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Spaceflight

The International Magazine of Space and Astronautics

A VISIT TO
SPACE CAMP

PEGASUS
WINGED LAUNCHER

MISSION STS-29

Spaceflight
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Editor:
G. V. Groves

Assistant Editor:
S. Young

Managing Editor:
L. J. Carter

Spaceflight Sales:
Shirley A. Jones

Advertising:
Suszann Parry

Spaceflight Office:
27/29 South Lambeth Road,
London, SW8 1SZ, England

Tel: 01–735 3160.
Fax: 01–820 1504.

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Front Cover: (Background) A distant shot of the Tracking and Data Relay Satellite after deployment fromDiscovery in September 1988. A third Tracking and Data Relay Satellite is due to be launched on STS-29 in mid-March.

(Emblem) The STS-29 mission patch - designed by the five crew members to capture and represent the energy and dynamic nature of the US space programme. The stylistic Orbital Maneuvering System burn symbolizes the powerful forward momentum of the shuttle and a continuing determination to explore the frontiers of space. In the border, the seven stars between the STS-29 crew names are a tribute of the crew of Challenger. *NASA*

Mid-March Launch for Discovery

This month *Spaceflight* continues its extensive coverage of shuttle missions with a preview of the next flight, STS-29. During the five day flight, Discovery's crew will deploy the third Tracking and Data Relay Satellite (TDRS) and conduct a number of scientific experiments.

STS-29 Crew

Discovery's crew consists almost entirely of the crew for STS 61-H, due for launch in June 1986, but cancelled after the Challenger accident. Discovery is to be commanded by Michael Coats, who previously flew as pilot on the orbiter's maiden flight, in August 1984. Coats was born January 16, 1946, he joined NASA in 1978. Pilot John Blaha will be making his first space flight. Blaha enrolled to be an astronaut in 1980, he was previously an Air Force test pilot. Blaha was born on August 26, 1942.

The three remaining crew members are mission specialists. James Buchli rode the shuttle into orbit on two previous occasions: STS 51-C in January 1985 and STS 61-A in October 1985. Buchli was a test pilot and aeronautical systems engineer before becoming an astronaut in 1978. He was born on June 20, 1945. Robert Springer is making his first trip into space. Born on May 21, 1942, Springer was an operational test pilot before joing NASA in 1980. James Bagian is the only crew member not to be transferred from the cancelled STS 61-H. He was scheduled to fly on STS 61-I in September, 1986, the mission was also cancelled. STS-29 will be his first space flight. Bagian, a medical doctor, was born on February 22, 1952 and joined NASA in 1980.

Launch Preparations

The launch of Discovery has been postponed until mid-March after cracks were found in one of Atlantis' main engines. The cracks were located in the high pressure turbopump of engine No.3. The damage is believed to have been caused when moisture formed in the pump during manufacture. As a precaution, it was decided that pumps manufactured by a new process should be used on STS-29. Rocketdyne, the manufacturers of the engine, worked to prepare the new pumps, which were tested at the Stennis Space Center before being transported to the Cape. All three turbopumps were expected to

STS-29 Mission Specialist James Bagian during emergency egress training at the Johnson Space Center. *NASA*

arrive at the Kennedy Space Center before February 17. The old turbo-pumps were removed from Discovery on the launch pad.

Discovery was rolled over to the Vehicle Assembly Building (VAB) from the Orbiter Processing Facility (OPF) on January 23. The move was delayed by 24 hours because of torrential rain in the Cape Canaveral area. After arrival, a small nick was discovered in the orbiter's right outboard man landing gear tyre. The tyre was replaced before the vehicle was hoisted vertical for mating.

At 6:00am EST on February 3, Discovery was rolled out to pad 39B. The STS-29 crew rode the Mobile Launch Platform for part of the slow move to the pad.

Countdown Demonstration Test

The five STS-29 crew members took part in a countdown rehearsal at the Kennedy Space Center on February 7. The countdown included a simulated main engine ignition at 11:37am EST. The test gave the astronauts and the ground crews a valuable practice run. A number of malfunctions were introduced during the course of the test, including a complete engine shutdown before lift-off.

The previous day the astronauts had practiced emergency egress from the orbiter and launch pad.

TDRS-D

Discovery's primary payload for STS-29 is the TDRS-D satellite. Two of these satellite are already in orbit, the first launched by Challenger in April 1983, the second was launched in September of last year. A third satellite was lost onboard Challenger in January 1986 1986. (For full details of the TDRS system see ***Spaceflight***, November 1988, p.443).

The TDRS satellite is to be deployed by Discovery during orbit 5, about six hours, 13 minutes into the flight. Back-up opportunities for deployment occur during orbits 6 and 7, and also the following day. After the satellite has been deployed, Commander Coats will distance Discovery from the satellite and its IUS booster. To protect the orbiter windows from the IUS ignition Discovery will be turned so its belly faces the satellite. The first stage ignition will occur an hour after deployment, the second stage will fire 12 hours, 26 minutes into the flight.

TDRS-D is to take over the work of TDRS-1, which is now six years old.

SHARE

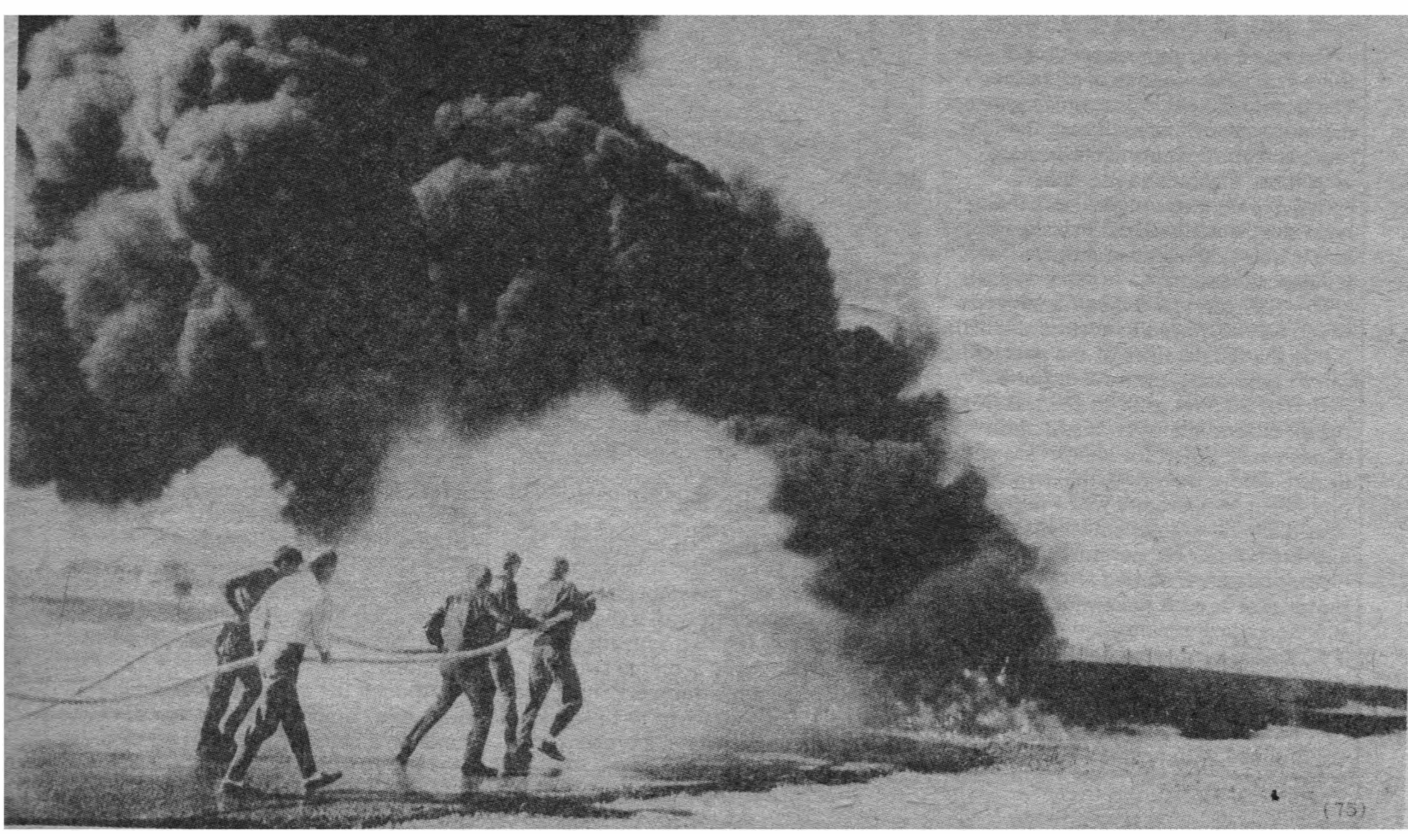
The Space Station Heat Pipe Advanced Radiator Element (SHARE) is being developed to cool the space station Freedom, the first full scale test of the system will take place on STS-29. The 15.5 metre long radiator occupies a sill on the starboard side of the payload bay (the sill was originally intended to carry a second remote manipulator arm, but to date shuttle flights have carried just one arm, mounted to the port side).

During the orbital tests, three electrical heaters will warm the evaporator end of SHARE. In the evaporator, a fine wire-mesh wick that works on the

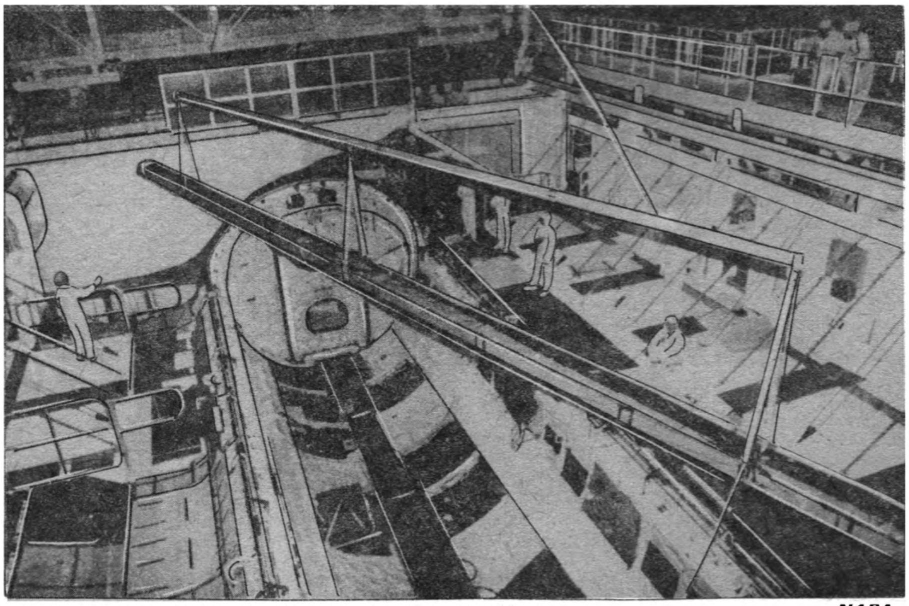
(Top) Discovery will be manned by these five astronauts. (Front row) Michael Coats (right) and John Blaha, (left to right back row) James Bagian, Robert Springer and James Buchli.

(Bottom) A little known part of shuttle training - fire fighting. The STS-29 crew are seen here extinguishing a blaze.


COATS
BLAHA
SPRINGER



STS-29 PREVIEW



The SHARE radiator is loaded into Discovery's payload bay. *NASA*

same principle as the wick of an oil lamp will pull liquid ammonia from the smaller pipe into the larger pipe, where it is vapourised by the heat. The vapour will carry the heat the length of the radiator through the large vapour pipe. The radiator element dissipates the heat into space, leaving cooled condensed ammonia. Small circumferential grooves on the wall of the larger pipe allow condensed ammonia to drop back through the narrow slot into the smaller pipe, which recirculates the liquid ammonia back to the evaporator.

An early heat pipe experiment flew aboard STS-8 in August 1983. Although it was small in scale it demonstrated the concept's potential. The SHARE experiment was scheduled to fly in 1986 but has been delayed by the halt in shuttle flights.

During STS-29, crew members will switch on the heaters using controls in the aft flight deck. The experiment's two 500-watt heaters and one 1,000-watt heater are controlled individually and will be switched on in turn, applying heat that will increase steadily in 500-watt increments up to a maximum of 2,000-watts.

The experiment will be activated for two complete orbits in each of the different attitudes, the first with the payload bay towards the Earth and the second with the Orbiter's tail towards the Sun.

For space station Freedom, 50 to 100 radiator panels such as the SHARE would make up two arrays along the station's truss structure. Each radiator will operate independently, thus preventing the failure of a single panel from disabling an entire array.

If the SHARE tests are successfully conducted, the next step will be to evaluate methods for the assenble of the panels in orbit.

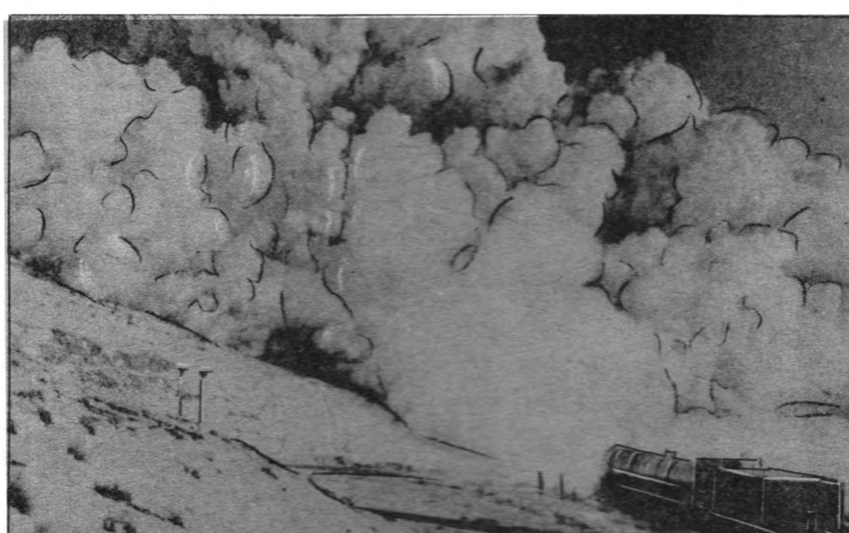
Final Shuttle Booster Test

The final test firing of a full-scale space shuttle Solid Rocket Booster (SRB) was successfully conducted on January 20. The firing took place at the T-97 test stand at Morton Thiokol's facility 25 miles west of Brigham City, Utah.

The test marks the completion of the three-year SRB redesign programme. The booster's field joints, which connect the motor segments, each had the capture feature tang-and-clevis design, with three Viton O-rings and an adhesively bonded J-shaped deflection relief slot, which reduces stresses and also increases the sealing action of the bonded surfaces.

The T-97 test stand features a hanger which can be moved to enclose the SRB. Inside the temperature of the booster can be accurately controlled. For a period of 30 days prior to the test firing the air around the booster was chilled to -6 degrees C. When the hanger was withdrawn, before the firing, the average bulk propellant temperature was 4 degrees C. This is several degrees cooler than any expected motor temperature at launch.

Joint heaters mounted around the motor case at each field joint, are thermostatically controlled to maintain a minimum joint temperature of 24 degrees C. In addition, the igniter joint heaters maintain a minimum temperature of 19 degrees C and the aft skirt was conditioned with heated air to assure a minimum case-to-nozzle temperature of 24 degrees C.

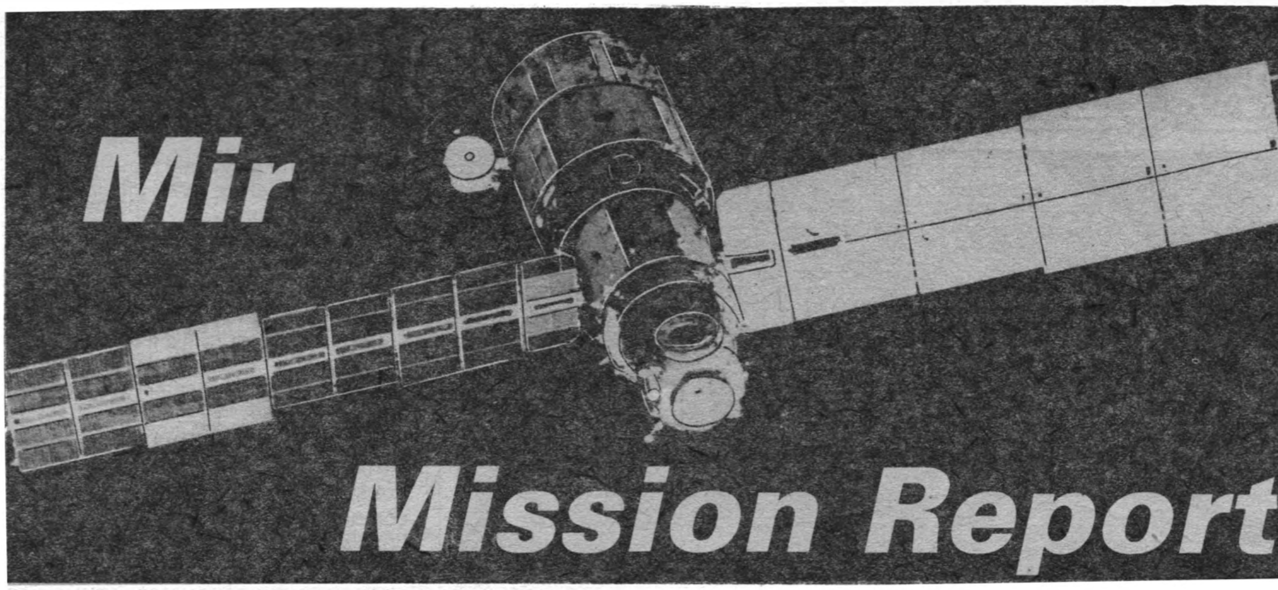


The QM-8 booster during its January 20, test firing.

Unlike some previous test firings, this booster did not contain intentional manufacturing or assembly defects. The motor was equipped with a flight design External Tank (ET) attachment ring. Three hydraulically actuated struts, which simulate the motor's connection to the ET, were attached to the ring. During the motor firing, a programmed series of dynamic loads were applied through the ET attach struts to simulate ignition, lift-off and flight loads.

The QM-8 motor was fitted with more than 600 instruments to measure acceleration, pressure, deflection, thrust, strain, temperature, electrical properties and other conditions.

Although the initial reports say the test was a complete success, it will be some time before this can be verified.



Neville Kidger continues his Mir Mission Report with full details of the joint Soviet/French mission. His report includes the space walk to erect the ERA stucture, and the return to Earth of cosmonauts Vladimir Titov and Musa Manarov, who spent a record breaking year in orbit.

By Neville Kidger

Orbital Experiments Begin

Medical and biological experiments were prominent amongst the first day's work on the complex, November 29. With the Echograph ultrasound instrument Cretien monitored his cardiac activity and the flow of blood through the vessels of his inner organs. The unit is an improved version of the one used by Cretien on Salyut 7 in 1982 and Patrick Baudry on the Shuttle 51-G flight in 1985. Images of the heart are displayed on a small screen during the tests and these are videotaped for later study.

Combined with the Echography tests, biochemical experiments under the code-name Medilab used collected plasma and urine samples to study hormonal changes experienced by the cosmonauts during the flight. The plasma would be studied from blood samples collected by means of a Czechoslovak-made instrument. The blood was then to be placed into a centrifuge to separate out the plasma which would then be put into a freezer. Two sets of samples were to be provided - Cretien and a Soviet cosmonaut - so that laboratories in the USSR, France and Czechoslovakia could analyse the plasma and urine together with samples collected before and after the flight.

Michel Tognini, Cretien's reserve later told reporters that there had been problems with the collection of the samples.

Officials admitted that the six men in Mir were working in a crowded environment. A TV shot of Cretien wired up to another experiment showed a maze of cables and wires. The operation of the experiments was also reportedly straining Mir's power supply.

Another novel experiment conducted during the first working day also involved the Echograph unit. By attaching an optical tunnel to the video screen of the unit and linking up a mini-joystick the unit could be used for coordination tests of the subject under the Vinimal codename. The Echograph/Vinimal combination had a total weight of 165kg.

At least six sessions of work involving four scientific objectives were planned for the flight with the first session being on November 29.

The Circe and Ercos units, designed to register radiation levels in the complex and their effect on electronic components, were placed on the walls of the station.

The astronomers on Earth also used the complex to conduct seven observation sessions with the Roentgen observatory on Kvant. They studied the Supernova in the Large Magellanic Cloud as part of the long-term astronomy programme.

The Soviets said that recent observations of the supernova had revealed that the output of hard X-rays had decreased noticably compared to the output at the start of 1988. They linked the decline to the decay of radioactive cobalt.

On November 30 Cretien conducted more Echography tests. He donned the Chibis pneumatic suit during this session to simulate the pull of Earth's gravity.

During this day the first use was to be made of the Physalie experiment which used a number of devices to determine the body's sensory-motor physiology in weightlessness. The equipment used registered numerous physiological signals which included the bioelectrical activity of the heart, muscles, eyeballs and limb movements simultaneously. The subject was also videotaped in stereo.

Before the flight, Cretien had reportedly complained about the complexity of the experiment with a total mass of 75 kg In space he reported that the equipment took up to 2.5 hours to set up. Describing his problems he noted that the complex experiment made the men feel like laboratory animals and that if the windows on Mir opened, then Physalie would be thrown out of them!

The equipment was to be used over eight days of the joint flight with six major scientific objectives being studied.

Okeans Prepare for Return

On December 2 the Soviets said that Titov and Manarov were undergoing special training to adapt their cardiovascular systems and muscles to loads they would encounter on Earth. The regime had become "particularly rigorous" in the final month before the reentry.

The men continued to wear their Penguin load suits almost the whole of their waking hours. The Chibis suit was used often to condition their cardio-vascular systems and water-salt additives help the men to retain liquid and thus increase the amount of blood in their circulatory systems.

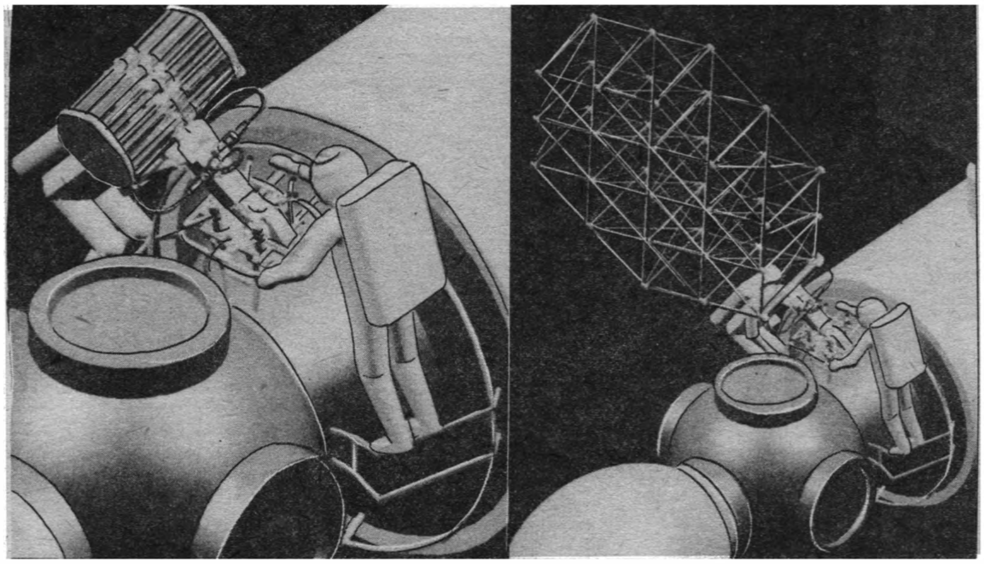
Dr Anatoli Grigoryev said that the men had experienced slight changes in their weight and shin sizes. But these did not exceed those encountered by Yuri Romanenko during his 326-day flight in 1987. He said it was necessary for the two to keep up their exercise programme just as effectively now as they had done for the previous portions of the flight.

On December 4, breaking off from their work, the men held a press conference. Cretien told journalists that he felt better than he had during his first flight in 1982. "Whereas during the previous space mission I was afflicted by space motion sickness, though in a slight form, now I did not feel any sickly sensation," he said.

In TV coverage of the flight the Soviets showed that FCC had been adorned with advertising placards along the base of the display screens. Other reports said that the French had turned down suggestions that Cretien should carry advertising on his spacesuit. French officials were against that in case the cosmonaut resembled a racing car driver! There were also suggestions that adverts should be placed on the walls of the Mir station.

On December 8 a group of over 50 diplomats from 47 countries visited the FCC to view its facilities. They were given a tour by Aleksandr Dunayev the head of Glavkosmos, and Vladimir Lobachev, the centre's director.

The head of the delegation, the Senegalese ambassador, spoke briefly to the joint crew. After addressing them as "ladies and gentlemen" he wished them every success. The crew thanked the



Computer simulations of the ERA structure in the stowed position (left) and after deployment (right). *CNES*

diplomats for their interest and apologised for having to cut the discussions off after a short reply - the cosmonauts were preparing for the EVA of Volkov and Cretien the next day.

EVA for ERA

When Soyuz TM-7 was launched, the EVA to place the ERA structure on the outside of Mir was scheduled to take place between 0850 - 1350 GMT on December 12. During the first days of the flight the Soviet and French specialists changed their minds and set the date of December 9 (the original date when the launch had been set for November 21). This was to allow another EVA on December 12 if there was a problem with the first attempt to attach and deploy the ERA structure or problems in jettisonning the structure after it had been deployed. Conditions for a second EVA after December 12 were unfavourable, reports said.

After having checked out their EVA suits, early on December 9 cosmonauts Volkov and Cretien entered the Mir front docking unit and sealed themselves inside. The compartment was depressurised and, at 0957 GMT, opened one of the docking unit hatches. The complex was over Japan at the time.

Cretien was the first outside, leaning out to install handrails. Once fully outside at 1016 Cretien attached the Enchantillons experiment to Mir's exterior. This was a 15.5 kg container with several sets of samples inside. There were five different technological experiments being performed:

- Comes, studying the behaviour of materials in space amongst them paints, reflectors, adhesives, filament reinforced composites and optical materials.
- Mapol, studying the behaviour of polymeric materials under exposure to space conditions for evaluation of their feasibility of space applications in inflatable modular structures which can be made rigid.
- DIC and DMC, studying the nature and distribution of dust in space with one active and one passive collector. The active detector measures particle flows.
- MCAL, studying the evolution of solar absorptivity and emissivity over time of white paints to refine mathematical models.

Cretien attached the container to the handrails by means of hooks and springs and connected up a container of electrical leads to the Mir supply. The lids of the containers were then opened to expose the samples. Some difficulties were experienced during this activity.

The experiment is to be retrieved after about six months exposure to open space.

Volkov left Mir's hatch at 1033.

The cosmonauts then moved onto the main purpose of the EVA - the erection of the ERA structure.

The total weight of the experiment amounted to almost 240 kg and comprised four parts - a control panel in Mir, a mounting platform for the structure, the deployable structure itself and a filming block. (It was the largest part of the whole "Aragatz" science equipment which totalled 580 kg.)

The mounting platform was set up on the conical part of the station between the docking module and the work compartment and was attached to handrails. The cosmonauts experienced a problem connecting the cable from the platform to the control panel inside Mir. This further slowed the pace of the EVA, which had been expected to last for 4 hours 20 minutes.

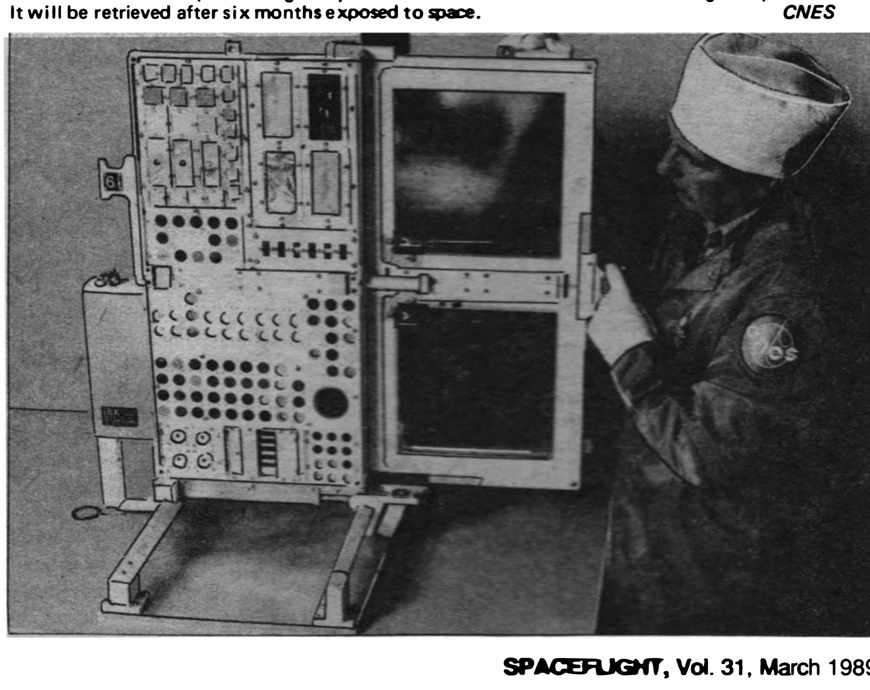
The deployable structure, in its container, was attached to the platform's deployable support arm. Plans called for the arm to be at an angle of 45 degrees with the capability of being raised to 90 degrees if the deployable structure had to be manually jettisoned.

The structure was attached by means of a translation and rotation movement along the axis of the system by the cosmonauts. The operation was videotaped by a camera nearby.

The final operation for the EVA was the actual deployment of the ERA. It consisted of 24 identical prismatic cells made from carbon fibre. Each of the cells had three parallel bars and 12 folding articulated bars with a diameter of 30mm and a thickness of 0.4mm.

When deployed, the structure was 1 metre high with a diameter of 4 metres. The deployment from the bundled configuration was expected to take just 4 seconds and would be videotaped. The structure carried accelerometers,

The Echantillons sample bearing rack, fixed to the exterior of the station during the spacewalk. It will be retrieved after six months exposed to space. *CNES*



temperature sensors and electrical cables to measure loads on it during and after deployment.

However, when Krikalev, from Mir's control panel, commanded the deployment the ERA remained tightly bundled. The cosmonauts applied vibration to the structure, to no avail.

With frustration setting in (one report said much swearing was heard), the Soviet and French engineers met to decide a course of action. Mir passed out of contact with the ground. It was decided that the structure would be cast off undeployed if it failed on the next attempt.

But when communications were restored, via the research ship Akademik Sergei Korolev, the cosmonauts reported that the ERA had deployed. It later emerged that Aleksandr Volkov had kicked the structure several times, against the orders of ground control. The French said the kick which freed ERA was worth FF50 million.

With the experiment accomplished, the structure was cast off. The men brought equipment back into Mir and closed the hatch after a 5 hour 57 minute long EVA, a new Soviet record.

Viktor Blagov, deputy flight controller, said that work was underway to find out why the structure did not deploy.

Later, Phillipe Coillard, director of France's Hermes programme, paid tribute to Volkov's "Courage and resourcefulness" during the EVA. The experience, and the flight of Cretien in general, was helping in the preparation of the Hermes project, the first flight of which is now scheduled for about 1997-1998.

Final Days in Orbit

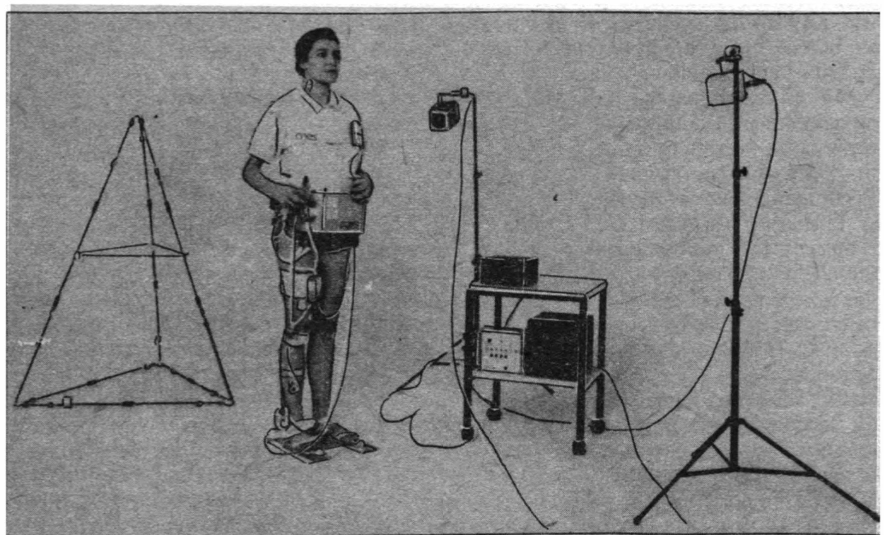
During the next few days Volkov and Cretien finished the final tasks linked to the EVA. Cretien took part in more medical experiments and the complex was oriented in space so that the Kvant module's X-ray telescopes could see the supernova.

Cretien performed two experiments with a model of a frictionless articulated solar panel arm which was being tested for use on future satellites. The experiment, called Amadeus, called for two sessions of unfolding the 28 kg model of the solar arm and for videotaping the results.

On December 14 the crews were involved in more experiments with the Physalie, Vinimal and Medilab equipment. Volkov and Cretien were thoroughly examined with the Mir's multi-functional Gamma medical installation. Titov and Manarov, their year-long flight drawing to a close, had further work-outs with the Chibis suit.

Later in the day the complex was linked up by TV channels to a studio of the French FR-3 station where a group of children from the "Astronaute" Club of Young Cosmonauts were waiting to ask questions of the cosmonauts.

Cretien told the children that after his EVA he was glad to report that he had quickly regained form. He also told them that the crew had taken pictures of the devastated regions of Armenia, where a massive earthquake had claimed many thousands of lives. Cretien said they had learned of the tragedy with "pain and sorrow."



The Physalie experiment. The complex equipment took 2.5 hours to assemble in the weightless environment of Mir. *CNES*

Early on December 15 the cosmonauts broadcast pictures of Dr Valeri Polyakov taking blood samples from Cretien as part of the Minilab experiment. During the day Titov and Manrov officially surpassed the record of Yuri Romanenko for the longest single space flight. He had been in space for 326 days 11 hours and 38 minutes. Titov and Manarov became the offical record holders when they passed 359 days 3 hours and 12 minutes, or 10 per cent more than Romanenko.

In the final few days of the joint flight the cosmonauts took more pictures of the earthquake zone in Armenia and Cretien completed his work with the medical equipment. Physalie and Vinimal were used again.

The resident crew continued their preparations for descent and also monitored how seeds of wheat and lentil were growing in their greenhouses on the walls of the station.

On December 19 the systems of the Soyuz TM-6 spacecraft were checked in preparation for the descent, due on December 21. Titov and Manarov would land with Cretien. The next day the Soviets said that the landing was planned for 0645 GMT on December 21.

During December 20 the cosmonauts stowed the results of the work they had done with photographic and cine films, video and magnetic tapes, spectrograms and biological objects being placed in the descent cabin.

Titov and Manarov conducted the final sessions with the Chibis suit under the watchful eye of Valeri Polyakov.

The Soviets announced that Soyuz TM-7 would be redocked on December 22. Volkov and Krikalev were checking that spacecraft out.

Return to Earth

At 0333 GMT on December 21 Soyuz TM-6 with Titov, Manrov and Certien aboard undocked from Mir's front docking unit. TV pictures showed it moving away from the complex. The landing time was now set at 0648. However, that did not happen. TASS announced a delay in the landing of three hours because of a "Disorder of ... automatic systems."

Viktor Blagov later explained that the fault had arisen due to the faulty interaction between some of the new computer software with the old package of programmes in the Soyuz's on-board computer.

He blamed the problem on a programme for protecting an infra-red sensor against interference. The sensor is responsible for orienting the Soyuz TM before retrofire, Blagov said. The new programme had been inserted after the problems with the landing of Soyuz TM-5 in September, with the Soviet and Afghan cosmonauts aboard.

At that time the TM-5's engines were to be fired as the spacecraft passed the terminator on Earth, but solar rays were falling at an angle of 90 degrees to the sensor's axis and caused the spacecraft to be oriented towards the Sun.

When the angle changed, the sensor reacted by ordering Soyuz to be oriented towards the Earth, but by that time the opportunity for retrofire on that pass had been missed.

The new safeguard programme had been developed to avoid similar situations in the future, Blagov said, but "as it was loaded into the computer and tested on the ground, the possibility of a computing breakdown like the one (which occurred) today was not foreseen.

"The computer signalled that its memory was overloaded, and cut out the landing programme. Then, after consulting ground control, the crew changed to a back-up programme," Blagov continued.

"The on-board computer system

responsible for descent (then) functioned without a hitch. Specialists will now have to adjust the programme taking into account today's problems," he concluded.

An American source notes that the landing date of December 21 was during a period of maximum orbital daylight so that there would be no sunrises or sunsets to confuse the infrared sensor.

The cosmonauts changed the programme in the computer memory at 0808 GMT and exactly an hour later fired the retro engine of the craft to begin the descent as the ship passed over the South Atlantic. Retrofire lasted 4 minutes 30 seconds.

Eight minutes after engine shutdown the Orbital Module was cast off (the module had been retained due to the experience of the Soyuz TM-5 problems) followed at 0933 by the engine section at an altitude of about 140 km.

The descent cabin continued its controlled desent with the use of aerodynamic lift. The cabin became enveloped in plasma and radio contact was lost between 145 to 80 km above Earth. The aerodynamic braking cut the speed to 200m/sec.

At 0944, at an altitude of 10 km the parachute container cover was cast off and the parachute system deployed the 1,000 square metre main chute. Contact was then established between the cabin and the helicopters of the search and rescue service. TV was later shown of the cabin under the parachute desending into a layer of thick cloud.

There were five helicopters carrying journalists but due to the low cloud ceiling (200 metres) the helicopters were told to return to Dzhezkazgan airport. Aleksei Leonov said that a large concentration of vehicles in one area in the conditions created by the low cloud and poor visibility could create a very dangerous situation. The search and rescue teams were coping well with a reserve plan with the landing site having shifted due to the delayed landing.

Soyuz-TM-6 touched down at 0957 GMT some 180 km south east of Dzhezkazgan. Initial reports from the landing site said that Titov had remarked to the rescuers "It has been a long time since I've been here - a whole year." From the controlled environment of Mir the cosmonauts alighted into a chilly minus 14 degrees below zero and a wind speed of six metres per second.

Titov and Manarov had been in space for 365 days 22 hours 39 minutes. Cretien for 24 days 18 hours 8 minutes.

The chief of the search and rescue service reported that the three men were in good health. Cretien was said to have a "wonderful" blood pressure of 120/70.

The cosmonauts were flown by helicopter to Dzhezkazgan and from there to Moscow - a 3.5 hour flight - where they landed at Star Town. The men were to readapt at the training facility rather than at Baikonur, as all previous cosmonauts had done because of an outbreak of hepatitis at the Cosmodrome. TV pictures of the men showed them to be happy and smiling.

The men received a message of congratulation from President Mitterand and were awarded high Soviet and French honours. The French awards were also made to the reserve crew.

Redocking Soyuz TM-7

At 0645 GMT on December 22 Soyuz TM-7, with Volkov, Krikalev and Polyakov inside, undocked from the Kvant port and backed away from the station. The station was commanded to rotate 180 degrees and, under Volkov's manual control, TM-7 was redocked with the front of the station at 0659. It was announced that a Progress ship would be launched on December 25.

Progress 39 was launched at 0312 on December 25 and docked at 0555 two days later with the Kvant port.

On December 25 the cosmonauts and the BBC made British television history when, during a christmas show hosted by Noel Edmonds, a live link-up was made between London and Mir. The three cosmonauts answered questions put to

French cosmonaut, Jean-Loup Cretien, is lifted from the Soyuz T-6 capsule by the recovery team. *Novosti*

them through an interpreter by Edmonds and showed examples of their food, a waste disposal container and the electronic organ left by Crętien.

Volkov also sent greetings to the people of Barnsley, the twin town of his home Gorlovka and showed a mascot - "Sam Barn" - given to him by the staff of the local newspaper in Barnsley.

Finally, Polyakov wished the viewers "A Happy New Year" in English.

For the Soviet space programme 1989 promises to be a very busy year indeed.

Cosmonauts Readapt to Earth

On January 11 TASS reported that Titov and Manarov had almost fully restored their weight, the volume of their muscular tissue and vestibular functions after their extended flight.

During the flight Titov lost almost 3 kg in weight whilst Manarov actually put on weight - almost 2 kg. (Cretien lost 900g during his shorter flight.)

Titov and Manarov developed partial muscular atrophy of the shins, a usual consequence of long-stay flight, the Soviets said. Immediate post-flight examinations showed that their shin volume had decreased by 20 per cent - a little more than Yuri Romanenko. Previously, the Soviet doctors had seen volumes diminish by 25 per cent in cosmonauts who had stayed for shorter periods in space than Romanenko. This was largely due to the loss of intramuscular fluid and not of muscular tissue. This also explains the rapid rehabilitation, Soviet experts said.

Dr Anatoli Grigoryev said that the data on the cosmonauts' bone tissues was still being processed but preliminary results showed that the calcium loss was not as significant as after several previous flights.

Immediately after touchdown, the two men suffered from minor changes in their vestibular function, which passed quickly, and from traditional changes in the water- and-salt metabolism which showed in a 5-6 per cent reduction of the potassium content of their blood.

The men were working to a programme of rehabilitation measures which included jogging, swimming and exercising with a variety of equipment. Grigoryev said that, from the fifth day after their landing, the two men had walked 3 to 4 kilometres and had swum 400 to 500 metres in the pool.

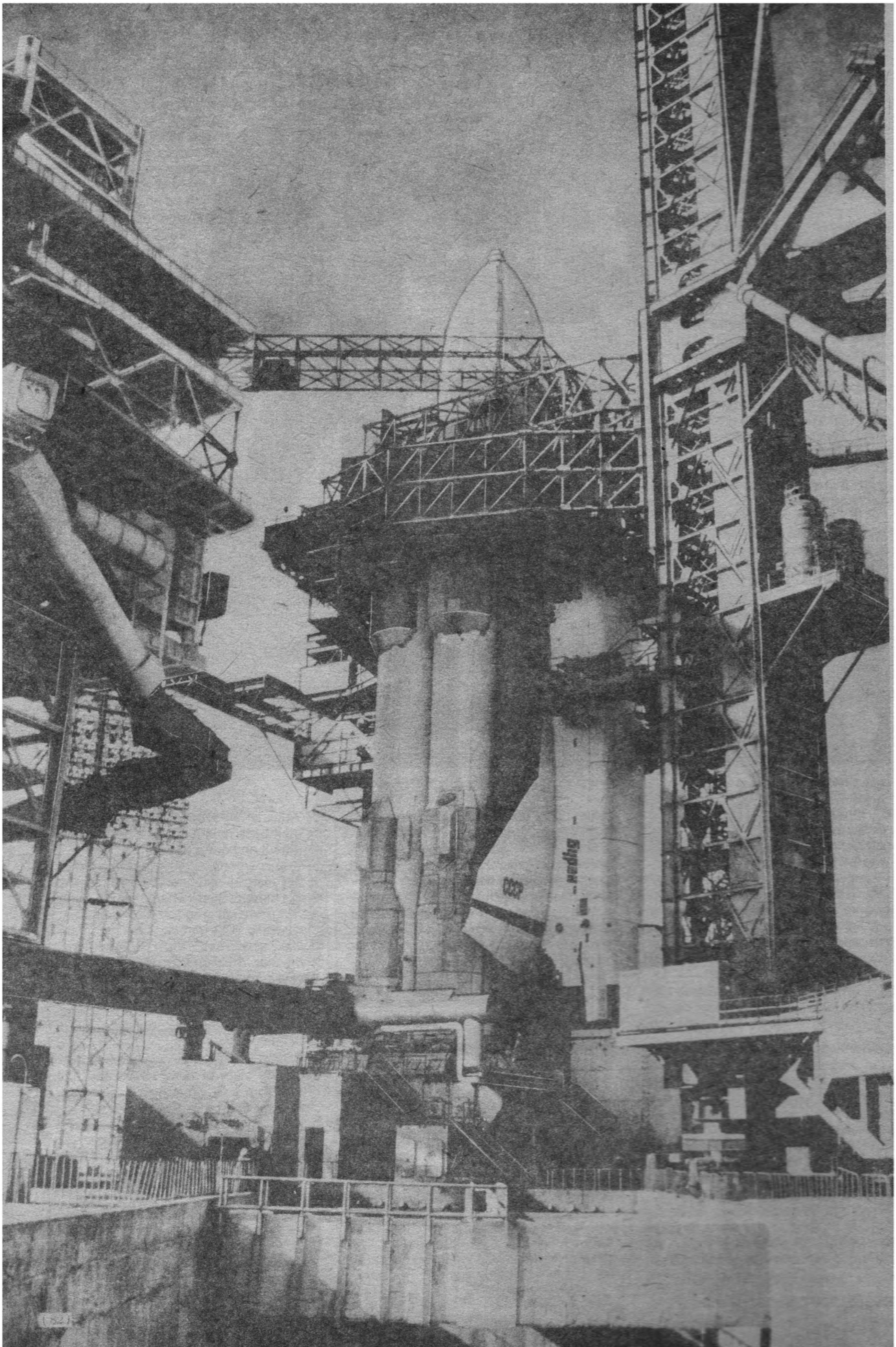
At this time they began intensive training of their back muscles, shins and thighs, for about an hour a day.

The cosmonauts went to the resort of Kislovodsk in mid-January to continue their readaptation where, along with walking, swimming and physical exercises, they would play games, take mountain walks and rest. Yuri Romanenko, Aleksandr Aleksandrov and Aleksandr Laveykin spent time at the resort in January and February 1988. It was anticipated that by the end of February 1989 Titov and Manarov would be fully restored to their pre-flight physical form.

"After this period we will again study in detail the state of bone tissue and the metabolism," Grigoryev said. "Medical control will also be exercised after this for a long time. We must be completely convinced that no unfavourable consequences were left by such a long flight."

Acknowledgements:

The author would like to thank Dr Gerald Skinner of the University of Birmingham, Andrew Salmon, the staff of the Centre National d'Etudes Spatiales and Theo Russell of the Novosti Press Ageny for their help in compiling the past two issues of the Mir Mission Report.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INTERNATIONAL SPACE REPORT

A monthly review of space news and events

Soviet Lunar Mission

The Soviet Union intends to launch a probe to the moon in 1992, according to Professor Yuri Surkov, Head of the Geochemistry and Analytic Chemistry Institute of the USSR Academy of Sciences. The project is titled Luna '92.

Surkov said previous missions to the moon had yielded an enormous amount of scientific information. "Now it is time to get down to the practical utilisation of the moon. This involves first and foremost, telephotography of the lunar surface, including the polar regions, with a resolving power of only a few metres. This is exactly what the Luna '92 and similar projects now on the drawing boards of the United States, Japan and the European Space Agency are intended for." He said.

According to Professor Surkov, the Soviet lunar spacecraft will carry a telecamera, gamma and X-ray spectrometers (to analyse the chemical composition of the lunar soil), an infrared spectrometer (for studying mineral composition), and a magmetometer (for gauging the exact parameters of the magnetic field).

"Apart from the purely explorative purposes, the Luna '92 project will allow us to test once more the equipment for Soviet Mars expeditions." Added Professor Garri Rogovsky of the Babakin Scientific Test Centre. "We intend to make use of the basic design of the Phobos automatic station and its principal systems and components, both for the Luna spacecraft and for subsequent Mars missions."

Phobos Arrives

The Soviet Phobos 2 probe has entered Mars orbit after a 200 day, 470 million km flight. The spacecraft will at first study Mars, then in April it will turn its attention on to the Martian moon Phobos.

Operations to bring Phobos 2 into Mars orbit began on January 23, when the probe's trajectory was corrected for its final approach to the Red Planet. Its braking thrusters fired at 3:55pm Moscow time, on January 29, placing the spacecraft in a 79,750x850km orbit, inclined 1 degree to the Martian equator, with a period of 76.5 hours.

The probe is to carry out a comprehensive survey of the surface, atmosphere, plasma and magnetic envelopes of the planet.

Buran Designers Meet the Press

The designers of the Energia/Buran combination have been speaking to the press about the Soviet Union's reusable space shuttle. The engineers gave an insight into this latest addition to the USSR's space fleet.

The chief designer of the Buran/Energia combination, Yuri Semenov, outlined planned missions for the Soviet shuttle in an interview with the Soviet national daily *Izvestia*.

"Work to develop a new-generation orbital complex to accommodate the heavy-lift booster, Energia, and the orbiter Buran will begin in the next decade."

Buran would "launch costly facilities fitted out with unique scientific instruments, for example large optical telescopes with sophisticated electronic equipment."

Semenov said that helping to construct in orbit a 450-tonne vehicle for Martian manned expedition is among the tasks to be performed by the Energia booster and the Buran reusable orbiter.

He added that the space shuttle could return unique space vehicles to Earth, for example the Salyut 7 space station, which was lifted to a higher orbit in 1986 to delay its reentry.

Semenov pointed out that, unlike the US shuttle, which carries its main engines on the orbiter, Buran only carries orbital manoeuvring engines. Energia delivers Buran to an orbit of about 150–160km, the orbiter then uses its engines to insert itself into the correct orbit.

The Soviet space shuttle, Buran, stands on the launch pad prior to its first flight. This is the first photograph to show the massive 100m main tower in position around Buran. *Novosti*

Semenov said, "to reach an orbit of 250km with a 30-tonne payload, Buran needs eight tonnes of [manoeuvring] fuel. With 14 tonnes of fuel, it can get as high as 450km with 27-tonne payload.

"If an orbit of 800–1,000km has to be reached, Buran can carry an extra 14 tonnes of fuel in supplementary tanks." He added.

Energia 'spin-offs' are being considered. Each of Energia's four strap-on boosters have a thrust of 800 tonnes and is capable of lifting 12 tonnes of payload to orbit. Semenov said the possibility is being studied to use them to launch a new supply spacecraft which will replace the Progress freighters currently in use. This would cut the cost of delivering one kilogramme of payload to orbit by a half.

The various abort modes of the Soviet Shuttle were outlined by the spacecraft designers. Semenov explained: "In the case of a threat to the crew already onboard the ship, there are provisions for their evacuation by slipways into a special bunker guaranteeing their safety. From the moment of the blast-off and in the active period of the lift-off, which means for about two minutes, two members of the crew can be catapulted out with their chairs, just as in ordinary aircraft. The only difference is that on Buran the special powered system will catapult the cosmonauts out to a safer distance of several hundred metres. I repeat that so far only two men can be catapulted out of the ship, but work in that direction is continuing.

"There is also the possibility of the booster rocket going out of control during the lift-off. In that case the orbiter will immediately separate from the booster and would land at one of the airfields along the flight route."

Gleb Lozino-Lozinsky, who was in charge of the development of the Buran orbiter, provided more information on the abort modes.

If one of the rocket's boosters fails, the spacecraft will reach a low orbit and return to Earth after circling once, Lozino-Lorinsky said.

Finally if two boosters fail, Energia would automatically perform a return manoeuvre – a loop with a radius of hundreds of kilometres – and then Buran will detach itself and land on a runway.

Vladimir Barman, chief designer of space launch complexes, said that when the two new launch pads were built at the Baikonur space port, provision was made for every emergency. The facilities at one pad will not be damaged even if there is an explosion at the other.

Besides the landing strip at Baikonur, two more runways are under construction in the vicinity of Simferopol in the Crimea and in the East of the Soviet Union to enable Buran to land from any orbit.

The space shuttle can also use an ordinary airfield if it has no other choice.

"All systems of the orbiter have an in-built redundancy factor," explained Vladimir Lapygin, the chief designer of the Energia/Buran control systems. "In my opinion, this is the main safeguard.

"It is impossible to guarantee absolute safety in such sophisticated systems. This is an axiom. This means all manned flights involved a certain degree of risk. The important task is to minimize that risk as much as possible, and the Buran designers have done their best to accomplish it. This is confirmed by the numerous pre-launch tests, in which the seats were occupied by live people: six cosmonauts headed by the experienced Igor Volk. It is still undecided who will be among the first Soviet pilots to go into orbit onboard Buran. In any case, their actions will be backed up by the automatic systems whose reliability was proved during the unmanned flight."

"US Space Leadership in Danger"—Says Fletcher

Dr James Fletcher, NASA Administrator has warned that the budget of the space agency is "as taut as possible" and "even a nick can mean organic rupture" of the US civil space programme. His words came a week after he unveiled NASA's $13.2 billion budget for the Fiscal Year (FY) 1990.

Speaking to the Explorers' Club in New York, he warned that the US space programme is vulnerable to serious dislocation by even small budget cuts.

He went on to say, the space station project had been subject to so much redesign and modification that "there is simply no room for further trimming, or shaping or cutting. We are either going to build it - and build it right - or not build it at all."

Dr James' Fletcher

NASA's FY 1990 budget request calls for an increase of $2.4 billion over FY 1989. Much of the increase will be spent on the build-up of the Space Shuttle flight rate, the development of an Advanced Solid Rocket Motor, and the development of Space Station Freedom. The Freedom project will receive $2.05 billion, an increase of $1.15 billion. The space station now accounts for over a third of NASA's Research and Development budget.

$341.8 million will be spent renovating and constructing facilities at NASA's field centres. Included in this amount is the $26 million required to convert the Orbiter Modification and Refurbishment Facility, at the Kennedy Space Center, into a third Orbiter Processing Facility bay. This will allow three orbiters to be prepared for launch simultaneously.

Fletcher appealed to the Bush Administration, Congress and the public, to support NASA's budget, which has yet to receive approval.

National Aeronautics and Space Administration FY 1990 BUDGET SUMMARY

(Millions of Dollars)

	FY 1989	FY 1990
RESEARCH AND DEVELOPMENT		
Space Station	900 0	2050.2
Space Transportation Capability Development		
Spacelab	88.6	98.9
Upper Stages	138.8	88.6
Engineering & Technical Base	155 4	189 8
Payload Operations & Support Equipment	64.7	81.1
Advanced Programs	52.7	48 7
Tethered Satellite System	26 4	19.9
Orbital Maneuvering Vehicle	73 0	107 0
Advanced Launch System	81.4	5.0
Space Science and Applications		
Physics and Astronomy		
Hubble Space Telescope Development	95.9	67.0
Gamma Ray Observatory Development	41 9	26 7
Advanced X-Ray Astrophysics Facility	16.0	44 0
Global Geospace Science	64.4	112 3
Payload and Instrument Development	81 7	71.4
Shuttle/Spacelab Payload Mission Management and Integration	69.7	86 1
Space Station Integrated Planning and Attached Payloads	8.0	23 0
Explorer Development	82 1	93.2
Mission Operation and Data Analysis	143 2	204 8
Research and Analysis	85.8	112.5
Suborbital Program	45 4	53 5
Life Sciences		
Human Space Flight and Systems Engineering	27 6	42.8
Space Biological Sciences	10 1	27 6
Research and Analysis	40.4	53.8
Planetary Exploration		
Galileo Development	73 4	17 4
Ulysses Development	10 3	14 5
Magellan Development	43.1	
Mars Observer	102.2	100 5
Comet Rendezvous Asteroid Flyby/Cassini		30.0
Mission Operations & Data Analysis	110 7	155 4
Research and Analysis	76.9	79 1
Space Applications		
Earth Sciences		
Upper Atmosphere Research Satellite	94 2	73 9
Ocean Topography Experiment	83 0	72 8
Scatterometer	10 6	13 8
Earth Science Payload Instrument Development	46.4	66.5
Airborne Science and Applications	23 0	19.7
Geodynamics	32.9	38 0
Missions Operations and Data Analysis	17.6	24 8
Research and Analysis	106 0	124 8
Materials Processing	75 6	92 7
Space Communications	92.2	18 6
Information Systems	19.9	34 1
Commercial Programs		
Technology Utilization	16.5	22.7
Commercial Use of Space	28.2	38 3
Aeronautical Research and Technology		
Research and Technology Base	315 6	335.7
Systems Technology Programs	88.6	127.1
Space Research and Technology		
Research and Technology Base	134.1	130 1
Civil Space Technology Initiative	121.8	144 5
Pathfinder Program	40.0	47.3
In-Space Flight Experiments		16.2
Transatmospheric Research and Technology	69.4	127 0
Safety, Reliability and Quality Assurance	22.4	23.3
University Space Science and Technology Academic Program	(22 3)	35.0
Tracking and Data Advanced Systems	18.8	19.9
SPACE FLIGHT, CONTROL AND DATA COMMUNICATIONS		
Shuttle Production and Capability Development		
Orbiter Operational Capability	281.8	237.0
Propulsion Systems	582.2	727 3
Launch and Mission Support	264.2	341 0
Space Shuttle Operations		
Flight Operations	685 7	772.6
Flight Hardware	1112.7	1236.5
Launch and Landing Operations	506 8	553 6
Expendable Launch Vehicles	85 5	169 5
Space and Ground Networks, Communications and Data Systems		
Space Network	433 9	582.3
Ground Network	228 1	269 6
Communications and Data Systems	233 3	250 2
TOTALS		
Research and Development	[illegible]	5751 6
Space Flight, Control and Data Communications	[illegible]	5139.6
Construction of Facilities	[illegible]	341.8
Research and Program Management	[illegible]	2032.2
Inspector General	[illegible]	8.8
TOTAL BUDGET	**[illegible]**	**13274.0**

OBITUARY

Valentin Glushko

We are sorry to record the death of Academician Valentin Glushko (aged 81), an outstanding Soviet scientist and rocket designer. Glushko was involved in the Soviet space programme since its conception. His most recent projects were the Mir space station and the Buran reusable space shuttle.

In the late 1920's Glushko began working on the development of electro-thermal jet engines and liquid propellant rocket motors. In the early 1930s he designed the first Soviet liquid fuel rocket engine.

Glushko was a close colleague of Sergei Korolev, the founder of the Soviet space programme, and in 1974 he took over Korolev's space working group.

During his career he was awarded numerous honours including the Hero of Socialist Labour twice and the Order of Lenin four times. An indication of Glushko's importance was his official obituary, signed by Mikhail Gorbachev, the members of the Politburo, prominent scientists, designers and cosmonauts.

Gorbachev, and other senior government and party figures stood in memory before Glushko's body, lying in state in the hall of the Soviet Army Central House. A funeral service was held at the Novodevichy Cemetry in Moscow.

More Deltas

The US Air Force has ordered the production of six more McDonnell Douglas Delta II rockets.

By placing the order, the Air Force exercised its last production option on an earlier contract. The original contract agreed upon in January 1987 called for seven Delta II rockets and contained two options for a total of 20 rockets. In February 1988, the Air Force exercised the first option for seven more rockets. Total contract value is approximately $680 million and includes start up costs, special studies and launch services.

The Delta II will be used primarily to boost the Air Force Navstar Global Positioning System (GPS) spacecraft into orbit. The GPS is a navigation satellite system the Air Force will use to provide "pinpoint" accuracy for users anywhere on the globe.

In addition to the Air Force business, McDonnell Douglas has received contracts for two Deltas and five Delta II's, which will be used to launch satellites for commercial and civilian purposes.

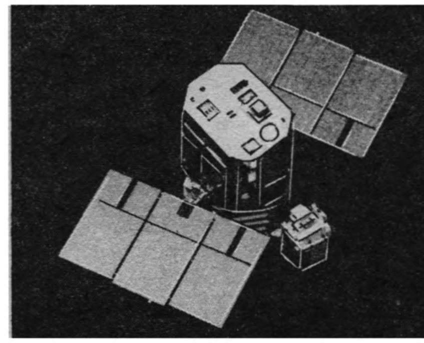
Solar Max Doomed

The Solar Maximum Mission Satellite, better known as 'Solar Max', has been sentenced to an early death by the very forces it was designed to study.

Launched in February 1980, Solar Max has been observing Sun spots, solar flares, the output of the Sun and has contributed towards the study of Supernova 1987A.

NASA scientists had hoped Solar Max would remain in orbit until late 1990 to early 1991. However, an intense burst of solar activity is due to start this year peaking in early 1990 - this will cause the Earth's atmosphere to expand, increasing air drag on the satellite. It is now believed this will cause Solar Max to tumble out of control by the end of the year, and reenter in early 1990.

In December 1980, Solar Max suffered electrical problems which were repaired during shuttle mission STS 41-C in 1984. It was hoped a second rescue mission could boost the satellite into a higher orbit, and carry out further repairs. Unfortunately it proved impossible to include the emergency rescue mission in the tight 1989 shuttle schedule.



Astronaut 'Pinky' Nelson approaches Solar Max, during the 1984 repair mission. *NASA*

SATELLITE DIGEST - 219

Robert D. Christy

Continued from the February 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.

[illegible]

Launched: 1020, 22 September 1988 from Plesetsk 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 18 days.
Orbit: 356 × 415 km, 92.30 min, 72.87 deg.

[illegible]

Launched: 1007*, 24 September 1988 from Vandenberg AFB by Atlas-E.
Spacecraft data: Roughly cylindrical body, approx 4 m long and 2 m diameter. Power is provided by a single solar panel at right angles to one end. The mass is 1710 kg.
Mission: Meteorological satellite in sun-synchronous orbit, returning cloud-cover pictures and other weather data.
Orbit: 849 × 865 km, 102.14 min, 98.91 deg.

[illegible]

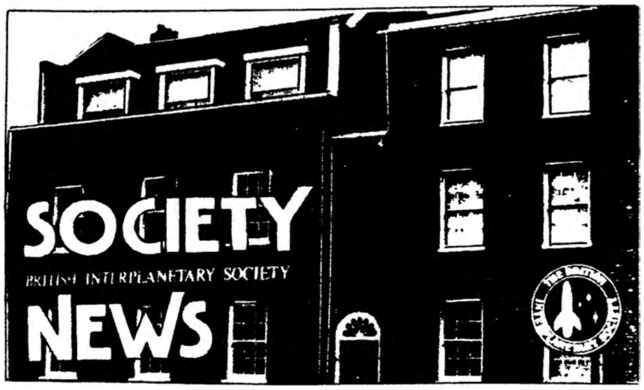
Launched: 0907, 29 September 1988 from Plesetsk by A–2–e.
Spacecraft data: Cylindrical body with a conical orbital adjustment motor section at one end. The opposite end of the vehicle carries communications aerials and a 'windmill' of six solar panels set in a plane at right angles to the main axis of the body. Stabilisation is by the use of momentum wheels. The length is about 4 m, the maximum diameter about 1.6 m, and the mass around 1800 kg.
Mission: Communications satellite providing telephone, telegraphic and television links through the 'Orbita' system both within the USSR and abroad.
Orbit: Initially 629 × 38924 km, 701.59 min, 62.86 deg, then raised to 628 × 39714 km, 717.51 min, 62.87 deg to ensure daily repeats of the ground track.

[illegible]

Launched: 1537*, 29 September 1988 from the Kennedy Space Centre.
Spacecraft data: Shuttle Orbiter 'Discovery'.
Mission: Carried crew of Hauck, Hilmers, Lounge, Nelson and Covey. A primary mission objective was to launch the third TDRS-C satellite (TDRS-B was lost aboard 'Challenger' in 1986), 'Discovery' landed at Edwards AFB at 1737, October 3 1988.
Orbit: 299 × 304 km, 90.36 min, 28.42 deg, then raised to 302 × 332 km, 90.68 min for launching TDRS 3.

[illegible]

Launched: 2150*, 29 September 1988 from the payload bay of 'Discovery' by IUS.
Spacecraft data: Hexagonal, box-shaped body, supporting a 'cross' consisting of two dish aerials and two solar panels. The span is about 17 m, and the mass 2225 kg.
Mission: Communications satellite for use in tracking other satellites in low orbit.
Orbit: Geosynchronous above 150 deg west longitude.



Council Convenes for 1989

The first council meeting of 1989 falls due shortly and we take this opportunity to record current Council Membership following new elections at the last Annual General Meeting. Current members are:

Mr. R.A. Buckland	Mr. A.T. Lawton
Mr. G.W. Childs	Dr. L.R. Shepherd
Mr. M.R. Fry	Prof. I.E. Smith
Dr. R. D. Gould	Mr. G.V.E. Thompson
Prof. G.V. Groves	Mr. C.R. Turner
Dr. R. Holdaway	Mr. G.M. Webb

Following our consitutional procedure, the Society's President and two Vice-Presidents, have to be elected annually so this event will be among the first business to be transacted.

£12,000 For HQ Extension

The Society's plans to build an extension over part of its courtyard to enable the Meetings Room and Library services to be extended received massive encouragement from the Will of the late James Hugo Ford, who was not only a Fellow of many years standing but one dedicated to supporting the Society's work.

The late Mr. Ford not only gave freely to assist the Society in the original acquisition of its premises but, by his Will, has enabled the Society to receive a gift of £12,000 from his Estate.

The Council has determined that this sum be placed in the funds being accumulated to enable the Extension Programme to go forward and thus provide a fitting tribute to the generosity of Mr. Ford which will be available to benefit all members.

The total accumulated to date in the Building Extension Fund has reached £62,000, which now enables the Council to undertake a realistic study of present-day costs and timescale requirements for the undertaking of this work.

At the outset, the Council divided its plans for the Headquarters building work into four main Phases with Phase 1 as emergency and essential work, Phase 2 as improvements and renovation to existing structure and Phase 3 as the Building Extension for which we are currently raising funds.

As members and visitors will know, we have now completed Phase 1 which includes a brand new roof on both buildings and a new-looking basement, where the heating, electrical and other services are housed.

Phase 2 has required both funding and planning permission but is well underway and provides the most visible evidence of the renovation taking place. The fact that No. 29 is a Grade II Listed Building means that improvements need to adhere to Local Government regulations, Building Inspection requirements, Fire Officer regulations and the like, so the resolution of these has inevitably imposed limitations on progress.

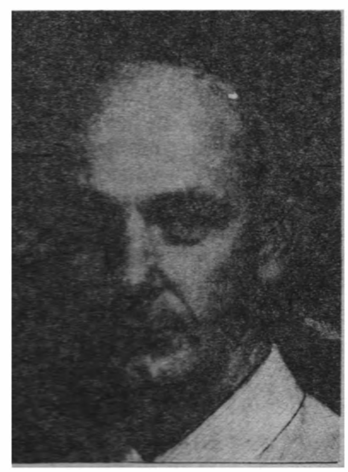
Much of the work now underway or completed also forms essential preliminaries to the Extension by providing better access. At the same time, various outlet pipes are being re-routed to improve working space. All this is additional to the essential repairs which began after the October 1987 storm when we took the opportunity, assisted by a grant from the English Heritage, to rebuild part of the frontage of No. 29 and to re-roof both properties completely.

Many members see the Society premises as more than purely functional offices and want the Society to possess an HQ which gives them both pride and pleasure.

In view of this, the Council has decided to hold a New Members' Evening to give members an opportunity to see the improvements made and to hear about the Society's work. Although the meeting is primarily for new members and a small number of Guests, an invitation is also being extended to longer-standing members, who may not have seen our HQ before and who would like to come along. Full details of the arrangements will be published shortly.

Dr. Richard Holdaway Joins BIS Council

The five Council nominees confirmed in office at the Society's 43rd Annual General Meeting (***Spaceflight***, November 1988, p.435) included one new Council member, Dr. Richard Holdaway, to whom a warm welcome is extended on taking office for the first time.



Dr. R. Holdaway

Dr. Holdaway has been Head of Space Systems Division, Rutherford Appleton Laboratory since 1986, with responsibility for the project management of many space programmes including ISAMS, ZEBRA and SPECTRUM-X. He is also responsible for astrodynamics research and development, including dynamics for orbit determination and prediction, as well as space electronics.

After graduating in Aeronautical and Astronautical Engineering at the University of Southampton in 1970, he worked as a design engineer on the environmental control system for the Harrier VTOL aircraft before returning to the University the following year to carry out research into the use of electric propulsion for spacecraft systems.

After gaining his Ph.D degree in 1974, he joined the Appleton Laboratory (later to become Rutherford Appleton Laboratory) and was Software Design Engineer for the Ariel VI X-ray satellite and Software Manager for both IRAS and the AMPTE satellite programs. In 1984–6 he was UK Ground System Manager for the Roentgen Satellite ROSAT

Among his other professional activities Dr Holdaway is Chairman of the BNSC Orbits Panel and a member of the Royal Society Space Geodesy Working Group

Joint BIS-IEE Meeting

'Electric Propulsion' is the subject of a colloquium on March 8, which the Society will be co-sponsoring with the Institution of Electrical Engineers. A previous joint meeting of our two organisations on Electric Propulsion took place in 1973 and the Society welcomes the opportunity to join forces again with the IEE in an important area of Space technology of common interest.

Much progress in developing the techniques of Electric Propulsion has been made over the intervening years and it can be taken as a sign of the times that the forthcoming meeting is to discuss the applications of Electric Propulsion and not the technology itself.

The Society's Representative at the meeting will be Dr. David G. Fearn of Space Department, Royal Aerospace Establishment, Farnborough, who has authored many contributions on ion thruster technology and applications in JBIS.

Dr John Becklake Elected to IAA

We congratulate Dr John Becklake on his recent election to Section IV of the International Academy of Astronautics. Dr Becklake is a Fellow of the Society and is the Chairman of the BIS History Working Group. His present historical research interests are on the history of British Rocketry.

In 1972 he joined the Science Museum in London as the Curator in charge of the Space Technology Collection and now heads the Museum's Department of Engineering while still retaining responsibility for Space Technology. He organized the first major gallery on Space Technology at the Science Museum which opened in 1977 and has since been responsible for the new Exploration of Space Exhibition which tells the story of the development of astronautics from the gunpowder rocket to the space station. A report of the opening of this Exhibition on October 21, 1986 appears in ***Spaceflight,*** December 1986, p.436.

Dr John Becklake examines the Congreve Rocket Troop diorama in the Exploration of Space Gallery at the Science Museum in London *Science Museum*

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
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.

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. (The 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. Admission for members only. Please apply to the Executive Secretary, enclosing a SAE.

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

Obituary

'Doc' Slater being presented with the Silver Medal of the Royal Aero Club by HRH The Prince of Wales in 1979

We much regret to record the death of Dr. Alan Edward Slater, M.A., M.R.C.S., L.R.C.P., a few weeks before his 93rd birthday.

'Doc' was born in 1894, and educated at Abbotsholme School, Cambridge University, and St. Thomas' Hospital. He obtained a Cambridge B.A. degree in Mathematics and Music (obtaining a 1st Class degree in Music), and then took up medicine as a more certain means of livelihood, qualifying as a medical practitioner in 1922 and joining the Fever Hospital Service of the L.G.C. in 1924.

Doc became the first British Glider Pilot to obtain a gliding certificate without previously flying aeroplanes. In 1933 he accepted a spare-time post as editor of *Sailplane and Glider* but this soon grew to such proportions that he had to give up his medical career in 1936 to start a new career in journalism. He returned to medicine during the war, this time with the L.C.C. Mental Hospitals Service.

Dr. Slater joined the Society in 1945 and became editor of the revived BIS Journal in 1946, but was forced to give it up after editing three issues owing to pressure of other work. He served on the BIS Council from 1946 to 1973.

In 1952 he gave the first of many of papers on Space Medicine to IAF Congresses, beginning with the likely physiological problems of weighlessness in space flight. A further paper in 1957 was concerned with the improbability of homo sapiens developing elsewhere in the Universe and, in 1958, he played a leading role in organising, on behalf of the Society, its first international symposium on Space Medicine.

MEETINGS DIARY

Society meetings, unless otherwise stated, are held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ. Meetings are restricted to Society members unless otherwise stated. Tickets should be applied for in good time by writing to the Executive Secretary at the above address enclosing an SAE. Subject to space being available members may also apply for a ticket for one guest.

March 1 1989, 7.00-8.30 p.m. Lecture

SOME INTERESTING SPACE PIONEERS

This lecture by Professor Ian Smith reviews the contribution made by a number of noted space pioneers known to the speaker.

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

8 March 1988, 2.00-5.00 pm Colloquium

ELECTRIC PROPULSION COLLOQUIUM

A meeting co-sponsored by the British Interplanetary Society and the Institution of Electrical Engineers The primary aim of the meeting is to discuss the applications of Electric Propulsion, not the technology itself

For more information please write to the Executive Secretary, 27/29 South Lambeth Road, London, SW8 1SZ

5 April 1989 7.00-8.30 p.m. Lecture

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

13 May 1989, 10.30 am Visit

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 Apr enclosing a stamped addressed envelope

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
Forms are available from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

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.

The Pegasus Launch Vehicle

Following the loss of the Space Shuttle Challenger, an intensive effort got underway to build up the United States' expendable booster capability for both Air Force and civil users. These boosters include the Atlas II, Delta II, Titan II, Titan IV and, on the horizon, the heavy lift Advanced Launch Vehicle and Shuttle-C. As part of this, work began on a small booster that would use a completely different profile. This is the Pegasus air-launched booster.

Air Launched Systems

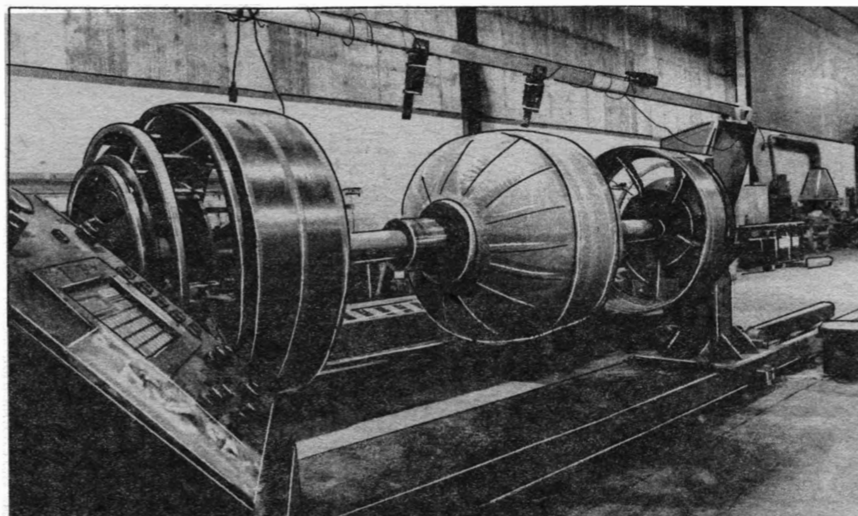
The idea of launching a satellite from a conventional aircraft is not new. In the early 1960s, the U.S. Navy undertook Project Hi Ho. This involved the launching of a small Caleb rocket from a McDonnell F–4 H Phantom. It was to test the feasibility of launching satellites and space probes from aircraft. Two test launches were made at the Pacific Missile Range in April and July 1962. The second rocket reached about 1,600 kilometers. [1]

More ambitious was a study of using the NB–52/X–15/Blue Scout as a partially reusable launcher. The X–15 would be launched in the normal way. As it climbed through 47,550 meters, the X–15 pilot would launch the Blue Scout. The missile was to be carried on the X–15's underside on a rack/fairing forward of the lower fin. The Blue Scout had three solid fuel stages – an ABL X–259 first stage, an AJ–10 second stage (both from the U.S. Air Force Blue Scout Junior) and small NOTS 100A third stage. [2] The project did not go beyond studies and the concept of an air-launched satellite fell out of favour.

This changed in 1986–87 with the start of the 'Defense Advanced Research Projects Agency (DARPA) "Lightsat" program. Rather than single, very large, expensive and long lived satellites such as the Big Bird and KH–11, the Lightsat envisioned using small, relatively cheap, but more numerous satellites. Work on the Pegasus began in early 1987 when Dr. Antonio L. Elias, chief engineer at Orbital Sciences Corporation (OSC), suggested the company look at a low-cost, air-launched booster. Development work began in April 1987 with the $40–45 million cost split between OSC and Hercules Corporation. In February 1988, DARPA issued a request for an air-launched booster. During the summer of 1988, a contract was finalized between OSC/Hercules and DARPA. This cleared the way for construction of the first Pegasus booster [3,4]

Pegasus

The Pegasus booster is 15 metres long, has a wingspan of 6.7 metres and weighs 18,144 kilograms. This is virtually the same as the North American X–15. It is not a coincidence – the Pegasus is designed to fit the NB–52B used to carry the X–15 two decades ago. X–15 test data was used during



The Pegasus launch vehicle under construction at Hercules Aerospace's facility in Utah. OSC

By Curtis Peebles

the Pegasus' early design as it was found both had similar low-speed release dynamics and separation trajectories.

The Pegasus has three Hercules solid fuel stages each 1.27 metres in diameter. The wings and fins are of graphite composite and are being built by Burt Rutan's Scaled Composites (which also built the Voyager round the world aircraft). Originally OSC looked at wingless boosters but found that adding a wing gave several advantages. First was that at a 4:1 supersonic lift over drag ratio, the wing's lift exceeded the performance of the rocket alone. A wing also means a flatter trajectory can be flown which lessens stress and control problems. A delta wing was used to fit under the NB–52's wing. The design of Pegasus was done using NASA's Cray 2 and Cray XMP supercomputers rather than in a wind tunnel.

The advantages of an air-launched booster are several – the airplane's velocity adds 1–2% to the rocket's performance. More important the air pressure at launch altitude is 25% that at sea level. This allows a better rocket nozzle design as it does not have to be compromised for operation from sea level up to a near vacuum. The high altitude launch means lower dynamic pressure as well as lower structural and thermal stresses. Taken together this means a 10–15% reduction in the total velocity it would have to achieve for a given payload.

The result is the Pegasus can put a 272 kilogram payload into a 463 kilometre polar orbit or 408 kilograms into a 463 kilometre equatorial orbit. The satellite is fitted into a payload shroud 1.83 metres long with a 1.17 metre diameter. This large volume and payload weight will allow various satellite designs including ones with large optical systems. [5]

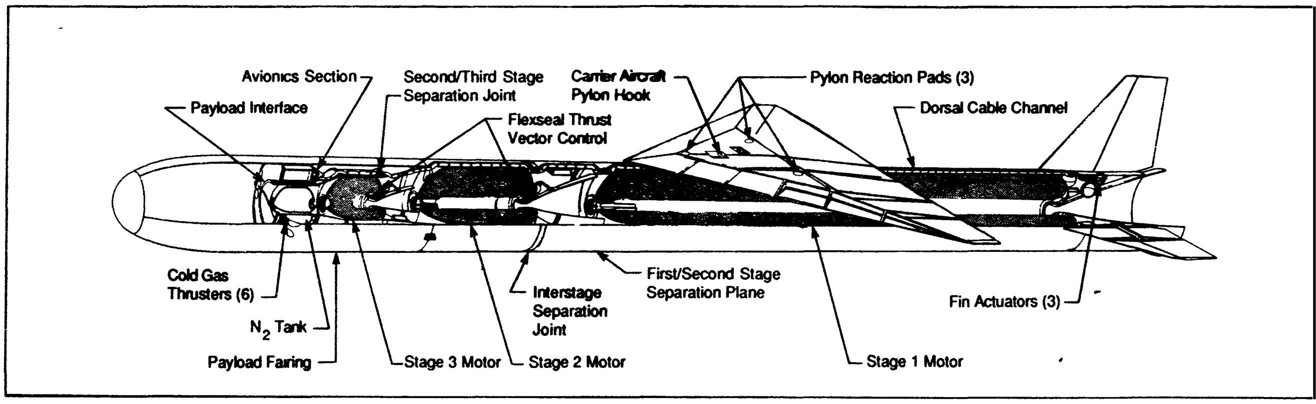
Pegasus Launch Profile

The launch profile of the Pegasus is unlike that of a conventional booster. Its three stages are assembled horizontally on a truck trailer by a 6 man team. Preparation will take about two weeks once the project is fully underway. To protect the booster, assembly is made in an air conditioned building. As additional protection, a tented area on the trailer provides a clean room environment for the satellite until the payload shroud is in place.

The complete Pegasus will be brought out to the NB–52B launch aircraft about two hours before takeoff. Joining the two vehicles will take about an hour. Once linked, the NB–52 will provide 28 volt D.C. electrical power and the Pegasus will be controlled by the aircraft's mission computer. Check out will be through the Pegasus' own telemetry system.

The NB–52 will takeoff from Dryden Flight Research Facility at Edwards

The Pegasus climbs towards orbit. Its NB-52 carrier aircraft is visible below the launcher.



Continued from p.89

AFB. The Aircraft Commander, for the first few launches, is planned to be Col. Gordon Fullerton, ex-Shuttle astronaut and chief B–52 pilot at Dryden. The drop point will be off Vandenberg AFB. The Control Panel Operator had a PC-sized mission computer, a telemetry receiver and a reference inertial measurement unit for updating the Pegasus' guidance system. The operator also downloads mission data into the guidance system and turns on the pilot's drop switch. If the drop has to be halted, the Control Panel Operator carries data for alternate drop points. This adds flexibility. It is the pilot who makes the final drop decision for the Pegasus. [6]

At the drop, the NB–52 is flying at Mach 0.8 and 12,000 metres. The Pegasus free falls for 5 seconds and 100 metres below the NB–52 before the first stage ignites. The Pegasus makes a 2.5 G pull up under the control of the three tail fins. The first stage has a maximum thrust of 59,422 kilograms. As first stage burn out nears, the wings began to char. First stage burn out comes at 81.3 seconds after the drop at an altitude of 63,390 metres and a speed of Mach 8.7. Separation and a 5.8 second coast follows. A cold gas reaction control system stabilizes the booster. The second stage then ignites 87.1 seconds into the flight. At 121 seconds, the payload shroud separates. The second stage burns for 71.4 seconds with a maximum thrust of 14,061 kilograms. Guidance control for the second and third stagesis by a gimballed nozzle. At 158.5 seconds, when the Pegasus is at 167 kilometres and a speed of 5,425 metres per second, the second stage burns out. The Pegasus then coasts for 310.6 seconds. At 469 seconds into the flight, when the third stage reaches an altitude of 459 kilometres, it ignites for a 64.3 second burn to accelerate the payload into orbit. The cold gas jets, used to stabilize the booster during coasts, now spin up the satellite before release. [7,8]

Plans and Prospects

In the summer of 1988, it was planned the first Pegasus launch would be made in July 1989. The payload would be a DARPA built package of several small store and dump communication satellites. The second launch, carrying a military satellite, would be made in October. The third launch would follow in December 1989 with a NASA space science payload. [9] In late 1988, this plan changed. The first launch's payload was now to be a NASA instrument package to measure wing and body data. The goal of the flight is a final test of the launcher before risking a costly payload. If all goes well the second flight will carry the multiple satellites. [10] The first 15 or so Pegasus launches will be made using NASA's NB–52B. In late 1990, OSC hopes to shift to a heavy transport as launch aircraft. Not surprising, given the NB–52 will, by that time, be almost 40 years old and have made over 450 drops (including 199 X–15 flights). Edwards AFB is seen as the only base for the foreseeable future.

OSC and Hercules believe 16–18 launches over 2 to 2.5 years will be needed to reach the break even point. The launch rate is projected to be 10–12 launches per year. They believe a viable launch service can be based on as few as 5–6 per year. A Pegasus launch is estimated to cost $10 million. (The NB–52 cost $30,000 per hour and a launch takes four hours). The small assembly crew, the sealing of electronics, thrusters and other critical systems, so they do not need a clean room, and a lack of back up systems (except for the destruct system) are all intended to keep costs down. The estimate is a Pegasus launch will cost half that of a conventional booster. [11]

Among the prospective satellites for Pegasus are, in addition to the Lightsats, communications satellites, remote sensing, materials processing, geolocation and certification of electronics for space flight. These could be both U.S. and international. Another possibility is acquiring data for the National Aero Space Plane. Pegasus could carry a 680 kilogram data payload. The early Pegasus flights will be instrumented for NASP data. [12]

Once past the initial flights, Pegasus will then have to find a part of the commercial launch services market. OSC believes there is a broad enough market for Pegasus to thrive. If one segment does not develop as anticipated, it will not threaten the whole. Still there are uncertainties – the difficulties of an advanced commercial project, possible technical problems, changes in space policy by the incoming Bush administration or renewed questions about the Lightsat programme (which achieves low costs at the price of reduced capabilities).

Whatever the final outcome, Pegasus is a unique project. It is a booster developed through private funding that uses an unconventional launch profile to achieve low cost and flexibility. Pegasus can also be seen as the historical continuation of such experimental aircraft as the X–1, D–558 II, X–2 and X–15. All used air-launching as the first step to ever higher speeds and altitudes. Pegasus would carry that tradition into orbit.

References:

1. Paul B.Stares, *The Militarization of Space U.S. Policy, 1945–1984*, (Ithaca· Cornell University Press, 1985), 110, 111.
2. Ben Guenther, Jay Miller and Terry Panopalis, *North American X–15/X–15A–2*, (Arlington Aerofax Inc, 1985), 27, 61.
3. Craig Covault, "Commercial Winged Booster To Launch Satellites From B–52", *Aviation Week & Space Technology*, (June 6, 1988): 16
4. John R Stodden, "Orbital Sciences Charts Rapid Growth With Reduced Risk for Pegasus", *Aviation Week & Space Technology*, (June 27, 1988): 51.
5. Craig Covault, "Commercial Winged Booster To Launch Satellites From B–52", *Aviation Week & Space Technology*, (June 6, 1888) 14, 16.
6. Stanley W. Kandebo, "Pegasus Development Stresses Design Simplicity, Limited Testing", *Aviation Week & Space Technology*, (June 27, 1988) 49
7. Craig Covault, "Commercial Winged Booster To Launch Satellites from B–52", *Aviation Week & Space Technology*, (June 6, 1988) 16.
8. Tim Furniss, "Pegasus Winged Workhorse", *Flight International*, (13 August 1988) 30, 31
9. Craig Covault, "Commercial Winged Booster To Launch Satellites From B–52", *Aviation Week & Space Technology*, (June 6, 1988)· 14–16.
10. "DARPA Changes Pegasus Payload To Reduce First Flight Risks" *Aviation Week & Space Technology*, (November 21 1988) 24
11. John R. Stodden, "Orbital Sciences Charts Rapid Growth With Reduced Risk for Pegasus Investment", *Aviation Week & Space Technology* (June 27, 1988): 52.
12. Craig Covault, "Commercial Winged Booster To Launch Satellites From B–52", *Aviation Week & Space Technology*, June 6, 1988). 14–16.

Acknowledgement

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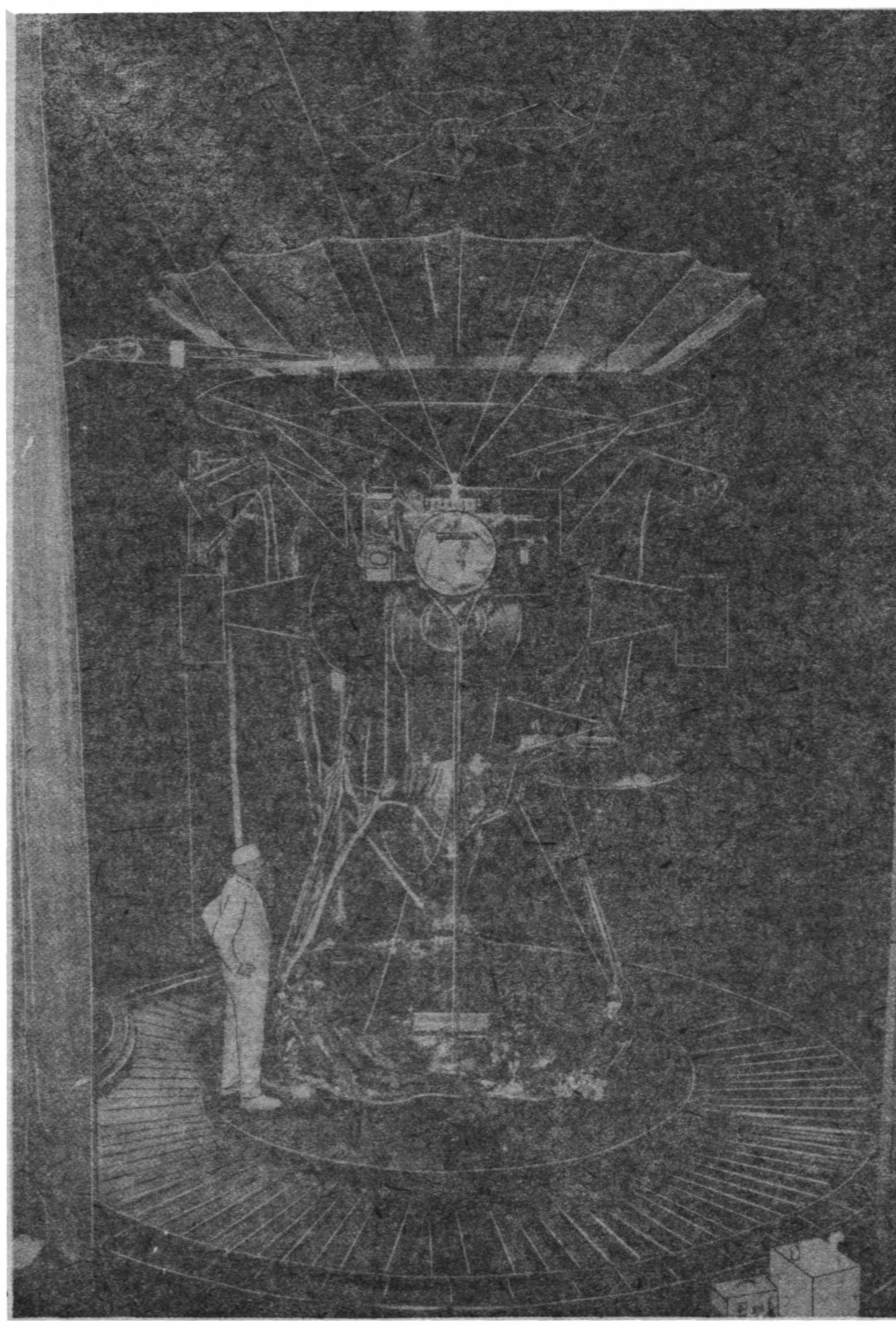
Galileo at Venus

The launch period for the Galileo mission to Jupiter opens on October 8, 1989, and the spacecraft will arrive at Jupiter on December 7, 1995. However, prior to arrival at Jupiter, six encounters with solar-system bodies are planned: Venus (Feb. 1990), Earth/Moon (Dec. 1990), asteroid Gaspra (Oct. 1991), and Earth/Moon (Dec. 1992). A seventh, with asteroid Ida (Aug. 1993), is also an option if the Gaspra results indicate the required expenditure of propellant is justified. The three planetary encounters are scheduled in order to give Galileo gravity assists which will send it to Jupiter. Prior to the Challenger accident in 1986, the powerful Centaur rocket, serving as an upper stage for the Shuttle, would have enabled the spacecraft to cruise directly to Jupiter in about two years. After cancellation for safety reasons of the combination of Shuttle with Centaur, mission designers at JPL created this tour of the inner solar system, substituting planetary energy to cover the shortfall in chemical energy.

Galileo's flyby of cloud-covered Venus, at an altitude of 15,000 km, provides a scientific bonus which complements the Magellan mission to that planet (April 1989 launch and August 1990 arrival); the Magellan orbiter will primarily map the Venusian surface with a synthetic aperture radar while Galileo's payload is suited for atmospheric studies and investigations of fields and particles phenomena.

The scientific investigations planned for the February 1990 visit of Galileo to Venus have been parcelled into three categories: first time, collaborative and corroborative. The first category is self explanatory. The second, a scientific collaboration, will be undertaken between Galileo and NASA's Pioneer Venus Orbiter, launched in 1978, which is still actively engaged in Venusian research. The



The Galileo spacecraft is subjected to realistic environmental conditions in JPL's space simulator prior to its scheduled October 1989 launch. *NASA/JPL*

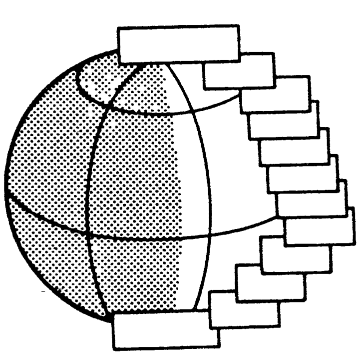
third refers to observations which relate to investigations carried out by previous spacecraft at Venus.

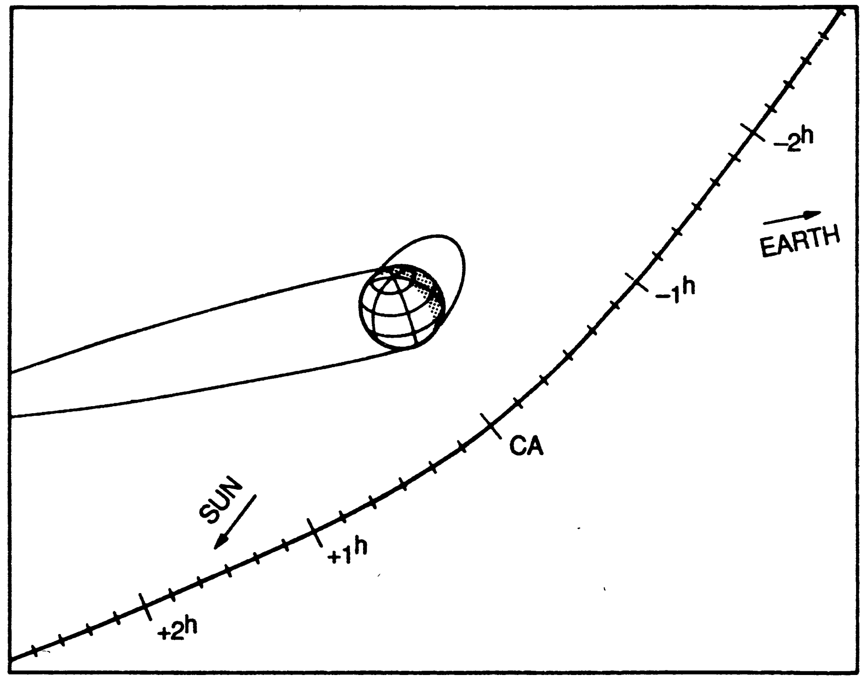
One of the first-time scientific objectives is to map, in the infrared, features and motions in and below the cloud deck on the dark side of Venus. Observations from Earth have revealed areas of surprising brightness variations on the dark side of Venus in the spectral range of 1.5 to 2.5 microns. (A micron is one millionth of a meter and the wavelength of visible light lies between 0.4 and 0.7 microns. Electromagnetic waves of a few microns are said to constitute the "near infrared," that is, infrared radiation near to the visible region.) These observations should yield information concerning atmospheric circulation and cloud properties and may establish correlations with features on the surface of the planet. The investigation will employ Galileo's Near-Infrared Mapping Spectrometer (NIMS).

A second objective in the category of first-time science at Venus is to track atmospheric features (convection cells, eddies, etc.) moving in the midlatitudes and equatorial regions. Temporal variability at very short time scales will be determined while observing the features from Venusian morning to afternoon. The observations will be carried out with the spacecraft's camera — formally designated The Solid-State Imaging (SSI) subsystem. The NIMS will also participate in this scientific objective by hotspot coverage on the dark side of the disk.

Previous U.S. and Soviet missions to Venus have made measurements that indicate the possibility of lightning on Venus, but no strikes have ever been imaged. Science planners are computing the probability of observing lightning, based upon the number of SSI images which could be taken and the presumptive frequency of the phenomenon. The outcome will determine whether or not the optical detection of lightning is worth attempting at Venus.

One of Galileo's planned investigations at Venus employs a series of scans of the planetary limb with the spacecraft's Near-Infrared Mapping Spectrometer (NIMS) *NASA/JPL*





Although the prime mission of Galileo is exploration of the Jovian system, the spacecraft will fly past Venus in February 1990 with the opportunity of conducting valuable scientific investigations. (The longer elongated zone at Venus represents a region, in the plane of the trajectory, where Earth would be occulted by Venus, the shorter zone shows the area of solar occultation.) *NASA/JPL*

Finally, in the category of first-time science, the NIMS will be used to conduct a program of spectroscopic measurements in the middle and deep atmosphere and to map the airglow phenomenon (at 1.27 microns and due to the recombination of molecular oxygen) which has been observed from Earth but not by previous space missions.

The durable Pioneer Venus Orbiter (Pioneer 12), managed by NASA's Ames Research Center, has been unlocking the secrets of Venus for over a decade. During Galileo's flyby, the two spacecraft will collaborate in achieving several scientific objectives: global (atmospheric) feature tracking, investigations of the mechanism of auroral excitation, magnetic-field measurements, and studies of particles and waves in the magnetosphere. In addition to the NIMS and SSI, Galileo's ultraviolet spectrometer and photopolarimeter will participate in the program of joint measurements along with several fields and particles instruments.

Venus has been a prime target for planetary scientists since the early days of space exploration — the Mariner 2 flyby of Venus in 1962 was JPL's first successful interplanetary mission — and numerous lines of investigation have been initiated with regard to the second planet. Galileo will contribute to this reservoir of research by corroborating and refining results in several areas including the energy budget of the planet (see the December edition of this column for similar studies for the outer planets); spatial variability of water, sulphuric acid, and sulphur dioxide in and above the clouds; planetary limb studies; nightglow in the ultraviolet; and cloud-top temperatures.

Dr. James A. Dunne is the chief of Galileo's Science Requirements and Operations Planning (SROP) team and is working with investigators on the Project Science Group and project engineers to formulate in detail the scientific plan at Venus.

The principal constraint on the development of this plan, according to Dunne, is the limited amount of space available on the spacecraft's tape recorder for the storage of observational data. Galileo's high-gain antenna must remain furled to protect it from thermal damage while in the inner solar system, and real-time communications must utilize one of two low-gain antennas. At the time of the Venus flyby, 1200 bits per second can be pumped to Earth through the low-gain antenna, and this will be devoted to engineering telemetry. Hence, scientific observations of Venus must be recorded on the spacecraft's tape recorder and played back many months later when Galileo draws closer to Earth.

The tape recorder has four tracks. One will be reserved for recording key engineering data, such as generated during spacecraft manoeuvres, to assist in the later analysis of any anomalies that might arise. The remaining three tracks will store the scientific data from Venus encounter with two tracks devoted to the category of first-time science.

The Venus encounter will span the period of one day prior to closest

approach to three days after that event. Normally, a planetary encounter poses severe problems for science planners in their attempt to fit all desired observations into a conflict-free timeline. But Dunne said the tape-recorder constraint is so severe that it restricts the allowable number of observations to the point that interleaving them in the time domain is relatively easy.

The encounter of Galileo with Venus is a bonus accruing from the long trek to Jupiter, but it is, of course, secondary to the primary mission of Jovian exploration. In recognition of this fact, two separate command sequences will be prepared for the period of time which includes the Venus flyby. The first will include scientific activities, as described above, while the second will only contain engineering activities conducive to the maintenance of the spacecraft in interplanetary cruise; the Mission Director will decide which sequence is to be uplinked to Galileo based upon an evaluation of the state of affairs in early 1990.

That Galileo has the opportunity to make unique contributions to Venusian science is a turn of events that would have seemed inconceivable just a few years ago.

German Space Operations Centre

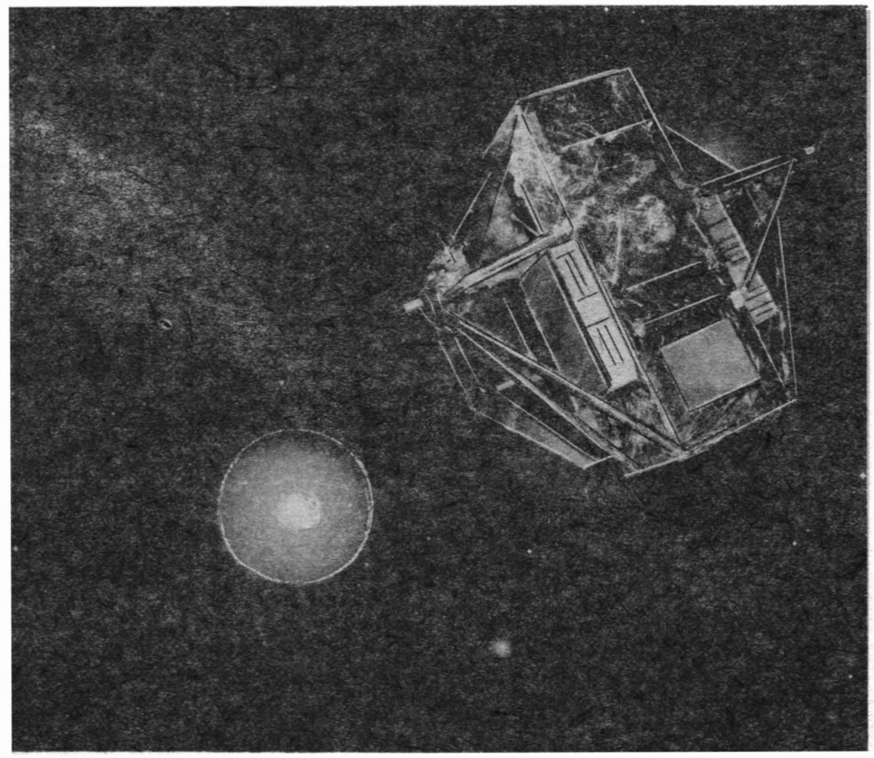
Driving through the Bavarian countryside on a sunny afternoon in early October furnishes a setting of great beauty, with the trees starting to colour and, nearing Munich, the white heads of distant Alps visible on the skyline. My destination was the German Space Operations Centre (GSOC), which is located in Oberpfaffenhofen about 30 km west of Munich. The 300-person staff of GSOC is contained within a larger DFVLR (Die Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt) facility of approximately 1000 people. DFVLR is the national space agency for Germany and has five field centres with headquarters in Cologne. Roughly one half of the German space budget is invested in national activities, and the other half supports projects of the European Space Agency (ESA).

The sunlight was especially welcome since I had come from a period of rain while visiting the European Space Operations Center (ESOC; see January's column) 300 km to the north, in Darmstadt.

The Director of GSOC is Dr. Franz Schlude, whose organization chart lists seven Divisions. The primary purpose of my visit was to confer with Hubertus Wanke, head of the Mission Operations Division for Unmanned Projects, which includes scientific spacecraft and communications satellites.

GSOC was established in 1968 and has supported a number of missions including Helios (two spacecraft in heliocentric orbit), the German-French Symphonie communications satellites, and AMPTE. Starting in the mid 1970s, there was a pause in the flow of new operational opportunities, but Spacelab and Galileo support have helped bridge the gap.

Currently, the only missions in flight are the Indian Remote Sensing satellite, IRS–1A, for which GSOC comprises the European node, and the damaged TV-SAT 1, which is used primarily for training purposes.



The celestial sphere will be surveyed in the X-ray and extreme ultraviolet regions of the electromagnetic spectrum by ROSAT. This astronomical satellite is scheduled for a 1990 launch and will be operated from the German Space Operations Center (GSOC) at Oberpfaffenhofen *Dornier*

The menu of future missions is as substantial and varied as the legendary cuisine of the region. (Necessary digression: hot Weisswurst from a stand in Munich's Viktualienmarkt is a gastronomic joy.) Geostationary satellites are TV-SAT 2 (1989), DFS 1 and 2 (Deutsche Fernmelde Satelliten) for the Bundespost (1989), and four communications satellites for Eutelsat (starting in 1990). Scientific Earth satellites are represented by IRS–1A and ROSAT (Röntgen satellite, 1990), and interplanetary operations are achieved through support of NASA's Galileo flight to Jupiter, which is scheduled for a 1989 launch.

The principal support to Galileo consists of receiving telemetry from the fields and particles experiments during the cruise to Jupiter. This tracking will begin once the spacecraft leaves the inner solar system (where it will receive a gravity assist from Venus), and the high-gain antenna is unfurled. Five passes per week are scheduled, using GSOC's station at nearby Weilheim. (The Weilheim station possesses two 15m antennas, S-band, and one 30m dish, X-band and S-band. The 30m antenna will be used for Galileo tracking.) In addition to capturing this scientific data during cruise, GSOC will merge the Weilheim portion with similar data gathered by NASA's Deep Space Network and distribute the resulting Experiment Data Records to investigators. Commands can also be sent to the Galileo spacecraft from the Weilheim station at the request of the control team at JPL.

Plans for manned space flight operations are quite extensive. The "D2" and "D3" Spacelab missions are scheduled for 1991 and 1993, respectively, while Columbus, the European component of the international Free-

dom Space Station, will be operated later in the 1990s.

My interest focused on ROSAT, and Fritz Guckenbiehl, the Mission Operations Manager, described the basic structure of the mission (see the August 1988 issue of *JBIS* for three technical papers on ROSAT). The satellite will conduct a six-month survey of the celestial sphere in the X-ray and extreme ultraviolet regions of the electromagnetic spectrum.

A feature of mission planning which may represent an important trend in operations in Europe and within NASA (the 1992 Mars Observer is a case in point) is the provision for remote scientific operation ("telescience") of the ROSAT scientific instruments from the Max Planck Institute in Garching. The scientists are responsible for generation of command files for the two instruments — an X-ray telescope and a wide-field camera for the extreme ultraviolet — and will deliver them to the GSOC control centre via data lines. The files can then be transmitted to the appropriate location in the data system of the spacecraft. Engineering control of the spacecraft, such as pointing commands and downlink of data to the tracking station, is retained as a function at the Oberpfaffenhofen site.

The integrated sequence of commands that ROSAT will receive from the ground will result from a blend of these scientific and engineering activities. Receiving inputs from scientific investigators as to what astronomical targets are desired for observation, the Mission Timeline Generator program at the GSOC control center will formulate an observing plan consistent with constraints such as interference from the Earth, Sun, and Moon. The computer program will utilize observer-supplied priorities to assist in construction of the observing schedule. Approach to optimization of the observing plan will be achieved by rerunning the Mission Timeline Generator until a satisfactory conclusion is achieved.

The actual sequence of time-tagged commands for ROSAT will be produced by another piece of software which will draw upon the mission plan and the above-mentioned instrument-control files supplied from scientific investigators at Garching (e.g., an instrument-calibration sequence). Guckenbiehl said that a sequence would usually be loaded onboard to guide activities for the next 24 hours, but, when possible, a 48-hour sequence would be uplinked to the spacecraft. Three years of orbital operations are planned.

Launch and early operations for a spacecraft are conducted from the Main Control Room. After commencement of the routine phase, the project migrates to a dedicated control room to be operated by a small staff, with experts on-call for anomalistic situations. I asked Herbert Wusten (who is the Flight Operations Manager for GSOC support of Project Galileo) whether they had considered using a multimission team for spacecraft control (JPL is pondering the same question). Indeed, they have discussed the multimission option but, so far, have concluded that conflicts during periods of intense activity and possible confusion between differing spacecraft properties rule in favour of the dedicated-control concept.

With its Spacelab experience, GSOC is slated to play a major role in manned-space flight operations in Europe. The Columbus programme consists of the Attached Pressurized Module (APM), the Man-Tended Free Flyer (MTFF) and the Polar Platform. The APM will be controlled from the U.S. with GSOC providing operations coordination of European experiments and serving as a single point of contact in Europe. With regard to the MTFF, however, control will be vested at GSOC, and a large Manned Space-Laboratories Control Center will be constructed for MTFF and APM support.

Lothar Bierling and Jürgen Fein briefed me on the range of activities planned for Columbus. Three modes of MTFF operation are envisaged: (1) automatic (analogous to the ROSAT task — generate a timeline, then produce a sequence), (2) teleoperated, and (3) crew supported. Generally, the MTFF would operate without human presence for six months, followed by a servicing visit by astronauts for about one week. Coordination of operations would revert to ESOC at Darmstadt during combined operations of more than one Columbus element, such as approach of the planned European spaceplane Hermes to the MTFF for servicing, but control of the elements would remain in the relevant control centres.

Perseverance has paid dividends for GSOC. Maintenance and steady development of capabilities have put them on the threshold of a period of strong growth as the tempo of European space activities increases.

SETI and the Supernova

The search for extraterrestrial intelligence (SETI) is an enterprise which derives considerable impetus from the fact that either outcome would be of absorbing interest. While logic's law of the excluded middle guarantees either the existence of intelligent extraterrestrials or the fact of our existence as the unique thinking substance of the universe, there is, unfortunately, no guaranteed method for rapidly resolving this dichotomy. The most common method employed in SETI is scanning for electromagnetic signals which could be interpreted to have been sent by intelligent extraterrestrials, and several such searches have been conducted since Frank Drake's pioneering effort — Project Ozma — in 1960.

The difficulties facing a practitioner of SETI trace back to two root problems: (1) the immense volume and variety of cosmic signals that must be sifted in the hunt for a glimmer of intelligent representation, and (2) the intended reference (meaning) that such a representation would contain.

A large number of proposed methods for coping with these problems have emerged in the past few decades. A popular approach is to assume radio waves are a likely carrier of incoming signals and search Sun-like stars for radio emissions. This strategy helps to narrow the size of the event space that must be searched, and a further contraction is achieved by emphasizing inspection of radio wavelengths in the neighborhood of the 21cm line emitted by interstellar hydrogen. This neighbourhood has been dubbed "the water hole" due to symbolic associations of the resident interstellar chemical species with the chemistry of water, a compound so important to terrestrial life. In addition to advantages relative to both of the root problems of SETI, the water hole confers the technical benefit of being located in a region of minimum background noise in the radio spectrum. (The book *Communication with Extraterrestrial Intelligence (CETI)*, MIT Press, 1973, edited by Carl Sagan, treats the water hole and other aspects of "classical" SETI with insight.)

The NASA SETI programme, begun in 1983, is addressing the "volume and meaning" problems through construction of a balanced search strategy which employs both an all-sky survey over a broad range of frequencies and a more focused and sensitive search in selected, preferential domains. The programme is reviewed in the April 1986 edition of this column.

Although one can readily understand the difficulty of sorting through large amounts of data, the second problem, recognizing and interpreting a SETI datum when it is presented, is not as easy to appreciate. In an attempt to enhance this appreciation, three examples will be given of the vice of subjectivity and the way in which it con-

stricts our views of the wide world and its potential inhabitants.

We commonly view bacteria as single-celled organisms. Writing in the June 1988 *Scientific American*, J. A. Shapiro describes complex multicellular structures and functions associated with certain bacterial colonies. He claims that our view of these creatures as unicellular persists because of our subjective focus on their role as agents of disease.

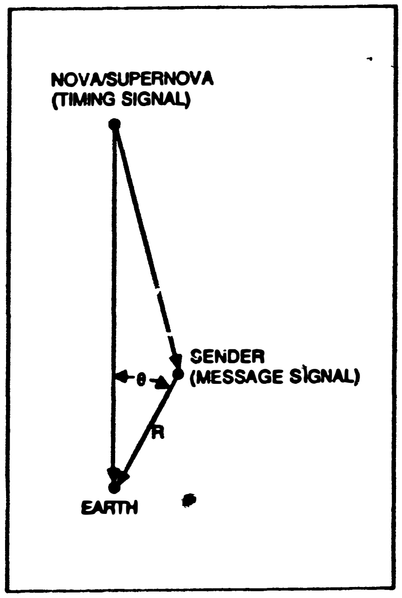
A second, more complex example can be developed through considering Dr. Paul D. MacLean's theory of the triune structure to the human brain. MacLean, Chief of the Laboratory of Brain Evolution and Behaviour, National Institute of Mental Health, has elaborated an anatomical and functional view of our brain which identifies three components: an old reptilian-based formation, a more recent mammalian "limbic system", and the most evolutionarily recent contributions of the neocortex. The two older components are not only a part of our neural machinery but also possess their own, unique, subjective viewpoints. According to MacLean, the reptilian brain is a factor in mass hysteria and mob violence and "behaves as though it were neurosis-bound by an ancestral superego," while the limbic system "might be likened to a primitive television screen giving the mammal a better picture for adapting to its internal and external environment". (See p. 12 of MacLean's *A Triune Concept of the Brain and Behaviour*, U. of Toronto Press, 1973.)

The theory, as it stands, provides a biological complement to psychological analyses (like those of Freud) of the individual unconscious and once more demonstrates how difficult it is to recognize the stranger in our midst. Continuing to mine the same vein and taking a cue from MacLean's finding that the limbic system has access to substantial information, including visual, about the external world, might · ε not presume the possibility of interaction between the limbic systems *per se* of different humans?

The idea of a "Limbic Society" with its own practices and institutions as a shadowy presence coexisting with our human civilization seems fanciful and even a bit eerie, but it might supply the physical setting for Carl Jung's (1875–1961) notion of the "collective unconscious." Consider that the familiar mechanisms of human interpersonal communication are not directly neocortex-to-neocortex but require passage through intervening systems of organic and inorganic material in a most complicated manner. Could not interlimbic communication similarly prosper?

From the perspective of the Limbic Society, the community of our upper-brain faculties would not, we hypothesize, be recognized as such. Instead, it would constitute a set of constraints and rules — laws of nature — to be accommodated in the best way possible, e.g., Freud's theory of the coding of dream material to evade upper-brain censorship. The basis for this assertion is that our higher constructions would lie beyond the ken of the limbic system (which is nonverbal), and it would only be feasible to reduce perceived regularities to rules. In short, the Limbic Society might recognize no higher form of life inhabiting its world, barring a successful search for extralimbic intelligence!

The two preceding examples, bacterial colonies and my postulation of the prob-



The occurrence of a bright nova or a supernova furnishes a timing pulse that can serve to synchronize sending and receiving activities for an interstellar message. The message is sent when "Sender" first observes the celestial explosion, and then "Receiver" tries to detect the message $R(1-\cos\theta)$ years after observing the explosion at Earth (R is the distance in light years from Earth to Sender, and the distance to the nova or supernova need not be known provided it is large compared to R).

NASA/JPL

lematic Limbic Society, have dealt with entities below us in the evolutionary chain. Dr. James Lovelock began to speculate on planetary life during his stint at JPL as a scientist for the Viking expedition to Mars, a project primarily devoted to the search for extraterrestrial life. Since then, Lovelock has developed and championed the hypothesis that the Earth, taken as a whole, is a living organism: the Gaia hypothesis (Gaia was the Greek goddess of the Earth). But he does not claim a human-like consciousness for Gaia.

The Gaia hypothesis rests upon what Lovelock asserts is purposive behaviour of the Earth in maintaining the existence of the biosphere in the face of great adversity. He claims, for example, that the stability of the temperature of the atmosphere over thousands of millions of years could not have been achieved by a simple physicochemical system's reactions. The evidence is skilfully marshalled in his latest book, *The Ages of Gaia* (W.W. Norton, 1988).

As in the case of the Limbic Society, we are not concerned so much with the truth of Gaia as with the deficiencies it illustrates in our cognitive faculties; Gaia, for this purpose, is a thought experiment — a stimulus to the imagination — that puts us in the analogous position of a limbic system trying to comprehend a complex environmental entity. In other words, the Gaia concept presents a possible instance of an epistemological limit; if Gaia were true, could we expect ever to know that fact? Would it be more advanced than us? Less advanced? Not comparable?

In February 1987, a naked-eye supernova was observed in the Large Magellanic Cloud and was the brightest supernova to be observed since 1604. (See the September 1988 "Space at JPL".) The employment of astronomical explosions in SETI was analyzed in my December 1977 paper in *Icarus*. In brief, explosions, novae or supernovae, can serve as celestial clocks (albeit with one tick and no tock) to synchronize the communcation efforts of sender (the extraterrestrial for the case of greatest interest) and receiver (us). The clock principle states that the sender transmits a message upon observing the celestial explosion. We can then calculate how much later than *our* observation of the explosion the message would arrive. The calculation only depends upon the speed of light and the relative geometry of sender, Earth, and exploding star.

Just as the water-hole convention narrows the wavelength domain to be searched, the clock convention narrows the time domain, when a clock is available. The bright nova in Cygnus in 1975 furnished the material for construction of a celestial clock, and some observational opportunities were discussed in the July/August 1986 edition of this column.

The theory is equally applicable to the 1987 supernova, and, applying the simple calculations prescribed in my *Icarus* paper to the nearby Sun-like stars Tau Ceti and Epsilon Eridani, it is found that the prime observing time for signals from the former ranges from June 1993 through January 1994, while the latter's range is November 1992 through February 1993. A span of time is given in each case because of uncertainties in the distances of these two stars (the calculation is relatively insensitive to the exact distance of the supernova). For further candidate stars, the SETI practitioner is advised to utilize W. Gliese's *Catalogue of Nearby Stars* (1969 — but a new edition is in preparation). The stars Tau Ceti and Epsilon Eridani are fabled in SETI lore and, in fact, were the two examined by Drake in 1960.

The clock convention (like the water-hole convention) addresses the two root problems of SETI: reducing the volume of data to be gathered and establishing a common occasion of reference for sender and receiver.

The reduction in the time domain that must be searched for a signal is easily calculated if we assume that a supernova occurs in the galactic neighborhood about once every 100 years. Ratioing this time period to the above-mentioned (uncertainty) time ranges yields a reduction factor of about 150 for Tau Ceti and 300 for Epsilon Eridani.

The preceding discussion on epistemology indicated that organisms of greatly differing capabilities probably do not share cognitive domains to any appreciable extent. The idea behind a convention like the clock principle is to throw the burden of insight onto the more advanced entity — presumably sender in this application — and hope that it guesses exploding stars are objects of temporal significance to planetary dwellers at our stage of evolution. We would be hard pressed to guess what might attract the attention of Gaia (with its slow time scale) or its ilk.

The goal of SETI is, of course, contact with intelligent life beyond our planet. We do not know when such an event might come to pass, if ever, but the literature of the subject shows steady progress in our grasp of methodology. An important by-product of SETI, with or without "first contact," appears to be insights we gain concerning human nature and its place in the cosmos.

V27 **MISSION REPORT**

Ariane 4 Goes Commercial

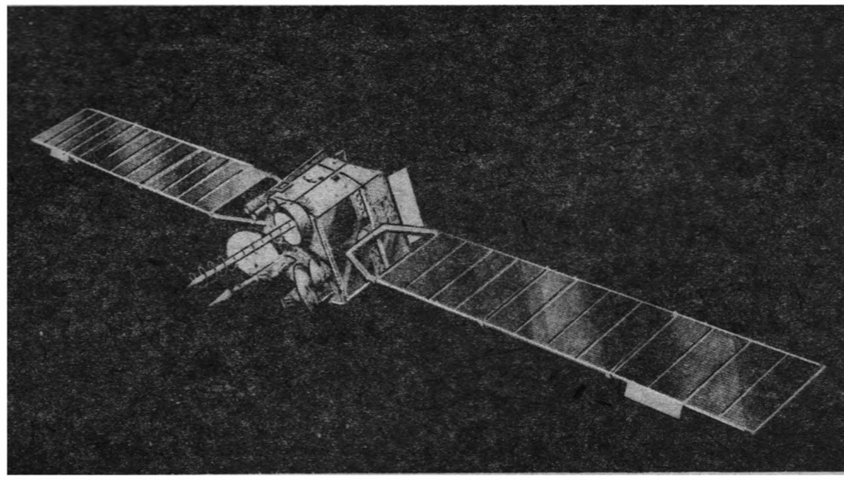
The first commercial Ariane 4 blasted off from the Guiana Space Centre carrying the Skynet 4 and Astra satellites. The satellites were successfully injected into a Geostationary Transfer Orbit (GTO) less than 18 minutes after launch. This is the second flight for Europe's most powerful launcher, the Ariane 4. The vehicle was first tested in June 1988 (*Spaceflight*, August 1988, p.304).

The Ariane 4 was launched from pad ELA 2 at Kourou on December 11, 1988 at 00:33:38 GMT. The Ariane 4 was equipped with two solid and two liquid strap-on boosters (an Ariane 44LP). The launch was threatened by bad weather, but the storm clouds cleared and the countdown went ahead. A launch the previous night had to be aborted when problems with the third stage engine sensors were detected.

Provisional parameters calculated for the injection into GTO were:

Perigee: 202 (+/−1)km for 199.8km intended
Apogee: 36,200 (+/−100)km for 36,010km intended
Inclination: 7.06 (+/−0.05) degrees for 7.00 degrees intended.

Frederic d'Allest, Arianespace Chairman, declared. "Arianespace is especially proud tonight to have launched successfully and simultaneously one satellite for the UK Ministry of Defence as well as the first private European satellite for the 'Société Européenne des Satellites' of Luxembourg. For Arianspace this represents the inauguration of commercial services with the new generation of Ariane 4 launcher. Flight 27 is also the seventh launch in 1988 and establishes a new record launch of 16 satellites into precise Geostationary Transfer Orbit in the past 15 months."



An artist's impression of the British Ministry of Defence communications satellite, Skynet 4.
BAe

Skynet 4B

Skynet was built by the Space and Communications Division of British Aerospace, with Marconi Space Systems responsible for the communications package.

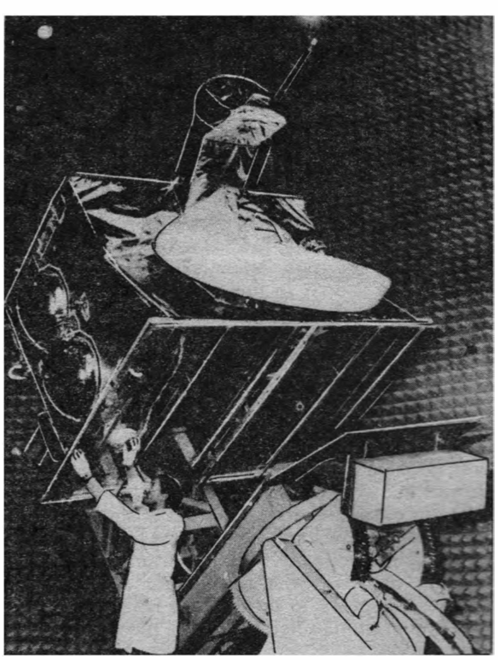
Once in position, at 1 degree West, the spacecraft will provide the UK's armed forces with a radio relay in space with greatly increased strategic and tactical communications and improved anti-jamming capacity. Skynet's antennae provide a variety of footprints ranging from spot to global coverage.

The Skynet 4 system consists of the satellites, or space segment, and the ground segment, which is composed of various fixed and transportable ground station on land and at sea. The system will provide communications between these stations on the SHF band for surface vessels and land stations. Communications to submarines will be by UHF. The satellites will be monitored and controlled from the main control centre in the UK using X-band and S-band transmissions.

Skynet 4 was originally scheduled and designed for launch aboard the US Space Shuttle, which would have also carried the first Britain in space. The disruption to the shuttle schedule caused by the Challenger accident resulted in the modification of the spacecraft for the launch by Ariane 4.

Skynet 4 is the first dedicated military payload to be launched by Ariane. The second Skynet 4 is scheduled for launch by Titan 3 in August 1989 and the third for launch by Ariane 4 in May 1990.

Astra 1A



The Astra satellite belongs to the Société Européene des Satellites (SES), a private company incorporated in Luxembourg.

Astra is to be located in geostationary orbit at 19.2 degrees East. It has 16 operational transponders, each of which retransmits a television channel, and six spare or redundant transponders. These spares provide for an in orbit back-up for Astra's television channels.

Each transponder on Astra has 45W of power output. The satellite has been designed so that its footprint, the geographical area within which signals can be received, is shaped to cover the areas with the highest consumer purchasing power of Western Europe. In the area of Astra coverage in which the television signal has a power of 52dbW it will be possible for a television viewer to install a parabolic reception antenna (dish) as small as 60cm in diameter, and a tuner attached to an existing television set, to receive high quality television signals. Viewers outside this area will have to use progressively larger dishes.

The Astra 1A satellite during pre-flight tests.
Arianespace

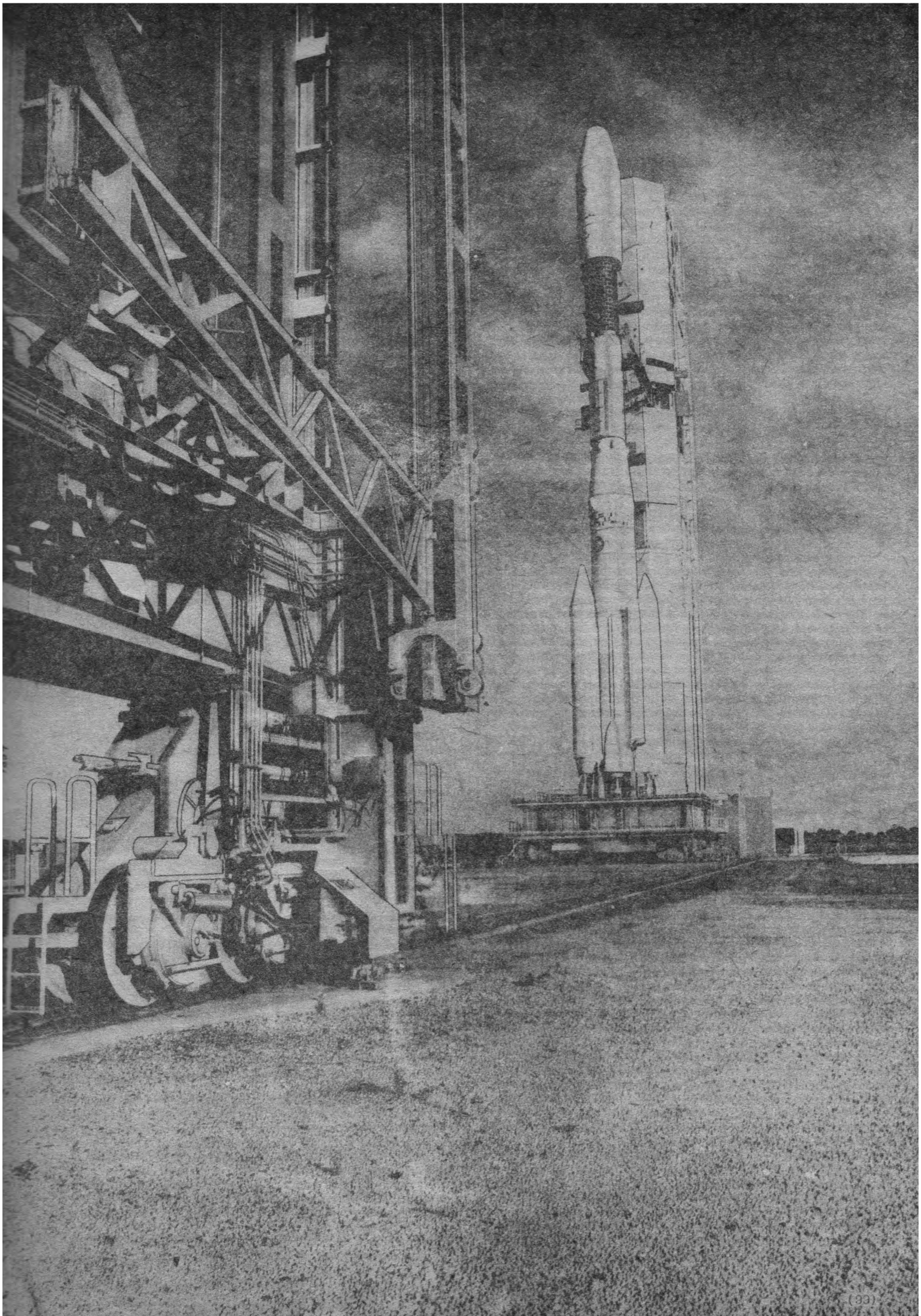
Ariane V28 Success

Ariane V28 was launched on January 28, at 01:21 (GMT); the tenth successive flight since September 1987.

The Ariane 2 blasted off from launch pad ELA-2 at the Guiana Space Centre, Kourou. 16 minutes later the launcher placed the 15th, and final, Intelsat V communications satellite into a Geostationary Transfer Orbit. The satellite can handle 15,000 simultaneous telephone calls and two colour television channels. In September an Ariane 4 will launch the first Intelsat VI.

The next launch is scheduled for February 28. An Ariane 4 is to orbit the Japanese communications satellite, JC-SAT 1 and the European Meteosat (MOP) 1.

Ariane V27 stands poised for launch at the Guiana Space Centre, Kourou.
Arianespace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BOOK NOTICES

Schirra's Space

W.M. Schirra Jr, with R.N. Billings, Gazelle Book Services Ltd. Falcon House, Queen Square, Lancaster, LA1 1RN, 1988. 227pp, £12.50

The history of space research in the US has been absorbing, if not sometimes controversial, from the earliest days and reached a fever of excitement with the manned Apollo flights to the Moon.

This book is the autobiography of the only astronaut who participated in all three pioneering manned space programmes, i.e. Mercury, Gemini and Apollo. It takes us almost into the inner sanctum of the US space programmes, to learn at first hand about the intense competition which took place at every stage of the process as well as the rigorous training which each astronaut had to undergo and thus provides a chronicle of an important era in space history by a major participant.

The co-writer named on the cover is a professional writer who has already "ghosted" other personal stories about American astronauts and their wives.

Introduction to the Space Environment

T.F. Tascione, Orbit Book Co. Inc., P O Box 9542, Melbourne, FL 32902-9542, U.S.A., 1988, 116pp, $34.50.

Our understanding of the near-Earth space environment has grown rapidly over the last twenty years or so as a result of the detailed measurements returned by increasingly sophisticated orbiting satellites. This book summarises complicated, and sometimes conflicting, theories that have been derived from such measurements and presents them in a clear and readable fashion.

The book is organised into 10 main chapters which review plasmaphysics and solar physics, the formation and dynamics of the solar wind and interplanetary magnetic fields, the structure and origin of the geomagnetic field and its interaction with the solar wind. An understanding of the structure of the neutral atmosphere is basic to understanding the atmosphere, for neutral winds are very important in determinging the dynamics of the lower ionosphere. Further discussion on the interaction between the ionosphere and magnetosphere follows, concluded by final chapters which look at relevant ground-based and space-based systems.

The Harlow-Shapley Symposium on Globular Cluster Systems in Galaxies

J.E. Grindlay & A.G. Davis Philip. D. Reidel Publishing Co., PO Box 989 3300 AZ Dordrecht, The Netherlands. 1988. 751pp, £85.00

This volume is intended to highlight the large-scale properties of globular clusters during their formation and evolution in galaxies. It reviews some of the recent spectacular progress and prospects for the future study of globular clusters, whether in our own or in external galaxies and looks forward to the prospects for further discoveries which will emerge with the use of the Hubble Space Telescope.

The book is in honour of Harlow-Shapley, an astronomer who first noted the concentration of globular clusters in the sky in 1915 and which, by 1917, had enabled him to locate the position of our solar system far from the gala tic centre. Actually, the attempt to produce a three-dimensional model of the Milky Way goes back much further, and to a most unlikely origin viz. William Stukeley, who proposed to Isaac Newton on one occasion that the Sun and the brightest stars of the night sky made up what we would today term a globular cluster, surrounded by a gap outside of which lay the other stars of the Milky Way in the form of a flattened ring. Stukeley's remarkable suggestion is recorded only in his memoirs so, unlike the work of Harlow-Shapley, it had no effect on the subsequent history of astronomy.

Much of the book records the remarkable advances in observations made possible with CCD detectors and the ready availability and use, nowadays, of desk top computers to help with both data analysis and theoretical modelling. Specific topics deal with the discovery of what appears to be a correlation between cluster metallicity and the slope of the luminosity function of its stars as well as comprehensive studies of the globular clusters in the Magellanic Clouds, M 31 and Local Group Galaxies. The evolution of globular clusters past their stage of core collapse and the possibility for re-expansion and tidal disruption are also considered, with the disruption aspect expanded to include tidal shocks in the galactic disc and encounter with giant molecular clouds.

Space Nuclear Power Systems 1986

M.S. El-Genk & M.D. Hoover, Orbit Book Co. Inc., P O Box 9542, Melbourne, FL 32902-9542, U.S.A., 1987, 482pp.

This volume, reproducing 45 papers, is based on a meeting held in Albuquerque, USA in January 1986, the object of which was to summarise the current state of knowledge of nuclear power systems and to provide a forum where the most recent findings could be presented. The text is, therefore, very wide ranging. It discusses the possibility of using nuclear power to open new vistas in space exploration as well as examining the power requirements for a number of proposed future missions. Safety, of course, is a critical issue and one which is also considered, particularly to avoid a repetition of the sort of re-entry problems which have provided such adverse publicity in recent years.

Much of the volume is concerned with the characteristics of space nuclear power reactors, i.e. problems of designing, simulating and testing as well as thermal management in space. Progress in the development of energy conversion systems, including the analysis of transient behaviour and the development of fuel cells, is also considered.

The question of materials technology for such things as superconductors and insulators and the suitability and performance of various refractory alloys for use in a space reactor environment is crucial. Expert systems for developing space power supplies and the user-interface are analysed.

Radiation damage is a problem which might prove acute, hence the inclusion of an examination of mechanisms for dealing with breakdowns, including ground-based reactor testing.

Large Space Structures: Dynamics & Control

Eds: S.N. Atlun & A.K. Amos. Springer-Verlag GmbH & Co KG, Heidelberger Platz 3. Postfach. D-1000 Berlin 33, Germany, 1988, 363pp Hard Cover DM 148.

The aim of this monograph is to summarise the present state-of-the-art as it applies to the technologies of the dynamics and control of large space structures.

Considerable activity on a world-wide scale has developed over the last decade in getting to grips with the need to establish a suitable technical base for such systems. Work has ranged from systems concept studies and laboratory experiments to preliminary flight experiments The objectives have been to establish the interaction between large space structures and the space environment. e.g. as regards durability of materials and devices. assembly and repair operations and the dynamic behaviour of the structures themselves.

It is this last area which provides the prime basis for this book, with its clear emphasis on basic analytical experimental methods

Among the main themes considered are the development of models for beam-like and plate-like lattice space structures and the resulting problems of dynamics and control. This latter includes such matters as vibration, friction between contacting surfaces and how non-linear dynamic motion may be controlled with the use of active and/or passive mechanisms.

A Catalogue of Southern Peculiar Galaxies and Associations

H.C. Arp, B.F. Madore & W.E. Roberton, Cambridge University Press, The Edinburgh Building. Shaftesbury Road, Cambridge, CB2 2RU, England, 1987, 2 Vols £80.00)

Galaxies do not exist in total isolation. They interact with their environments and modify their surroundings through nuclear activity, galactic winds. tidal encounters and collisions. Although not necessarily continuous phenomena. the effect of all these factors on the long-term evolution of galaxies must undoubtedly be significant. The galaxies we see today are the accumulated result of both quiescent and catastrophic evolution.

The purpose of this catalogue is to highlight the most spectacular phases of such evolution. and possibly galactic formation, by attempting to identify and to set out in basic form how all these activities have or are being manifested.

It is not enough to catalogue individual galaxies: the identification of galactic-associations is also important and here the UK wide-field Schmidt Telescopes in Australia have come into their own by providing a new perspective, unavailable earlier. in making pairs, triples and clusters of galaxies immediately apparent besides, incidentally, making whole sky surveys possible.

The matenal thus available has been used as the source for compiling, for references purposes. this detailed catalogue of all the interesting

galaxies and of most striking (apparent) association of galaxies detected in the Southern sky.

Volume I is largely tabular in character. Following a short introduction, it lists and describes each galaxy in turn, indicating its position, apparent appearance and the relevant identifying photographic plate.

Volume II consists almost solely of photographs. These provide representative examples of galaxies falling within the various categories adopted for the Vol.I classification scheme. Naturally, the largest and most spectacular examples have been included but so have many others to show a morphological transition and continuing progression towards later categories.

All the Galaxies listed deviate significantly from equilibrium forms and show disturbances in the form of jets, distortions in shape or the existence of bridging material The cause, in most cases, seems to be small near-by galaxies which either cause the distortion or which, themselves, are being distorted.The classification scheme adopted is really empirical. It has been made simply from a visual inspection on the presently-available plates and could well be amended in the light of further investigations.

Cooling Flows in Clusters and Galaxies

A.C. Fabian, Kluwer Academic Publishers Group, PO Box 9889, 3300 AZ Dordrecht, The Netherlands, 1988, 391pp, £54 00

The use of x-rays some 20 years ago enabled astronomers to discover the diffuse gas existing within glactic clusters and led, subsequently, to the realisation that the central gas density in some clusters, and in elliptical galaxies, may be so high that radioactive cooling time decreases rapidly towards the centre of a cluster or galaxy. The result indicates a cooling flow which suggests that mass is being deposited in some clusters to the tune of several hundreds of solar masses per annum.

The implications of this are profound because it indicates that there is an on-going star formation within the centres of galaxies. This makes the subject of cooling flows of immense interest in understanding star' formation, though other evidence appears to suggest that these deposits produce very low-mass stars or other dark matter. If this is so, it offers an insight into the origin of at least some of the dark matter in the universe and of the envelopes which surround some giant elliptical galaxies.

This is an area where there are still many unknowns and where there is still room for lively debate, as nearly fifty highly-specialised contributions here amply testify.

Astronomical Ephemerides: 1989

Masson, 120 Boulevard Saint Germain 75280 Paris, Cedex 06, France, 1988, 312pp, 150F

This book is an annual publication of the mathematical department of the Bureau des Longitudes which undertakes research in the field of celestial mechanics and basic astronomy.

The opening chapter provides data on the various events in the almanac and the civil and religious festivals arising. The two succeeding chapters contain astronomical definitions (systems of coordinates; time scales etc). The following chapters, indicating how the ephemerides are used, constitute the major part of the book. Explanations are given for the calculation of sunrise and sunset times, star setting times, the duration of a particular day, twilight periods and the time at which a star crosses the meridian.

These accurate mean ephemerides are provided for the Sun, the Moon, planets, asteroids, comets and for the major satellites of Jupiter and Saturn. Data required for the observation of the surfaces of the Sun, Moon, and planets and the shape and size of the four large satellites of Jupiter is supplied with the necessary explanations

Finally, the ephemerides of bright stars, double stars, star clusters, nebulae and galaxies are included together with data on astronomical phenomena such as eclipses of the Sun and Moon, star and planet occulations by the Moon, conjuctions, oppositions etc.

Orbital Motion

AE Roy, Adam Hilger, Techno House, Redcliffe Way, Bristol, BS1 6NX, England, 1988, 53299, £15.00 (Paperback).

This is the third edition of a comprehensive textbook which deals with the analytical methods of classical celestial mechanics, the recent numerical experiments into the orbital evolution of gravitating masses and the astrodynamics of artificial satellites and interplanetary probes. It requires little or no prior familiarity with astronomy or space science but does require a knowledge of calculus and elementary vector analysis. Problems, with answers, are included as are appendices of relevant astronomical and mathematical data. This text is intended primarily for postgraduate and advanced undergraduate students but its discussion of orbital computation will be of interest to serious amateur astronomers.

This edition includes new data about various bodies in the solar system, particularly relating to the systems of Jupiter and Saturn. New results from recent work on the stability of the solar system and its sub-systems have also been included, thereby enabling the text to be updated throughout.

The Wonderful Apparition: The Story of Halley's Comet

R.B. Peterson, Univelt Incorporated, PO Box 28130, San Diego, California 92128, USA, 1985, 195pp, $18.95

This book traces the history of one of the most interesting celestial objects from antiquity to the present. It details the fascinating story of the contributions made by generations of scientists who contributed towards understanding the nature of comets generally and to identifying the special place held by Halley's Comet particularly.

Bioastronomy - The Next Steps

G. Marx, Kluwer Academic Publishers Group, PO Box 989, 3300 AZ Dordrecht, The Netherlands, 1988, 434pp £69.00

Even though the potential rewards, or potential hazards, arising from a successful search for extraterrestrial intelligence may be great we are, at present, still groping in the dark for ideas on how best to conduct such a search.

This volume presents an abundance of stimulating, if not provocative, ideas about how such a search might be prosecuted, as well as providing a summary of the progress made over the past few years in the search for extra-solar planets and radio signals from outer space.

The most remarkable development in recent times has probably been the number of projects aimed at detecting the existence of planets around other stars. Significant improvements in instrumentation have brought this possibility well within reach and, if proved successful for some of the nearer stars, will undoubtedly show that planetary systems must be abundant throughout the galaxy. At the same time, sophisticated equipment and techniques under development will greatly enhance the search for radio signals and result in an effort which will dwarf previous work.

The present volume is divided into a number of major sections which cover such things as clues to the habitability of other worlds available within the solar system, and the search for extraterrestrial civilizations on the one hand the primitive life on the other. The question of alternate biologies also arises, i.e. will we recognise different life forms when we see them? There is the further question on whether intelligence arises inevitably in the evolutionary scale and, if it does, what are the prospects then for detecting other technological civilizations?

The book concludes with a short section on attitudes to be adopted if other civilizations are detected. In that event, it will undoubtedly give rise to wide-ranging responses. For example, *who* will respond - and on behalf of *whom?* Should it be a political,scientific or philosophical response - to indicate just some of the possibilities - or will it actually be made off-the-cuff by someone who represents nobody but himself?

We still have a long way to go in resolving such questions.

The Motion of the Moon

A. Cook, Adam Hilger, Techno House, Redcliffe Way, Bristol, BS1 6NX, England, 1988, 222pp, £35.00

The passage of the Moon across the night sky has long been a familiar, but mysterious, sight. Newton, with his Laws of Motion and Inverse Square Law of Gravity, was able to predict all the planetary orbits - at least in principle, but the theory of the lunar orbit was one which, he says, gave him a headache. In the event, an exact solution of the Moon's motion in the gravitational fields of the Sun and Earth defeated both Newton and his successors, even though complex analytical methods have since been evolved which give very good approximations. More recently, the advent of modern computers has allowed even more accurate numerical calculations to be performed. Radar observations of the distance of the Moon followed by lunar laser ranging and very long base-line interferometric observations made possible by the Apollo landings have outdistanced theory and set a further challenge. Even the predictions of general relativity can now be tested with greater precision.

This book provides a comprehensive account of all these theoretical developments over the past three centuries and up to the present time Although there is much good reading matter, fair knowledge of mathematics is also required.

SOVIETS in SPACE

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.

By Neville Kidger

First unscheduled EVA : August 15, 1979

The third EVA from Salyut 6 came at the very end of a six-month-long mission that would have seemed to have had its share of problems already.

Vladimir Lyakhov and Valeri Ryumin had already isolated a leaking fuel tank when the Soyuz 33 spacecraft, carrying Nikolai Rukavishnikov and Bulgarian Georgi Ivanov, experienced an engine problem during the final approach to the station. The two men narrowly escaped being marooned in orbit and returned to Earth after a flight of just two days.

This forced cancellation of a Soviet / Hungarian visit to Lyakhov and Ryumin. The Soyuz 34 spacecraft, which would have carried the visitors arrived at Salyut unmanned.

The final month of the mission witnessed a major first for the Soviet space programme with the deployment of a ten metre diameter radio telescope dish – the KRT-10.

There are suggestions that the telescope dish did not open fully when it was deployed after the separation of the Progress 7 cargo ship which delivered it.

After a month-long series of joint observations with a Soviet Earth-based radio telescope the time came to jettison the assembly. On August 9 the command was given. Ryumin described how he had activated the separation mechanism and watched on TV expecting to see the dish pushed away by pyro-bolts and springs. The dish, however, did not separate.

Ryumin later wrote that examination through a porthole and by TV showed that the wire dish had become entangled in a beam of the docking target. "If it were left there, the station would not be able to fly unmanned, as its orientation system would not work. We tried rocking the station, but to no avail. We could only spill out our emotion in the most impressive words we could find to address the bloody thing."

Ryumin outlined the stark choice : leaving the dish as it was, then thus abandoning the station ("for what had we kept it so spick and span, done all the necessary repair work and replaced the worked-out instruments with new ones?") or going outside to try and free the recalcitrant dish.

"The protective suits were two years old and had twice been used," Ryumin wrote. "Besides, work in open space was a great strain, and we were just out of practice, what with our half-a-year in weightlessness."

Nevertheless, the decision was taken to go outside. Aleksei Yeliseyev spoke to the two men. The veteran cosmonaut, who made his EVA in 1969, told the men they had done their duty and said they might refuse the task. But Ryumin wrote that they "would not listen, and began discussing the job in detail."

Ryumin confirmed that the men transferred into Soyuz 34 the equipment that they were to bring back: films, tapes, plants in ampoules and samples of alloys obtained in the furnaces in case they were unable to return to the station. James Oberg has said that both men wrote last letters to their families.

On August 15 both men ate dinner and began to don their undergarments and the main spacesuits. Ryumin described his donning: "It wasn't a picnic for me, with my six foot two height, and Vladimir had to push me into my suit."

Once sealed in Salyut's forward transfer compartment the air was vented. When the time came to open the hatch Ryumin radioed worrying news: the hatch was stuck. Both men applied pressure and finally, a minute late, Ryumin was able to open the hatch. It was 1416 GMT.

Ryumin "saw the sunlit Mediterranean far below, and felt some force – not wind – suck me out." Viktor Blagov, a deputy flight controller, radioed up to tell the men to be calm. "Quiet," Ryumin admitted saying to himself, "meaning it first of all for my wife. I knew she would be beside herself with fear." His heart rate was reportedly 134 beats per minute.

Ryumin stepped out and stood on the skip-plating holding a handrail. He watched the grandeur of an orbital sunset. With the EVA already behind schedule and the station in orbital darkness the two men were instructed to wait for the sunrise. Ryumin said that he saw floodlit cities in Japan and "if I had ever visited Tokyo, I might have recognised its main streets."

The station passed over the Pacific Ocean. The night was moonless. Ryumin said the wait, holding onto the handrail, made him feel like a man on the footboard of a crammed bus.

This Soviet stamp illustrates the daring spacewalk by cosmonauts Lyakhov and Ryumin to remove the KTR dish jammed in the Salyut 6 rear docking port.

The men were struck by the beauty of the stars. "They look like huge diamond pins on the black velvet," Ryumin said. He felt he could stretch out and hold one in his glove.

"In about half an hour, a bluish-green streak of light appeared on the line dividing Earth and its atmosphere. It grew broader and broader, and soon shone with all the colours of the spectrum. The Sun was about to rise," wrote Ryumin. "It was time to begin."

Ryumin, attached to the hatch with a safety line, began moving down the length of the station. Lyakhov came outside the station to inform Ryumin about the behaviour of the dish and, if needed, drag his comrade back in with the tether "if the worst came to the worst."

"I reached the station's tail and saw that the antenna was caught in several places instead of one, as we had thought," Ryumin wrote. "Its metal spikes had torn the soft skin plating. Quite a bit of work for me." At that moment the station was out of contact with Earth. Consulting Lyakhov, Ryumin decided to cut the four steel cables by which the dish was held. Ryumin had to be careful – the dish might well cover him like a net.

Oberg described how Ryumin tried to shield his eyes from the Sunlight by lowering his visor but had to raise it again when condensation from his rapid breathing caused the inner part of his faceplate to cloud over. He had to work with "sweat-soaked eyes."

"Full of apprehension, I approached the first cable, taut and as stiff as a poker, chose the necessary tool-...took aim... click! and it was cut in two," said Ryumin. There was no sound but the dish shook and moved towards the flight engineer prompting a call from Lykahov: "Look out! To the right, quick."

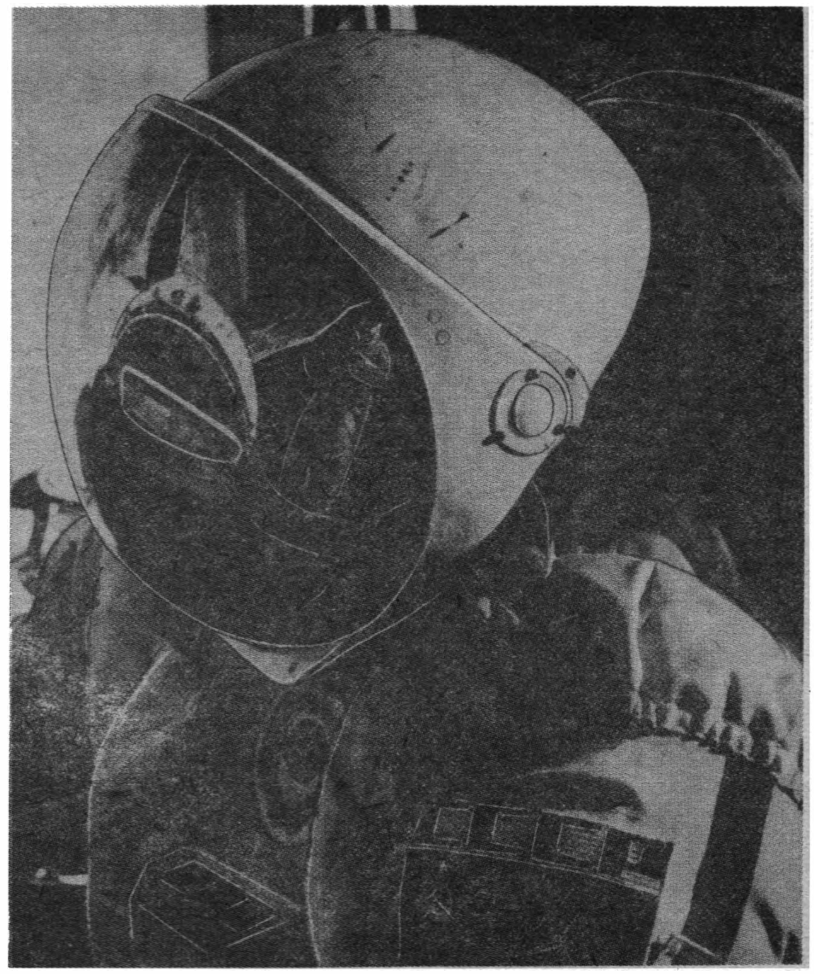
"I had a narrow escape this time," Ryumin reflected. When the dish stopped vibrating Ryumin cut another cable and the dish moved again, but in another direction. He then cut two other cables quickly "I was now a dab hand at it."

Ryumin then rested for a while before using a long forked stick to push the dish away from the station towards Earth.

Ryumin looked back at the station; he reflected that the job had seemed too easy "so I must be in for trouble. I made up my mind to examine the entire station from the outside. It looked well-worn, with the skin-plating faded and ragged in some spots."

He wiped a porthole with a piece of cloth and put it in his pocket. He knew experts on Earth would welcome samples of the dust. Ryumin also took samples of the plating added to the station by Kovalenok and Ivanchenkov for return to Earth.

At that point communications were restored with the control centre. "Of course, they had been on tenderhooks. We reported that the antenna was gone; no reply. They could not believe their ears; we were so far ahead of schedule," Ryumin said. "We said once more that the antenna was removed and we were on our way back, and had almost reached the entrance to the station. The control centre reacted with thunderous applause."



Kovalenok is photographed just outside the Salyut 6 hatch by fellow cosmonaut Ivanchenkov. Note the reflection of Ivanchenkov in Kovalenok's visor.

Observations from southern England some hours after the operation confirmed a wide separation of station and KRT-10 dish.

The next day was Ryumin's birhtday and he received congratulations all day from the control centre. He was congratulated on the "fine piece of work" he had done the previous day which ensured the continuity of work on the Salyut 6 space station.

The world's first unscheduled EVA had lasted for 1 hour 23 minutes.

Salyut 6 : Two More Crews

Valeri Ryumin found himself back on Salyut 6 in 1980, replacing the prime flight engineer of Soyuz 35, Valentin Legedev, who had injured himself. There were no further EVAs during this busy 185-day flight.

In 1981 Salyut 6 was again manned. Vladimir Kovalenok and Viktor Savinykh made a 75-day spaceflight during which they played host to two international crews. There were no EVAs on this flight which saw an end to Salyut 6's manned operation. This was the last time a resident crew manned a Salyut station without being scheduled to conduct an EVA.

First Outside Salyut 7 : July 30, 1982

Four years and one day after Kovalenok and Ivanchenkov had made their EVA to collect samples from Salyut 6's exterior, the first resident crew to Salyut 7 made a similar EVA, also involving some technical tests.

Anatoli Berezovoi and Valentin Lebedev boarded the new station in May 1982. Salyut 7 was designed with EVA in mind. Essentially a duplicate of Salyut 6, it did feature provision for spacewalking cosmonauts to attach extra solar power panels to the edges of the main array of three solar panels.

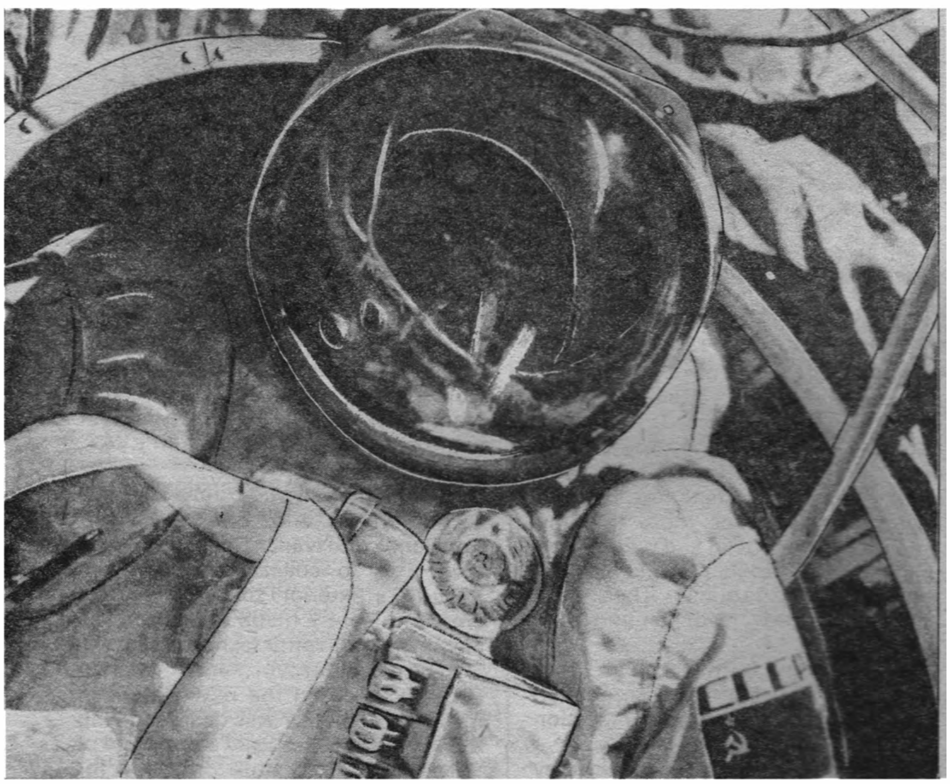
The task for the first crew on their EVA was, however, less demanding. In his diary of the flight Valentin Lebedev gave details about his attitude and activities before and during the EVA, which was scheduled for July 30.

On July 26 he described talking to Valeri Ryumin and asking for permission to traverse the length of the station (Ryumin was the only cosmonaut to have done this to date on Salyut 6.) Ryumin said that it was necessary to check the improved spacesuits as there was no sense in taking chances. The preparations for the walk were taking up so much time that there was not even time to gaze out of the window.

On July 27 Lebedev tried out the spacesuit. "As I started to wriggle myself into the spacesuit, I had the impression of having grown broad in the shoulders, and having too big a head for the helmet... zero gravity was of no help and I had to assist myself in with my hands to sink the legs into the suit. I took much effort, much panting and mumbling to get in," he wrote.

The final instructions for the EVA were radioed up on July 29. The timing was fixed to the minute and the duration was set at "more than a circuit" of Earth. Both men did not sleep well on the night before the EVA.

At 0239 GMT on July 30 the cosmonauts opened the hatch on Salyut 7's side for the first time.



Berezovoi at the Salyut 7 EVA hatch, during his July 1982 space walk.

Lebedev said that once the hatch was opened sunlight burst in; "dust from the station flew in like little sparklets, looking like tiny snowflakes on a frosty day. Space, like a vacuum cleaner, began to suck everything out. Flying together with the dust were some little washers and nuts that had got stuck somewhere; a pencil flew by." Lebedev recalled feeling neither fear nor excitement. The huge Earth gave him a feeling of "unreality."

"Space is very beautiful. There was the dark velvet of the sky, the blue halo of the Earth and fast running lakes, rivers, fields and cloud clusters. It was dead silence all around, nothing whatsoever to indicate the velocity of the flight... No wind whistling in your ears, no pressure on you," wrote Lebedev, "the panorama was very serene and majestic."

The cosmonaut installed TV cameras and a floodlight. He made his way to the Yakor (Anchor) point near the hatch and began to collect a series of cassettes and instruments including the Medusa experiment, a panel with ampoules of the simplest organic compounds to study how life may have begun. Lebedev replaced the units with analogous ones after he had retrieved them. Other external experiments involved a cassette with 20 samples of metals under various loads of compression or tension and samples of rubber and heat-insulation materials. A micro-meteorite detector was also retrieved.

Lebedev conducted the Istok experiment involving using a special spanner on a board with nuts and bolts. The spanner featured a central rod with small spheres on the sides. It was designed to undo bolts much easier than before and also avoid the resultant metal slivers from being shaved off.

Several operations were conducted by the cosmonaut to evaluate the effective use of thermomechanical and threaded connections from different metal pairs. An assembly of pipes connected by a "memory metal" which shrinks to a pre-determined form at room temperature to form a hermetic seal was tested. The pipes joined in this manner were tested to an internal pressure of 150 atmospheres to check on their properties.

Berezovoi spent most of the EVA in Salyut's hatch passing out tools and taking TV and still pictures. At one point Lebedev complained that his feet were cold. Aleksei Leonov said this was the result of the new powerful heat extraction unit. The suit was said to be flexible and the cosmonauts were not heard to be breathing heavily.

The first EVA from Salyut 7 lasted 2 hours and 33 minutes.

In 1988 James Oberg reported that new accounts about Salyut 7 said that the Berezovoi / Lebedev EVA also saw the deployment of a synthetic aperture radar on Salyut's exterior. The 10 m long antenna was supposed to be dismantled by Kizim and Solovyov, Oberg says. However, pictures of the Salyut 7 station taken in late 1985 do not reveal any such antenna.

Soyuz T-8 : A False Start for 1983

The next resident crew to Salyut 7 were scheduled to perform at least one EVA to erect the first two sets of additional solar panels. However, after their launch on Soyuz T-8, Vladimir Titov, Gennadi Strekalov and Aleksandr Serebrov found themselves without a usable rendezvous antenna on their ship.

Despite an heroic attempt by Titov to conduct a manual approach and rendezvous to Salyut 7, docked with the large Kosmos 1443 module which contained the extra panels, the three men returned back to Earth after a two-day flight.

It is assumed that the EVA (s) would have been conducted by Titov and Strekalov.

New Solar Panels : November 1 and 3 1983

Titov and Strekalov were scheduled to be launched to Salyut 7 again on September 26, 1983 to take over the station from Vladimir Lyakhov and Aleksandr Aleksandrov who had boarded in late June to work with the heavy Kosmos.

But fate was to intervene again. Titov and Strekalov were to perform the solar panel addition EVA, an activity that Lyakhov and Aleksandrov had not trained extensively for.

Just 90 seconds before the launch of Soyuz T-10, with Titov and Strekalov aboard, a fire broke out at the base of the rocket. Thanks to the quick reactions of two ground controllers the cosmonauts became the first live passengers to test the Soyuz Launch Escape System. The cosmonauts, in the descent cabin of their Soyuz landed 4 km from the blazing launch pad. They were shaken but uninjured.

For Lyakhov and Aleksandrov the news of the failure came after their own problems with Salyut which made world headlines. An oxidiser

leak on September 9 had almost led to the men's recall. But controllers decided that the problem could be lived with and left the crew aboard awaiting the new team.

It became clear that the team already on Salyut should go outside to erect the new set of solar panels. Two separate EVAs were scheduled - the first time that the Soviets were to conduct two EVAs during a single mission and also making Lyakhov the first Soviet to conduct two sessions of EVA.

The new panels (Soviet acronym DSB) were 5m long and 1.5m wide. They provided 50 per cent of the power of the main array when both were attached. Engineer O Tsyganokov said that up to 48 different operations were needed to winch the DSB onto the sides of the existing panel. But with contingency operations there might be as many as 189 operations. To guard against these, engineers had developed various sets of rules and procedures.

The first EVA began at 0447 GMT on November 1. Aleksandrov was first out, attaching himself to an anchor point. He later recalled that there was an interesting reversal of roles for the EVA - when Ryumin made his 1979 EVA Aleksandrov was the shift chief at the control centre, now Ryumin was in that role.

"It is so very hard to describe one's emotional state on the first space walk," Aleksandrov later said. "Aboard the station the spacesuit looks like an impressive, even cumbersome device. You don't put it on, you enter it. But outside the station you feel like you're in a tiny crib suspended at a dizzy altitude."

Aleksandrov was "stunned" by the colour scheme of space. "Through the porthole you see a limited sector, but outside the station you see all the many colours of the dawn fading here and gathering intensity there. The colours merge into one another sharply and contrast each other intensely. I don't know why but I suddenly want to carry out a small experiment - to let loose some small object and see what would happen to it. I found such an object and it floated away, shining like a small star," he said.

"We were immediately told off by the control centre for our antics," recalled Lyakhov. "These small 'stars' can upset the positioning system's work."

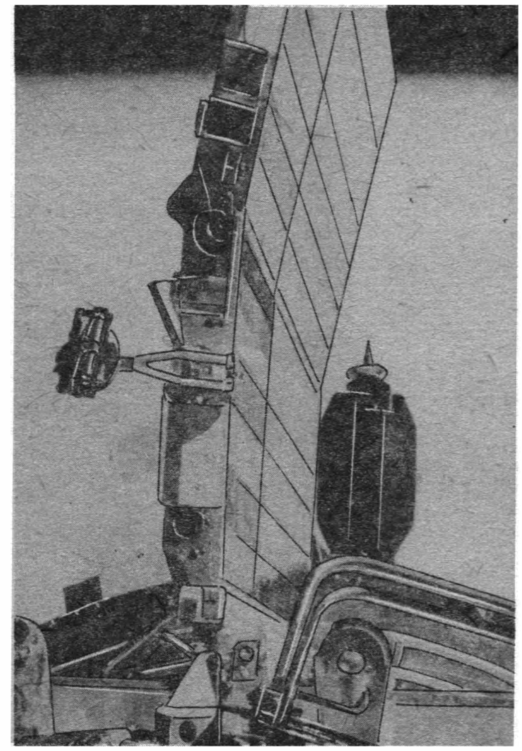
It was reported that the men took with them portable hand holds and a multipupose hand-held manipulator which made it possible to reach out the whole length of the main solar array.

Lyakhov passed a TV camera to his comrade to set up so that controllers could view the working area. The camera was mounted on a movable hinge. The two men carried a metal container to the area of the station's central solar panel. The folded DSB was removed from the container.

A full scale replica of a main and auxiliary solar panel was positioned in front of the desks in the control room at FRC.

By the time the men had reached the site of the work the EVA was already 40 minutes old.

There followed a series of exchanges between the men: "... no, this big one!"; "Oh! OK." A Soviet correspondent called the exchanges businesslike. The cosmonauts were still engaged in their preparations as radio communications



Salyut 7's solar panel before the addition of extra panels.

were lost as the station drifted out of the range of the Soviet ground tracking stations.

Almost 50 minutes passed before contact was reestablished with FCC. Much of that time was spend in darkness. As Salyut began its passage through the daylight portion of the orbit, Aleksandrov began to winch the DSB up.

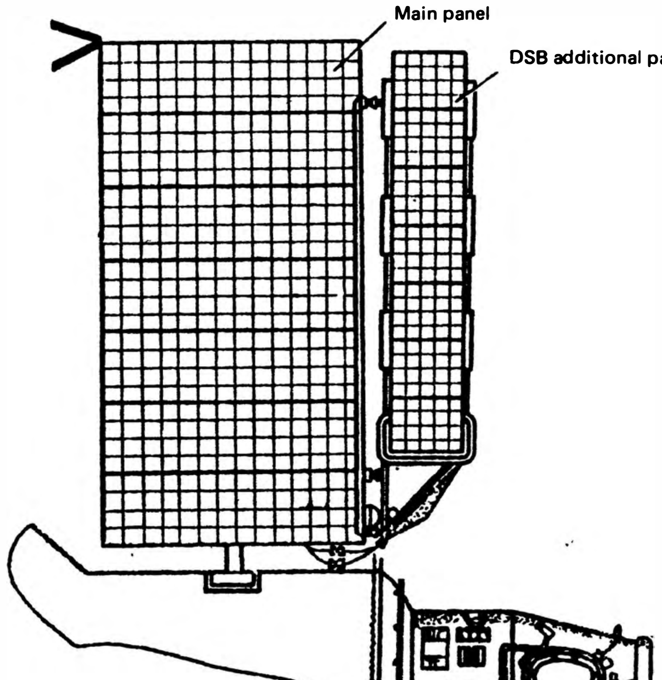
The cable to connect the DSB to the main panel was then attached, establishing the electrical connection. The work was described as being "complicated and laborious."

With the successful completion of the work the two men returned into the station after an EVA lasting 2 hours 49 minutes and 12 seconds.

In a post-EVA medical debriefing with Dr AD Yegorov, Alexandrov said that his only sensation was "of having done something well."

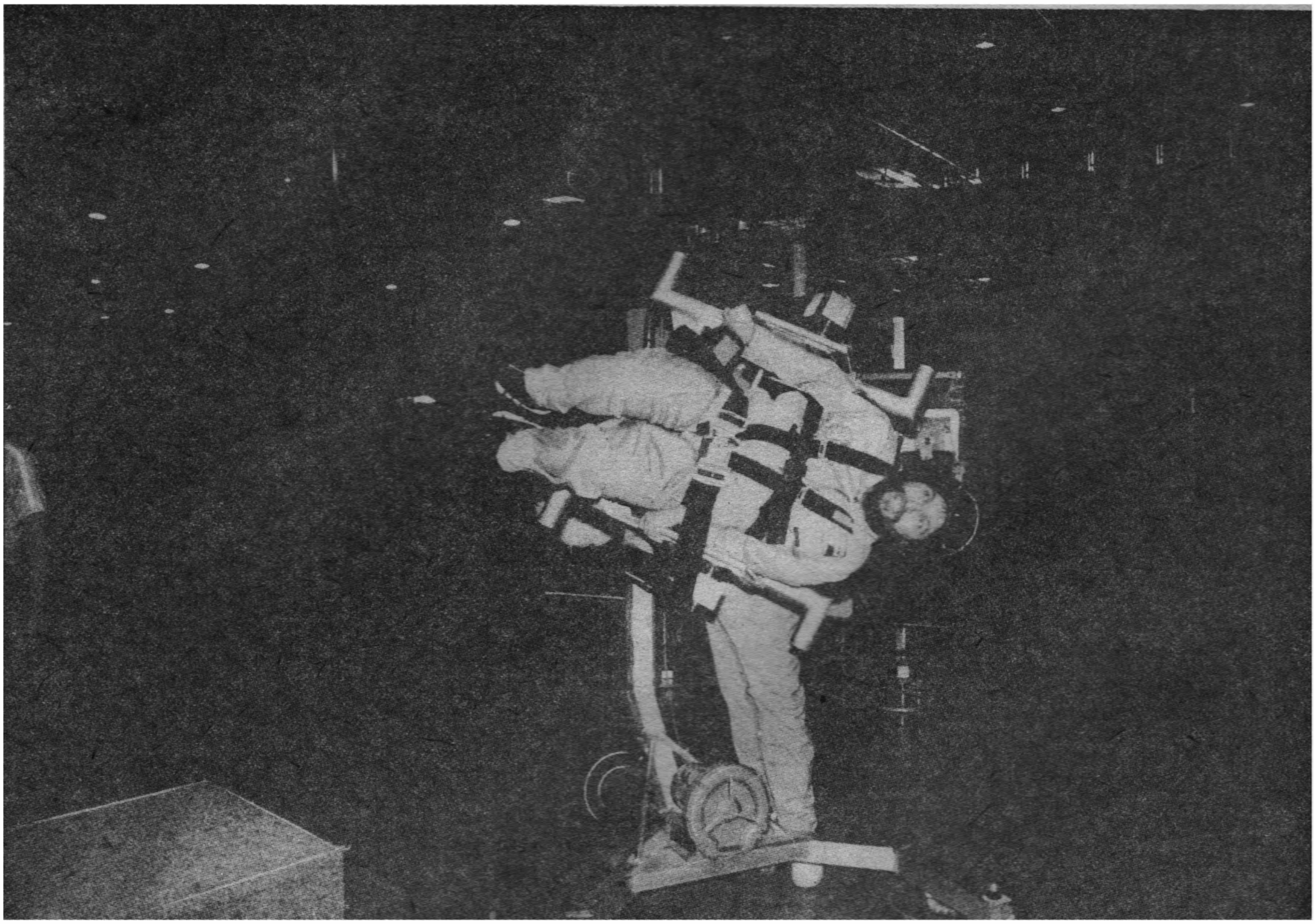
The second EVA began at 0347 GMT on November 3 and proceeded in a similar manner to the first. Aleksandrov reached the panel after 46 minutes. The Soviets said that two cosmonauts were duplicating the work in the tank at Star Town, a western source identified them as Leonid Kizim and Vladimir Solovyov.

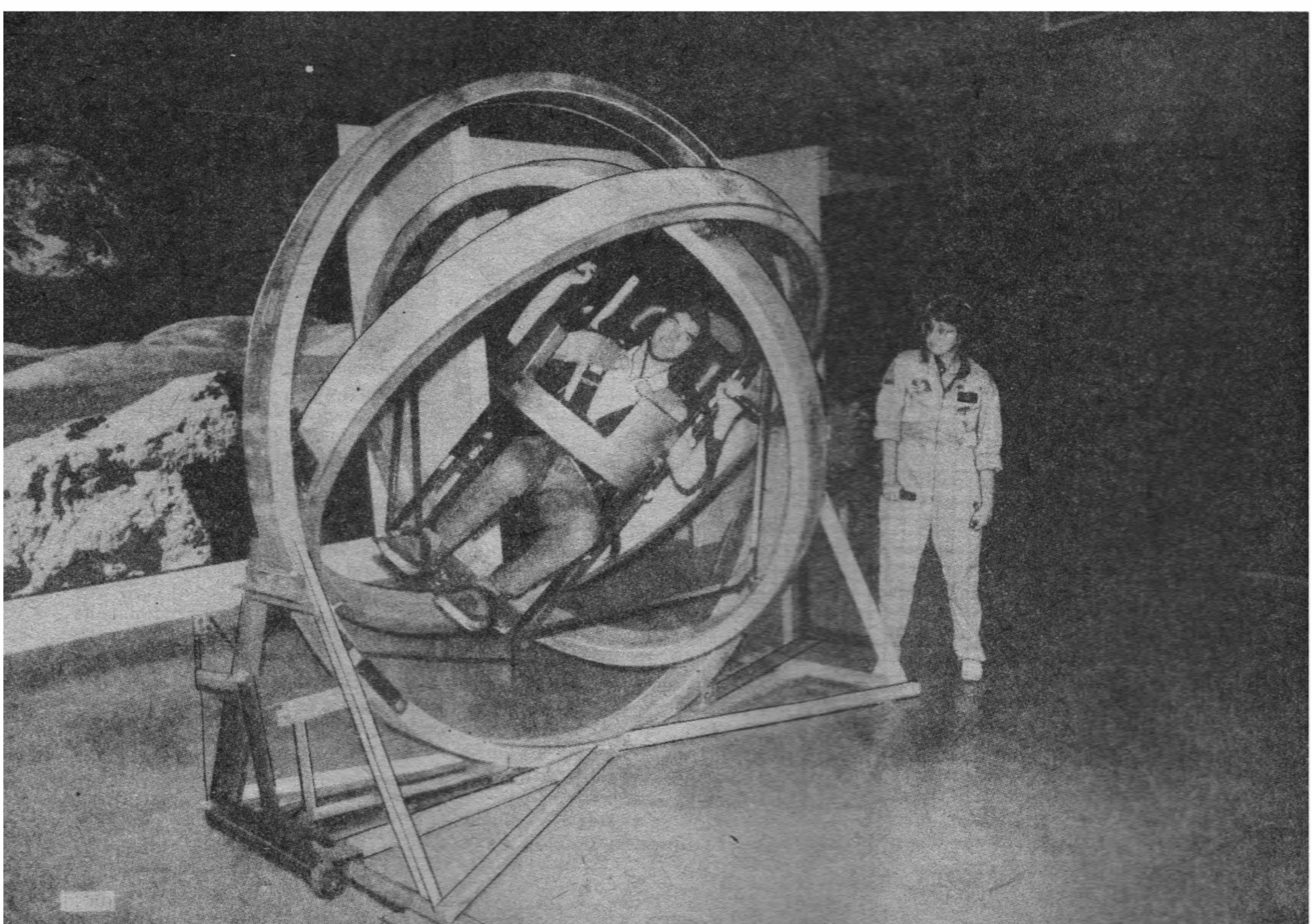
The solar panel's second DSB was erected successfully and the cosmonauts returned to the station after 2 hours and 55 minutes. The Soviet coverage of the second EVA was very low-key. The work was linked to future large-scale assembly work which is to be performed during future missions.



Salyut 7

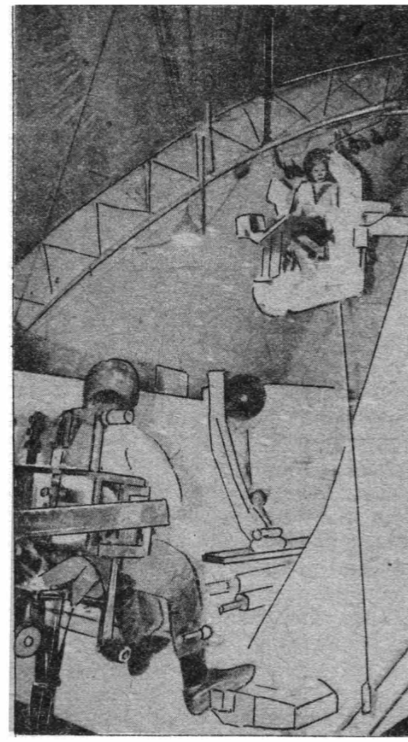
This major feature on Soviet EVA operations continues in the next edition of *Spaceflight*.





A Visit to SPACE CAMP

'*Into Space*' articles highlight the work and activities of individuals in Space Education, Space Technology and all areas of involvement with space. In this article *Trevor Sproston* a BIS member, recounts three memorable days spent at the US Space Camp at Hunstville, Alabama.



Space Camp students during payload bay training.

It might appear odd at first sight for a teacher of French to go off to Space Academy. Like most people, I participated with the exploits of the spacemen only at a distance and was resigned to being an outsider until my newsagent got hold of the first ***'Spaceflight'*** Supplement, which discussed at length the NASA Space Camp. Not long before, the QED television series had run a programme about four English children winning a trip to Huntsville and what they did when there.

With the kind cooperation of the personnel at Space Camp, especially Ms Dale Pagano, I was given a place on their 3-day 'Teacher's Space Orientation Course' and was able to fill out the spare days on my ticket by taking in Houston as well. I flew from Houston to Huntsville - and I arrived the day before Space Camp was due to start, at the same time as George Bush chose to tour the facilities.

I devoted that Thursday to loading myself with tourist goodies as I had anticipated, quite rightly, that my time would later be occupied by the course. A purchase I found difficult to make was that of my flightsuit: I am not exactly slimline and it took me until size 50 before I found one that I could get on *and* get off. The social mix of the campers needs to be commented on; there was an investor, a USAF officer, university lecturers, teachers, ... all at ease with each other and all intent on enjoying themselves.

Friday began with breakfast. We then adjourned for the group photograph, each group being assigned an orbiter name - Pathfinder, Enterprise and, for my own team, Discovery. Following this happy ritual we all loaded into two buses for the first event of our day, which was a tour of the Marshall Space Center. The itinerary for the tour included a slide show and presentation on the Center given by Bill Anderson of Public Affairs; Mr Anderson was to be our courteous guide during the tour. Next followed a visit to the External Tank warehouse, where we gained an idea of the vast scale of the ET and of its internal complexity. Thence to the neutral buoyancy facility to see tests being carried out on the feasibility of converting the ET into an orbiting gamma-ray telescope. Debate ensued within our group as none of us knew of a material which reflects gamma rays The technicians maintained a diplomatic silence, stating that they just did the testing, leaving the theory to the scientists.

(Top) The author in the Five Degrees of Freedom apparatus.
(Bottom) A student in the Multi-Axes trainer.

Industrial efficiency occupied the next stage of our tour, and we were treated to an interesting exposition on the way some of the methods used in NASA could be applied in industry. This section was most interesting and included a demonstration of problems associated with the Shuttle Main Engine turbine blades. We were allowed to watch the deposition of ceramic materials on the blades and saw the great technical difficulty of arranging perfect deposition.

The Space Station mock-up was next on the list, showing how lessons learned from Skylab were being put into practice for the Station, eg showers which use a continuous downflow of air to make washing easier, colour-coded walls to give a consistent "up and down" as the astronauts move from room to room, and the provision of windows - an engineer's nightmare, but a necessity for the astronauts.

On our return to the Camp, we were assigned our flight positions for the two simulated missions we were to fly. In mission A, I was to be the Spacelab Principal Investigator in charge of the experiments carried on Spacelab. For mission B I was awarded the post of Commander. Our positions were sorted out by means of a test that we had sat before camp started. There then followed Shuttle Orientation, during which we had a tour of the Shuttle system, which proved quite fascinating, both from the point of view of the complexity of the hardware, and for the insight into how many things could go wrong.

After lunch, we enjoyed ourselves on various pieces of simulation equipment. The joys to be experienced comprised an F86 cockpit simulator, a GMMMU (Ground Mounted Manned Manoeuvering Unit) which responds to control via four air-cushion feet and gives a very good approximation of the stately, drama-like progress of the real thing, and last for that day, the FDF (Five Degrees of Freedom). This is a gimballed chair, which allows rotation through the centre of gravity of the occupant, ably demonstrating the problems encountered in zero-g when you try to turn a spanner and find it is you who turns. The next two hours were spent in training for our first mission. We all assiduously studied the very thick folders that were our scripts, background information and emergency procedures.

The early evening of this first day consisted of a ride on the "Lunar Odyssey", a centrifugal ride that takes you up to 3g. Final mission practice was followed by the Omnimax film "Hail Columbia". The depth and visual impact of this system literally has to be seen to be believed. On several occasions I instinctively closed my eyes such was the impression of actuality. Then the remaining two hours of the evening (8.30-10.30 pm) were devoted to training for mission B.

Day 2 began with the 1/6 gravity chair, the manoeuvering pod and the multi-axis trainer. The manoeuvring pod is a delightful man-carrying ball suspended by an airflow within a plastic tube. I was strapped into the multi-axis trainer, and spun at considerable speed through more axes than I thought I had. Nausea was not a problem however as the stomach always remains at the centre of rotation. Admittedly, these thoughtful considerations didn't enter my head as I was spinning, my main impression being the pain of the straps digging into my shoulders. My admiration for astronauts as a breed increased enormously on

hearing that they endured this treatment for hours at a stretch, in the dark, while maintaining communication with experimenters.

Day 2 also saw our allocation of lecturers. First off the mark was Konrad Dannenberg, giving a talk on propulsion systems. This was of course only an introduction to the principles. A talk on the Hubble Space Telescope suffered from the sad fact that the subject is still on the ground awaiting a flight. Next was a talk on space suit design and so to our first mission.

Feeling most apprehensive, I entered the dimly-lit "Mission Control" and took my place at the console, very aware that the smooth running of the experiments in the Spacelab mock-up was as much my responsibility as it was that of those aboard. Fortunately all went well, the only short-coming being the non-existent radio link between myself and the Mission Director eight feet away, leaving us to call across to each other to confirm the progress of the experiments. Happily, the mission reached a successful conclusion and we emerged into the glare of the neon lights, congratulating each other on a job well done. We adjourned for dinner, attended a talk by Mr Vick and watched "The Dream is Alive". Charles Vick's lecture on the USSR space effort was fascinating and, for me the outstanding lecture of the course, containing as it did remarkable facts, excellent presentation and a challenge to the West. Mission debriefing ended the activities for the day, and many of us spent the remaining time revising our roles for the morrow.

Day 3 dawned, the day *I* was to command a Shuttle! Thankfully the mission started at 09.00, so there wasn't long to wait. The most stressful part of the simulations was having to keep to a set timetable of events, marked out for us in Mission Time (slightly behind normal). This is essential and quite difficult, as the instructor has carte blanche to throw into the sequence any fault from a screw falling out to full Main Engine Abort. Incidents on our mission were: launching a satellite through half-open payload bay doors, serendipitous docking with the Space Station, a Mission Specialist doing an EVA without a suit, and our landing minus landing gear because our instructor had omitted to show us the relevant buttons! However, despite gouging a six-foot deep furrow in Edwards Air Force Base runway, we all surfaced, having had a wonderful time being spacemen.

Either side of lunch were the two remaining lectures of the course. Space Physiology and orbital mechanics. The former was very informative, although tending to lose itself in tables and charts towards the end; but this was compensated for by a lively question time.

The final afternoon was devoted to a talk by Al Bean on his paintings of space themes. It was refreshing to hear an astronaut talking about his personal interests, and to see the high standard he reaches in his paintings. Then followed graduation and the final goodbyes.

An impromptu dinner party took place at a local hotel, and it was here that I really came to appreciate the significance of the Shuttle to the American people. It is not just a vehicle, but a symbol of all that Americans believe in - pioneering spirit, high technology, open-hearted enthusiasm and a sense of vision. My fellow-students came from a wide variety of backgrounds, from the very rich to the relatively modest, but the only currency around was enthusiasm for the space effort.

As for my thoughts on the Camp itself. I have often said since I came back, that those three days were among the most stimulating that I have ever spent. The friendliness and courtesy of students and staff was remarkable, from the young lady who came to the hotel to take me to the Camp, through the caterers to the most senior administrator. I wholeheartedly recommend the experience to any who have the opportunity to go.

Readers are invited to submit material about their work (including its technical aspects) and any space related activities in which they have been involved for inclusion in the *'Into Space'* series of articles