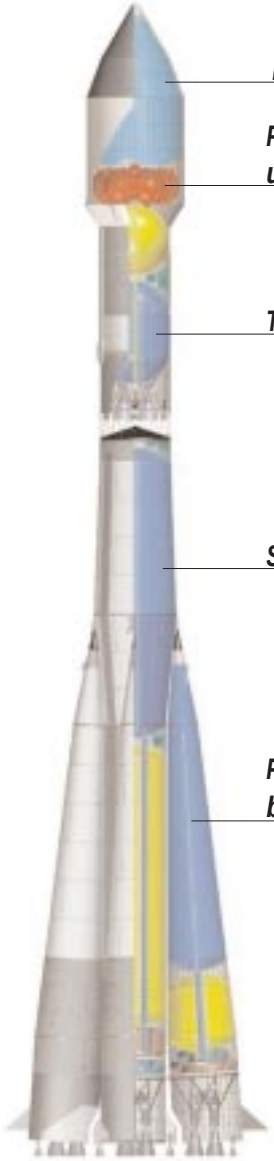
# SOYUZ-FREGAT qualification flight

PRESS KIT

**Baikonur, February 2000**

# Soyuz-Fregat launch vehicle




The mission planned for this month will mark Fregat's first use on Soyuz.

All Starsem flights in 2000 will use the Soyuz-Fregat launcher configuration. They include two missions with the European Space Agency's Cluster II scientific satellites.

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.

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 low height and low dry mass, multistart capabilities and 3-axis orientation, for versatile spacecraft delivery.

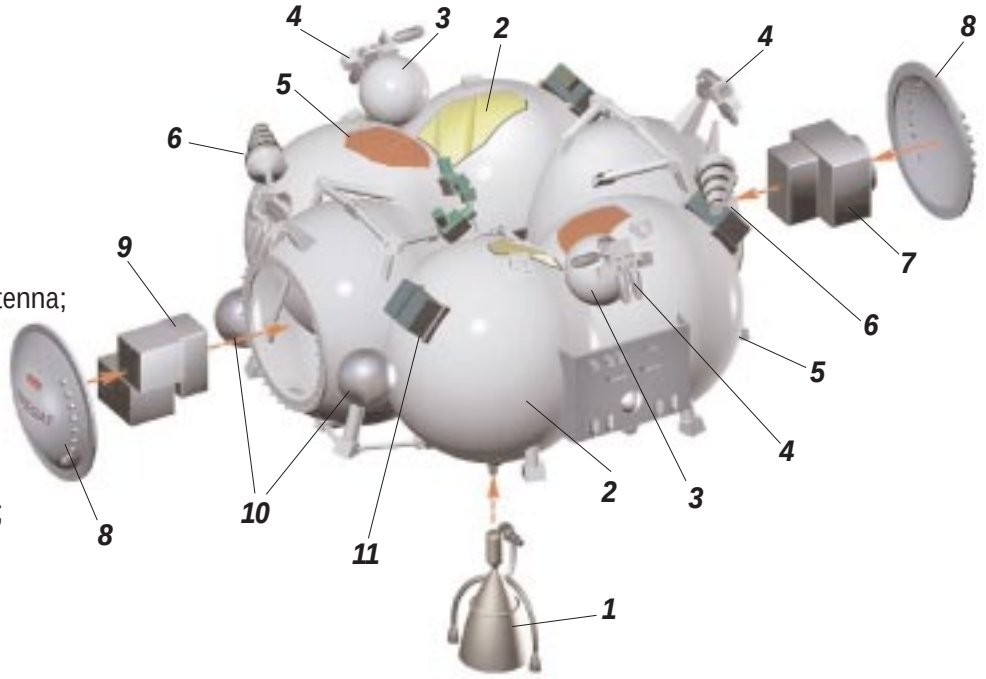
## Fregat upper stage's main purposes:

- spacecraft injection into MEO, HEO, Sun-synchronous, geotransfer, geostationary orbits and Earth escape trajectories;
- spacecraft dispersal into operational orbits in case of multisatellite launch;
- spacecraft transfer from suborbital trajectory into parking orbit (additional injection);
- spacecraft orientation and spinning-up before separation;
- performance of non-coplanar orbital maneuvers;
- Fregat deorbitation in a safe drop zone

# SOYUZ-FREGAT qualification flight

## FREGAT upper stage main components

1) S5.92 main engine;
2) fuel tank (UDMH);
3) hydrazine tank;
4) orientation control engines;
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.



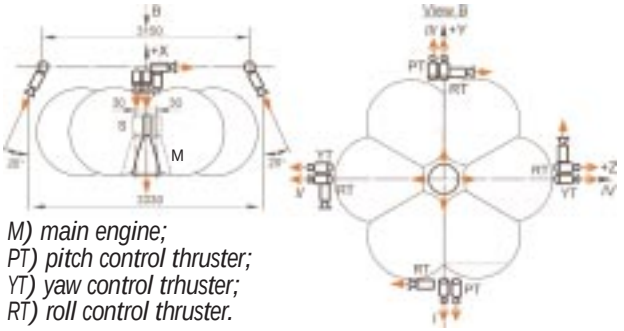

## FREGAT upper stage main characteristics:

| 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)<br>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:

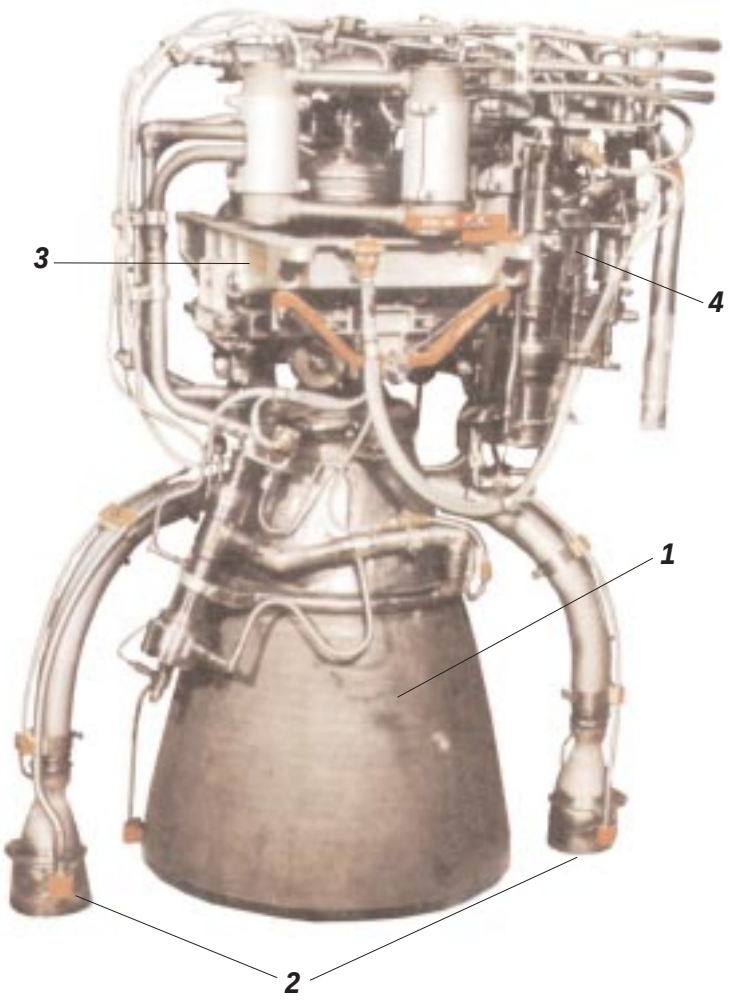
- Main engine start acceleration
- Roll stabilization during the work of main engine
- Small maneuvers
- Attitude control
- Spin-up

### 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) | 9.8 | 6.85 |
| Mixture ratio | 1.95 - 2.05 | 2.0 - 2.1 |
| Feed system | Turbopump | |
| Total burn time (s) | 870 | |
| Restart capability | up to 20 | |

## 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 |

# Description of Soyuz-Fregat qualification flight

## Mission overview

The Soyuz-Fregat qualification flight will qualify the new launcher's configuration to take onboard Cluster II spacecraft. The main mission objective is to qualify Fregat operation by a two-burn injection of a demonstration payload into final circular orbit. These multistart capabilities of Fregat will also be used during the Cluster II mission.
For the last part of the mission organized under responsibility of the Russian Aviation and Space Agency an inflatable re-entry and descent technology (IRDT) system will be deployed.

## Brief mission data

The Fregat upper stage and its payload will be injected into circular orbit by the Soyuz-Fregat launch vehicle. The flight will occur on Wednesday, February 9, 2000 at 4:20 a.m. local time (00:20 a.m. Paris time) from the Baikonur cosmodrome in Kazakhstan. For this flight as well as for the Cluster II mission, the Soyuz launch pad #6 will be used. The total mass of the upper composite at take off will be 7760 kg.
Injection orbit parameters:

- Circular orbit height: ~600 km
- Inclination: 64.9 deg (the same as for Cluster II mission)

## MISSION PROFILE

### Soyuz launch vehicle flight:

The Soyuz launcher will inject the upper composite into a suborbital trajectory. The drop zone for the III-rd stage of the Soyuz launcher is allocated in the Okhotsk Sea (the same as for Cluster II mission).

### Fregat upper stage flight:

***1) The first Fregat burn:***
After separation from the III-rd stage of Soyuz, Fregat will inject the upper composite from the suborbital trajectory to the elliptical transfer orbit:

- height of perigee ~185 km,
- height of apogee ~600 km.

Before the start of the main engine, the attitude control and stabilization engines provide axial acceleration during 55 sec. Velocity increment at the first Fregat burn is ~589 m/sec.

***2) Fregat coast phase of flight:***
After the first burn begins the coast phase, which lasts ~49 minutes.
The three-axis stabilized coast phase starts at the main engine cut-off (784 sec. of flight) and finishes ~460 sec. after it (~1244 sec. of flight). During this part of the coast phase Fregat provides the three axis stabilized mode for the upper composite. Then the upper composite turns to the attitude necessary for Fregat thermal mode. This phase starts at ~1270 sec. and finishes at ~3270 sec. of flight.

***3) The second Fregat burn:***
At the apogee of the transfer orbit, Fregat injects the upper composite into the circular orbit with a height of 600 km (velocity increment ~129 m/s).

***The successful injection into the final circular orbit represents the successful completion of the first Soyuz-Fregat qualification flight. The extended mission is under responsibility of the Russian Aviation and Space Agency.***

***Note:*** Actual time of events may be slightly different from the nominal values, presented in a table below.

### *Environmental measurements during the flight*

Soyuz and Fregat are equipped with telemetry systems for measuring the environmental parameters during the flight. Fregat manages two TM systems:

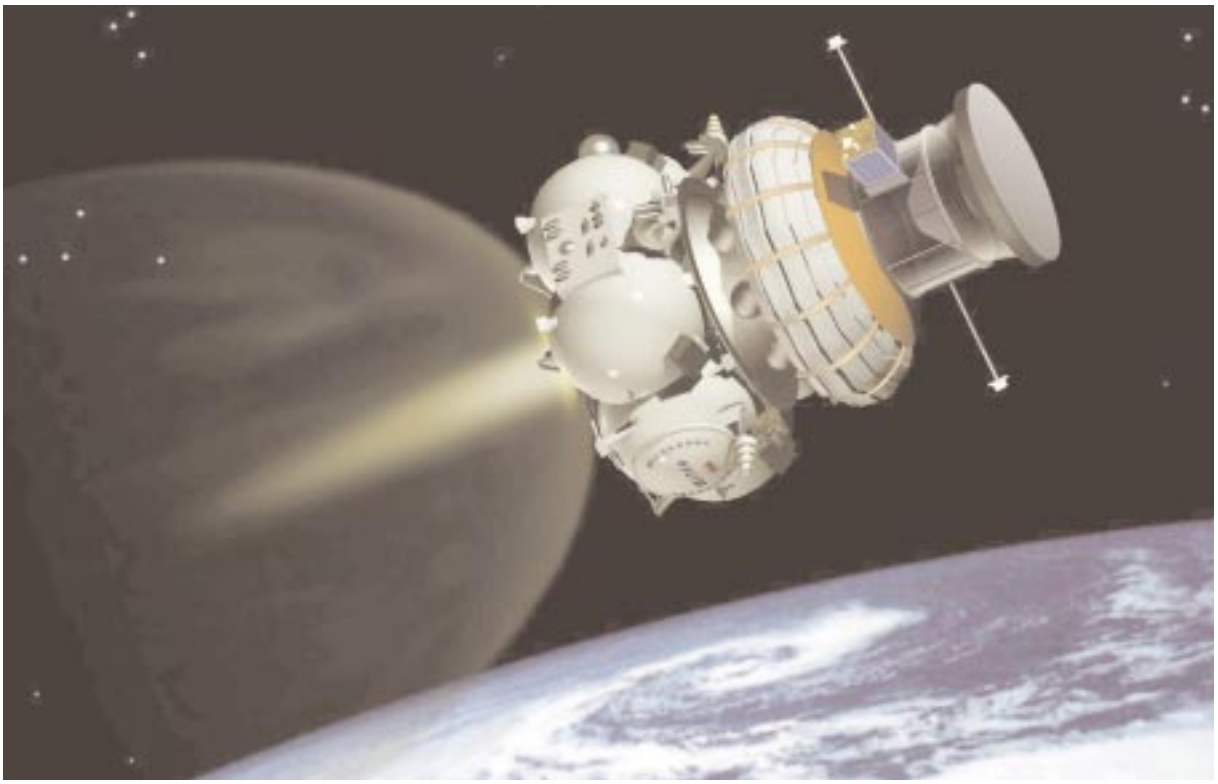
1) TMS M-6 for measuring the high-rate parameters (vibrations, etc.). TMS M-6 is located in the inter-stage section. It stops its operation after Fregat separation from the Soyuz III-rd stage (Inter-stage section remains attached to the III-rd stage).

2) TMS M-4 for measuring the low-rate parameters (on-board computer data, temperatures, etc.).TMS M-4 is installed on the Fregat board. This configuration is similar to the Cluster II mission.

During the qualification flight the following parameters will be measured:

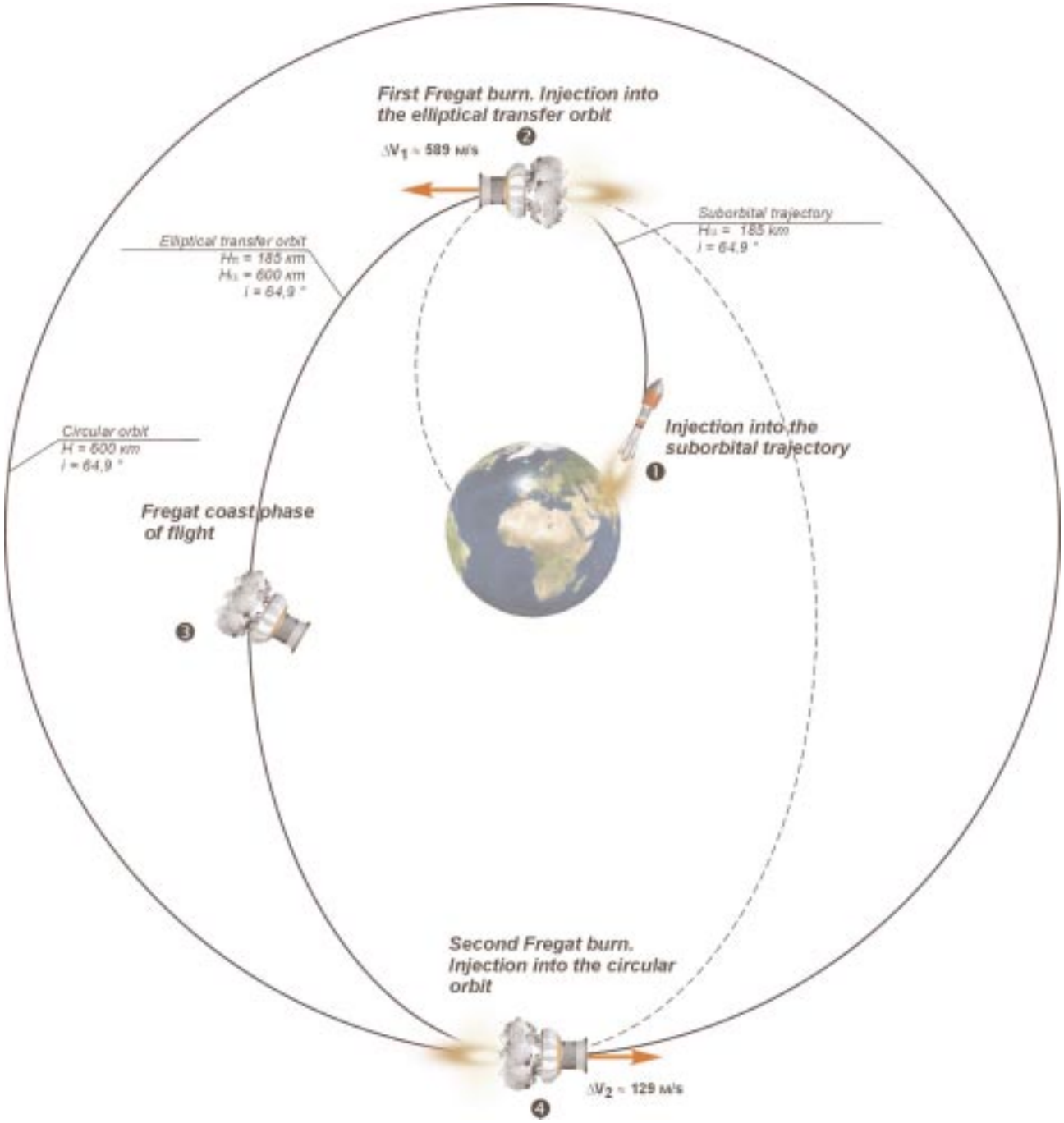
- Thermal environment,
- Dynamic environment,
- Quasi-static parameters and pressure parameters.

The telemetry data on the Soyuz flight and the first Fregat burn will be directly transmitted to the ground tracking stations. The data concerning the coast phase of flight and the second Fregat burn will be stored in the memory and recovered after the entrance to the visibility zone of Russian tracking stations.



***Artist view of Fregat upper stage and IRDT payload.***

# Mission profile



# About Starsem

Starsem was founded in 1996 to perform commercial launch services using the Soyuz launch vehicle family.

Responsibilities of Starsem are:

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

Starsem was created by four of the world's leading space-sector organizations: Europe's Arianespace, Aerospatiale Matra of France, the Russian Aviation and Space Agency and Russia's Samara Space Center. As a result, Starsem brings together the resources of integration and launch teams with years of experience gained through thousands of missions.

## Aerospatiale Matra

Aerospatiale Matra is one of the world's leading aerospace companies, having been created on June 11, 1999 through the merger of France's Aerospatiale and the Lagardère group's Matra Hautes Technologies. Its business spans nearly every sector of the industry, including space transportation, satellites, commercial jetliners, regional transports, light aircraft, civil and military helicopters, missiles, system engineering and information technology. As the industrial architect and main stage integrator for Ariane launchers, Aerospatiale Matra is Western Europe's no. 1 company in space transportation systems. It has held this role since the beginning of the Ariane program.

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. Aerospatiale Matra 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.

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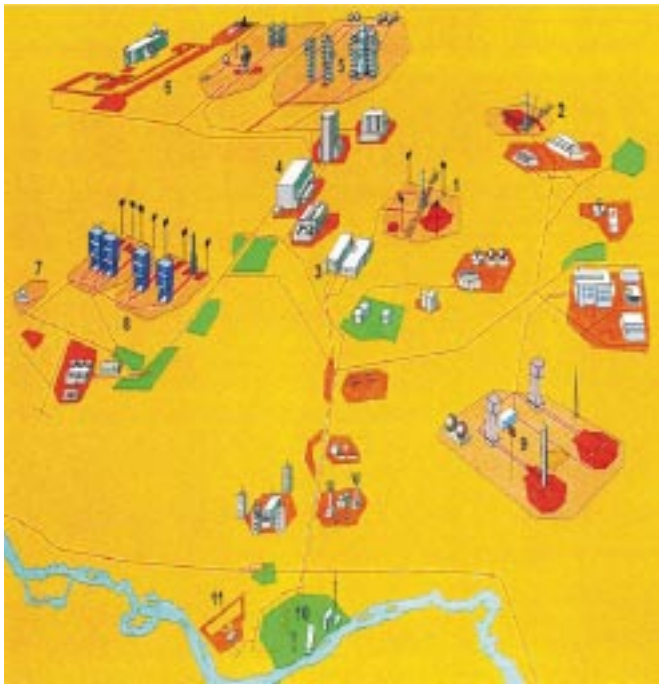
# The Baikonur cosmodrome

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

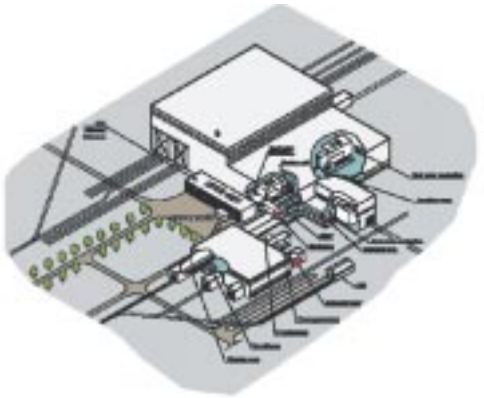
Baikonur Cosmodrome is located in the Republic of Kazakhstan in Central Asia between 45 deg. and 46 deg. North latitude and 63 deg. East longitude.



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

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.

*Starsem Flight ST 05 Soyuz-Ikar-Globalstar Baikonur, October 18, 1999, 13:32 GMT*

# Baikonur facilities adapted to Soyuz-Fregat missions

***Fregat upper stage 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.

Activities leading up to this month's Soyuz-Fregat launch included operations with a full-scale Fregat model to validate the upper stage's pre-launch processing procedures.

*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 and specific work has been conducted before the first launch:

- 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, specific modifications are in progress to accommodate 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.