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Spaceflight

The International M... ...tics

PRIORITY LAUNCH TO VENUS

Shatalov – SOVIET SPACE PLANS

MARS ROVER

NEPTUNE FLY-BY

EUVE Satellite

Payload Specialists

SOVIETS in SPACE
CONTINUED

Vol.31 No.4

Spaceflight
The International Magazine of Space and Astronautics

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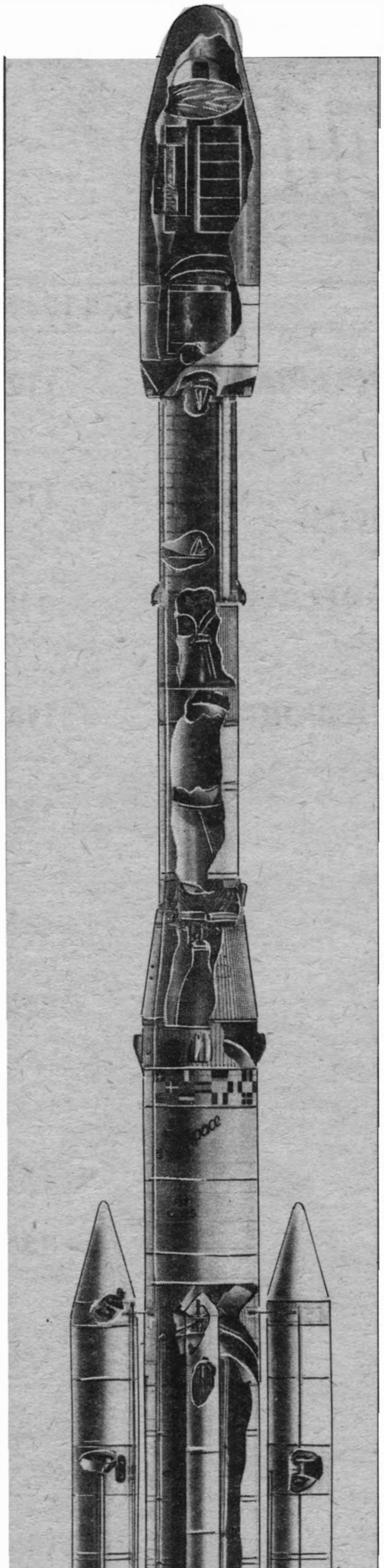
Front Cover: A dramatic view of Atlantis blasting off on Mission STS-27. This month she will make her fourth flight and deploy the Magellan probe.
NASA



Record Order Follows Ariane Success Run

Arianespace has signed a contract with Aerospatiale, MBB, SEP and Matra for the construction of 50 Ariane 4 launchers, the world's largest launch vehicle production order. The contract follows a run of ten successful launches, orbiting 17 satellites.

The agreement was signed by representatives of Arianespace and the four manufacturing companies in Evry, France on February 15. The 50 launch vehicles are in addition to the 21 originally ordered.

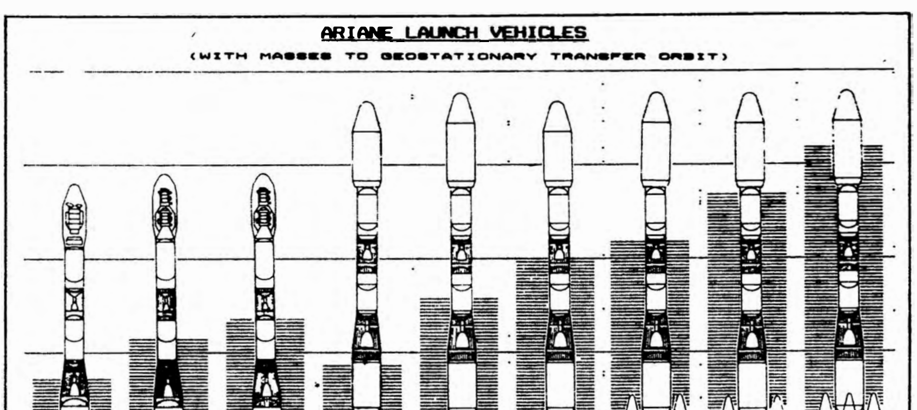
Since the resumption of flights in September 1987, following a series of failures, there have been 11 successful Ariane launches, placing 19 satellites into orbit. With its confidence restored, Arianespace placed the $3 billion Ariane 4 bulk order. The contract will lead to reduced production costs, which, according to Arianespace, will make the European launcher more competitive in the growing commercial market. Arianespace's Chairman, Frederic d'Allest, was in optimistic mood after signing the agreement, he said, "This contract emphasizes the industrial scope of the Ariane programme and strengthens Arianespace's position in an increasingly competitive environment". D'Allest has recently resigned from his position as head of the French space agency, CNES, to devote his full attention to marketing the Ariane launch-r.

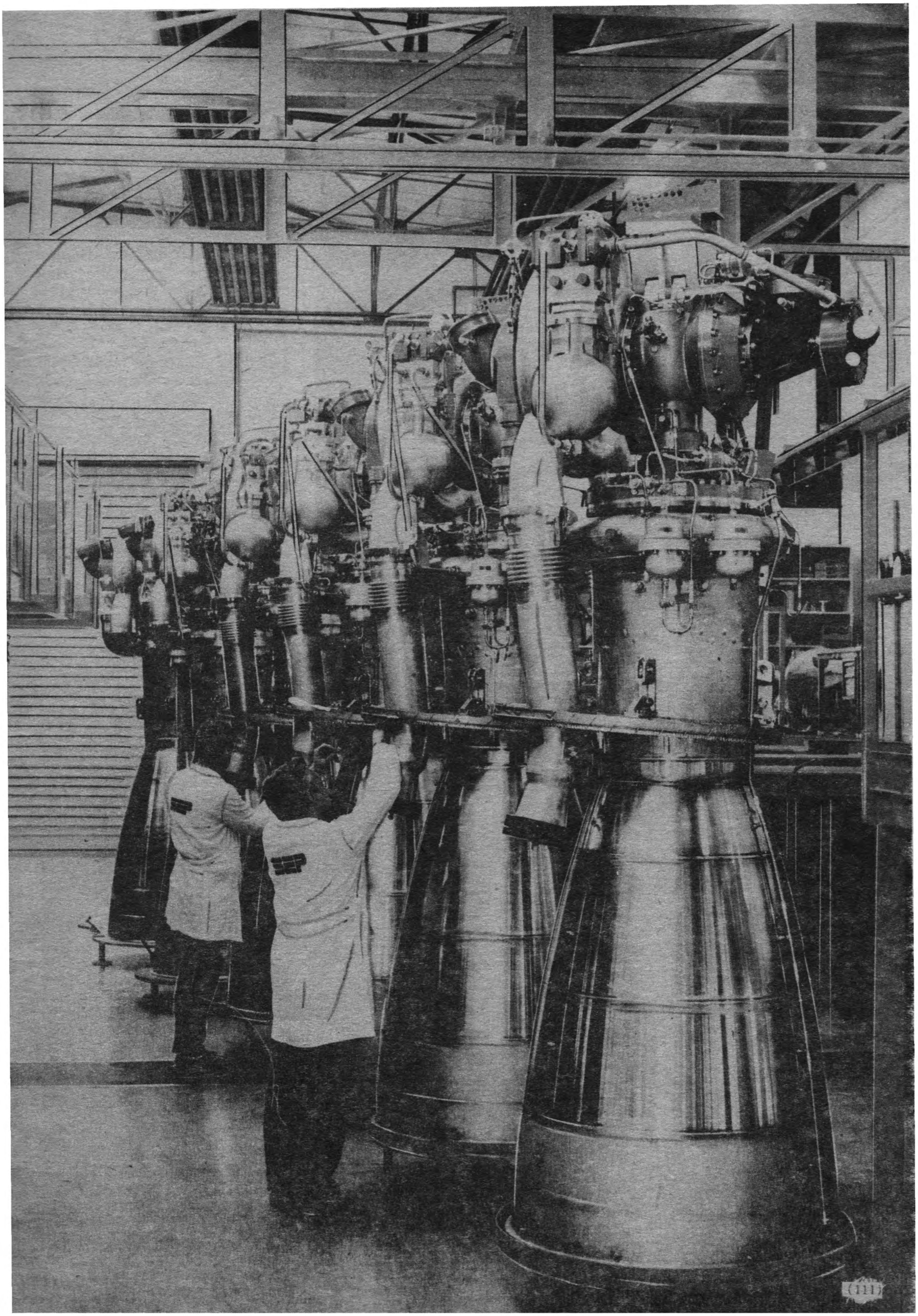
Under the agreement Aerospatiale is to provide 50 first and third staues and 60 strap-on solid rocket boosters. MBB/ERNO will supply 50 second stages and 96 strap-on liquid propellant boosters. Matra will manufacture 50 vehicle equipment bays, which carry the Ariane's guidance and control systems. The Societe Europenne de Propulsion (SEP) will provide 346 Viking engines (each Ariane 4 first stage has four Viking V motors, the second stage is powered by a single Viking IV and the strap-on liquid boosters each carry one Viking VI engine). SEP will also be responsible for the construction of 50 HM7B cryogenic engines for the third stage. The construction rate of the Ariane 4 will be five to eight vehicles per year, the first is to be delivered in late 1991 and the last in 1999.

The contract will be a boost for the Ariane subcontractors in eleven European nations, including the UK's British Aerospace, which manufactures the Spelda payload structure, and Ferranti who supply the gyro platform for the Ariane's guidance systems. Arianespace believes the contract will ensure the jobs of 12,000 people employed throughout Europe in the Ariane programme.

The production line for the Viking motor used in Ariane first, second and strap-on stages. *SEP*

(Left) A cut-away of the Ariane 4 illustrates the complexity of the vehicle. Arianespace sees the booster as its 'work-horse' for the 1990s. During this period fifty launchers will be delivered to the company, which expects to take a large slice of the satellite launching market. *Arianespace*





VLADIMIR SHATALOV

An example of the new openness in the Soviet space programme was displayed recently. The Soviet newspaper *Trud* gave its readers the opportunity to put questions to Vladimir Shatalov ex-cosmonaut and Chief of the Cosmonaut Training Centre.

A. Rodionov, Leningrad: Following Buran's brilliant debut, has the question of the second flight been decided? What is your personal opinion — should it be manned or unmanned? To put the question more broadly: Why do we trust automatic machines more than man on space flights, and why do we endeavour to allocate him a secondary role?

Shatalov: I will begin by answering the last question. This is a rather old discussion: who should have priority on a space flight — man or an automatic machine. A person has his functions, while machines have theirs. Today it is impossible to imagine a space flight without modern high-speed computers and all the very complex technology. But it is still the cosmonaut who is master aboard the craft. He is not a 'passive observer' — it is the pilot and researcher who resolve the complex problems which frequently arise on a flight.

In the past there was a clash of two positions, two approaches to manned flights. Certain designers stubbornly believed that technology must be trusted more than people. A serious blow was dealt to these views back in 1965 at the time of Voskhod-2. The craft was unable to return to Earth from the orbit because of faults in the automatic equipment. It was only by using the manual control system that the crew guided the craft onto the descent path.

Later too, cosmonauts repeatedly found a way out in very complex critical situations. Recall, for example, how in June 1985 Vladimir Dzhanibekov and Viktor Savinykh approached in the manual mode the uncontrolled and unoriented Salyut-7 station, flew around it, executed a meticulously precise and very complex docking manoeuvre and repaired the systems which had gone out of commission.

As for Buran's next flight, I believe that it could be a manned one, after comprehensive training of course. However, there are, of course, other opinions. As far as I know, the final decision has not yet been made. First we have to conduct a careful investigation of the craft which has returned from space.

V. Timofeyev, Voronezh: How many crew members will there be on Buran's first manned flight? What is the largest possible crew on board a shuttle? Who is training to fly on Buran?

Shatalov: Two cosmonauts will conduct test flights on Buran before it becomes operational. Subsequently, there could be four people manning Buran. And for individual tasks requiring the participation of different kinds of researchers, as many as 10 people could fly aboard Buran.

The cabin is divided into two compartments — upper and lower. The total volume is 73 cu.m. (more than seven times that of the three-seater Soyuz-TM).

Now, about those who are being trained to fly in Buran. They are experienced test pilots — I. Volk (group leader), V. Zabloltskiy, R. Stankevicius, U. Sultanov, M. Tolboyev, S. Tresvyatskiy and Yu. Sheffer.

K. Khasanov, Oktyabrskiy, Bashkir ASSR: The newspapers have written that reserve landing strips will be constructed for Buran-type shuttles. Where precisely? Will Buran be our only vehicle, or is it planned to build other shuttles?

Shatalov: One reserve landing strip for shuttles will be completed in the region of Simferopol, and another in the east of the country. Of course, the present Buran will not be our only space shuttle. A second craft is now being assembled in the Baikonur Cosmodrome's assembly and testing block.

D. Shumilin, Minsk: How many flights can a shuttle make? How long can it stay in orbit?

Shatalov: The shuttle is designed for 100 space flights. Its stay in orbit depends on the mission. At the first stage — up to seven days; subsequently — up to one month.

T. Grishchenko, Kiev: What is the fate of the Salyut-7 orbiting station?

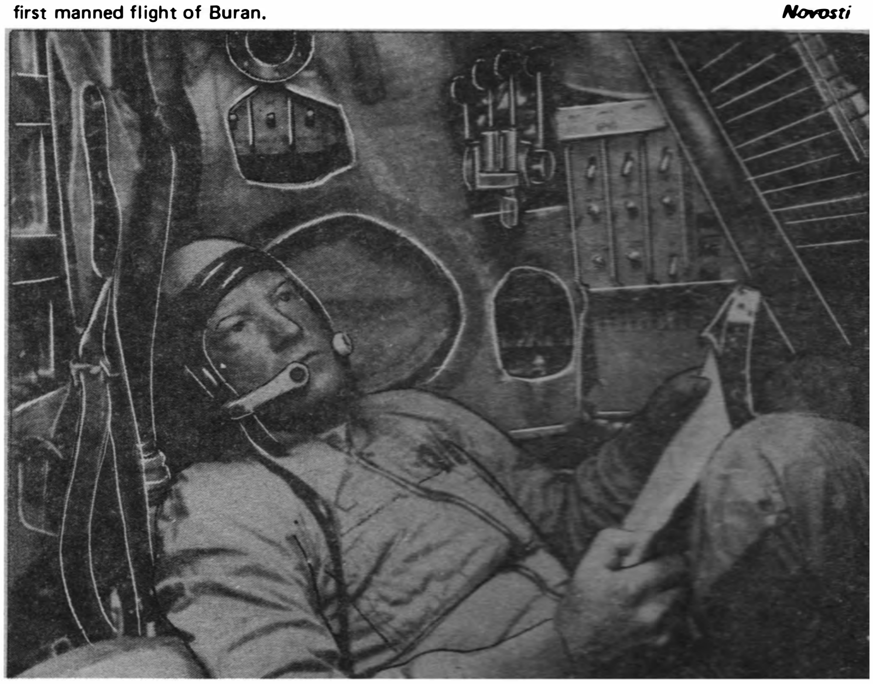
Shatalov: It has been decided to leave this station in space in order to conduct service life tests. This is important to designers for Mir has largely been manufactured from the same materials as Salyut-7. Therefore, it would be interesting to learn how long these materials retain their properties and how they change under the impact of cosmic rays, meteorites, the vacuum and the tremendous temperature gradient. We have to check the thermal and meteorite protection and so forth. After the service life tests have been completed, Salyut-7 will either be returned to Earth by Buran or sunk in the ocean after descending from orbit.

This question was the subject of 67 letters to *Trud*: Is it not time to cut appropriations for space exploration?

Shatalov: Space exploration is of tremendous significance for the development of science and economic progress is impossible without it.

Let's see what space exploration gives us directly for the practical needs of the Soviet economy.

Igor Volk, group leader of the Soviet shuttle cosmonaut corp. Volk is expected to command the first manned flight of Buran. *Novosti*



First, the satellite communications system. Television broadcasting and multichannel long-distance telephone and telegraph communications embrace practically the entire population of the USSR (93%). By the year 2000, seven out of every ten messages carried by all communications channels will be transmitted via space. But if we were to lay down cable the cost would be fantastic.

There is the Tsikada satellite navigation system, which serves ships in the World's oceans. Weather satellites — the use of meteorological information from space ensures an annual saving of up to 500-700 million roubles.

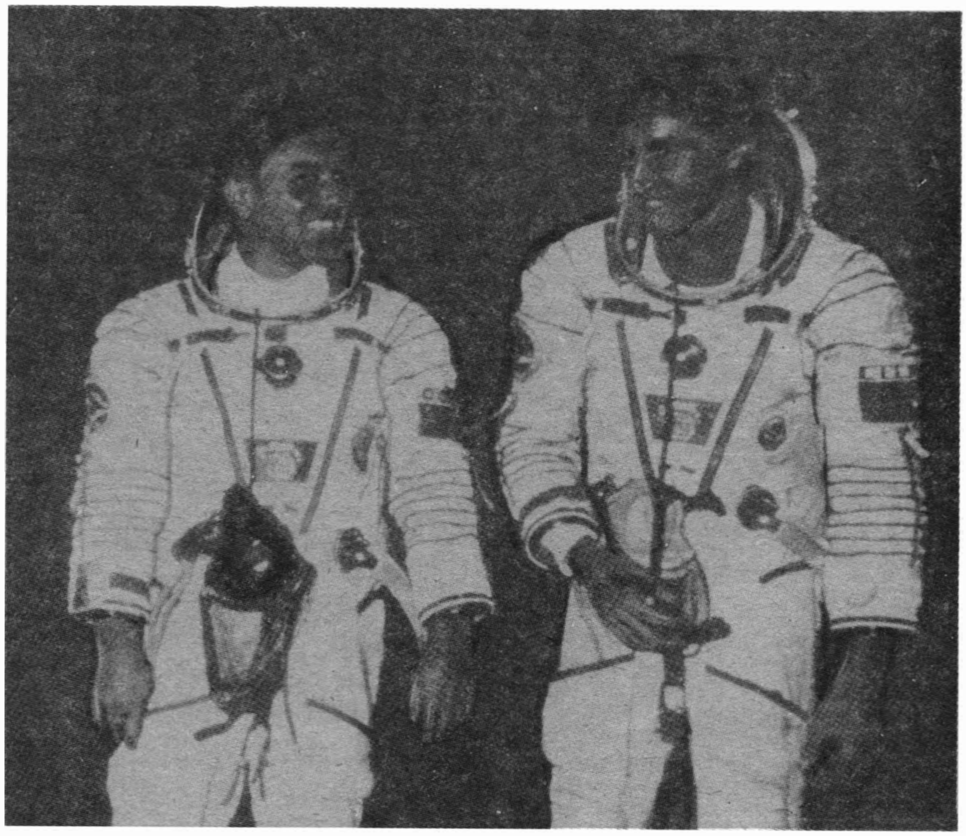
And then such a very important area as study of the Earth's natural environment and resources. Photographs from space combined with aerial and traditional geological exploration methods and with geophysical and geochemical research make it possible more quickly and more cheaply to determine promising areas to look for minerals. For example, a comprehensive analysis of data from an investigation of the Kola peninsula, the Verkhoyansk range and the region around the Sea of Okhotsk revealed a number of promising areas to prospect for ore deposits. Judge for yourselves: what is more profitable — to extract our own metal or purchase it from abroad?

We have begun looking for minerals in remote desert regions: rare metals in the Far East, copper in the region of the Baykal-Amur mainline railway and tin in Yakutia. The Astrakahn oil and gas bearing region was selected for priority development. The prognosis was brilliantly confirmed.

As we see, there is considerable practical return on space research. But I must say that those readers are right to put this question: Why is such insignificant use made of space flights to resolve urgent national economic tasks?

To speak of manned flights, for example, the return on them for our economy could, in my view, be immeasurably greater. It was proved long ago that under weightless conditions in orbit it is possible to obtain invaluable medical preparations and unique crystalline materials, to carry out manufacturing processes that cannot be achieved on Earth.

Experiments have been finalised, but what now? On a permanently manned orbiting station it would be possible to organise semi-industrial production of medicines, crystals, semiconductors and many other things. The technical possibility for this already exists. But for some reason no one is interested in it. Perhaps we have not yet woken up after the 'stagnation hibernation'? Industrial firms in the West are fighting vigorously to buy space aboard the US shuttle, a fight for every gram of payload stowed aboard the craft. Their aim is to open up space for industry as quickly as possible. Unfortunately, such an attitude is very rare in our country. We have a big shortfall here.



Aleksandr Volkov (left) and Sergei Krikalev will return to Earth on April 29. *CNES*

D. Bortsov, Novosibirsk: What is the programme of manned flights in 1989?

Shatalov: A Volkov, S. Krikalev and V. Polyakov are currently on duty aboard the Mir. They will be relieved by another crew in April. Volkov, Krikalev and Polyakov will return to Earth on April 29th. The new crew will work until the autumn, when there will be another change of watch.

S. Markina, Yaroslavl: Are long flights necessary — lasting one year, for example?

Shatalov: If we seriously want to open up space, we cannot do without such flights.

A number of specialists consider work by space crews lasting one year to be the optimum. Others, however, are convinced that crews work most efficiently for four to six months. If we disregard superlong flights designed to study the effect of weightlessness and other space factors on the human organism then orbital flights lasting no more than six months, with the possibility of a 'shift overlap', should in my view be the norm.

I believe it to be expedient to change crews, not over the space of a few days, but over a longer period. It is a matter of having both crews work together for a month or two and carry out the most difficult, intensive programme during this period. During the remaining three or four months the one crew should tackle research, manufacturing processes, the unloading of Progresses and so forth. Thus two or three missions could be carried out over the period of one year. Foreign cosmonauts could work on the station during those few months when two crews will be working simultaneously on the orbiting complex.

S. Grachev, Kursk: The newspapers have written that specialised modules will be dispatched to the Mir complex. When will this happen?

Shatalov: It is planned to launch two modules and dock them with the complex this year. The designers want the interval between the docking of the first and the second modules to be minimal. For an asymmetry will arise in the space complex when one of them docks — which will complicate control of the station.

D. Krutoyarov, Tomsk: Ground services — controllers, designers — have recently been making rather a lot of mistakes. One of the two automatic interplanetary interplanetary stations now flying towards Mars went out of commission because of an incorrect command. There were two malfunctions in a row when international crews returned last September and December — the landings had to be postponed. What accounts for this?

Shatalov: The growing complexity of space programmes demands special composure, attentiveness and responsibility on the part of all involved in a space flight, of cosmonauts, designers, scientists and ground control services. Unfortunately, no one is insured against mistakes. Thus, what is needed are systems which will provide, for example, back-up insurance and additional verification of the correctness of commands transmitted to space from Earth.

The growing breadth and complexity of space programmes, including the organisation at the mission control centre of parallel work with other space objects

The patch for the joint Soviet-French mission. Shatalov says talks are underway with Britain and Malaysia for similar international flights. *CNES*

(Buran and Phobos, for example), requires the involvement of a large number of young specialists in flight control. Maybe they have not all been trained adequately for such work. At the cosmonaut training centre every specialist who deals with the crews must receive the same training as the cosmonauts themselves. Only then can he be considered a real specialist.

V. Shurgot, Moscow: What international flights are planned in the future?

Shatalov: An accord has been reached on a Soviet-Austrian space flight.

In an interview in the newspaper 'Express' the FRG Minister of Research and Technology expressed the hope that the first joint Soviet-West German space flight would take place no later than 1991.

Talks are being held with Britain and Malaysia. The USSR Chief Directorate for the Development and Use of Space Technology for the National Economy and Scientific Research is ready to receive applications from any country to participate in flights on a commercial basis.

The French side wants month-long joint Soviet-French flights to be made once every two years. This has greatly heartened Michel Tognini, the back-up for Jean-Loup Chretien, who recently returned from space. Tognini now has a real chance of going to an orbiting station in 1990 or early 1991.

V. Molchanov, Tula (A *Spaceflight* reader in the USSR): I am very interested in cosmonautics. I was told that a women's crew — S. Ye. Savitskaya, Ye. A.Ivanova and Ye. I. Dobrokvashina — had been training to fly to an orbiting station. Nothing was reported about this. Who were their back-ups?

Shatalov: Yes, in 1984 it was decided to prepare a women's crew to fly to the Salyut-7 orbiting station. The commander was to be Savitskaya, who had already made a space flight in July of that year. The crew also included engineer Ivanova and physician Dobrokvashina. Their back-ups were A. Viktorenko, A. Aleksandrov and V. Solovyev. Why a male crew? The answer is simple: every crew must include one cosmonaut who has already made a flight. In the women's crew this was Savitskaya. But there was no woman cosmonaut for a back-up women's crew who had experience of a flight and who was ready at that time for a new one. That is why the standbys were men. But after the birth of Savitskaya's baby the women's flight did not take place.

V. Petrovicheva, Ivanovo: Will women fly in space this year?

Shatalov: No, such a flight is not planned. Women are not currently being trained at our centre.

V. Korablev, Voronezh: Are our cosmonauts training for a Moon flight?

Shatalov: There is no such need at present. But it is impossible to imagine space exploration in the future without exploring the Moon and setting up lunar bases there.

S. Trunova, Baku: Why is nothing heard about cosmonauts A. Zaysev and A. Kaleri, who were reported earlier to be members of back-up crews? How many cosmonauts are in the detachment now?

Shatalov: Kaleri and Zaytsev are not undergoing training for medical reasons. Five crews are now preparing for future flights, and each one consists of two men: commander and flight engineer. Ten people in all. Depending on the future intensified flight programme researchers who are being trained in their own programmes may later be included in the crews. The group which is training to fly the shuttle also has a special programme (based on flight tests).

T. Spiridonov. Arkhangelsk: Are V Savinykhm, G. Grechko, A. Yeliseyev, V. Askenov and V. Bykovskiy training for new flights?

Shatalov: No, they are not. Savinykh is now Rector of the Moscow Institute of Engineers of Geodesy, Aerial Surveying and Cartography. Grechko is working in an institute of the USSR Academy of Sciences. Yeliseyev is Rector of the N.E. Bauman Moscow Higher Technical School. Askenov is director of a scientific research institute. Bykovskiy is Director of the House of Soviet Science and Culture in Berlin (GDR).

S. Orlov, Sudjarvi: I still remember with anguish the tragic demise of the first Soviet crew of an orbiting station — G. Dobrovlskiy, V. Volkov and V. Patsayev. Everything connected with that flight is dear to history. Would it not be possible to name the cosmonauts who were in the back-up crew?

Shatalov: The thing is that Dobrovolskiy, Volkov and Patsayev were members not of the first but of the second crew for the Soyuz-11 and Salyut orbital station flight. The first crew consisted of A.A. Leonov, V.N. Kubasov and P.I. Kolodin (he now works at mission control centre). But when there were just a few days to go to the launching of Soyuz-11, physicians at Baikonur grounded Kubasov. If one crew member is taken off a flight, this means that the entire crew cannot fly. The state commission made the decision: the second crew — Dobrovolskiy, Volkov and Patsayev — would go into space.

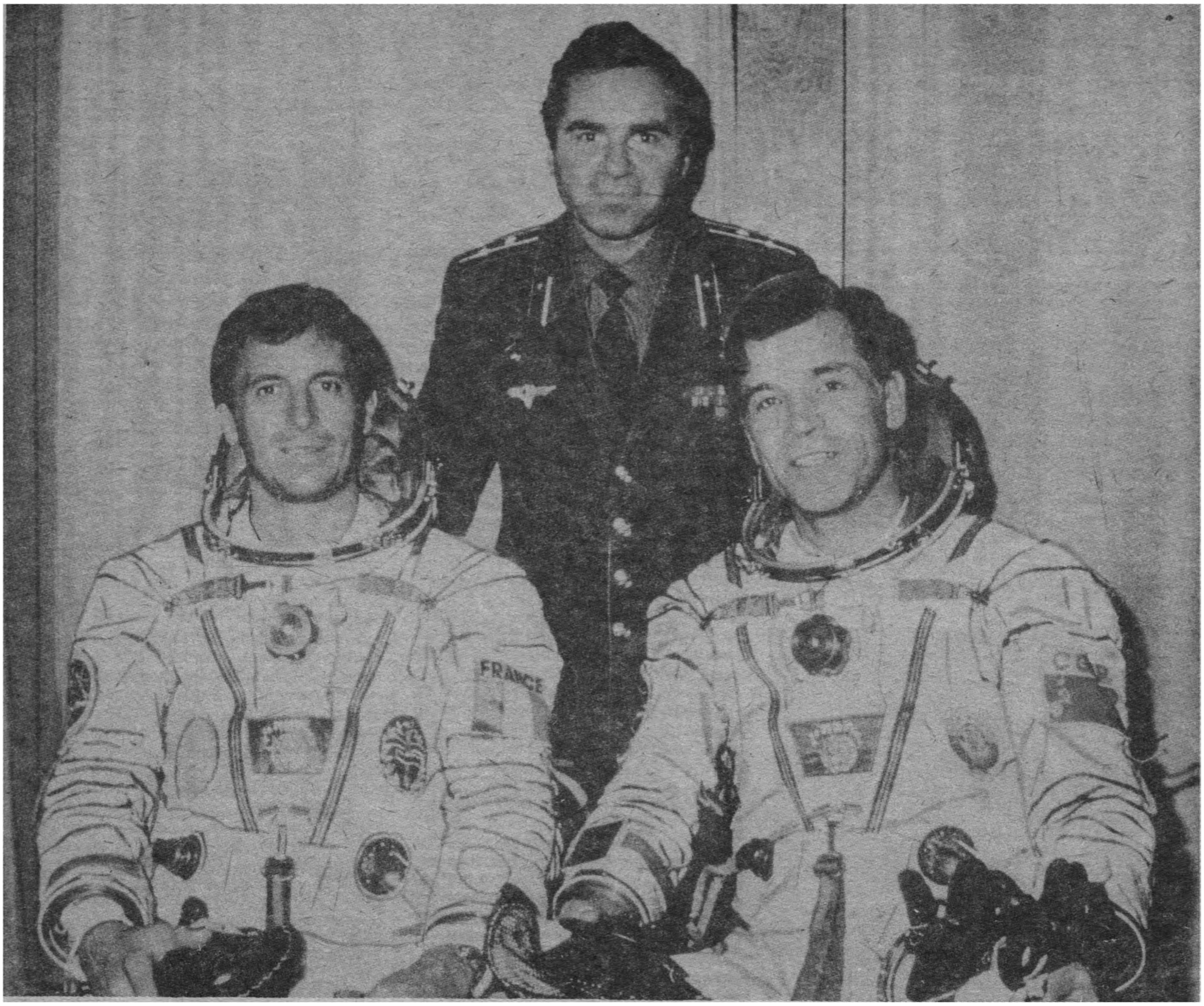
I remember how upset Leonov, Kubasov and Kolodin were at being taken off the flight. But a truly dreadful blow still awaited us when our comrades died during their return to Earth. Everyone took it unbearably hard at the time. It was impossible to look at Kubrasov, Leonov and Kolodin with their darkened, pinched-looking faces, feeling deeply the death of the cosmonauts with whom they had flight trained and who had taken their places.

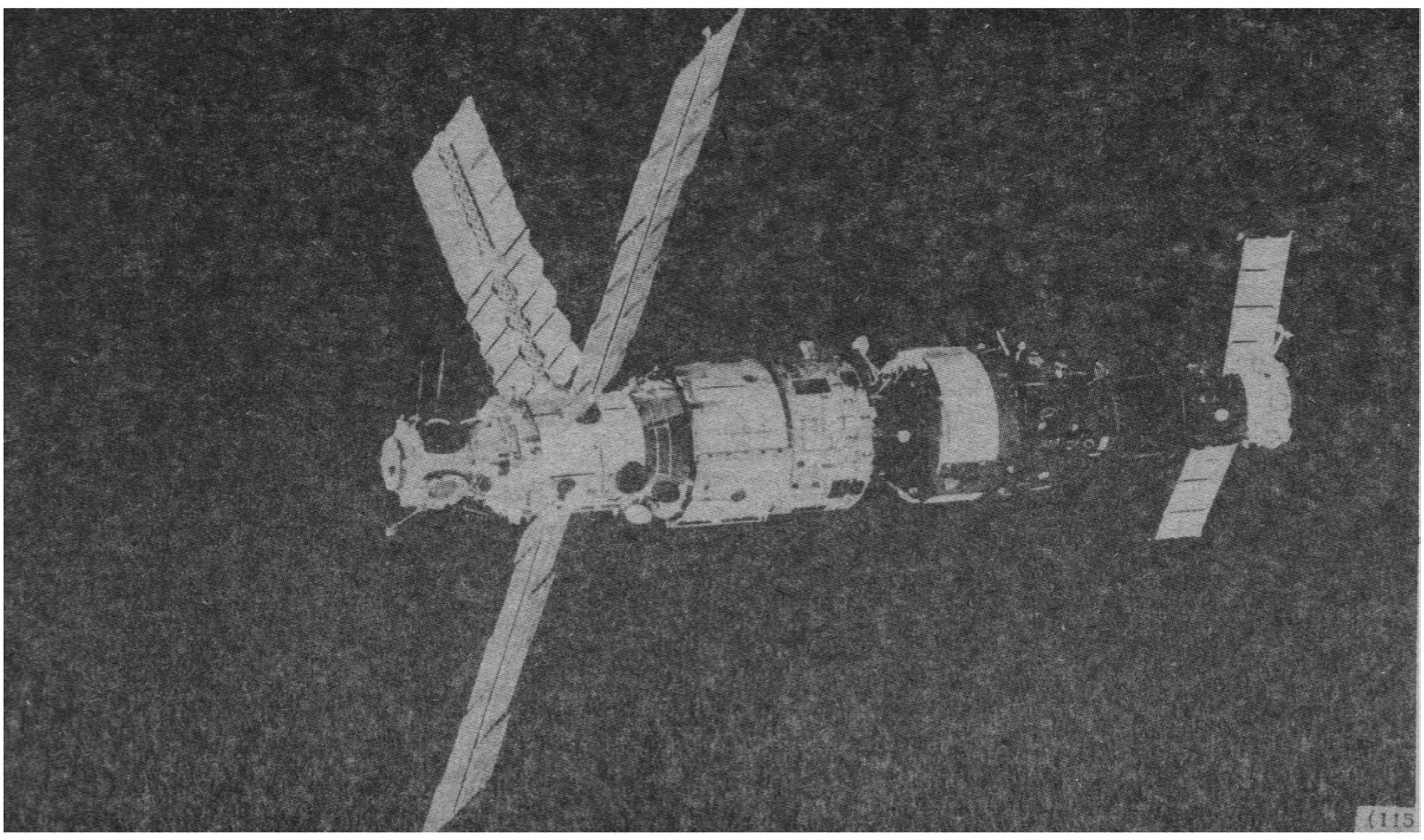
V. Trofimov, Chelyabinsk: How do you see the future of cosmonautics?

Shatalov: The industrialisation of space. Plants in orbit which will give people materials and medicines that are inaccessible on Earth. Satellite information systems. High-capacity orbiting power stations.

I am also sure that there will be lunar settlements (with the aim of producing many rare materials from lunar rock for terrestrial needs and for lunar bases) and interplanetary expeditions.

TOP: The back-up crew for the Joint Soviet-French mission (left to right) Michel, Tognini, Aleksandr Viktorenko and Aleksandr Serebrov. BOTTOM: The Mir space station in orbit, seen from an approaching Soyuz spacecraft. ***CNES***





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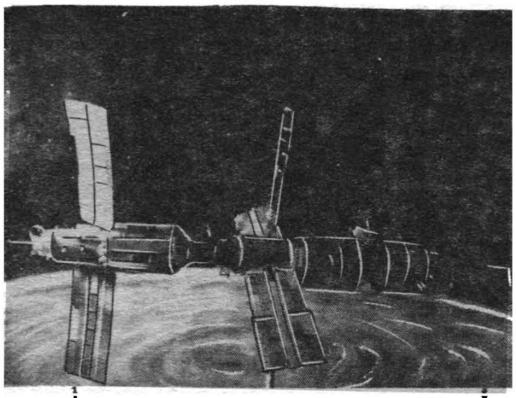
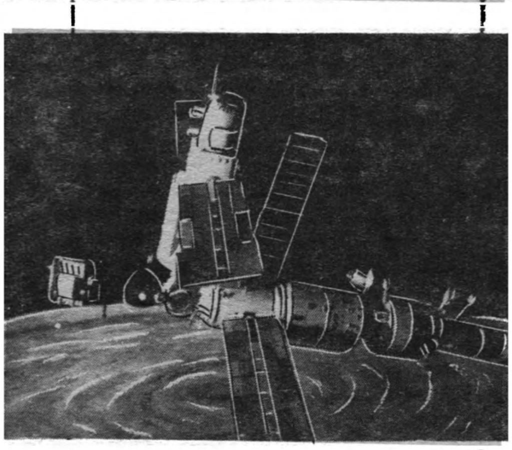
Mir Expansion Delayed

The Soviet space agency, Glavkosmos, has provided *Spaceflight* with up-to-date, accurate information and diagrams of Soviet spacecraft. The material includes information on the first Mir module, the launch of which has been delayed from April to later this year. Regular *Spaceflight* correspondent, *Neville Kidger*, outlines the changes made to the Soviet plans.





Models by *Phil Mills* illustrate the docking procedure for the first Mir module. The module first docks with Mir's front axial port (top) and is then transferred by a remote manipulator arm on the module to the radial port (bottom). The module is expected to dock with Mir later this year.

By Neville Kidger

The Mir space station is currently manned by Aleksandr Volkov, Sergei Krikalev and Dr. Valeri Polyakov. Under the original flight plan Volkov and Krikalev were to conduct two EVAs to install additional solar sensors to Mir's exterior to aid the orientation of the complex.

At the end of April the complex was to receive a 're-equipment' module, which would feature a section for EVAs with a 1 metre diameter exit hatch at the front. It was also to contain a multi-spectral camera system made in East Germany, and a life science experiment featuring small Japanese canaries.

The crew was to have been relieved on the complex by cosmonauts Aleksandr Viktorenko and Aleksandr Serebrov. The latter of these two was to have conducted an EVA from the new module with the brand new Soviet Manned Manoeuvring Unit (MMU), which was shown to Western visitors at Baikonur in November 1988.

Soon after the launch of the 're-equipment' module, a second module was to have been docked with Mir so that the complex did not become asymmetric. With a single module attached to Mir the complex would become difficult to manoeuvre, expending much fuel.

However on February 21 chief spacecraft designer, Yuri Semenov, told Soviet TV viewers that the first module would now be launched in the second half of 1989. The MMU test would take place after this.

The second large module would be a technological one. This is to be a mini-factory for growing crystals in weightless conditions. These are intended for enterprises in the USSR making electronics and lasers. The space-grown crystals will make possible the creation of new super-fast integrated circuits Semenov said

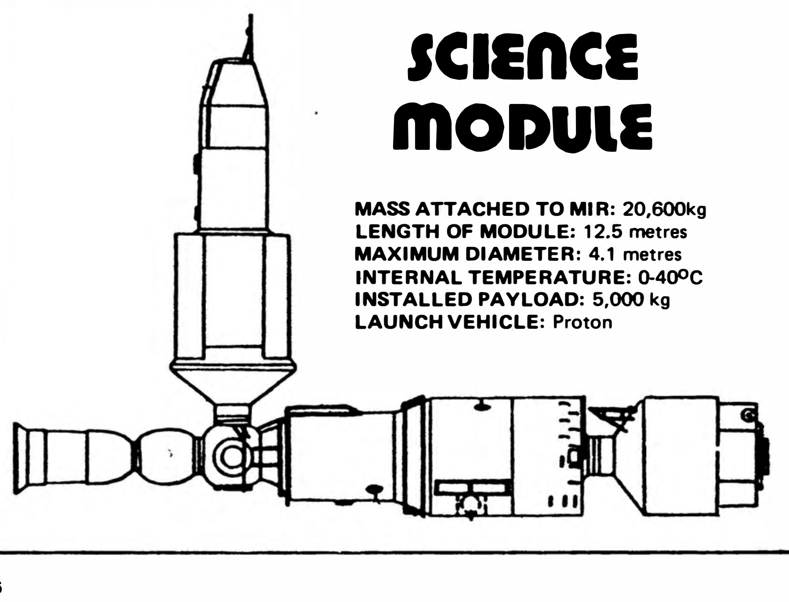
The module will also carry a special unit for work in biotechnology and will produce up to 100 kg of products per year after it begins operations in late 1990 or early 1991.

Semenov said that ecological monitoring equipment, being developed at the moment, would be placed on the module This possibly accounts for the delay of the first module which Volkov's crew was expecting. The task of launching the modules is complex because they have to be prepared simultaneously — a problem with one would ground the other.

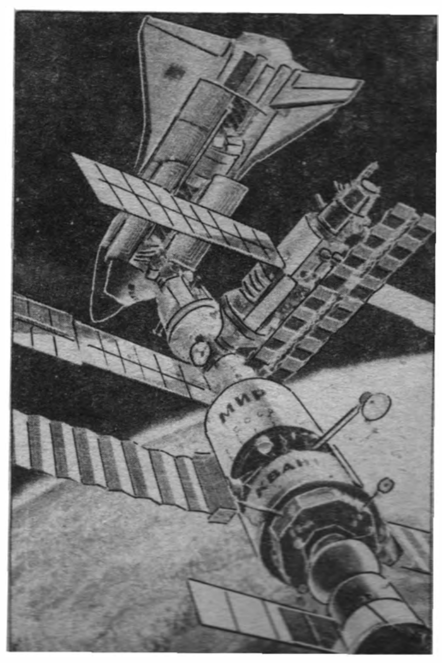
The result of the delay is a major change to the Volkov crew's mission. The EVAs have reportedly been cancelled and the replacement crew, due to be launched on April 19, although still headed by Viktorenko may not contain Serebov, who trained extensively for the MMU spacewalk. The Volkov mission ends on April 29. Polyakov may remain onboard to continue his work with the new crew, which will return after a six month period in orbit.

The next instalment of ***Spaceflight's*** regular Mir Mission Report will contain full details on the flight of Volkov, Krikalev and Polyakov.

SCIENCE MODULE



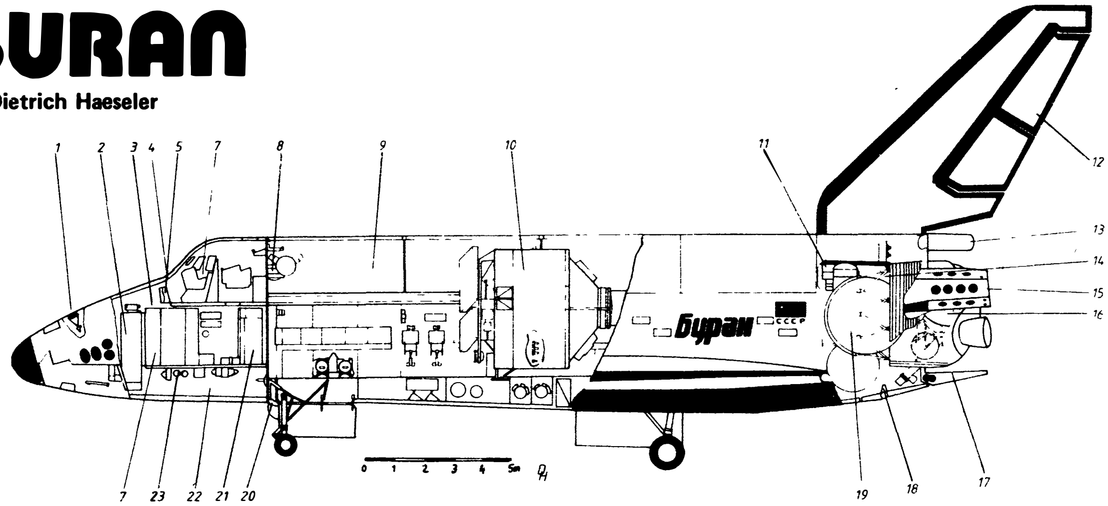
MASS ATTACHED TO MIR: 20,600kg
LENGTH OF MODULE: 12.5 metres
MAXIMUM DIAMETER: 4.1 metres
INTERNAL TEMPERATURE: 0-40°C
INSTALLED PAYLOAD: 5,000 kg
LAUNCH VEHICLE: Proton



A Soviet painting of Buran docked to the Mir space station. *Soviet Union*

BURAN

By Dietrich Haeseler

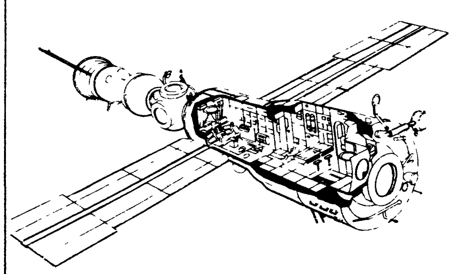


1. Forward reaction control thruster block
2. Equipment bay 1
3. Habitable module
4. Cabin
5. Equipment bay 6
6. Equipment bay 7 and 7A
7. Flight deck
8. Module with command equipment
9. Payload bay
10. Block of additional equipment (space station module)
11. Auxiliary power unit
12. Vertical stabilizer with airbrake
13. Braking parachutes
14. Basis block of the unified propulsion system
15. Reaction control thruster block
16. Fuel tank (kerosine)
17. Body flap
18. Lower central stage attachment point
19. Oxidizer tank (liquid oxygen)
20. Upper central stage attachment point
21. Equipment bay 2
22. Instrument section
23. Temperature regulation system

( ): Denotes authors additions.

Source: Soviet Union 1/89. p.10-13

MIR

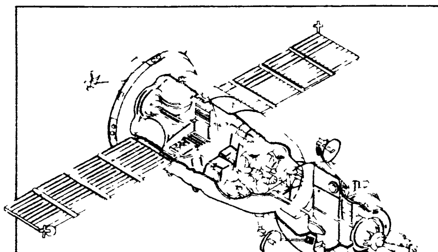


MASS OF BASE BLOCK: about 21,000 kg
LENGTH OF BASE BLOCK: 13.13 metres
LENGTH OF WORKING COMPARTMENT (WC): 7.67 metres
MAXIMUM DIAMETER OF WC: 4.2 metres
DIAMETER OF TRANSFER COMPARTMENT (TC): 2.2 metres
LENGTH OF TC: 2.84 metres
ORBIT: 300 to 400 km
INCLINATION: 51.6°
ORBITAL PERIOD: 90.3 to 93.4 minutes
PRECISION OF ORIENTATION:
- **COARSE MODE:** not less than 1.5°
- **FINE MODE:** not less than 15'

ATMOSPHERE:
- **PRESSURE:** 800 to 970 mm mercury
- **COMPOSITION:** as Earth atmosphere

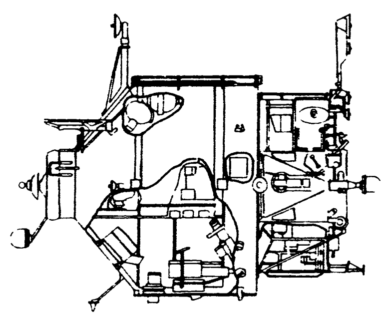
TOTAL LENGTH OF COMPLEX (SOYUZ-MIR-KVANT-PROGRESS: 32.9 metres
MAXIMUM WIDTH ACROSS SOLAR PANELS: 29.7 metres
NUMBER OF MODULES: 5
NUMBER OF CREW:
- **RESIDENT CREW:** 2 to 3 people
- **VISITING CREW:** 2 to 3 people

Mir, Kvant, Soyuz, Progress and Science Module data and diagrams courtesy of Glavkosmos.



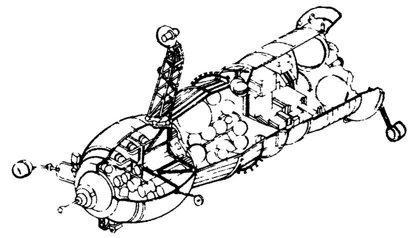
SOYUZ TM

SPACECRAFT MASS: 7,070 kg
LANDING CABIN MASS: 3,000kg
LENGTH OF SPACECRAFT: 6.98 metres (minus docking probe)
MAXIMUM DIAMETER: 2.72 metres
WIDTH OF SOLAR PANELS: 10.6 metres
CREW: up to three people
FLIGHT TIMES:
- **AUTONOMOUS:** up to 3.2 days
- **ATTACHED TO MIR:** up to 180 days



KVANT

MASS ATTACHED TO MIR: 11,000 kg
LENGTH OF MODULE: 5.8 metres
MAXIMUM DIAMETER: 4.15 metres
VOLUME OF PRESSURISED COMPARTMENT: 40 cubic metres
PAYLOAD MASS: 4.1 tonnes

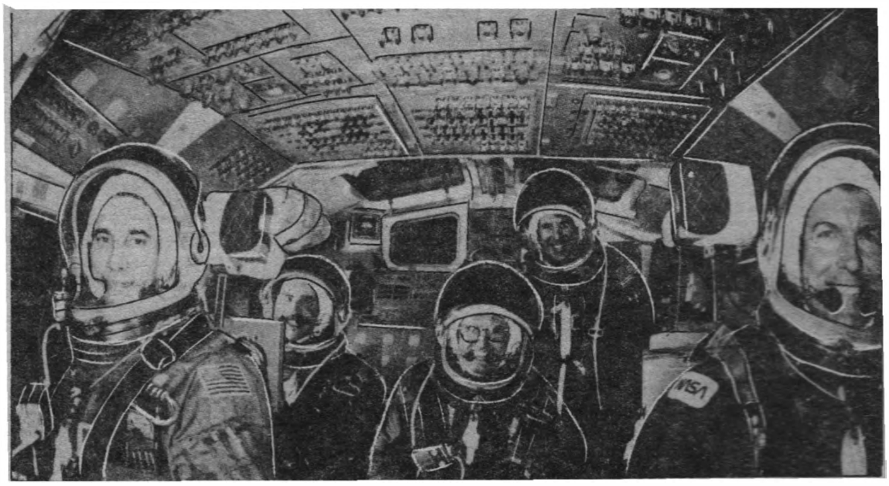


PROGRESS

SPACECRAFT MASS: 7,240 kg
CARGO CAPACITY: up to 2,400kg
DRY CARGOES: up to 1,400 kg
FUEL: up to 1,200 kg
LENGTH OF SPACECRAFT: 6.98 metres (minus docking probe)
FLIGHT TIMES:
- **AUTONOMOUS:** up to 3 days
- **ATTACHED TO MIR:** up to 90 days

SPACE SHUTTLE

Shuttle Fleet Status



The STS-29 crew during pre-flight training. (left to right) Pilot John Blaha, Mission Specialists Jim Bagian, Jim Buchli and Bob Springer, and Commander Michael coats. *NASA*

With seven shuttle flights planned for 1989, the shuttle processing facilities at the Kennedy Space Center (KSC) are a hive of activity. *Spaceflight* continues its regular Shuttle Fleet Status report, bringing readers up to date with the very latest news from the Cape.

Discovery OV-103 STS-29

At the time of going to press there was a race against time to launch Discovery on mission STS-29. The mission was scheduled for March 11, but delayed until March 13, when Discovery's Master Event Controller failed. Columbia's controller was removed and installed in Discovery on March 7.

Replacement high pressure oxidizer turbopumps were successfully installed in Discovery's engines out on the launch pad. The pumps were delivered and fitted earlier than expected and the work was completed on February 22.

If Discovery's launch slips beyond March 18 the mission would have to be postponed so Atlantis can meet the April 28-May 27 launch window for Magellan. A postponement could prompt a major reorganisation of the shuttle schedule. Discovery is to launch the third Tracking and Data Relay Satellite (TDRS), a vital communications link for the Hubble Space Telescope, which is due for launch in December. ***Spaceflight*** will provide a full report on the outcome of the mission next month.

During the preparations for STS-29, Discovery was modified to carry the Galileo Jupiter probe and the Ulysses solar polar orbiter. Both require additional cooling equipment whilst in the payload bay. Atlantis has already undergone the necessary modifications and is scheduled to launch both probes. By converting two orbiters NASA can switch the payloads if Atlantis is unable to make the flight.

Atlantis OV-104 STS-30

Atlantis has to meet the vital 30 day launch window for the Magellan probe. Stacking of the Solid Rocket Boosters for STS-30 was completed on February 17, the External Tank was attached several days later. Atlantis was scheduled to be rolled over from the Orbiter Processing Facility (OPF) to the Vehicle Assembly Building (VAB) on March 9 and mated the SRB/ET stack later that day. While in the VAB work will begin on changing Atlantis' oxidizer turbopumps in the same manner as Discovery. Depending on the STS-29 launch date, the pump replacement could be completed at the launch pad.

Atlantis' tires were installed over the weekend of February 18/19, as were the crew seats. A new location for the seats will allow more room and greater reach for the crew while in their launch and re-entry partial pressure suits.

Meanwhile work on Magellan continued, the probe was mated to its IUS booster and will be moved to the launch pad about a week after the launch of Discovery — this will allow time for the payload facilities at the pad to be fully cleaned.

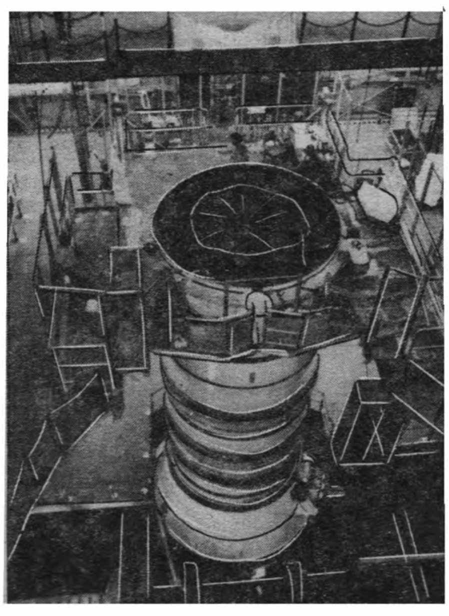
Spaceflight will carry an update on the preparations for STS-30 next month.

Columbia OV-102 STS-28

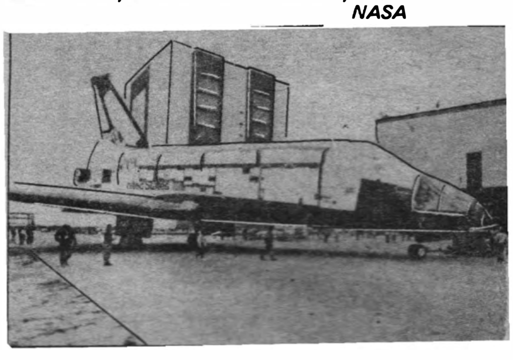
Columbia has been undergoing modifications introduced after the Challenger accident. She was transferred from the Orbiter Maintenance and Refurbishment Facility to Bay 1 of the OPF on January 23, where work accelerated to prepare her for a July launch. Much tile work remains on NASA's oldest orbiter, so much in fact, that Columbia's launch will almost certainly be delayed.

Work to assemble the SRBs for STS-28 began on February 23.

(Left) Engineers replace one of Discovery's high pressure oxidizer turbopumps, out on pad 39B at the Kennedy Space Center. (Right) Stacking of the STS-30 boosters begins in the VAB. *NASA*



Columbia, with many of her tiles missing, is towed to Bay 1 of the OPF on January 23. *NASA*



NASA-DoD Study Highlights Debris Threat

A six month joint NASA-Department of Defense (DoD) study of orbital debris has concluded that, left unchecked, the growth of debris could threaten the safe and reliable operation of manned and unmanned spacecraft in the next century.

The study reviewed current policies and activities designed to reduce the amount of space debris or mitigate its effects and explores potential opportunity for further action. International efforts, legal issues and commercial regulations were also examined.

The report cites satellite and rocket body fragmentation as the principal source of orbital debris. But it recognises that current knowledge of the orbital debris population is limited by the current observation methods.

An estimated 7,059 trackable objects are in orbit around the Earth, the report states Of that number 1,695 are active and inactive spacecraft, 1,076 are spent rocket bodies and 4,288 are fragments and other debris. The report estimates that the number of trackable objects represents only about 0.2 per cent of the orbital debris population. The estimated mass of man-made objects in various orbits is about 6.6 million pounds.

Uncertainty as to exactly how much debris is in orbit makes it difficult to assess the true risk posed to spacecraft, the report states, and that in turn creates uncertainty as to the urgency for action and the potential effectiveness of any corrective action.

NASA's Jet Propulsion Laboratory recently issued a request for proposals for a ground based radar to track orbital debris as small as 1 cm in diameter at an altitude of 500 km. The US Space Command today tracks objects only as small as 10 cm in diameter.

The report also details the effects of collisions that occur at the extremely high speeds these objects are travelling, called hypervelocity In low-Earth orbit (LEO), debris circles the globe at 7 km per second When these objects collide with each other or with operational spacecraft at a combined velocity of 10 km per second, the results can be serious or catastrophic, the report states.

For example, a 0 3 cm object travelling at 10 km a second has the destructive power of a bowling ball travelling at 60 miles per hour. Or a 1 cm aluminium sphere travelling at 10 km per second has the destructive power of a 400-pound safe travelling at 60 miles an hour.

The study group recommends that the NASA-DoD team develop a comprehensive research and development plan to improve orbital debris monitoring, modelling and data management capabilities. It also recommends that NASA and DoD develop a basic plan for generic technologies and procedures for minimizing debris and protecting spacecraft. Both plans are requested by January 1, 1990.

Don Kessler, a scientist at the Johnson Space Center's Space Science Branch and a member of the working group that prepared the debris report, said unless the amount of orbital debris created in orbit is constrained a 'critical density could be reached by the mid-21st Century. Critical density is the point at which the number of collisions creates a runaway increase that renders some altitudes unusable.

"It's something that needs to be looked at in more detail," Kessler said. "You don't want to be wrong one way or the other. If you're wrong about the possibility of losing LEO, then you've done a lot of work towards nothing trying to save it, but if you don't take it seriously you may end up losing LEO."

NASA Issues Call for Reuseable Satellite

The NASA Johnson Space Center (JSC), Houston, Texas has released a request for proposal for study and design of an unmanned reuseable reentry satellite that could significantly expand the agency's capability to investigate the weightless environment. The satellite, called "LifeSat" would be placed into orbit by expendable launch vehicles.

The satellite is planned to be almost completely reuseable and capable of being reflown within two months of the previous flight. Designs are expected to be derivatives of the often-flown Discovery, Gemini, and Apollo designs of the 1960s, calling for a vehicle roughly six feet in diameter, weighing over 2,000 pounds, and carrying a useful payload of 500 pounds.

The LifeSat would be used primarily in the fields of life sciences and materials processing and would fly experiments in a variety of orbits, including those incurring large radiation dosages, for periods up to 60 days. Upon completion of the flight, the spacecraft would soft-land at a ground site where scientists and engineers would have immediate access to the experiments.

Roelof Schuiling

This computer graphic illustrates the vast swarm of debris that surrounds the Earth
ESA

Phobos Returns First Pictures

The Soviet Union's Phobos-2 probe has returned its first images of the Martian moon, Phobos. The probe is due to drop two landers onto the surface of the moon in early April.

The probe transmitted the first pictures of Phobos between 15:35 and 16:25 (all times Moscow Time) on February 21, when it was 860 to 1,130 km from the moon. The pictures were at first stored onboard Phobos-2, then relayed to Earth during a regular communications session. The images will provide information for the probe's more detailed examination of Phobos.

Before returning the pictures, Phobos-2 had been manoeuvred into a more circular 'observation orbit' at 17:06 on February 18. After completing the manoeuvre Phobos' engine unit was jettisoned. The probe will use its own low thrust motors to approach Phobos.

Aurora Satellite

The Japanese Institute of Space and Astronautical Sciences has launched a satellite to study the Aurora Borealis, better known as 'the Northern Lights', and the Auroral Australis, the same effect, but occurring in the Southern hemisphere.

The satellite, named Exos-D, was launched by a M3-SII-3 solid rocket, from Japan's Kagoshima launch site on February 21. It was placed into high inclination orbit of 75 degrees, with a perigree of 300km and an apogee of 8,000km.

It is hoped the satellite will define the mechanism of the aurora particles.

Spacelab Payload Specialists Selected

Dr Ulf Merbold, European Space Agency (ESA) and Dr Roger K Crouch, NASA, have been selected as candidate payload specialists for materials sciences experiments on the International Microgravity Laboratory (IML)-1 mission aboard the shuttle Columbia in April 1991. NASA also announced that it has extended to the government of Canada through the Ministry of Science and Technology an invitation to nominate two candidate payload specialists for the life sciences experiments on the IML-1 mission.

Dr Merbold flew as ESA's Payload Specialist on the Spacelab-1 Mission which was carried out in November/December 1983. He is a solid state physicist from the Max Planck Institute for Metals Research where his main fields of research was crystal lattice defects and low temperature physics. He jointed ESA in 1977.

After the initial training period, NASA will designate, in consultation with ESA, a prime and a backup payload specialist for the materials sciences portion of the IML-1 mission and will also designate, in consultation with the Canadian ministry, a prime backup payload specialist for the life sciences portion.

IML-1 is the first of a series of microgravity investigations using the Spacelab module. It will focus on material and life sciences, two disciplines needing access to a laboratory in reduced gravity. IML-1 will use the Spacelab long module and is a dedicated microgravity mission.

The investigations will use five life sciences experiments, designed to be used and flown again - Biorack, Protein Crystal Growth Facilities, Gravitational Plant Physiology Facility, Microgravity Vestibular Investigations and Space Physiology Experiments; and three materials facilities - Fluid Experiment System, Vapor Crystal Growth System, Mercury-Iodide Crystal Growth System and the Critical Point Facility. These reusable facilities have been built by US, European, Canadian and Japanese investigators and organisations for reflight Critical Point Facility for thermodynamic studies under microgravity.

In addition to the experiments which require the reusable facilities, three other life science and three other materials science experiments with unique hardware will fly aboard IML-1.

The IML series are designed to fly at 17 to 25 month invervals, enabling investigators to analyse and understand the results of flight experiments and use that knowledge to design additional aboard the NASA-ESA Spacelab system.

ESA provides two major facilities for the IML-1 mission: the enhanced version of the Biorack of which a first version was already flown successfully on Spacelab D-1 in 1985 and the newly developed experiments.

Columbia will fly in a 160 (nautical) mile-high, 28.5 degree orbit. Mission duration is nine days and the crew will consist of two payload specialists and five additional astronaut/mission specialists. The orbiter will fly in a tail-down attitude called "gravity gradient" thereby producing the least gravitational disturbances on the Spacelab during the mission flight duration.

The IML series is intended as an ongoing international research programme in materials and life sciences in a microgravity environment.

Soviet Shuttle Cover

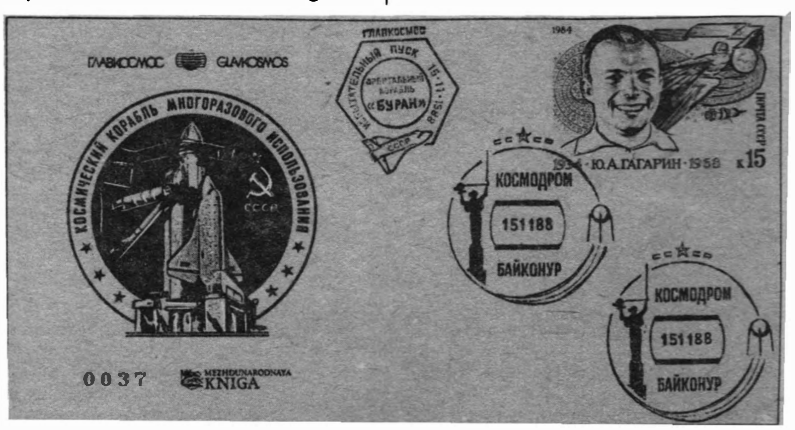
A philatelic envelope has been prepared by Mezhdunarodnaya Kniga, the Soviet export agency, in cooperation with Glavkosmos, the Soviet space agency, to commemorate the first test flight for the space shuttle Buran. The covers were not aboard the shuttle itself, but were at the Baikonour space facility for the launch and recovery.

The beautiful red and blue multicolour, printed cachet reads, "Multipurpose Reuseable Cosmic Ship," and the rubber stamp shows a line drawing of the space shuttle and reads "Experimental Flight 15.11.1988 Orbital Rocket 'BURAN'."

The postmarks on the Yuri Gagarin postage stamp are from the "Baikonour Cosmodrome" and are dated November 15, 1988. There are two postmarks, one for the launch and one for the successful landing at the space centre.

The back of each cover has a rubber stamp, with the legend in Russian and English, "Commemorative Cover Devoted to the Test Launching of 'Energia' Carrier Rocket and Space Shuttle Buran 15.11.88. Glavkosmos USSR and V/O Mezhdunarodnaya Kniga." Each cover is individually authenticated and signed by A. Ya. Belostotsky, General Director of Kniga, the official Soviet export agency.

Les Winick



Scout Agreement

NASA and the Missiles Division of LTV Missiles and Electronics Group, Dallas, Texas, have announced the signing of an agreement which grants the firm exclusive rights to commercially produce and market the Scout launch vehicle.

LTV has manufactured the NASA-developed Scout rockets since 1958 under a series of government contracts which procured flight vehicles in support of NASA science missions.

Under the new agreement, LTV is granted rights to produce and launch the Scout on a commercial basis and is provided access to NASA-controlled production tooling and special test equipment used in the production of the Scout rockets. The agreement also enables LTV to obtain the use of Scout launch support facilities at the NASA Wallops Island, Virginia, and Vandenberg Air Force Base, California launch sites.

The Scout launch vehicle became operational in 1960 and has undergone upgrading since 1976. The standard Scout is a solid-propellant four stage vehicle approximately 75 feet in length. The lift-off thrust is 132,240 pounds. Improvements have increased the Scout's capability to place payloads in low Earth orbit to approximately 210 pounds. Over 100 Scouts have been launched to date. They have placed payloads into inclined, equatorial, and polar orbits for a variety of missions.

Roelof Schuiling

SATELLITE DIGEST-220

Robert D. Christy

Continued from the March 1989 issue

A monthly listing of satellite and spacecraft launches, compiled from open sources. The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1974, 1988-92A, 19554

Launched: 2225, 3 October 1988 from Plesetsk, USSR by A-2-e.
Spacecraft data: Probably similar to the Molniya satellites, in which case it has a cylindrical body with a conical orbital adjustment motor section at one end. The opposite end of the vehicle carries sensors and a solar panel array set in a plane at right angles to the main axis of the body. Stabilisation is probably by the use of momentum wheels. The length is about 4 m, the maximum diameter about 1.6 m, and the mass around 1,800 kg.
Mission: Part of the USSR's ballistic missile early warning system.
Orbit: Initially 585 × 39,431 km, then raised to 586 × 39,784 km to ensure daily repeats of the ground track.

COSMOS 1975, 1988-93A, 19573

Launched: 0803, 11 October 1988 from Plesetsk, USSR by F-2.
Spacecraft data: Possibly a truncated cone with a pair of sun seeking solar panels at right angles to the centre of the body, and an Earth pointing sensor array at the larger end. The length is probably about 4 m, maximum body diameter 1.5 m and mass around 1,600 kg. Stabilisation may either be by by the use of a gravity gradient boom or by momentum wheels.
Mission: Electronic intelligence gathering.
Orbit: 631 × 666 km, 97.76 min, 82.54 deg.

COSMOS 1976, 1988-94A, 19582

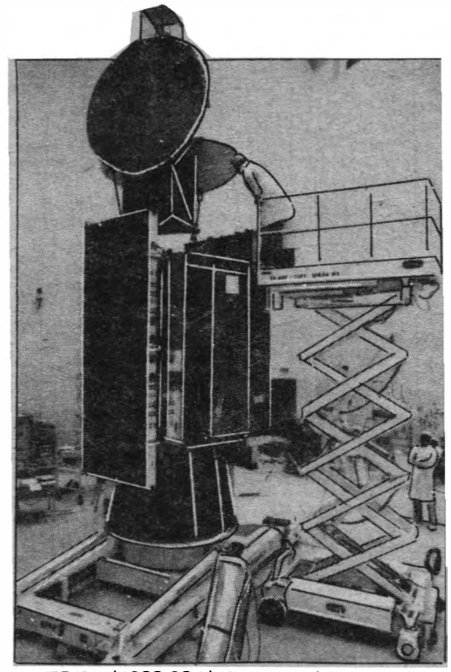
Launched: 1120, 13 October 1988 from Plesestk, USSR by A-2.
Spacecraft data: Based on the Vostok manned spacecraft and consisting of a spherical, camera carrying re-entry module supported by a conical instrument unit containing batteries, control equipment and a rocket motor system. A 2 m diameter, 0.5 m deep, cylindrical, supplementary instrument package may be carried at the forward end. The overall length is about 6 m, maximum diameter 2.4 m and the mass is between 6 and 7 tonnes.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 359 × 410 km, 92.29 min, 72.86 deg.

RADUGA 22, 1988-95A, 19596

Launched: 1543, 20 October 1988 from Tyuratam, USSR by D-1-e.
Spacecraft data: Probably similar to the Gorizont satellites, being a stepped cylinder with a dish aerial array at one end. Electrical power is provided by a pair of rotatable solar panels at right angles to the body. Station keeping is by the use of gas jets, and three-axis stabilisation is achieved by momentum wheels. The length is about 5 m, the maximum diameter about 2 m, and the mass around 2,000 kg.
Mission: Communications satellite providing continuous telephone, telegraphic and television links within the USSR.
Orbit: Geosynchronous above 35 deg east.

COSMOS 1977, 1988-96A, 19608

Launched: 1803, 25 October 1988 from Plesetsk, USSR by A-2-e.
Spacecraft data: Probably similar to the Molniya satellites, in which case it has a cylindrical body with a conical orbital adjustment motor section at one end. The opposite end of the vehicle carries sensors and a solar panel array set in a plane at right angles to the main axis of the body. Stabilisation is probably by the use of momentum wheels. The length is about 4 m, the maximum diameter about 1.6 m, and the mass around 1,800 kg.
Mission: Part of the USSR's ballistic missile early warning system.
Orbit: Initially 630 × 39,253 km, 708.23 min, 62.90 deg then raised to 634 × 39,728 km, 717.91 min, 62.90 deg to ensure daily repeats of the ground track.



TDF 1 (1988-98A) during preflight checks. The satellite was launched by Ariane on October 28, 1988. *Arianespace*

COSMOS 1978, 1988-97A, 19612

Launched: 1130, 27 October 1988 from Plesetsk, USSR by A-2.
Spacecraft data: Based on the Vostok manned spacecraft and consisting of a spherical, camera carrying re-entry module supported by a conical instrument unit containing batteries, control equipment and a rocket motor sytem. A 2 m diameter, 0.5 m deep, cylindrical, supplementary instrument package may be carried at the forward end. The overall length is about 6 m, maximum diameter 2.4 m and the mass is between 6 and 7 tonnes.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 229 × 282 km, 89.66 min, 72.87 deg.

TDF-1, 1988-98A, 19621

Launched: 0217*, 28 October 1988 from Kourou, French Guiana by Ariane 2 (V-26).
Spacecraft data: Box shaped body with an aerial mast on one face, approx 2 m all round. Power is provided by a 19.3 m span solar array. The mass (in orbit) is 1318 kg.
Mission: French, domestic directbroadcasting television satellite.
Orbit: Geosynchronous above 19 deg west.

USA-33, 1988-99

Launched: 6 November 1988 from Vandenburg AFB, USA by Titan 34D.
Spacecraft data: not available.
Mission: Probably a pair of satellites in the Satellite Data System, used for military communications to and from northern polar regions.
Orbit: Approx. 600 × 39,700 km, 718 min, 63.4 deg.

BURAN F-1, 1988-100A, 19637

Launched: 0300*, 15 November 1988 from Tyuratam, USSR by K-1 (Energia).
Spacecraft data: Winged re-entry vehicle, 36 m long, with wingspan 24 m and fuselage diameter 5.6 m. The mass at launch was 105 tonnes.
Mission: Unmanned test flight of the Soviet Union's first shuttle orbiter. It landed on the Baikonur runway at 0625, after two circuits of the Earth.
Orbit: 248 × 256 km, 89.48 min, 51.63 deg.

2,000th Cosmos Launched

The Soviet Union launched the 2,000th Cosmos satellite on a Soyuz (SL-4) launcher from Plesetsk on February 10. Earlier the same day a string of military communications satellites, Cosmos 1994-1999, lifted off from Plesetsk, Cosmos 2001 was launched four days later.

The Cosmos series has become known as the 'catch all Cosmos'. The Soviets use it to categorise, many would say conceal, their military satellites, experimental spacecraft and launch failures. The first Cosmos satellite was launched on March 16, 1962, since then Cosmos launches have steadily increased, reaching just under 100 satellites per year.

Cosmos 2000's Earth resources mission includes mapping the central areas of Antarctica. Yuri Kiyenko, General Director of the State Research and Production Centre Priroda, said the satellite would provide unique data on the ice cover, on the outcrops of rocks and the formation of glaciers and icebergs. Also, new data might be obtained on the formation of the 'ozone hole' over the area. The satellite will also photograph areas of the Soviet Union.

A Tass statement, issued to commemorate the 2,000th launch, confirmed Cosmos 1374, 1445, 1517 and 1614 were the tests of the Soviet mini shuttle, which according to the statement: "were the first Soviet aerospace vehicles, which tested [the] heat protective covering for the Buran reusable spaceship".

BOOK NOTICES

The Moon Book

K. Long, Johnson Books, 1880 South 57th Court, Boulder, Colorado 80301, USA., 1988, 128pp, $6.95.

This paperback concisely summarises many fascinating facts about the Moon, including explanations of the times of Moonrise and Moonset, eclipses, lunar phases, Moon lore, lunar photography and the like.

It is very readable, filled with diagrams, and both erudite yet easy to understand.

The same publisher also issues a striking annual black and white poster-calendar, providing a graphic display of the phases of the Moon for each day of the year. It adds information on perigee, apogee, etc and is also available in card form. The poster size, 31½" x 20½", is available at $6.95, the card size, 6½" x 10½" at $1.95.

Annual Review of Astronomy and Astrophysics Vol. 26

G. Burbidge *et al*. Annual Reviews Inc., 4139 El Camino Way, PO Box 10139, Palo Alto, CA 94303-0897, USA. 1988. 703 pp. $51.

This volume contains sixteen contributions which provide authoritative reviews of some of the most active areas of astronomy and astrophysics today. The range, as ever, is extensive, beginning with a current view of comets in the wake of Giotto, the origin of the solar system, star formation and supernovae remnants and reaching finally to the large-scale structure of the Universe.

The information-content is invariably very high so, although the contributions would be valuable to any student or intelligent layman interested in astronomy, careful reading is essential if one is to make the most of the information imparted.

All contributions are carefully and fully referenced and prepared to a high standard.

A Manual of Advanced Celestial Photography

B.D. Wallis & R.W. Provin, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, England, 1988, 388 pp, £25.00.

Recent improvements in photographic emulsions, hypersensitization techniques and telescopic equipment have made it possible for amateurs to make real contributions to astronomy. This is a unique technical handbook which brings together topics generally not available to the non-specialist, thus bridging the gulf between the novice and the advanced astrophotographer. It includes a detailed discussion of topics not usually mentioned in general surveys, e.g. photographic optics, instrument design, techniques at the telescope, films and developers, advanced darkroom methods, sensitometry and film hypersensitization. Emphasis is placed on understanding basic photographic principles and professional laboratory methods.

A number of special techniques are discussed which add to the comprehensive nature of this work and have the aim of encouraging readers to obtain celestial photographs of a high order.

ETI A Challenge for Change

P. Schenkel, Vantage Press Inc., 516 West 34th Street, New York, NY 10001, U.S.A., 1988, 248 pp, $16.95.

In this book the author postulates what contact with advanced intelligent life and other planetary systems could mean to mankind. He believes that such life exists and urges increased SETI efforts.

Part I examines some of the economic and political problems facing mankind today, hence a fair amount of comment on the current political scene and the inclusion of all sorts of political worthies in the index. Part II not only supports the idea of the existence of extraterrestrial intelligence but stresses the probability that this is likely to be more advanced than we are, both in technology and in other respects. The author argues that older civilizations must necessarily have undergone similar evolutionary stages to ourselves and propounds the view that such meetings would be highly beneficial to mankind.

Satellite Astronomy: The Principles and Practice of Astronomy from Space

J.K. Davies, John Wiley & Sons Ltd., Baffins Lane, Chichester, West Sussex, PO19 1UD, England, 1988, 198 pp, £34.50.

Satellites are now the key tools in astronomy which have revolutionised the way in which we perceive the Universe. This book provides a comprehensive review of how astronomy is now carried out from space and examines, in some detail, those historic missions which provided the quantum leaps in our ability to observe and understand the Universe.

It begins with an introduction to the basic principles, operational methods and engineering challenges posed by space astronomy. This is followed by chapters which describe the use of satellites for investigating various regions of the electromagnetic spectrum. The main types of instruments applicable to each energy band are described and several important satellites and their results reviewed in detail. Additionally, a number of smaller missions are summarised and guidance given as to further reading.

Each chapter concludes with details of further missions already approved and due for launch over the next few years. A final chapter examines a developing role expected for astronomical satellites over the next century, including instruments attached to space stations and installed on the Moon.

Guidance and Control 1988

R.D. Culp & P.L. Shattuck, Univelt Inc., PO Box 28130, San Diego, CA 92128, U.S.A., 1988, 576 pp, Hard back $75, Soft back $60.

This book, Vol. 66 in "Advances in the Astronautical Sciences", is based on a conference held early in 1988. Sections include spacecraft attitude control and autonomy, guidance and control storyboards displays, space station system control techniques and offboard navigation and attitude systems.

Astrodynamics 1987

J.K. Soldner *et al*, Univelt Inc., PO Box 28130, San Diego, CA 92128, U.S.A., 1988, 1774 pp, Hard back $180, Soft back $150.

This volume, in two parts plus a microfiche supplement, presents the proceedings of the latest of a series of annual Astrodynamics Conferences, held in August 1987. Wide-ranging session topics included space transportation, LEO orbit determination, optimal control, gravity assist missions, precise orbit determination, multi-body dynamics and tethered satellite, the NASA Mars exploration programme, semianalytic satellite theory, a special NORAD session, structural identification and control, planetary mission and payload analysis, satellite debris and orbit decay, dynamics and control of rotating structures and outer planetary exploration.

The Cambridge Atlas of Astronomy

J. Audouze and G. Israel, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, England, 1988, 431 pp, £35.00.

The exploration of our Universe is one of the great intellectual adventures of the present age. Telescopes on the Earth and in space have enabled us to see the stars as never before, to perceive our own galaxy more clearly and to penetrate the vast reaches of space. Radiation of all types collected by modern instruments e.g. light, radio waves, x-ray and ultraviolet radiation, when analysed by the latest image processing techniques, has provided a new perspective of star formation, interstellar matter and the turmoil which takes place within active galaxies and quasars.

This second edition of an outstanding compendium of information contains results from the most recent space missions such as the Voyager 2 encounter with Uranus, the Giotto mission to Halley's Comet and the series of Soviet spacecraft used to explore Venus and its atmosphere. It has been extensively revised and brought completely up to date.

The atlas provides detailed information on planetary science, modern astronomy and astrophysics and cosmology generally. Many of the illustrations have been computer-processed to emphasise features of significance. There are 350 colour photographs, 420 in black and white and over 300 other illustrations prepared specially for the book, all accompanied by extensive captions.

Quasars, Redshifts and Controversies

H. Arp, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, England, 1988, 198 pp, £12.50.

In this book the author contests the accepted view that quasars are the most distant objects in the universe and presents observations and data to explain why he has concluded them to be associated with relatively nearby galaxies.

He takes the view that the enormous redshifts of quasars do not arise from the expansion of the universe but are an intrinsic property of the quasars themselves, adding that galaxies and quasars probably have an origin far different from that assumed by the "Big Bang" model of the universe.

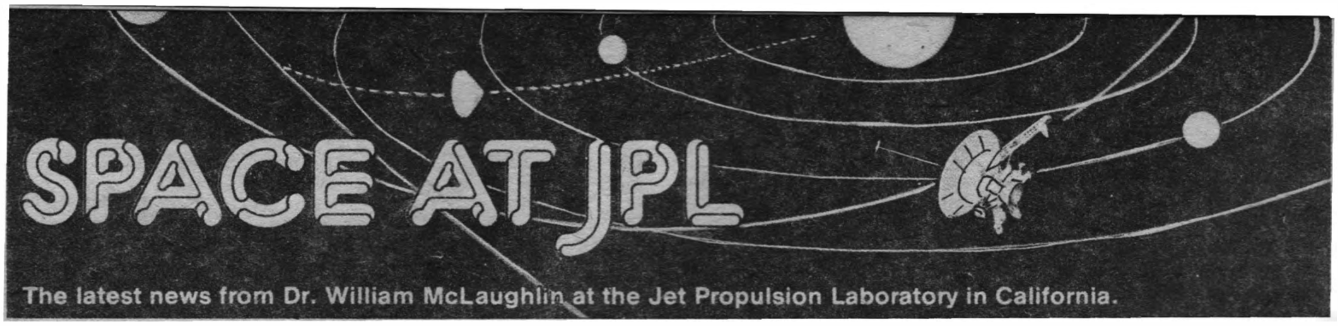
The Guide to Amateur Astronomy

J. Newton & P. Teece, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1988, 327 pp, £15.00.

Amateur astronomy is still an area of scientific activity where modest equipment can offer the chance of making exciting discoveries.

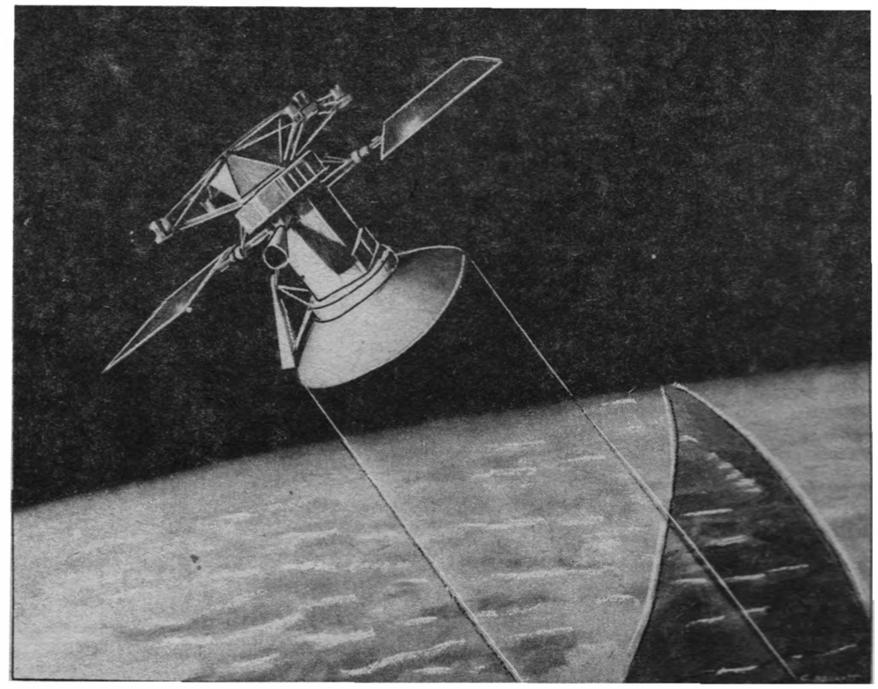
This book introduces the fundamentals of astronomy and explains how one can get started in making one's own observations. It includes maps of the night sky to help with indentification, as well as information on how to recognise and locate planets.

After acquiring some basic knowledge, a new observer will wish to turn to some of the more advanced projects described in the book. An important feature is the emphasis placed on practical techniques, including how to build a telescope from first principles, make an observatory for it and experiment with astro-photography. Other areas lie in observing variable stars or using a personal computer. There are plenty of additional suggestions for investigation, including asteroid and comet hunting, nova and supernova searches, observing binary stars, etc.



Magellan to Venus

For thirty years the primary assignment of JPL has been to conduct unmanned exploration of the Solar System within the NASA programme. However, no JPL-managed missions have been launched to the planets since Voyagers 1 and 2 in 1977. Thus, the scheduled lift-off this month or in May of the Space Shuttle Atlantis, carrying the Magellan spacecraft mated to an upper-stage rocket, is not only an event of scientific importance but also constitutes a refreshment of the Laboratory's prime purpose. The feeling of refreshment is broadly based since, as I write this piece in January, President Reagan's budget submission to Congress includes a project start in Fiscal Year 1990 for the first two Mariner Mark II missions: Comet Rendezvous Asteroid Flyby (CRAF) to Comet Kopff and Cassini to Saturn.


In this artist's concept, the Magellan probe orbits Venus, mapping the surface of the planet.
Martin Marietta

New beginnings are certainly not unique to the space programme, but they are often more visible in such a progress-oriented endeavour. When I joined the Apollo lunar-landing project in 1968, recovery from the devastating fire of 1967 which killed three astronauts was well underway, and the Christmas circumnavigation of the Moon by Apollo 8 dramatically certified that fact (along with the October 1968 flight of Apollo 7). Similarly, one can view the Magellan launch as a healing event for the trauma inflicted on planetary exploration by the explosion of Challenger in 1986. For me, the cumulative low point was reached after the Challenger's destruction when I walked through the flight-team areas of Galileo and Ulysses, scheduled for May 1986 launches (Galileo is now rescheduled for October 1989 and Ulysses for October 1990). The sense of lost opportunity was a palpable companion for the people who sat in those offices and tried to guess what an uncertain future would bring.

Prior to the Challenger accident, Magellan was scheduled for an April 1988 launch — almost two years after Galileo's and Ulysses' planned ascents — and consequently the project was earlier in its development cycle. Hence, while Galileo and Ulysses had to de-staff many positions, Magellan adjusted its build-up profile. (The modifications to the Galileo spacecraft have also been extensive since it must now be equipped to survive the thermal rigours of the inner Solar System while receiving a gravity assist from Venus; see the May 1987 "Space at JPL" for these changes and last month's column for some scientific plans which this outer-planet mission has formulated to take advantage of the 15,000 km flyby of Venus in February 1990.)

Space exploration is a feasible and rewarding activity, as the record attests, but it often poses a series of challenges that manifest themselves as threats to a schedule. In order to meet President Kennedy's goal of a successful lunar expedition by the end of the decade, Apollo managers had to juggle flight schedules to suit the occasion. For example, the Apollo 8 circumnavigation of the Moon was a late interpolation between the Earth-orbiting Apollo 7 and 9 missions, designed to accommodate the current state of hardware development and stay on the critical path to the first lunar-landing mission. Magellan has built its schedule not to conform to a presidential mark but to meet the realities of planetary alignments and Shuttle manifests.

Magellan experienced two hardware challenges to its schedule when, in October 1988, a short-lived but intense battery fire took place just after the spacecraft arrived at the Kennedy Space Center (KSC) and later in the year when fabrication flaws were detected in portions of the radar and spacecraft-data subsystems. Through the fall and winter, project personnel added work shifts and eliminated holidays to recover lost time.

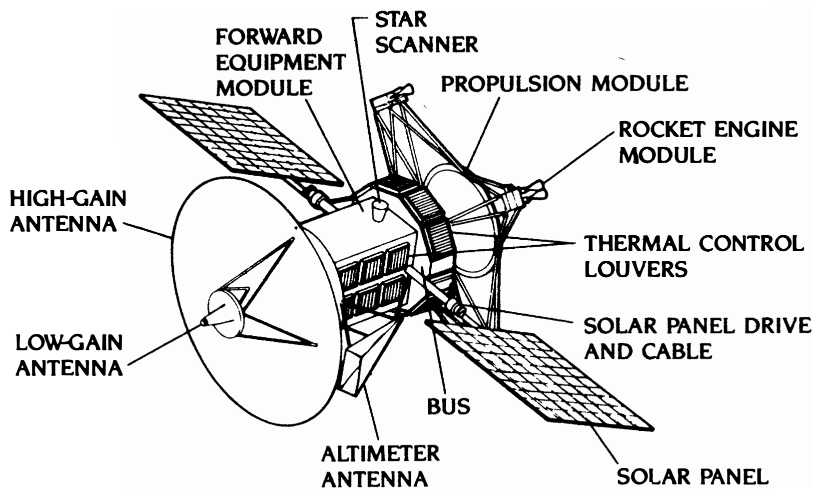
The rectification of these two problems had to be accomplished against a background of scheduled work; the business of readying a spacecraft for launch is an intensive activity. In order to keep abreast of progress, I subscribe to the daily spacecraft status reports, issued from the project office at KSC. One or two pages are spent on these high-level summaries wherein, typically, accurate measures of mass and centre-of-mass are compared with previous estimates, electronic components tested, compatibility of spacecraft and ground systems veri-

fied, and apparently anomalous measurements explained.

James S. Carter was Deputy Chief of the Sequence Team (responsible for generating command loads for the spacecraft) for Project Galileo in 1986 when the mission was delayed. Carter's previous experience had included service with the Viking and Voyager projects, and, with the Galileo destaffing in this area, his experience was transferred to Magellan's flight team. He is the Chief of that project's Mission and Sequence Design Team (MSDT), and he briefed me on Magellan-in-cruise, as reported below.

After launch, and up to the August 1990 arrival at Venus, the spacecraft will be in interplanetary cruise and, unlike cruise phases for most missions, scientific experiments will not be undertaken (the spacecraft's payload, a synthetic aperture radar and an altimeter, are designed for planetary mapping applications). However, just as during the period of the spacecraft's residence at KSC, engineers on Carter's MSDT and other flight teams will be kept busy maintaining and conditioning the vehicle for its future rendezvous with Venus — see the September 1987 edition of this column for a review of the Venusian survey strategy.

The MSDT occupies an intermediate position on Magellan's flight team, between the Mission Planning Team and the Spacecraft Team. The Mission Planning Team considers scientific options and engages in long-term mission analysis, including possibilities following the prime (243-day) mapping mission. The results of these analyses are expressed, in the main, in a continually updated Mission Plan. Accepting the Mission Plan as input, the MSDT produces as its primary output the "Skeleton Orbit Profile" (SOP). As the name implies, the MSDT unit of planning, during Venusian orbital operations, will be the orbit; the spacecraft swings in an eccentric orbit about Venus every 3.15 hours, mapping the surface of the planet with its radar at lower altitudes near periapsis and then turning toward Earth to pump the recorded data back to the antennas of the Deep Space Network. The SOP is fed to the SpacecraftTeam for the production of the actual sequence of commands which are radioed to the spacecraft.



The Magellan probe.

The building blocks for a SOP are called, fittingly, "blocks". The blocks are a standard set of subroutines into which the MSDT inserts the appropriate parameters in order to achieve desired performance of the spacecraft (and cues for supporting actions on the ground).

The spacecraft must be cared for during its year-plus cruise to Venus. Carter detailed some of the more important responsibilities with which he and his team are charged.

Two fundamental activities are placing periodic "STARCALS" and "DESATS" in the SOP; both relate to controlling the attitude (orientation) of the spacecraft. In the STARCAL, stars are observed by means of the spacecraft's star sensor in order to correlate accurately the internal reference system of the vehicle with the external world.

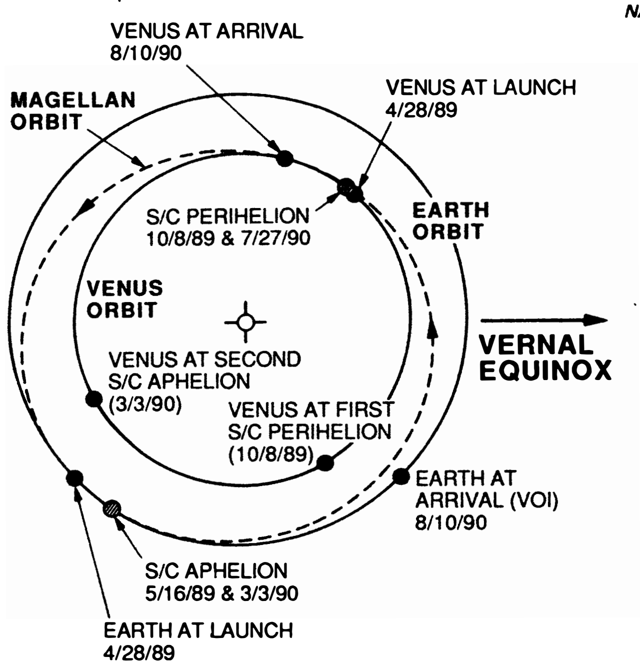
The DESAT function refers to unloading (desaturating) excess momentum from the reaction wheels. The three reaction wheels store angular momentum (derived from the electrical energy generated from the solar panels) used to place the spacecraft in its desired attitude; changing the angular velocities of the wheels in a calculated manner will turn the spacecraft to a new attitude. In the course of time, holding the spacecraft's attitude under buffeting by the solar wind, and similar disturbances, will result in one or more of the wheels spinning at a rate which approaches the design limit. Hence, momentum is proportionately removed from the set of wheels by a DESAT to return the system to a state well within its normal operating range (physically, the spacecraft's hydrazine thrusters are used to accomplish the momentum unloading).

The STARCALS and DESATS (Carter said that informally the team has labelled the dual activities "DECALS") will be done about once per day during the initial portion of the cruise, relaxing to every other day after about three months. While the unit of orbital planning is 3.15 hours in length, each cruise SOP is about two weeks long, yielding a rough measure of relative complexity between orbital and cruise operations.

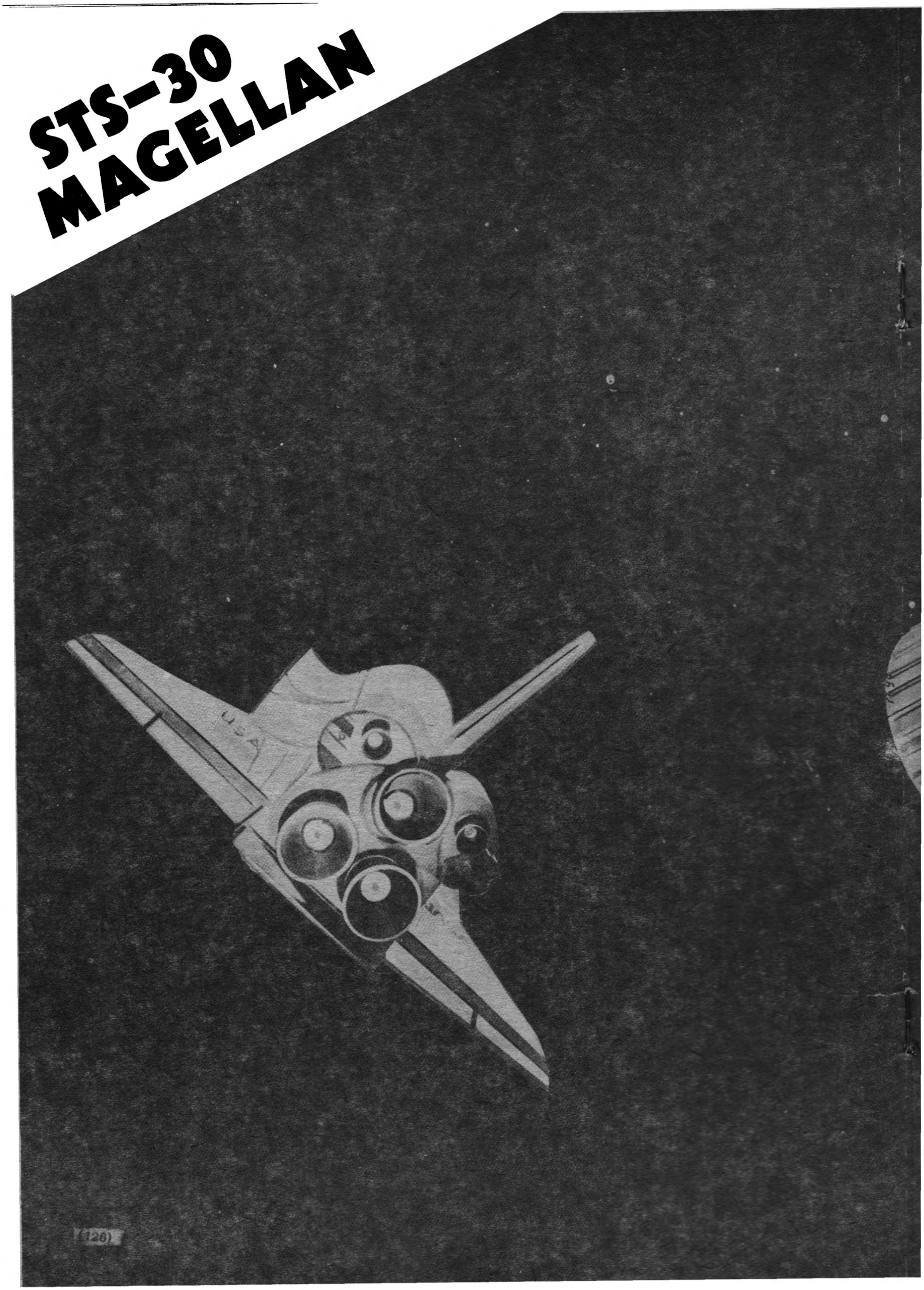
A key ingredient in most missions is the set of trajectory-correction manoeuvres (TCM) which will maintain the spacecraft on its proper course. Just

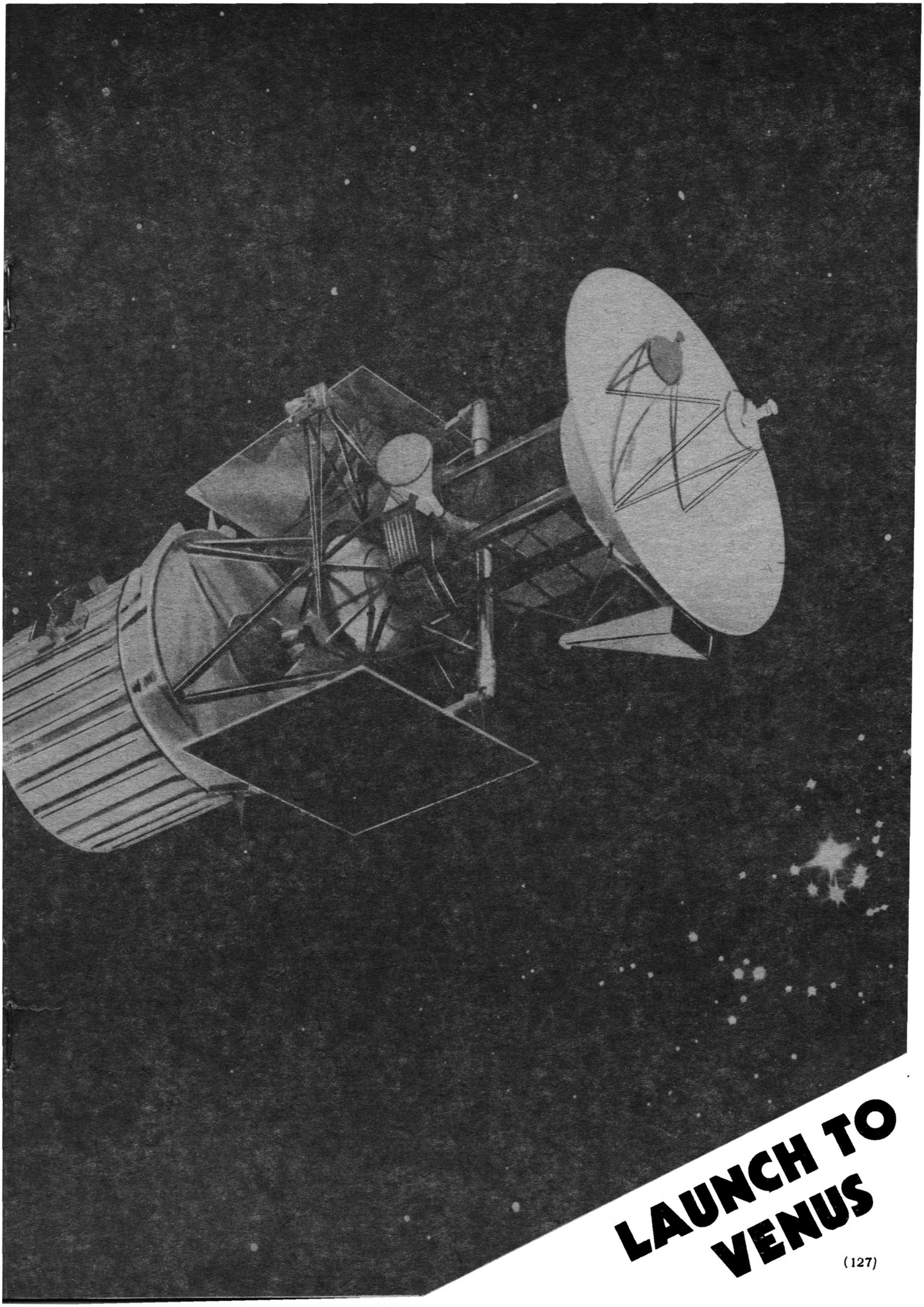
Continued on p. 128

The Magellan spacecraft will wrap itself around the Sun about 1.6 times in its cruise from Earth to Venus.
NASA/JPL



STS-30 MAGELLAN





LAUNCH TO VENUS

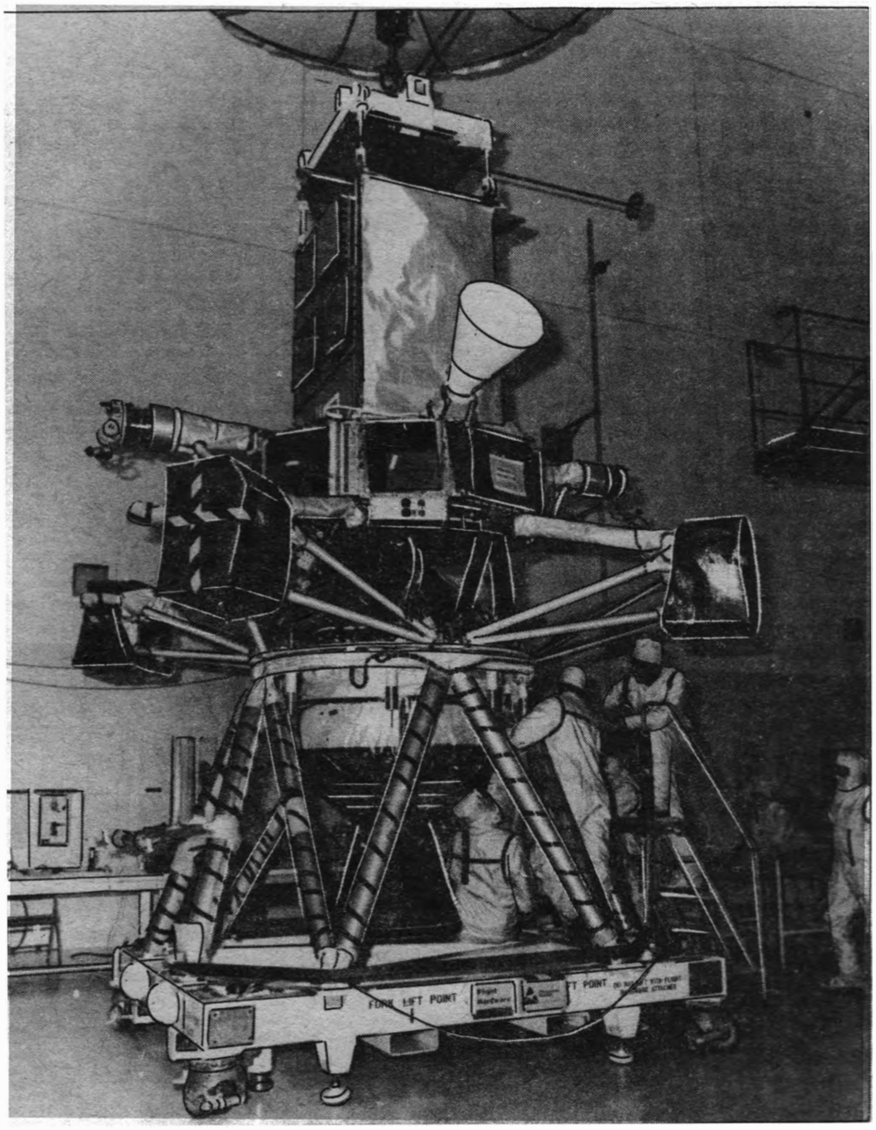
Continued from p.125

as angular momentum is employed to manage the attitude of the spacecraft, linear momentum, generated by the familiar method of mass expulsion through a "motor burn", is used to adjust the trajectory. Prior to insertion into orbit about Venus, three TCMs are planned for Magellan. The first, scheduled for about 15 days after injection into interplanetary cruise, will clean up any small errors resulting from that injection burn. The second, approximately one year into cruise, will also serve as a cleansing agent, as will the third, about 17 days prior to insertion into orbit about Venus. The transfer from interplanetary cruise to a planetary orbital trajectory is accomplished by igniting a STAR 48 solid-rocket motor.

The solid-rocket motor must be tended during cruise by providing it with the proper thermal environment. When far from the Sun, the STAR 48 is warmed by adjusting the spacecraft attitude so that the Sun shines on the motor; nearer to the Sun, shading is required.

No data will be acquired by the synthetic aperture radar during cruise, but the spacecraft's tape recorder will be supplied, prior to launch, with a load of radar data. These data can be played back during cruise (the plan is to do this three times) for the purpose of exercising computers and people on the ground, prior to orbital operations.

Five days a week, eight hours per day, Carter's team and other elements of the flight team will guide Magellan to Venus for its mission of scientific exploration. We wish them all well in that most exciting undertaking — the exploration of space — and see in Magellan a celebration of the return to deep space.



The STAR 48 solid-rocket motor is mated to the Magellan probe. *NASA*

Burning Curiosity

With Voyager 2 bearing down on Neptune for a flyby in August, curiosity becomes a factor in our anticipation of that event. Does Neptune have rings? If so, are they partial arcs? Will we be able to see the surface of the large satellite Triton? If so, will it have lakes of liquid nitrogen? Will the spacecraft receive a strong dose of radiation from trapped particles?

Several times in the last three years I have tried to express, verbally and in writing, the experience of watching Uranus draw near, from the vantage of Voyager 2. I will try again. It seemed to me, and still does, the most exciting thing in the world: the seventh circle of curiosity. Two TV monitors sat on my desk at JPL, principally for monitoring spacecraft telemetry channels, but when images were coming down I frequently switched over to see them. As the spacecraft approached the Uranian system, the satellites were transformed from points of light to disks with obscure features. A white blur on Miranda gradually took form and, in the closest-approach images, became a chevron imbedded in some of the most bizarre topography in the Solar System. The "Columbus experience" has been invoked on many occasions but none more appropriate than here. The drama will repeat at Neptune.

Several years ago (see the August 1980 *JBIS*) I became interested in the history of discovery relating to planetary rings. Rings were discovered in 1610 (Saturn), 1977 (Uranus), and 1979 (Jupiter). These dates, particularly the last two, represent the termini of discovery — the satisfaction of curiosity — but what transpired in the prediscovery period? Frequently we find ourselves struggling with unresolved problems and failing to learn from the completed tasks of the past.

When Galileo observed Saturn through his telescope, he did not realize that the objects he saw were rings. In fact, it fell to Christian Huygens in 1655 to deduce the true nature of the Saturnian rings. But with the Saturnian example in hand, theoreticians and observationalists poked for the next few centuries at the possibility of rings about other planets.

The Jovian rings were discovered from Voyager 1 by direct imaging as the spacecraft passed through the equatorial plane of Jupiter. Prior to that time, Jovian rings were predicted on theoretical grounds in 1962 by the Soviet astronomer S.K. Vsekhsvyatskii and, using different assumptions, by Hannes Alfvén (1972) and J. Boynton (1975). Analyzing charged-particle data from the Pioneer 11 flyby of Jupiter in 1974, Mario Acuna and Norman Ness perspicaciously saw the possibility of a ring about Jupiter.

Prediscovery evidence for the rings of Uranus has an even longer history. The discoverer of Uranus (1781), William Herschel, noted in his journal in 1787, "the suspicion of a ring returns often when I

adjust the focus." (It is likely, however, that Herschel was responding to a defect in the optical system of his telescope.) A probable prediscovery observation of the rings was made by a balloon-borne telescope, Stratoscope II, in 1970, but recognition of this fact did not occur until 1977, following the actual discovery, when special data processing techniques were used to search for signs of the newly discovered rings Alfvén also predicted, as in the case of Jupiter, rings about Uranus.

The Uranian rings were detected from Earth by observing the occultation of a 9th magnitude star, SAO 158687, by the planetary system. Dips in brightness were correctly interpreted as being caused by rings about the planet, and, in the next few years, the ring system was quite accurately mapped by the occultation technique The same method has been employed with regard to Neptune, but the results have been less conclusive (see, for example, a paper by C.E. Covault *et al.* in *Icarus 67,* pp. 126-133, for some of the observations) Neptunian ring hunting has, like the Uranian case, a long history, e.g., in 1847 J. Challis used an 11¾ inch refractor at Cambridge to "detect" rings about Neptune (like Herschel's Uranian rings, the observation is almost certainly invalid, unless these objects have very great temporal variation).

The prediscovery histories of the planets Uranus, Neptune, and Pluto make a fascinating story from which many methodological morals can be extracted (see "Juggling Numbers" in the September 1988 "Space at JPL" for some connections with the Titius-Bode law). But my favourite example of burning curiosity concerns the long trail of investigation that led from puzzlement to an understanding of the source of the Sun's energy. Trust me and read on; the history is far superior to the pun.

Mankind had been curious about the source of solar energy, as part of the general development of a scientific world view, but it was not until the middle of the nineteenth century that an explanation became imperative. The problem arose from a conflict between physics on the one hand and biology and geology on the other. Julius Mayer, Hermann Helmholtz, and James Joule had formulated, in the 1840s, the law of the conservation of energy — one of the grandest generalizations of physics. Mayer and Helmholtz postulated that the gravitational contraction of the Sun was the source of solar energy and, using conservation of energy, calculated the required rate of contraction (somewhat over 200 feet per year). More importantly, it was shown that through contraction the Sun could only meet its energy needs for a few tens of millions of years.

But even prior to the solar-lifetime estimates, the geologist Charles Lyell had dated the oldest fossil-bearing rocks at 240 million years, and the work of Charles Darwin in evolutionary biology added weight to the geological testament. The astronomical and geological estimates were clearly at variance.

An alternative to solar contraction was entertained by some. the infall of meteors onto the solar surface. However, it was soon realized that an impossibly high flux of meteors would be required to maintain the Sun's temperature.

It is interesting to track the subject, over the years, through the lens of popular works on astronomy as authors wrestled with the astronomical/geological contradiction and then, slowly, saw hope in the mysterious subatomic phenomena that came upon the scene towards the turn of the century.

Thus, Joel Dorman Steele in his *New Descriptive Astronomy* (1884, p.54) ignores the geological problem and states, "The heat of the sun is generally considered to be produced by condensation, whereby the size of the Sun is constantly decreasing, and its potential energy thus converted into kinetic."

In a more careful analysis, *A Textbook of General Astronomy* (1889), Charles A. Young rejects the meteoric theory as insufficient and says (p.223), "We seem to be shut up to the theory of Helmholtz, now almost universally accepted; namely, that the heat necessary to maintain the sun's radiation is principally supplied by the slow contraction of its bulk." Despite some discomfort evident in his phrasing, Young makes no explicit reference to the geological-evidence.

In his popular work, *The Stars* (1901), the astronomer Simon Newcomb does explicitly note (pp.224-225) the conflict between geological estimates and the conclusions of the contraction theory and makes an oblique reference to alternative modes of energy generation: "Facts are accumulating which converge to the view that forms of substance exist which are neither matter nor ether, but something between the two — perhaps primeval substance from which matter was evolved. In this ethereal substance is stored an almost exhaustless supply of energy." Recall that in 1896 Antoine Becquerel had discovered "Becquerel rays" emitted by uranium salts. And, in his *Side-Lights on Astronomy* (c. 1906), Newcomb says (p.59), "Who knows but that the radiant property that Becquerel has found in certain forms of matter may be a residuum of some original form of energy which is inherent in great cosmical masses, and has fed our sun during all the ages required by the geologist."

By 1912, Young in his *Manual of Astronomy* has been partially weaned from the contraction theory. Although on page 254 he says, "[the contraction theory] has high probability in its favour," on page 570 he admits, "radium and its congeners may have played an important part, and the sun's age may be many times greater than the limit we have named."

Concluding our survey of popular attitudes on solar energy generation, we find that by 1934 the tide has definitely turned away from support of the contraction theory, with Edward Fath (*The Elements of Astronomy*, third edition, p 117) summarizing, "Various theories to account for the maintenance of the solar radiation have been proposed, but the only one which seems worthy of consideration at the present time is the one which places the source in the disintegration of the atoms of the sun's mass. Much still remains to be done before this theory can be considered as proved, but it appears to be the only one which will account for the radiation of the sun for the period of time which now seems necessary." He was apparently referring to fission, rather than the fusion processes which actually power the Sun and stars, but the basic issues were settled.

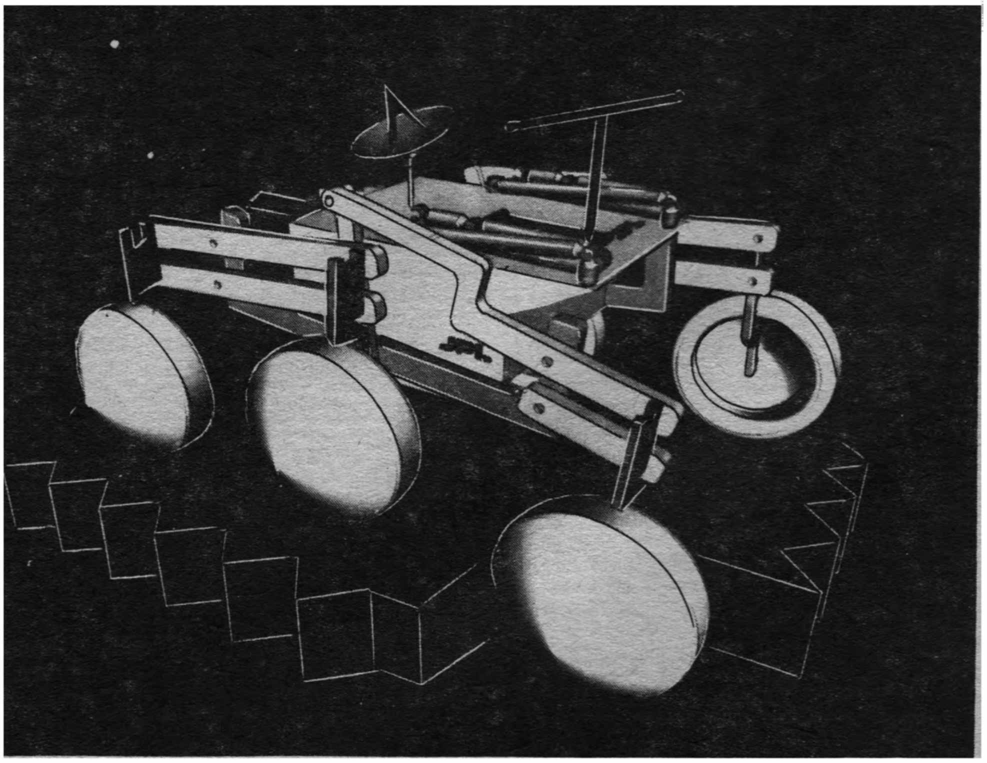
We started out by contemplating the Voyager 2 exploration, this coming August, of the Neptunian system and detoured through previous adventires in ring discovery and the source of the Sun's energy. No certain rules of discovery are apparent, but the mathematician George Polya in his classic *How to Solve It* (1945) lists "have you seen it before?" as one of his basic precepts for discovery. Perhaps exercises, such as the above, help to build intuition by stocking our minds with material so that we are better equipped to follow Polya's guidance. Well — does Neptune have rings? (I said "yes" in my 1980 paper.)

Roving on Mars

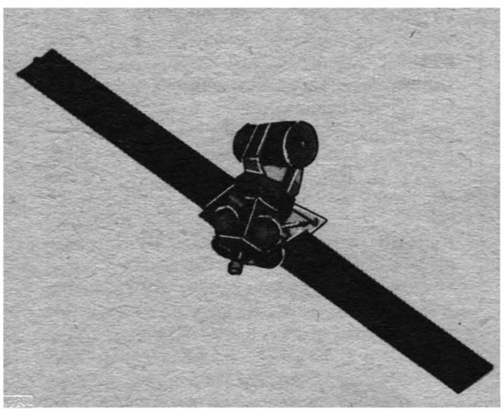
The age-old fascination with Mars is once more asserting itself. The Red Planet burned bright in our night skies last year – the most favourable opposition in many years – stimulating ground-based telescopic studies. The Soviet Phobos mission is underway, and NASA's Mars Observer mission is scheduled for a 1992 launch. Even more ambitious plans are being made by U.S. and Soviet mission planners with regard to the exploration of the planet. Given the persistent interest in Mars and the continuing growth in space technology, intensive investigation of the surface, by humans and machines, seems only a question of time. The Mars Rover Sample Return (MRSR) mission is being studied by NASA as an option for the late 1990s, with a launch that could occur as early as 1996 (sending the first portion of the MRSR system elements to Mars).

Since MRSR was last reported on in this column (November 1987), the joint study, by the Jet Propulsion Laboratory and NASA's Johnson Space Center, has made notable progress. Much of this progress was documented in 17 papers given at the AIAA Aerospace Sciences meeting in Reno, Nevada, in January. The mission of MRSR is centered upon returning about 5 kg of Martian surface samples to Earth, and its technical challenges are considerable, but, the study has shown, they appear to be within the grasp of current technological capabilities.

The objectives of MRSR are broad and



A descendant of this conceptual design for a Rover may traverse the surface of Mars around the turn of the century if the Mars Rover Sample Return (MRSR) mission is approved. *NASA/JPL*



A Mapping and Communication Orbiter (MCO) is planned for deployment in an elliptical orbit about Mars as part of the proposed Mars Rover Sample Return (MRSR) mission. *NASA/JPL*

fall into two basic categories: (1) scientific studies relating to geology, climatology, and biology, and (2) experience which will prepare the way for the eventual human exploration of Mars. Factors in the second category include environmental information and the testing of key engineering technologies.

Four major elements of the MRSR system have been identified: (1) Rover, (2) Mapping and Communication Orbiter (MCO), (3) Sample Return Orbiter Segment (SROS), and (4) Mars Ascent Vehicle (MAV). The combined mass of these elements would require a launch vehicle with heavy-lift capability, such as the proposed Advanced Launch System (ALS) or the proposed Shuttle C. Consequently, in order to base the mission upon existing launch vehicles, most of the mission scenarios which have been developed utilize more than one launch to transfer the elements from Earth to Mars. Quite satisfactory element packaging and delivery can be achieved with Titan IV/Centaur G launch vehicles.

Upon arrival at Mars, two options exist for insertion into orbit about the planet: propulsive and aerocapture. One mission scenario packages the MCO and SROS in one Titan/Centaur launch, separates them after launch, and propulsively inserts each into Mars orbit. In the same scenario, the Rover and MAV go up in a second Titan/Centaur launch and employ aerocapture techniques to achieve orbit about Mars.

Once in orbit, the MCO will observe 10 × 10 km potential landing sites to provide information for site selection. The imaging resolution to support this process will be about 0.25 m per picture element (pixel). Later, the MCO will also serve as a telecommunications relay satellite, linking elements on the surface of Mars to antennas on Earth. An elliptical orbit is prescribed for the MCO; the low periapsis (250 km altitude) facilitates imaging, and telecommunications functions are performed in the upper reaches of the orbit.

Two different kinds of surface operations are being studied: local and areal. In the local scenario, a modest Rover would be landed together with the MAV, and the Rover would collect samples within a region extending no further than 100 m from the MAV. The areal approach envisages the Rover and MAV either landed together or separately. The Rover range would be much greater than for the local option, travelling 20 to 40 km for sample-collecting activities.

In several months on the surface, sample collecting will be effected by a variety of methods: raking (for pebbles), scoops of soil, collection of individual rocks, sampling portions of rocks, and core samples of the regolith at a metre or more in depth. The latter mode might be accomplished by special equipment onboard the MAV rather than the Rover.

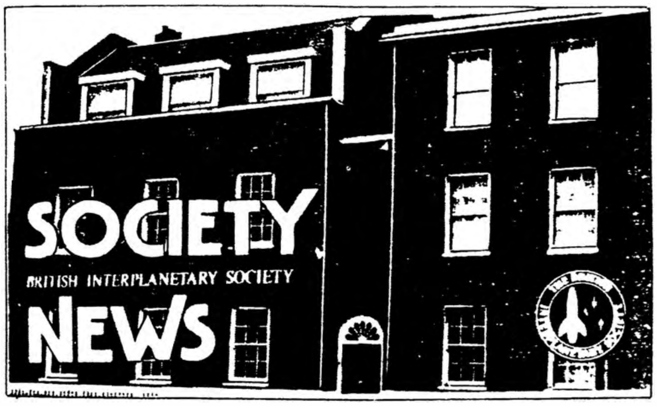
Several technologies are being investigated to develop an efficient Rover. Two general schemes for directing the Rover are applicable to both the areal and the local regimes: computer-aided remote driving (CARD) and semi-autonomy. In the CARD method, an operator on Earth makes decisions based upon stereo pictures taken by the Rover. The Earth-based operator examines the images and selects a safe path for the next leg of traverse (up to 30 m) for the Rover. A prototype CARD-operated vehicle has been tested in the Arroyo Seco near JPL — it is an interesting experience to be carried along dirt roads in a vehicle intermittently directed by an operator one quarter of a mile away! The CARD method results in rather slow traverse of the Martian terrain; progress is limited by the round-trip light time between Earth and Mars, the necessity of an Earth-Mars communications link, and the time required for Earth-based decision procedures. Semi-autonomy is more technologically ambitious but would yield a greater effective range for the Rover. It relies upon high-resolution, three-dimensional information extracted from MCO pictures and stored onboard the Rover. Sophisticated Rover software would move the Rover through the terrain, sending imaging reports of progress back to Earth, but only halting its autonomous journey if an impasse of some sort were reached (the Rover would halt from time-to-time during normal traverse to do its own route planning).

The physical mode of locomotion of the Rover could be one of several types now under investigation. Wheels or legs are obvious candidates (see the November 1987 and November 1988 editions of this column for illustrations of both classes). One imaginative concept, "the walking beam", is constructed of two nested tripod platforms. The platforms are alternately translated with respect to one another in order to produce motion.

Upon completion of surface activities, the MAV will lift off the surface of Mars and dock with the SROS. An Earth Return Vehicle (ERV), part of the SROS, will carry the sample back to terrestrial laboratories for analysis. Near Earth, a Sample Return Capsule will be separated from the ERV and either placed in Earth orbit or sent directly to the surface via parachute.

The rationale for a Mars sample-return mission has been presented in some detail in *Planetary Exploration through the year 2000: An Augmented Program* (U.S. Government Printing Office, Washington D.C., 1986, pp. 58-101). An obvious benefit of a sample-return mission over *in situ* studies is that the full force of scientific judgement and technology can be brought to bear on a wide variety of problems: chemical, geological and biological. The analyses can continue to yield scientific results for years, as the Apollo lunar samples have shown, including investigation of questions that arise long after the mission is complete.

A strong team within government and industry has been formed to make feasible the return of a rich Martian inventory around the turn of the century. Their results indicate the technological directions that would lead to success, and the scientific value of the undertaking is clear. Approval of MRSR as a project awaits a larger set of decisions concerning NASA's next big step in the exploration of the solar system.



President For 1989

At the Council meeting held in late February Mr. G.W. Childs was unanimously re-elected President of the Society for a second annual term of office.

Mr. G.W. Childs

After his re-election Mr. Childs said, 'I look forward with confidence to the Society continuing to play an important role in promoting the advancement of astronautics in the year ahead. 1989 promises to be a year of significant new developments for space technology and applications in an improving international climate'. Enlarging on the role of the Society, he said, 'The contribution of individuals will continue to count for much of what is achieved and the Society, as a long-standing Learned Body, has a vital role to play in support of the work of the individual through its programme of meetings, publications and other activities'.

At the same Council meeting the two offices of Vice-President were filled for 1989 by the re-elections of Mr. A.T. Lawton and Professor I.E. Smith.

JBIS — A Leading Journal

Members who receive *JBIS*, the Society's main technical and scientific publication, will have noted that a number of changes have been introduced over the last year or two to the journal's general presentation. Most changes, considered individually, have been of a minor nature, but their introduction has been motivated by the over-riding requirement to give the Society a worthy and leading publication and to provide the best possible service to those who submit material to the Society for publication.

It may have been noticed, for example, that from January 1987 all articles have started in a right-hand page. This change was prompted by the decision to supply preprints (50 copies free-of-charge) to author(s) of each paper published. A further preprint service offered to authors also enables them to be supplied with copies in excess of 50 for a nominal charge.

Since April 1987, *JBIS* has carried the Society's Coat of Arms on a re-styled and more attractive front cover while the issue of October 1988 saw the introduction of colour printing, which can now be provided by special arrangement when there is an essential need for illustrations to be in colour.

JBIS Editorial Advisory Board

During 1988, the Society introduced a *JBIS* Editorial Advisory Board and revised and enlarged its Panel of Reviewers to strengthen the procedure by which submitted papers are processed and, if necessary, revised before acceptance for publication.

The composition of the Editorial Board is as follows:

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PROF. K.A. POUNDS	Dept. of Physics, University of Leicester
PROF. J.D. ROSENDHAL	The George Washington University
PROF. A.E. ROY	Dept. of Physics & Astronomy, University of Glasgow
PROF. I.E. SMITH	School of Mechanical Engineering, Cranfield Institute of Technology
DR. G. WHITCOMB	Future Science Projects, European Space Agency

JBIS has a current world-wide distribution of 2,000 copies per monthly issue to BIS members and subscribers, including many technical libraries.

***JBIS* Special Issues**

A well-known and much appreciated feature of *JBIS* is the coverage given to a special topic or subject area, such as space technology or space science, in special issues. Readers of ***Spaceflight*** who do not have a regular subscription to *JBIS* may like to know details of issues which relate to their own particular interests. Those for which there has been considerable demand in recent years hace been on Soviet Astronautics and Interstellar Studies. Stocks available of some *JBIS* issues from last year are detailed in the *JIBS* advertisement. Copies can be supplied post free at the prices stated on sending the appropriate remittance to the Society's Office.

Professor K.A. Pounds

We welcome to the *JBIS* Editorial Advisory Board Prof. Ken Pounds of the X-ray Astronomy Group, Department of Physics, University of Leicester who writes, 'I am delighted to accept your invitation to join the Editorial Advisory Board and look forward to helping to maintain the high standard of your Journal'.

Prof. Pound's contributions to Space Science have also been recognised by his election as a Member of the International Academy of Astronautics, which prompted us to invite him to update details about his career in the space

field and the work of the Leicester Group. He has written, saying:

My research career is contemporary, in a sense, with the space era in that I started out as a graduate student at UCL working with Dr (now Sir) Robert Boyd on a project to probe the Earth's ionosphere. My own part was to develop X-ray and Ultra Violet sensors which were flown on a series of Skylark rockets to measure the controlling solar flux. I moved to Leicester in 1960 to establish a new group to study solar physics within the department of Professor Stewardson. Throughout the 60's the Leicester Group continued to collaborate closely with the group at UCL in a series of rocket and satellite experiments including ARIEL 1, ESRO-2 and the NASA OSO-4 and 5 spacecraft. Highlights during this time were some of the first X-ray images and spectra of the solar corona.

Following the discovery of Sco-X1 in 1962 we were keen to move into this exciting new field and flew our first cosmic X-ray experiments at Woomera in 1967. From that time until the mid 1970's the Leicester Group carried out a series of Skylark experiments which were largely responsible for the first surveys of the Southern sky, the Northern sky being well covered by our US counterparts.

ARIEL 5, launched in 1974, moved our cosmic X-ray studies into the satellite arena and I believe the success of this mission is well documented. Our primary involvement was on the Sky Survey Instrument which made many discoveries, including several bright X-ray novae and the establishment of X-rays as a common property of active galaxies. ARIEL 6 followed in 1969 but this was much less productive scientifically because of a variety of technical problems, the most serious of which was interference by Soviet radars on the satellite command system.

The next major space mission for us was EXOSAT in which the Leicester Group was responsible for the design of one of the main instruments. We also have a much earlier connection with this first ESA X-ray Astronomy mission dating back to its original conception in 1970 and my own presentation of the mission to ESRO (as it then was in 1973). The science impact of EXOSAT is also well documented and resulted for a time in the centre of activity in this field of space science moving to Europe. Most recently we have been involved with the Institute of Space and Astronautical Science in Tokyo, a collaboration in which we jointly built the main X-ray detectors and are now sharing the operation and scientific analysis of the GINGA satellite. The significance of GINGA is underlined by it being currently the only operational X-ray mission worldwide.

Finally, looking to the future, we are now eagerly anticipating the launch of ROSAT in 1990 and JET-X three years later. My own role is as PI for the UK Wide Field Camera on ROSAT, which as you know is being produced by a Consortium of UK University groups, and as Project Scientist for JET-X. This latter instrument, which will form a major part of the Soviet Spectrum-X mission, is being developed by a consortium in the UK, Italy and Germany.

Work undertaken by Prof. Pound's X-ray Astronomy Group on the ROSAT Wide Field Camera is the subject of two papers published by the Society in the August 1988 issue of *JBIS*.

Fire Causes Delay

A major fire at the premises of the company who undertake the overseas dispatch of ***Spaceflight*** destroyed a number of copies. We apologise for any delay in the receipt of the March issue by overseas subscribers which may result and have made arrangements for additional copies to be printed and dispatched as quickly as possible.

Obituary

Kenneth J. Staples

We regret to record the death of Kenneth James Staples, a Fellow of the Society for over 30 years and a former aerodynamicist at the Royal Aircraft Establishment at Farnborough.

Joint International Conferences

The following conferences are being cosponsored by the Society:

The 8th Annual 1989 International

Space Development Conference

May 26-29, 1989

Themes will be Apollo: 20 years later. An Overview of Space. Space Technology, Business and Space. Meet Space Leaders, etc, etc. To be held at the Hyatt Regency O'Hare Hotel, Chicago USA.

International Conference on Space Power

Organised under the auspices of the IAF Space Power Committee.

June 5-7, 1989

To be hosted by Lewis Research Center in Cleveland, Ohio, USA.

Towards the International Space Station and Columbus

Hosted by the DGLR Hamburg, W. Germany.
October 4-6, 1989

Further details of the above meetings can be obtained from the Executive Secretary. Please enclose a SAE.

40th IAF Congress

The 40th Congress of the International Astronautical Federation (IAF) will be held at Beijing, China on October 7 to 13, 1989.

Members of the Society wishing to present papers may obtain procedural details for submission of abstracts from: The International Astronautical Federation, 3-5 Rue Mario-Nikis, 75015 Paris, France.

Future IAF Congresses are to be held at the following venues:

1990 Dresden (GDR) 6-12 October
1991 Ottawa (Canada) 5-12 October
1992 Washington, DC (USA) 27 August-5 September
1993 Ljubjana (Yugoslavia)
1994 Haifa (Israel)

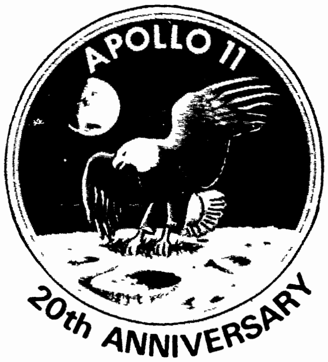
SPACE '90

Members attending SPACE '38 and previous SPACE meetings asked that information on plans for future SPACE meetings be made available as soon as possible.

We are, therefore, pleased to announce that SPACE '90 will be held at the White Rock Theatre, Hastings on October 5th-7th, 1990. The theme will be 'Steps to Space'.

A full programme and other details will be available in due course. In the meantime the Society invites offers of papers, generally of 20-30 minutes duration, for consideration by the Organising Committee.

Special Event



To commemorate the 20th anniversary of the historic Apollo 11 lunar landing, the British Interplanetary Society has organised a series of lectures to celebrate Man's first steps on the Moon, concluding with a dinner at the Society's Headquarters.

Details of the meetings follow:

21 June 7.30-8.30pm

'I WAS THERE'

Reg Turnill and Frank Miles recall the atmosphere and events of twenty years ago. Reg Turnill was reporting from the US during Apollo 11, while Frank Miles was a member of ITN's "Space Unit" covering the mission from London.

28 June 7.30-8.30pm

LEGACY OF APOLLO

A lecture by Douglas Arnold illustrated by striking photography of Man's first steps on the Moon.

5 July 7.30-8.15pm

GOING TO THE MOON

Dr. R.C. Parkinson considers the BIS contributions to manned lunar concepts. Beginning with its design for a Moonship in 1939, the BIS continued thinking about ways of reaching the Moon throughout the 1950s. This talk illustrates some of the concepts, which culminated in the US Apollo programme.

19 July 7.00-8.30pm

INSTRUMENTATION ON THE MOON

Keith Wright talks about his work on the Apollo lunar surface experiments, in particular the 'Moonquake' instruments.

21 July 8.00pm

APOLLO ANNIVERSARY DINNER

The Society will conclude its Apollo 11 celebrations with a four course meal on the anniversary of Man's first steps on the Moon. (Guests of honour will be announced later).

All events will be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ. Meetings are restricted to Society members. Subject to space being available members may also apply for a ticket for one guest. Please apply to the Executive Secretary, enclosing a SAE.

Admission to lectures is free. Apollo Anniversary Dinner tickets are £28.

Symposia

3 June 1989 10am-4.30pm **Symposium**

SOVIET ASTRONAUTICS

Venue: Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Offers of Papers
Authors wishing to present papers should contact the Executive Secretary

Registration

Admission is by ticket only Members should apply in good time enclosing a stamped addressed envelope

27 September 1989 9.30am-4.30pm

BRITISH SOLID PROPELLANT ROCKETRY

Venue: Conference Room, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

The emphasis will be on British post-war solid propellants and the development of associated rocket motors and launch vehicles.

Offers of Papers
Authors wishing to present papers should contact the Executive Secretary.

Registration
Forms are available from the Executive Secretary. Please enclose a SAE.

General Lectures

5 April 1989 7.00-8.30 p.m.

THE PROSPECTS FOR SPACE TOURISM

This lecture by David Ashford, will propose that Europe should develop a small fully reusable aeroplane-like launcher, as an alternative to Hermes, which could actually cost less to develop It could lead to a space tourism industry starting this century and developing into a large, if not the largest commercial issue of space

Admission is by ticket only Members should apply in good time enclosing a stamped addressed envelope

3 May 1989 7.00-8.30pm

UK INVOLVEMENT IN SATELLITE NAVIGATION

Dr. I.L. Jones

The UK has a long tradition of innovation and excellence in navigation based on our background as a trading nation. The UK has been particularly active in the application of the new techniques of satellite navigation. The presentation will describe the evolution of satellite navigation, highlighting the important scientific and commercial contributions of the UK to systems such as Transit and Navstar.

Finally, what does the future hold in this most exciting of fields?

Admission is by ticket only. Members should apply in good time enclosing a SAE.

Visit

13 May 1989, 10.30 am

UKAEA CULHAM LABORATORY

A tour of the United Kingdom Atomic Energy Authority's Culham Laboratory which is concerned with nuclear fusion and plasma physics research, and is the home of the Joint European Torus (JET) Project The tour will include the Control and Assembly Rooms

Admission is by registration only Members should apply before 15 April enclosing a stamped addressed envelope

LIBRARY OPENING

The Society Library is open to members on the first Wednesday of each month (except August) between 5.30 pm and 7 pm. Membership cards must be produced.

Payload Specialist Flight Hopes

A new crewing policy in the United States may cause a number of payload specialists who were in training at the time of the Challenger accident on January 28, 1986 to lose their seat on the Space Shuttle. The following article provides a summary of those payload specialists and others who may still get a chance to fly.

The November 1985 Space Shuttle Payload Manifest showed a number of payload specialists from the sponsoring country or organisation. The resulting changes are outlined below.

STS 62-H

Since Palapa B3 was transferred to an Expendable Launch Vehicle (ELV), it is doubtful whether an Indonesian will now fly on the US shuttle. The seat was occupied by Pratiwi Sudarmono, who would have been the first non-Soviet, non-American woman in space. Born on July 31, 1952 in Bandung (Indonesia), she received an MD from the University of Indonesia in 1976, and a PhD in genetic engineering from the Research Institute of Microbial Diseases, Osaka University in Japan. A resident of Jakarta, Sudarmono is married and has a son, born in 1977. Her back up was Taufik Akbar, an engineer working for Perumtel, the Indonesian telecommunications corporation. He was born in Medan (Indonesia) in January, 1951.

STS 62-A

This was to be the first flight from Vandenberg Air Force Base in California: a DoD mission carrying the AFP-888/Teal Ruby satellite built by Rockwell International. Since the launch has been postponed for several years the spacecraft has been placed in storage.

Two payload specialists were scheduled for this flight. The first was John Brett Watterson, an Air Force Major and a member of the Manned Space Flight Engineer (MSE) cadre (see ***Spaceflight***, January 1989, p.26). Born in Garden City, New York, in 1949, he graduated from the Virginia Military Institute in Lexington with a Bachelor of Science degree in physics in 1971. He was selected for the MSE programme in February 1980. His back up was Captain Randy Odle.

By Bert Vis

The second payload specialist was to have been Edward C. Aldridge, an Air Force Under-Secretary at the time of his selection. He would have been the third politician to go up in space after Jake Garn (STS 51-D) and Bill Nelson (STS 61-C).

Aldridge was appointed Secretary of the Air Force and will not now ride the shuttle.

STS 61-I

Two payload specialists were also due to fly on this mission. One would have been the first journalist in space, whose selection was postponed indefinitely after the list of candidates had been narrowed to 40 on May 14, 1986. The other seat was reserved for an Indian payload specialist representing the ISRO (Indian Space Research Organisation).

Two Indian candidates had been selected and were in Houston at the time of the 51-L accident, although no final decision had been made regarding who would actually accompany the INSAT 1C satellite into orbit. INSAT was transferred to Europe's Ariane and was successfully launched on July 21, 1988 on Ariane flight 24. It is doubtful whether either of the two candidates, Nagapathi C. Bhat and P Radhakrishnan (P not being an initial but the first letter of his father's name, Paramaswaran), will make it into space via the shuttle.

Bhat was born on January, 1, 1948 in Sirsi (North Kanara) India. He graduated from Karnatka University in 1970 (BE Mech.) and the Indian Institute in Bangalore in 1972 (BEM/C Design). After working for Jyoti Ltd in Baroda from August 1972 to June 1973, he joined ISRO in July and started work at the ISRO Satellite Centre in Bangalore. He was worked on various Indian satellites like ARYABHATA, BHASKARA, APPLE and IRS. Bhat is married and has a son and a daughter. P Radhakrishnan was born on October 2, 1943 in Trivandrum, Kerala State in India. He holds a BS in Physics and Mathematics from the University College in Trivandrum (1963) and a MS in Physics from the same university (1965). He joined ISRO in April 1966 as a trainee and became a regular employee at what is now known as the Badram Sarabhai Space Centre in Trivandrum in September 1967, where he participated in the ARYABHATA, ROHINI, APPLE and INSAT projects. From January 1977 until February 1981, he was a member of the Programme Planning and Evaluation Group of theBakram Sarabhai Space Cente. In March, he became Head of the Test and Evaluation Division of the Systems Reliability Group. At present he is the Group Director of the Electronics group. Radhakrishnan is married and has a daughter and a son.

STS 61-L

The second Hughes Company payload specialist was scheduled to fly on this mission, with Syncom IV-5 as part of its payload. The new policy of not flying payload specialists unless they are of crucial importance to the mission will probably cost Konrad his seat. On the other hand, there is the possibility he may get the chance to perform the experiments that Greg Jarvis was to have carried out on STS 51-L, although no plans for a flight exist at this time.

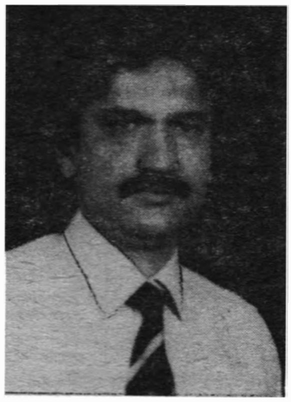
STS 71-C

Two non-NASA satellites were planned for launch from Columbia's payload bay during this flight: ASC-2 for the American Satellite Company and Skynet 4B of the British Ministry of Defence - both were rescheduled for launch by ELVs.

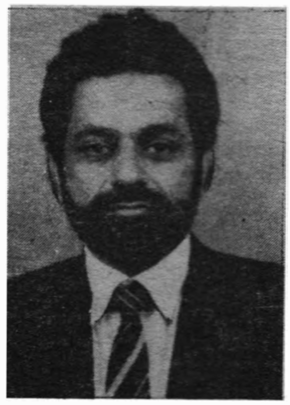
The ASC payload specialist's name had not been submitted to NASA by

Pratiwi Sudarmono

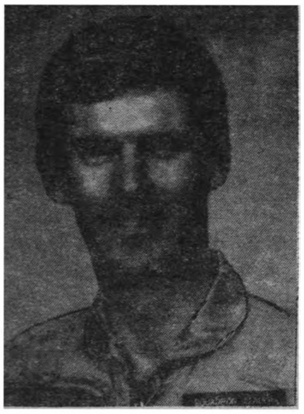
Nagapathi C. Bhat



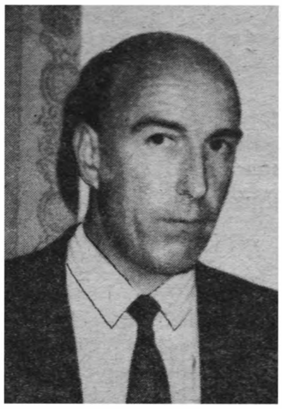
P Radhakrishnan



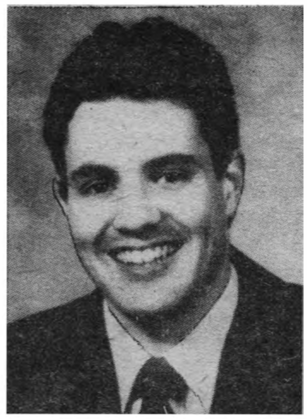
Edward C. Aldridge



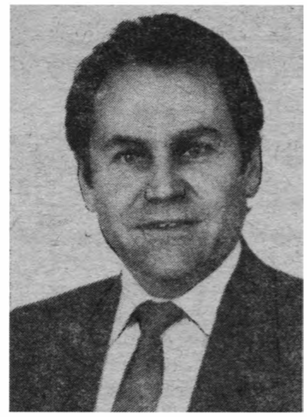
Nigel R. Wood



Peter H. Longhurst



Robert J. Wood



Otto W. Hoering

January 1986, as the company was still in the selection process, although one candidate, Otto W. Hoering Jr. had been provisionally chosen in November 1985. Hoering was born on July 21, 1938 in Kansas City, Missouri. In 1960, he received a BS in Mechanical Engineering from the Texas A&M University. Prior to joining ASC, in June 1984, he worked as an independent satellite communications consultant to industry and government. Since February 1987, Hoernig, who is married and has two children, has been Vice-President, Business Development with Contel ASC.

The UK's second payload specialist Cdr. Peter Longhurst, is also unlikely to fly especially following the MoD decision to reschedule Skynet 4B to Ariane.

Other Missions

A number of people that were already assigned to missions can still be fairly certain they will make their flight and these include scientists, selected as payload specialists for scientific missions, who have a vital role in carrying out the experiments.

Although such flights are facing considerable delays, specific knowledge of instruments and fields of research will make a strong case for Lampton and Lichtenberg (STS 61-K), Nordsieck and a second ASTRO-3 payload specialist (STS 71-M), a Japanese scientist on STS 81-G and Hughes-Fulford on STS 81-M. Durrance and Prise, originally scheduled for STS 61-E, the mission that was to fly after 51-L, have been recently assigned as payload specialists for STS-35.

Also, Bob Wood, of McDonnell-Douglas, will probably get his chance: the complexity and importance of the EOS (Electrophoresis Operations in Space) programme requires skilled personnel to accompany the equipment aboard the Shuttle. A test device was operated by McDonnell-Douglas engineer Charles Walker on missions 41-D, 51-D and 61-B.

Some candidates may be helped by politics: the fact that Nigel Wood would be Britain's first astronaut could be of help to him and Canadian Steve MacLean may fly if Canada remains a partner in the Space Station programme. MacLean was due to operate the Space Vision System on 71-F. This system is designed to increase the accuracy of the Remote Manipulator System and docking operations.

Uncertain is what will happen on DoD missions. The MSE fell victim to a steadily declining interest from the Air Force, and most of the 32 members of the group were transferred or have resigned from the military. Only two of them Craig Puz and Maureen LaComb, are officially assigned to a shuttle mission: the Starlab defence spacelab flight. Their back-ups have not been announced. In June 1988 however, Puz and LaComb were involved in an automobile accident in Boston, in which both were injured. It is to be seen if and how this will affect their assignment.

Another military payload specialist candidate is Major Carol Belt, a meteorolgist of the Air Weather Service. Belt was born on January 30, 1953 in Red Oak, Iowa. She is single. Her back-up is Major Lloyd Anderson (36).

Conclusion

The only real conclusion that can be made is that none of the candidates that were scheduled for a flight can be 100 per cent sure of getting the seat he or she was to occupy prior to the Challenger tragedy, except maybe for Durrance and Parise, the payload specialists in the only crew (61-E) that was not disbanded shortly after the accident.

NASA's decision not to fly payload specialists on the first five missions currently has no influence on this as Astro-1 is scheduled for the eleventh flight designated STS-35.

Space Shuttle manifest for November 1985 snowed a large number of missions carrying payload specialists

Mission	Launch	Prime	Back-up
61-E	Mar 6, 1986	Samuel T. Durrance Ronald E. Parise	Kenneth N. Nordsieck
61-H	June 24, 1986	Pratiwi Sudarmono Nigel R. Wood	Taufik Akbar Richard A Farrimond
62-A	July 1986	J. Brett Watterson Edward C. Aldridge	Randy T. Odle
61-J	Sept 27, 1986	Nagapathi C. Bhat or Journalist-in-Space	P. Radhakrishnan Journalist-in-Space B/U PS
61-K	Oct 27, 1986	Michael L. Lampton Byron K. Lichtenberg	Dirk D. Frimout Charles R. Chappell
61-L	Nov 6, 1986	John H. Konrad	Stephen L. Cunningham
71-A	Jan 12,1987	Kenneth H. Nordsieck ASTRO-1PS	(1)
71-C	Jan 27, 1987	Peter H. Longhurst Otto W. Hoernig	Christopher J. Holmes ASC B/U PS
71-D	Feb 16, 1987	Robert J. Wood	Charles D. Walker
71-E	Mar 16, 1987	Francis A. Gaffney Robert W. Phillips	????? ?????
71-F	Mar 24, 1987	Steven G. MacLean	Bjarni V. Tryggvason
71-M	Aug 18,1987	Kenneth H. Nordsieck ASTRO-3PS	(1)
81-G	Feb 23, 1988	Spacelab J PS (2)	Spacelab J B/U PS
81-M	July 20, 1988	Millie Hughes-Fulford SLS-1 PS (3)	?????

Notes to Table

1 The Astro payload specialist team consisted of three members, all of whom were to make two flight and serve as back up on the third This means that the back up for STS 61-E, Kenneth H Nordsieck, would fly on STS 71-A and 71-M, while both Ronald E Parise and Samuel T Durrance would be back up on one mission.

2 Three scientists were selected as candidates for this mission Takao Doi, Mamoru Mohn and a woman, Chiaki Naito One of these three would fly while another would be back up

3 A second payload specialist was to be selected "shortly" when the flight assignments for Gaffney, Philips and Hughes-Fulford were announced on April 24, 1985 At the same time of the Challenger accident he or she still had to be named however

Space Shuttle

Will NASA again save Solar-Max?

Sir, Now that the euphoria over the return of the Space Shuttle has died down following the flights of Discovery and Atlantis perhaps it's a good time for NASA to review America's future in Space.

However, I am disturbed to hear NASA is forgetting about the present. It has now in orbit amongst other spacecraft America's only functional Solar/Meterological observatory. Called Solar-Max it provides the West with its only source of combined solar and atmospheric data: it studies solar flares thus giving us a better understanding on how the Sun works and how it affects medium-term global weather phenomena. It even studies the 'ozone' layer! . . . And its going to 'reenter' the Earth's atmosphere and be destroyed in little under 13 months time.

Is NASA going to unwittingly kill this valuable national-asset-in-space just like it did the Skylab 9 years ago? All that would be needed to effect a rescue is a meagre $25m and one quarter of the cargo-bay of a Space Shuttle to carry the necessary equipment to re-boost its orbit. Or would they rather save $25m and see one $250m spacecraft be destroyed in the process? We'll soon see which way they'll decide; for Solar Max comes back for good in 1990, in a burning shower of debris.

RAMON HARTOPP
Barcelona, Spain

Ed. There is little hope that a 1989 rescue mission can be mounted on account of the already tight shuttle schedule. (See ***Spaceflight***, March 1989, p.85)

Payload Specialists

Sir, Recent developments in astronaut flight assignments for NASA space shuttle missions have helped to clarify the question of whether non-astronaut 'passengers' will be permitted to fly on the shuttle in the foreseeable future. On January 11, 1989 the National Research Council of Canada announced that the second solo flight of a Canadian Payload Specialist on the shuttle has been delayed one year to 1992. Canadian physicist Steven MacLean is scheduled to conduct experiments with the Space Vision Systems (SVS), designed to provide the basis of 'artificial vision' for automated remote manipulator systems for the planned Freedom Space Station. The first Canadian shuttle payload specialist, Marc Garneau, flew aboard the shuttle Challenger on mission 41-G in October 1984.

The day following the announcements at NASA Headquarters in Washington, the space agency announced that except for scientist-astronauts aboard Spacelab missions and a limited number of Payload Specialist opportunities such as the Canadian astronaut flight in 1992, non-astronauts (such as school teacher Christa McAuliffe who perished in the Challenger accident) will no longer be permitted to make shuttle flights. By way of provid ng an 'escape clause' for the sternly worded policy, NASA announced that exceptions could be made in cases where flying a certain passenger would 'contribute to their approved NASA objectives or to be in the national interest.'

Additionally the National Research Council of Canada announced two payload specialist candidates for the International Microgravity Laboratory (IML) Spacelab flight, currently scheduled for launch in February 1991. The two Canadian astronaut candidates are Dr. Roberta Bondar, a 43 year old neurologist, and Ken Money, 54, internationally recognised as an expert on weightlessness and human physiology. A decision will be made in 1990 as to which researcher will actually make the flight. The European flight candidates have yet to be announced for IML-1.

J.W. POWELL
Calgary, Alberta, Canada

Ed. For a review of the effect that the Challenger accident had on the future plans and flight opportunities of Payload Specialists see p.134.

External Tank

Sir, The space shuttle's vast external tank, if only it was delivered to orbit, could become its unique asset.

The planned space stations with their pretty modules must be crammed with kit to be cost-effective, but at a price. They lack workspace. In time the lack will be felt of a "Tank Farm" to provide repair bays, storage, life-boat hangars, waste-holding, stability, strong-points for mooring and/or boost, and rare recreational volume. Also, shielding.

N. KELLY
Liverpool, UK

Space Station Resupply

Sir, Although the Freedom Space Station (FSS) will need the Space Shuttle to set it up, there are arguments in favour of smaller shuttle craft to assist in routine resupply and crew rotation etc.

Instead of about three Shuttle resupply missions per year, the FSS could be visited every four to six weeks by a mixture of Shuttle and Hermes craft. This would have the following advantages:

(1) The variation in routine by regular visits would improve morale on the FSS. There would be more opportunity to see new faces, get fresh food, letters etc. The crew would also feel less isolated.
(2) Crew members could be rotated one or two at a time rather than in bulk providing continuity, ie at any time there would only be one or two crew members finding their 'space legs'. This may also reduce clashes in personality caused by long periods in close proximity.
(3) The existence of two independent supply systems would improve safety.
(4) A failure of equipment or crew illness on the FSS is less likely to present a major problem when on average a resupply flight will only be two or three weeks away.
(5) New materials and the results of experiments etc would be returned to Earth more frequently for analysis and this would speed up feedback to the FSS.
(6) A missed, delayed or re-scheduled flight is less likely to be critical.
(7) Provision of logistics would be far easier because it would not be necessary to predict all FSS needs three or four months in advance. (Just how many Mars bars will eight crew members consume in four months?)

I wonder if NASA may have been better joining the ESA in developing Hermes than spending money on a replacement for the Challenger orbiter. Regrettably, whatever the practicalities of such a mixed shuttle fleet, one must be realistic and conclude that the possibility of the US putting money into a European inspired venture in favour of its own space program is somewhat remote.

PETER R. HALL
Bucks, UK

Soviet Space Programme

Keen interest in Soviet space activity is reflected in correspondence to Spaceflight

Energia Payload

Sir, As far as payload capabilities are concerned, the launch mass of a fully-loaded Energia by Soviet statements can be 2,400 tonnes but if you measure the launch accelerations from both the Energia 1 and the Eenergia 2/Buran missions you derive a launch mass of 2,400 tonnes from the known sea level engine thrusts. My own figures indicate the fully laden Energia with four strap-on boosters can loft just over 150 tonnes to the point which the shuttle orbiters separate: this implies a payload to low Earth orbit of about 140 tonnes after subtracting the orbital injection propellant and kick stage. Clearly Buran will never use the fully laden Energia and the Energia-1 was carrying a less-than-maximum payload mass.

PHILLIP CLARK
Lee, London SE13

Energia Dimensions

Sir, Mr Lawton's letter in ***Spaceflight***, November 1988, p.438 about the Energia engines is highly relevant. The vehicle would seem better called Enigma.

The basic question is the dimensions. The initial "about 60 metres height" and 8 metres for the core diameter can hardly be simultaneously correct, in view of of the aspect ratio as seen in pre-launch photographs, these being genuine although taken on the slant and with partially obstructed sightlines.

Other less reliable, but more accessible, representations reconcile these dimensions but include a suspiciously long engine section. Mr Lawton's suggestion removes a few metres from the engine length of Energia as launched. This is what is needed, for if the 8 metres is correct the height is about 56 metres, not 60, and the latter is a hardly justifiable approximation.

The interest of the dimensions is the light they shed on the size and capabilities of Energia, and this might seem to have been resolved anyway by the Chief Designer's *Pravda* article (***Spaceflight*** October 1988, p.381). But this is not the case.

The basic factors determining the capabilities of a vertically-launched rocket are the take-off thrust and the propulsive technology. The Chief Designer parades before us a vehicle surpassing Saturn V in these respects. Yet the culminating achievement of a quarter of a century of technical advance is, apparently, to reduce the low earth orbit payload by more than 30 per cent. Perhaps yet another alternative name for Energia would be Economia, symbolising the economy with the truth.

TONY DEVEREUX
Essex, UK

Piggy-Back into Orbit

Sir, The recent introduction of the Antonov An-225 six engined transport aircraft has opened new horizons to the future of Soviet Space Transportation Systems (STS). With a payload of 250 tons carried inside the fuselage or piggyback on top, it has been officially stated that the aircraft is to transport parts of the Energia and Buran type orbiters. This heavy payload capability will make it an ideal platform for fully reusable STS. Two basic configurations can be proposed:

1. A HOTOL type spaceplane with an air breathing rocket engine using less demanding and sophisticated technologies, having an overall mass of over 200 tons. Note that Bernard Carr proposed to get the HOTOL on a jumbo jet modified for this purpose [1]. The jumbo here was working well above its designed payload levels and was criticized by J.C.E. Moore [2]. In fact even Mr Moore's 200 ton payload limit for a jumbo jet is optimistic. The latest version '747-400' with an extended wing and uprated engines took off at a record breaking weight of about 405 tons (gross wt.) compared with 600 tons for the An-225. The floor loading on the fuselage is an important factor in determining the maximum payload carried by an aircraft, so one cannot simply add its internal cargo load together with a large portion of fuel carried mostly in the wings to assume a maximum carriable payload on top of an aircraft. This is one reason why the Lockheed C5B is used in the USA as a strategic air lift aircraft with a maximum designed payload inside the fuselage of about 120 tons. A typical B 747 will not do any better. This is the main difference between a dedicated cargo aircraft and a passenger aircraft of the same size. One can exceed the designed internal payload at the expense of fuel by an amount not exceeding 20-30%. As an example to this, the An 124 has a designed max. cargo of 150 tons giving a range of 4,500km. It has been certified in a record breaking mission to carry 188 tons. The same applied to earlier smaller aircraft. Taking this into consideration we find that the British HOTOL with an overall mass of 230 tons can fit neatly on top of an An-225 with no modifications to the aircraft basic design, since it already possesses a widespan twin tail very similar to the one proposed by Mr. Carr on his modified B 747. The internal fuel available will give it a cross range for launching the HOTOL of over 2,000km from where it took off. This will be very useful for different inclination missions, giving it flexibility and no danger of cross winds.

It remains to be seen whether the Soviets will be capable of building a HOTOL type spaceplane of their own.

2. A Teledyne Brown Engineering spaceplane type [3] but scaled up to a factor of around two to give a total mass around 250 tons, and LEO payload of around 10 tons.

Note that a lot of the Soviet launches still use the A-2 launcher after 30 years of reliable operation in its different versions, showing no signs of phasing out. By the turn of the century there will still be a need for a launch vehicle in the ≤10 ton category capable of replacing the A-2 and maybe even the Cyclone launchers, used at a rate of once weekly, mainly for LEO missions both manned and reconnaissance. Fully reusable systems should provide the solution. Later on the Proton booster could be phased out in favour of SL-16 launcher for both GEO and planetary missions, leaving the Energia and the shuttle orbiters for heavy space station construction and assembly. There will still be a need for a small expendable launcher in the C-1 category accomplishing the remaining missions.

M.Q. HASSAN
Baghdad, Iraq

References.
1 ***Spaceflight*** March 1987, p.90
2 ***Spaceflight*** May 1987, p 207
3. ***Spaceflight*** December 1987, p 413

Ed. *Readers may be interested in the following Tass statement issued on December 12, 1988:*

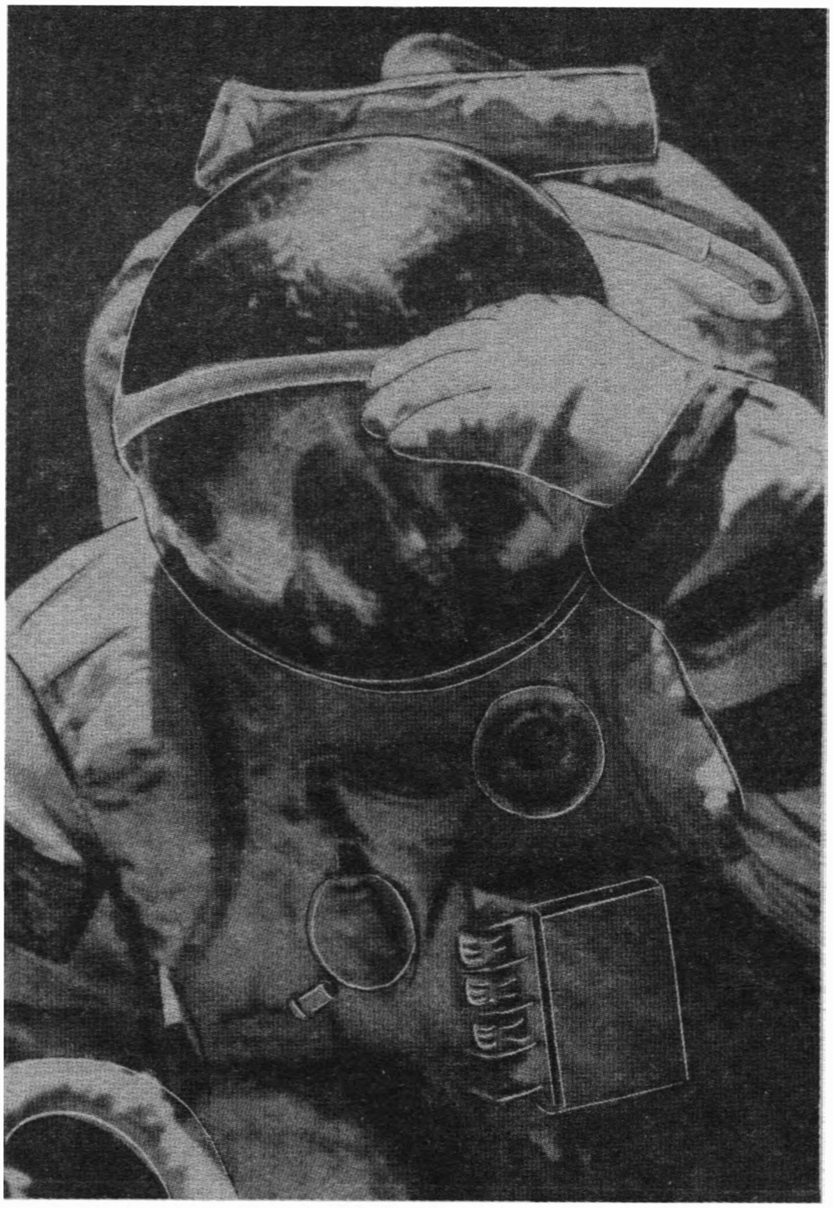
'Academician Struminskiy believes that the future belongs to aircraft-type vehicles different from both the shuttle and Buran — aerospace craft costing between two and five times less that the present systems. It would be a modification of the hypersonic passenger aircraft now under development in the USSR and elsewhere; prototype engines using hydrogen were tested in the Tu-155 airliner in April. Cryogenic hydrogen could be used to improve the dynamic characteristics of the wing by cooling its surface'.


САЛЮТ

Above the Planet

Salyut EVA Operations

Regular *Spaceflight* correspondent *Neville Kidger* continues his review of spacewalks made from the Soviet Union's Salyut series of space stations.



Kizim gives a salute during a space walk from Salyut 7.

1984: A Banner Year

On September 9, 1983 the Salyut 7 station suffered an oxidiser pipe leak which was first reported in the west and which the Soviets originally did not acknowledge.

As the Soviets later admitted, the leak was potentially serious. "A blow-out of oxidiser could take place (from two oxidiser tanks) into the unpressurised assembly module," a report on the incident said in 1987.

After an initial concern for the cosmonauts' safety (Lyakhov and Aleksandrov were aboard Salyut 7 at the time) it was determined that the flight could continue. In order to determine the specific area of the leak gas was pumped from a Progress cargo ship through the oxidiser pipelines.

The area of the leak was established and the probable cause determined, but the problem still troubled engineers. It was decided that the next crew would effect a full restoration of the Combined Engine Installation (Soviet acronym ODU) to gain "the capability and technological experiences in conducting operations in outer space". Salyut 7 had been operating normally on account of the branching dynamic pressure design of the ODU.

The next Salyut crew would have three members - Leonid Kizim, Vladimir Solvyov and Dr. Oleg Atkov. The first two were to conduct a number of EVAs to by-pass and seal the leaking pipe.

More than thirty different tools were developed for the operation including special ladders and cutting tools, wrenches, hydraulic crosspieces for by-passing the unsealed area and a tool container and waste carrier, according to Solvyov. About 90 per cent of these tools were declared inventions by the Soviets.

The cosmonauts practiced the activities on mock-ups of the system on an IL-76 aircraft flying a parabolic trajectory to create weightlessness, and used test bench models. Training was also done in the Star Town hydro tank. All-in-all the men held about 30 EVA training sessions involving almost two hundred contingency situations.

In addition, the men were also scheduled to make an EVA to erect the second pair of DSB solar panels.

The Soviet Union's most experienced space [illegible] Leonid Kizim (right) and Vladimir [illegible]. They have made eight space [illegible]

Kizim, Solovyov and Atkov were launched in Soyuz T-10 on February 8 1984. They docked with Salyut one day later and, for seven days in April, played hosts to the Soviet/Indian visiting flight before commencing their work outside.

Four Times Outside: April 23 to May 4 1984

Prof. Konstatin Feoktistov notes, after the end of the 1984 flight, that many variants of the work needed to be accomplished with the ODU had been developed the most unlikely one requiring six EVAs to fulfil the programme. This was precisely what happened. Progress 20 was docked for the first 4 EVAs. It had a special platform attached to it for the cosmonauts to stand on. At 0431 GMT on April 23 Kizim and Solovyov opened the EVA hatch. Atkov was inside Salyut's working compartment monitoring medical parameters).

The first EVA was dedicated to the installation of a 5 m ladder and the arrangement of the working site, according to Solovyov. "Then with the help of a piercer and special cutter we succeeded in opening the plastic hatch cover, behind which in an unpressurised container were the hydraulic connections of the propulsion system," wrote Solvyov.

The package of tools, with a weight of

about 40 kg, was attached to the work area. The two men returned to Salyut, closing the EVA hatch after an EVA lasting 4 hours 15 minutes.

The second EVA began at 0240 GMT on April 26. After 20 minutes of clambering along the ladder to the work area the men made holes in the station's outer skin over the area of the ODU's reserve conduit. There the men installed a valve. The conduit was blown through and its airtightness checked. However, at one stage a stubborn nut, covered with epoxy putty, refused to budge. The men used a special wrench to undo the nut, but that cost them about two hours of the scheduled 4 hours and 5 minutes allotted to this EVA.

Kizim and Solovyov asked for permission to carry on with the work but flight controller Valeri Ryumin told them to return to Salyut saying "we realise that you're enjoying [the work], but soon enough you'll have the opportunity to get on with the job again and carry it through. So don't rush it, or you'll deprive yourselves of that satisfaction."

The hatch was closed on the second EVA for Kizim and Solovyov after 4 hours and 56 minutes (reported by Tass as 5 hours).

Original plans called for two EVAs in April, according to Soviet sources. (The EVAs were planned for early morning Moscow Time for daylight coverage. Tracking ships in the Atlantic and Pacific ensured up to 50 minutes of contact with the men per orbit.) The men asked for, and received, permission to conduct a third EVA in April.

At 0135 GMT on April 29 the hatch opened again. Once at the work site they connected two filler tubes with a metal bypass line. This added a new conduit to the main reserve. Nitrogen was blown through the pipe to ensure that it was airtight. The thermal covering was reinstalled over the work area to ensure the correct thermal conditions. They packed away their tools and returned to Salyut after an EVA lasting 2 hours and 45 minutes. Kizim and Solvyov were the first Soviets to make three EVAs on a single flight.

At 2315 GMT on May 3 the men opened Salyut's hatch yet again and made their way to the work site. Solvyov later wrote that each time they made their way to this site the men had to pull bulky containers with equipment and tools in them. "During the first EVAs this route was not easy for us and gave us a lot of trouble. We had to stop very often and sometimes return to free the tether or take the tools or TV camera out of an undesirable position," Solvyov said. "Experience was gained after the second and third EVAs and we got the hang of doing it and passed our route 'almost running'."

During this EVA the men removed the thermal blanket again and installed a second extra conduit, checking its airtightness after installation. It was only now, according to Solovyov, that using "a very original logic based on the commands from the ground and the pressure checks by the propulsion system control panels that the unsealed point was finally located. This was performed by cosmonaut Atkov who was inside Salyut 7 at that moment."

The thermal blanket was replaced and the men returned into Salyut after an EVA of 2 hours 45 minutes.

Svetlana Savistskaya.

New Solar Panels: May 18 1984

Progress 20, which had been used extensively during the first 4 EVAs of the tenure of Kizim, Solovyov and Atkov departed on May 6 to be replaced four days later by Progress 21.

This cargo ship brought the second set of DSB additional solar panels. The new set contained solar cells made from gallium-arsenide which would give 6 amps more power than the existing silicon cells.

At 1752 GMT on May 18 the hatch opened again and Kizim and Solovyov exited. The men carried out tool boxes and two containers with the folded DSB's in them. The men soon winched up the first panel.

Atkov, inside Salyut, then commanded the array to rotate 180 degrees so that the other side faced the cosmonauts outside. At one stage of the operation the winch handle broke, giving rise to concern by the previous crew to complete such a task - Lyakhov and Aleksandrov - about microsatellites flying off. The two containers become microsatellites when the cosmonauts in orbit cast them off into space.

Solovyov then began attaching the electrical cables to connect the DSBs to the main panel. The flight engineer "puffed and panted" as he struggled to tie two knots in the bundles of wire in a repeat of problems encountered by the previous crew. "Like trying to thread a needle in boxing gloves," Aleksandrov told a reporter.

With both panels installed and connected the men returned to Salyut's interior and closed the hatch on a three hour five minute EVA. Their record now stood at five EVAs for a total time outside of 17 hours 50 minutes.

A Woman Walks in Space: July 25 1984

Although it was unkown in the west, the four EVAs of Kizim and Solvyov had not completed the repair of the Salyut oxidiser line. Soviet planners scheduled yet another foray to the site of the leak to seal off the leaking pipe entirely.

Procedures were developed and tools built and tested for this purpose. The Soviets also trained a ground-based cosmonaut, Vladimir Dzhanibekov, in the operation and initially proposed that he would perform the work outside the station. Kizim and Solvyov objected to this so a plan was devised where Dzhanibekov would fly to Salyut and train the men in orbit with a model of the clamping device and show videotapes of the operation as Dzhanibeko had practiced it in the Star Town hydrolab.

It is unclear when the next addition to Dzhanibekov's mission was made - the first walk in space by a woman.

The Americans had assigned Kathryn Sullivan to Shuttle Mission 41-G in November 1983, that flight was to include an EVA by her and a male crew-member. Also on the flight would be Sally Ride, America's first woman in space, who would be making her second trip into space. The Soviets, never ones to allow the Americans to set a space first without a try themselves, planned to achieve both those records by flying Svetlana Savitskaya, who made her first flight in 1982 to Salyut 7.

Savitskaya was also to perform an EVA to test out a multipurpose welding, cutting, soldiering and spraying tool (Soviet acroynum URI) in open space. The device was developed by the Paton Institute in Kiev where automated tools, called Vulkan and Ispaatel had been developed and tested in Soviet spacecraft from 1969. URI's purpose was to replace the automated tools with a manual tool.

The heart of the tool, two electron beam guns, was housed in a container along with a step-up transformer and a high-voltage rectifier. A voltage convertor, which stepped up low-voltage direct current from the spacecraft to 5-6 kV alternating current for the URI, was housed separately. The gun and its accessories - an airtight electronics box, a control unit, fixing handles, etc, were housed in a single container.

The weight of URI was less than 3 kg and the mass of the entire package was 30 kg without the holder for the samples. The power source was the heaviest element.

The Soviets say that URI took some time to be included in the mission. Physicians, were yet to overcome the psychological barrier." Until the very last moment reservations were voiced about using the tool."

URI was tested in a pressure chamber where experimenters gained proficiency with it over three sessions and in an aircraft flying a parabolic trajectory.

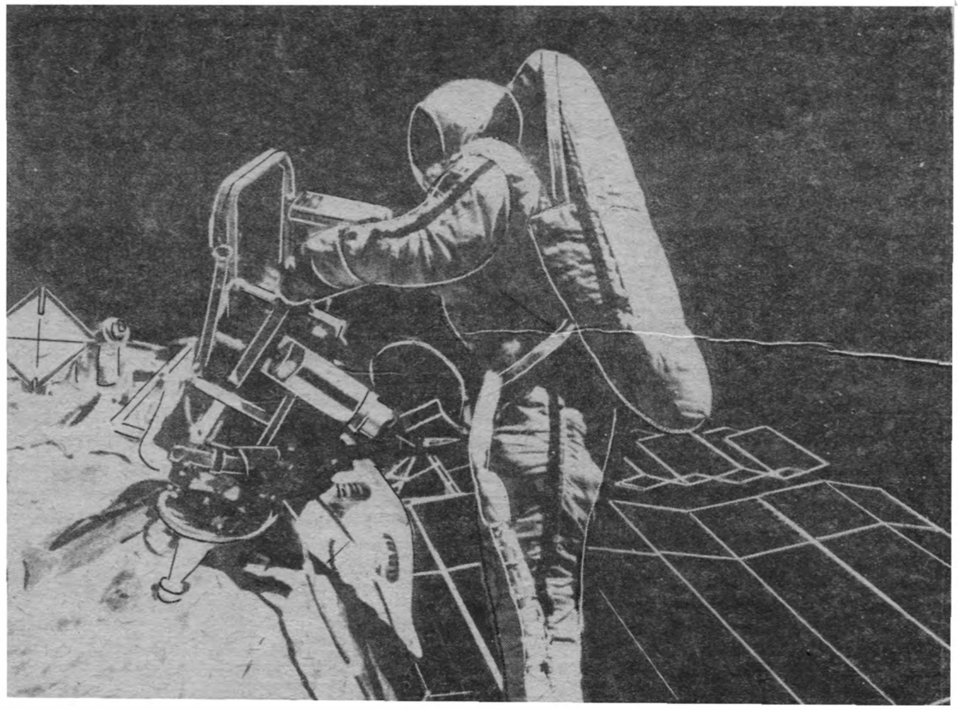
Soyuz T-12, carrying Dzhanibekov, Savitskaya and Igor Volk (included at the request of the Ministry of Aviation Industry as part of his preparation for flying the Soviet shuttle) was launched on July 17, 1984 and docked with Salyut 7's rear port the next day.

The EVA was scheduled for the seventh day of the flight. With six cosmonauts aboard Salyut provision was made for an emergency return to Earth should there be a problem with the EVA. Whilst Dzhanibekov and Savitskaya were on EVA Solovyov was sealed into Soyuz T-11 at the front of the station. If an emergency occured, the two spacewalkers would enter T-11 and return to Earth. Kizim, Atkov and Volk were located inside Salyut's working compartment.

In the afternoon of July 25 the cosmonauts assumed their positions and at 1455 GMT the hatch of the station was opened for the sixth time of the 1984 occupation.

Dzhanibekov was first outside. He stepped onto the Yakor platform and secured himself. The Yakor had been folded for two years. A sample container was removed for return to Earth and a lamp set up.

The URI, and its associated test boards, was handed out by Savitskaya and plugged into an external power outlet. The task took slightly longer than planned but, as the complex passed over Africa, Svetlana Savitskaya floated out of the hatch.



Svetlana Savitskaya during her 3 hour 35 minute EVA, on July 25, 1984. She became the first woman to walk in space and the first woman to make two space flights.

The first woman to conduct an EVA at first caught her tether and complained that "the sunlight is blinding my eyes." Dzhanibekov advised caution. Once on the Yakor Savitskaya rested.

Dzhanibekov, now back in the hatchway, set up a TV camera. Direct contact was established with FCC. Flight controller Valeri Ryumin asked for a status report.

"Can we start?" Savitskaya asked. "Well, if you're so impatient, then start it," was the reply.

"I have begun the work. I have switched on the instrument. We have power," Savitskaya reported. The first task involved cutting a 0.5mm thick sample of titanium. It took less than one minute to make a 10 cm cut.

Turning to another set of pre-cut samples she began to weld them together. The samples were 1 mm thick. At first the weld did not give a very even result, Savitskaya reported. She later reported that she had achieved "three tack welds and the seam is good."

TV pictures showed her flipping the four sample boards up and down as she continued the tests of the URI. Six welding experiments were conducted - two samples of titanium and four of stainless steel, She conducted six cutting experiments - three of titanium and three of stainless steel. Six soldering experiments involving tin and lead were conducted and, using the second electron emitter, fitted to a special crucible, melted solder and sprayed it onto anodised aluminium discs. The crucible took 45 seconds to heat the solder. There was concern that the work would not be done before nighttime.

Kizim was asked how the world's first woman spacewalker was doing: "Sveta is working fine," was his reply from inside Salyut, Atkov told Savitskaya that a dinner had already been prepared for the celebration of the EVA. However, she replied that she was not returning until the work was done.

Before the complex entered darkness Savitskaya reported to FCC that the cutting and welding experiments appeared good but that she was having difficulty seeing the solder and the spraying results, the Sun had hindered her.

Savitskaya, responding to a question from FCC said that although not cold her right leg was slightly numb.

As the complex passed through orbital nighttime the two spacewalkers swapped positions. Savitskaya described what she could see:

"Earth is beautiful not only when lit up by the Sun but also when in the shadow .. I was overwhelmed by the fantastic spectacle of thunderstorms with brilliant flashes and play of colours against the black background of the clouds. These light phenomena seem to remind us that there are still many enigmas in nature. Meanwhile, in areas not hidden by clouds, the lights of lots of cities and towns could be seen. Looking from outer space, it is obvious that the Earth is an inhabited place and that there is intelligent life on it."

When contact was resumed with FCC, after a 40 minute break, Dzhanibekov was operating the URI. Speaking about the spraying operation, the veteran cosmonaut said that it was "like painting a wall ... the tool is very handy and I am sure we'll be using it a lot."

When Dzhanibekov finished the URI tasks he put the electron gun back into the container, closed the plate holders, fixed them and handed the whole assembly to Savitskaya in the hatchway.

Before returning into Salyut's compartment the two placed a container with bio-polymers on the outside of Salyut. This was a continuation of the Medusa experiment and was designed to non-biogenetically synthesise the components of nucleic acids in open space. Other cassettes were removed and placed inside Salyut.

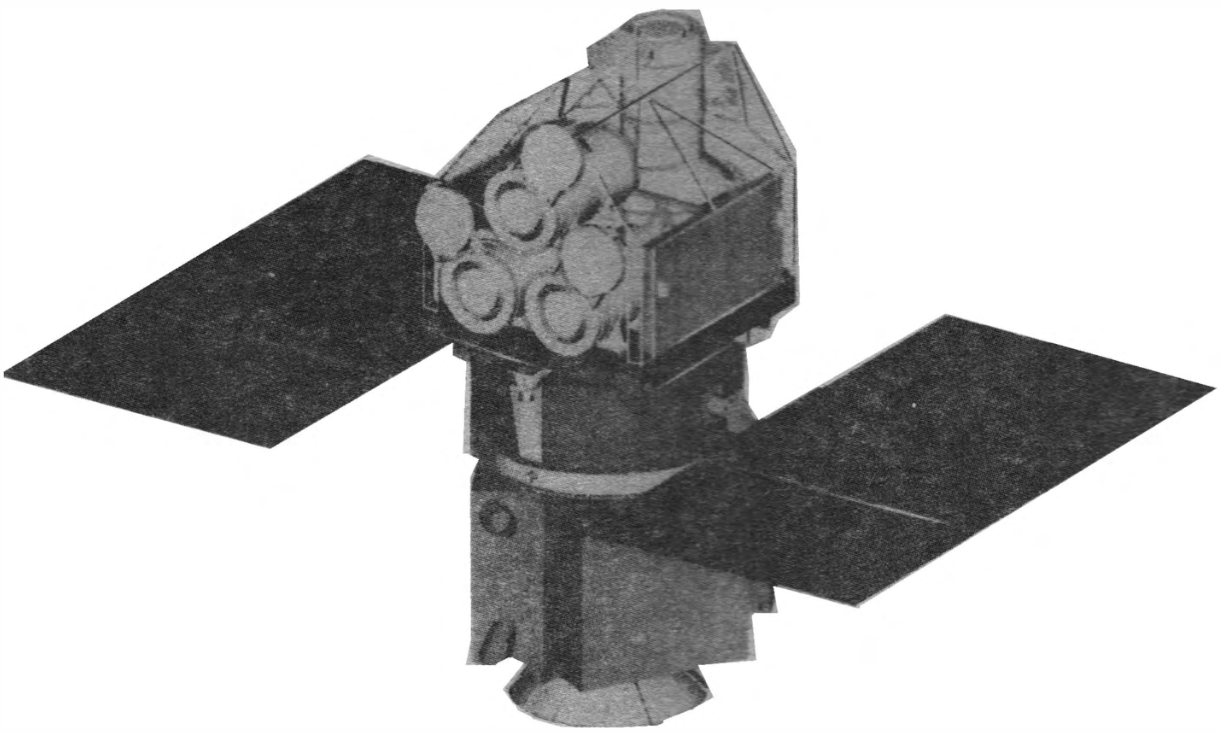
The hatch was closed on the EVA after being opened for 3 hours 35 minutes. Inside the station, as the cosmonauts waited to doff their spacesuits, Dzhanibekov beamed TV pictures of Savitskaya to FCC. She gave a heartfelt thanks to the makers and testers of URI in the Ukraine.

On October 5 1984 Sally Ride and Kathryn Sullivan were launched as members of the seven-strong Shuttle 41-G crew. Ride became the first American woman to make two flights and, later in the flight, Sullivan made her EVA with David Leestma. But by then both records were held by Savitskaya.

In 1988 Georgi Grechko told a reporter that Savitskaya had found herself in trouble during the EVA "and had to be rescued " He said that women were "no good" in space and that they should stay on Earth!

This major feature on Soviet EVA operations continues in the next edition of *Spaceflight*.


SPACE SHUTTLE FLIES AGAIN
ASSEMBLY
THE CREW
TESTING
TRAINING



Making Space News

in New Zealand

The resumption of shuttle launchings with mission STS-26 on September 29, 1988 did not go unnoticed in New Zealand thanks to the special efforts of *David Maclennan*, Fellow of the BIS and Vice-President of the New Zealand Spaceflight Association, who writes about his 'STS-26 Awareness Program'.

The STS-26 Awareness Program really began only two weeks before launch, when I learned of the launch date itself. The work involved displays, newspaper features, lectures and radio features, and until I had this firm date I could not do much about organising sites for displays, for example.

To assist the news media I prepared a media kit on the mission based on the NASA one. As the NASA one did not arrive until less than a week before launch, the media had this kit only a couple of days before launch. Despite the lateness, it was well appreciated, as far as I can tell. Earlier in the month I had sent out a news release altering the media dto the fact that the launch was near, and that it would be a newsworthy event.

I took a weeks leave from work to prepare the displays and organise other aspects of the Awareness Program. There were two displays: the one in the photo opposite, which was in a bank window downtown, and a larger display on the shuttle programme as a whole was part of a 'Space Shuttle Day' held at the local Planetarium the day after launch. The latter also continuously-screening Shuttle mission videos.

I wrote two feature articles on the Shuttle recovery programme and STS-26, which were published in two of the country's major dailies, the Evening Post and the New Zealand Herald.

Of the various news media here, radio was by far the most responsive. I was interviewed on air several times in the weeks leading up to the flight and during the mission itself. I also persuaded the national radio network here to broadcast the Voice of America commentary on the launch, though I could not talk Television New Zealand into covering the launch live (TVNZ virtually ignored the flight together). In the hours leading up to the launch the national radio network also broadcast NASA "Space Story" tapes on STS-26 that I had supplied.

Although coverage of the mission here was not as good as it could have been, I feel the STS-26 Awareness Program did at least ensure that more New Zealanders were aware of what was going on than might otherwise have been the case. From my point of view I was pleased that despite the shortness of time, everything planned got done.

And of course, the most gratifying thing of all is that the mission was a success! I only wish I could have gone to the Cape to see the launch in person.

(Top) A display on the shuttle programme mounted in the window of a high street bank in Wellington, New Zealand as part of the STS-26 Awareness Program.

(Bottom) The Explorer Platform with solar panels extended and the EUVE payload module consisting of three identical 'Scanning' Telescopes plus the Deep Survey/ Spectrometer (see diagrams in p.144).

Satellite Telescopes

Extreme Ultra Violet Explorer (EUVE) Mission

EUVE is a new project to be launched by NASA in the summer of 1991. The satellite will map the entire sky in the extreme ultraviolet band of the spectrum, something which has not yet been attempted. Under development since 1979, EUVE is expected to find a whole array of new sources in space, from new stars to quasars and white dwarfs.

***Dr. Roger Malina*, a Fellow of the BIS, is a member of the project's Science Team and Principal Investigator of the EUVE Instrument Development Project. He now provides *Spaceflight* readers with an insight into some of the novel features of this mission.**

Introduction

The Space Astrophysics Group (SAG) at the University of California, Berkeley is an organization devoted to the expansion of scientific discovery and research. Employing over 100 people, the group is responsible for several projects in collaboration with NASA and other research groups and universities. Through the direction of Professor Stuart Bowyer, SAG has been a leader in the study of the extreme and far ultraviolet bands of the spectrum; new, high-efficiency detectors and spectrometers; research on the interstellar medium; the search for extraterrestrial intelligence; and ground-based observations of high energy sources.

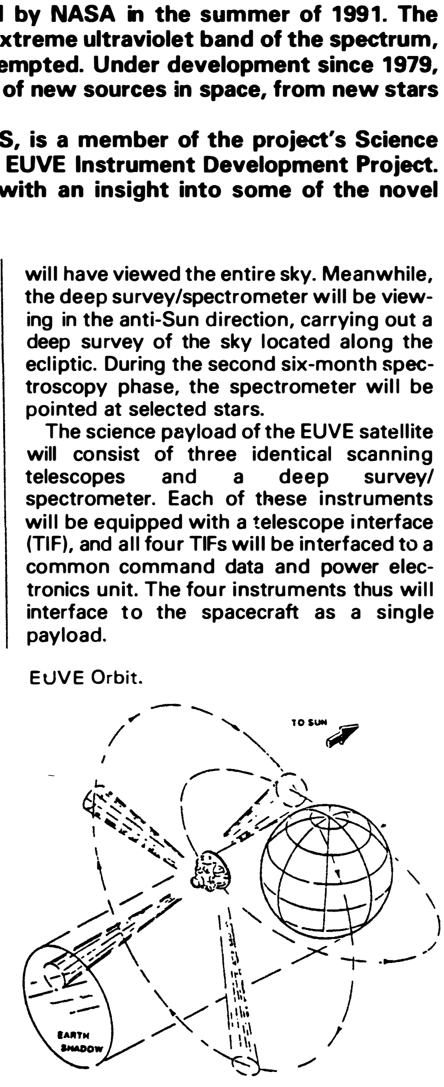
The Extreme Ultraviolet Explorer

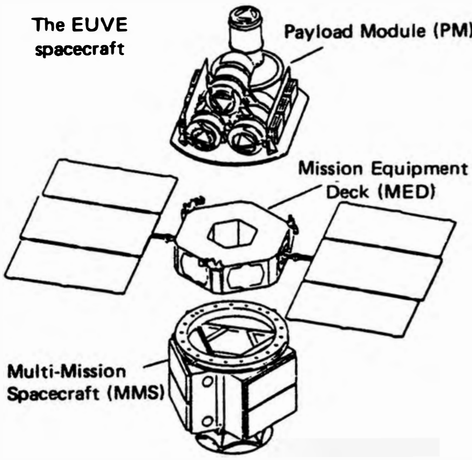
The Extreme Ultraviolet Explorer (EUVE) will be launched by a Delta 2 expendable launch vehicle and attached to a multi-mission spacecraft (MMS) similar to that used for the Solar Maximum Mission. After completion of the EUVE mission, the shuttle will be used to retrieve the EUVE science payload and install a second science user. The MMS Explorer platform itself will remain in orbit for 15 years.

The EUVE satellite will be placed in a circular orbit at an altitude of 550 kilometers. Mapping of the extreme ultraviolet will occur through the spin motion of the MMS, which uses the Sun as its orientation point. At the end of this six-month "sky survey" phase, the scanning telescopes will have viewed the entire sky. Meanwhile, the deep survey/spectrometer will be viewing in the anti-Sun direction, carrying out a deep survey of the sky located along the ecliptic. During the second six-month spectroscopy phase, the spectrometer will be pointed at selected stars.

The science payload of the EUVE satellite will consist of three identical scanning telescopes and a deep survey/ spectrometer. Each of these instruments will be equipped with a telescope interface (TIF), and all four TIFs will be interfaced to a common command data and power electronics unit. The four instruments thus will interface to the spacecraft as a single payload.

EUVE Orbit.





Historical Note

The first non-solar EUV source was discovered using a SAG telescope on the Apollo-Soyuz Mission in 1975. Previous enthusiasm for this part of the electromagnetic spectrum was dampened by the realization that there was a reasonably dense interstellar medium and, absorption coefficients being about as high as they can get at these wavelengths, it would be almost opaque.

In 1974 calculations indicated that direct observations of stars in the EUV should be possible out to about 100 pc. These stars would have to have a surface temperature in excess of 20,000 K and would have to lie on a line of sight in a direction where the neutral hydrogen density was very low. During the early 1970's, many people were reporting measurements indicating that in certain directions, neutral hydrogen densities could be as low as 0.01 cm^3.

Apollo-Soyuz offered the opportunity to make extended observations and 20 hours of observational time was logged. On the seventh day of the mission, July 22, 1975 at 22h 26m, the spacecraft was rolled to a target in Coma Berenices. Over the instrument horizon something came into view, and with it, a new field of astronomy. Subsequent raster scans confirmed that the countrate was reproducible and that the source was localized to a region centered at RA 13h 14.0m and Dec +29d 22m. At that position exists the hot white dwarf known as HZ43.

Back on Earth, the analysis of the data obtained through different filters gave a crude estimate of spectral energy density. A simple blackbody fit enabled the extraction of the following information regarding both the nature of this new type of star and the interstellar medium. The surface temperature of the star could be as high as 110,000 K (compared to our Sun's 5000 K), and this would mean its radius is about 7800 km (compared to the Earth's 8000 km). The density of the interstellar medium (in that direction) would be 0.014 cm^3.

Having proved that observations to distances well beyond 300 light years were feasible, the Berkeley group headed by Prof. Bowyer (SAG) realized that over 100,000 stars could be found in that volume, many of which could be expected to be bright at EUV wavelengths. A survey of this volume of space would provide fundamental new information about the local stellar population, energy transport in stellar atmospheres, and the ionization and opacity of the interstellar medium.

Confirmation was provided by a number of new rocket payloads, which were launched in rapid succession as thesis projects by Webster Cash (November 1976), Roger Malina (November 1978), Randy Kimble (June 1982) and Pat Jelinsky (November 1983). The flight of the "Blue Rainbow" by Roger Malina in April 1978 obtained the first spectrum of HZ43, indeed of any stellar EUV source, and reported the discovery of helium in the photosphere of the white dwarf.

With a speed which can only be described as awesome, by December 1976 the group had prepared for submission to NASA a 300 page proposal which gave a detailed description for an Extreme Ultraviolet Explorer.

EUVE Spectrometer

The six-month phase following the All-Sky Survey by the EUVE Scanners will be dedicated to spectroscopy of the brightest sources newly-discovered by the Survey. The EUVE Spectrometer to be used for this task will have a novel slitless design incorporating variable line space (VLS) gratings which correct for the fact that the light from the mirror is converging.

The Spectrometer will have three wavelength channels, each of which will use one-sixth of the Wolter-Schwarzscild II telescope aperture. The remaining half of the beam will be focussed onto the Deep Survey Detector, which will perform a long-exposure survey of a portion of the sky along the ecliptic and in the direction of the spectroscopy targets.

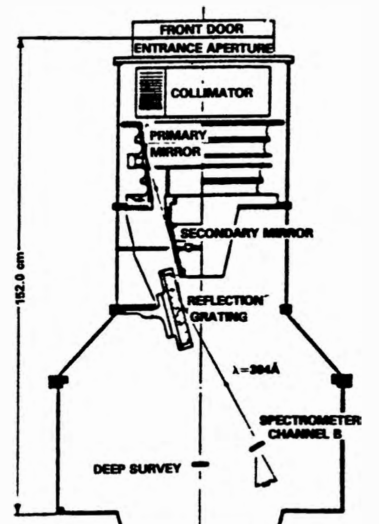


Diagram of the Deep Survey/Spectrometer Telescope which has a Wolter-Schwarzschild Type II mirror. The ray path is traced for channel B which is sensitive to HeII 304Å line emission.

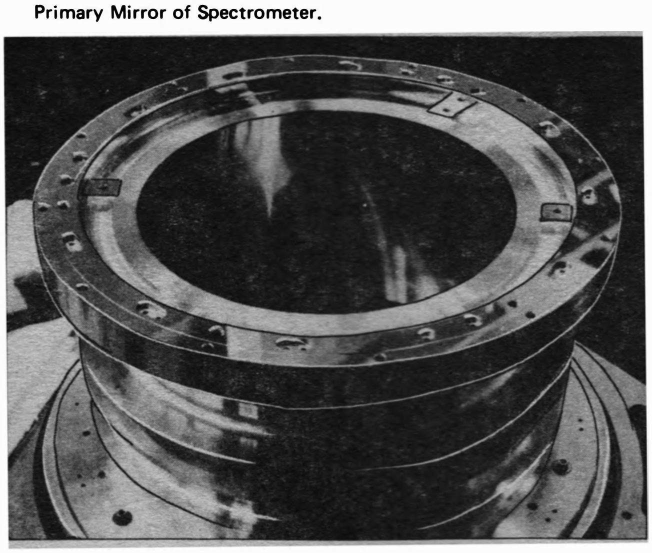
Roger F. Malina

Roger Malina graduated from the Massachusetts Institute of Technology in 1972 with a B.S. degree in Physics and a year later embarked on a career in astronomy at the Space Sciences Laboratory, University of California, Berkeley, undertaking research on UV and X-ray emissions from astronomical sources and gaining his Ph.D degree in 1979. The following year he was appointed Associate Research Astronomer at Berkeley and has since played a leading part in the EUVE mission acting as Principal Investigator for EUVE Science Instruments.

Roger Malina was elected to the British Interplanetary Society in 1976 and maintains a close interest in the Society's activities. In 1988, he was joint author of a technical paper on the EUVE mission which was published by the Society [1].

[1] S. Bowyer, R.F. Malina and H.L. Marshall, 'The Extreme Ultraviolet Explorer Mission: Instrumentation and Science Goals', *JBIS*, 41, p.357-361 (1988).

Primary Mirror of Spectrometer.



Secondary Mirror of Spectrometer.