LAUNCH KIT

December 2017

VA240

Galileo FOC-M7
SAT 19-20-21-22

esa

GALILEO
19-20-21-22

cnes

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

For its 11th launch of the year, and the sixth Ariane 5 liftoff from the Guiana Space Center (CSG) in French Guiana during 2017, 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 second 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 VA240 in Arianespace's launcher family numbering system, 22 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 European program

Galileo is Europe's own global navigation satellite system. Under civilian control, Galileo offers guaranteed high-precision positioning around the world. Its initial services began in December 2016, allowing users equipped with Galileo-enabled devices to combine Galileo and GPS data for better positioning accuracy.

The complete Galileo constellation will comprise a total of 24 operational satellites (along with spares); 18 of these satellites already have been orbited by Arianespace.

ESA transferred formal responsibility for oversight of Galileo in-orbit operations to the GSA (European GNSS Agency) in July 2017.

Therefore, as of this launch, the GSA will be in charge of the operation of the Galileo satellite navigation systems on behalf of the European Union. GSA will be responsible for operating these satellites as soon as they separate from the launcher. Satellite positioning operations and system operation will be carried out in conjunction with ESA.

THE ARIANESPACE FAMILY: SUPPORTING THE DEPLOYMENT OF GALILEO

Arianespace orbited the Galileo IOV 1 and 2 (In-Orbit Validation) satellites on Soyuz Flight VS01 on October 21, 2011, followed by IOV 3 and 4 on Flight VS03 on October 12, 2012.
Under ESA-EU co-financing, this phase has allowed the validation of the overall concept.

Previously, the ESA GIOVE-A and GIOVE-B experimental satellites were orbited by Soyuz from the Baikonur Cosmodrome in Kazakhstan (via Arianespace's Starsem affiliate) in 2005 and 2008.

The first two Full Operational Capability (FOC) satellites for Galileo (Sats 5 and 6) were launched on August 22, 2014. From 2015 to 2017, the Galileo Sats 7 to 18 satellites were deployed by Arianespace Flights VS11, VS12, VS13, VS15, all via Soyuz; and VA233, the first dedicated Ariane 5 ES version launch.

Flight VA240, the second dedicated Ariane 5 ES mission for the Galileo constellation, will orbit Galileo FOC-M7 satellites 19 to 22. Arianespace will then deploy the next four satellites on the third and last Ariane 5 ES version mission in mid-2018.

The A62 version of Ariane 6 will then take over, with two launches used to orbit another four satellites, during a timeframe between December 2020 and June 2021.

The Flight VA240 mission will be Arianespace's 56th performed for ESA. Arianespace has seven more ESA missions in its launch manifest: three for the European Commission, carrying eight Galileo spacecraft; 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.

For Flight VA240, these will be the 19th, 20th, 21th and 22th OHB-built satellites launched by Arianespace (18 for Galileo).
The next four Galileo spacecraft are under construction by OHB in Bremen.

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MISSION DESCRIPTION

The sixth Arianespace Ariane 5 launch of the 2017 will place the four Galileo satellites into MEO (Medium Earth Orbit) circular orbit.

The launcher will be carrying a total payload of approximately 3,282 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 **Tuesday, December 12, 2017** at exactly:

> **3:36:07 p.m.,** Kourou time
> **1:36:07 p.m.,** Washington D.C. time
> **18:36:07, Universal Time (UTC)**
> **7:36:07 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 45 seconds.

TARGETED ORBIT

Circular orbit
MEO-plane A

Altitude
22,922 km.
Semi-major axis: 29,300 km.

Inclination
57.00 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 six 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 3,000 meters/second, and will be at an altitude of 22,925 kilometers, 300 km. under Galileo's operational orbit.

PAYLOAD CONFIGURATION

> **Payload: Galileo FOC M7, SAT 19, 20, 21, 22**
Mass at liftoff: 715 kg. each, for a total of 2,860 kg.

> **Medium version of the payload fairing**

> **Dispenser (carrying structure and deployment system) for the four Galileo FOC-M7 payloads, developed and built by ArianeGroup.**

Galileo FOC-M7, SAT 19-20-21-22

CUSTOMER	The European Space Agency (ESA) on behalf of the European Commission
PRIME CONTRACTOR	OHB System AG (spacecraft bus, prime), SSTL (payload)
MISSION	Navigation
MASS	Mass at launch of 715 kg. each, for a total of 2,860 kg.
DIMENSIONS	2.7 m. x 1.2 m. x 1.1 m.
WIDTH (with solar array deployed)	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 ArianeGroup as production prime contractor.

47.4 m

Fairing

(RUAG Space): 14 m
Mass: 1.9 t

760 tons
(total mass at liftoff)

4 x Galileo Satellites

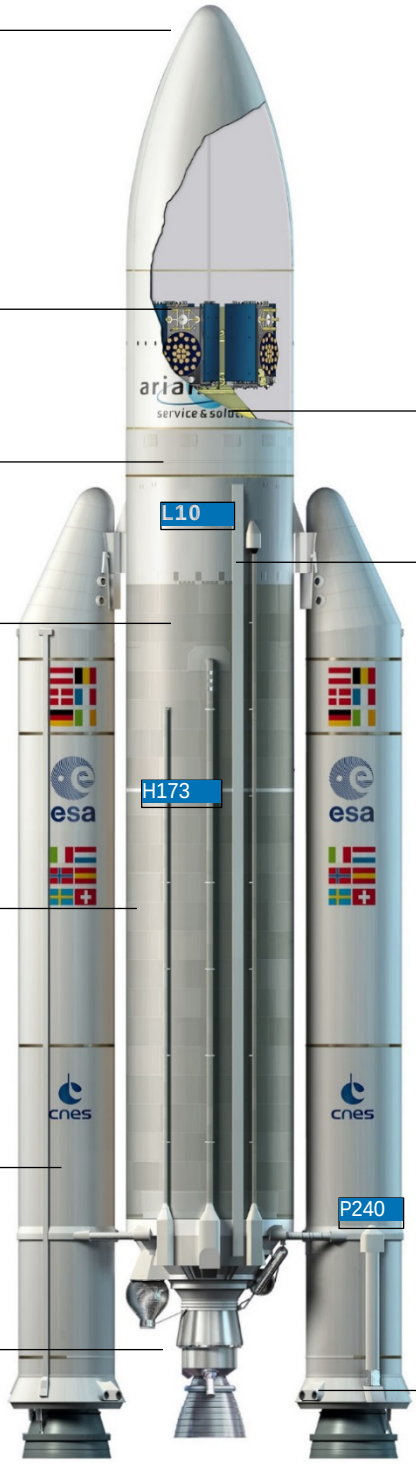
(**ESA**)
Mass: 2,860 kg.

Dispenser FOC A5 - Internal structure

Mass: 416 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-M7, SAT 19-20-21-22 SATELLITES

SATELLITES AND LAUNCH VEHICLE CAMPAIGN CALENDAR

DATES	SATELLITE ACTIVITIES	LAUNCH VEHICLE ACTIVITIES
September 18, 2017	Arrival in French Guiana of the two first Galileo satellites; beginning of preparation in the S1A hall	
October 17, 2017	Arrival in French Guiana of the two other Galileo satellites; beginning of preparation in the S1A hall	
October 19 to 24, 2017	Fitcheck of the four Galileo satellites in the S1A hall	
October 23, 2017		Campaign start review EPC unpacking - EPC erection
October 24, 2017		EAP 1 transfer – EAP 2 transfer
October 25, 2017		EAP positioning
October 26, 2016		EPC/EAP integration
November 2, 2017		EPS erection - Vehicle equipment bay integration
November 9, 2017	Transfer of the two first Galileo satellites to the S3B hall	
November 10, 2017	Transfer of the two last Galileo satellites to the S3B hall	
November 14 to 17, 2017	Galileo satellite fueling operations in the S3B hall	
November 22, 2017		Transfer from the BIL (Launcher Integration Building) to BAF (Final Assembly Building)
November 22 to 27, 2017	Four Galileo satellites integration on dispenser	
November 28, 2017	Transfer of the four Galileo satellites to BAF	

SATELLITES AND LAUNCH VEHICLE CAMPAIGN FINAL CALENDAR

DATES	SATELLITE ACTIVITIES	LAUNCH VEHICLE ACTIVITIES
Wednesday, November 29, 2017	Integration of the four Galileo satellites on the launcher	
Thursday, November 30, 2017	Encapsulation of the four Galileo satellites in the payload fairing	
Friday, December 1, 2017	Completion of composite integration on launcher and payload check	
Monday, December 4, 2017		N2H4 fueling of SCA SCA pressurization for launch
Tuesday, December 5, 2017		MMH fueling of EPS
Wednesday, December 6, 2017		Launch rehearsal N2H4 fueling of EPS
Thursday, December 7, 2017		Arming of launch vehicle
Friday, December 8, 2017		Launch readiness review (RAL), final preparation of launcher and BAF for the chronology
Monday, December 11, 2017		Rollout from BAF to Launch Zone, launch vehicle connections. Filling of the EPC liquid helium tank. Heating of EPS tank.
Tuesday, December 12, 2017		Final 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
- 11 h 23 min	Check of electrical systems
- 04 h 53 min	Start of filling of EPC with liquid oxygen and hydrogen
- 04 h 03 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 20 s	EAP separation
+ 3 min 44 s	Fairing jettisoned
+ 8 min 55 s	End of EPC thrust phase
+ 9 min 01 s	EPC separation
+ 9 min 08 s	EPS ignition
+ 19 min 58 s	Shutdown of EPS (first boost) and beginning of the 1st ballistic phase
+ 3h + 27 min 50 s	EPS ignition
+ 3h + 34 min 08 s	Shutdown of EPS (second boost) and beginning of the 2nd ballistic phase
+ 3h + 35 min 45 s	**Separation of the Galileo satellites 19 and 21**
+ 3h + 55 min 45 s	**Separation of the Galileo satellites 20 and 22**
+ 4h + 09min 18 s	Upper stage passivation
+ 4h + 40min 52 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).

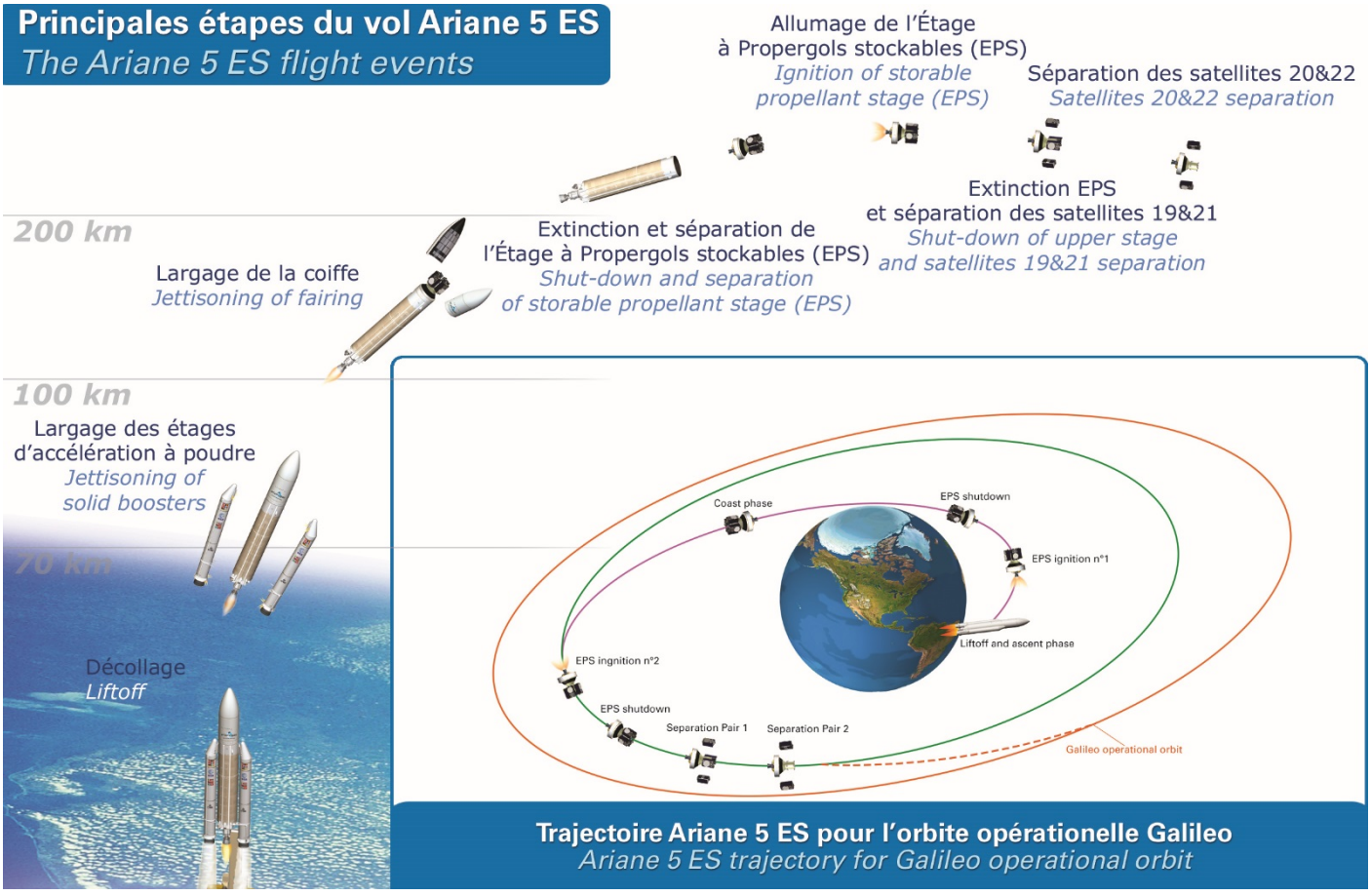
At T-4 seconds, the onboard computer takes over control of final engine startup and liftoff operations. It:

> 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 is a subsidiary of ArianeGroup, which holds 74% of its share capital; the balance is held by 17 other shareholders from the European launcher industry.

Since the outset, Arianespace has signed over 530 launch contracts and launched 550-plus satellites. More than half of the commercial satellites now in service around the globe were launched by Arianespace. The company posted sales of approximately 1.4 billion euros in 2016.

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 ArianeGroup - 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 ArianeGroup 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.