FLIGHT ST 10

PRESS KIT

Baikonur, August 2000

Starsem flight ST 09, Soyuz - Fregat - Cluster II, July 16, 2000.

Completing an important scientific mission for ESA

Mission overview

Starsem's flight ST10 is the second of two missions to launch a quartet of Cluster II spacecraft for the European Space Agency. Both flights use the new Soyuz-Fregat launcher version developed by Starsem. The first mission, performed on July 16, 2000 at 6:39 p.m. from Baikonur Cosmodrome, successfully delivered the initial set of Cluster II satellites into an elliptical orbit.
The purpose of flight ST10 is to launch the remaining Cluster II spacecraft pair. Once released, the satellites will use their own on-board propulsion system to reach the final operational orbit. This involves changing the orbital inclination from 64.8 degrees to 90 degrees, and raising the orbit's highest point above Earth to 119 000 km and the lowest point to 19 000 km.

The flight at a glance

After lifting off from Baikonur Cosmodrome on Starsem's Soyuz-Fregat launcher, the Cluster II spacecraft will be injected into a highly elliptical orbit inclined 64.8 degrees.
The mass of the two Cluster II spacecraft is 2 373 kg. Starsem validated the ground handling, preparation and launch of the Soyuz-Fregat vehicle with its Cluster II payload during flight ST08 which carried a Dumsat mockup payload that represented the Cluster II satellite stack.

Launcher profile

During its 8 min., 49 sec. of flight, the Soyuz launch vehicle will inject the upper composite, consisting of the Fregat upper stage and its Cluster II satellite payload, into a suborbital trajectory.

Flight of the Fregat upper stage

First Fregat burn

Once separated from Soyuz, the Fregat upper stage will place the upper composite into a circular parking orbit.

Fregat coast phase

After its first burn, the Fregat upper stage will ensure that the upper composite remains in a three-axis stabilized mode during the coast phase, maintaining proper thermal conditions for the Cluster II satellites.

Fregat second burn

Once the upper composite reaches the appropriate initial orbit, Fregat will inject it into a highly elliptical orbit for satellite separation. The orbital parameters will be:

Minimum altitude:	251 km
Maximum altitude:	18 053 km
Orbit inclination:	64.8 degrees

Payload separation

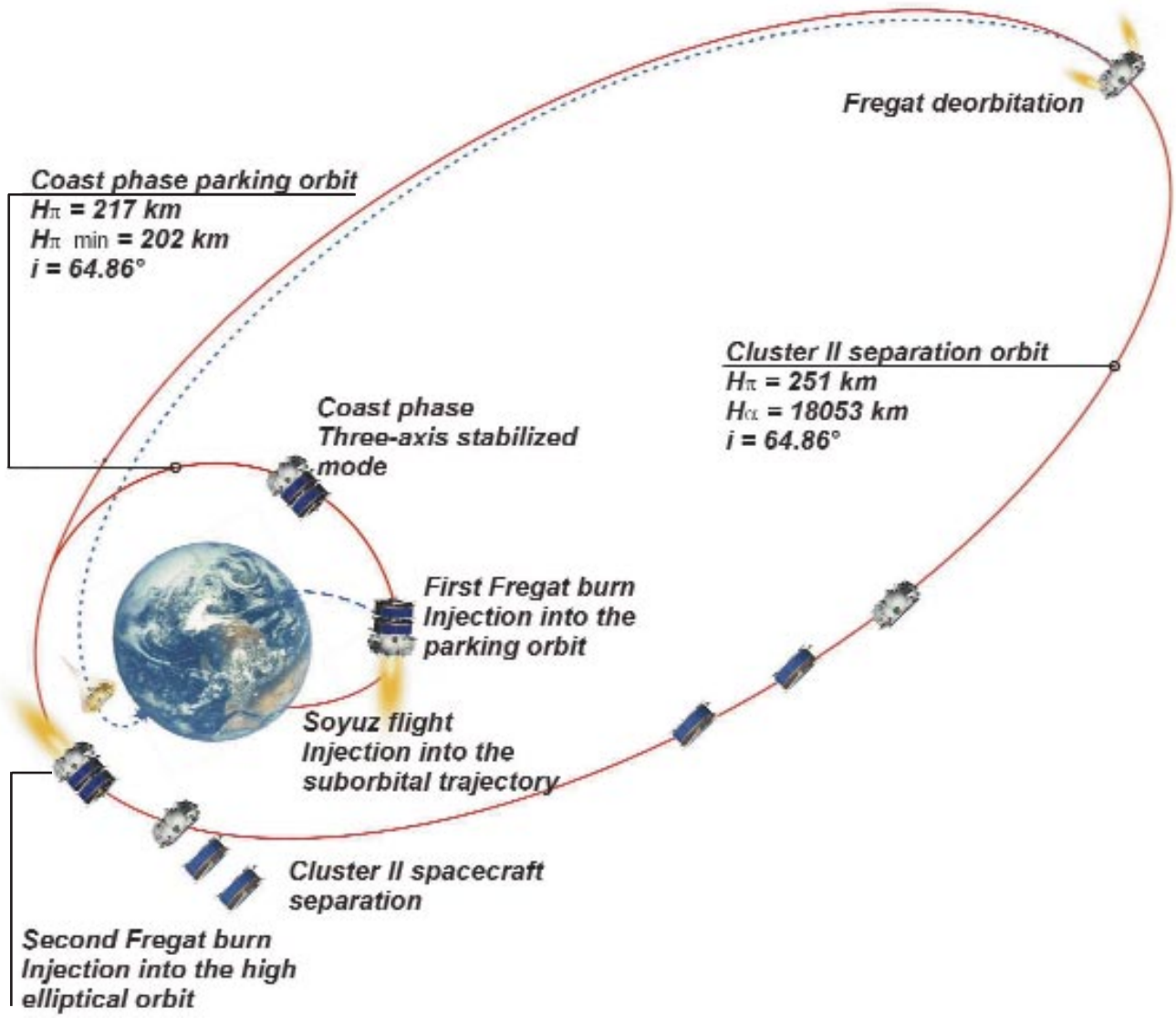
After the Fregat's second burn, the upper stage will accurately align the upper composite in the desired separation attitude. Once this is accomplished, Fregat will spin up the upper composite and then release the Cluster II satellites one after the other. Release of the two spacecraft will occur 1 h 30 mn after liftoff.

Fregat deorbit and reentry

Four hours after liftoff, the Fregat stage will decelerate into a reentry orbit. Its controlled destructive reentry will occur 6 h 40 mn after liftoff.

Successful injection of the Cluster II spacecraft into the planned highly elliptical orbit will represent a successful completion of Starsem's second Soyuz-Fregat mission with the European Space Agency's Cluster II scientific payload.

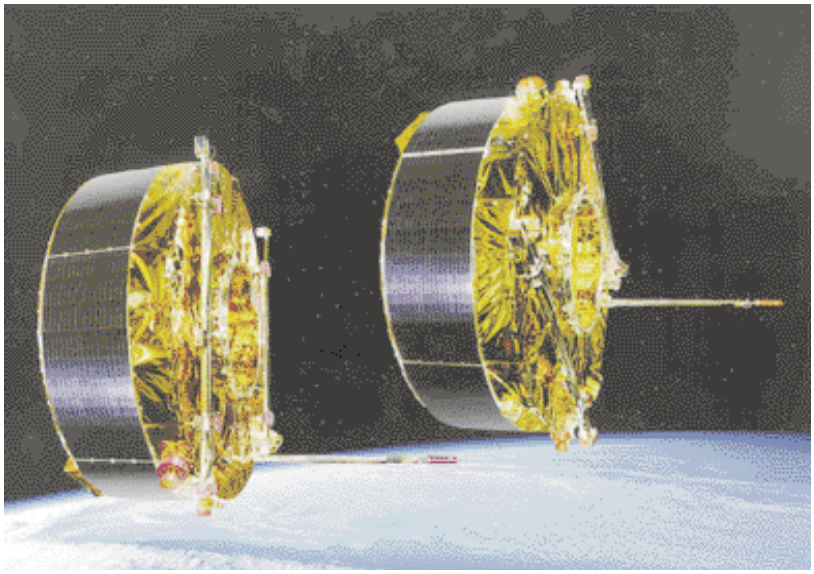
Mission profile



Cluster II spacecraft

Cluster II is part of an international program to find out more about how the Sun and Earth interact. Once in orbit, the four Cluster II spacecraft will spend two years passing in and out of the Earth's magnetic field. Their mission will be to complete the most detailed investigation yet made into the ways in which the Sun and Earth interact.

By making simultaneous measurements and sometimes flying in a lopsided pyramid or tetrahedron formation, they will be able to make the first detailed, three-dimensional, study of the changes and processes taking place in near-Earth space. The Cluster II mission will be the first time that four identical spacecraft have flown in formation around the Earth. When they are only a few hundred kilometers apart, they will be able to study small-scale features in the surrounding space. At other times, they may be separated by up to 20 000 km, in order to obtain a broader view of what is going on. The satellites will follow highly elongated, polar orbits which will take them between 19 000 and 119 000 km above the planet. Sometimes, they will be inside the Earth's magnetic shield and sometimes they will be outside, fully exposed to the supersonic solar wind. The main task for the Cluster II spacecraft will be to look at what happens when these solar particles slam into the Earth's protective magnetic shield.



The day-to-day operation of the spacecraft will be carried out by the European Space Operations Center (ESOC) in Darmstadt, Germany. ESOC will be responsible for the transfer of the spacecraft into their operational orbits, combined operation of the spacecraft and their payloads throughout their lifetime and collection and distribution to scientific community of all the raw science data.

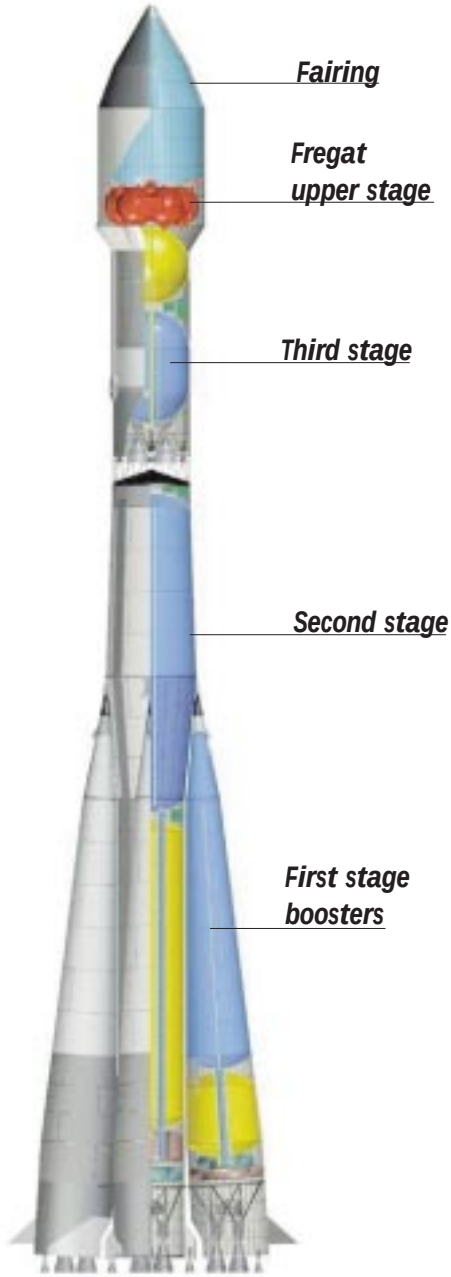
Each of the four Cluster II spacecraft is shaped like a giant disk, 1.3 m high and 2.9 m in diameter. In the center is a cylinder with an aluminum honeycomb structure covered with a skin of carbon fiber reinforced plastic. The equipment panel inside this cylinder supports the main engine, two high-pressure tanks and other parts of the propulsion system. Six spherical fuel tanks made from titanium are attached to the outside of this central cylinder. Most of the fuel on each satellite will be consumed soon after launch, during the complex maneuvers required to reach its operational orbit. Each spacecraft carries eight thrusters for smaller changes of orbit. Electrical power is provided by six curved solar panels attached around the outside of the platform. Various rod-shaped booms open out once the satellite reaches orbit.

Each Cluster II spacecraft carries an identical set of 11 scientific instruments. These are designed to study space weather inside and outside the region influenced by the Earth's magnetic field, the magnetosphere.

Industries in almost all of the 14 ESA member States and the United States have provided hardware for the Cluster II project. The prime contractor is the German company Dornier Satellitensysteme, but many other companies have also participated.

Soyuz-Fregat launch vehicle

The Soyuz is one of the world's most reliable and frequently used launch vehicles. More than 1 630 launches have been made with Soyuz launchers to orbit satellites for telecommunications, Earth observation, weather, and scientific missions, as well as for manned flights.



Designed to offer cost-effective solutions for missions to medium and high Earth orbits, including constellation deployment and escape trajectories, Soyuz-Fregat is a key asset in Starsem's commercial launch service offering.

Soyuz-Fregat is a multiple stage vehicle comprising a lower composite grouping four boosters, a central core second stage, a third stage and an upper composite combining a Fregat upper stage and a fairing.

The First Stage Boosters

The first stage's four boosters are assembled laterally around the second stage central core. The boosters are identical and cylindrical-conic in shape with the oxygen tank located in the cone-shaped portion and the kerosene tank in the cylindrical portion.
An NPO Energomash RD 107 engine with four main chambers and two gimbaled vernier thrusters is used in each booster. The vernier thrusters provide three-axis flight control.
Ignition of the first stage boosters and the second stage central core occur simultaneously on the ground. When the boosters have completed their powered flight during ascent, they are separated and the core second stage continues to function.
First stage boosters separation occurs when the predefined velocity is reached, which is at about 118 seconds after liftoff.

The second stage

An NPO Energomash RD 108 engine powers the Soyuz second stage. This engine differs from those of the boosters by the presence of four vernier thrusters, which are necessary for three-axis flight control of the launcher after the first stage boosters have separated.
An equipment bay located atop the second stage operates during the entire flight of the first stage and second stages.

The third stage

The third stage is linked to Soyuz second stage by a latticework structure. When the second stage's powered flight is complete, the third stage engine is ignited. Separation of the two stages occurs by the direct ignition forces of the third stage engine.
A single-turbopump RD 0110 engine from KB KhA powers the Soyuz third stage.
The third stage engine is fired for about 240 seconds, and cutoff occurs when the calculated velocity increment is reached. After cutoff and separation, the third stage performs an avoidance maneuver by opening an outgassing valve in the liquid oxygen tank.

Launcher telemetry tracking & flight safety systems

Soyuz launcher tracking and telemetry is provided through systems in the second and third stages. These two stages have their own radar transponders for ground tracking. Individual telemetry transmitters are in each stage. Launcher health status is downlinked to ground stations along the flight path. Telemetry and tracking data are transmitted to the mission control center, where the incoming data flow is recorded. Partial real-time data processing and plotting is performed for flight following and initial performance assessment. All flight data is analyzed and documented within a few hours after launch.

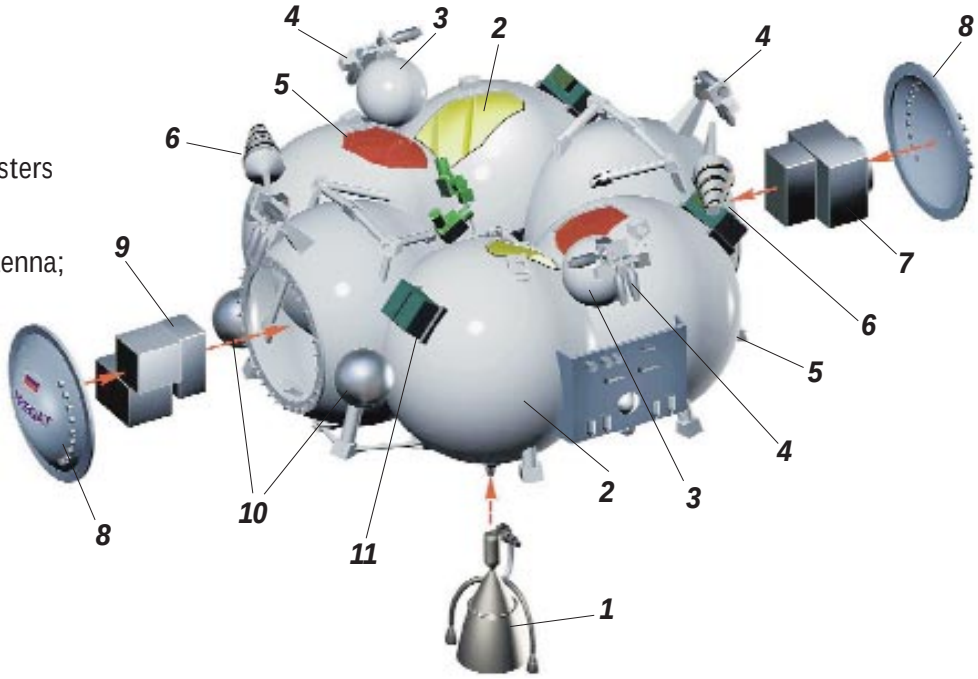
The Fregat upper stage

Using flight-proven technologies, the launcher's Fregat stage is constituted by a main engine and propulsion subsystem inspired by spacecraft propulsion systems proven on 27 lunar and deep space missions. During these missions, the engine functioned under extreme conditions. Fregat control system is also qualified to severe Russian domestic specifications.
Incorporating numerous flight proven innovative design solutions, the Fregat upper stage offers compact design and low dry mass, multistart capabilities and 3-axis orientation, for versatile spacecraft delivery.

FLIGHT ST 10

FREGAT upper stage's main purposes

1) S5.92 main engine;
2) fuel tank (UDMH);
3) hydrazine tank;
4) Attitude control thrusters
5) oxidizer tank (N_2O_4);
6) telemetry system antenna;
7) control system;
8) equipment bay cover;
9) telemetry and orbit radio control system;
10) helium tanks;
11) chemical battery.



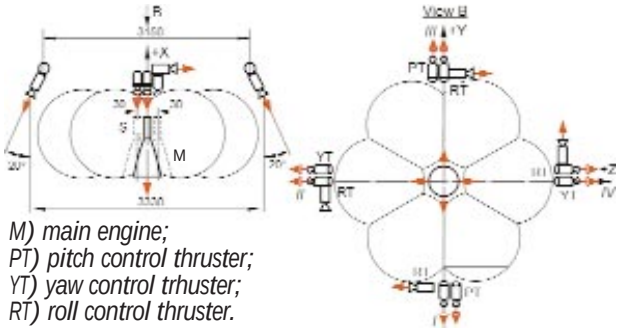
FREGAT upper stage main characteristics:

Dimensions:	
❑ Height (m)	1.5
❑ Diameter (m)	3.3

Mass:	
❑ Dry mass (kg)	950 - 1150
❑ Lift-off mass (kg)	up to 6535
❑ Propellant mass (kg)	up to 5350
❑ Propellant	UDMH-N_2O_4

Control:	
❑ Pitch, Yaw	by main engine (active leg) by thrusters (coast leg)
❑ Roll	thrusters
❑ Guidance	autonomous inertial 3-axis
❑ Lifetime (hours)	up to 48

Fregat attitude control



M) main engine;
PT) pitch control thruster;
YT) yaw control trhuster;
RT) roll control thruster.

Functions of attitude control thrusters:

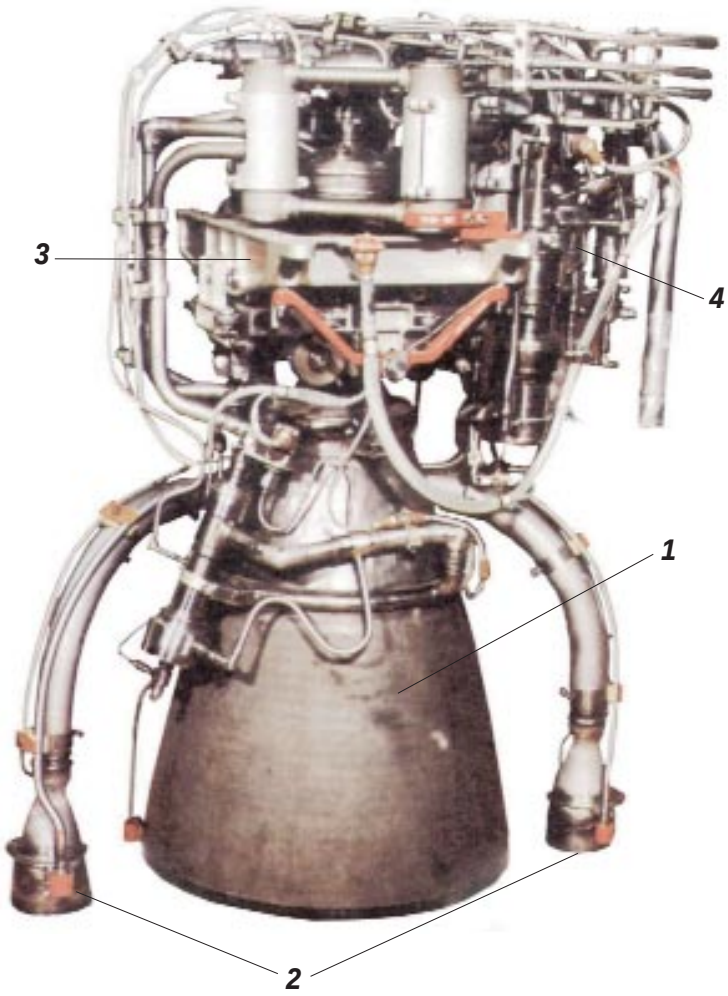
- Main engine start-up acceleration
- Roll stabilization during the main engine operations
- Small maneuvers
- Attitude control
- Spin-up

Manufacturers:

- Structure, integration and tests - NPO Lavochkin
- Main engine and small thrusters - A.M. Isayev Design Bureau of Chemical Machine Building, Ust-Katav Mechanical Plant
- Control system - N.A. Pilyugin Scientific and Production Centre of Automatic Instrument Engineering
- Telemetry system - Izhevsk Radio plant
- Power supply system - Design Bureau ORIONT-HIT

S5.92 ENGINE

The S5.92 engine is a single chamber, with a turbopump feeding system.
The turbopump assembly turbine works with the main propellant components. The exhaust is implemented through two fixed exhaust nozzles.
The salient feature of S5.92 engine consists in installation of its chamber not in the gimbal mount, as usual, but in the hinge ensuring plane-parallel motion of the engine inside the propulsion system.
The engine S5.92 is capable to operate in two modes : large and small thrust. On the first mode the spacecraft maneuvers connected with large velocity change are performed, on second, maneuvers requiring high accuracy or relatively small velocity increment.



1) main chamber;
2) exhaust nozzles;
3) hinge ensuring plane-parallel motion;
4) turbopump assembly.

Propulsion system characteristics:

Thrust mode	Large thrust	Small thrust
Dry mass (kg)	75	
Overall dimensions (m)	0.677 x 0.838 x 1.028	
Propellant	UDMH/N_2O_4	
Main chamber thrust (kN)	19.6	14.7
Isp (s)	327 s	316 s
Pressure in chamber (MPa)	9.80	6.85
Mixture ratio	1.95 - 2.05	2.00 - 2.10
Feed system	Turbopump	
Total burn time* (s)	870	
Restart capability	up to 20	

* Depending on propellant capacity

FREGAT performances:

Examples	SOYUZ-FREGAT
Circular orbits	
h=500 km; i=51.8°	5300 kg
h=1000 km; i=51.8°	4900 kg
h=1500 km; i=51.8°	4500 kg
Elliptical orbits	
hp=200 km; ha=10000 km; i=51.8°	3100 kg
Escape mission	
Mission to Mars	1100 kg

Baikonur cosmodrome

Soyuz missions use the Baikonur Cosmodrome's proven infrastructure, and launches are performed by trained personnel with extensive operational experience.

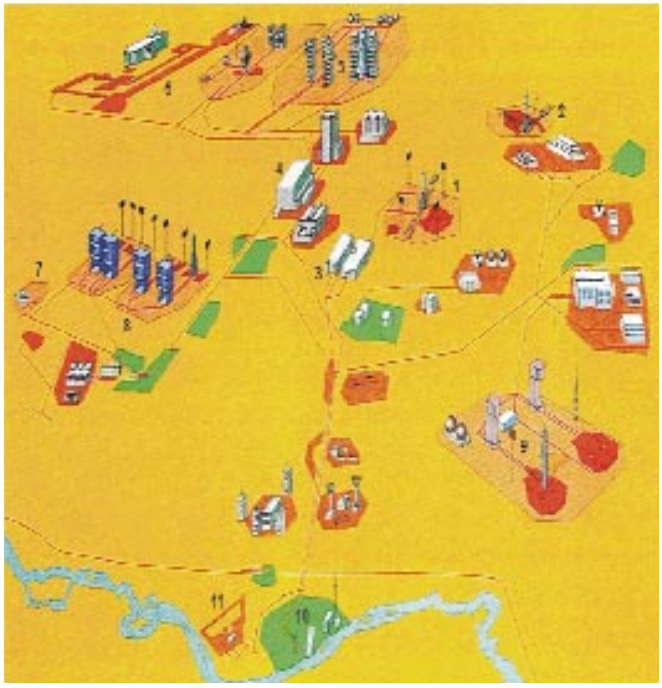
Baikonur Cosmodrome is located in the Republic of Kazakhstan in Central Asia between 45 deg. and 46 deg. North latitude and 63 deg. East longitude.

Two launch pads are dedicated to Soyuz missions. Areas for customers and spacecraft ground test equipment are located in dedicated rooms in the pad basement and launch bunker.

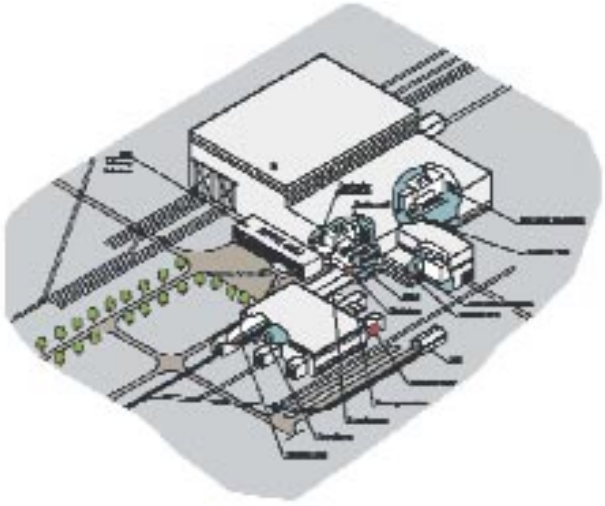
For Starsem, a modern new facility called the Starsem Payload Processing Facilities (SPPF) have been built for operations at Baikonur Cosmodrome.

This 1,158-square-meter operations complex is situated in the former Energya launcher integration bulding and consists of:

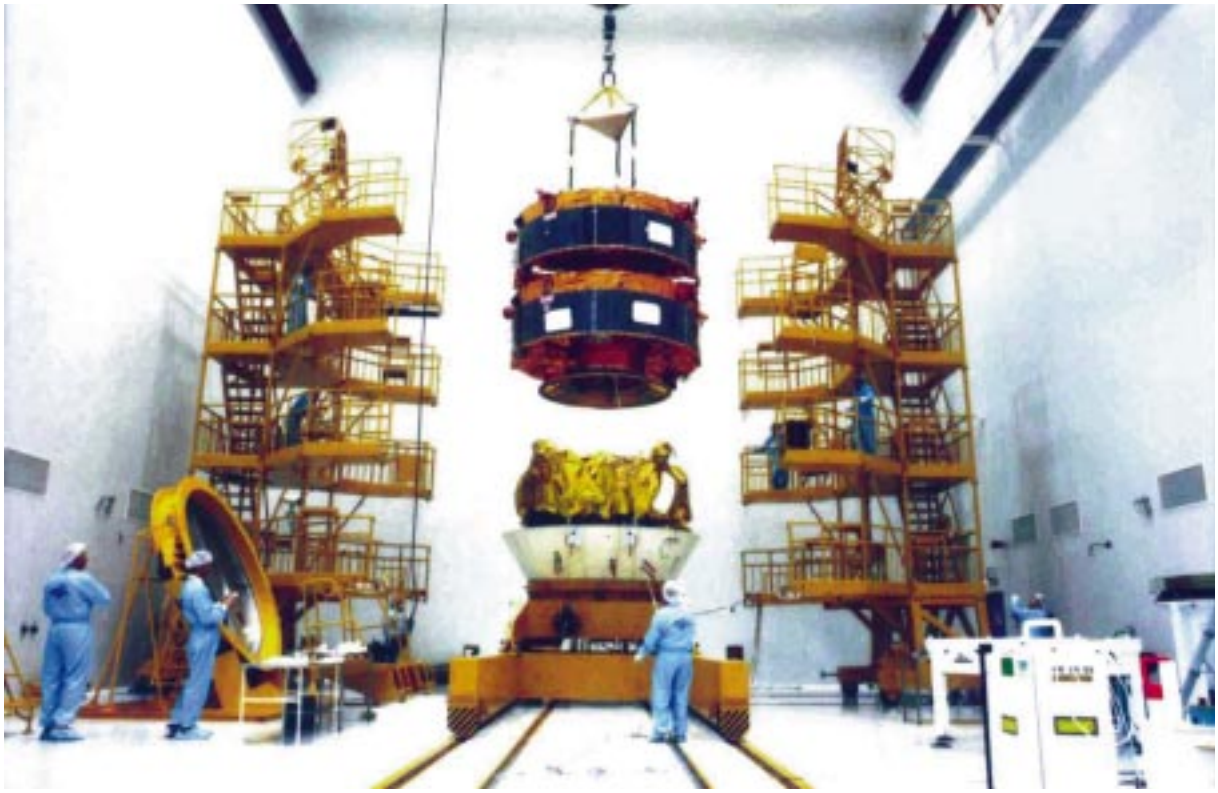
- The Payload Processing Facility (PPF) - The 286 square meter PPF includes a Class 100,000 high bay and two control rooms.
- The Hazardous Processing Facility (HPF) - The HPF covers a surface of 285 square meters, and incorporates a Class 100,000 high bay, control room and safety shower.
- The Upper Composite Integration Facility (UCIF) - This 587-square meter high bay has a Class 100,000 high bay.



1. Soyuz launch pad
2. Soyuz launch pad used for FREGAT
3. Soyuz launch vehicle préparation building (MIK)
4. Energia hall with STARSEM PPF
5. Energia / Buran launch pads
6. Yubileyny airport
7. Cyclon launch pad
8. Proton launch pad
9. Zenith launch pad
10. Cily of Leninsk
11. Krayny airport



Baikonur facilities adapted to Soyuz-Fregat missions



Cluster II spacecraft and Fregat upper stage integration in the UCIF

At the cosmodrome's facilities, Starsem has achieved, along with its Russian partners, a number of upgrades and adaptations dedicated to serve new Soyuz-Fregat pre-launch processing procedures. At the cosmodrome's Energya Hall, where Starsem has installed its **Payload Processing Facilities (PPF)**, the following upgrades have been made:

- The **Hazardous Processing Facility (HPF)**, designed to process dangerous operations like proof pressure tests and spacecraft loading, has been adapted to accommodate bi-propellant spacecraft. A new remote control room with dedicated data transmission system and color video network has been installed to improve operation's safety.
- At the **Upper Composite Integration Facility (UCIF)**, designed to handle spacecraft preparation and integration with IKAR or FREGAT upper stages, the ground cable network has been improved allowing extended S/C testing with check out equipment remaining in the PPF control room.
- Dedicated internal networks allow both voice and data exchange between rooms and offices. A VSAT system provides direct access to Paris where specialized connections can be organized by STARSEM with other locations.

MIK 40 with Fregat processing facility

Fregat bunker

Soyuz-Fregat on the launch pad #6

Two Soyuz integration buildings and two launch pads are used depending on the upper stage configuration. The complex #5 was used for SOYUZ-IKAR during GLOBALSTAR launches. The launch complex #6 will be used for the SOYUZ-FREGAT launches:

- The **Soyuz launch vehicle integration building** (MIK 40) has been revalidated to allow the preparation and integration of the Soyuz three stages.
- A specific area has been upgraded to carry out the mechanical and electrical preparation of the Fregat upper stage and was fully operational for the first campaign.
- The launch pad #6 itself received dedicated improvement to realize pre-launch and launch operations with the SOYUZ-FREGAT rocket system.

In addition to that, some other modifications are specific to the CLUSTER II launch equipment:

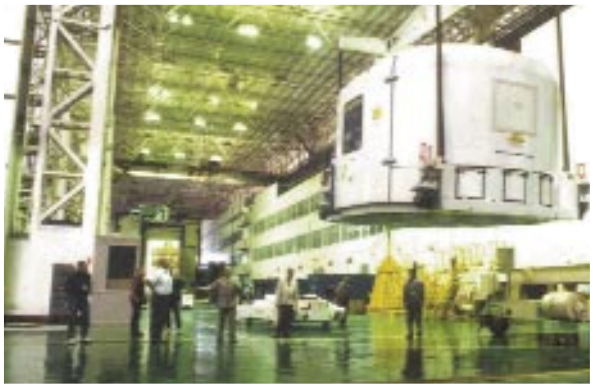
- New mast umbilical harness and under table dedicated room;
- A 64kbps data line for live communication to the customer's remote mission control center;
- Dedicated offices for FREGAT flight monitoring with live tracking display;
- Independent 50 m2 bunker with no break power supply to house EGSE for satellite support during pre-launch and launch sequence.

Cluster II launch campaign

All four Cluster II spacecraft and their associated equipment have been safely delivered to Baikonur at the end of April and the beginning of May 2000 using two Antonov 124 cargo planes. The spacecraft were lifted onto a special train for transportation to the Starsem Payload Processing Facilities. Little time was wasted in getting the launch campaign under way. Since the beginning of May, different system tests and scientific experiments were carried out on satellites, which are dispatched between PPF, HPF and UCIF. All necessary data is centralized in the PPF's new remote control room where the necessary check out hardware is located.

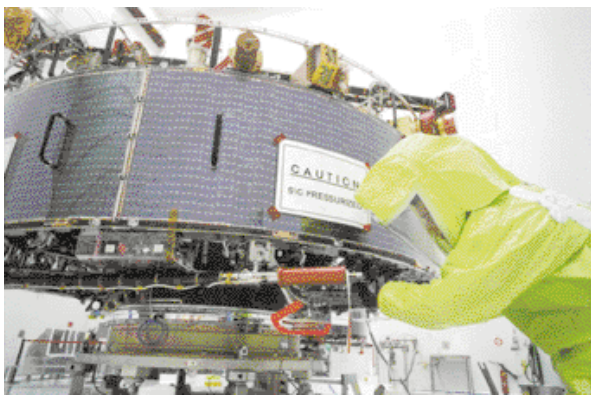
.

Cluster II spacecraft arrival at Baikonur



Cluster II spacecraft arrival at Energya hall

Cluster II spacecraft in PPF



Fueling operation in HPF

About Starsem

The shareholders

Starsem is a European-Russian company dedicated to providing Soyuz family launch services to the commercial market.
Starsem's activities include:

- Exclusive marketing, sales and management of commercial launch services using Soyuz launchers.
- Supervision of Soyuz commercial launcher production.
- Soyuz launch operations at the Baikonur cosmodrome.
- Development of new European and Russian joint space programs.

Starsem shareholders are four of the world's leading space organizations: European Aeronautic, Defense and Space company, Arianespace, the Russian Aviation and Space Agency and Russia's Samara Space Center. Starsem brings together commercial and operations teams with years of experience gained on hundreds of missions.

EADS

The European Aeronautic, Defense and Space company (EADS) is the world's third largest aerospace and defense company, created through the merger of France's AEROSPATIALE MATRA, Spain's CASA and Germany's DASA. EADS will be the world's second leading jetliner manufacturer (with 80% of Airbus), and number one in helicopters (100% of Eurocopter) and commercial launch vehicles (Ariane). It will also be among the world leaders in satellites (Astrium), military aircraft (A400M, Eurofighter, Mirage, Rafale) and defense systems (N°2 in missile systems).

Its business spans every sector of the industry, including space transportation, satellites, commercial jetliners, regional transport, light aircraft, civil and military helicopters, missiles, systems engineering and information technology. EADS is also the main industrial architect and stage integrator of Ariane launchers and Europe's first company in space transportation systems.

The company has the equivalent of more than 200 years of operational in-orbit service experience with telecommunications satellites it has built, while it designs and produces both military and civil spacecraft for Earth observation/reconnaissance. EADS launch vehicles holds the prime contractor for the ATV (Automated Transfer Vehicle) - one of the major European elements for the International Space Station, and it produced the Atmospheric Reentry Demonstrator (ARD) capsule that demonstrated Europe's ability to construct and operate a guided and controlled reentry vehicle.

Arianespace

Arianespace is the international leader in commercial launch services, and today holds more than 50 percent of the world market for satellites launched to geostationary transfer orbit (GTO). From its creation in 1980 as the first commercial space transportation company, Arianespace has successfully performed more than 100 launches and signed contracts with approximately 50 operators/customers for more than 200 payloads.

Arianespace oversees the marketing and sales, production and operation of the Ariane launch vehicles. The proven Ariane 4 is an industry reference for reliable launchers, and it continues to serve as Arianespace's workhorse vehicle. The increased-lift Ariane 5 was qualified for service in 1998, providing a capable launcher that will serve into the next century.

Based in Evry, France, Arianespace has 53 European corporate shareholders.

The Russian Aviation and Space Agency "ROSAVIACOSMOS"

The Russian Aviation and Space Agency (ROSAVIACOSMOS) was created in February 1992 by a decree issued by the President of the Russian Federation. It is the central body of the federal executive authority defining the Russian Federation's national policy in the field of space research and exploration. The agency also performs interdisciplinary coordination of national scientific and application space programs.

ROSAVIACOSMOS responsibilities include development and implementation of national space policy; acting in the capacity as the government customer in the development of scientific application space systems, facilities and equipment; international cooperation and collaboration in space research, and organization/coordination of commercial space programs. Operations under ROSAVIACOSMOS responsibility include TsNII Machine Building (TsNIIMash), Keldysh NII for Heat Processes (NIITP), NII of Chemical Engineering (NIIKhImMASH), the AGAT organization, and more than 40 other companies and organizations in which ROSAVIACOSMOS is a shareholder.

The Samara Space Center "TsSKB Progress"

The Samara Space Center "TsSKB Progress" was created by a Russian Presidential decree in 1996 by combining the TsSKB Central Samara Design Bureau and the Progress production plant.

TsSKB is one of the world leaders in the design of launchers, spacecraft and related systems. Its history goes back to the start of the space program in 1959 when a branch of the Moscow OKB-1 design bureau was established in the city of Kuibyshev (now known as Samara).

TsSKB evolved a family of launch vehicles from the OKB-1's R-7 intercontinental ballistic missile. Approximately 10 versions were developed, including Sputnik (which carried the first man- made satellite into orbit), Vostok (used for the initial manned space flight), Molniya and Soyuz.

The organization also has developed - or is involved in - a range of spacecraft, including the Foton, Bion, Resurs, and Nika. TsSKB has facilities for static, vibration, thermal and environmental testing, as well as simulators and test benches.

STARSEM
Tour Maine-Montparnasse
33, Avenue du Maine – BP 30
75755 Paris Cedex 15 - FRANCE
Telephone 33 (0) 1 56 80 09 60
Facsimile 33 (0) 1 40 64 05 62
E-mail: communication@starsem.com
www.starsem.com

Starsem's assets

Since its creation, Starsem has fully demonstrated its ability to provide a comprehensive package of launch services for scientific, telecommunications and other payload operators who need quick, reliable and affordable access to space.

Since initiating service in February 1999, Starsem performed six flights for Space Systems/Loral and one mission for the European Space Agency - all successfully placing their payloads into accurate orbits. The launches for Space Systems/Loral lofted a total of 24 satellites for the Globalstar constellation, providing a fast-paced launch rate that met Globalstar's timing requirements. A seventh launch, as well as additional mission options placed by Globalstar, will support the constellation in future years.

Starsem's mission for the European Space Agency carried the Cluster II scientific payload into orbit, marking the first of two flights for the satellite quartet. An important milestone in the Soyuz launcher's evolution was achieved in the first quarter of 2000, when Starsem and its Russian partners performed qualification and validation flights for the Soyuz-Fregat launch vehicle configuration in February and March 2000.

Starsem Flight STO9

Starsem Flight STO8

Starsem Flight STO7

Starsem Flight STO4

These flights fully confirmed the in-flight re-ignition and orbital maneuvering capabilities of the Fregat upper stage, and validated the mission profile for the subsequent Cluster II launches. These accurate preparatory missions were followed by the first Cluster II flight on July 16, 2000. In the future, the European Space Agency will use Starsem's services again for the launch of the Mars Express interplanetary probe in 2003.

Soyuz/ST

Moreover, and in order to implement its long-term strategy to broaden the family of reliable Soyuz launchers, Starsem started at the end of 1999 the development of Soyuz/ST, a new version of the proven Soyuz launch vehicle that will enter service in late 2001. Upgrades for the Soyuz/ST include the systematical use of the Fregat upper stage, the use of an increased-volume fairing in the 4-meter diameter class, the integration of new digital flight control and telemetry systems, the redesign of combustion chamber injectors in the first and second stage engines and other changes. Advantages of the Soyuz/ST will be in its payload fairing adapted for large satellite payloads, in more accurate trajectory and ability to reach a wider range of launch inclinations and altitudes than the current Soyuz versions.

In April 2000 Starsem has been selected to become equity partner and launch service provider for the SkyBridge constellation. SkyBridge will provide telecom operators with broadband capacities enabling them to offer business and residential users access to high-speed, highly interactive multimedia services anywhere in the world. Alcatel, prime contractor for the in-orbit delivery of the SkyBridge constellation, has selected Starsem to launch 32 SkyBridge satellites on 11 Soyuz/ST launch vehicles, each able to carry three satellites, beginning in 2002. Also included in the contract are options for additional launch services as required by SkyBridge.

In the future, Starsem is going to continue to broaden its response to market needs. Soyuz/ST will be the company workhorse as a part of a coherent European launch vehicle product line along with the heavy-lift Ariane 5 and the Rockot lightweight booster.