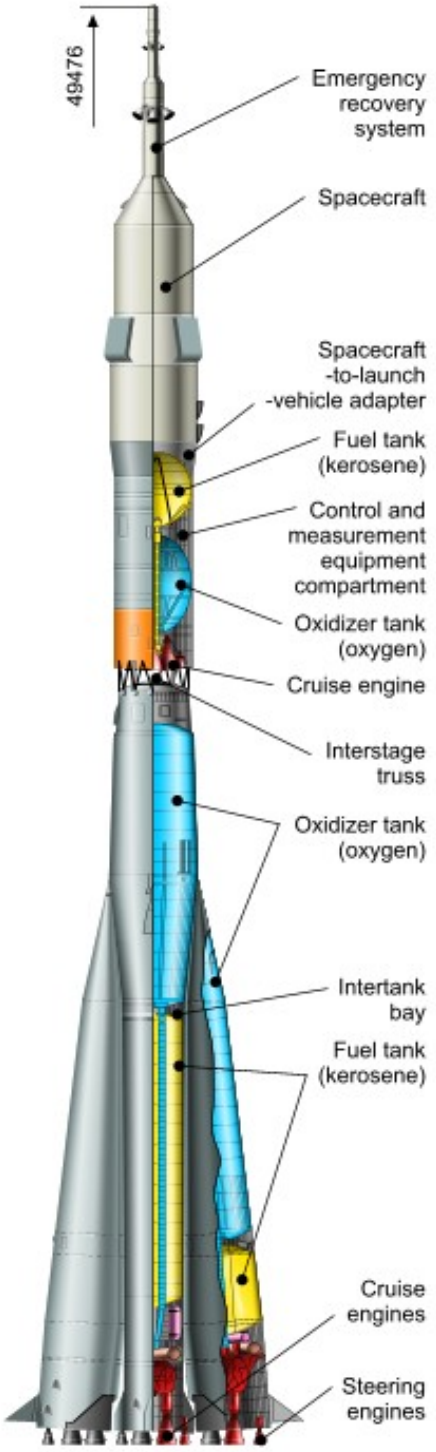
Soyuz Launcher



Artist's Impression of Soyuz FG launcher (Image: Roscosmos)

The Soyuz TMA-15 spacecraft that ESA astronaut Frank De Winne and members of the ISS Expedition 20 crew will travel to the ISS in will be launched into orbit by a Soyuz FG launcher from the Baikonur Cosmodrome in Kazakhstan.

The history of the Soyuz launcher developed from the Russian military rockets, which started production in the late 1940's with the R-1 and R-2 rockets, the R standing for 'Raketa'. Further developments led to the launch of the first intercontinental ballistic missile, the R-7, or 'Semyorka' on 21 August 1957, Semyorka meaning "The Seven" in Russian. It was the R-7 launcher configuration, which put Sputnik 1 into orbit on 4 October 1957.

Russian launchers normally take their name from the payload or spacecraft they are launching. The R-7 that launched Sputnik 1 into orbit was therefore called the 'Sputnik launcher'. The Sputnik launcher thereafter developed into the three-stage Vostok-L launcher for launching lunar probes and then the Vostok launcher, which put Yuri Gagarin into orbit in 1961.

After six further manned Vostok missions, the Vostok launcher was developed into the 4-stage Molniya launcher, for putting satellites into high elliptical orbits, and the Voskhod 2 launcher. This led to the development of the Soyuz launcher, which used a stronger third rocket stage. It was first launched on 16 November 1963 and was named after the manned Soyuz spacecraft for the launch of which it was designed.

The first manned Soyuz launch took place on 23 April 1967. A more powerful version called the Soyuz-U followed in 1971, which developed into the Soyuz-U2 in 1982, a rocket with a 7 tonnes maximum payload that used a new synthetic kerosene called Sintin, whose use is now discontinued for cost reasons.

The current version of the launcher is the Soyuz FG, which was used for the first time on 30 October 2002 to launch the Soyuz TMA-1 spacecraft on ISS flight 5S with Frank De Winne on the Odissea Mission. The FG stands for 'Forsunochnaya Golovka' meaning injection head in Russian. It is an improved version of the Soyuz-U as the injection head in the FG has 1000 holes instead of 200 for distributing kerosene and liquid oxygen to the combustion chamber. This leads to a 1.3% higher specific impulse, which increases the thrust by 500kN. This in turn leads to an increase of 250-300kg in the payload.

Launcher and Spacecraft

Soyuz launcher with clear view of lateral boosters arranged around central core stage (Image: ESA/S. Corvaja)

The Soyuz launcher and all its predecessors consist of four conical lateral boosters, which first appeared on the R-7 rocket, arranged around a core stage. In Russian terminology, the core stage and the lateral boosters are called “blocks”.

Each block of the launcher is designated a letter, which follows the Cyrillic alphabet. The lateral boosters are called blocks B, V, G and D.

Together they make up what in western terminology would be called stage one as they are the first stage to finish burning and separate after launch. The central block, or second stage, is called block A and the final block or third stage is called block I. Each block runs on a fuel mixture of kerosene and liquid oxygen.

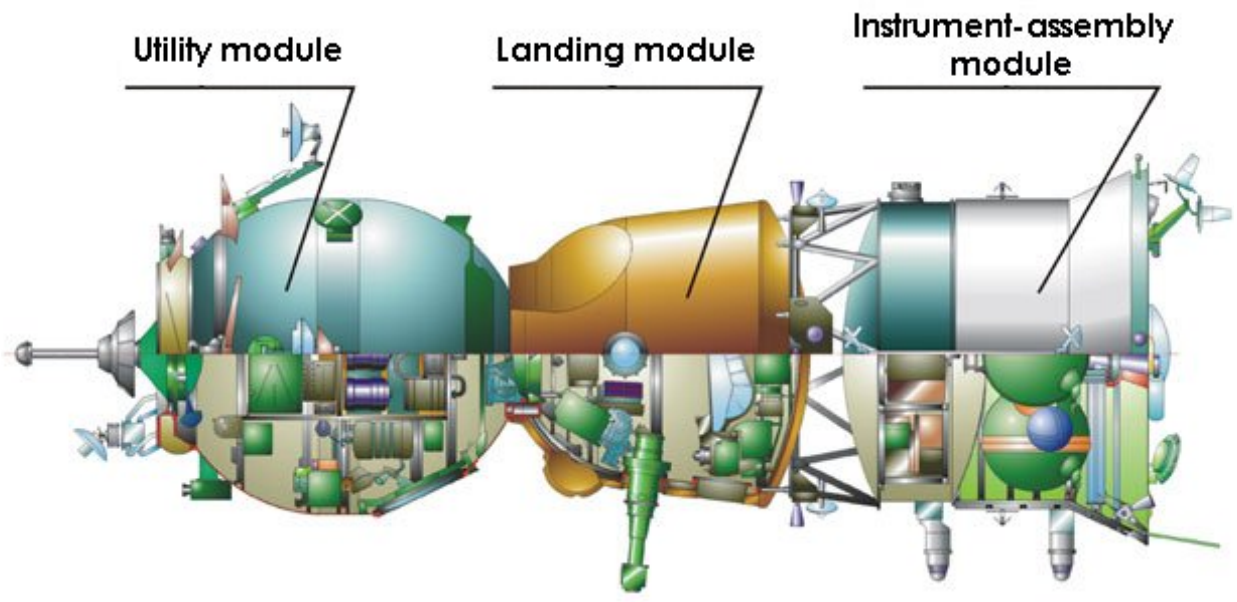
Each lateral booster is about 20 metres long by up to 2.7 metres in diameter. Each has an RD-107A propulsion unit. In combination the four boosters have an empty mass of 15 tonnes and a capacity for 160 tonnes of fuel.

Together the boosters provide nearly 3300kN thrust on launch when they are ignited together with the central stage. The boosters have finished burning after two minutes when they separate.

The central block, block A, is nearly 28 metres long and up to nearly 3 metres in diameter. It has an RD-108A propulsion unit and an empty mass of 6 tonnes, which provides a capacity for 95 tonnes of fuel. It provides a thrust of 940kN and has finished burning 288 seconds after launch after which it separates.

At five minutes after launch the third stage is ignited. This third stage burns until eight minutes and 40 seconds after launch when it is cut-out and thereafter jettisoned. This third stage or block is just over 8 metres long, (or just over 21.5 metres if the Soyuz TMA and rescue system are also included). This stage has an empty mass of up to 2.5 tonnes with provision for up to 22 tonnes of fuel. It has a liquid fuel propulsion system, which provides nearly 300 kN in thrust.

Soyuz TMA Spacecraft



Artists impression. Soyuz TMA Spacecraft.
(Source: RSC Energia)

For more than 40 years Soyuz spacecraft have been launched into Earth orbit and are the longest serving access to space. Its design goes back to the Vostok spacecraft, which was used for the first ever manned space flight in 1961 with Yuri Gagarin, and its successor, the Voskhod spacecraft.

The Soyuz spacecraft is capable of accommodating 3 astronauts/cosmonauts. It has the capability to actively manoeuvre, rendezvous and dock whilst in orbit. The Soyuz spacecraft has gone through various improvements, since the first launch of a manned Soyuz in 1967, with the introduction of the Soyuz-T series on 6 June 1980, the Soyuz TM series on 2 February 1987 to the current Soyuz TMA series, which was launched for the first time on 30 October 2002 with ESA astronaut Frank De Winne from Belgium on board. The last launch with an ESA astronaut was in April 2005 of the Soyuz TMA-6 with ESA astronaut Roberto Vittori on the Eneide mission. De Winne will launch (together with Thirsk and Romanenko) on Soyuz TMA-15, which will act as an emergency lifeboat for the ISS crew during the OasISS mission and will return on the same spacecraft at the end of his mission.

The TMA series has a soft landing system and allows for a greater height and weight range of astronauts. The A in TMA stands for anthropometric.

Soyuz spacecraft consist of three compartments: The utility or orbital module; the landing or command module; and the instrument assembly or service module. It has a length of 6.9 metres, a maximum diameter of 2.7 metres (over 10 metres with solar arrays attached to service module) and a total mass of 7.1 tonnes.

Utility or Orbital Module
This spherical module has a mass of 1.3 tonnes and can be classed as the astronauts living quarters as it is used for work, hygiene and sleeping during orbital free flight. It is the largest module of the Soyuz spacecraft with a volume of 6.5 m^3.

Contained within this section are remote controls, food cupboards and the toilet. A hatch connects it to the Command module, which together are completely pressurised. Opposite this hatch is another hatch with associated docking mechanism, docking system (KURS), antennae and lamps for docking with the ISS. The orbital section is also equipped with a hatch and airlock for provisional extravehicular activities (spacewalks).

Landing or Command Module
This module is the middle portion of the Soyuz spacecraft. It is 2.7 metres high and 2.2 metres in diameter with a habitable volume of 4 m^3 and a mass of about 2.9 tonnes. This is the only module

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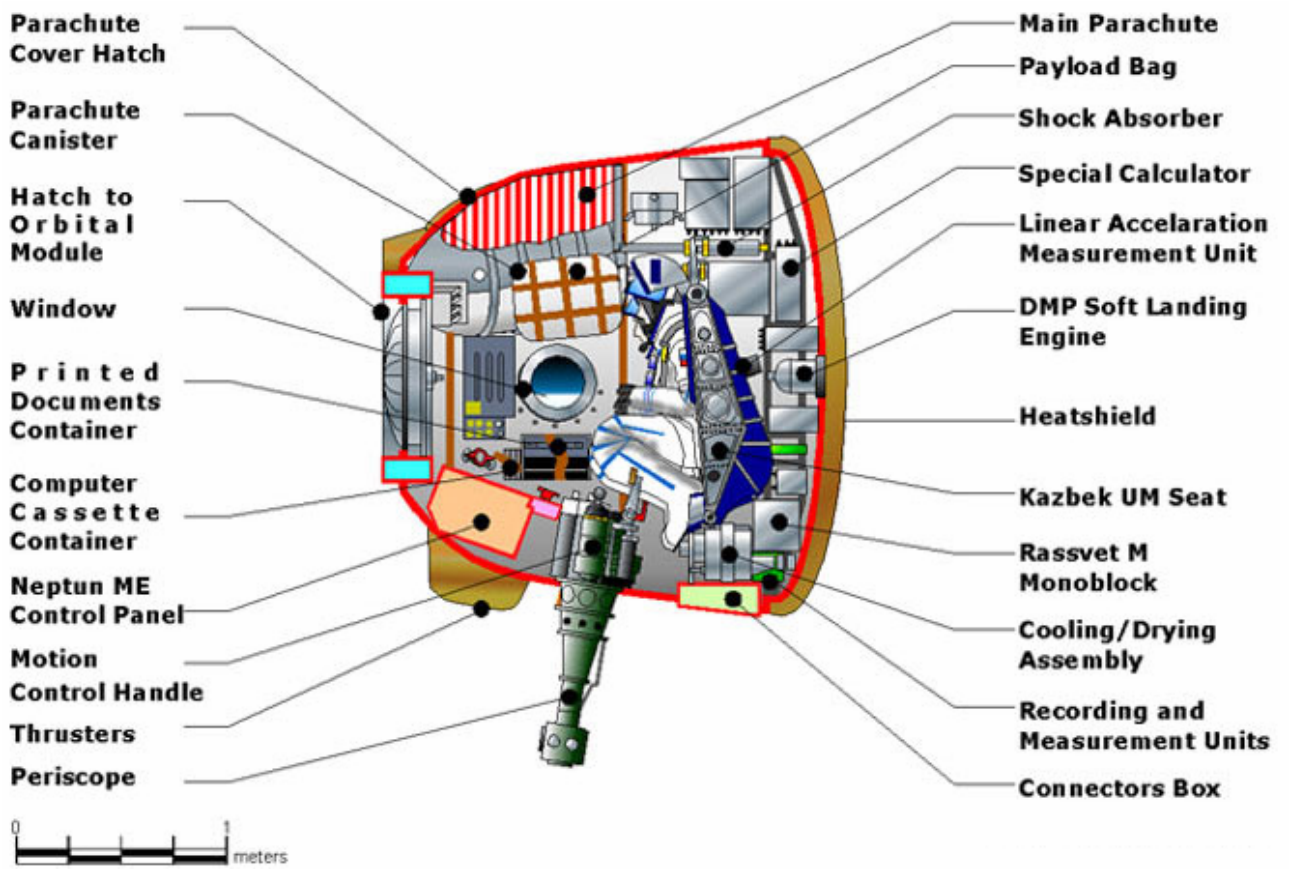

Soyuz TMA Landing or Command Module.
(Source: G. De Chiara Mars Center/2002)

to return to Earth after module separation and so is designed to resist the aerodynamic stresses of re-entry. Up to three individually moulded crew seats are situated at the bottom of the landing module's bell shape. They are shock absorbing to provide a safe landing together with the parachute system in the outer shell and the soft landing engines.

The control panel in front of the crew can be used to control navigation and guidance, life support, energy supply and communication systems. Environmental systems keep the module's temperature at around 18-20°C, the humidity at 40% and constant nitrogen/oxygen atmosphere like that on Earth.

Up to 50kg of cargo can be returned in the module (150kg if there are only two crew members).

Instrument-assembly or service module
The cylindrical service module has a mass of 2.6 tonnes and a diameter of 2.7 metres, 10.7 metres wide with solar arrays deployed. It contains oxygen storage tanks, the propellant tanks, attitude control thrusters, electronics for communication and the primary guidance and navigation control. Cosmonauts have no access to the service module and all functions are controlled remotely.

Two engines are used to perform rendezvous, docking and de-orbit/orbit procedures before module separation occurs. These engines use a propellant of nitrogen tetroxide and unsymmetric dimethylhydrazine.

Rescue system
Soyuz rockets are equipped with a rescue system in case of an accident during the two hours before and first minutes after launch. In this case the utility and landing modules are separated from the instrument-assembly module and launcher and fired one kilometre higher within seconds.

This system performed successfully on the one time it had to be used, before take-off of Soyuz T-10 in 1983. The rescue system activated in response to a fire during the countdown. The launcher exploded after the module separation and both cosmonauts were rescued.