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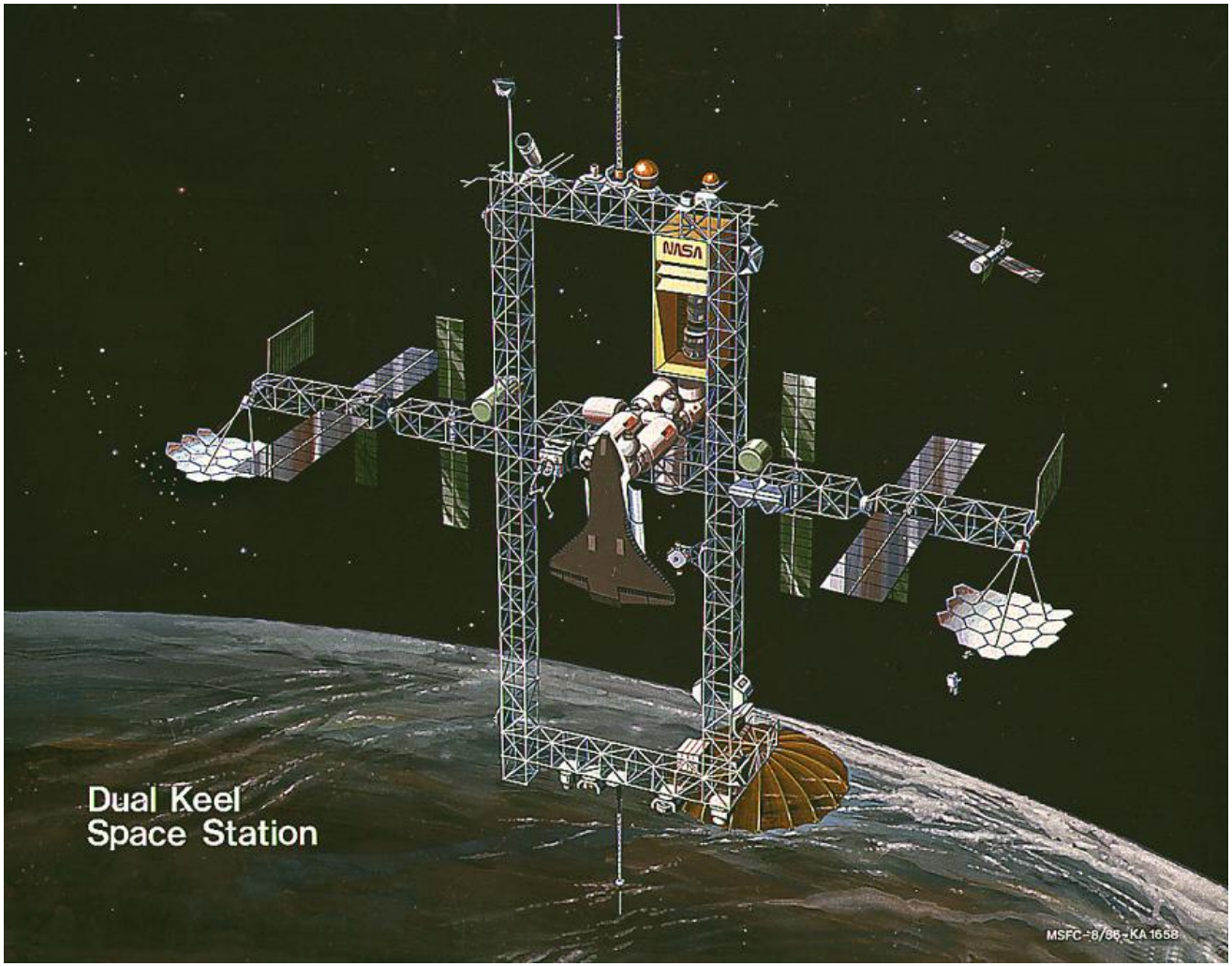
In this issue:



Space Station Freedom: Dual keel concept (1986)

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The *Tiros Space Information (TSI) - News Bulletin* is published to promote the scientific exploration and commercial application of space through the dissemination of current news and historical facts.
In doing so, Tiros Space Information continues the traditions of the Western Australian Branch of the Astronautical Society of Australia (1973-1975) and the Astronautical Society of Western Australia (ASWA) (1975-2006).
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Calling card...

This News Bulletin is sent to you from somewhere deep in the USA as Mrs H and myself are travelling. By the time you receive this News Bulletin I should have seen Space Shuttle in Los Angeles and the Space Shuttle mock-up in Houston as well those lovely aircraft in the National Museum of the Air Force, in Dayton, Ohio. The latter included the Space Shuttle's Crew Compartment Trainer (CCT)-1 to which a mock-up of the payload bay was added, allowing visitors to appreciate the size of the payload bay.
The Space Shuttle on the Intrepid Air and Space Museum in New York and the one in Washington DC are still on the schedule.
So, no visit to Florida to see the orbiter Atlantis that is located there. Why not? Simply not enough time. And four out of five is not bad and it gives me something to look forward to on a future trip.

This reminds my 1995 visit to Florida's Kennedy Space Centre and the fate of the News Bulletin of June 1995, an issue in the pre-email days. It had been printed at home and I carried all of them around the US to post them from the Kennedy Space Centre in the hope that they would receive a special stamp and/or postmark. That would have made those covers interesting pieces.
Instead, when I finally got back home, I found out that the News Bulletin I sent to myself had just a very common stamp and an even more common postmark.

I felt cheated – all that work, for nothing.

Well, the internet does not give postmarks but if you trace this despatch, it comes from Bemidji, Minnesota, close to the source of the Mississippi River at Lake Itasca. Nothing special…..

Jos Heyman

Cancelled Projects: Space Station Freedom

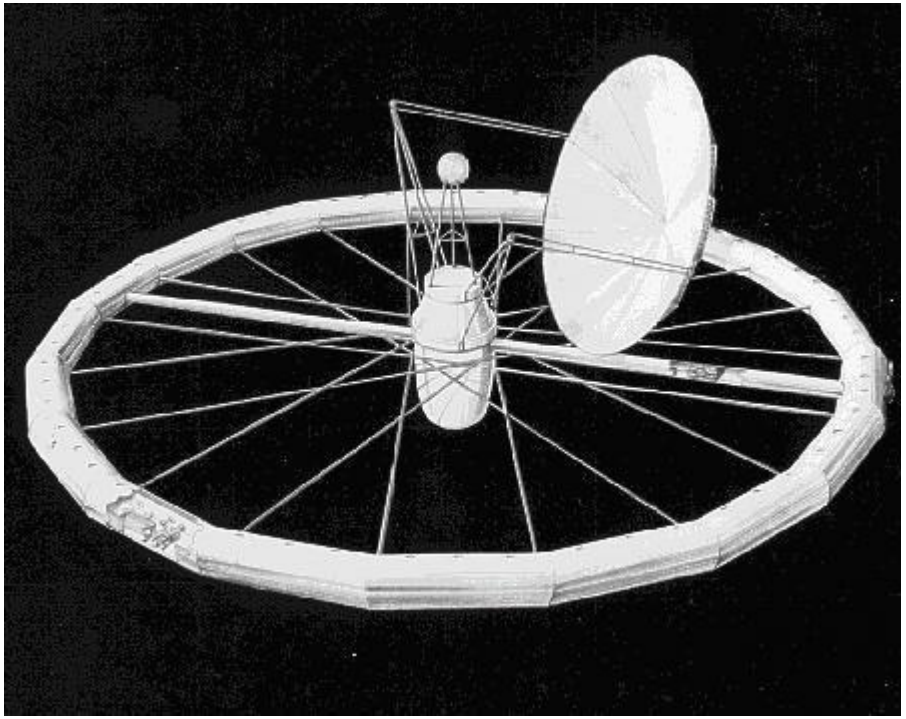
By Jos Heyman

The idea of a permanent space station has been with us ever since men ventured into space and even before that.

Noordung 'Life Wheel'

One of these early examples was the 'Living Wheel' described by Hermann Noordung in 1929. A Slovene rocket engineer who was also known as Hermann Potocnik, his description included the first detailed technical drawings of a space station. The space station consisted of three components, an observatory and a machine room, as well as a large concave mirror in the center to collect sunlight. Unfortunately, Noordung died shortly after publishing his 'Living Wheel'.

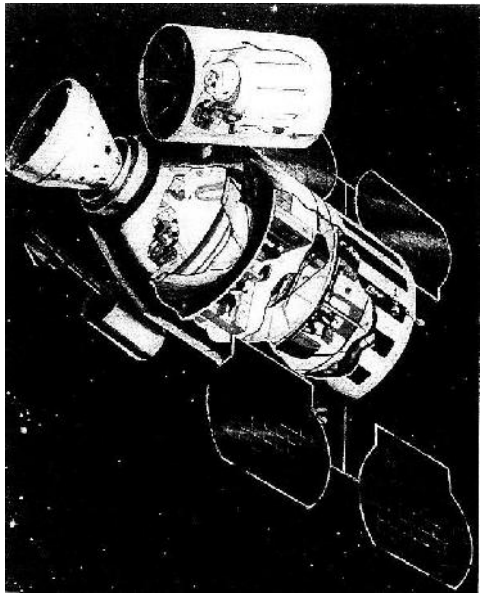
In 1946 Wernher von Braun, now working for the Americans, developed a space station proposals that would have used 20 cylindrical sections, each about 3 m in diameter and 8 m long. These were to be assembled like a wheel with a diameter of 50 m and an 8 m diameter central power module.



Von Braun 1946 space station

By 1952 the station proposal was enlarged to 75 m and the cylindrical sections had been replaced by an inflatable sections made of reinforced rubber. This space station would have accommodated a crew of 80. It was envisaged that it would have been in a 1730 km circular orbit that would have been corrected daily by so called space taxis.

The first cautious move by the US towards a space station was the Manned Orbiting Laboratory (MOL). Commenced in 1963, the objective of this programme was to demonstrate the use of a crew in performing military functions in space. This knowledge was deemed essential before any specifications of an operational nature could be drawn up and as such, the programme was more scientific and engineering in nature than direct military. It was anticipated that during a series of 30 day duration flights a range of scientific, technical and biological experiments could be conducted whilst an number of EVA's would evaluate the ability of an astronaut to work outside the spacecraft.
Given the go-ahead on 25 August 1965, MOL was to consist of the Gemini B, a Gemini spacecraft with the original Service Module removed and an access hatch cut through the heat shield, and a new, non-recoverable, Laboratory Module which could accommodate the two crew members during their mission. The latter would have an aft section with living quarters and a forward section for the mission experiments.
The dimensions of the Laboratory Module, which was to be built by Douglas, have been quoted as 3.05 m in diameter and 12.8 m in length. The mass was 9100 kg. The MOL project was eventually cancelled on 10 June 1969.



MORL

At about the same time NASA was considering the Manned Orbital Research Laboratory (MORL), a 10 crew space station to remain in orbit for over 2 years. The space station, to be built by Douglas, consisted of a control deck, crew quarters, a docking test area and a short radius centrifuge. Based on the Saturn 1B stage, it may be regarded as a precursor to Skylab, the space station that was placed in orbit on 14 March 1973 and was visited by three crews, the last one leaving the station on 8 February 1974.

Separately NASA studied more advanced space station concept, such as a 1969 concept for a space station that would rotate around its axis to generate gravity.

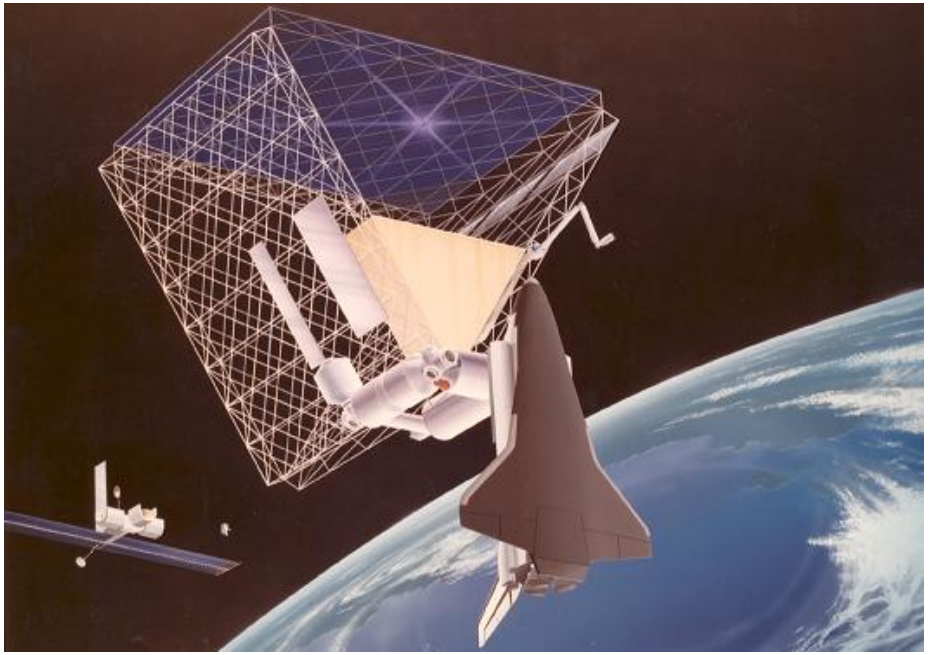
NASA 1969 space station concept

In 1970, the Nixon administration had advanced the Space Shuttle and it was intended that this vehicle would become the main vehicle to fly between Earth and an orbiting space station. The space station was seen as the next logical step.

And indeed, with the completion of the Space Shuttle development culminating in its first flight on 12 April 1981, NASA's attention turned towards the creation of a large, permanently crewed space station. Named Space Station Freedom, it was to function as an orbiting repair shop for satellites, an assembly point for spacecraft, an observation post for astronomers, a microgravity laboratory for scientists, and a microgravity factory for companies.

Technical difficulties and cost overruns with the Space Shuttle meant that NASA had to delay the space station idea for a few years and it was not until January 1984 that President Reagan announced in his State of the Union address that the development of a space station would commence with operations to begin in 1991.

In April 1984 the various baseline configurations were advanced by the newly established Space Station Program Office at Johnson Space Centre.



JSC roof concept

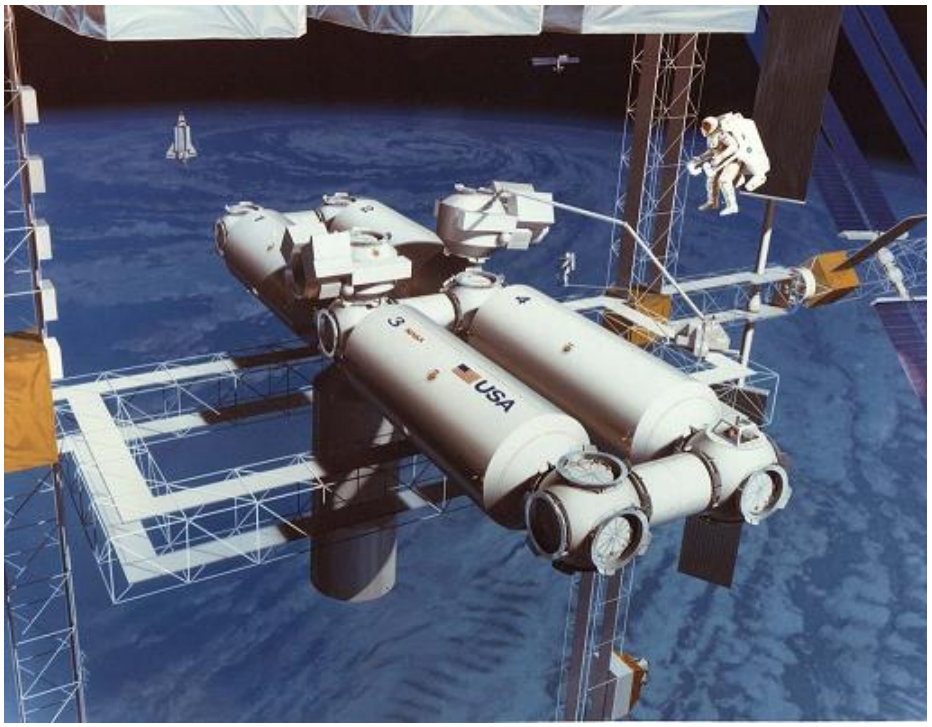
One of these was a "roof" concept where the roof was covered with solar array cells, that were to generate about 120 kilowatts of electricity. Within the V-shaped beams there would be five modules for living, laboratory space, and external areas for instruments and other facilities.

Power Tower concept

The design that was most favoured was the labelled the "Power Tower" and consisted of a long central keel with most mass located at either end. The keel of this design pointed towards the Earth and it was expected that this arrangement would reduce the need for thruster firings. The various designs had a cluster of modules at the lower end and a set of articulated solar arrays at the upper end. The design also included a servicing bay.
At the same time, the USA's allies, the European nations through the European Space Agency (ESA), Canada and Japan were invited to take part whilst the aerospace industry was invited to submit proposals for the space station design in September 1984.

In 1985 NASA advanced the concept of a 122 m truss that would have a cluster of pressurized modules at one end of this truss and a solar array and astronomical payload at the other end. The initial assembly was expected to take seven Space Shuttle flights. At about the same time the ESA had committed itself to a pressurized laboratory as well as a polar orbiting free flying platform.

After the establishment of the initial baseline design, the project evolved extensively, growing in scope and cost. Also some construction technologies were tested during spacewalks on Space Shuttle flights during the 1980s.

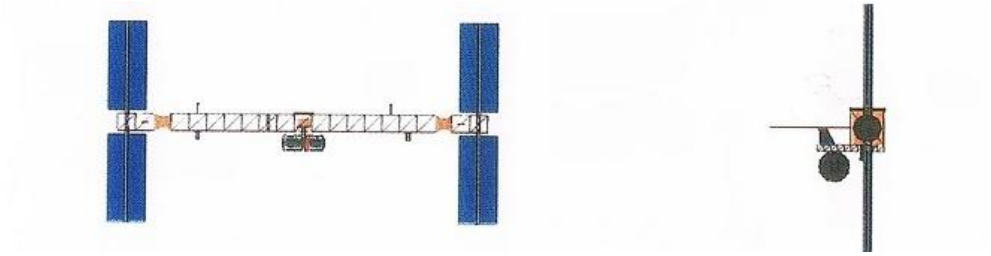


McDonnell Douglas proposal

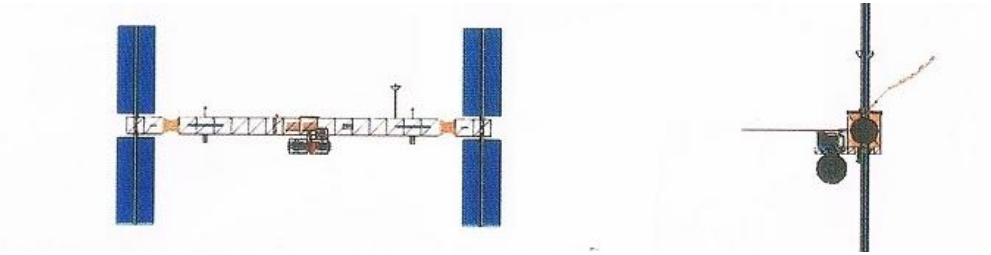
In March 1986, the design was modified to a so called "Dual-Keel" design, consisting of a 94.5 x 45.7 m rectangular truss assembly with a central truss. The design had the pressurized modules placed on a central truss, placing then in the center of gravity to get a better microgravity environment. The astronomy payloads were to be mounted on the upper truss whilst the lower truss would carry remote sensing payloads.

The 'Dual-Keel' design envisaged seventeen STS flights for the assembly.

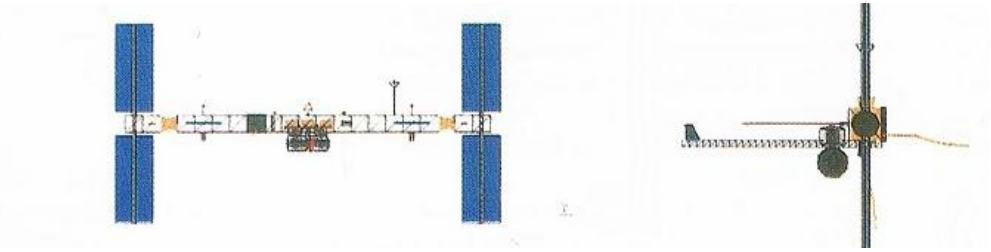
Flight 1: Starboard truss and forward node



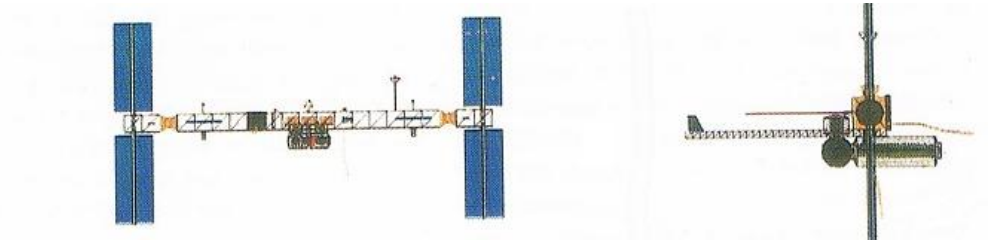
Flight 2: Post truss and forwards node



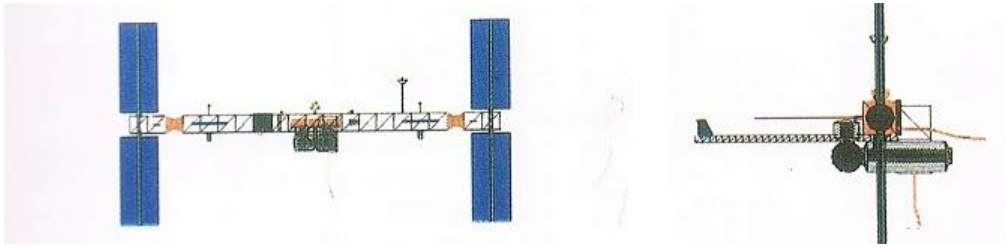
Flight 3: Airlock and initial payloads



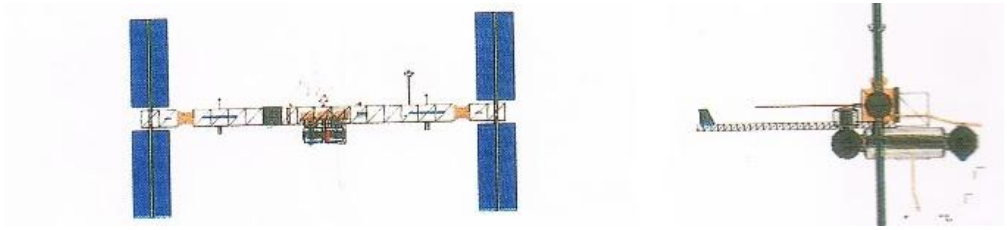
Flight 4: Central truss



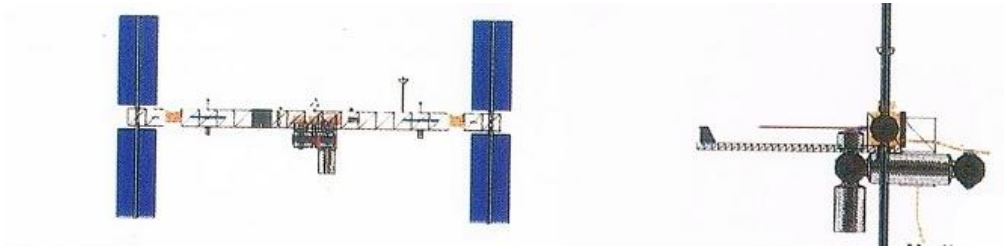
Flight 5: US Laboratory Module



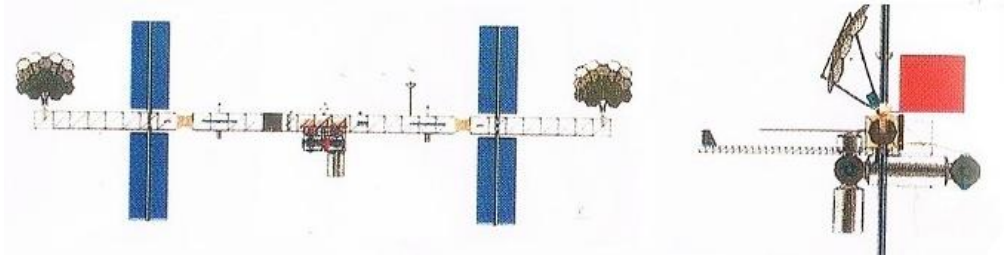
Flight 6: US Habitation Module



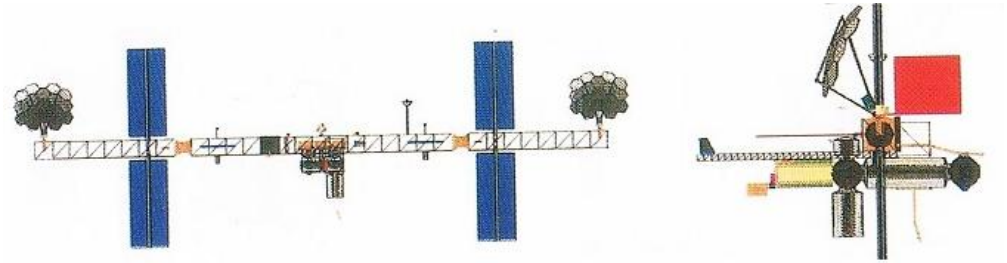
Flight 7: Forward node cupolas



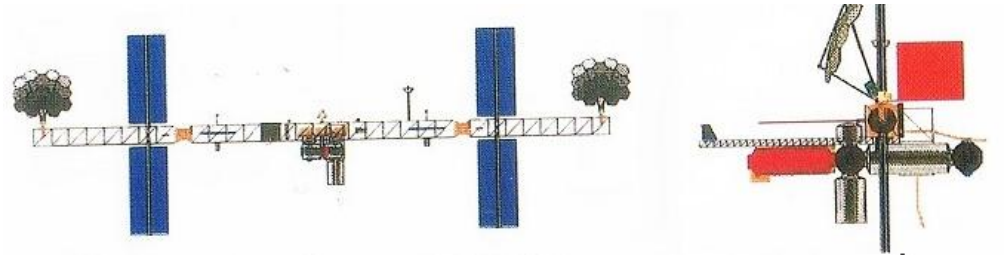
Flight 8: Logistics Module and first crew



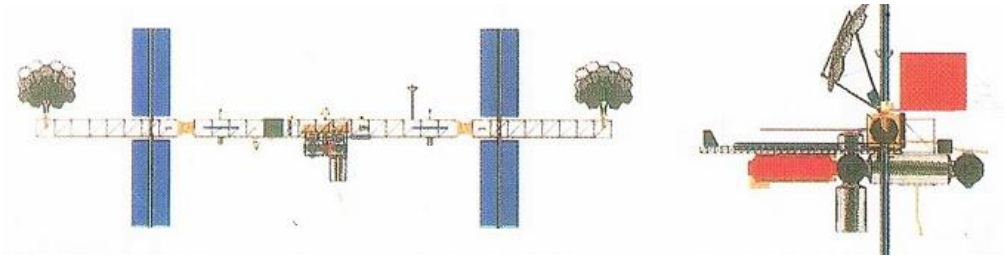
Flight 9: Two solar dynamics power units



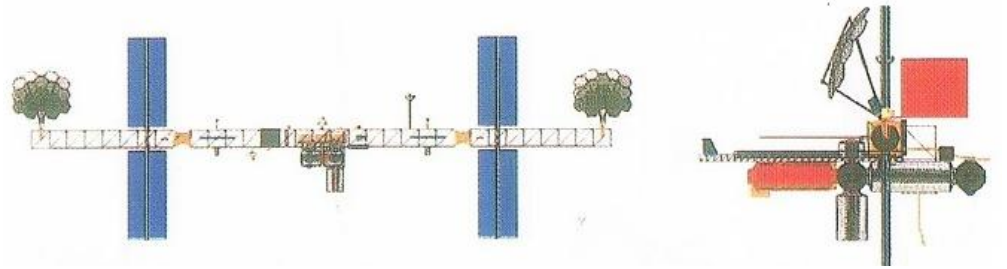
Flight 10: Japanese Exposure Facility #1



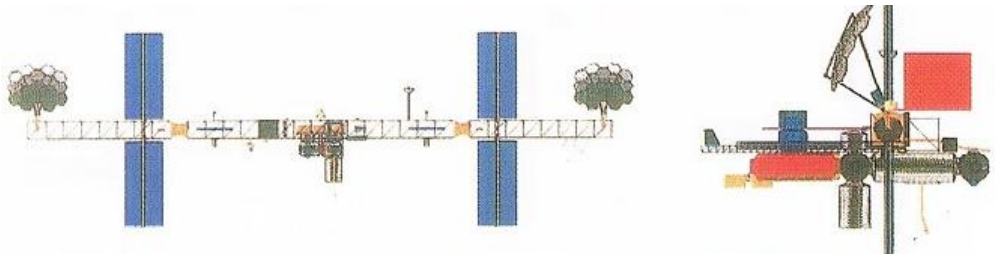
Flight 11: ESA module (Columbus)



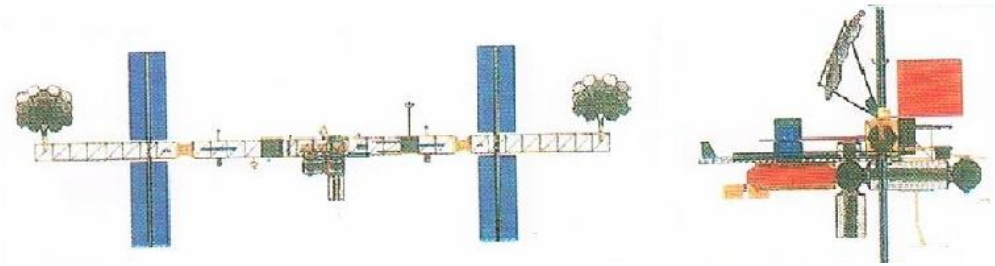
Flight 12: Servicing Facilities flight #1



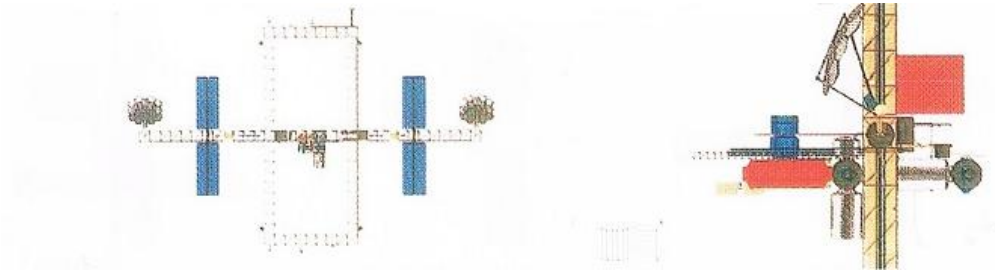
Flight 13: Servicing Facilities flight #2



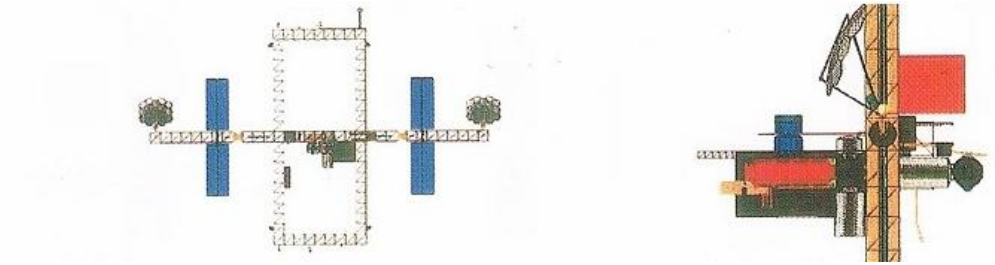
Flight 14: Japanese Exposure Facility #2 and Laboratory Module (Kibo)



Flight 15: Canadian Mobile Servicing Centre



Flight: 16: upper trusses and keels



Flight 17: Servicing Facilities flight #3
(Source: The Cambridge Encyclopaedia of Space)

Following the accident with the orbiter Challenger (STS-51L) on 28 January 1986 a Critical Evaluation Task Force was set up to review the validity and safety of the space station design. Although this review validated the basic Dual-Keel design, various safety concerns led to changes in the assembly plans, as well as assorted minor changes. In particular there was a concern that there were so many EVAs required for the assembly.

By May 1986 NASA also advanced the assembly sequence with the intent of providing early "man-tended" capacity, ensuring that at an early stage, despite the station not being able to support a crew, research work could be carried out by occasional visiting Shuttle flights.

By then Japan had also joined the programme and it was agreed that the US would be responsible for 71.4%, ESA 12.8%, Japan 12.8% and Canada 3%. This allowed the US to reduce the number of its modules from two to one, being the Habitation Module, giving provisions for the planned European and Japanese modules. An Orbital Maneuvering Vehicle (OMV) that was to be based at the station was also deferred and eventually cancelled.

OMV

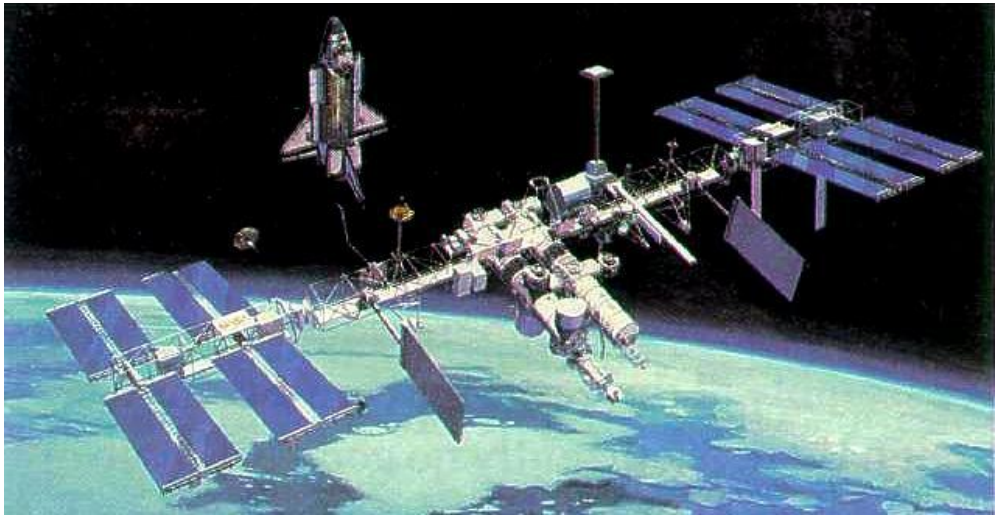
The Orbital Maneuvering Vehicle (OMV) was to be developed by TRW as a means to fly payloads to their desired orbit as well as retrieve payloads for servicing. The OMV was to be a flat vehicle of 1.5 m length and a diameter of 5.00 m. In the center was a propulsion module which would have provided the thrust for the vehicle for the flight between the home base and the target. Around this module were the various flight control, communication and telemetry packages as well as 24 reaction control thrusters for short range operations and attitude control.
Initially the OMV was to be equipped with a docking mechanism only but at a later date it was envisaged to attach other components such as a satellite refueling kit or robotic arms. The first flight was anticipated in 1991 but development was eventually cancelled in 1989.

In September 1986 a major cost review of the program was undertaken and its was found that the total development cost for the Dual-Keel configuration would cost US$18.2 billion (in FY1989 dollars) and that the first-element launch (FEL) would be delayed from January 1993 to January 1994.

The increased costs of the 'Dual Keel' Space Station led to a political uproar in Congress with many politicians beginning to express doubt about the project. In addition it was expected that the number of Space Shuttle flights was to be decreased. The Dual Keel design was replaced by a single truss that would hold all components. This single truss would orbit in a horizontal path.
Also the size of the modules had been expanded to allow them to carry more equipment, thereby reducing the need for mounting exterior components. This was to reduce the number of required EVAs to install and maintain these experiments.

The number of Space Shuttle assembly flights was reduced and the first launch was to take place in March 1994. The space station would be permanently manned from April 1995 onwards and be completed in March 1997 after 17 flights.
It was also envisaged that the space station would require eight Space Shuttle flight per year for operations and logistics, rotating four crew at a time with the aim of extending individual stay times to 90 days.

In June 1987 President Reagan called this design the Space Station Freedom.



1987 design

Scientists were not pleased with the reduced capabilities. Whilst the Dual Keel design had five berths to attach payloads, the new design had only two.
Also scientists were concerned that materials science received more research opportunities while deploring the lack of a variable-gravity centrifuge, animal holding facility and a dedicated life sciences laboratory.
It had also become increasingly obvious that there would be no major market for commercial space manufacturing on the Space Station.

In addition NASA and ESA were unable to reach agreement on Europe's role in the program. A particular point was that the US Congress did not want to use the ESA module, now known as Columbus, for materials research. Furthermore ESA wanted a better return that the small percentage originally agreed.

Finally the US military sought access to the space station for military research which, NASA and its international partners objected, causing a political furor in Congress.

In spite of all these problems, NASA was permitted to award development contracts in September 1987.

In September 1988 the Space Station Intergovernmental Agreement was finally signed. It allocated 97% of the US lab resources to NASA while the Canadian Space Agency would receive 3% in return for its contribution to the program. Europe and Japan would retain 51% of their own laboratory modules. The United States and Canada would receive 46% and 3%, respectively.
The permanent crew would consist of six Americans and two international astronauts. The length that each crew member would stay on the space station was increased to 120 days, reducing the number of Space Shuttle flights to five per year.
As there was a concern about the Space Shuttle's reduced capability, NASA was also requested to examine unmanned heavy-lift rockets and alternative manned backup spacecraft in case the Shuttle would have to be grounded again.

Also in September 1988 the first steps towards hardware fabrication were made. Budget cuts caused further modifications. For instance, the radiators and attitude control thrusters were simplified. NASA also briefly the use of solar thermodynamic power generators instead of solar array but, although this would have reduced the long term costs, t would have required more funds in the research and development stage.

Meanwhile the schedule slipped and the first launch was now envisaged in March 1995 with permanent occupation starting in June 1977 and completion scheduled for February 1998. These delays were not received well by the international partners

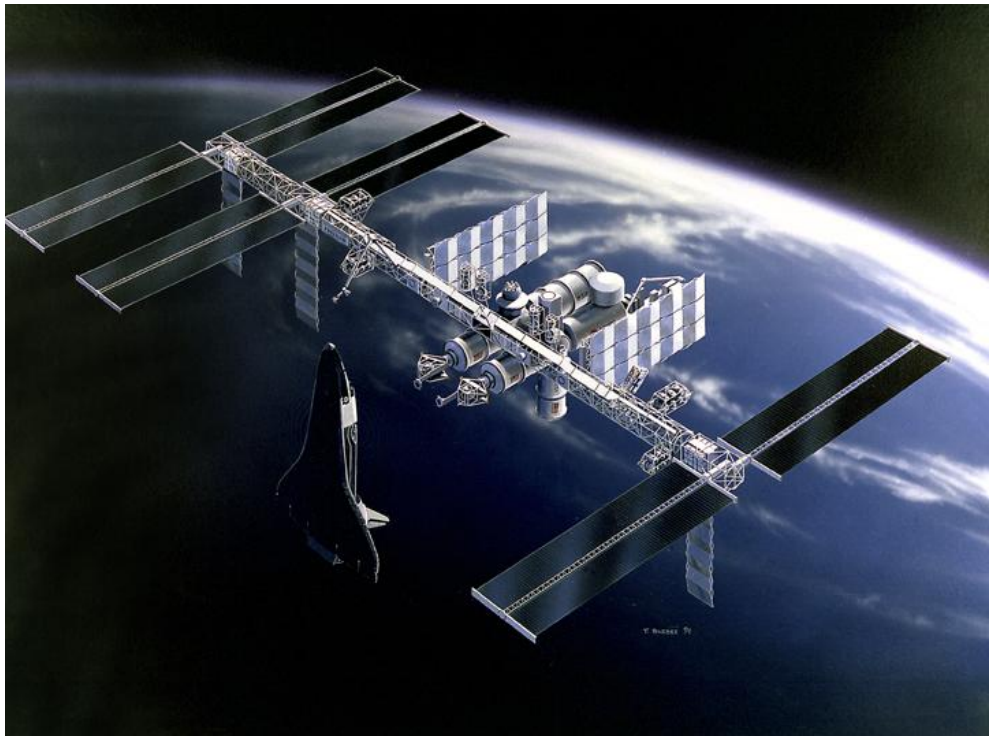
In 1989 President Bush briefly advanced space station Freedom as a basis for mission to the Moon and Mars. Known as the Space Exploration Initiative (SEI) this would have resurrected the Double Keel configuration and would have seen a crew of 14 to 16. The initiative led a database of thousands of possible missions and payloads; studies were also carried out with a view to supporting potential planetary missions, as well as those in low-earth orbit. Bush had proposed a Moon base by 2001/2005 and a mission to Mars by 2018 but the SEI initiative never materialised as further budget cuts were made.

By 1990 Space Station Freedom was found to be 23% overweight, over budget, too complicated to assemble while providing 34% too little power for its users. It was also found that up to 3275 hours of EVAs would be required per year instead of the originally envisaged 500 EVA hours/year.

As a result Congress demanded another redesign in October 1990 leading to a single truss with a length of 155 m and eight solar arrays. This design was revealed in March 1991 and would have required 20 Space Shuttle flights to assemble. The fourth flight would have delivered the 13.5 m

long and 4.22 m diameter US Manned Laboratory that would have been placed in the center of the complex to support multi-disciplinary payload such as materials research and life science.
By the eleventh flight permanent occupancy by 8 astronauts would have been possible through the US Habitation Module. The European Columbus and the Japanese JEM modules would have been delivered after this.
The Canadian Service System, equipped with a remote manipulator arm, would have been installed on the truss, where ot could be moved along rails.

In 1991 the Space Station design was further scaled down to a main truss of 108 m with the pressurized modules being reduced from 13.4 m to 8.2 m.



1991 configuration

By now President Clinton was in the White House and Congress was not inclined to provide more money for a project that had lost most of its science capacity due to the many redesigns. Between 1984 and 1993 the design went through seven major re-designs, losing capacity and capabilities each time. Budget cuts in early 1993 resulted in significant reviews of the Freedom programme with three options:

1. Option A, with an estimated cost of US$ 5 billion over a 5 year period, was a simpler and more spartan version of the original idea. It would provide for missions of 30 days duration and would have to maneuver frequently thereby inducing some gravitational force and vibrations which would affect microgravity experiments. Commencing as a single orbiting spacecraft, which could be constructed with three shuttle flights, it would use the shuttle orbiter as a 'plug-in' habitat for the astronauts with the experiments being conducted on the orbiter. It would, however, have a growth potential as the core beam of the spacecraft could be extended and more modules could be added.
2. Option B, with a price tag of US$ 9 billion over 5 years, was a half-length version of the original design requiring six to seven shuttle flights to construct but with no crew quarters in the initial phases. Again, there was a potential for later additions which would require up to 13 shuttle flights and would require by far the most space construction work.
3. Option C was perhaps the most radical departure from the original design and foresaw a large module with a length of 28 m and a diameter of 7 m and, subsequently a significant larger volume than any of the other designs but, at the same time, limited by the extend of solar panels that could be attached, a limitation that would preclude simultaneous running of all the experiments. Whilst the option allowed for the radial docking of the ESA Columbus (eventually launched on 11 February 2008) module and the Japanese JEM module, the large solar panels may have limited the effectiveness of some experiments by blocking the observation range. This option would have cost US$ 7 billion over 5 years. The C option module would be launched on a single flight, using the main engines and solid boosters of the space shuttle.

At the same time consideration was given to Russian involvement in the programme which led to a change from the original orbit with a 28.5^{o} inclination to an orbit with a 51.6^{o} inclination. Although the higher inclination would require a bigger shuttle boost, meaning more flights and lesser capacity, the orbit would allow more scientific observation of the Earth's surface and a better coordination of science endeavors with the Russians.

Finally in late 1993 the Clinton administration selected the A option, also known as Alpha and with the Russians joining the project, the name was changed to International Space Station (ISS). In orbit assembly commenced in 1998.

It is debatable if the Freedom space station should be regarded as a cancelled project, considering that it could be considered as a precursor to the ISS. However, the design that eventually 'moved' to ISS had little to do with the original design. Rather than being completed in a decade, as Reagan had predicted, Freedom was never built due to the lack of political support.