arianespace
service & solutions

LAUNCH KIT

November 2016

VA233

Galileo FOC-M6
SAT 15-16-17-18

esa

GALILEO
15-16-17-18

cnes

ARIANESPACE'S FIRST ARIANE 5 LAUNCH FOR THE GALILEO CONSTELLATION AND EUROPE

For its ninth launch of the year, and the sixth Ariane 5 liftoff from the Guiana Space Center (CSG) in French Guiana during 2016, Arianespace will orbit four more satellites for the Galileo constellation.
This mission is being performed on behalf of the European Commission under a contract with the European Space Agency (ESA).

For the first time, an Ariane 5 ES version will be used to orbit satellites in Europe's own satellite navigation system. At the completion of this flight, designated Flight VA233 in Arianespace's launcher family numbering system, 18 Galileo spacecraft will have been launched by Arianespace.

Arianespace is proud to deploy its entire family of launch vehicles to address Europe's needs and guarantee its independent access to space.

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Galileo, an iconic project for Europe

Galileo is a European initiative to develop a new global satellite navigation system. Under civilian control, it will offer a guaranteed, high-precision positioning service and will end Europe's dependence on the American GPS system.

The Galileo constellation will comprise a total of 24 operational satellites, along with spares, with 14 already orbited by Arianespace.

Galileo is funded by the European Union. It features innovative technologies developed in Europe for the benefit of all citizens.

THE ARIANESPACE FAMILY: SUPPORTING THE DEPLOYMENT OF GALILEO

Arianespace orbited the Galileo IOV 1 and 2 (In-Orbit Validation) satellites on the first Soyuz flight from the Guiana Space Center (Flight VS01) on October 21, 2011, followed by IOV 3 and 4 on Flight VS03 on October 12, 2012, also performed from CSG. Previously, the GIOVE-A and GIOVE-B experimental satellites were orbited from Baikonur Cosmodrome in Kazakhstan with Soyuz (via Arianespace's Starsem affiliate) in 2005 and 2008.

The first two Galileo FOC satellites (5 and 6) were launched from CSG on August 22, 2014. Despite injection into a non-compliant orbit, ESA teams were able to modify their orbits and test them extensively. Their integration in the constellation's operation is subject to the European Commission decision. Soyuz launches on Arianespace Flights VS11, VS12, VS13 and VS15 from CSG on March 27, September 10 and December 17, 2015, then last May 24, respectively, orbited the Galileo FOC satellites number 7 to 14.

The upcoming Flight VA233 Ariane 5 ES mission will orbit Galileo FOC-M6 satellites number 15 to 18. After this latest launch, Arianespace will continue to deploy the next eight satellites on two Ariane 5 missions scheduled for the third quarter of 2017 and 2018.

The Flight VA233 mission will be Arianespace's 54th performed for ESA.

Arianespace has seven more ESA missions in its launch manifest: three for the European Commission, carrying nine satellites (eight Galileo spacecraft, and Sentinel-2B), and four other missions (to orbit EDRS-C, Bepi-Colombo, the James Webb Space Telescope and ADM-Aeolus).

These launches clearly show that Arianespace is meeting its assigned mission of ensuring independent access to space for Europe.

MADE IN EUROPE

The Galileo satellites are built by prime contractor OHB System in Bremen, Germany, with the payloads supplied by UK-based Surrey Satellite Technology Ltd (SSTL), which is 99% owned by Airbus Defence and Space.

These will be the 11th, 12th, 13th and 14th OHB-built satellites launched by Arianespace.

The next eight Galileo spacecraft are under construction by OHB in Bremen.

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MISSION DESCRIPTION

The sixth Arianespace Ariane 5 launch of the year will place the four satellites into MEO (Medium Earth Orbit) circular orbit.

The launcher will be carrying a total payload of approximately 3,290 kg.

The launch will be performed from Ariane Launch Complex No. 3 (ELA 3) in Kourou, French Guiana.

DATE AND TIME

Liftoff is planned on **Thursday, November 17, 2016** at exactly:

> **10:06:48 a.m.,** Kourou time
> **08:06:48 a.m.,** Washington D.C. time
> **13:06:48 ,** Universal Time (UTC)
> **02:06:48 p.m.,** Paris time

MISSION DURATION

The nominal duration of the mission (from liftoff to separation of the satellites) is:

3 hours, 55 minutes and 44 seconds.

TARGETED ORBIT

Circular orbit
MEO-plane C

Apogee altitude
22,900 km.
Semi-major axis: 29,300 km.

Inclination
54.57 degrees

THE LAUNCH AT A GLANCE

The launcher's attitude and trajectory are controlled by the two onboard computers, located in the Ariane 5 vehicle equipment bay (VEB).

About seven seconds after start of the ignition of the main stage cryogenic engine at T-0, the two solid-propellant boosters are ignited, enabling liftoff. The launcher first climbs vertically for 6 seconds, then rotates towards the East. It maintains an attitude that ensures the axis of the launcher remains parallel to its velocity vector, in order to minimize aerodynamic loads throughout the entire atmospheric phase until the solid boosters are jettisoned.

The fairing protecting the payload is jettisoned at T+225 seconds.
The flight of the Ariane 5 lower composite, comprising two solid boosters and the cryogenic main stage, will last about nine minutes. This stage then separates from the upper stage and falls back into the Pacific Ocean, off the coast of Peru.

The storable propellant upper stage will ignite its own engine at this point, to bring the upper composite, comprising the Galileo satellites and their dispenser, into a transfer orbit. Following this initial ignition, the upper composite is spun up for a ballistic phase lasting 3 hours and 8 minutes.
At a predetermined point in this orbit, the upper stage will again ignite its engine, for a little more than six minutes, to reach a circular separation orbit. Once stabilized, the dispenser will release the first two satellites, followed by the second pair 20 minutes later.

The upper stage will be passivated at the end of the mission. The Galileo satellites will then perform a maneuver to increase their altitude and reach the operational orbit at 23.222 km.

At orbital injection, the launcher will have attained a velocity of approximately 3,688 meters/second, and will be at an altitude of 22,925 kilometers.

PAYLOAD CONFIGURATION

> **Payload : Galileo FOC M6, SAT 15, 16, 17, 18**
Mass at liftoff: 715 kg., 717 kg., 716 kg., et 717 kg. – Total mass: 2,865 kg.

> **Medium version of the payload fairing**

> **Dispenser (carrying structure and deployment system) for the four Galileo FOC-M6 payloads, developed and built by Airbus Safran Launchers**

Galileo FOC-M6, SAT 15-16-17-18

CUSTOMER	The European Space Agency (ESA) on behalf of the European Commission
PRIME CONTRACTOR	OHB System AG (bus, prime), SSTL (payload)
MISSION	Navigation
MASS	Mass at launch of 715 kg., 717 kg., 716 kg., and 717 kg. – Total mass of 2,865 kg.
DIMENSIONS	2.7 m. x 1.2 m. x 1.1 m.
ORBITAL WIDESPREAD	14.67 m.
DESIGN LIFE	More than 12 years
ONBOARD POWER	1,900 W
ORBITAL POSITION	Medium Earth Orbit (MEO)
NAVIGATION SIGNAL	3 bands (E5, E6 and E1)

PRESS CONTACTS

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ARIANE 5 ES LAUNCH VEHICLE

The launcher is delivered to Arianespace by Airbus Safran Launchers as production prime contractor.

50.5 m

Fairing

(RUAG Space): 14 m
Mass: 1.9 t

770 tons
(total mass at liftoff)

4 x Galileo Satellites

*(***ESA***)*
Mass: 2,865 kg.

Dispenser FOC A5 - Internal structure

Mass: 430 kg.

Vehicle Equipment Bay

Height: 1.13 m.
Mass: 1.4 t.

EPS – Storable Propellant upper Stage

Height: 3.36 m.
Mass: 1.9 t.

AESTUS engine

Thrust: 29 kN (in vacuum)
12,300 sec. of propulsion

EPC - Cryogenic main stage

Height: 31 m.
Mass: 188 t.

Propellants (in metric tons) at T-O
L: Liquid
H: Cryogenic
P: Solid

EAP - Solid Rocket Boosters

Height: 31.6 m.
Mass: 277 t. approx.

Vulcain 2 Engine

Thrust: 1,390 kN (in vacuum)
540 sec. of propulsion

MPS - Solid Rocket Motor (SRM)

Average thrust: 5,060 kN
Maximum thrust: 7,080 kN (in vacuum)
130 sec. of propulsion

13,000 kN at Liftoff
(at T+7.3 sec.)

LAUNCH CAMPAIGN
ARIANE 5 – Galileo FOC-M6, SAT 15-16-17-18 SATELLITES

SATELLITES AND LAUNCH VEHICLE CAMPAIGN CALENDAR

DATES	SATELLITE ACTIVITIES	LAUNCH VEHICLE ACTIVITIES
September 6, 2016	Arrival in French Guiana of the four Galileo satellites; beginning of preparation in the S1A hall	
September 8 to 12, 2016	Fitcheck of the four Galileo satellites in the S1A hall	
September 27, 2016		Campaign start review EPC unpacking
September 28, 2016		EPC erection – EAP 2 transfer
September 29, 2016		EAP 1 transfer and EAP positioning
September 30, 2016		EPC/EAP integration
October 4, 2016		Vehicle Equipment Bay integration
October 5, 2016		EPS erection
October 12 and 14, 2016	Transfer of the four Galileo satellites to the S3B hall	
October 18 to 21, 2016	Galileo satellite fueling operations in the S3B hall	
October 26, 2016		Transfer from the BIL (Launcher Integration Building) to BAF (Final Assembly Building)
October 25 to 28, 2016	Four Galileo satellites' integration on dispenser	
October 31, 2016	Transfer of the four Galileo satellites to BAF	

SATELLITES AND LAUNCH VEHICLE CAMPAIGN FINAL CALENDAR

DATES	SATELLITE ACTIVITIES	LAUNCH VEHICLE ACTIVITIES
Wednesday, November 2, 2016	Integration of the four Galileo satellites on the launcher	
Thursday, November 3, 2016	Encapsulation of the four Galileo satellites in the payload fairing	
Friday, November 4, 2016	Completion of composite integration on launcher and payload check	
Monday, November 7, 2016		N2H4 fueling of SCA SCA pressurization for launch
Tuesday, November 8, 2016		MMF fueling of EPS
Wednesday, November 9, 2016		Launch rehearsal N2H4 fueling of SCA
Thursday, November 10, 2016		Arming of launch vehicle
Monday, November 14, 2016		Launch readiness review (RAL), final preparation of launcher and BAF for the chronology
Tuesday, November 15, 2016		Rollout from BAF to Launch Zone, launch vehicle connections.
Wednesday, November 16, 2016		Filling of the EPC liquid helium tank. Heating of EPS tank
Thursday November 17, 2016		Start of launch countdown, EPC filling with liquid oxygen and liquid hydrogen

COUNTDOWN AND FLIGHT SEQUENCE

The countdown comprises all final preparation steps for the launcher, the satellites/spacecraft and the launch site. If it proceeds as planned, the countdown leads to ignition of the main stage engine, then the two boosters, for a liftoff at the targeted time.

The countdown culminates in a synchronized sequence, which is managed by the control station and onboard computers starting at T-7 minutes.

If an interruption in the countdown means that T-0 falls outside the launch time, then the launch will be delayed by one, two or more days, depending on the problem involved, and the solution developed.

TIME	EVENT
- 12 h 08 min	Start of final countdown
- 10 h 38 min	Check of electrical systems
- 05 h 07 min	Start of filling of EPC with liquid oxygen and hydrogen
- 03 h 33 min	Chilldown of Vulcain main stage engine
- 01 h 10 min	Check of connections between launcher and the telemetry, tracking and command systems
- 7 min	"All systems go" report, allowing start of synchronized sequence
- 4 min	Tanks pressurized for flight
-1 min	Switch to onboard power mode
- 04 s	Onboard systems take over
T-O	**Ignition of the cryogenic main stage engine (EPC)**
+ 07 s	Ignition of solid boosters (EAP)
+ 07 s	Liftoff
+ 12 s	End of vertical climb, beginning of pitch motion
+ 17 s	Beginning of roll maneuver
+ 2 min 19 s	EAP separation
+ 3 min 44 s	Fairing jettisoned
+ 8 min 56 s	End of EPC thrust phase
+ 9 min 01 s	EPC separation
+ 9 min 08 s	EPS ignition
+ 19 min 57 s	Shut down of EPS (first boost) and beginning of the 1st ballistic phase
+ 3h + 27 min 49 s	EPS ignition
+ 3h + 34 min 7 s	Shut down of EPS (second boost) and beginning of the 2nd ballistic phase
+ 3h + 35 min 44 s	**Separation of the first and third Galileo satellites**
+ 3h + 55 min 44 s	**Separation of the second and fourth Galileo satellites**
+ 4h + 8min 28 s	Start of upper stage passivation
+ 4h + 40min 50 s	End of the Arianespace mission

ARIANE 5 ES MISSION PROFILE

The launcher's attitude and trajectory are entirely controlled by the two onboard computers in the Ariane 5 Vehicle Equipment Bay (VEB).

The synchronized sequence starts seven minutes before ignition (T-0). It is primarily designed to perform the final operations on the launcher prior to launch, along with the ultimate checks needed following switchover to flight configuration. As its name indicates, the sequence is fully automatic, and is performed concurrently by the onboard computer and by two redundant computers at the ELA-3 launch complex until T-4 seconds. The computers command the final electrical operations (startup of the flight program, servocontrols, switching from ground power supply to onboard batteries, etc.) and associated checks. They also place the propellant and fluid systems in flight configuration and perform associated checks. In addition, they handle the final ground system configurations, namely:

> Startup of water injection in the flame trenches and exhaust guide (T-30 sec).

> Hydrogen aspiration for chilldown of the Vulcain engine in the exhaust guide (T-18 sec).

> Burnoff of hydrogen used for chilldown (T-5.5 sec).

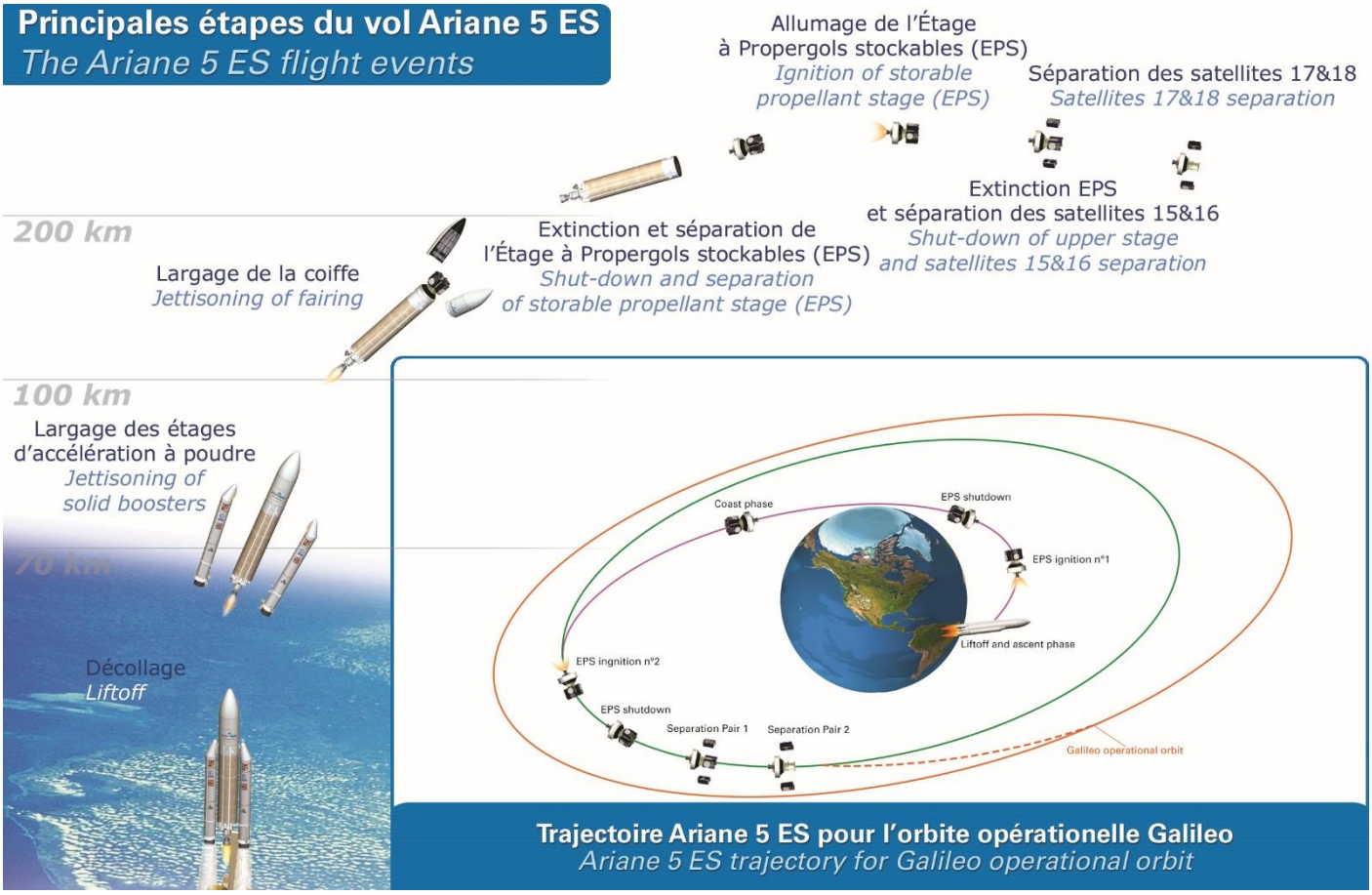
At T-4 seconds, the onboard computer takes over control of final engine startup and liftoff operations. It:

> Starts the ignition sequence for the Vulcain main stage engine (T-0).

> Checks engine operation (from T+4.5 to T+6.9 sec).

> Commands ignition for the solid boosters at T+7.05 sec for liftoff at T+7.3 seconds.

Any shutdown of the synchronized sequence after T-7 minutes automatically places the launcher back in its T-7 minute configuration.



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 530 launch contracts and launched 540-plus satellites. More than half of the commercial satellites now in service around the globe were launched by Arianespace. The company posted sales of more than 1.4 billion euros in 2015.

The company's activities are worldwide, with the headquarters in Evry, France (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-lift launcher, operated from the Guiana Space Center in French Guiana.

> The Soyuz medium-lift launcher, currently in operation at the Guiana Space Center and the Baikonur Cosmodrome in Kazakhstan.

> The Vega light-lift 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 more than 40 years, the Guiana Space Center (CSG), Europe's Spaceport in French Guiana, has offered a complete array of facilities for rocket launches. It primarily comprises the following:

> The 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 (ECPU), 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 participating in the production of Ariane 5 components. A total of 40 European manufacturers and local companies are involved in the launcher 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 Arianespace as the operator. 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 France's space program, the Guiana Space Center has evolved into 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 the 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.

Arianespace supervises the integration and functional checks of the Ariane launcher - built by Airbus Safran Launchers as production prime contractor - in the Launcher Integration Building (BIL). It then carries out acceptance tests of the launcher at the same time as satellite preparations in the Payload Preparation Complex (EPCU), which is operated by the Guiana Space Center (CNES/CSG). Next, Arianespace oversees final assembly of the launcher and integration of satellites in the Final Assembly Building (BAF), followed by transfer of the Ariane launcher to Launch Zone No. 3 (ZL3), and then the final countdown and liftoff - which are managed from the Launch Control Center No. 3 (CDL3).

Arianespace deploys a top-flight team and technical facilities to ensure the launchers and their satellite payloads are 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.