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 Starset 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 EDRSC, 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.
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)
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

4 x Galileo Satellites
Mass: 2,865 kg.

Vehicle Equipment Bay
Height: 1.13 m.
Mass: 1.4 t.

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

EPC - Cryogenic main stage
Height: 31 m.
Mass: 188 t.

EAP - Solid Rocket Boosters
Height: 31.6 m.
Mass: 277 t. approx.

Vulcan 2 Engine
Thrust: 1,390 kN (in vacuum)
540 sec. of propulsion

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

770 tons
(total mass at liftoff)

Dispenser FOC A5 - Internal structure
Mass: 430 kg.

EPS – Storable Propellant upper Stage
Height: 3.36 m.
Mass: 1.9 t.

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

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

For more information, visit us on arianespace.com
# LAUNCH CAMPAIGN
## ARIANE 5 - Galileo FOC-M6, SAT 15-16-17-18 SATELLITES

### SATELLITES AND LAUNCH VEHICLE CAMPAIGN CALENDAR

<table>
<thead>
<tr>
<th>Dates</th>
<th>Satellite Activities</th>
<th>Launch Vehicle Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 6, 2016</td>
<td>Arrival in French Guiana of the four Galileo satellites; beginning of preparation in the S1A hall</td>
<td></td>
</tr>
<tr>
<td>September 8 to 12, 2016</td>
<td>Fitcheck of the four Galileo satellites in the S1A hall</td>
<td></td>
</tr>
<tr>
<td>September 27, 2016</td>
<td>Campaign start review</td>
<td>EPC unpacking</td>
</tr>
<tr>
<td>September 28, 2016</td>
<td>EPC erection – EAP 2 transfer</td>
<td></td>
</tr>
<tr>
<td>September 29, 2016</td>
<td>EAP 1 transfer and EAP positioning</td>
<td></td>
</tr>
<tr>
<td>September 30, 2016</td>
<td>EPC/EAP integration</td>
<td></td>
</tr>
<tr>
<td>October 4,  2016</td>
<td>Vehicle Equipment Bay integration</td>
<td></td>
</tr>
<tr>
<td>October 5, 2016</td>
<td>EPS erection</td>
<td></td>
</tr>
<tr>
<td>October 12 and 14, 2016</td>
<td>Transfer of the four Galileo satellites to the S3B hall</td>
<td></td>
</tr>
<tr>
<td>October 18 to 21, 2016</td>
<td>Galileo satellite fueling operations in the S3B hall</td>
<td></td>
</tr>
<tr>
<td>October 26, 2016</td>
<td>Transfer from the BIL (Launcher Integration Building) to BAF (Final Assembly Building)</td>
<td></td>
</tr>
<tr>
<td>October 25 to 28, 2016</td>
<td>Four Galileo satellites’ integration on dispenser</td>
<td></td>
</tr>
<tr>
<td>October 31, 2016</td>
<td>Transfer of the four Galileo satellites to BAF</td>
<td></td>
</tr>
</tbody>
</table>

### SATELLITES AND LAUNCH VEHICLE CAMPAIGN FINAL CALENDAR

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

<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-12h 08min</td>
<td>Start of final countdown</td>
</tr>
<tr>
<td>-10h 38min</td>
<td>Check of electrical systems</td>
</tr>
<tr>
<td>-05h 07min</td>
<td>Start of filling of EPC with liquid oxygen and hydrogen</td>
</tr>
<tr>
<td>-03h 33min</td>
<td>Chilldown of Vulcain main stage engine</td>
</tr>
<tr>
<td>-01h 10min</td>
<td>Check of connections between launcher and the telemetry, tracking</td>
</tr>
<tr>
<td></td>
<td>and command systems</td>
</tr>
<tr>
<td>-7min</td>
<td>“All systems go” report, allowing start of synchronized sequence</td>
</tr>
<tr>
<td>-4min</td>
<td>Tanks pressurized for flight</td>
</tr>
<tr>
<td>-1min</td>
<td>Switch to onboard power mode</td>
</tr>
<tr>
<td>-04s</td>
<td>Onboard systems take over</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T-O</th>
<th>Ignition of the cryogenic main stage engine (EPC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+07s</td>
<td>Ignition of solid boosters (EAP)</td>
</tr>
<tr>
<td>+07s</td>
<td>Liftoff</td>
</tr>
<tr>
<td>+12s</td>
<td>End of vertical climb, beginning of pitch motion</td>
</tr>
<tr>
<td>+17s</td>
<td>Beginning of roll maneuver</td>
</tr>
<tr>
<td>+2min</td>
<td>EAP separation</td>
</tr>
<tr>
<td>+3min</td>
<td>Fairing jettisoned</td>
</tr>
<tr>
<td>+8min</td>
<td>End of EPC thrust phase</td>
</tr>
<tr>
<td>+9min</td>
<td>EPC separation</td>
</tr>
<tr>
<td>+9min</td>
<td>EPS ignition</td>
</tr>
<tr>
<td>+19min</td>
<td>Shut down of EPS (first boost) and beginning of the 1st ballistic</td>
</tr>
<tr>
<td>phase</td>
<td></td>
</tr>
<tr>
<td>+3h 27min</td>
<td>EPS ignition</td>
</tr>
<tr>
<td>+3h 34min</td>
<td>Shut down of EPS (second boost) and beginning of the 2nd ballistic</td>
</tr>
<tr>
<td>phase</td>
<td></td>
</tr>
<tr>
<td>+3h 35min</td>
<td>Separation of the first and third Galileo satellites</td>
</tr>
<tr>
<td>+3h 55min</td>
<td>Separation of the second and fourth Galileo satellites</td>
</tr>
<tr>
<td>+4h 8min</td>
<td>Start of upper stage passivation</td>
</tr>
<tr>
<td>+4h 40min</td>
<td>End of the Arianespace mission</td>
</tr>
</tbody>
</table>

For more information, visit us on arianespace.com
ARIAINE 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, servos, 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.

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Principales étapes du vol Ariane 5 ES

**The Ariane 5 ES flight events**

- **200 km**
  - Allumage de l’Étage à Propérgols stockables (EPS)
  - Séparation des satellites 17&18
  - Jettisoning of fairing
  - Shut-down and separation of storable propellant stage (EPS)
  - Shut-down of upper stage and satellites 15&16 separation

- **100 km**
  - Jettisoning of solid boosters

- **70 km**
  - Décollage
  - Lancement

Trajectoire Ariane 5 ES pour l’orbite opérationnelle Galileo

**Ariane 5 ES trajectory for Galileo operational orbit**

For more information, visit us on arianespace.com
ARIANESPACE AND THE GIUANA 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 GIUANA 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 (ECPUs), 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.