIT EUROPE'S LISA PATHFINDER DEMONSTRATOR

On its 11<sup>th</sup> launch of the year, and sixth flight overall of the Vega light launcher from the Guiana Space Center, Arianespace will orbit the LISA Pathfinder technology demonstrator for the European Space Agency (ESA).

This is Arianespace's seventh launch of the year overall for European Governments, this time focusing on space research and science. It once again reflects the company's assigned mission of ensuring independent access to space for Europe.

#### Arianespace at the service of space research and science

Developed by ESA, LISA Pathfinder is a technology demonstrator that will pave the way for future spaceborne gravitational-wave observatories.

Gravitational-waves, the "ripples in the fabric of space-time" predicted by Albert Einstein's general theory of relativity, are produced by massive bodies in acceleration. However, despite the attempts of ground-based experiments to detect them directly, gravitational waves so far remain elusive.

LISA Pathfinder is a first step in observing these perturbations; in effect proving the innovative technologies needed, rather than detecting the waves themselves. The spacecraft creates the most "silent" place in the solar system, testing whether it is possible to put two test masses into a near-perfect gravitational free-fall. If the two bodies are moving under the effect of gravity alone, only a gravitational wave passing between them would change their separation – and this is what will ultimately be monitored.

LISA Pathfinder comprises two modules: scientific and propulsion. After separation of the propulsion module, LISA Pathfinder will test the instruments needed to reduce external influences on the test masses and measure their relative motion: inertial reference sensors, high-precision laser interferometer, Drag-Free and Attitude Control System (DFACS) and proportional micronewton thrusters.

LISA Pathfinder is the 16<sup>th</sup> satellite to be launched by Vega.

It also is the 114<sup>th</sup> spacecraft built by Airbus Defence and Space (and predecessors) to be launched by Arianespace. The company's current launch manifest includes nine other satellites from Airbus Defence and Space, along with the special order from OneWeb (over 600 satellites).

#### 3 for 3 for Vega in 2015: Arianespace and ELV/AVIO, a successful partnership

Arianespace's third launch of the year on Vega, marks the operational ramp-up of this light launcher, as well as its ability to sustain its nominal annual launch rate.

The Vega development phase (VERTA) is concluded with this sixth flight, because it has performed the full range of missions: into a ballistic trajectory (IXV); a low Sun-synchronous orbit/SSO (Sentinel 2A); and a transfer orbit to the L1 Lagrange point (LISA Pathfinder).

The Vega launcher program is now fully operational, and Arianespace is gearing up for the future, which includes the active development of the Vega C project.



### CONTENTS

#### The Launch:

- > VV06 mission PAGE 1-2
- > LISA Pathfinder spacecraft PAGE 3

#### Further information:

- > Vega launch vehicle PAGE 4-5
- > Launch campaign PAGE 6
- > Countdown and flight sequence PAGE 7
- > LISA Pathfinder mission profile PAGE 8
- > Arianespace & the Guiana Space Center PAGE 9

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# VV 06

## LISA Pathfinder



### MISSION DESCRIPTION

The sixth Vega launch from the Guiana Space Center (CSG) will place the LISA Pathfinder spacecraft on an elliptic low earth parking orbit, from where the satellite's own propulsion module will bring it on its operational orbit around the L1 Lagrange point.

The launcher will be carrying a total payload of 1,986 kg., including 1,906 kg. for the LISA Pathfinder spacecraft, which will be released into its targeted orbit.

The launch will be from the Vega Launch Complex (SLV) in Kourou, French Guiana.

- Orbit:** Elliptic low earth parking orbit for a mission to the L1 Lagrange point (at 1.5 million km from Earth)
- Apogee altitude:** 1,540 km
- Perigee altitude:** 207 km
- Inclination:** 5.96 degrees

Liftoff is scheduled for **Wednesday, December 2, 2015**, at exactly:

- 01:15:00 a.m. (local time in French Guiana),
- 11:15:00 p.m. (Washington, DC), on December 1<sup>st</sup>
- 04:15:00 a.m. (UTC),
- 05:15:00 a.m. (Paris).

### The launch at a glance

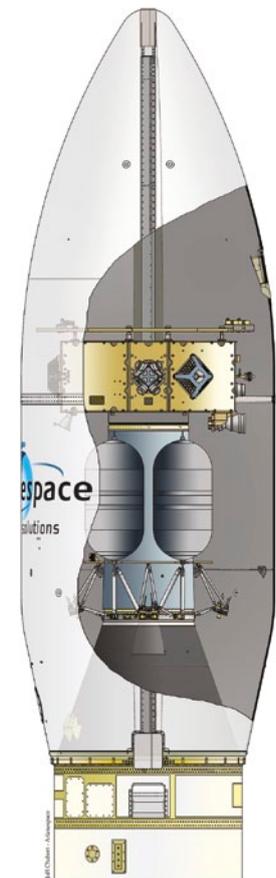
Following liftoff from the Guiana Space Center, the powered phase of Vega's first three stages will last 6 minutes and 30 seconds. After this first phase, the launcher's third stage will separate from the upper composite, which includes the AVUM upper stage, a payload adapter and the and the LISA Pathfinder demonstrator. The lower three stages will fall back to sea.

The AVUM upper stage will ignite its engine for the first time, operating for about nine minutes, followed by a ballistic phase lasting approximately 85 minutes. The AVUM stage will then reignite its engine for about one and a half minutes, prior to releasing the LISA Pathfinder demonstrator spacecraft two and a half minutes after the engine is shut down.

The LISA Pathfinder demonstrator will be released at 1 hour, 45 minutes and 33 seconds after liftoff.

### Vega payload Configuration

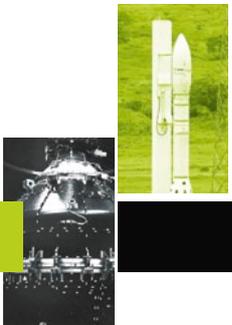
The LISA Pathfinder spacecraft was designed and built by Airbus Defence and Space on behalf of the European Space Agency (ESA).



### Mission duration

The nominal mission duration (from liftoff to separation of LISA Pathfinder) is

**1 hour, 45 minutes and 33 seconds.**

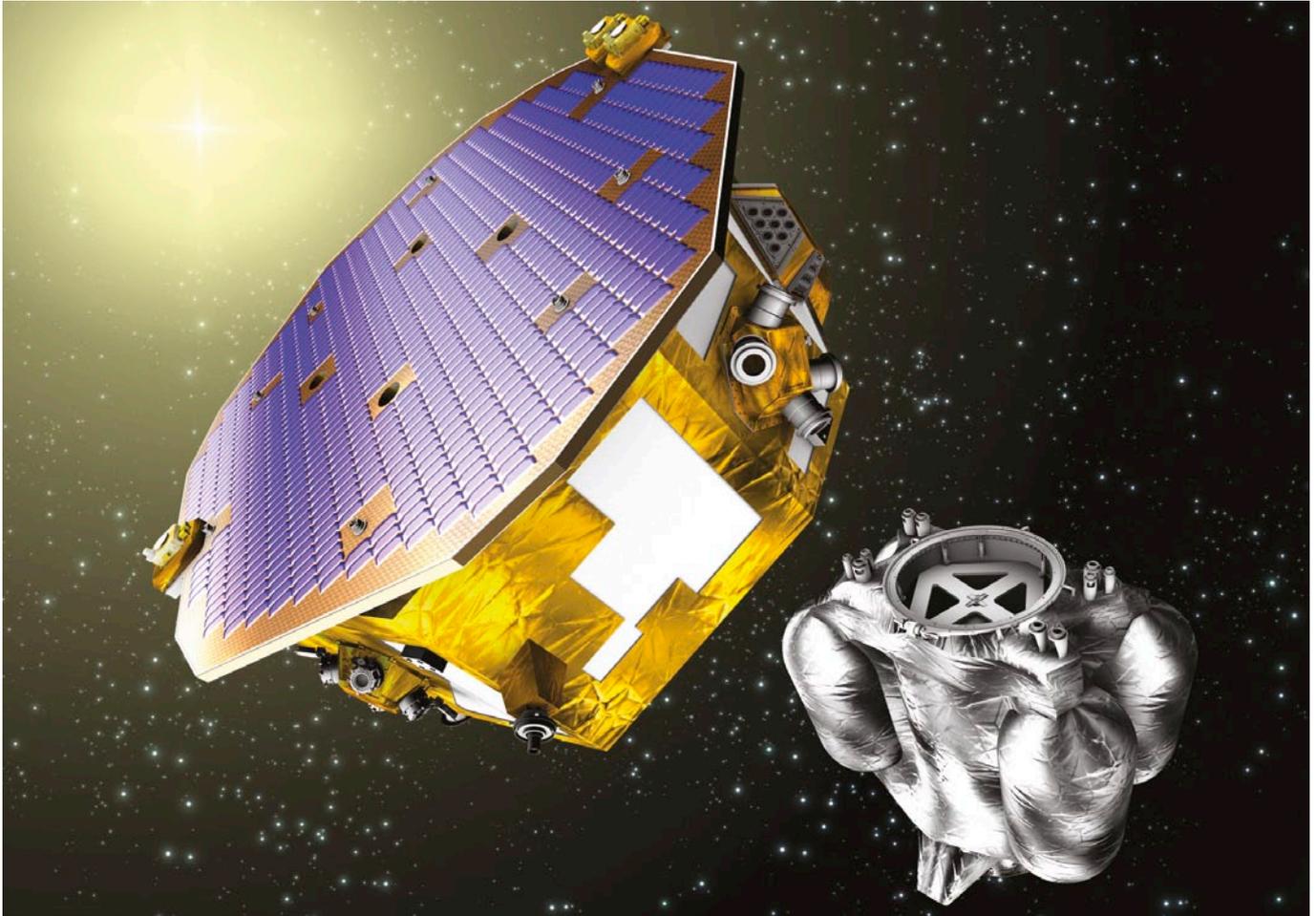


# VV 06

LISA Pathfinder



## ▼ LISA Pathfinder spacecraft



<b>Customer</b>	The European Space Agency (ESA)
<b>Prime contractor</b>	Airbus Defence and Space
<b>Mission</b>	Technology demonstrator of instruments to measure gravitational waves
<b>Platform</b>	Specific / PLA937 / propulsion unit based on E2000 platform
<b>Mass</b>	1,906 kg. at liftoff approximately
<b>Stabilization</b>	3 axis
<b>Dimensions</b>	3.137 m in height x 2.429 m in diameter
<b>Targeted orbit</b>	Elliptical low earth parking orbit for a mission to the L1 Lagrange point (at 1.5 million km from Earth) Final orbit Lissajous L1
<b>Onboard power</b>	Lithium battery
<b>Design life</b>	Approximately 1 year

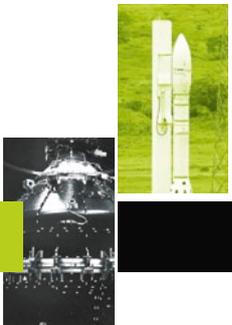
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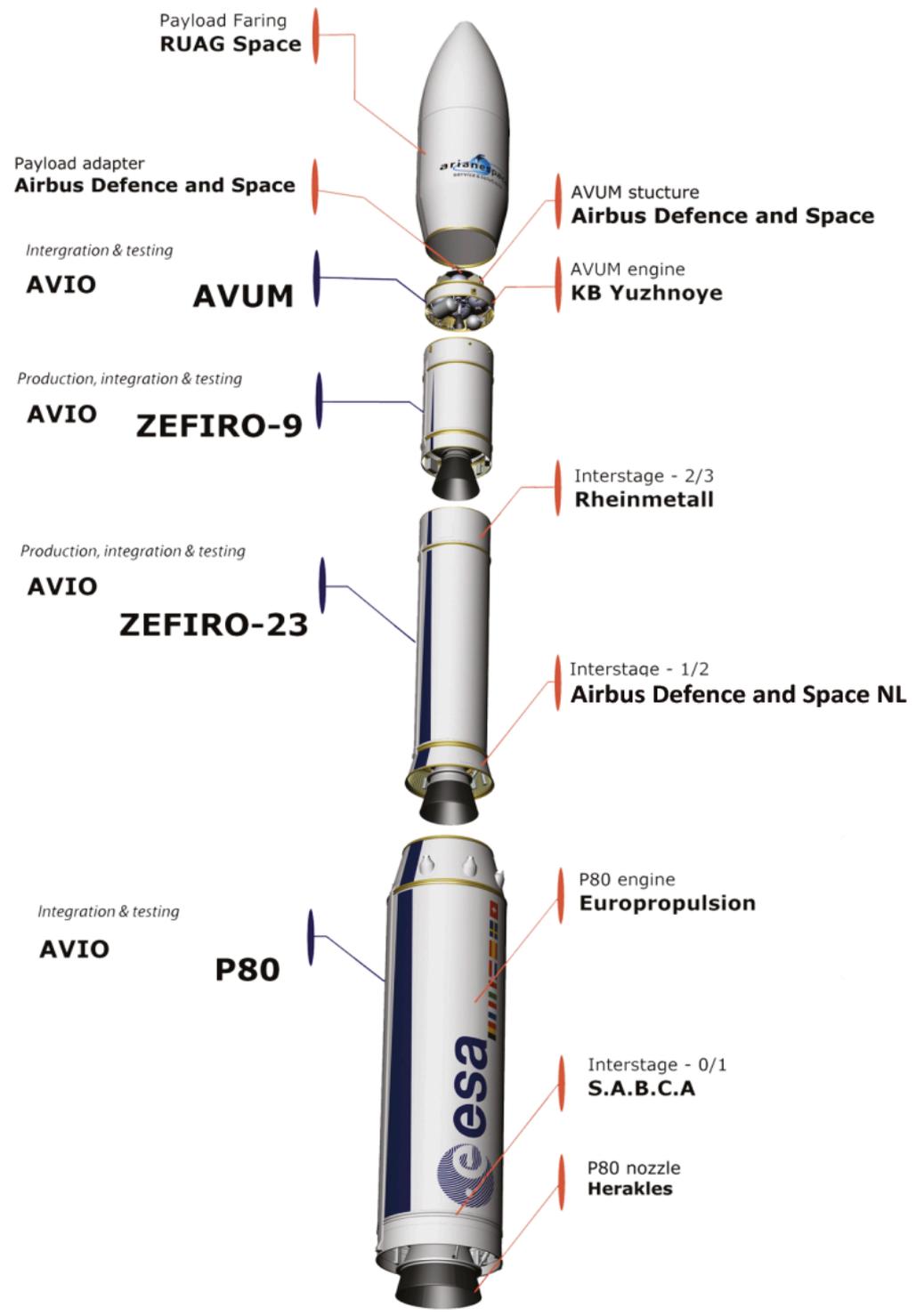


# VV 06

LISA Pathfinder



## THE VEGA LAUNCHER



Thrust vector control system  
(P80, Zefiro-9, Zefiro-23 & AVUM)  
**S.A.B.C.A**

Igniters (P80, Zefiro-9 & Zefiro-23)  
**APP**

Avionics  
**Thales, IN-SNEC, Selex Avionica,  
CRISA, RUAG Space, SAFT**



# VV 06

## LISA Pathfinder



## VEGA CHARACTERISTICS

Vega is a launch vehicle comprising three stages with solid rocket motors:

- P80 first stage
- Zefiro-Z23 second stage
- Zefiro-Z9 third stage

The AVUM bi-propellant liquid upper stage ensures mission versatility as Vega's fourth stage, injecting the payload(s) into precise orbits.

The 2.6-meter-diameter fairing can accommodate one or several payloads.

The total weight at liftoff is 139 metric tons. The launcher is 30 meters high and has a maximum diameter of 3 meters.

### Launcher performance

The baseline performance set for Vega is to inject 1,500 kg. into circular polar orbit at 700 km. altitude, inclined 90 degrees to the Equator, with injection accuracy of 5 km. for altitude and 0.05° for inclination (1σ).

The diversity of launch elevations possible from Europe's Spaceport in Kourou, along with the flexibility provided by the AVUM, enable Vega to inject a wide range of payloads into different orbits, including 2,500 kg. payloads into quasi-equatorial circular orbit at 200 km., 2,000 kg. payloads for the International Space Station, or 1,300 kg. payloads to be injected into Sun-synchronous orbit at an altitude of 800 km.

### P80 first stage

Vega's first stage is powered by a large single-piece solid rocket motor containing 87,710 kg. of HTPB 1912 solid propellant. This solid rocket motor delivers maximum vacuum thrust of 3,015 kN and burns for 110 seconds prior to being jettisoned at an altitude of about 55 km.

The P80 stage, a filament-wound carbon-epoxy case, has the same diameter (3 meters) as the solid boosters used on Ariane 5 and its overall length (11.2 meters) is similar to that of one of the longest segments of the Ariane 5 solid booster.

### Zefiro stages

Vega's second and third stages use Zefiro solid rocket motors. These two stages, each 1.9 meters in diameter, comprise a filament-wound carbon-epoxy case, with low-density EPDM insulation and a nozzle with flex-joints, equipped with electromechanical actuators to direct the thrust.

The Zefiro-Z23 stage is 8.39 meters long, and is loaded with 23,820 kg. of HTPB 1912 solid propellant, providing maximum vacuum thrust of 1,120 kN. It operates for 77 seconds in average.

The Zefiro-Z9 stage is 4.10 meters long and is loaded with 10,570 kg. of HTPB 1912 solid propellant, providing maximum vacuum thrust of 317 kN. Although it is the smallest solid rocket motor on Vega, it offers the longest burn time of 119 seconds in average.

### AVUM

The AVUM (Attitude & Vernier Upper Module) has a bipropellant propulsion system to provide orbital injection, and a monopropellant propulsion system for roll and attitude control.

It is designed to inject different payloads into different orbits, and ensures the fine pointing of satellites prior to separation.

At the end of the mission, it is deorbited under safe conditions to limit the amount of orbital debris.

The AVUM contains about 577 kg. of liquid propellant (UDMH/NTO), distributed in four tanks. It is powered by an engine derived from the reignitable RD-869, providing 2.45 kN of thrust. It also has two sets of three monopropellant thrusters to control roll and attitude. Additionally, the AVUM contains Vega's avionics module, which handles flight control and mission management, telemetry and end-of-flight functions, along with the electrical power supply and distribution.

### Fairing and payload adapters

Vega's fairing is 2.6 meters in diameter and has a volume of 20 sq. meters. The fairing is made of two half-shells, each 7.90 meters long.

### The launch complex

The Vega launch pad ("Site de Lancement Vega" or SLV) was built on the former Ariane 1 launch pad (ELA-1). It is located about 1 km. southwest of the ELA-3 launch pad, used for Ariane 5.

The concrete launch pad was modified to handle Vega and the new 50 meter mobile gantry, weighing about 1,000 metric tons, along with the umbilical mast, stretching 32 meters high. Four 60-meter-tall masts protect the pad against lightning strikes.

The three solid propellant stages and the bipropellant module are assembled on the launch pad. The payload composite is integrated on Vega about two weeks prior to launch. The mobile gantry is rolled back on its 80-meter long rails several hours before the launch.

The Vega launch center (CDL) is in the building that already houses its Ariane 5 counterpart, situated 1.3 km. from the launch pad.

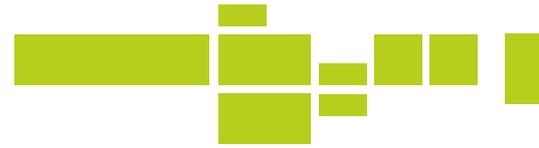
Mission control is handled from the Jupiter building, already used for Ariane and Soyuz launches.





# VV 06

## LISA Pathfinder



### LAUNCH CAMPAIGN: VEGA - LISA Pathfinder

#### LISA Pathfinder and launch vehicle campaign calendar

Dates	Spacecraft activities	Launch vehicle activities
September 25, 2015		Campaign start review - Launch transfer P80
October 8, 2015	LISA Pathfinder's arrival in Kourou and beginning of the preparation campaign in the S5 building	
October 9, 2015		Interstage 1/2 integration
October 13, 2015		Z23 integration
October 19, 2015		Z9 integration
October 23, 2015		AVUM integration
October 28, 2015		Synthesis control test
November 2, 2015	Transfer to the S5B fueling hall	
November 6, 2015		Launcher final inspection
November 13, 2015	LISA Pathfinder mating on payload adapter	
November 16, 2015	Encapsulation of LISA Pathfinder in the S5 building	
November 17, 2015		Completion of fairing, upper composite preparation for transfer

#### LISA Pathfinder launch vehicle campaign final calendar

Dates	Spacecraft activities	Launch vehicle activities
Wednesday, November 18, 2015	LISA Pathfinder transfer from S5 to the Vega launch pad	
Thursday, November 19, 2015	Integration of the composite with LISA Pathfinder on the launcher	
Monday, November 23, 2015		Beginning of the launcher fueling operations (RACS et AVUM)
Thursday, November 26, 2015		AVUM final pressurization and rehearsal
Monday, November 30, 2015		Launch rehearsal review (RAL), final preparation of launcher and final inspection of the fairing
Tuesday, December 1 and Wednesday, December 2 2015		Final launch countdown





# VV 06

## LISA Pathfinder

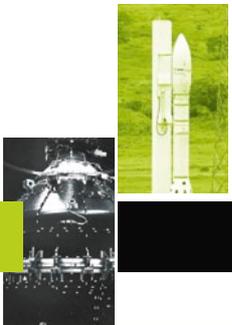


### ▼ COUNTDOWN AND FLIGHT SEQUENCE

The countdown comprises all final preparation steps for the launcher, the satellite and the launch site, including the steps leading up to authorization of P80 first-stage ignition.

TIMES		EVENTS	
- 8 h	00 mn		Start of countdown
- 5 h	30 mn		Activation of MFU (Multi Functional Unit)
- 5 h	10 mn		Activation of Inertial Reference System (IRS)
- 5 h	10 mn		Activation of telemetry
- 4 h	20 mn		Activation of onboard computer and loading of flight program
- 4 h	50 mn		Activation of SMU (Safeguard Master Unit)
- 4 h	15 mn		Removal of safety devices
- 4 h	00 mn		IRS alignment and checks
- 2 h	40 mn		Mobile gantry withdrawal (45 min)
- 1 h	55 mn		IRS alignment and checks after withdrawal of gantry
- 1 h	15 mn		Activation of telemetry transmitter after withdrawal of gantry
- 1 h	15 mn		Activation of transponders and receptors
- 0 h	34 mn		Launcher system ready
- 0 h	10 mn		Last weather report prior to launch
- 0 h	04 mn		Start of synchronized sequence
TO		LIFTOFF	
+ 0 h	1 mn	53 s	1st stage (P80) separation
+ 0 h	1 mn	54 s	2nd stage (Zefiro-23) ignition
+ 0 h	3 mn	37 s	2nd stage (Zefiro-23) separation
+ 0 h	3 mn	49 s	3rd stage (Zefiro-9) ignition
+ 0 h	4 mn	3 s	Fairing separation
+ 0 h	6 mn	30 s	3rd stage (Zefiro-9) separation
+ 0 h	7 mn	29 s	1st ignition of AVUM
+ 0 h	16 mn	23 s	1st cut-off of AVUM
+ 1 h	41 mn	19 s	2nd ignition of AVUM
+ 1 h	42 mn	53 s	2nd cut-off of AVUM
+ 1 h	45 mn	33 s	<b>Lisa Pathfinder PL release command</b>
+ 1 h	55 mn	10 s	3rd ignition of AVUM (de-orbiting)
+ 1 h	55 mn	17 s	3rd cut-off of AVUM



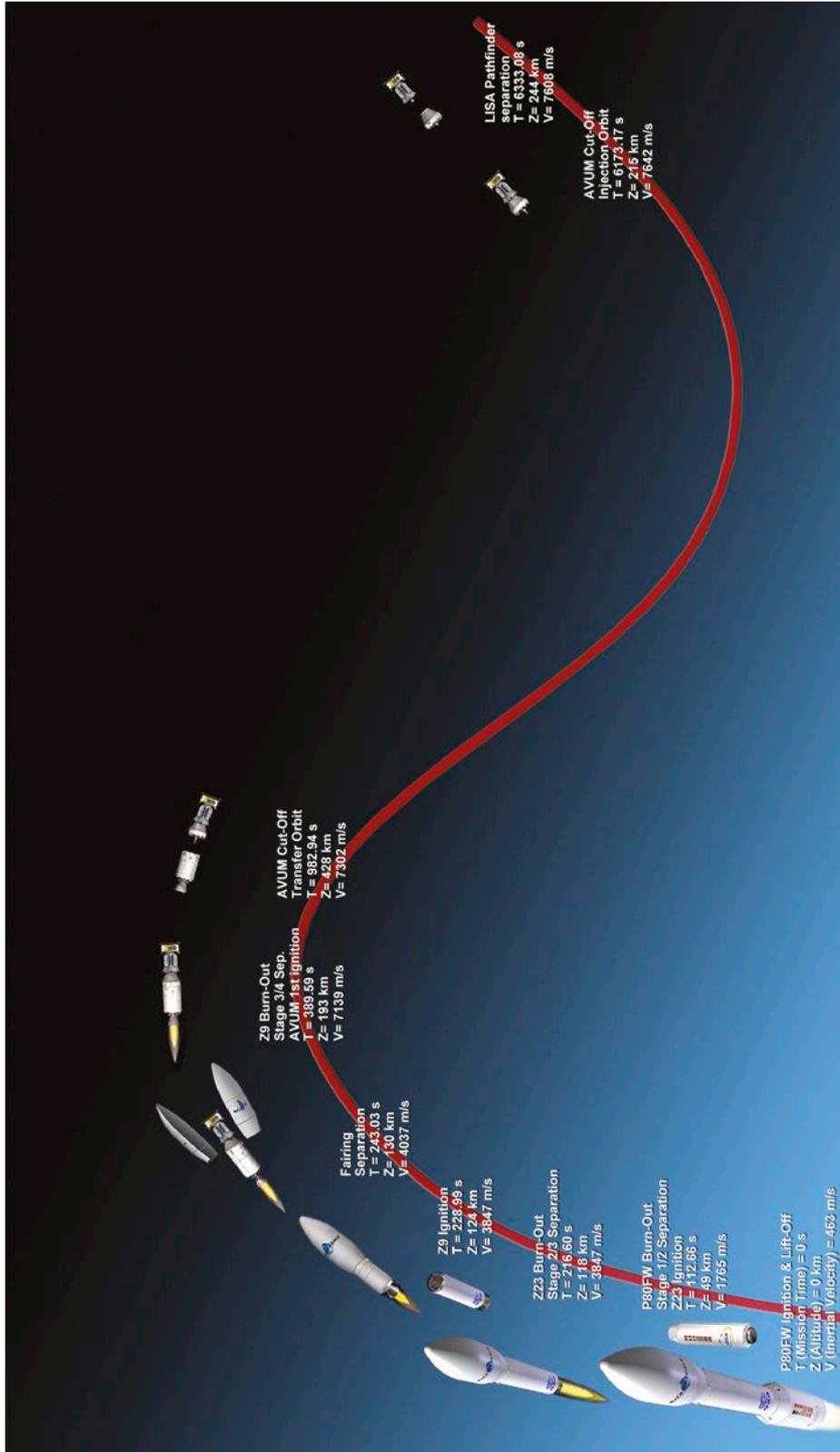


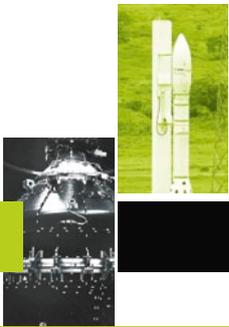
# VV 06

## LISA Pathfinder



### MISSION PROFILE LISA Pathfinder





# VV 06

## LISA Pathfinder



## ARIANESPACE AND THE GUIANA SPACE CENTER

### Arianespace, the world's first launch services company

Arianespace was founded in 1980 as the world's first launch Services & Solutions company. Arianespace now has 20 shareholders from 10 European countries (including Airbus Safran Launchers, CNES and all European companies participating in the production of Ariane launchers). Since the outset, Arianespace has signed over 450 launch contracts and launched 500-plus satellites. More than two-thirds of the commercial satellites now in service worldwide were launched by Arianespace. The company posted sales of 1.399 million euros in 2014.

As of March 1, 2015, Arianespace had 322 employees, working at the company's headquarters in Evry (near Paris); the Guiana Space Center in French Guiana, where the Ariane, Soyuz and Vega launch pads are located; and offices in Washington, D.C., Tokyo and Singapore. Arianespace offers launch services to satellite operators from around the world, including private companies and government agencies. These services call on three launch vehicles:

- The Ariane 5 heavy launcher, operated from the Guiana Space Center in French Guiana.
- The Soyuz medium launcher, currently in operation at the Guiana Space Center and the Baikonur Cosmodrome in Kazakhstan.
- The Vega light launcher, also operated from the Guiana Space Center.

Building on its complete family of launchers, Arianespace has won over half of the commercial launch contracts up for bid worldwide in the past two years. Arianespace now has a backlog of more than 70 satellites to be launched.

### The Guiana Space Center: Europe's Spaceport

For 40 years, the Guiana Space Center (CSG), Europe's Spaceport in French Guiana, has offered a complete array of facilities for rocket launches. It mainly comprises the following:

- CNES/CSG technical center, including various resources and facilities that are critical to launch base operations, such as radars, telecom network, weather station, receiving sites for launcher telemetry, etc.
- Payload processing facilities (EPCU), in particular the S5 facility.
- Ariane, Soyuz and Vega launch complexes, comprising the launch zones and launcher integration buildings.
- Various industrial facilities, including those operated by Regulus, Europropulsion, Air Liquide Spatial Guyane and Airbus Safran Launchers - all involved in the production of Ariane 5 components. A total of 40 European manufacturers and local companies are involved in operations.

Europe's commitment to independent access to space is based on actions by three key players: the European Space Agency (ESA), the French CNES space agency and Arianespace. ESA is responsible for the Ariane, Soyuz and Vega development programs. Once these launch systems are qualified, ESA transfers responsibility to the operator Arianespace. ESA has helped change the role of the Guiana Space Center, in particular by funding the construction of the launch complexes, payload processing buildings and associated facilities. Initially used for the French space program, the Guiana Space Center has gradually become Europe's own Spaceport, according to the terms of an agreement between ESA and the French government. To ensure that the Spaceport is available for its programs, ESA takes charge of the lion's share of CNES/CSG fixed expenses, and also helps finance the fixed costs for the ELA launch complexes.

The French CNES space agency has several main responsibilities at the Guiana Space Center. It designs all infrastructure and, on behalf of the French government, is responsible for safety and security. It provides the resources needed to prepare the satellites and launchers for missions. Whether during tests or actual launches, CNES is also responsible for overall coordination of operations and it collects and processes all data transmitted from the launcher via a network of receiving stations to track Ariane, Soyuz and Vega rockets throughout their trajectories.

### Arianespace in French Guiana

In French Guiana, Arianespace is the contracting authority in charge of operating the family of three launchers, Ariane, Soyuz and Vega.

For Vega, Arianespace supervises the integration and inspection of the launcher built by ELV, production prime contractor. Before taking official delivery of the launcher, it coordinates the preparation of satellites in the payload preparation facility (EPCU) operated by CNES/CSG, handles the final assembly of the launcher and integrates satellites on the launcher, and oversees the final countdown and launch from Launch Control Center 3 (CDL3).

Arianespace deploys a top-flight team and technical facilities to get launchers and satellites ready for their missions. Building on this unrivalled expertise and outstanding local facilities, Arianespace is now the undisputed benchmark in the global launch services market.

