Soyuz at the European Spaceport

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In the spring of 2009, a Russian Soyuz rocket will ascend from the European Spaceport, the Centre Spatial Guyanais (CSG) in French Guiana, for the first time. Soyuz will complement Europe's launcher family of Ariane-5 and Vega. The 'Soyuz at the CSG Programme' is a key element in the strategic partnership between ESA and the Russian space agency. The programme encompasses building the new launch facility at CSG, adapting the vehicle to withstand the tropical conditions in French Guiana, and participating in the development of an improved third stage.

Introduction

ESA and Roskosmos, the Russian space agency, have a long-term partnership for the development and operation of launch vehicles. The 'Soyuz at the CSG Programme' is a key element, with important benefits for both Western Europe and Russia. Their industries have joined forces to face the fierce competition in the world's launch services market.

The Earth's rotational speed at the CSG, located 5°N of the equator, increases the Soyuz payload capacity to

The Soyuz launch site

geostationary transfer orbit (GTO) by almost half in comparison to the Baikonur Cosmodrome in Kazakhstan.

As a medium-size vehicle, Soyuz will perfectly complement Europe's operational Ariane-5 heavy-lift launcher and the upcoming small Vega. From CSG, Soyuz will carry major European research and applications missions, including the Galileo constellation of navigation satellites.

While targeting primarily satellite missions, Soyuz offers the growth potential for manned flights from CSG, should that political decision be taken in the future.

Programme Scope and Partners

The 'Soyuz at the CSG Programme' began in 2004 to exploit launches to a variety of orbits, including GTO, Sun-Synchronous Orbit and Medium Earth Orbit. The programme has three main elements:

- the construction of a new launch site in the community of Sinnamary, French Guiana.
- the adaptation of Soyuz to handle the different flight and range safety requirements, the climate and the interfaces with the existing ground segment at CSG.
- European participation in developing the Soyuz 2-1b version, featuring a third stage offering improved performance.

The overall cost of the programme is €344 million (2002 terms). €223 million is being funded by seven ESA Member States (Austria, Belgium, France, Germany, Italy, Spain, Switzerland) and the European Union, through its 6th Framework Programme and the Trans-European Network. Arianespace, the Soyuz operator at CSG, is providing the remaining €121 million through a loan from the European Investment Bank.

During the development phase, from 2004 to spring 2009, the roles of the major partners are:

- ESA is responsible for the overall management of the programme;
- Roskosmos is in charge of activities within the Russian Federation;
- the Launcher Directorate of CNES is ESA's main contractor as System Architect, in charge of development, and responsible for both European and Russian activities;
- CNES is also responsible for range and flight safety at CSG by delegation of the French government;
- Arianespace is in charge of the Russian activities and will be the commercial operator.

The key Russian companies are:

- TsSKB-Progress, the Soyuz designer and manufacturer, in Samara.
- NPO Lavotchkin, in Moscow, the designer and manufacturer of the Fregat upper stage.
- KBOM, in Moscow, responsible for all Russian ground equipment in the launch zone.

Soyuz ST Launcher

Soyuz is the most reliable workhorse in Russia's launcher fleet. In its different versions, it has flown almost 1800 successful missions, from the world's first satellite in October 1957 and the first manned flight in 1961, to manned and unmanned ferry missions for the International Space Station.

The Soyuz-ST version for CSG is based on the Soyuz-2 developed by TsSKB-Progress within the Russian Federal Space Programme. Soyuz-ST has three main stages using kerosene and liquid oxygen as propellants.

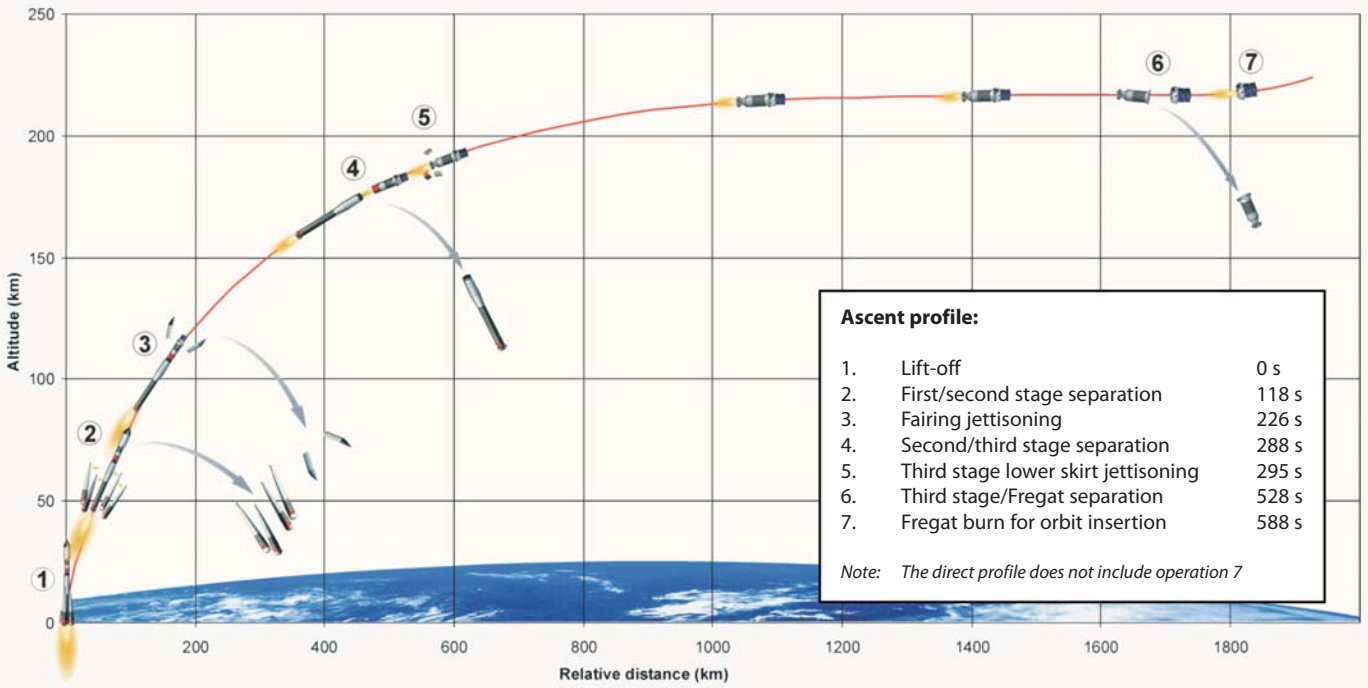
The first stage comprises four strap-on boosters, referred to as Block B, V, G and D. Each has a length of 19 m, a diameter of 2.68 m, a gross mass of 44.2 t and a dry mass of 3.8 t, powered by an RD-107A engine with four chambers and nozzles. The thrust per engine at lift-off is 838 kN.

The Block A second, core, stage also ignites for launch. Its length is 28 m, diameter 2.95 m, gross mass 101.9 t and dry mass 6.9 t. Its RD-108A engine with four chambers and nozzles delivers 792 kN at lift-off.

The Block I third stage has a length of 6.7 m, a diameter of 2.66 m, a gross mass of 25.2 t and a dry mass of 2.4 t. The RD-0110 engine provides 298 kN.

The 'upper composite' on top of Block I consists of the Fregat storable-propellant reignitable upper stage, which also provides 3-axis stabilisation and spin-up to the payload, the payload fairing (11.4 m long and 4.11 m diameter) and the payload itself.

There are two versions of Soyuz-2. The Soyuz 2-1a features an advanced digital command and telemetry system, and upgraded injector heads in the first and second stage engines. Its maiden flight came on 8 November 2004 from the Plesetsk Cosmodrome in northern



Ascent profile:

1.	Lift-off	0 s
2.	First/second stage separation	118 s
3.	Fairing jettisoning	226 s
4.	Second/third stage separation	288 s
5.	Third stage lower skirt jettisoning	295 s
6.	Third stage/Fregat separation	528 s
7.	Fregat burn for orbit insertion	588 s

Note: The direct profile does not include operation 7

Above: the ascent profile of Soyuz for a typical GTO mission has seven main steps

Below: the mobile gantry and launch table

Russia. It carried ESA's MetOp satellite from Baikonur on 19 October 2006, and the Meridian satellite from Plesetsk on 24 December 2006.

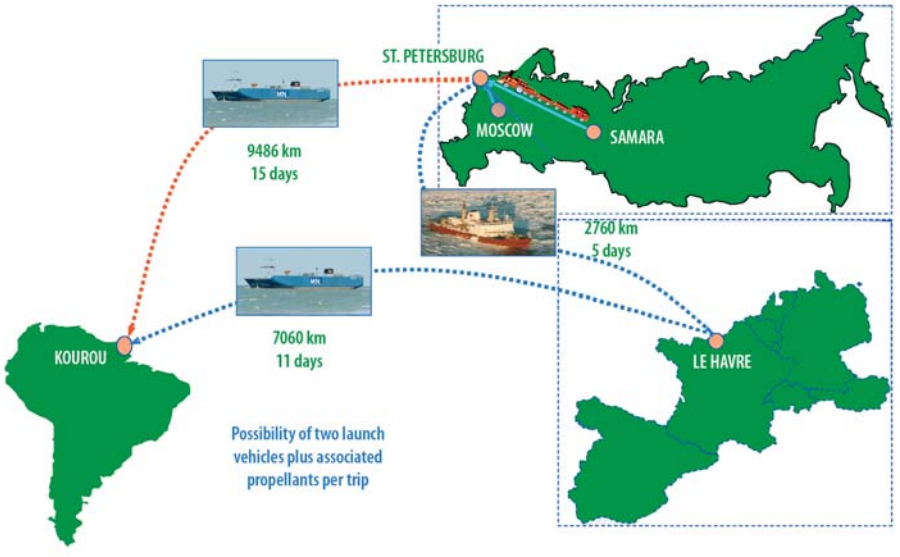
The newer Soyuz 2-1b uses the more powerful RD-0124 third stage engine. Its first flight, on 27 December 2006 from Baikonur, carried the CNES COROT astronomy mission.

Soyuz-STa (with the RD-0110 stage-3 engine) will be able to deliver 2730 kg into GTO, and 4450 kg in Sun-synchronous orbit (660 km altitude, 98.1° inclination). The more powerful Soyuz-STb (RD-0124 stage-3 engine) will be able to handle 3060 kg and 4900 kg, respectively.

Specific adaptations were required for Soyuz-ST to fly from French Guiana. It must cope with the tropical climate (especially the high humidity) and the salty sea-air, as well as meeting new flight and range safety rules. The boosters are equipped with valves to ensure they sink in the Atlantic. The launcher also features new S-band telemetry systems. The automatic emergency flight termination system has been been extended to allow manual command from the ground. The existing 'AVD' onboard system detects critical anomalies and automatically commands a rapid engine shutdown by closing the main engine valves. CSG safety rules demand that emergency engine shut-down can also be ordered by ground controllers.

The command is routed via the 'European Safety Kit', developed in Europe from the Ariane-5 original. It receives the ground order and channels

Construction of the launch pad



How all the elements reach CSG

it into the Soyuz-ST command system. In addition, its radar transponders are used for tracking the vehicle, to ensure that the correct course is being followed.

The Soyuz Launch Site

The Soyuz-ST launch area is situated on the north-western part of CSG, about 27 km from the town of Kourou and 18 km from the community of Sinnamary.

The site has 17 building complexes within an area of 120 ha. Teams of up to 350 European workers dug out around a million cubic metres and began constructing the main buildings in early 2005. They will be ready by the end of this year, before the arrival of the Russian teams and equipment early next year.

The main buildings comprise:

- the pad itself, a multi-floor launch table sitting on a 200 000 m^3 flame trench, protected by four lightning towers and equipped with powerful water pumps to remove any rain water before lift-off.
- the launcher integration building (MIK, after the Russian acronym), in the preparation zone, allowing the horizontal integration, preparation and test of the three stages;
- the launch control centre, a 420 m^2 three-storey all-concrete building for launch monitoring and command, protects the teams against explosions and falling debris during countdown and launch;
- storage for air, nitrogen and helium;
- power generation and air-conditioning;
- the kerosene storage area;
- the liquid oxygen storage area;
- storage for hydrogen peroxide, which powers the turbo-pumps of the Soyuz first- and second-stage engines.

The mobile servicing tower is specifically designed for Soyuz at CSG. It is a major improvement over the Baikonur and Plesetsk facilities, as it protects Soyuz from the climatic conditions in French Guiana and allows the vertical integration of the upper composite. The gantry retreats from the Soyuz shortly before launch powered by its own four electric motors.

Operations

Soyuz is built, integrated and tested at TsSKB-Progress in Samara, Russia, while the Fregat upper stage is produced at NPO Lavotchkin in Moscow. Both are transported by rail in protective containers to St Petersburg's harbour, where they are transferred to a roll-on/roll-off vessel for shipping to Kourou's Pariacabo harbour.

At Kourou, the containers are taken by lorry to the launch site. The 3-stage vehicle is integrated horizontally and tested in the MIK and then rolled out horizontally to the pad by rail, where it is raised to the vertical. The mobile gantry is then moved around it for protection from the climatic conditions and to begin the final launch preparations.

In parallel, Fregat is prepared in the MIK building for the journey by road to the S3B building in CSG's existing Payload Preparation Complex, where it is filled with propellants (unsymmetrical dimethyl hydrazine, UDMH; and nitrogen tetroxide, NTO) and then mated vertically to the satellite and fairing. Four days before launch, this upper composite travels to the launch zone, where it is lifted to the gantry's upper platform by a special crane and mated with the vehicle. During all of these operations, the payload is kept under controlled environmental conditions.

A few hours before launch, Soyuz is filled with propellants while the mobile gantry is still in place. About an hour before launch, the gantry moves to its rear position around 80 m away for safety. During lift-off, the gantry's large gates remain open to reduce acoustic reflections back to the Soyuz and to limit pressure loads on the gantry structure.

Summary

The 'Soyuz at the CSG Programme' is well under way to ensure the first launch of the Soyuz-ST from the European Spaceport in spring 2009. The European facilities and buildings will be completed on schedule by the end of 2007 before the arrival of the mobile gantry and the first Russian teams and equipment. The period from early 2008 to spring 2009 will see the arrival, assembly and testing of all the Russian equipment and the technical and operational qualification of the facilities. The first launch campaign under the responsibility of Arianespace, the future operator, is expected to take place in March 2009 before a gradual build-up to two to four flights per year.