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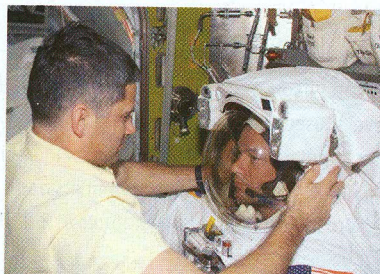
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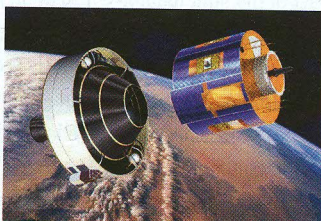
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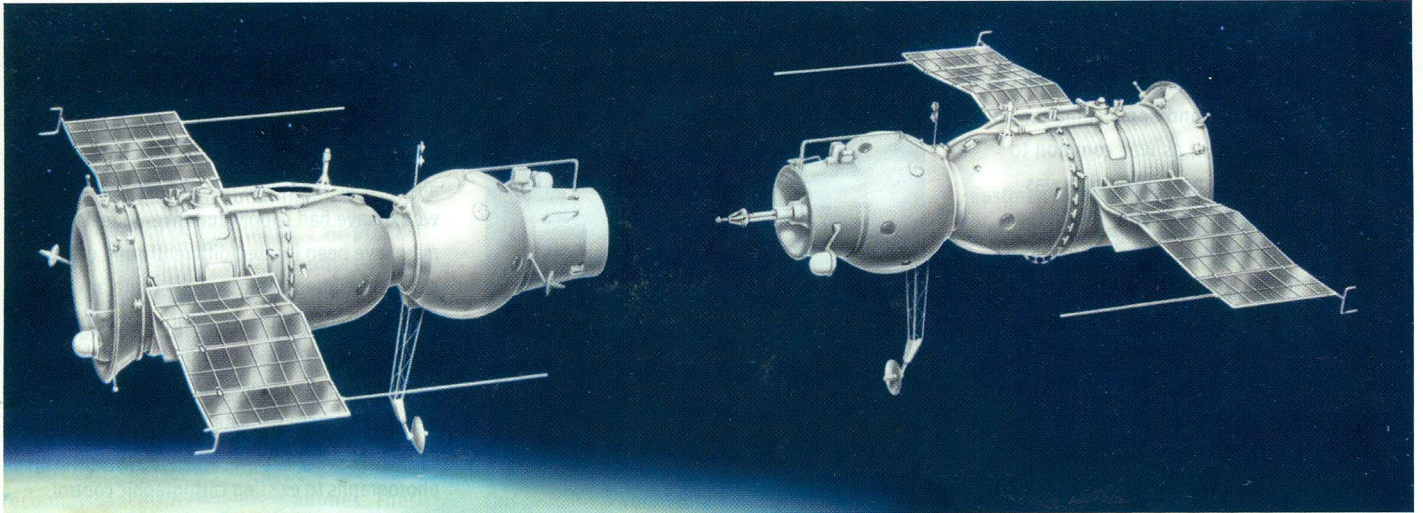
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An official NASA portrait of the STS-107 crew prior to launch on a mission that was to turn into tragedy. Pictured are Pilot William McCool (left), and Commander Rick Husband, (second row) Mission Specialists Kalpana Chawla (left) and Laurel Clark, and in the rear Payload Specialist Ilan Ramon, Payload Commander Michael Anderson, and Mission Specialist David Brown. See page 92.

NASA



This is a drawing of two Soyuz vehicles of the 7K-OK variety about to dock in space. On the right is the active version or 7K-OK(A) and on the left is the passive version or 7K-OK(P). The Soviets accomplished such a docking in January 1969 with the Soyuz-4 and Soyuz-5 spacecraft. Strangely enough, the spacecraft did not allow internal transfer of cosmonauts. Note the large Igla radar antennae on each spacecraft. [Source: Dave Woods].

## Soyuz variants - a 40-year history

By Asif A. Siddiqi

It has now been 40 years since the Soviet Union began development of the Soyuz spacecraft. In 1962, the famous Experimental-Design Bureau No. 1 (or 'OKB-1') of Chief Designer Sergey P. Korolev initiated work on a new versatile multi-crew spacecraft that flew into orbit for the first time in 1966. The following year, now openly known as Soyuz, it carried its first cosmonaut into space.

Unfortunately, the mission ended tragically with death of cosmonaut Vladimir Komarov. Since that time, the Soviets – and since 1991, the Russians – have launched over 100 Soyuz spacecraft in seven different variants. Soyuz spacecraft have carried cosmonauts from dozens of countries to numerous space stations such as Salyut, Mir, and the International Space Station (ISS). At least for the near future, most Russian cosmonauts will continue to lift up to orbit in this unique and reliable spacecraft.

This article will briefly describe all the known variants – both flown and unflown – of the Soyuz spacecraft.

### Designation system

Before presenting the Soyuz variants, it may be useful to explain the designation system for the Soyuz vehicle. Soviet engineers had two main internal naming methods.

The first, the design designation that was established by the design bureau, used a number-letter system (such as '7K') followed by a suffix (such as '7K-OK'). 'K' stood for 'Korabl' which is the Russian word for 'Ship'. All Soyuz vehicles used the '7K' system, to denote the

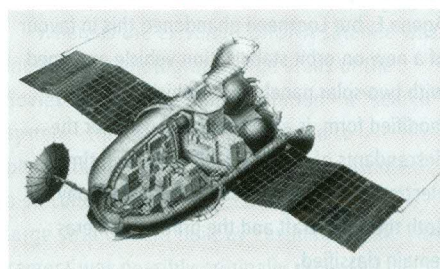
seventh manned or manned-related vehicle designed by the Korolev design bureau. Of previous systems, 1K and 3K were Vostok and Voskhod variants, 2K and 4K were used by the Zenit reconnaissance satellites, and the 5K was used by an abandoned vehicle named Sever. Since the dissolution of the Soviet Union, the Korolev design bureau (now known as RKK Energiya) appears to have abandoned use of this naming convention.

The second, the 'index number', was normally established by the military and was more confusing. It used a number-letter-number system such as '11F615' and was most commonly used for production purposes by factories. Traditionally, every Soviet military object and sub-component had a production index number. These bewildering index numbers are still used by many defense contractors in Russia although their use is lessening.

A third system, used publicly, were the Soyuz, Soyuz T, Soyuz TM, Progress, etc. designations. During the Soviet era, these names would

The 7K-L1 version of the Soyuz, more commonly known as the Zond which was flown between 1967 and 1970.

[Source: Energiya 1946-1996 via Dave Woods]



normally only be introduced after one or more unmanned test flights. RKK Energiya, the makers of the Soyuz spacecraft, now commonly uses these names in public in planning phases.

### Soyuz variants

#### Original three variants, 1962-65

##### 7K:

The original Soyuz variant was the 7K. The spacecraft was to be a versatile two-man spacecraft, whose primary goal was to accomplish a circumlunar mission as part of the larger 7K-9K-11K complex. The overall name of the project was Soyuz, the Russian word for 'Union'. The 9K (a rocket stage) and 11K (a fuel tanker) were 7K-derived unmanned vehicles. The 7K had the three-module configuration that is still characteristic of current day Soyuz spacecraft: it had a 'living compartment', a 'descent compartment', and a 'instrument-aggregate compartment'. In the West, these are known as the 'orbital module', the 'descent module', and the 'service module' respectively. Korolev's 7K-9K-11 plan was approved in 1962 but cancelled in 1964 when an alternative proposal from General Designer Vladimir N. Chelomey was adopted. As such, no 7K hardware ever made it into orbit.

##### 7K-PPK:

This was one of the early military versions of the Soyuz, part of the Soyuz-P ('P' for Perekhvatchik or 'Interceptor') project, a programme for manned anti-satellite missions in Earth orbit. Work on the Soyuz-P project proceeded from 1962 until 1965 at Korolev's Kuybyshev branch until it was

superceded by automated systems.

#### **7K-TK:**

This was a second early military version of the Soyuz, part of the Soyuz-R ('R' for Razvedchik or 'Reconnaissance') project, a programme for manned optical reconnaissance from Earth orbit. The Soyuz-R complex included a small space station for joint work in space. Work on the Soyuz-R project proceeded from 1962 to 1965 at Korolev's Kuybyshev branch until it was superceded by the 7K-VI variant. The 7K-TK was also briefly considered as a ferry to the future Almaz space station, but this option was dropped after about 1968.

### Rethinking objectives, 1965

#### **7K-OK (Soyuz):**

Despite the cancellation of the original 7K in 1964, the Korolev design bureau soon emerged with several new versions of the 7K in 1965. The first and most commonly used was the 7K-OK, an Earth orbit version. The 'OK' stood for Orbital'nyy korabl' or 'Orbital Ship'. The 7K-OK was designed to carry one to three cosmonauts into Earth orbit and perform complex rendezvous, docking, and spacewalk operations in support of the future lunar landing project. Although it had a docking system, it did not allow internal crew transfer from one vehicle to another.

It is this variant which served as the basis for numerous descendents and may be considered the de facto 'parent' of all Soyuz spacecraft. Subvariants of this base prototype included the 7K-OK(A) and the 7K-OK(P) which differed in the use of active or passive docking systems. There was also a subvariant known as 7K-OK-T which was never launched, but which was intended to serve as a ferry for Earth-orbit-rendezvous operations during circumlunar missions. There were a total of 17 attempted launches of the base 7K-OK variant between 1966 and 1970 of which 16 reached orbit. Of these, eight were manned. All of the manned vehicles were publicly known as 'Soyuz'.

#### **7K-VI:**

This version of the original 7K was a new military variant that superceded the earlier Soyuz-R project. 'VI' stood for Voenno-issledovatel'skiy or 'military-research'. As a whole, the project was known as Zvezda ('Star'). The 7K-VI, designed by Korolev's Kuybyshev branch, differed significantly in design from the common 7K-OK version in that its 'living compartment' and 'descent apparatus' switched places in terms of layout. Thus, the reentry module was fixed at the forward end of the entire spacecraft. The 7K-VI was equipped with space weapons and a nuclear power source. Work on this version proceeded from 1965 until its cancellation in 1968. No hardware ever made it into orbit, although some systems were evidently transferred

to automated reconnaissance spacecraft such as Yantar'. The aims of the Zvezda programme, ie, manned reconnaissance, were taken over by the Soyuz-VI project (see below under 7K-S).

#### **7K-PLK:**

This little-known version was a Proton-launched Soyuz spacecraft conceived in 1965 for lunar operations. It was briefly considered as an alternative to the 7K-L1 circumlunar version.

#### **7K-L1 (ZOND):**

Another lunar variant based on the original 7K was the 7K-L1, also proposed in 1965. The 'L1' stood for Luna-1 or 'Moon-1'. This spacecraft was designed to carry two cosmonauts around the Moon. It was a stripped down 7K-OK vehicle without the frontal 'living compartment'. There were a total of 15 attempted launches of the 7K-L1 in 1967-70 in versions known as the 7K-L1 (launched by the Proton for circumlunar tests), 7K-L1P (launched by the Proton for reentry tests), 7K-L1A (launched by the N1 rocket), and 7K-L1E (launched by the Proton for Earth orbit tests). None of these, however, were manned. The ones that left Earth orbit were publicly known as 'Zond'. The project was cancelled in 1970.

#### **7K-LOK:**

Yet another new variant based on the original 7K was the 7K-LOK, proposed in 1964-65 as part of the Soviet programme to land cosmonauts on the Moon. 'LOK' stood for Lunnyy orbital'nyy korabl' or

'Lunar Orbital Ship'. Although the 7K-LOK shared the same design layout as the 7K, the 7K-LOK was considerably larger and more capable than its predecessor and shared very little in terms of actual equipment. There was only one attempted launch of the 7K-LOK, in 1972, which failed to reach Earth orbit. The project was cancelled in 1974.

### Updated versions, 1968-70

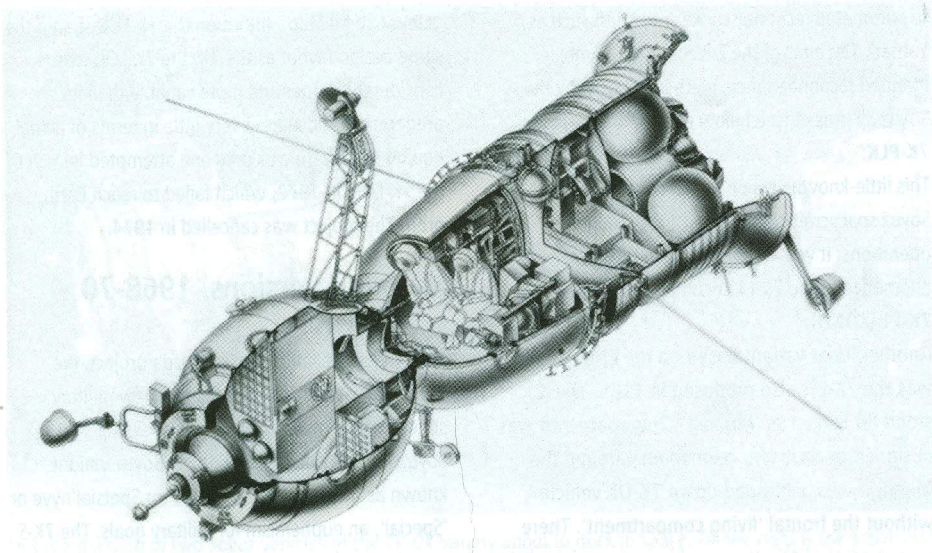
#### **7K-S (KOSMOS):**

With the cancellation of the Zvezda project, the Korolev design bureau proposed a new military space station known confusingly as Soyuz-VI. The Soyuz-VI complex included a new Soyuz variant known as the 7K-S. The 'S' stood for Spetsial'nyye or 'Special', an euphemism for military goals. The 7K-S was derived from the 7K-OK base model. The plan was to equip it with new digital computers and also an internal crew transfer docking system. The 7K-S would have two subvariants, the 7K-S-I and the 7K-S-II. The former was for short-duration flights and the latter was for long-duration flights. The Soyuz-VI complex also included a space station proper and a cargo spacecraft, the 7K-G. Work on the Soyuz-VI complex proceeded from 1968-70 but was superceded by the DOS/Salyut space station programme. Despite the project's termination, the Korolev design bureau continued work on the 7K-S ferry vehicle since it had such promising characteristics. Revisions to the original design were

The new Soyuz TMA-1 spacecraft, which carried the Soyuz 5 taxi crew, is docked to the Pirs docking compartment on the International Space Station (ISS).

NASA





The 7K-T version of the Soyuz, used between 1971 and 1980 as a ferry craft to various Salyut space stations. Note that it had no solar panels and carried only two crew members in space suits as opposed to the earlier 7K-OK version which had solar panels and carried up to three cosmonauts. [Source: Yu.P. Semenov, ed, *Raketno-Kosmicheskaya Korporatsiya "Energiya" imeni S.P. Koroleva* (Korolev: RKK Energiya named after S.P. Korolev, 1996), subsequently cited as "Energiya 1946-1996"]

made in 1972. A total of three 7K-S spacecraft were launched in 1974-76, all of them unmanned and under the 'Kosmos' designation. By the end of flight-testing, Soviet designers had already terminated the 7K-S variant in favour of the improved 7K-ST ferry version.

#### 7K-G:

The military Soyuz-VI complex also included a new cargo version of the 7K-S known as the 7K-G. The 'G' stood for Gruzovyye or 'Cargo'. Work on it coincided with design of the Soyuz-VI between 1968-70. No hardware ever made it into orbit although the Korolev design bureau worked on a similar cargo tanker in the early 1970s known as 7K-TG, later known as Progress.

#### 7K-T (Soyuz):

With the advent of the new space station programme known as DOS or Salyut, the Korolev design bureau decided to modify the basic 7K-OK variant to enable crews to transfer internally from one vehicle to another. In 1969, they began work on the new 7K-T variant. The 'T' stood for *Transportnyy* or "Transport," since its only function would be to deliver and return crews from space stations. After the Soyuz-11 disaster in 1971, engineers incorporated some more modifications to the spacecraft such as deleting the solar panels and redesigning the vehicle for two-man crews with spacesuits (instead of three men without). A subvariant of the 7K-T, often known as 7K-TA, was specifically designed to deliver crews to the military Almaz space station. It differed from the main 7K-T only in the design of the Igla rendezvous radar antenna. There were 33 attempted launches of the 7K-T between 1971 and 1981 of which 29 were launched with crews on board. All crewed flights were known publicly as 'Soyuz'.

## New versions for new goals in the 1970s

#### 7K-TM (Soyuz):

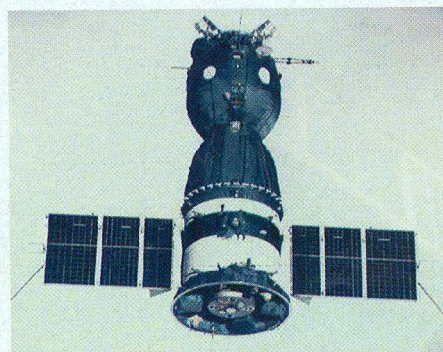
This version, the 7K-TM, was specifically conceived to serve in the Apollo-Soyuz Test Project (ASTP). Proposed in 1972, the spacecraft was derived from the 7K-T ferry version, and was equipped with a new androgynous docking system and improved life-support and power systems. It was also launched on an improved launch vehicle. Between 1974 and 1976, there were five launches of the 7K-TM including three manned ones. All the manned launches were publicly named 'Soyuz'.

#### 7K-ST (Soyuz T):

This version, the 7K-ST, was the 'working horse' of the Soviet space programme in the early 1980s. It was derived from the military 7K-S spacecraft developed in the late 1960s. In 1974, the Soviet military, however, decided not to use that spacecraft for military missions. As a result, the Korolev design bureau modified the original 7K-S (capable of independent flight) into the 7K-ST space station ferry version. The 7K-ST could carry three spacesuited

Soviet Soyuz spacecraft in orbit as seen from American Apollo spacecraft.

NASA



cosmonauts and had new solar panels. It was also the first Soviet manned spacecraft to carry digital computers that actually flew with a crew. There were 18 attempted launches of the 7K-ST between 1978-86, of which 15 were manned. One of these failed to reach orbit. All crewed flights were known publicly as 'Soyuz T'.

#### 7K-TG (Progress):

Designers had been toying with converting the basic 7K-OK Soyuz into a cargo spacecraft since the late 1960s. The first such proposal had been the abandoned 7K-G version in 1968-70 (see above). Later, in 1973, designers began work on a new Soyuz-based cargo ship named the 7K-TG. 'TG' stood for *Transportnyy Gruzovyy* or 'Transport Cargo'. The cargo ship, derived from the 7K-T ferry version of the Soyuz, housed special sections to carry both fuel and supplies. The tanker also had the capability to transfer propellant by automatic control after docking. The 7K-TG, which was publicly called 'Progress', was launched 43 times between 1978-90.

## Upgrading the Soyuz in the 1980s

#### Soyuz TM:

By the early 1980s, Soviet designers started planning for a new multi-modular space station later to be called Mir. For this station, in 1981, designers proposed a modernization to the standard 1980s version of the Soyuz ferry, the 7K-ST. As such, with upgraded avionics, new rendezvous systems, extended lifetimes, and a new combined engine unit, the 'new' vehicle was called the Soyuz TM, being a modernized version of the earlier Soyuz T. Cosmonauts used the Soyuz TM for 34 missions between 1986 and 2002. During these flights, the spacecraft visited the Salyut-7, Mir, and ISS.

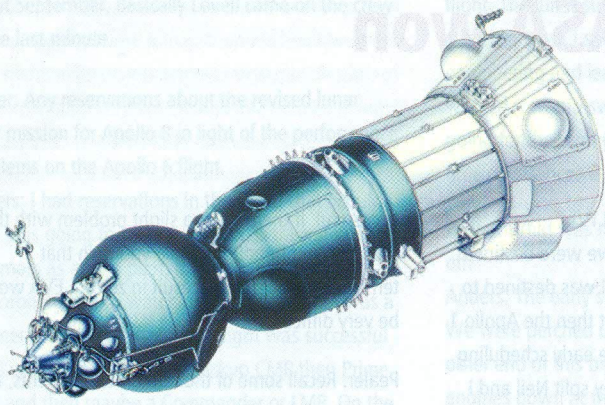
#### 7K-TGM (Progress M):

At the same time, in 1986, Energiya also proposed a modernized version of the 7K-TG cargo tanker. Designers used the Soyuz T and Soyuz TM crew ferry versions as the basis to develop this new cargo vehicle called the 7K-TGM. Since 1989, there have been 47 launches of the 7K-TGM, including one flight of the special Progress M-SO1 version orbited in 2001.

## Upgrades and proposals

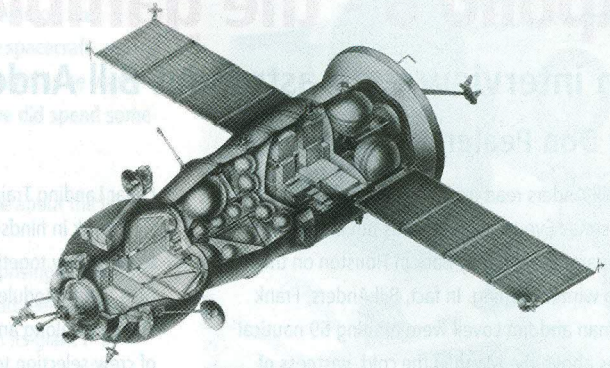
#### Soyuz Rescue Ship:

In the late 1980s, NPO Energiya began development of a Soyuz TM variant known informally as the 'Soyuz Rescuer' for emergency rescue of crews from the Soviet Buran space shuttle. As such, it was equipped with a special androgynous docking system known as APAS-89 that would allow it to dock to the airlock chamber in Buran's payload bay. When the Buran programme fell into limbo by 1992, Energiya decided to use one of the Soyuz rescue



A painting of the 7K-LOK version of the Soyuz destined to carry Soviet cosmonauts to the Moon in the late 1960s.

[Source: Videocosmos via Dennis Newirk/Dave Woods]



A cutaway drawing of the updated Progress variant known as Progress M which has flown since 1989. Note the addition of the two solar panels.

[Source: Energiya 1946-1996]

ships to deliver a crew to Mir. In 1993, one of these APAS-89-equipped Soyuzes was launched to Mir as Soyuz TM-16. No other such Soyuzes were launched again. Energiya also proposed the use of a similar 'Soyuz Rescuer' in 1992-93 for the American space station Freedom but this project never left the drawing boards after Freedom was cancelled in 1993.

#### **Soyuz TMA:**

In 1996, Energiya began work on a fully modernized version of the Soyuz TM. However, after the agreement with NASA on ISS, Energiya decided to limit the changes only to the possibility of expanding the height of crew members who could use the Soyuz. NASA paid some of the cost of the modifications. This version was called the Soyuz TMA, the 'A' standing for 'anthropometric'. The first manned launch of Soyuz TMA was on 30 October 2002, when the Odissea crew of three lifted off from Baikonur Cosmodrome, Kazakhstan on a mission to the International Space Station. The new generation Soyuz was the fourth taxi flight to exchange the Soyuz 'lifeboat' at the Space Station in case of an on board emergency evacuation, and it has a certified on orbit lifetime of 200 days.

#### **Soyuz TMM:**

Beginning 1996, Energiya, also began work on a fully modernized version of the older Soyuz TM. The plan was to replace all essential avionics and primary systems with new updated and lighter versions, to use only Russian subcontractors for systems, and to increase the lifetime of the vehicle. Due to a severe financial crisis, in 1999, Energiya had to postpone development of the Soyuz TMM until a later time.

#### **Soyuz TMS:**

Although Energiya had to postpone development of a fully modernized version of the Soyuz TM known as the Soyuz TMM (see above), in 1999, it decided to begin work on an partially modernized intermediate version known as the Soyuz TMS. The spacecraft would use new computers, and improved attitude control and parachute systems. Launch

would be on the new Soyuz-2 launch vehicle.

Energiya expects to launch the Soyuz TMS by 2006-2007 when it will replace the Soyuz TMA.

#### **Progress M2:**

In 1993, Energiya began work on a very advanced version of the 7K-TGM (or Progress M) cargo vehicle known as the Progress M2. The plan was to develop a heavier version that could be launched by the heavy-lift Zenit-2 launcher. The cargo vehicle was intended solely for ISS. The project was terminated in 1996 due to variety of financial and political reasons. There was also an earlier version alternative version of the Progress M2 designed for a future Mir-2 space station, which was abandoned.

#### **Progress M1:**

After abandoning the advanced Progress M2 cargo ship proposal, Energiya, in 1996, began work on a more modest version named the Progress M1. It is an improved version of the earlier 7K-TGM (or Progress M). Since 2000, the Russians have launched nine such cargo ships to the ISS.

#### **Progress MM:**

In 1996, as Energiya began work on the Progress M1, it simultaneously started work on another Progress variant known as the Progress MM, whose design was based upon the fully modernized version of the Soyuz called Soyuz TMM. However, when work on the latter was

terminated in 1999, work on Progress MM was also stopped.

#### **Progress MS:**

Like Progress MM, Progress MS was a cargo version of a proposed Soyuz spacecraft. It was intended to be the cargo version of the partially modernized Soyuz TM known as Soyuz TMS. Development began in 1999. Energiya has plans to phase out the older Progress M and Progress M1 in favour of the Progress MS in a few years.

#### **Acknowledgement**

The author would like to thank Dave Woods for his gracious contribution of images for the article.

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A side cutaway view of the Soyuz TMA ferry first launched in October 2002 on a mission to the International Space Station.

[Source: RKK Energiya website at <http://www.energiya.ru/english/>]

