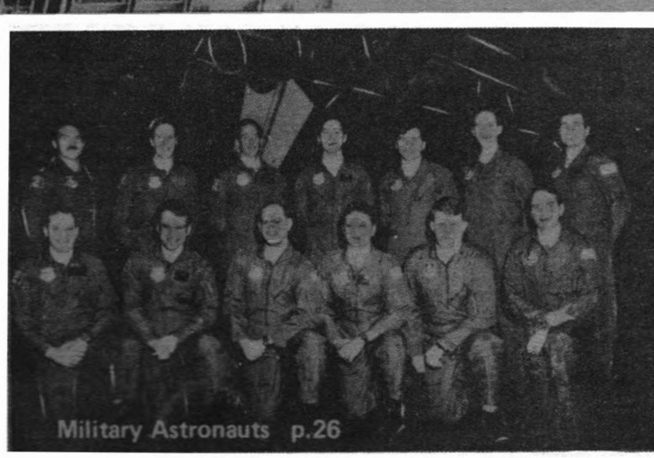


Military Astronauts p.26

88905 КОСМИЧЕСКИЕ ПОЛЕТЫ № .Т-1
(спейсфлайт)
По подписке 1989 г.

SOVIET SHUTTLE
MISSION REPORT

Vol.31 No.1

Editor:
G. V. Groves

Assistant Editor:
S. Young

Managing Editor:
L. J. Carter

Spaceflight Sales:
Shirley A. Jones

Advertising:
Suzann Parry

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

Tel: 01–735 3160.
Fax: 01–820 1504.

DISTRIBUTION DETAILS

Spaceflight may be received worldwide by mail through membership of the British Interplanetary Society. Details from the above address. Library subscription details are also available on request.

★ ★ ★

Spaceflight is distributed in the UK and overseas through newsagents by Magnum Distribution Ltd., Cloister Court, 22–26 Farringdon Lane, London EC1R 3AU. Tel: 01–253 3135.

★ ★ ★

Opinions in signed articles are those of the contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society.

★ ★ ★

Back issues of *Spaceflight* are supplied at £2.00 (US$4.00) each, inclusive of surface mail delivery.

★ ★ ★

Published monthly by the **British Interplanetary Society Ltd.**, 27/29 South Lambeth Road, London, SW8 1SZ, England. Printed by J.W.L., Ltd., Aylesbury, Buckinghamshire, England.

★ ★ ★

Spaceflight

The International Magazine of Space and Astronautics

Vol. 31 No. 1 January 1989

Front Cover: The Space Shuttle Atlantis blasts off on its first military mission STS 51-J, onboard is Manned Space Flight Engineer William Pailes. An article on the US military astronaut programme begins on p.26. *NASA*

SOVIET SHUTTLE

The Soviet space shuttle, Buran (Snowstorm), was successfully launched on November 15. Three hours and 25 minutes later it made a perfect landing on a concrete runway at the Soviet spaceport of Baikonur, just 12km from the launch pad it had started from. *Spaceflight* correspondent *Neville Kidger* reports on what must be the Soviet Union's greatest space achievement since the launch of Yuri Gagarin.

The unmanned flight of Buran was a very impressive display by the Soviet Union, however the initial launch attempt was aborted on October 29, just 51 seconds before the scheduled start.

The reason for that scrub was a delayed separation of an instrumented block of the azimuthal orientation system from the body of Energia. At the time Maj-Gen (Aviation) V. Gudilin, head of the test directorate of the cosmodrome told reporters that the fault had been with "the platform of the facility for emergency evacuation of the cosmonauts, [it] carries an accurate setting of the rocket's gyroscopes." It was because of this that the automatic countdown was terminated and the test flight rescheduled. The separation should have taken 3 seconds but actually took 38. Overcomplicated design of the joint was blamed. Aleksandr Dunayev, head of Glavkosmos, told a news conference on November 10 that preliminary tests of the Energia Buran system would be finalised the next day and a new launch date set.

Dunayev said that the USSR planned to build several Buran-type orbiters and operate them for decades. He stressed that they would be used to carry spacecraft into orbit "only in exceptional cases", citing the cost of operating the system. Their main tasks would be "the operation of space technology; maintenance operations and recovery of worn-out satellites." He said that no more than 2 or 4 flights could be expected annually. Manned flights would follow the unmanned testing.

The Soviets later announced that Buran would be launched at 0300 GMT on November 15.

Snowstorm and Birdie

TASS correspondent Valentin Ovcharov reported that he had visited the huge assembly building at Baikonur where the orbiters are prepared and saw a second orbiter, called Ptichka (Birdie). The orbiter was covered with 38,000 lightweight heat-absorbing ceramic tiles which could resist temperatures of 2000 degrees centigrade.

These tiles, according to another reporter, could be scratched with a fingernail (he was reprimanded for trying).

Buran can put 30 tonnes into orbit and return with 20 tonnes to land at the runway at Baikonur.

The dimensions of Buran were given by Tass, the orbiter has a length of 36 metres and a wing span of 24 metres. Buran features a crew cabin (split level, as evidenced by the location of the crew access arm) with a volume of almost 70 cubic metres. The craft can carry two to four cosmonauts and six passengers, the Soviets said.

The payload bay has the dimensions of 4.7 metres in diameter and length of 18.3 metres. Vladimir Shatalov revealed that the bay has a manipulator for releasing satellites for deploying them. The manipulator is man-operated.

The overall launch and landing mass of the orbiter can reach 105 tonnes and 82 tonnes respectively. Buran can put 30 tonnes into orbit and return with 20 tonnes to land at the runway at Baikonur.

Unlike the US shuttle, Buran does not carry large reusable rocket engines powered by fuel from a tank to which it is strapped. The orbiter is a payload for the 3,500 tonne-thrust Energia carrier rocket.

Energia takes Buran to sub-orbital speed where it separates from the orbiter. The Buran's propulsion system serves as an upper stage and is ignited at an altitude of 160 km to put the spacecraft into Earth orbit. It is activated once more to enter a circular 250 km orbit.

When gliding in the atmosphere the orbiter is controlled by ailerons, the control vane and air brakes, just as an ordinary aircraft. It is a glide approach without the capability of power landing of fly-around. The aerodynamic flight begins at 40 km and Soviets say that the orbiter can conduct a lateral manoeuvre of up to 2,000 km.

The landing tests at Baikonur, conducted by cosmonauts Igor Volk and the late Anatoli Levchenko, did foature "sustained aircraft engines" which enabled the craft to take off like an ordinary aircraft. However, the engines were switched off for the approach and landing phases to simulate an actual return from space. These types of flights helped to develop the fully automated landing system. The first tests of the automated landing came after the pilots had shown that the orbiter could conduct a controlled landing.

Touchdown speed at landing from an orbital mission is about 340 km per hour and the landing run 1,100 to 2,000 metres. A three-canopy "X" shaped parachute system deploys and is jettisoned when the speed of the orbiter is 50 km per hour. The landing strip at Baikonur is 4.5 km long by 84 metres wide.

Control Centre

A "united control centre" has been established for the landing of the

(Top left) Energia's core stage engines ignite, billowing clouds of steam.

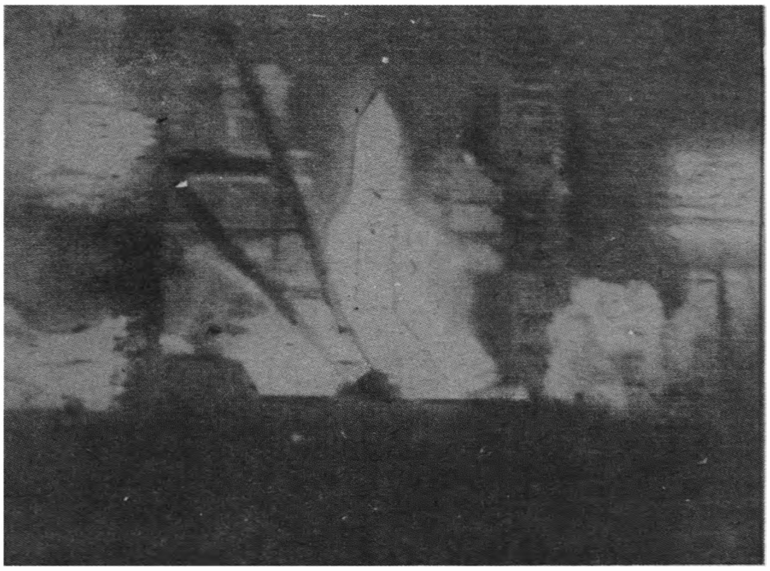
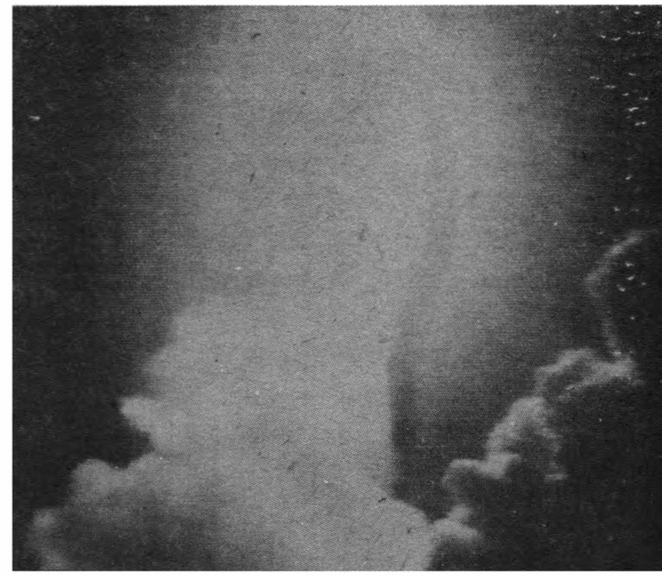
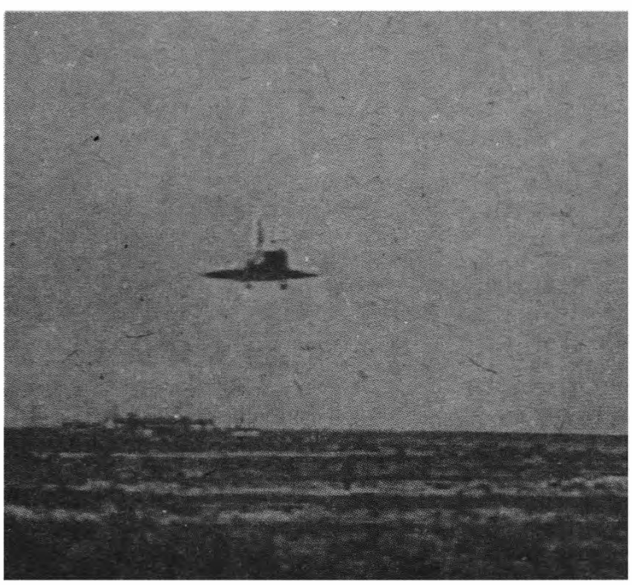
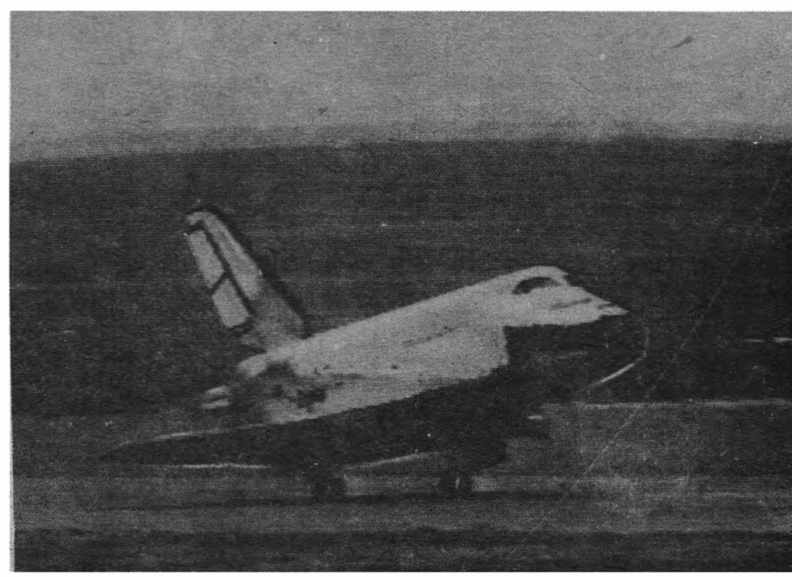
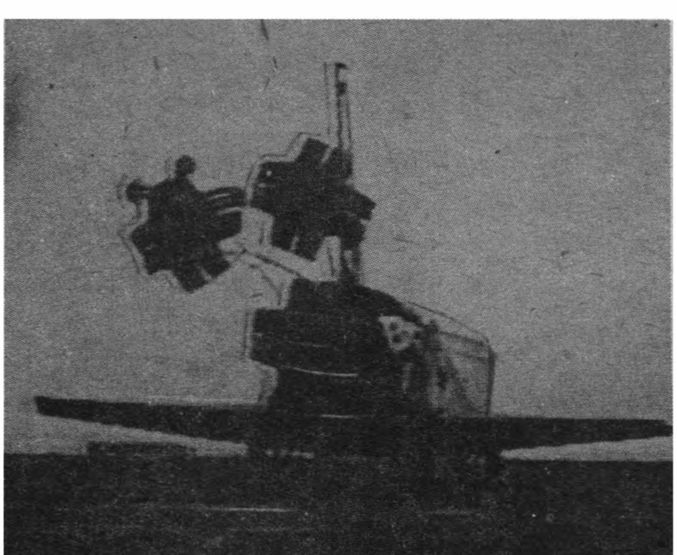
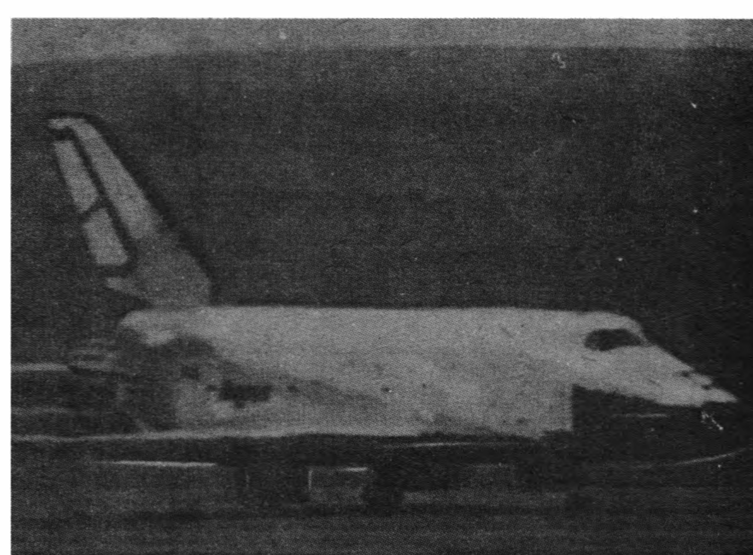
(Top right) Buran and Energia are obscured by the intense exhaust of the strap-on boosters, as the vehicle clears the launch tower.

(Centre left) After completing two orbits of the Earth Buran makes its final approach to the runway at the Baikonur Cosmodrome.

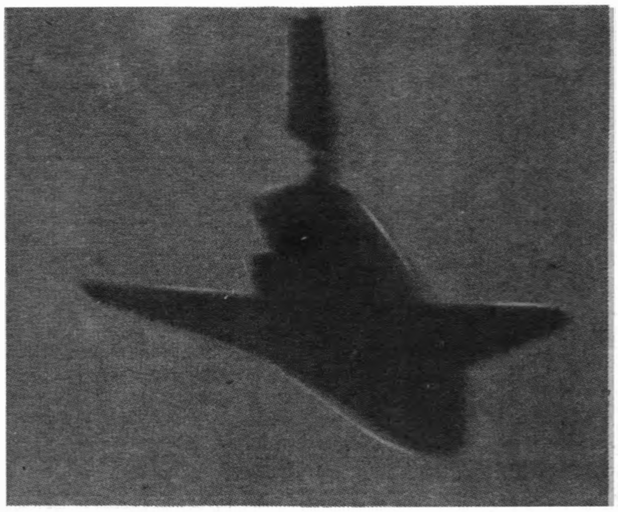
(Centre right) Buran touches down under automatic control.

(Bottom left) Buran is slowed by three parachutes.

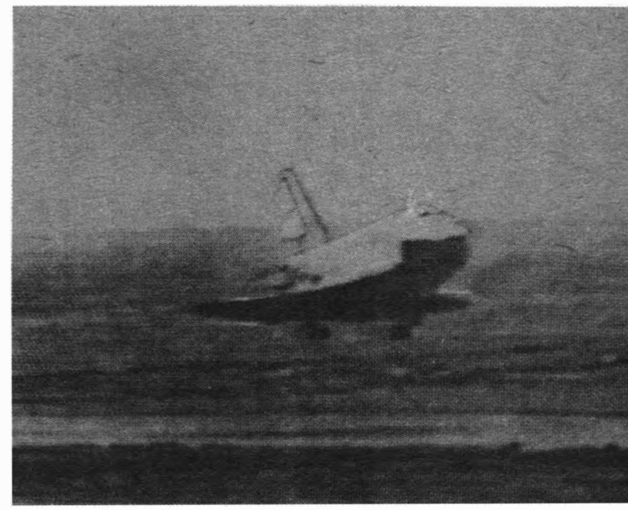
(Bottom right) Buran's aft area is discoloured by the firey blast-off and reentry into the Earth's atmosphere.

MISSION REPORT



Buran's split rudder air brake is clearly visible in this photograph taken from the Mig-25 chase plane during decent.



Buran seconds before her main gear touch down on the concrete runway at Baikonur.

orbiters, the Soviets said. The landing complex also includes radio aids, ranger finders, landing and air traffic control systems in the area of Baikonur, a six-storey building which contains equipment to receive telemetry and other information, a computer centre, units of navigational and landing systems, and communications and meteorological centres.

The tásks of the control centre are the detection and guidance of the landing approach and its post-flight maintenance.

Navigators in the main control centre have display units and plan-position indicators which give them information about the orbiter's height, range and speed amongst others.

The Flight of Buran

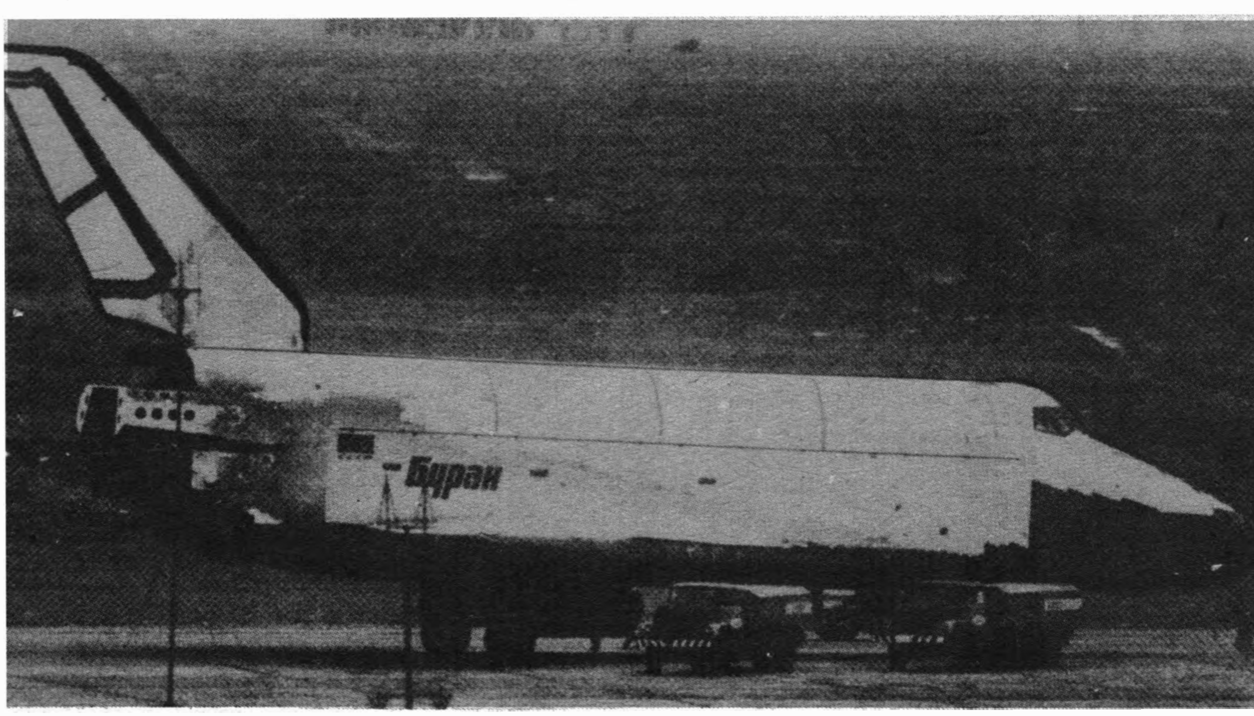
A. Dunayev had promised live coverage of the launch of the Soviet shuttle but in reality both the October 29 attempt and the November 15 launch were not covered in real-time by the Soviet media. Moscow radio announced the event, which occured at 0300 GMT, at 0411 GMT. The landing was reported after only a few minutes delay with the TV of the event being shown less than an hour later.

Pictures of the launch had taken almost 4 hours to be shown on Soviet screens.

The weather for the launch was grey and cloudy. Indeed, the State Commission which authorised the launch met urgently to decide if the conditions were right for the launch to proceed. There was concern because a cyclone was being monitored moving towards Baikonur from the Aral Sea bringing gusting winds. The fear was rain could form ice on Energia and Buran. The temperature at the launch site was just 4 degrees C, and the surface of Energia's fuel tanks would be even colder once loaded with their cryogenic propellants.

Thirty minutes before the launch, Tass said, the launch pad was deserted. During other launches the

Buran is attended to by a number of service vehicles after coming to a stop on the runway. *Novosti*



personnel had been on the launch pad until 15 minutes to ignition, but for Energia the pad was evacuated some six hours before launch when the rocket began to be loaded with liquid hydrogen.

The spacecraft's on-board computer system was activated at 0249 GMT. This put the pre-launch preparations into automated mode. Tass said, "man can no longer interfere". During the final minute the platforms and service towers dislocated from the Energia Buran system. At launch the combined weight was 2,400 tonnes, some 90 per cent of that was fuel.

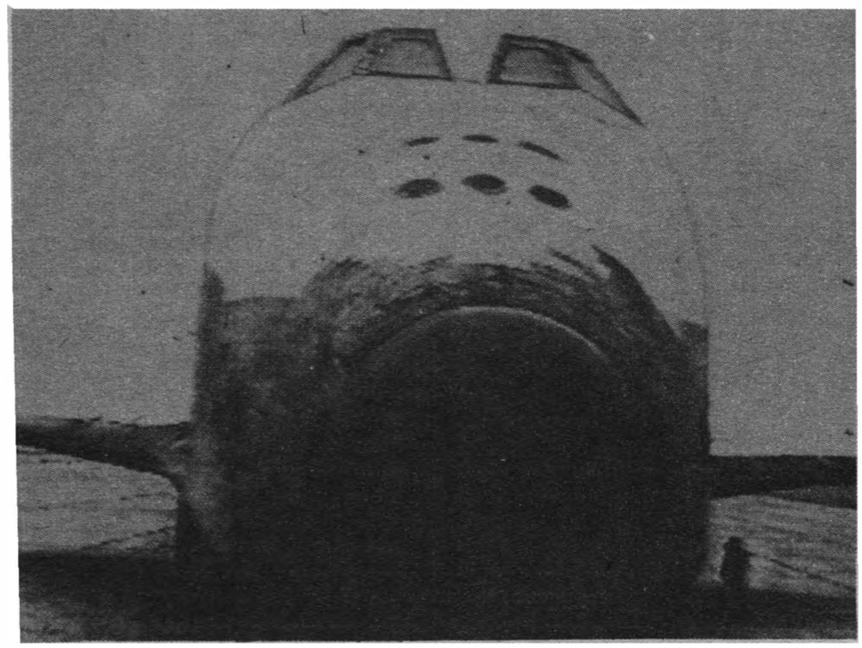
About 8 seconds before launch, according to the TV pictures, the liquid oxygen/hydrogen fuelled core stage, with four single chamber rockets each with a 200-tonnes thrust, ignited. The launch pad was surrounded with a huge cloud of steam as the exhaust was deflected down a 23 metre deep, 20 metre diameter shaft. Then the four strap-ons ignited simultaneously. Each of these liquid-fuelled strap-ons has a four-chamber RD-170 engine with a thrust of 800 tonnes and are powered by liquid oxygen and kerosene.

The pad was illuminated by the bright glow as the rocket lifted slowly off the pad and shortly ascended into low grey clouds. Two and a half minutes later the rocket was at an altitude of 60 km. The strap-on first stage rockets, having depleted their fuel, were separated in pairs to land back on Earth. The Soviets did not recover the stages this time, but will do so in future. The rockets can be parachuted to Earth for recovery and reuse.

The core stage continued burning until eight minutes after ignition when, at an altitude of 110 km it separated from the orbiter. This was to ensure that the core stage entered a sub-orbital trajectory that would ensure it was destroyed in the atmosphere over the Pacific Ocean. Buran, however, continued upwards. The orbiter began a "pre-start system for creating artificial gravity to separate the fuel and gas," Soviet TV reported.

The orbiter's own manoeuvring system fired for 67 seconds once an altitude of 160 km was reached. At 0347 GMT, after another 42 second burn, Buran reached the calculated 250 km orbit at an inclination of 51.6 degrees. It then flew over the Pacific Ocean, to the west of the southern tip of the south American continent. The orbiter was orientated in space with its port wing towards Earth.

During its planned two orbit mission Buran's telemetry was continuously monitored by the Soviets. The flow of data was uninterupted, not "even for a second," they said.



An unusual view of Buran standing on the runway at Baikonur soon after landing.

The communication system for the mission involved the Soviet Earth-based tracking network stretching from the Crimea to the Far East being supplemented by four ships and four satellites.

The research ships Cosomonaut Vladislav Volkov and Cosmonaut Pavel Belyayev were located off the western coast of Africa while the other two – the Cosmonaut Georgi Dobrovolski and Marshel Nedelin – were stationed near the western coast of South America.

Two Molniya satellites in highly-inclined, highly-elliptical orbits and two geostationary satellites – Luch and Gorizont – were also used to relay data.

The transmitted data was displayed in real time to the staff of the Moscow control centre.

The Soviets did not release any pictures from the shuttle in orbit. Although pictures of the rotating Earth were visible on screens at the Flight Control Centre, presumably transmitted from cameras onboard Buran.

After turning around with its nose now pitched up, the orbiter entered the Earth's atmosphere.

Western analysts said that the orbiter demonstrated an "extensive cross-range capability" on this portion of the flight with the spacecraft initiating a long banking manoeuvre to the right to put it on target for the Baikonur cosmodrome. Other banking manoeuvres were used to slow the spacecraft down from 25 times the speed of sound to landing speed.

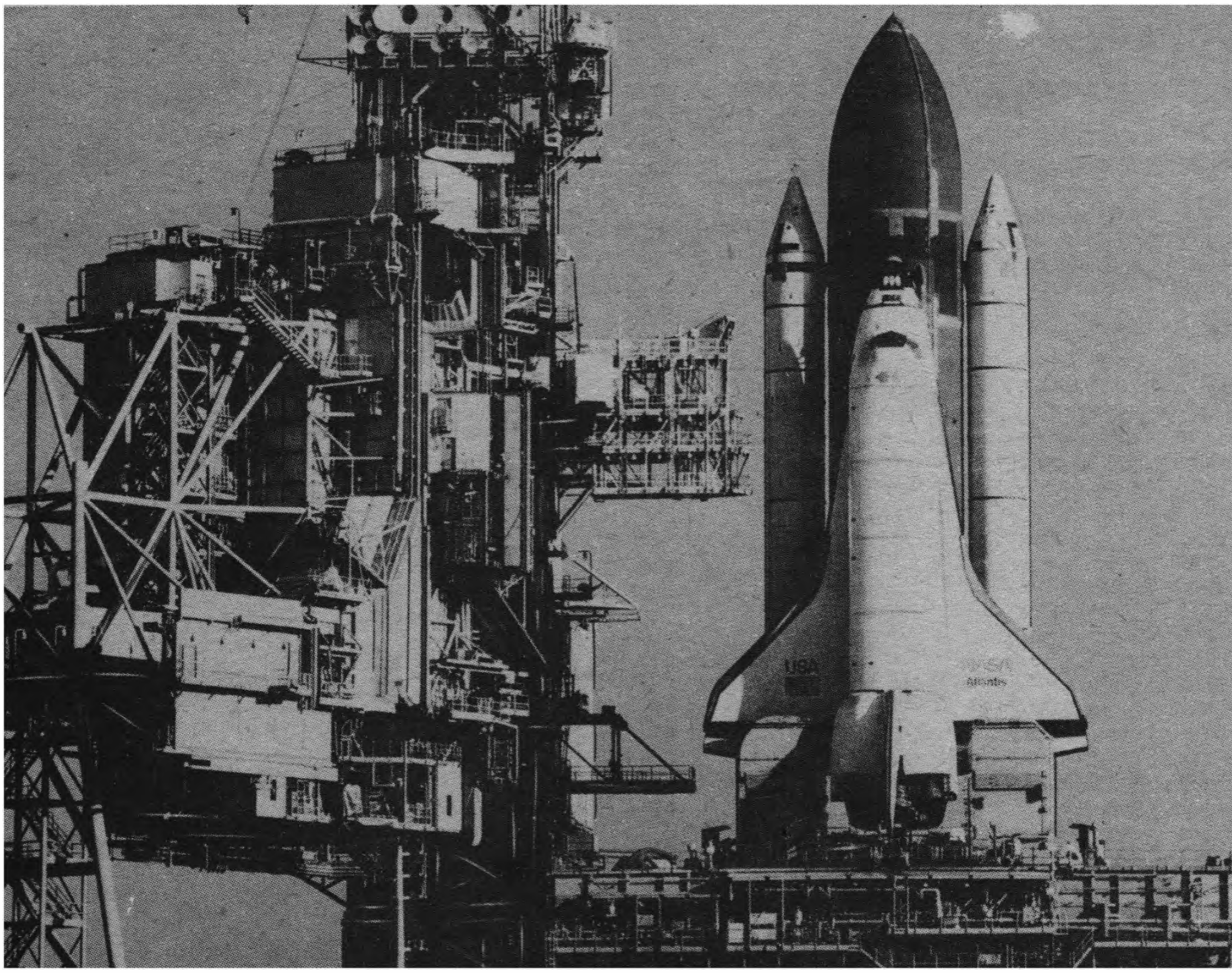
With the orbiter closing on Baikonur it completed a tight turn to put itself onto the proper heading for the approach and landing. Many features of the deorbit and landing were similar to those used by the US shuttle.

A Mig-25 fighter aircraft, piloted by a man who may be a trainee shuttle pilot, intercepted the descending orbiter and beamed TV pictures of the final approach to the concrete runway. Buran deployed its landing gear and, slightly unevenly, touched down at 0625 GMT. It rolled to a stop after about 30 seconds after discarding the three parachutes which had deployed after touchdown. The first mission of Buran had ended in complete triumph with the white-and-black vehicle looking slightly scorched and worn in certain areas.

Soviet leader Mikhail Gorbachev, whose policy of openness had allowed the Soviet people and the world to share the flight of Buran, said that the flight represented an "outstanding victory" which opened up a "qualitatively new stage in Soviet space research."

However, Mr Roald Sagdeyev described Buran and its American counterpart as costly mistakes. Sagdeyev, the retiring Director of the Soviet Space Research Institute, said the shuttle "is technology of the 21st century, why should we pay 20th century money for it?"

Soviet reports said that the next flight would be manned and that a docking with the Mir station was anticipated. The manned flight's date was not known, however, because the first flight's results would need to be analysed thoroughly.


USA
Atlantis


(8)

Atlantis in Action

The space shuttle Atlantis blasted off into almost complete secrecy on mission STS-27, the second shuttle flight following the Challenger accident. This was the third dedicated military shuttle mission and the second for Atlantis.

Atlantis was launched at 14:30 GMT on December 2, the final launch time was revealed just nine minutes before T-O. On November 28, shortly after midnight, NASA set an invisible countdown clock in motion. The launch had originally been scheduled for December 1, but the threat of showers and unacceptable high altitude winds caused a postponement of 24 hours. High winds also threatened to halt the second attempt but the winds died down and Atlantis lifted off into near perfect skies. The good weather conditions resulted in some of the best television pictures of a shuttle launch, with the Solid Rocket Booster (SRB) separation clearly visible.

Top: Atlantis on the launch pad prior to launch on December 2, 1988 on Mission STS-27.

Bottom: The five-member crew for Mission STS-27, dressed in their partially pressurized flight suits, walkout of the Operations and Checkout Building on their way to Pad 39-B. From right to left are: Commander Robert L. "Hoot" Gibson; Pilot Guy S. Gardner; and Mission Specialists William M. Shepherd, Richard M. (Mike) Mullane and Jerry L. Ross.

During the launch a NASA Public Affairs Officer provided commentary, but the usual communications between the crew and mission control were not broadcast. Soon after launch mission control made the following announcement:

> "This is Mission Control Houston at 4 hours 3 minutes 45 seconds mission elapsed time for the flight of STS-27. The crew of Atlantis has been given a go for orbit operations by the Mission Control Center. The Atlantic crew members are doing well, and all systems of the orbiter are performing satisfactorily."

This was the last status report from Mission Control until the re-entry and landing.

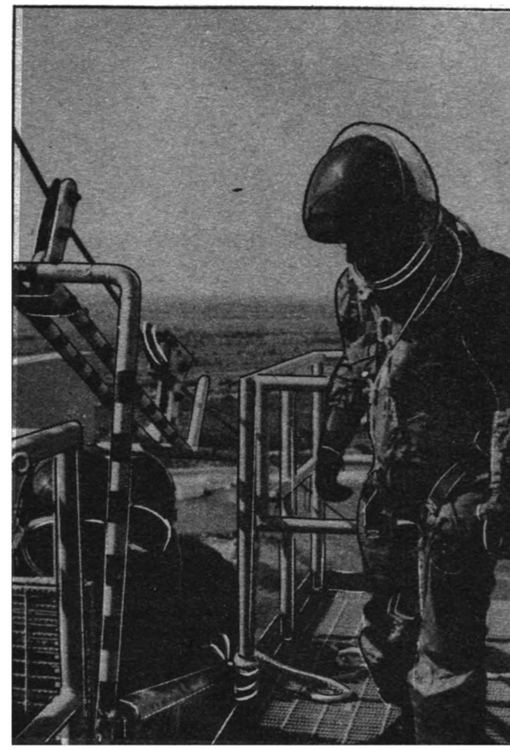
Despite various attempts by NASA and the Department of Defense the details of previous military missions were leaked to the press well in advance. STS-27 was no exception. Even the Soviet news agency Tass described the top secret payload:

> "The main task of the secret mission is to put into near-Earth orbit a new generation reconnaissance satellite, code-named Lacrosse. The satellite will conduct surveillance of the territory of the Soviet Union with the help of updated radar. The Pentagon plans to deploy in the next few years four other similar satellites which will play the role of an 'eye' for the new strategic bomber B2 known as "Stealth."

Atlantis was launched into a high inclination orbit to allow Lacrosse 80% coverage of the Soviet Union. The $500 million satellite was thought to have been deployed by the shuttle's remote manipulator the day after launch. Lacrosse's onboard systems were checked out while Atlantis stood by, if any malfunctions were discovered the expensive satellite could have been retrieved by the shuttle crew.

Atlantis returned to Earth and made a landing at Edwards Air Force Base on December 6.

The SRBs for STS-27 were returned to Cape Canaveral Air Force Station in the evening of December 3. Initial examinations of the booster exteriors revealed no damage to the joints that caused the Challenger accident.



STS-27 crew members rehearse getting into a slide wire basket on the 195 foot level of Pad 39-B during a countdown dress rehearsal for the astronauts and the KSC launch team prior to the launch of Atlantis. *NASA*

Freedom Docking Tests

Preliminary tests on a docking mechanism designed for use on the Space Shuttle orbiter and Space Station Freedom have been successfully completed. The tests were carried out by NASA, McDonnell Douglas and United Technologies.

The mechanism is designed to complete a docking manoeuvre in space between the orbiter and the station. It accommodates the capture of two free flying bodies while dissipating the energy from impact. Subsequent to capture, the mechanism also aligns the two space vehicles and provides a pressurised passageway.

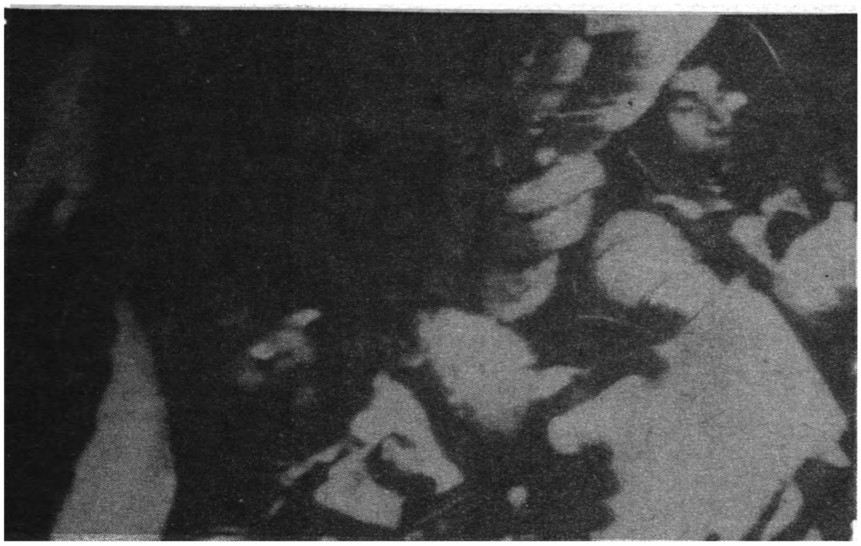
The dynamic testing was performed at NASA's Marshall Space Flight Center in Huntsville, Alabama, and actually achieved simulation of docking the orbiter to Space Station Freedom.

The mechanism achieves capture and energy absorption using computer controlled electro-mechanical actuators/attenuators. This is the first US space docking mechanism development since the Apollo–Soyuz docking system in the mid-1970's and is more complex because of the unique geometry of the shuttle orbiter.

The docking mechanism on the orbiter will be located 11.88 m (39 ft) forward of centre of gravity. Consequently, when contact is made with Space Station Freedom, there will be a jack knife effect. Thus, special effort must be applied to absorb that energy, and the computer controlled system is programmed to cause the electro-mechanical actuators/attentuators to respond correctly.

The overall design of the mechanism and the design and construction of the control system electronics was performed by McDonnell Douglas Astronautics Company. The construction of the docking structures was done by United Technologies Space Flight Systems in Huntsville. The work was completed under a NASA Marshall Space Flight Center research and development contract.

INTERNATIONAL SPACE REPORT



A TV picture transmitted from the capsule during lift-off of the Franco-Soviet mission to the Mir space station. The launch took place at 18:50 Moscow time on November 26, 1988 and the Soyuz TM-7 docked with Mir at 20:16 on November 28.

The white marks near the cosmonauts' faces are reflections of a light source in their space suit visors.

On board Soyuz TM-7 were Soviets, Alexander Volkov, Sergei Krikalev and French cosmonaut Jean-Loup Chretien.

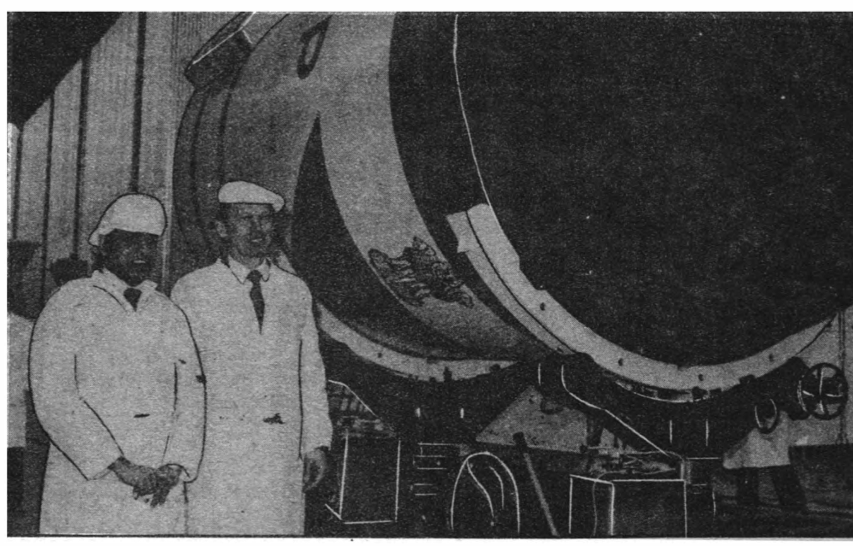
Vladimir Titov and Musa Manarov were due to return to Earth on December 21, 1988 after spending a year in orbit. Jean-Loup Chretien will return with them.

Soviet–Indian Cooperation

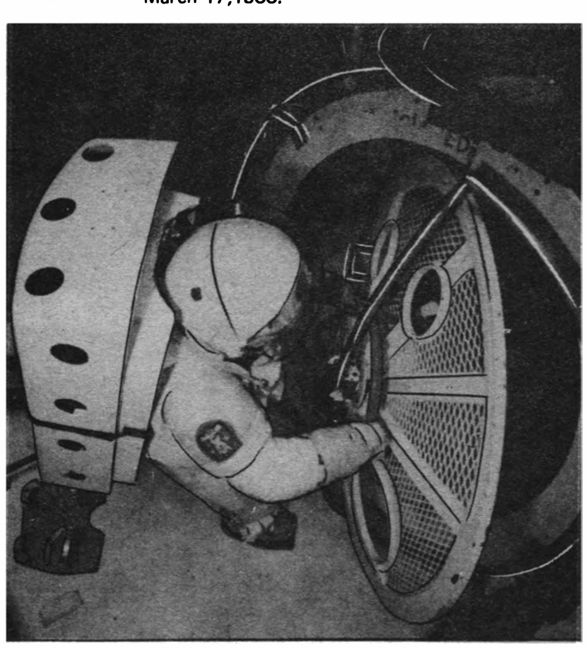
The Soviet Union and India have signed an agreement for the launch of the IRS 1-B satellite by a Soviet launch vehicle.

At a meeting in New Delhi the Soviet and Indian space officials drew up a plan for cooperation in space research for the next ten years. The plan includes an agreement for the launch of the ISR 1-B earth resources satellite in 1991. The Soviet Union launched the satellite's predecessor IRS-1A on March 17, 1988 by a Vostok (A1) vehicle.

Glavkosmos head Aleksandr Dunayev said India has been offered facilities for carrying out experiments onboard Mir and the possibility of launching a dedicated module to be docked to Mir was discussed. Dunayev said Soviet officials will meet again with their Indian colleagues to discuss the technical problems involved.



Dr. K. Kasturirangan, Project Director, IRS and Dr. I.V. Goreshkov, Project Director on the Soviet side stand by the launcher shroud of the IRS-1A operational remote sensing satellite launched on March 17,1988. *ISRO*



An airlock concept for the Freedom space station is evaluated by astronaut Gregory Harbaugh in the weightless environment of a 25-feet deep pool at the Johnson Space Center. The hatch seals with the assistance of pressure which may be applied in either direction. *NASA*

Astronaut Bobko Retires

Astronaut Karol Bobko (Col. USAF) retired from NASA and the US Air Force on January 1, 1989. Bobko has commanded three shuttle flights.

Bobko has been an astronaut since 1970 and was a member of the Skylab medical experiments altitude test in 1972. He served on the astronaut support crews for the Apollo–Soyuz Test Project in 1975 and the Shuttle Approach and Landing Tests at Edwards Air Force Base.

Bobko, a member of the British Interplanetary Society, flew three Shuttle missions, they were, STS-6 (the maiden flight of Challenger), STS 51-D and STS 51-J (a DoD mission and the first flight of Alantis).

Bobko will be joining the Space Systems Division of Booz, Allen and Hamilton, Inc. He will be directing their activities in the Houston area with initial emphasis on Space Station programme support.

Roelof Shuiling

Magellan Fire Report

The Magellan probe to Venus suffered a small but intense electrical fire on October 15, 1988. At the time Magellan was in the Spacecraft Assembly and Encapsulation Facility (SAEF-2) at the Kennedy Space Centre (KSC).

The Magellan was in the process of undergoing an extensive checkout of the electrical power system following the connection of a power control unit. A pair of test batteries had been installed in the spacecraft to support this activity. During this procedure sparks, flames and smoke were observed from the battery connector and fire fighting measures were initiated. A halon fire extinguisher was directed at the battery connector and its thermal blanket. The flames momentarily subsided and then rose again from beneath the battery thermal blanket. Technicians cut away portions of the blanket, sprayed the area again with the fire extinguisher and the flames died. Although some minor sparking was observed there was no further indication of fire or smoke.

An investigation board was formed to determine the cause of the fire, analyse the damage, and how to prevent such occurrences in the future. The board was formed under the chairmanship of Jon B. Busse, Director of Engineering at NASA's Goddard Space Flight Center. Additional board members included: Chester Vaughn, Chief of the Propulsion and Power Division of the Johnson Space Center (GSFC); William G. Mahoney, Chief of the Payload Processing Division of KSC; Brian Keegan, Deputy Director of the Office of Flight Assurance at GSFC; and G. Ernest Rodriquez of GSFC.

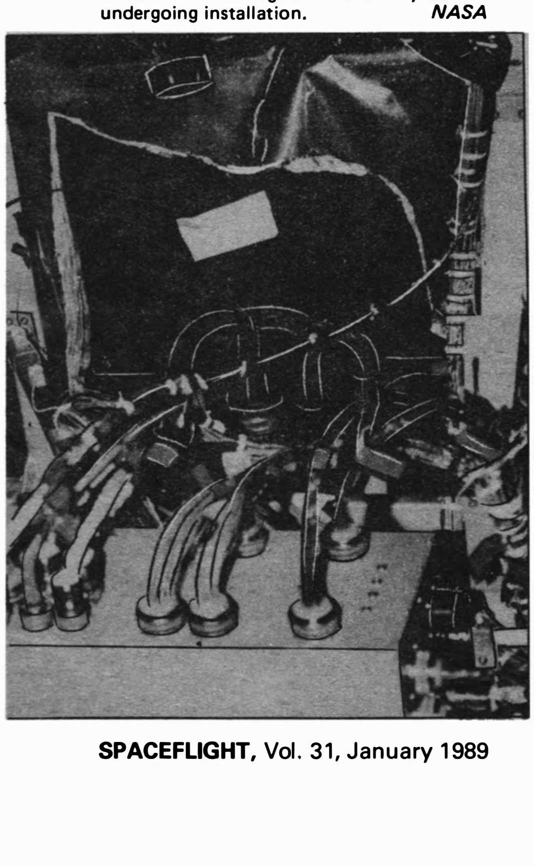
On November 9, the board released their findings. The primary cause of the fire was the incorrect connection of a jack. This created a short circuit within the connector that resulted in electrical arcs which created additional short circuits. This in turn caused damage to the battery connector and thermal blanket.

Contributing causes were that, although the jack was designed to prevent incorrect connections, it was possible to get electrical contact on several of the 37 pins in the jack. In addition the technician had to make the connection in a confined area without direct visibility of the jack.

The damage to Magellan was determined to be confined to the test battery, a connector, and a thermal insulation blanket. The total hardware cost is estimated at approximately $87,000. There remains no impact to the Magellan launch date as a result of the incident.

Roelof Schuiling

Part of the Magellan spacecraft in which an electrical fire damaged a test battery while undergoing installation. *NASA*



The insignia for mission STS-28. Designed by the astronaut crew, it depicts America (the eagle) guiding the American space program (the Space Shuttle) safely home from an orbital mission. *NASA*

Cassini Gets ESA Go Ahead

ESA's Science Programme Committee (SPC), at its meeting in Paris on November 24-25, selected the planetary Cassini/Titan probe mission as the Agency's next scientific project.

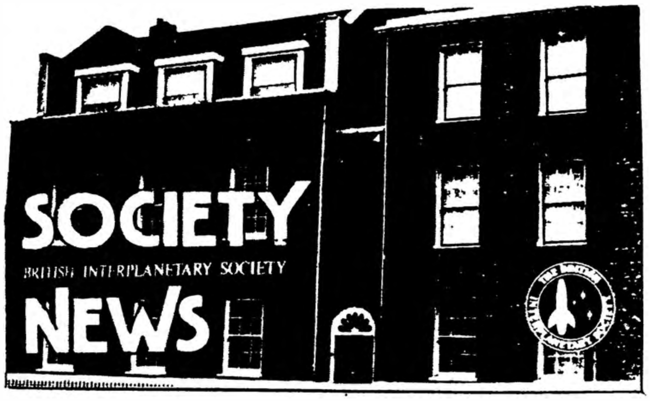
The Cassini mission was named after the French-Italian astronomer who, in the 17th century, discovered several of Saturn's moons and ring features, the so-called Cassini division. The project is a cooperative international mission involving NASA and ESA. The Saturn moon Titan, which is the largest moon in the solar system, is a special target for the Cassini mission. This intriguing body is also the only moon in the Solar System which is known to have a thick, organic-rich nitrogen atmosphere. The surface pressure is 1.5 bar and the temperature is 94K (−179°C). Scientists believe that the chemical processes in the Titan atmosphere may resemble those at work on the primitive Earth before the origin of life.

The SPC decision is the conclusion of a six-year study, which started in early 1983 after the initial proposal was received from a European team led by Dr. Daniel Gautier from the Observatoire de Paris, Meudon, France, and Dr. Wing Ipp of the Max-Planck-Instut für Aeronomie, Katlenburg-Lindau, Germany (FRG) who suggested that this mission be undertaken jointly with NASA.

"With Cassini, and after the remarkably successful Giotto probe mission, ESA is introducing planetary exploration as a major theme in Europe's Long term Space Science Programme, Horizon 2000" said Roger Bonnet, Director of ESA's Scientific Programme.

Saturn and its system of rings and satellites, in particular Titan, were briefly encountered in 1980-81 by the Voyager 1 and 2 spacecraft. The Cassini mission will place a NASA-built orbiter around Saturn which will target and deliver the ESA-built probe into Titan's atmosphere. Cassini is scheduled to be launced in April 1996 by NASA. It will arrive in the Saturn system in October 2002. En route to Saturn, the spacecraft will fly-by the asteroid 66 Maja in 1997 and Jupiter in late 1999.

The major event, which will take place upon arrival of the Cassini mission to Saturn, is the targeting and release of the ESA-built probe into Titan's atmosphere. The probe was named Huygens, after the Dutch astronomer and physicist (1629-1695) Christian Huygens who discovered Titan and the Saturnian rings in 1656. A large conical decelerator will slow the probe down to reach subsonic speed (266 m/s) at an altitude of 180 km. Then a parachute system will be deployed to allow a slow, two to three hour descent to the surface of Titan which may be covered by ethanemethane lakes or oceans, as many scientists speculate. The 5 m/s low-velocity impact may be soft enough to allow analysis of a surface sample before the probe diets. During the descent of Huygens, the orbiter will be used as a radio relay station to transmit the probe's data to Earth. Subsequently to Huygen's mission, the Cassini orbiter - during its four-year Saturn tour – will fly over Titan's surface more than 30 times, sometimes at an altitude of only 1000 km.



Membership

Our thanks to all members who have responded by completing and returning their forms for renewal of membership for 1989. Subscriptions to the Society for 1989 fall due on 1 January 1989 and it is now an urgent matter for anyone whose dues are outstanding to send to the Society if magazines are to be dispatched to them without interruption.

Many members take the opportunity when sending to the Society at this time of the year to add a few lines of comment about the Society. Replies are, of course, sent when called for, but usually this is not the case and we would like to express our appreciation for all viewpoints received. Lawrence Brown, ACT, Australia writes:

> Please find enclosed my payment for Fellowship of the BIS. My congratulations and thanks for another year of informative and challenging articles in the Society's publications. They form my most regular and in-depth source of news in the field of astronautics. Thank you for all your efforts.

The Society aims to continue to actively promote its objects in the coming year and it is with this in mind that fees for 1989 were determined. The increase in fees for 1989 has prompted very few comments and these have mainly centred on the use of the word 'modest'. Donald Babbage, Essex writes:

> I enclose my subscription for 1989. I think it only right to express my view that a 17½% increase cannot really be described as 'modest'. I thought long and hard before renewing.

Commenting on the increase the Executive Secretary points to the continuing need to counterbalance inflation which adds significantly to the cost of publications and their distribution and, additionally, to the need to ease the Society's tight budgets of recent years and so enable it to continue operating with adequate staff and modern office facilities. With inflation at its present level and possibly going higher, the extra money which the Society is asking of its members is, in real terms, a fractionally small amount that is considered essential to the Society's future operations. Seen in this light, the increase merits enthusiastic support and members who have not yet renewed for 1989 are urged to do so without delay.

Members Write:

I am delighted to enclose my re-subscription to ***Spaceflight.*** I am proud to be part of an organisation which helps to improve the quality of life on Earth for all Mankind by supporting the worldwide trend to explore and exploit the limitless environment of Space.

Enclosed is a cheque for a copy of the March 1988 issue of ***JBIS (Journal of the British Interplanetary Society).*** I wish that I had learnt about the British Interplanetary Society many years ago! I consider it an honour to be a Member now.

* * *

Eugene Popin – Obituary

We much regret to record the death of the Society's oldest Fellow, Dr. Eugene Popin, just a few months short of his 101st birthday.

Dr. Popin played a major role in the definition and development of many aspects of space law. His remarkable life included membership of the Central Drafting Committee of the Peace Conference from 1918 to 1920, an active role in the formulation of the Paris Convention on Civil Aviation in 1919 and Director of the Institute of Air and Space Law at McGill University. He was a founder and elected first President of the International Institute of Space Law in 1951 and authored numerous pioneering works on air and space law.

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.

LIBRARY

The Society Library is closed until further notice due to continuing building work at the Society's HQ.

4 January 1989, 7.00-8.30 p.m. Lecture

ROCKET MAIL

A lecture by James Goddard, Curator of Space Technology of the Science Museum. Three decades before satellite communications became a reality, rocket technology promised another means of communication over substantial distances. Before the 1930's, 'Rocket Mail' would, it was argued, result in publicity and funds for contemporary rocket pioneers. Was it ever a pragmatic approach to communications or, as some suggest, merely a fund-raising exercise resulting in a colourful and lucrative market for the philatelist?

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

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

THE DAWN OF THE SPACE AGE

A lecture by Dr. John Becklake. The space age began on October 4 with the launch of Sputnik 1. This was the culmination of a sequence of events dating from the start of the 20th Century. The development of rocket technology between 1900 and 1957 and the change on the political and public awareness of the imminence of space flight during this period will be discussed with the aid of slides and unique film clips.

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

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 number of noted space pioneers known to the speaker, including Wernher von Braun and Val Cleaver.

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

Delegates at the opening ceremony of the IAF Congress, Bangalore, India, October 1988.

Society at 39th IAF Congress Bangalore

The Bangalore Congress, held during the period 10th to 14th October 1988, attracted an attendance of 875 from 33 countries. The strong UK contingent included four Members of the Council and the Executive Secretary.

The Society's official delegates were Dr L. R. Shepherd (Vice-President) and the Executive Secretary.

The Opening Session began with a message from the Prime Minister, Mr Rajiv Ghandi, calling for a concerted effort to enable developing countries to have full access to the benefits of space technology. Mr Ghandi had intended to inaugurate the Congress personally but was prevented from doing so by other circumstances. His speech was read by the Union Minister of State and Technology, Mr K. Naryanan.

Mr Ghandi said that India had made important strides in its own space progamme, which was closely linked to its developmental needs. Space technology touched communication, meteorology, agriculture, education, environment, health, entertainment and disaster mitigation. It had the potential to provide a new perspective of the Earth.

The Indian Space Programme began 25 years ago with the establishment of a sounding rocket station at Thumba. India had launched 11 application satellites over the last two decades, eight of which they had built themselves. Today, the multi-purpose Insat satellites have revolutionised communications in India, enabling those in even the remotest parts to be in touch with the mainstream of the Nation, while remote sensing applications were providing vital inputs in the management of agricultural, mineral, environmental, forest and soil resources.

The President of the IAF, Dr J. Ortner, pointed out that the IAF now has more than a hundred members from 38 nations though the member-bodies belong to only one quarter of the nations of the world. He confirmed that an important goal of the IAF was to motivate all nations to work together in peace for the benefit of mankind. The fact that the Congress was being held in India showed the IAF emphasis on the developmental perspectives of space technology. The Congress theme was "Space and Humanity", with India an exceptional example of how a developing country could use space, even with limited funds, for the well-being of its people.

Dr V. Kopal read a message from the UN Secretary General, Mr Perez de Cuellar, emphasising that the benefits of space technology should be made available to all countries.

Professor U. R. Rao, Chairman of the Indian Space Research Organisation said that the Indian Space Programme had seen both its successes and failures. What sustained its development was the conviction that its space programme could transform the lives of the people of the country.

More than 600 scientific and technical papers were presented at the 70 sessions, attracting an average attendance of 40 per session. It was reported that 6000 had visited the accompanying Space '88 exhibition.

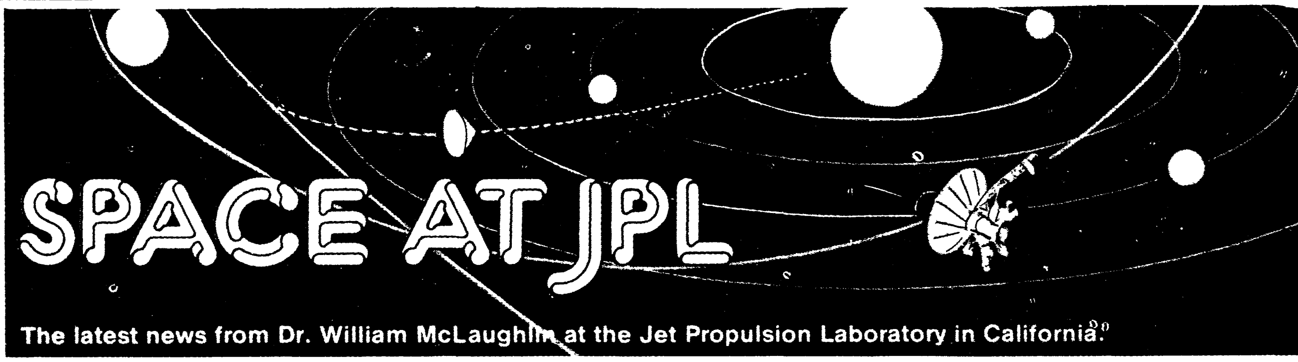
At the business sessions Dr G. Van Reeth was elected President of the IAF for the following year. The six Vice-Presidents also elected were Dr Chernyi, Dr Joachim, Dr Rao, Dr Lu Yuanjiu, Dr Alvaro Azcarrago and Mr J. Harford. The 40th IAF Congress will be held in Beijing, China over the period 7th-13th October 1989. The theme will be "The Next 40 Years in Space".

Technical sessions included a number organised by the International Academy of Astronautics, which was established in 1960 to recognize individuals of great achievement and to promote the peaceful uses of outer space and co-operation between nations in the advancement of aerospace science. In fulfilling these purposes the Academy's 1000 members have established liaison with other international aerospace bodies and with several National Academies of Sciences, hence a joint meeting of the IAA and the Indian National Academy (INSA) – preceeding the Congress proper – was held in New Delhi on 7th October at INSA.

The morning session of the INSA was convened by B. M. Reddy, Head, Radio Sciences Division, National Physical Laboratory and consisted of six papers describing the work on Low Altitude Aeronomy in India.

During the afternoon meeting, greetings from Dr George E. Muller, (President of the IAA) and Dr A. S. Paintal, (President of INSA) were presented to the delegates. The fourth IAA Scientific Lecture "Global Modelling and Space Data" was read by Prof. Jacques Louis Lions, President of the Centre National d'Etudes Spatiales (CNES) of Paris and member of the French Academy of Sciences.

Elections to the Academy included many well-known BIS Fellows, among them Jack Cherne, John Hodge, John Becklake, W. Geisler and Michael Michaud.



Asteroid Len Carter

In the *Minor Planet Circular* of August 27, 1988, it was announced that the asteroid formerly labelled 1979 MKL had been entered into the International Astronomical Union's (IAU) official catalog of asteroids as number 3817 and was named after Len Carter, Executive Secretary of the British Interplanetary Society. Discovered in 1979 by Eleanor F. Helin of JPL and S. J. Bus, a series of subsequent observations had allowed determination of a reliable orbit for the asteroid, and, hence, it became eligible for inclusion in the catalog.

The text of the IAU announcement reads:

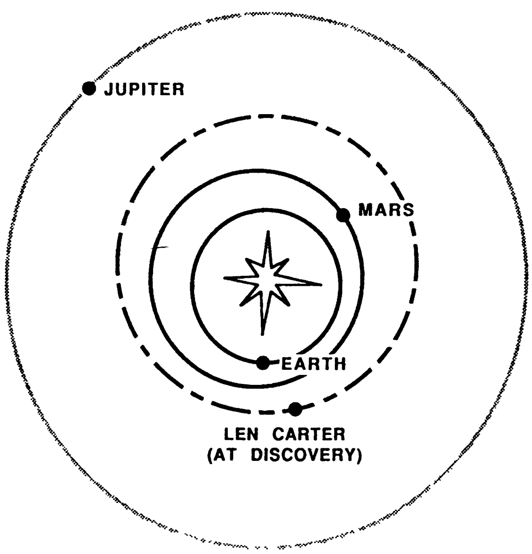
> "Named in honor of Leonard J. Carter, executive secretary of the British Interplanetary Society. For more than 50 years, his efforts have been the basis for the constructive role of the BIS in space advocacy, education and international communications. Name proposed by the first discoverer [E. F. Helin] following a suggestion by W. I. McLaughlin and endorsed by R. L. Staehle."

Asteroid 3817 Len Carter is the story of two people: Carter and Helin.

In 1937, at the age of 15, Len Carter joined the British Interplanetary Society, four years after its founding. He was one of the leaders in resuming development of the Society after a hiatus due to World War II. Assuming the position of "interim Honorary Secretary" in June 1945, as a member of the committee planning the re-formation of the BIS, he was formally installed in the position when the Society was incorporated on December 31, 1945.

The path of Carter's career can be tracked by observing the growth of the BIS itself. See, for example, historical surveys by Frank Winter and Dr. L. R. Shepherd in the November 1983 and January 1985 issues of ***Spaceflight***, respectively.

My acquaintance with his work has been limited in time and scope but represents direct knowledge. Although we had some limited contact in the early 1970s with respect to publications, it wasn't until I began to make regular trips to England in 1976, in conjunction



Asteroid 3817 Len Carter's orbit lies in the main belt of asteroids between Mars and Jupiter. The configuration of bodies is shown for June 25, 1979 when the asteroid was discovered by E.F. Helin and S.J. Bus. *NASA/JPL*

with the Infrared Astronomical Satellite (IRAS), that he and I got together on a more regular basis. The first occasions were visits to the small set of rooms in Bessborough Gardens which served as headquarters for the Society. When Carter talked about plans for the establishment of a more adequate site south of the Thames and the problems which such a move entailed, I came to realise the acumen and boldness of action of the undertaking. The present headquarters in South Lambeth Road is a facility of which all BIS members can be proud.

The quality of the Society's undertakings at all levels has been a concern of Carter: the wide-ranging collection of books in the BIS library (assembled in just a few years into a significant technical and historical resource); the Society's holdings in items of astronautical history; and programs of educational and scientific import, from specialized meetings to the Society's biennial space weekends (and hosting of the IAF Congress in 1987).

The most visible activity of the BIS is the publication of ***Spaceflight***, ***JBIS***, and occasional special studies. Carter's hand has supplied steady guidance along an upward path until, today, the voice of the BIS is a major contributor to the dialogue of the international space community. (On a mixed note, we have to hold him to account for asking me to begin the series of "Space at JPL" columns.)

It is a familiar observation that those imbedded in a period of historical change often fail to appreciate the flow of events about them. I remember sitting at the Saturday banquet at "Space 84", listening to Patrick Moore speaking in his inimitable style after dinner. When he said, "The Society exists today only because of the efforts of Len Carter", the material which I have sketched above clicked into place. Upon return to the U.S., I called Eleanor Helin and recommended that Carter enter the queue as a candidate for a named asteroid. The facts spoke for themselves, and four years later this event came to pass.

Eleanor Helin is a geologist by training, graduating from Occidental College in Los Angeles. In 1960, she joined the Lunar Lab at Caltech (the California Institute of Technology – Caltech – is JPL's parent organization). Hired by the geochemist Dr. Harrison Brown, she began work on analysis of the composition and structure of meteorites, extending these interests to statistical analyses of meteorite falls and finds.

Helen's career proceeded in a logical manner from meteorites to their larger brethren, asteroids. In the late 1960s, when she and Dr. Eugene Shoemaker

began research into near-Earth asteroids, there were only 8 or 10 of these objects known. Since that time, she and her team of investigators have concentrated on this category of celestial objects; over 100 near-Earth asteroids are now known, a figure due in no small part to their efforts.

Her first discovery of a near-Earth asteroid took place on July 4, 1973 using the 46 cm Schmidt telescope at Palomar, and the most recent asteroid of this class, discovered through the search programme, was picked up in August 1988 with the same instrument.

She reports that her team discovers two or three near-Earth asteroids per year, having to search approximately 13,000 square degrees of sky (almost one third of the celestial sphere) per asteroid discovery with a 46 cm Schmidt. Less amount of sky search, in square degrees, is required per discovery when the more powerful class of 122 cm Schmidt telescopes is utilized.

The search process with the smaller Schmidt employs a pair of 5-minute exposures of the same field separated by about one-half hour. The results are examined with a stereo microscope. To the trained eye, the slightly altered position of an asteroid will appear to levitate the image of that body into the third dimension above the general field of stars. The big Schmidt is used to take 60-minute exposures in the asteroid hunt. The exposure is not continuous; a time break is introduced to place a gap in the trail of the asteroid (the telescope is guided on the stars, which appear as point sources in the finished plate).

The presence of the gap allows one to eliminate the possibilities that the elongated image is due to a meteor, Earth satellite, or galaxy seen edge on. For a more complete review of the subject, see "Near-Earth Asteroid Searches: Status and Prospects," by E. F. Helin, in *The Evolution of the Small Bodies of the Solar System*, Soc. Italiana di Fisica, Bologna, 1987.

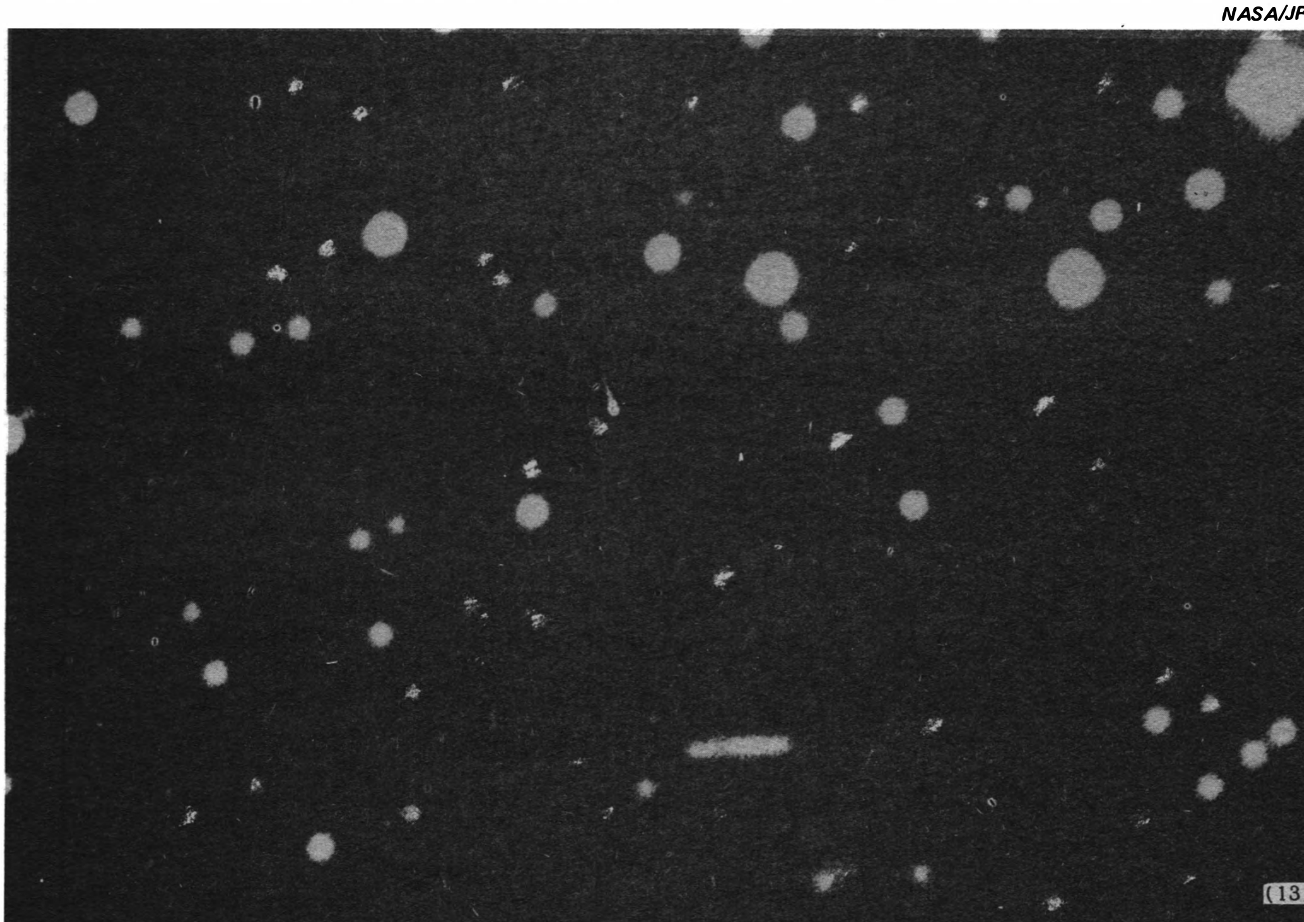
Asteroid 3817 Len Carter, with its semimajor axis of 2.27 AU and eccentricity of 0.11, plies the celestial routes between Mars and Jupiter, where the main belt of asteroids lies. Thus, it is not a near-Earth asteroid, but it represents a valuable scientific by-product of Helin's principal focus. In fact, her discoveries are numerically dominated by the classes of asteroids other than near-Earth objects. She estimates that she and her colleagues have contributed about 75 named asteroids to the catalog, and 406 "raw" (initial) discoveries were on her books for 1988 alone when we talked on November 1.

The selection of an appropriate asteroid is given careful thought by Helin when she is preparing to make an award (the IAU gives the discoverer of an asteroid the privilege of proposing its name, upon satisfaction of requirements concerning definite knowledge of its orbital elements). The asteroid which she selected for Len Carter was discovered (on June 25, 1979) at Siding Spring, Australia using the U.K. Schmidt, matching the ownership of the discovery instrument with the nationality of the recipient.

The award ceremony took place at "Space 88" in Hastings at the banquet on Saturday, October 1. Here, our two principals held centre stage as Eleanor Helin presented a plaque, with the discovery photograph and the official citation, to Len Carter. The interaction between these two accomplished people was one of those rare symbolic moments that give foundation to the thought that the world may be a rational place.

Afterwards, the general good feeling of the occasion was further augmented by a healthy sense of humour which bubbled through the evening. In mock indignation, Patrick Moore turned to Carter and said, "Your asteroid is bigger, brighter, and closer to the Sun than mine!" (Asteroid 2602 Moore was awarded to him in 1982 by the discoverer, Edward Bowell.) The Mayor of Hastings, the Honorable Mrs. Sandy Barr, said that the future might see use of the phrase "there is a beautiful, full Len Carter out tonight." The President of the Society, G. W. Childs, suggested that 100 years from now "Space 2088" might see the members holding their banquet on 10 km-diameter asteroid 3817 Len Carter, which, he said, would give a whole new meaning to the expression "dining out on Len."

Asteroid 3817 Len Carter is shown in this discovery photograph of June 25, 1979 as it moves through a star field in the constellation Capricornus.
NASA/JPL



Adventures in Software

The public face of the space program is replete with launch vehicles, images of distant worlds, astronauts and cosmonauts, funding shortfalls, and other familiar themes. Software – the computer programs and data that drive computer systems – is rarely discussed outside of specialised forums unless it has led a computer to do something exceptionally "dumb" or, at the other extreme, is reputed to codify near-human capabilities. In fact, a substantive fraction of the work of developing space systems is invested in producing flight and ground software to animate the more visible paraphernalia: hardware.

In a topic as extensive as machine computation, it is difficult to assign proper historical credit for advances, but the Hungarian-American mathematician John von Neumann (1903–1957) was a major contributor to the development in the 1940s of stored programs for real machines. In his paper, "From ENIAC to the Stored-Program Computer: Two Revolutions in Computers" (in *A History of Computing in the Twentieth Century*, Academic Press, 1980), Arthur Burks states: "His [von Neumann's] variable address EDVAC code was the basis of the modern computer software 'revolution.'" EDVAC was a computer developed at the Moore School of Electrical Engineering, University of Pennsylvania. The first revolution to which Burks's paper refers was accomplished with the construction of the ENIAC machine, a project begun in 1943 at the Moore school. "It was the first electronic, digital, general purpose scientific computer, and it computed 1000 times faster than its electromechanical competitors."

Languages for mediating between humans (programmers) and machines are continually being developed to meet the growing needs of users; one of the most successful languages, FORTRAN, was created in the mid-1950s.

A simple taxonomy of software for space applications distinguishes between flight and ground software. The former category, software carried onboard the spacecraft, can be further subdivided into programs, in more-or-less permanent residence, which provide the basis for spacecraft operations, and programs which carry out the mission plan and must be continually renewed as the mission progresses ("sequences"; see the following piece on ESOC).

Ground software systems are huge; JPL project and multimission program sets are built from millions of lines of code. My first involvement with ground software came in 1971 when I assumed the lead engineering role in developing the trajectory program for the Viking mission to Mars (1975 launch). The Program, DPTRAJ for "Double Precision Trajectory", was used for computing the flight paths for the two Viking orbiters during their interplanetary and Mars-orbit phases. It was derived from earlier trajectory programs, and its descendant flourishes to the present day at the Laboratory. (An historical survey of DPTRAJ and several other major JPL pieces of ground software is contained in my paper AIAA-88-0547, "Mission Operations Systems for Planetary Exploration", co-authored with D.M. Wolff and presented at the Aerospace Sciences Meeting in Reno, Nevada, in January 1988 TRP e.g. 1988.).

After more than two years of work on requirements analysis, design, and production of the computer code by our DPTRAJ team, the program was ready for testing prior to formal delivery to the Viking project. Testing involved two fundamental techniques: (1) comparisons of DPTRAJ results with those obtained by running earlier versions of the trajectory program ("regression testing"), and (2) independent calculation of special cases representing new Viking capabilities, and comparison of these cases with the numerical opinion of DPTRAJ.

Whatever shreds of sanity I emerged with after three months of testing, under schedule pressure, were undoubtedly preserved through the fortuitous advent of a new technology: the pocket calculator. I well remember the new-found ease with which the HP-45 calculator allowed construction of those special cases against which DPTRAJ could be judged. Prior to the invention of these delightful devices, engineers usually had to resort to consulting cumbersome tables of logarithmic and trigonometric functions and performing laborious interpolations by hand. But all is relative; one imagines the joy that spread through seventeenth century Europe when John Napier (1550–1617) conceived of the idea of logarithms and Henry Briggs (1556–1631) produced the logarithmic tables so useful in the simplification of calculations.

The unsophisticated methodology which I employed in testing the Viking version of DPTRAJ to free it from errors has been considerably improved in the last decade and a half. A conference, "Improving Software Quality", was held in Pasadena on July 13, 1988 under the sponsorship of the NASA Software Management and Assurance Program and JPL. A presentation by Al Pietrasanta, long a key manager at IBM, characterised the evolution of software quality from 1960 to the end of the century.

Pietrasanta said that statistical studies have shown that programmers introduce about 60 errors per thousand lines of code. Throughout the 1960s and 1970s the number of errors per thousand lines of code in the finished product decreased through improvements in the programmer's art and better methods of error detection. Late error detection, such as I pursued in DPTRAJ testing, cannot be expected to reduce the error rate to much less than 10.0 per thousand lines of code. However, in the 1970s the early detection of errors began to be emphasized, and a new spiral of error reduction was triggered. A software inspection technique created by Michael E. Fagan of IBM, who also spoke at the Pasadena conference, was a major factor in the drive for quality, and rates as low as 1.0 began to appear. Fagan's inspections probe each phase of the life cycle, from requirements through design and coding rather than just detecting errors at the end of the life cycle, prior to delivery of the program.

Current practice, emphasizing prevention, can yield error rates of about 0.1 in the delivered computer program. Pietrasanta sees the error rate going to 0.01 and even lower in the next decade. The quest for "zero defects" will be greatly assisted by automation of portions of the software-generation process.

The benefits of low error rates are of importance to mission success and dollar savings. It is not surprising that one of the strongest and most successful software-quality efforts has been conducted by IBM's System Integration Program at Houston in support of the Space Shuttle. In addition, intensive software inspections have been shown to pay for themselves, and more, by reducing the test time required in flushing out errors at the end of the software life cycle; testing a clean product goes swiftly and easily.

My wife, Karen B. McLaughlin, a systems analyst at JPL currently working on software standards, reminds me that I would be remiss not to go beyond the subject of software quality to address the larger topic of standards. Software standards are prescribed for the development process in order to insure application of the best methods throughout an institution, in this case JPL.

Software management standards address a wide class of subjects: contents of the software management plan, phases of the software life cycle, structure of the development organization, reviews (which could include software inspections), required documentation, software metrics used to monitor progress and quality, etc.

The ability to transfer some human control, through a stored program, to the rapid and accurate circuits of a machine is not only of value in space applications, or even engineering and science in-the-large, but also features prominently in the development of modern mathematics. Numerical experimentation and even the proof of some theorems have been accomplished using computers, but, to date, the most profound influence on mathematics has come through thinking about the nature of computation rather than through carrying out computations.

The English mathematician Alan M. Turing (1912–1954) was a theoretician of great originality and also played an important role in pioneering computer work in Britain during World War II. At Bletchley Park, Buckinghamshire, Turing and his colleagues worked to break the German code, among other activities.

One of Turing's most influential concepts was the Turing machine, as it has come to be called, presented in a 1936 paper. The Turing machine is a (usually) hypothetical device which is able to read and write on a tape of (potentially) infinite length. The tape is divided into cells of equal lengths and at most one symbol can appear in each cell; there is no loss of generality to assume that only two types of symbols, "0" and "1", are employed.

The Turing machine has two other features. First, at any one time it is characterized by being in one of a finite number of "states". Second, it contains a list of instructions on how to act and what state to go to after each action. The operation of a Turing machine begins when it reads the contents of its first

cell on the tape. The machine takes action based only on the contents of the cell and the current state of the machine. Only four actions are possible: move the tape one cell to the left, or move the tape one cell to the right, or write a "O" in the cell being read (erasing the previous contents), or write a "1' in the cell being read The Turing machine then assumes its next prescribed state, which can be the special state that tells the machine to halt, or, if the job is not done, it reads another cell on the tape and continues to compute

That is all there is to the concept, but the consequences are considerable. Despite the simplicity of the definition of a Turing machine, it captures the idea of everything a computer can do. Even using the most complex circuitry, no computer can, in principle, accomplish more than Turing's simple box with a tape running through it (if, of course, the Turing machine were given enough time to lumber through its computations). Any one Turing machine, with its list of instructions, can be thought of as instantiating an algorithm. For example, the data on the input tape it reads could represent a positive number (in binary notation), and the machine could be equipped with a list of instructions which would always result in it printing on the tape the (possibly truncated) square root of the number it read.

With some additional conceptual effort, the simple Turing machine can be transformed into a more flexible device called the Universal Turing Machine (UTM). The UTM does not depend upon its fixed set of instructions alone, but rather this set is supplemented by a stored program P which, coded into a binary string of O's and 1's, is read into the UTM on the tape along with the binary string of data D. The result of operating the UTM is the same as if a Turing machine with fixed set of instructions P had operated on data D. Roughly speaking, the transition from Turing machine to UTM is like that from ENIAC to EDVAC.

Turing used his machine representation to prove the unsolvability of what is called the halting problem. The problem is to determine in some mechanical (algorithmic) fashion whether P operating on D will ever halt (or will the machine keep running forever).

Turing applied his UTM to the halting problem by considering program P and data D, taken together to be a new data set, to be operated upon by a "master program" M for the UTM. He showed that there does not exist any such program M which would operate on P and D and always be able to indicate whether this program/data pair P/D would ever halt if used, itself, to drive a Turing Machine. No matter what master program M is devised, there is always some P/D pair for which it cannot predict if the pair would yield a finite run for a machine. That is, there is no automatic or algorithmic method of always determining beforehand how long a program and its data will run. In general, the only way to see if a computation will halt is to watch it in action and wait for it to halt.

The halting problem is closely related to the "decision problem" Given a statement S of mathematics (a theorem), is it always possible to establish mechanically whether S can be proved or not? (Note· "yes" or "no" is all that is asked for, the proof itself is not required.) It was shown (by Alonzo Church in 1936), that, in effect, there is no UTM which will gobble up statements and produce the required answer· the decision problem is also unsolvable. The best that can be done with regard to the decision problem for S is to take the basic set of axioms and start grinding out proofs of theorems: all proofs of length one, all of length two, etc. If the desired theorem S ever turns up, it is, *a posteriori*, provable But, the process may continue forever without producing S. (The relationship of the decision and halting problems is apparent)

Turing machines are also useful in an allied area; defining the complexity of a given object, say, a number. A number consisting of an infinite string of 1's is intuitively much simpler than a (binary) number consisting of a random string of O's and 1's The U-complexity of a number N is defined as the length of the shortest program P which will result in the Turing machine U printing out N, i.e., the length of an efficient recipe for N. For random strings N, the complexity of N is about equal to the length of the string representing N.

One of the founders of "algorithmic information theory", Gregory Chaitin of IBM, has said of mathematical complexity· "You can't prove a twenty-pound theorem with a ten-pound theory" An interpretation of Chaitin's statement is that a finite entity – be it a mathematical theory, a Turing machine, or a human – has limits on its ability to comprehend its environment. See Rudy Rucker's 1987 book *Mind Tools* (Houghton Mifflin Co., Boston) for a readable account of the limits that complexity imposes on the acquisition of knowledge.

Rephrasing Chaitin for the context of the search for extraterrestrial intelligence (SETI)· could an N-bit human recognize, say, an N^2-bit extraterrestrial? The May 1986 edition of this column explores some relations between SETI and the theory of knowledge.

Control of spacecraft, problems of abstract mathematics, and questions in exobiology illustrate the scope and power of the entities we classify as software.

European Space Operations Centre

Operations constitute a major component of every space programme, and the European Space Operations Centre (ESOC) is one of the world's premiere facilities for the control of missions beyond the atmosphere. Located in Darmstadt, Federal Republic of Germany, ESOC contains a broad range of capabilities related to flight practices, ground systems, and associated technology development. My visit to ESOC in October 1988 was made for the purpose of learning from the experience of this institution accumulated over a period of more than 20 years.

The main building at ESOC. *ESA*

The establishment of ESOC took place in September 1967, and the facility was fully operational by May 1968. Currently, about 650 people are employed at the Darmstadt location; approximately 300 belong to the European Space Agency (ESA) and the remainder are contractor personnel. There is a balance of various European nationals at ESOC as befits an ESA installation.

Kurt Heftman, as the Director of Operations for ESA, heads ESOC and reports to the Director General of ESA, Professor Reimar Lüst, along with seven other ESA directors. An Austrian citizen, Heftman assumed his present position in 1983 after retiring from JPL as a member of the senior technical staff, encompassing a 24-year career in which he participated in a large number of space projects from Ranger and Surveyor through Viking, Helios, and Voyager. At ESOC the deep-space facet of his career continued to shine with the successful 1986 flyby of Halley's Comet by Giotto.

The hierarchical structure of ESOC proceeds from "Department", of which there are five, down through "Division", "Section", and "Group". Heftman said that he holds in-depth staff meetings with his Department heads about every two weeks and, in turn, reports to ESA Headquarters in Paris with the same frequency. The connection with Paris exemplifies the distributed nature of the ESA enterprise, and the successful methods of co-ordination practiced within the Agency are of interest to all of us who must operate within an increasingly inter-connected environment.

Project management generally resides at the European Space Research and Technology Centre (ESTEC) at Noordwijk, The Netherlands. Representation of a project, such as Giotto or the Infrared Space Observatory (ISO: scheduled for a 1993 launch), at ESOC is effected through a Ground Segment Manager (GSM) within the Systems and Project Support Department at Darmstadt.

At launch, a spacecraft is operated under the control of the Flight Operations Director and his team from the large Main Control room. In a directly adjoining area is the Flight Dynamics room from which navigational and attitude-control functions are carried out.

After a project enters the routine operations phase, the flight team transfers to a dedicated facility, an Operations Control Centre, for the remainder of the mission. At the time of my visit, ESOC was supporting 10 missions in flight. Tracking and commanding support in all phases of the mission is provided by the network of ESA ground stations: ESTRACK. See also the June 1987 edition of ***JBIS***, which is devoted to ESOC (the June 1988 issue of *Interdisciplinary Science Reviews*, devoted wholly to ESA, is also relevant).

A tour of the Meteosat control center, in company with Dr. Johannes Schmetz, a staff meteorologist, revealed an array of video displays for telemetry and, in addition, facilities for processing the scientific data continually being returned by the satellite.

The Meteosat series entered its operational program in November 1983 and will continue until at least 1995. The satellite is positioned at the intersection of the Greenwich prime meridian and the equator (0 degrees longitude, 0 degrees latitude) at geosynchronous altitude, almost 36,000 km. The 320 kg (initial mass) satellite images the hemisphere every half hour in the visible and two bands of the infrared spectrum.

The Meteosat images are dissected into 6400 segments which are selectively processed by Schmetz and his colleagues to yield seven meteorological products describing winds, temperature, cloud cover, precipitation, etc. It was enlightening to a lay observer such as myself merely to observe a movie of changing cloud cover over Europe assembled from a series of Meteosat images.

The first in the Eureca (EUropean REtrievable CArrier) series of Earth satellites is scheduled for launch in 1991. It will be released from the Shuttle to conduct 15 scientific and engineering experiments over a period of approximately six months, when it will be retrieved by the Shuttle. Among the experiments are: crystal growth, variability of the solar spectrum, variations in solar luminosity, Earth-atmosphere studies, X-ray transient measurements, microparticle population sources, and solar-cell performance.

The Eureca mission was of particular interest to me because, after launch, the spacecraft will be controlled by sequences of time-tagged commands stored onboard. A common alternative, as with Meteosat, is to send up "real-time commands" which are acted upon by the spacecraft immediately upon receipt. My interest was based upon the fact that JPL spacecraft, generally operating at great distances from Earth, are controlled by stored sequences, with real-time commanding employed only as a supplement (see *"How to Feed a Spacecraft"* in the January 1987 edition of this column).

Kurt Aubeck, the GSM for Eureca, said that a "Master Schedule" (sequence of time-tagged commands) would be up-linked to the spacecraft every 24 hours, to cover the next 48 hours. Then, the succeeding uplink, a day later, would update the remaining 24 hours of the resident Master Schedule, if necessary, and, with its 48-hour span, add a new 24 hours of commands.

The criterion which was applied to decide upon stored commands – Master Schedules – versus real-time commands was geometrical; in its low Earth orbit, station passes by Eureca would be relatively short events and not suitable for full-orbit control via the real-time route. Meteosat, in its geosynchronous orbit, satisfied the geometrical criterion to be operable by real-time commanding.

One of the pleasures of circulating through the space community is meeting colleagues from past missions. The Eureca Spacecraft Operations Manager, Jan van Casteren of The Netherlands, and I continued the discussion of Eureca and renewed our acquaintance established when we both worked on the Infrared Astronomical Satellite (IRAS) earlier in the decade. The Mission Planning Aid and the Master Schedule Generator programs which van Casteren and his associates are developing were of interest since they address many of the same needs with which we are tasked in our flight projects at JPL.

The method for controlling the astronomical satellite ISO, according to the GSM, Andrew Robson, is a kind of hybrid. While the spacecraft will not be equipped with the capability to carry onboard sequences, mission planning requirements have led to a plan to store a two-day backlog of real-time commands in a ground computer and squirt them up as needed. The planning cycle itself will be two weeks in length.

Technology development is important for a space operations organization in order to satisfy the requirements of ever more demanding missions and to control costs through automation. Herwig A. Laue heads the System Engineering and Mission Analysis Division at ESOC, and we discussed technological research which he is supervising.

Expert systems prototyping of an operations adviser for the power system of a communications satellite is being undertaken. The two goals he has established are frequently seen with regard to expert systems; reduction of workforce and capturing expert knowledge in a computer program rather than relying on the memories of humans who can forget or disappear.

Another area of research concerns human-machine interfaces in the use of video displays: the best use of colour, promotion of common symbology among projects, and whether or not it is useful to provide the text of flight operations plans on video screens. Laue said that he would also like to develop a mission analysis assistant. Such a piece of software could, after having been given overall objectives, draw upon a large library of computer programs, set up the requisite files, and run the programs to produce, automatically, a mission analysis. For example, one might specify a flight to Mars with an Ariane 5 launch at a certain date and a specified flyby altitude at the planet. Trajectory details, including a possible atmospheric probe release, would be calculated by the mission analysis assistant.

After two days of talking to people, I again stopped by Kurt Heftman's office to say thanks for the hospitality and the information. I told him what he already knew: that he has a first-class team. The exciting program being undertaken by ESA will continue to be well served by its ESOC component.

ESA's Ten-Year Success Story

To mark the tenth Anniversary of ESA's communications satellite operations *David Wilkins*, Head of Spacecraft Operations Division at ESA's European Space Operations Centre (ESOC) and Fellow of the BIS looks back over this little-publicised success story*

In the 1970's the European Space Agency saw a tremendous potential for communications satellites and set about developing its first experimental telecommunications satellite.

Nowadays, when communications satellites no longer make the headlines, it is easy to overlook the excitement which accompanied this new technology and the part played by ESA in promoting European know-how in such an economically important field.

On May 12, 1978 ESA's Orbital Test Satellite, OTS, was successfully launched, marking the beginning of a series of communications satellites developed and operated by the Agency. This series, which includes the operational satellites ECS and Marecs designed for use by Eutelsat and Inmarsat, will be extended with the launch of the Olympus satellite, followed in the next decade by experimental satellites under the Agency's Payload and Spacecraft Development and Experimentation Programme and the operational satellites which will form part of its Data Relay Satellite Network. OTS was not only at the start of all these ESA programmes, but was also the forerunner of a large number of sales by European industry of communications satellites for national and international networks.

This pioneer spacecraft was initially intended for a period of three years in orbit. Now, ten years after its launch, the OTS spacecraft is still fully functional and capable of providing useful communications services.

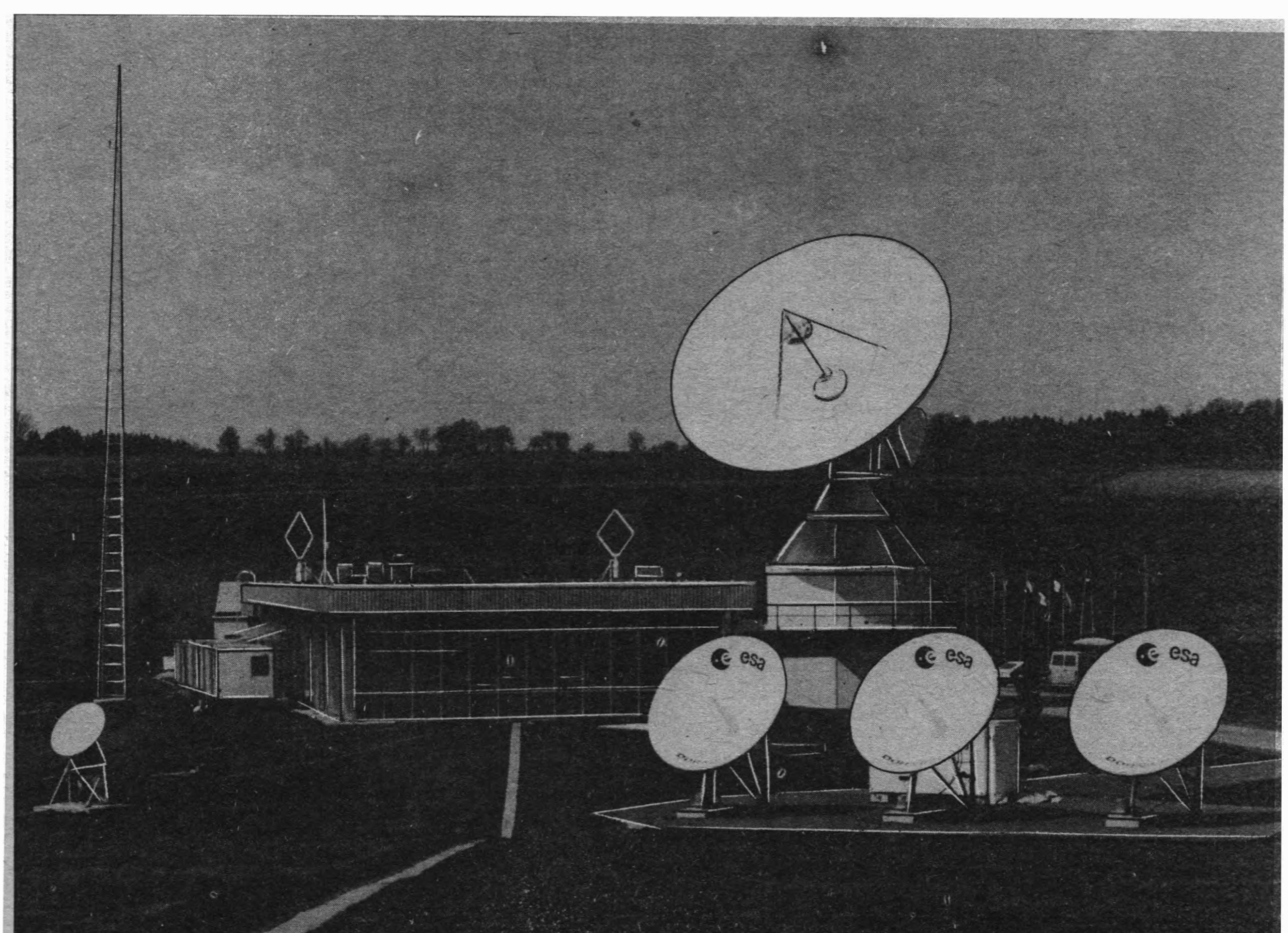
It is difficult to realize that more than ten years have passed since May 11, 1978 when OTS-2 began its journey towards orbit for a planned lifetime of 3 years. It is also difficult to realize that in the short time between September 13, 1977 when OTS-1 was destroyed by a Delta launcher explosion, and May 1978 a second OTS was constructed, tested and made ready for launch.

The night of September 13, 1977 is one that has many personal memories. I can still hear the announcement as it came clearly over the launch coordination circuit from Cape Canaveral "The vehicle has been destroyed". Our telemetry data from OTS

Continued p.20

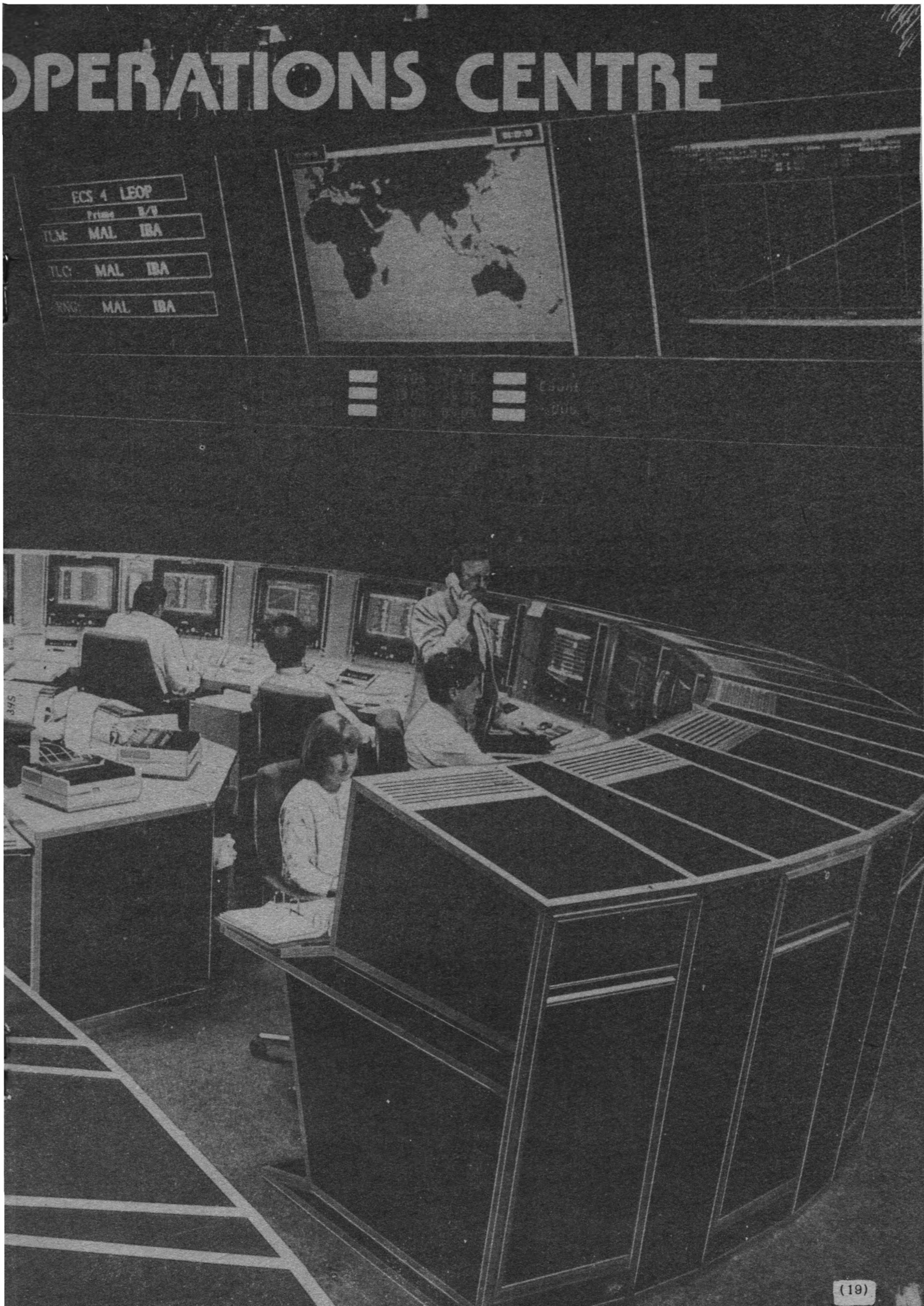
* Based on a lecture entitled "Communications Satellite Operations" presented at the 10th Anniversary Celebration of the OTS Mission, ESTEC, Noordwijk, The Netherlands on May 26, 1988.

The ECS antennas at the ESA Redu ground station in Belgium. *ESA*



EUROPEAN SPACE C

OPERATIONS CENTRE



Continued from p.17

which was being processed for some hours before launch at ESOC had ceased abruptly at 55 secs after liftoff making the mission of OTS-1 the shortest of all ESA missions. It is fitting that we pay tribute to the success of OTS-2 (which has been the longest mission of any ESA spacecraft) and to consider the experience which both ESOC, ESTEC and the Communications Programme gained from the in orbit operations of OTS and subsequent satellites.

What have we learned from OTS? It is useful to consider the history of operations activity in 1977/1978:

20 April 1977–GEOS-1
13 September 1977–OTS-1
22 October 1977–ISEE-B
23 November 1977–Meteosat-1
26 January 1978–IUE
11 May 1978–OTS-2
14 July 1978–GEOS-2

During a period of 15 months the Agency was involved in seven launch and orbital operations with an extremely heavy load on the Control Centre Staff. OTS was the first ESA 3-axis spacecraft using a complex AOCS (Attitude, Orbit Control System) and requiring high precision station-keeping. From the detailed Flight Operations Plan (FOP) prepared for GEOS, the first scientific geostationary spacecraft, a basic standard for future FOP's was developed. But in the case of OTS it was possible to use the ESOC main-frame computer to automate to some extent the preparation of FOP's. From this period of heavy operational activity we therefore gained both a standard method of Flight Planning and a computer-aided method of documentation development which has been in use with some minor changes since then. Of course today we use word-processors rather than mainframe computers but the basic Flight Planning and Flight Control Procedures were developed during the OTS mission preparation.

Since OTS was essentially a test satellite it was vital that a very exact method of reporting be established between the flight operations team at Darmstadt, the project team at ESTEC and the in-orbit test team at Fucino. This system of reporting, which led to the use of Spacecraft Anomaly Reports being issued from the Spacecraft Operations Manager at ESOC to the Project Manager with a wide distribution, has become a standard method of reporting for all ESA missions.

Orbital Operations

The initial phase of any geostationary mission is called the LEOP (Launch and Early Orbit Phase) and is the most critical in terms of spacecraft safety. Fig. 1 shows this sequence for a Marecs spacecraft, but the ECS/Marecs LEOP activities are very similar. The spinup and spindown sequences followed by Sun acquisition and Earth acquisition are similar in both cases. The need for rapid and accurate orbit determination was recognized early in 1975 and the flight dynamics software used at ESOC for all GTO (Geostationary Transfer Orbit) operations since 1977 has provided accurate and rapid results for orbit determination, attitude determination and manoeuvre support and were first used with OTS. For example in the case of ECS-4 the total fuel consumed between launch to orbit and first station acquisition was 8 kg out of a total of 119 kg loaded at launch. This was 6.8 kg less fuel than was predicted for this task. This means that approximately 6 months have been added to the planned lifetime of ECS-4 as a result of precise GTO operations.

In late 1981 Marecs-A was launched and placed on station according to plan. After some initial problems with onboard systems the operations control methods were modified and Marecs-A has been controlled from ESOC for the last six years. We hope to celebrate a tenth anniversary of Marecs-A in December 1991. Marecs-B2, launched in November 1984, has provided uninterrupted service to Inmarsat since February 1985.

In late 1985 ESOC was requested by Inmarsat to transpose the two Marecs satellites, i.e. to position Marecs-A in the Pacific region replacing Marecs-B and to position Marecs-B in the Atlantic region. This move provided Inmar-

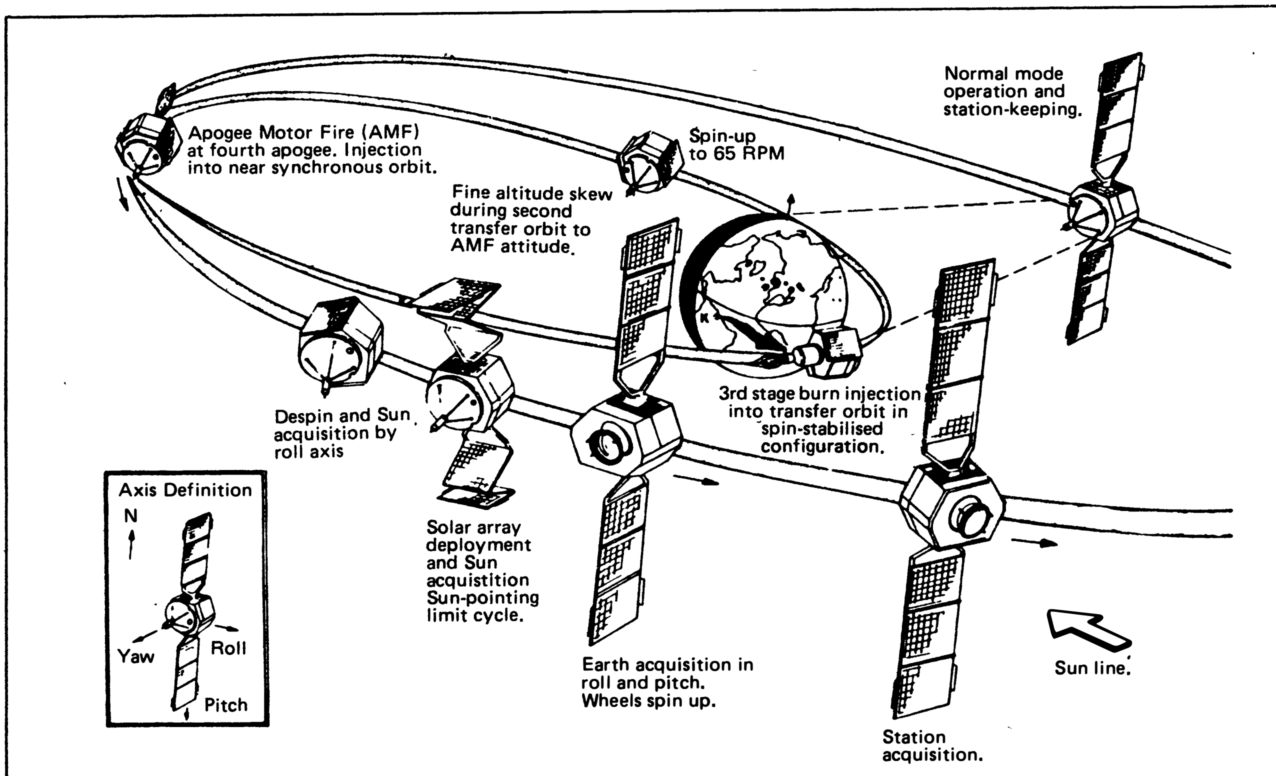


Fig. 1 MARECS SPACECRAFT TYPICAL FLIGHT PATH

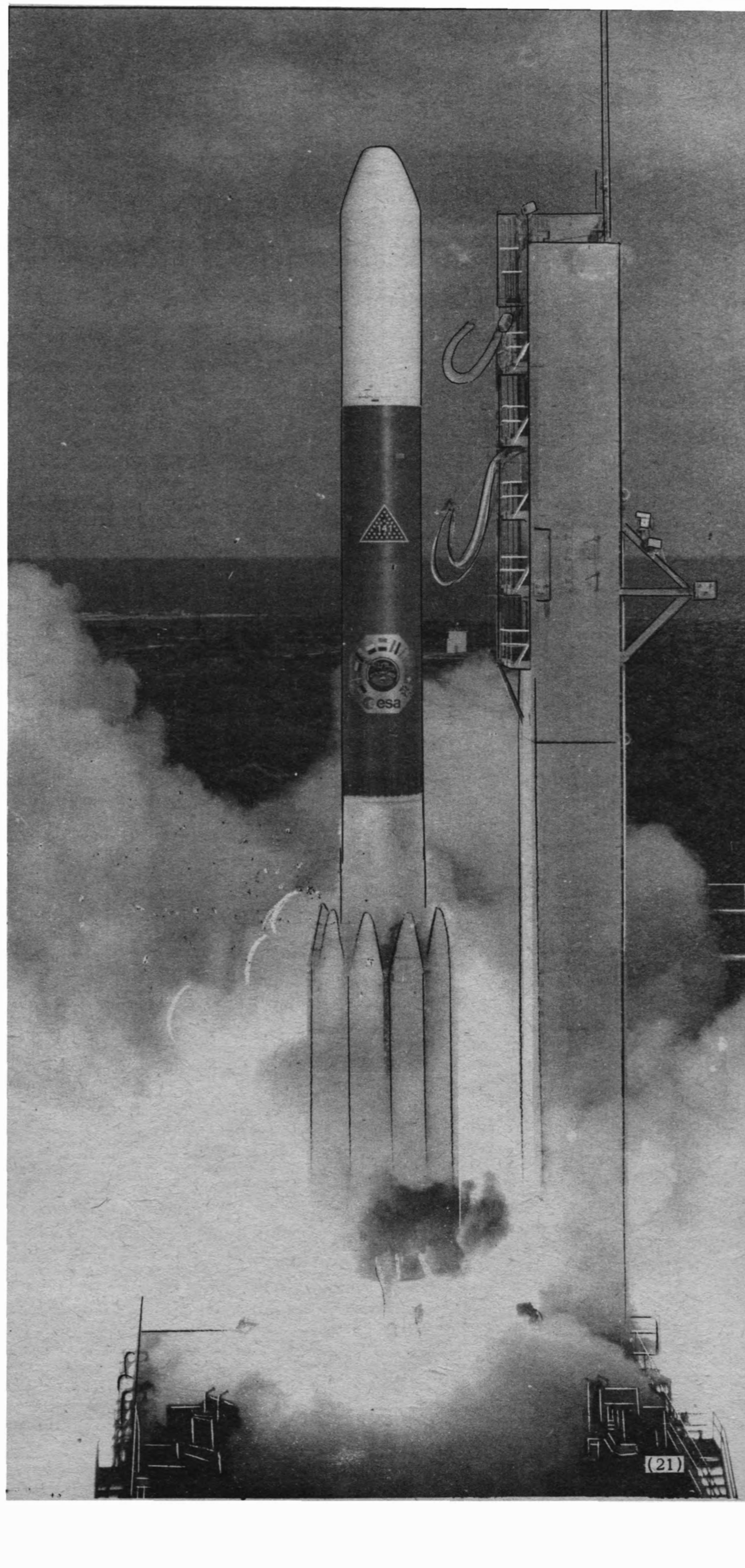
sat with a higher level of availability in the heavy traffic Atlantic region. The relocation process which began on January 13, 1986 and which was completed on May 12, 1986 required both spacecraft to be manoeuvred more than 200 degrees along the equatorial plane. The control of Marecs-B2 located at 26 degrees West is accomplished from ESOC via the ESA station at Villafranca near Madrid, while we control Marecs-A located at 176 degrees East via the Ibaraki station which is north of Tokyo.

ECS-1 was launched in June 1983 and for the first time an ESA spacecraft was operated at a distant control centre. The LEOP operations were conducted from ESOC but once the first station acquisition had been completed, operations were transferred to the newly-built ECS Control Centre at the ESA Redu Station in Belgium. This control centre designed to standards used at ESOC and using identical software systems is now operating ECS-1, ECS-2, ECS-4 and is awaiting the launch of ECS-5 which will be initially controlled during LEOP from ESOC and then handed over to Redu for on-orbit operations.

ESOC Experience

As we look back over the past ten years we realize that the agency has developed a broadly based expertise in the field of communications satellites from the nucleus of the OTS project. As an operations manager I feel that we have established an experienced team of experts at ESOC in all fields of expertise necessary to ensure the success of ESA communications missions. It is interesting to note that the Mission Operations Managers for both the ECS and Marecs missions together with several of their control team staff are all graduates of the OTS mission control team. Today tasks such as ABM Firing, GTO operations, Stationkeeping, Battery Reconditioning, Eclipse Operations and Solar Sailing, while not treated as merely routine are recognized as normal functions for our control centres. Before the launch of OTS we considered all of these activities with some trepidation.

ESOC has now conducted LEOP operations for 10 geostationary missions, six of these being communications satellites which are still in orbit. We look forward to the launch of Olympus in 1989 and to the challenge which that mission will imply. We also look forward to DRS (Data Relay Satellite) and the era of manned space flight when communications will truly be the vital link upon which mission success will depend.



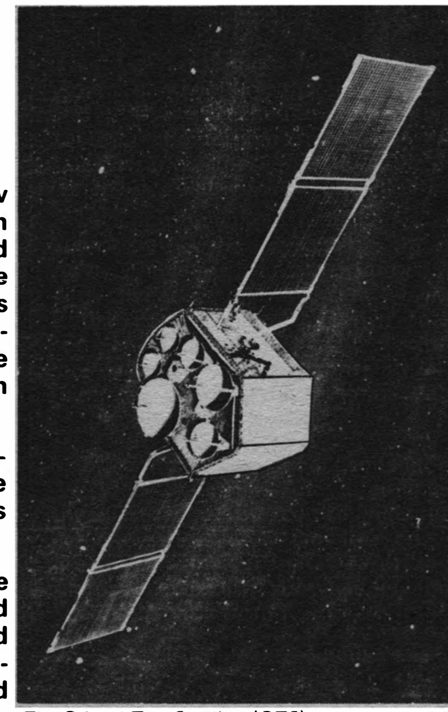
A Delta launches the European OTS-2 satellite in May 1978. *ESA*

TELECOMMUNICATIONS: THE OTS LEGACY

When you telephone Sydney, telex Tokyo or send computer data to New York, the odds are good that you will be using a communication satellite. Only a third of international tele-traffic goes by cable laid beneath the Oceans. The rest goes via satellites which have unique qualities that set them apart from other transmission media such as coaxial cables, optical fibres and radio links. Telecommunication satellites are injected into a geostationery orbit some 36,000 km above the Equator. Today there are more than 100 such telecommunication satellites orbiting the Earth.

They make it possible to establish wide-band links across considerable distances. Because satellites allow both multiple access at the transmitting end, and multiple destinations at the receiving end, links can be switched easily, with no need to switch centres.

Transferring information was important back in the Middle Ages – the era of information is not new – but telecommunications have pushed back the limits of the possible. Today, sounds, words, pictures and electronic data are transmitted at the speed of light: telecommunications have become the most dominant factor affecting commercial and social life.


The Orbital Test Satellite (OTS). *BAe*

The Orbital Test Satellite (OTS)

ESA became aware at an early stage that communications satellites have tremendous potential.

The European space Agency's first experimental telecommunication satellite was developed in the 70's and put into orbit in May 1978. Although it had a planned life-time of only three years, OTS continues to be operational and celebrates its tenth anniversary in orbit this year.

"OTS was developed to provide in-orbit verification of the technology to be used on the future ECS (European Communication Satellite) system and to provide the European PTT administrations with pre-operational satellite communications capacity" says René Collette, Head of Communication Programme Department at ESTEC. "By developing a European regional system, the Agency aimed at helping European countries to achieve commercial success and to acquire a significant share of the world market in this field. OTS also carried out a series of tests and experiments on radio-wave transmission through the atmosphere, frequency re-use, etc."

OTS was launched on May 11, 1978 from Cape Canaveral by a Thor Delta rocket, replacing an identical satellite, OTS-1, which was destroyed in September 1977 when its launcher exploded shortly after lift-off.

OTS is a three-axis stabilized geostationary satellite, consisting of a service module and a communications module carrying the payload.

At the beginning of its life in geostationary orbit OTS weighed 444 kg including its provision of fuel. The spacecraft is 2.39 m high, 2.13 m long and spans 9.26 m with its solar arrays deployed.

The satellite was designed at ESA's European Space Research and Technology Centre (ESTEC) in the Netherlands and built by a consortium of European companies led by British Aerospace.

To take advantage of the capacity provided by the OTS satellite a number of Earth stations were set up throughout Europe. The first one was built by ESA in collaboration with Telespazio at Fucino in Italy. The spacecraft Control Centre at ESOC controls the satellite's configuration and gathers information on its service functions via the Satellite Control and Test Earth Station (STSC) in Fucino.

Constant liaison was also established with other Agency stations at Villafranca, Dublin and Stockholm.

OTS successfully carried the hopes of Europeans anxious to improve the quality of their telecommunications and explore new technologies and techniques with worthwhile applications in the business world and in every-day life.

ECS

As OTS was being tested, ESA was preparing to launch its successors. The ECS series, of proven commercial interest and success, are operated by the European Telecommunications Satellites Organisation, Eutelsat, representing the European PTT's, which was set up in 1982 for the operation of a European regional satellite telecommunication system.

ECS-1, launched by Ariane in June 1983 can carry 12,000 telephone calls simultaneously. The ECS satellites have a 3-axis stabilized configuration based on OTS. All the communication antennas of the ECS-1 spacecraft are of the centre-fed type derived from the OTS programme.

However, ECS-2, which was launched on August the 4th 1984, has a new type of antenna with a multi-service receive/transmit function, which is more powerful and has a larger bandwidth capability. ECS-3 and ECS-4 (launched in September 1985 and September 1987) have the same type of antenna as does ECS-5 which was launched in July 1988.

Telecommunication satellites developed by the European Space Agency have inspired other European derivatives: Skynet 4 used by the British Forces, Nato 4, French Telecom, and the Eurostar family of satellites developed by Satcom International, an industrial consortium.

Mobile Communications For Land and Sea

In December 1981 Ariane launched the first maritime communications satellite Marecs-A from Kourou in French Guiana. Three years later Marecs-B2 was also successfully launched by Ariane from Kourou.

EUROPEAN RENDEZVOUS

The two Marecs satellites are leased from the European Space Agency by Inmarsat, the International Maritime Satellite Organisation.

The Marecs satellites serve as operational satellites covering the Atlantic and Pacific Ocean region. Marecs-B2 provides ships within the Atlantic Ocean region with a variety of commercial maritime telecommunications services including voice, teletype, facsimile and high-speed data, while Marecs-A covers the Pacific Ocean. Originally, Marecs A was located over the Atlantic and Marecs-B2 over the Pacific but the satellites were interchanged last year to take advantage of the more powerful Marecs-B2

ESA is taking another step forward in developing satellite communications to the shipping and off-shore industries: The Advanced Repeater for Aeronautical and Maritime Integrated Services, ARAMIS, will use sophisticated phase-array antenna techniques. The satellite will generate spot beams that can be directed from orbit to anywhere on the Earth's surface, enabling communications services to become cost-effective for aeroplanes and small ships and boats.

ESA is also developing mobile communications for land-based vehicles such as lorries or even personal cars. Under a programme called PRODAT, the Agency had demonstrated the efficiency of small terminals mounted on land vehicles and aeroplanes, allowing a two-way data communications link between the vehicles and suitable ground stations.

This technology can form the basis for an extensive land-mobile system within Europe. Not only could this bring immediate commercial benefits, but PRODAT could also foster a large export market for European industry to developing nations, where such communications services are sorely needed.

Olympus, the Future in Advance

With the exploitation of ECS and Marecs satellites safely in the hands of Eutelsat and Inmarsat and their control now a routine function of ESOC, the Agency has turned its attention to the next generation of larger and more powerful satellites.

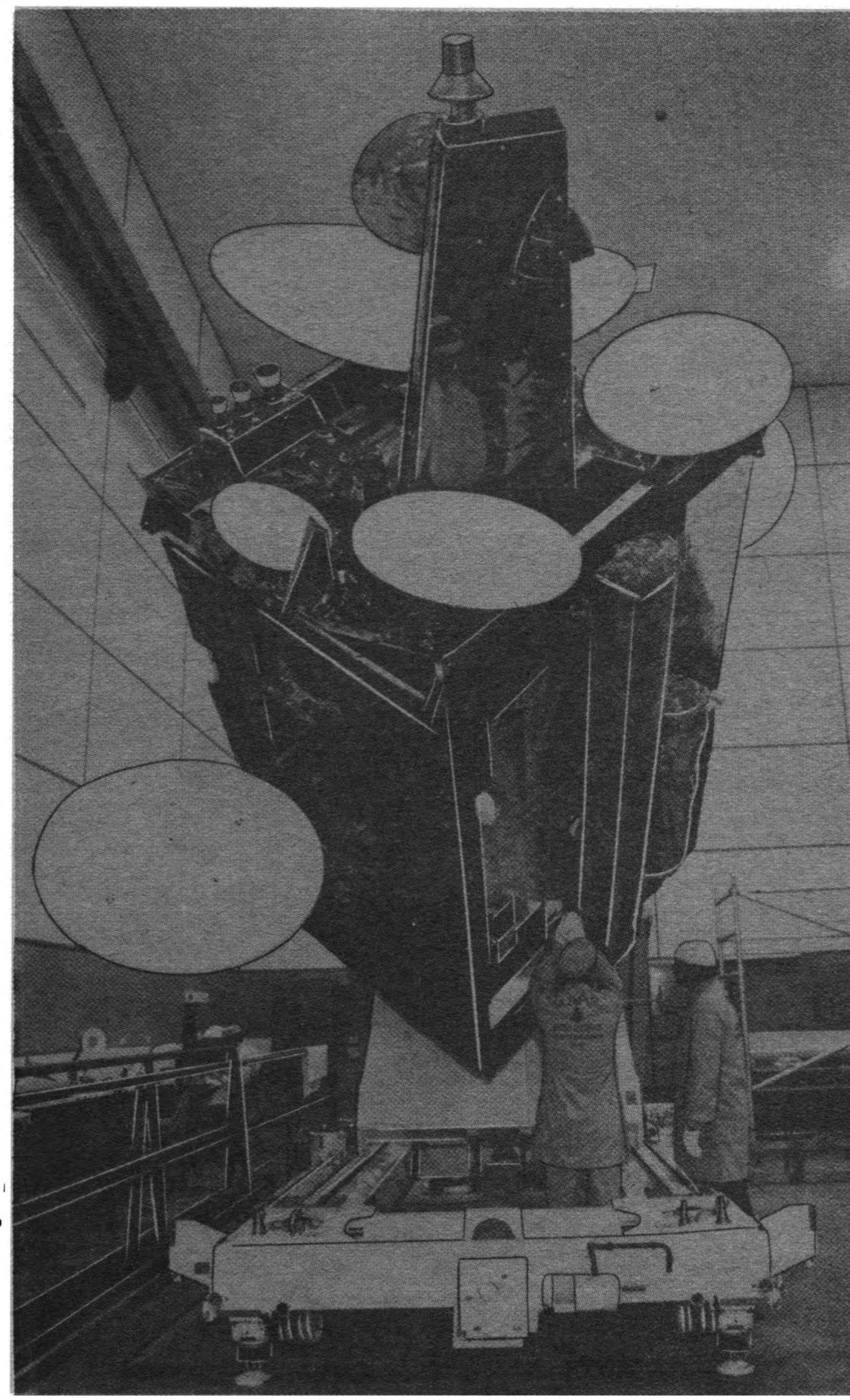
Like its predecessor OTS, the new Olympus satellite offers the potential to develop new services ahead of commercial exploitation.

Olympus represents a new generation of spacecraft which will extend European know-how in a field which has far-reaching international repercussions, with world-wide networks for teleconference, and the use of satellite links for the retrieval and transfer of information. With its powerful direct broadcast beams, Olympus will broadcast direct to millions of home and office antennas.

The Continuing March of Progress

ESA's telecommunication satellite programme continues in order to prepare for the missions of the future. Included in it are up to three experimental satellites which are scheduled for launch in the first half of the next decade, and the development of data relay satellites which will become operational in the second half, in support to the in-orbit infrastructure. According to Ed Ashford, Head of the Communication Satellites Division at ESTEC "the lessons learned in the development operations of OTS, ECS and Marecs have been invaluable in helping to shape the content of these future programmes".

The British Aerospace built Olympus telecommunications satellite is examined by two BAe technicians in an environmentally clean room. *BAe*



BOOK NOTICES

Jane's Spaceflight Directory 1988-89

Ed: R. Turnill, Jane's Defence Data, Sentinel House, 163 Brighton Road, Coulsdon, Surrey, CR3 2NX., 1988, 643pp, £80.00.

Jane's Spaceflight Directory, now in its 4th year of issue, represents what is probably the most exhaustive compilation of space data presented in a ready-to-hand form now available. There are over 500 pictures and more than 1,000 programmes are covered.

After several introductory but most useful chapters, the main bulk of the book thereafter divides into two major sections, of roughly equal length. The first, which amounts to about one half of the book, summarises national space programmes, taking each country alphabetically. The overview thus provided is both comprehensive and informative though many who read the entry under "Britain" will, no doubt, regard this either as a horror story or, at very least, a shambles of the first order. Most readers will draw their own conclusions though a common interpretation might be that it records how various entrenched interests successfully defend their positions on all fronts and shut out every chink of light from a dawning Age of Enlightenment.

The second half of the book is concerned with a variety of topics on various themes e.g. on international space programmes and military space. Sections are included on launchers, space facilities, astronauts and the space industry generally, this last being expanded over the previous edition. Space probes are also included, along with data on the various bodies which make up our Solar System. The Soviet section is fuller by the inclusion of data following the visit of the Editor to the USSR during the year who points out that, although Glasnost in space has not really arrived, US-Soviet collaboration on biosatellite activities has continued over the past fifteen years irrespective of political ups and downs.

Nearly Normal Galaxies

Ed: S.M. Faber, Springer-Verlag GmbH & Co., Postfach 10 51 60, Haberstrabe 7, D-6900 Heidelberg 1, Germany. 1987, 464pp, Hard Cover DM 72.

Subtitled "From the Planck Time to the Present" this book presents some fifty Review talks given in July 1986 as part of a two-week workshop which reviewed the latest research on galaxy formation and evolution.

A unique feature was the treament of galaxy formation from the earliest density fluctuations in the early Universe up to the latest phases of formation and evolution which we see at the present time.

Galaxies are really the basic building blocks of the Universe, the units whereby the large scale structure of the Universe may be recognised. The internal processes which take place within them involve all the fundamental components of astrophysics; so much so that, until recently, this occupied most attention. Now it is recognised that it is also essential to relate galaxies to their environments, for great numbers congregate into large structures which, in turn, influences them individually.

But how did galaxies originate in the first place? Were they the direct descendants of early density irregularities in the big bang? Indeed, and even more intriguing, do we live in a Universe where some unknown but probably large fraction of its mass exists in some unknown form?

The book is divided into sections which examine, in turn, both current theories and observations applied to Stellar Evolution, Small Objects (dwarf galaxies), Galactic structure, Galactic Parameters, the Relation of Galaxies to Larger Structures, Distant Galaxies and Dark Matter.

The Inner Limits of Outer Space

J.C. Baird, Trevor Brown Associates, Suite 7b, 26 Charing Cross Road, London, WC2, England. 1988, 226pp., £14.25.

The author, a psychologist who participated in a 25-strong NASA Study team to explore the feasibility of detecting radio signals from presumed extraterrestrial civilisations, states that he soon discovered, to his dismay, that the engineers, physicists and astronomers in the group settled on a narrow set of conceptions as to what form a message from outer space might take.

This, he regards, as a blind spot which could result in billions of dollars potentially being wasted in implementing a flawed search that might not even be able to recognise an alien message, let alone decipher it. From that point he advocates more involvement by social scientists able to analyse inherent human psychological biases and "whose minds are more open to alternative, though less-proven, modes of communication".

The R.A.E. Table of Earth Satellites 1957-1986

D.G. King-Hele *et al*, Macmillan Publishers Ltd., Distrib. by Globe Book Services Ltd., Canada Road, Byfleet, Surrey, KT14 7JI, England. 1987, 936pp, £95.

Even before the launch of Sputnik 1 on 4th October 1957, scientists at the RAe Farnborough had already made several studies of Earth satellites and their orbits, stemming from earlier work in the 1950's on the Blue Streak and Skylark rockets. Within a few days of launch, Sputnik 1 was regularly tracked by a radio interferometer at an RAE outstation, thus enabling its orbit to be determined and the decay rate used to evaluate a density of the upper atmopshere.

Since then, the RAE has specialised in the analysis of satellite orbits to determine upper atmosphere density and winds, as well as the Earth's gravitational field. In order to choose suitable satellites, a listing was necessary, thus leading, over the years, to the present volume containing data on more than 17,000 satellites, including fragments, in 893 pages of tabulation. Extensive revisions have been made to this, the third edition, to include not only all new launchings to extend the period covered to 1986 but also to incorporate over 1,000 revisions to the earlier data.

A major difficulty, shown clearly in this volume, is the lack of accurate information about the size, shape and weight of most satellites. The reason is that most launchings are of a military nature so that little information is released either about such satellites or their final-stage rockets. The compilers, therefore, have relied largely on deductions from the visual appearance in the night sky and on identifying previous launchings of similar character. By way of contrast, full details appear of most international satellites, particularly those launched by NASA.

New Opportunities for all People

Pergamon Journals Ltd., Headington Hill Hall, Oxford, OX3 OBW. 1987, 399pp.

This, a special volume of "Acta Astronautica" contains selected proceedings from the 37th IAF Congress at Innsbruck, Austria held in October 1986.

As is customary for such Proceedings nowadays, the text has been printed directly from MSS submitted by authors so some unevenness results, particularly in the matter of illustrations, in spite of, doubtless, every effort to ensure that authors adhere to some common practice.

A total of over forty papers are included, chiefly of a survey or state-of-the-art character, so the coverage is substantial. The text falls within five main sections viz Space Systems (including Policy, Utilization, Technology, Operations and Evolution), Space Transportation Systems (including Launchers), Astrodynamics and Space Exploration (including Interstellar Flight), Applications (including Earth observation, communications, microgravity sciences and education) and Technology (including propulsion and energy, structures and navigation) respectively.

The contributions include a considerable amount of "meat" and form a nice blend between present and near-future developments on the one hand, and a perception of where these will lead, on the other.

Interested readers might like to know that the previous volume in this series "Peaceful Space and Global Problems of Mankind" viz Selected proceedings from the 36th IAF Congress in Stockholm, Sweden in 1985 are also available from the same publisher.

Creation: the Story of the Origin and Evolution of the Universe

B. Parker, Plenum Publishing Corporations, 233 Spring Street, New York, NY 10013, U.S.A., 1988, 297pp, $22.95.

This book provides an insight into the violence that rocked the early Universe, as well as the billions of years of gradual evolution which followed and which have left their mark in the stars and elements around us. It is a quite remarkable tale to be told, beginning

with early theories and reaching to the very latest discoveries in cosmology.

The scenario is fascinating and wide-ranging, from happenings in the first few milli-seconds in the life of the Universe up to the role played by galactic objects, today including the enigmatic black holes.

The text is not all about cosmology. Much is about the scientists who contributed the ideas which have led to present concepts of the origin of the Universe.

Exploration of Halley's Comet

Eds: R. Reinhard *et al*, Springer-Verlag, Postfach 105160, Haberstrabe 7, D-6900 Heidelberg 1, Germany, 1988, 984pp, DM 196.

Halley's Comet is both the brightest periodic comet and the most famous of the 750 known comets. Five apparitions ago Edmund Halley discovered the periodicity of the comet and predicted its return in 1758, a remarkable event given the prevailing views on comets at the time. Its most recent return, during 1985/86, was one of the most important apparitions of a comet ever. It provided the worldwide science community with a wealth of exciting new discoveries, the most remarkable of which was undoubtedly the first images of a cometary nucleus.

The 1985/86 appearance began with the record-breaking recovery of the comet on 16th October 1982, while still 11 astronomical units from the Sun. This was 3½ years before perihelion so it was not until late in 1985 that the comet was close enough to the Sun to become fully active.

The combined studies of thousands of scientists around the globe throughout its return generated a huge amount of scientific data which has since undergone preliminary evaluation, with many of the results presented at a special Symposium held in Heidelberg in October 1986. Although the main emphasis then was, of course, on Halley's Comet, papers on other comets were also included in order to show the Halley results in proper perspective. Altogether a total of 370 papers were produced, many of which were published in ESA Special Publications SP-250.

After the Heidelberg meeting, many of the manuscripts were subsequently revised and re-written for publication in a special issue of the *Journal of Astronomy and Astrophysics* (Vol.187 Nos 1–2). The present book reprints all the papers from that issue together with a summary of the scientific results of the Heidelberg Conference and a further five papers which give background information about the various space missions to Halley's Comet and the special International Halley Watch set up to coordinate and maximise data obtained. The latter embraced more than a thousand astronomers from over 50 countries and resulted in an almost-continuous coverage of the comet over a wide range of wavelengths.

The result of all this is a basic reference book which not only embodies a comprehensive account of the current state of scientific knowledge about Halley's Comet but also indicates implications which apply both to other comets and to concepts on the origin and evolution of the Solar System.

The Home Planet

K.W. Kelley, Queen Anne Press, 3rd Floor, Greater London House, Hampstead Road, London, NW1 7QX, England, 1988, £20.00.

Feelings felt and expressed by many of the 200 men and women from 18 nations who have travelled in space and looked down at the Earth beneath are reproduced in this book, together with a 150 of the best photographs selected from Soviet and American Archives. The accompanying narratives are usually deeply personal, attributable to the astronaut involved, and appear both in the language of the publisher and in the native language of the flyer himself.

This is not a book to be read, as such. It is, basically, a selection of pictures of the Earth (and some of the Moon) reproduced side by side with relatively short utterances by those first involved and which reflect the feelings and experiences of awe, wonder and interest evoked by the sights below.

The Universe from your Backyard

D.J. Eicher. Kalmbach Publishing Co., 1027 N. 7th St., Milwaukee, WI 53233, USA. 196pp. 1988. $24.95.

This book provides a guide to finding and enjoying nearly 700 of the sky's finest objects, based on text previously published in *Astronomy* magazine. Included are double and multiple stars, variable stars, open and globular star clusters, bright and dark nebulae, planetary nebulae and galaxies.

The treatment is on a constellation-by-constellation basis, in alphabetical order. The text for every constellation is accompanied by a detailed star map showing the location of each object described, together with illustrations of a number of the more spectacular celestial "sights". Forty-six constellations are treated in this way.

The Supernova Story

L.A. Marshall, Plenum Publishing Corporation, 233 Spring Street, New York, NY 10013, U.S.A., 1988, 296pp, $22.95.

Supernovae represent a phenomenon fundamentally different from that of ordinary novae. Compared to a supernova, an ordinary nova sends out a few faint splutters of light and a few feeble puffs of gas whereas a supernova rends a star to pieces and plays a central role in the formation of elements, the shaping of galaxies and, undoubtedly, in the evolution of life itself.

The dazzling supernova SN 1987A which occurred in the large Magellanic Cloud, 160,000 years ago and which only recently became visible from Earth, provided one of the greatest cosmic events of modern times. This exploding star captured the imagination of scientists and amateurs alike. The brilliance of its display heralded a new era in the study of supernovae which has led to a deeper insight into the origin and complex history of such objects.

The present volume does not, however, relate solely to SN 1987A. It describes observations collected over many centuries, dating from ancient Chinese records to the Middle Ages. The result is an astonishing record of past stellar cataclysms.

Origins

A.C. Fabian, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, England, 1988, 168pp, £12.95.

In this volume a distinguished team of international authorities report on the latest research on the origins of some of the most fundamental features of our world.

The book begins with a bang, the Big Bang in actual fact, that heralded the probable start of our expanding Universe. Other contributors then focus on the origins of the Solar System, material complexity, and human origin and evolution. The volume ends with essays on the origins of social behaviour, society and language.

The Role of the Fine-Scale Magnetic Fields on the Structure of the Solar Atmosphere

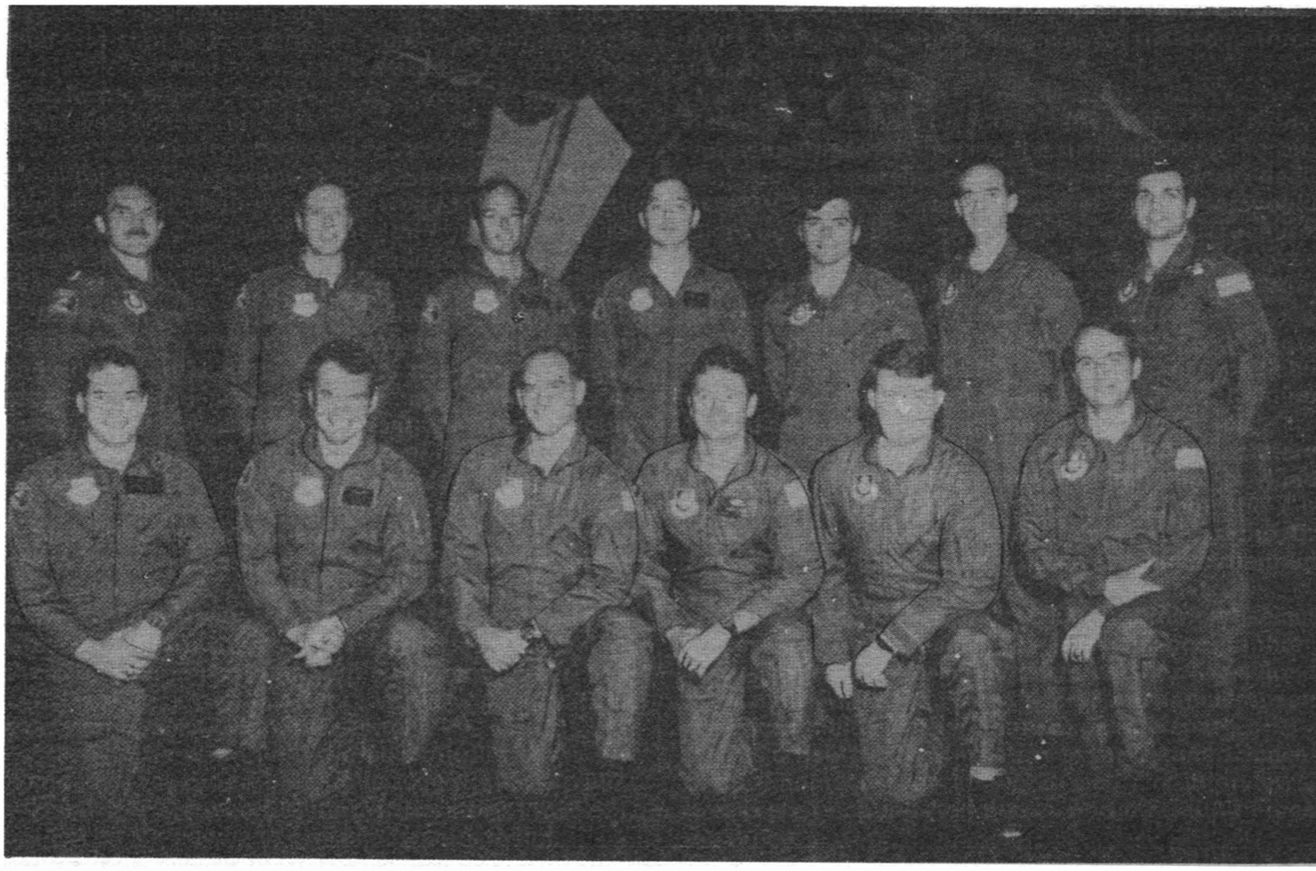
E.H. Schroter, M. Vazquez and A.A. Wyller, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU. 1987, 379pp, £35.00.

This volume arose from the inauguration of the international observatories at La Palma and Tenerife in 1985. The inaugural workshop, described in this book, was in the October of the following year. Its major aim was to stimulate discussion between observers and theoreticians on some of the current problems of solar physics. The first group of papers concerns the Sun's atmospheric structure and activity, e.g. the sunspot cycle, beginning with problems of the solar granules and the extent to which these may or may not be modified in regions of solar activity. This is followed by a discussion of the interaction between magnetic fields and convection and a number of contributions on the fine structures e.g. those close to sunspots or faculae. This includes contributions to the sub-surface structure of sunspot, particularly how these active regions originate. An interesting question concerns sunspots themselves. These consist of a dark central area (the umbra) surrounded by lighter area (the penumbra). But *why* this is so? Why should there be a penumbra at all?

A multitude of questions such as this indicate the nature of the work still to be done and suggest scope for future integrated observcational experiments, with all available solar observing facilities put into use simultaneously.

The instruments planned for La Palma and Izana, clearly, represent the highest concentration of solar instruments in the world. The sites are excellent and may be the best available, besides being easily accessible to European astronomers.

All the signs are that the study of the Sun is about to expand into a new phase.



First cadre Manned Space Flight Engineers at Rockwell International, November 1982. Back row, L–R: Sefchek, Rij, Wright, Detroye, Watterson, Higbee, Casserino. Front row, L–R: Vidrine, Payton, Lydon, Joseph, Sundberg, Hamel *All photographs USAF*

The Manned Space Flight Engineer Programme

by Michael Cassutt

From the moment it was approved in April 1972, America's space shuttle was intended to be a "national launch system" replacing all expendable military and civilian launch vehicles by 1980. It is unlikely that the shuttle would have been built without this goal: the famous Mathematica study "proved" that the shuttle would be economical only if it carried all of America's space traffic [1].

Since a majority of America's space launches have been for military purposes, it was inevitable that the shuttle would require the participation of the US Air Force, the official launch agency for not only the military services, but for American intelligence agencies as well.

In exchange for its grumbling support, the Air Force demanded – and got – changes in the design of the vehicle to accommodate its need for improved cross-range and large payloads, among others. For its part, the Air Force was to develop an inertial upper stage and fund the construction of orbiters 105, 106 and 107 [2].

These "blue" shuttles would have been "dedicated" to classified military missions launched (in some cases) into polar orbits from the re-designed space launch complex six at Vandenberg Air Force Base, flown by crews of military astronauts, and controlled from a custom-built DoD mission control – the Shuttle operations and Planning Center – which would be part of a new complex called the Consolidated Space Operations Center.

The Shuttle was the Air Force's third attempt at a manned space programme following the X-20 (1963-64) and the Manned Orbiting Laboratory (1965-69), both of which had been cancelled before flying.

However, the decision to "buy into" the shuttle never had total support from all elements of the Air Force, and by the late 1970's, with inflation and a Democratic administration eroding DoD budgets, what Air Force affection there was for the programme began to fade.

The new mission control centre, SOPC, was delayed in favour of modifications to the NASA Johnson Space Center and the three additional orbiters were not purchased – a brief attempt to dedicate OV-103 "Discovery" to the DoD failed. Nor would there be a special corps of "blue shuttle" astronauts. Military officers would have to be detailed to NASA as career astronauts in order to fly as pilots or mission specialists.

The only opportunity for an Air Force programme seemed to be in NASA's new class of "payload specialists," non-career astronauts whose training would centre on payloads, not the shuttle itself.

And so in January 1979, Air Force Under-secretary Hans Mark created a cadre of military payload specialists – people who could explain the Air Force to NASA while explaining the shuttle to the Air Force [3]. A military designation was coined: manned spaceflight engineers.

Even though the DoD would ultimately select senior Air Force officials, US Navy oceanographers and Air Weather Service officers as shuttle payload specialists, MSEs would be the first personnel from an American military programme to go into space.

This article traces the history of the Manned Spaceflight Engineer programme, based on interviews, press reports, published books, and official Air Force documents.

The First Cadre

Initial responsbility for the definition of the pilot MSE programme fell to Lt. Colonel Robert E. Christian III at Los Angeles Space Division, and his deputy, Capt. Gregory Gillis, both of whom had extensive experience in military space programmes. Christian had also been an Air Force representative at presentations made by Rockwell International concerning manned space programmes as early as 1969.

Among their many tasks was the requirement that the MSE be a "tri-service" programme creating a cadre of Air Force, Navy and Army personnel experienced in shuttle operations and the special requirements of military payloads. It was hoped that after tours of duty lasting from four to six years and following flights aboard the shuttle these officers would return to "normal" careers and eventually rise to command positions in the services' growing space programmes.

Selected organisations in the USAF, Navy and Army were briefed on the pilot programme. Requirements were drawn up and applications were solicited from qualified personnel. The first MSE candidates were required to:

- Have at least three to ten years' service as an officer on active duty.
- Rank from first lieutenant to major.
- Be able to pass a NASA Class III flight physical.
- Be holder of a bachelor of science degree in engineering, science or space operations, with a master of science in those areas desired.
- Have a minimum of two years' experience in programme acquisition, test and launch support, of flight and missile operations [4].

Flying backgrounds were not required, though pilot applicants had to have met their first "gates" (minimum requirements for flying time). In addition, of course, applicants had to hold the appropriate security clearance.

In August 1979, fourteen officers, 12 Air force and two Navy, were selected. One Air Force officer, Maj. Carl Hatlelid, declined the appointment and was replaced by an alternate, Capt. Gary Payton; Navy Lt. Commander Paul Schlein also declined and was not replaced, leaving 13, who reported to the Air Force Space Division in El Segundo, California, to begin initial training in February 1980 under the direction of Lt. Col. Christian. The officers were:

1Lt. Frank J. Casserino, (24), USAF
1Lt. Jeffrey E. Detroye, (25), USAF
Capt. Michael A. Hamel, (29), USAF
Capt. Terry A. Higbee, (30), USAF
Capt. Daryl J. Joseph, (30), USAF
Maj. Malcolm W. Lydon, (33), USAF
Capt. Gary E. Payton, (31), USAF
Capt. Jerry J. Rij, (30), USAF
Maj. Paul A. Sefchek, (33), USAF
Maj. Eric E. Sundberg, (34), USAF
Lt. Cmdr. David M. Vidrine, (36), USN
Capt. Keith C. Wright, (32), USAF
Capt. John B. Watterson, (30), USAF

The initial requirements were intended to recruit a cadre of military space professionals, and in that they succeeded. Vidrine was an engineer with the US Navy Space Project. Higbee, Joseph, Rij, Sefchek, Sundberg, Wright and Watterson were already working on various programmes at Space Division. Payton, the alternate selectee, had been a launch controller at Cape Canaveral in addition to being one of two flight-rated members of the group. Casserino and Detroye had only recently arrived at Space Division from the Satellite Control Facility at Sunnyvale, where they, like Lydon, had been satellite controllers and engineers.

Casserino and Detroye had less than three years as officers at the time of selection; Vidrine had served for 15. Detroye was the only MSE without a master's degree, though he had done graduate work.

Thus the MSE programme began, with high hopes and great expectations. Maj. Gen. John E. Kulpa, Jr., deputy commander for space operations (DCSO) of the Space Division and one of the programme's biggest supporters, welcomed the men with a speech calling them the "future of the Air Force in space".

But problems surfaced even during the first weeks of training. In addition to valuable exposure to shuttle systems at Rockwell International's flight systems laboratory in nearby Downey, California, the original programme relied heavily on a schedule of monthly, week-long visits by the 13 MSEs to various military satellite contractors. This proved to be unworkable and the contractor visits were reduced in favour of vists to other Air Force installations as well as the NASA Johnson and Marshall Space Centers [4].

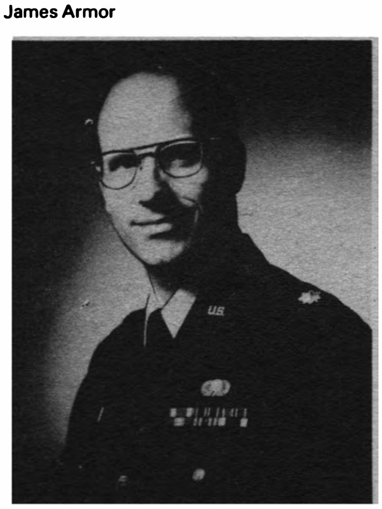
There were also immediate conflicts with NASA officials, in part because NASA had yet to define its own payload specialist training programme.

Early in the MSE programme, the civilian agency had suggested to the Air Force that it would be happy to accept the MSEs at the Johnson Space Center for two years of training, which is just what the Air Force did not want. In the words of one officer: "At that time any Air Force guy who went to NASA never came back!"

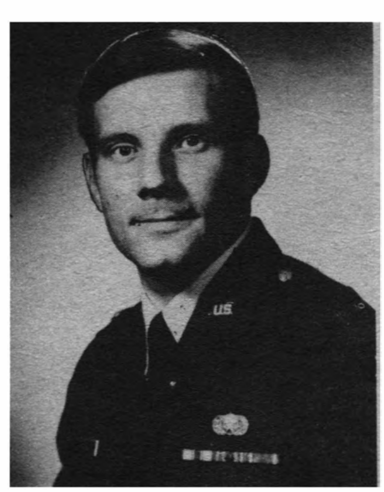
When the Air Force declined the offer, NASA refused assistance of any kind, taking the position that it had not selected and therefore could not control the MSEs [5]. As late as 1983 one NASA official wrote that he considered MSEs to be engineers and not "flyers", and that they should not partake in any flight training activities until selected as actual payload specialists [6].

Ironically, some MSEs and their managers found themselves frustrated by NASA's excessively-rigid insistence on secrecy. Differences in managerial style and control over flight issues escalated to the point where the more aggressive MSEs found themselves unwelcome at the Johnson Space Center, whose director, Christopher Kraft, was called upon to referee at least one dispute.

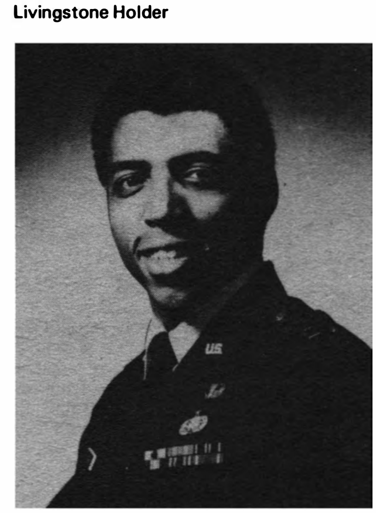
James Armor

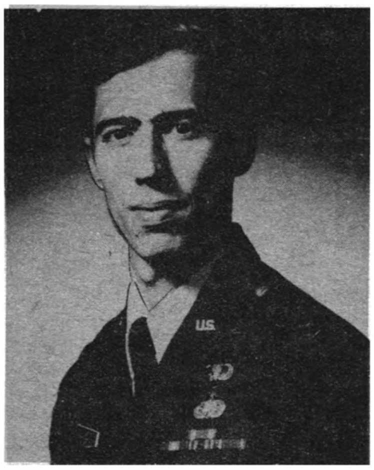


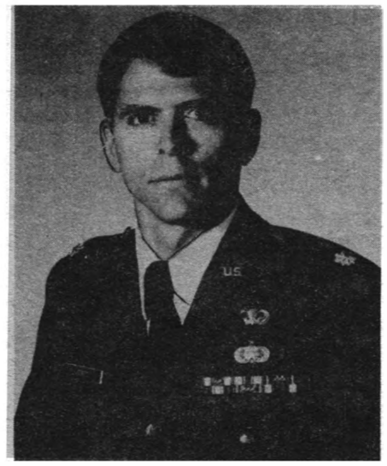
Michael Booen



Livingstone Holder




Larry James


Charles Jones


Maureen LaComb

Nevertheless, during the first months of training, members of the first cadre of MSEs had great expectations, having been told that each of them could anticipate flying in space at least once and several of them twice [7]. They took part in underwater EVA and manned manoeuvring unit simulations at NASA Marshall and Martin Marietta, respectively, and went through shuttle mission simulations at Rockwell. Ultimately some members of the group even rode in T-38 jets at Edwards Air Force Base. Such experience gave MSEs greater familiarity with shuttle systems and operations than any other payload specialists and, indeed, many NASA flight controllers [8].

In early 1980 the officers had also been assigned to different Space Division system project offices (SPOs) to become intimately familiar with the multitude of military payloads: the Space Test Programme of scientific experiments, the General Electric Defense Satellite Communications System, the Rockwell Navstar Global Positioning System, and especially classified systems – commonly known as Special Projects – developed by TRW, Hughes, Martin Marietta and Lockheed under the direction of the highly-secret National Reconnaissance Office [9].

In December 1981, the first cadre of MSEs completed training and the experimental programme was officially recognised as the Directorate for Manned Spacecraft Support, Space Division.

Lt. Col. Christian retired from the Air Force in October 1981 and was replaced by Lt. Col. David Richardson, who served until the spring of 1983, when Lt. Col. Thomas Redmond became Director, Manned Spaceflight Support. Redmond was replaced in November of that year by the ranking MSE, Cmdr. David Vidrine.

Second Cadre

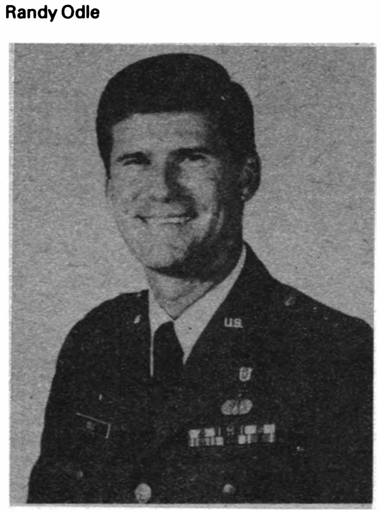
By the summer of 1982, it was obvious that more MSEs were needed if the programme was to be adequately represented in Space Division SPOs. Requirements for the second cadre were similar to those of the first, except that this time only USAF officers were to be considered. Announcements were circulated to personnel offices and published in the *Air Force Times* soliciting applications from officers eager "... to help change military space experiments that now are designed to be controlled from the ground to ones that can be directly manipulated by astronauts in orbit" [10].

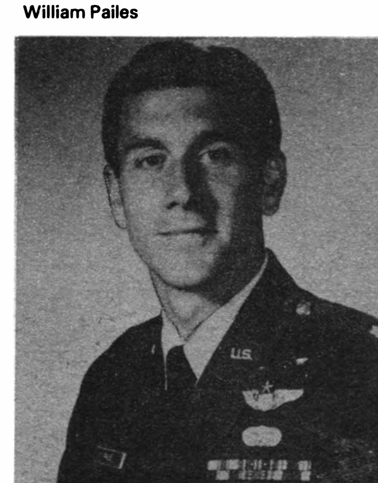
From 66 finalists, 14 officers were selected in August 1982, to report to Space Division in January 1983:

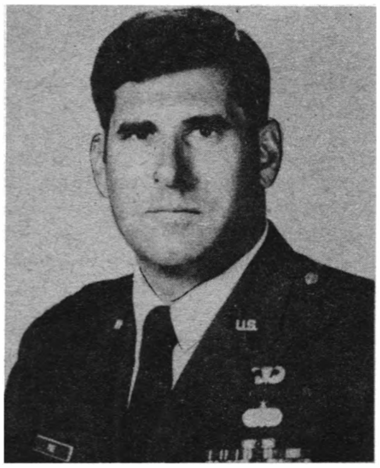
Capt. James B. Armor, Jr. (32)
1Lt. Michael W. Booen (25)
Capt. Livingston L. Holder, Jr. (27)
Capt. Larry D. James (27)
Capt. Charles E. Jones (30)
1Lt. Maureen C. LaComb (26)
Capt. Michael R. Mantz (28)
Capt. Randy T. Odle (31)
Capt. William A. Pailes (30)
Capt. Craig A. Puz (28)
Capt. Katherine E. Roberts (28)
Capt. Jess M. Sponable (32)
Capt. W. David Thompson (26)
Capt. Glenn Scott Yeakel (26)

The second cadre included two women (Roberts and LaComb) and a black officer (Holder). Backgrounds of the officers, unlike those of the first cadre, did not emphasize space engineering and operations. Odle, for example, had been a bio-environmental researcher at RAF Alconbury in the UK; LaComb and Mantz were primarily computer specialists. Pailes was a rescue pilot now working on microcomputer systems. Puz and Armor had been commanders of Minuteman

Michael Mantz


Randy Odle


William Pailes



Craig Puz


Katherine Roberts


Jess Sponable

missile crews. Booen was a weapons engineer.

Several of those who had worked on space projects had only two or three years' experience and they were also, on the average, younger than the first cadre. More significantly, the new selectees were told that only half of them might fly in space. It was as if the first cadre were pathfinders – pioneers – and the second cadre were homesteaders.

Training for the 14 new officers was similar to that of the first 13, though more organised, and "graduation" took place in January 1984, when they, too, were assigned to Space Division SPOs.

During 1984 there was some attrition: Commander Vidrine retired in October and one officer was dropped from the programme.

Assignments

MSEs gained their first mission experience working with astronauts T. K. Mattingly and Henry Hartsfield, the crew of STS-4, the last shuttle orbital test flight, which carried the P-80-1 experiment package. MSEs Sefchek and Watterson worked on the payload while Casserino, Detroye and Payton acted as "paycoms" (payload communicators) at the Air Force Satellite Control Facility in Sunnyvale, California. The best known of the "secret" experiments, a sensor known as CIRRUS, failed to operate as planned [11].

Just prior to STS-4, in June 1982 the first payload specialist selection board named seven MSEs as prime or backup candidates for three different shuttle missions scheduled for 1983 and 1984: STS-10 (Payton/Wright), STS-15 (Detroye/Sundberg/Watterson) and STS-16 (Casserino/Joseph). Reported payloads included a TRW/Defense Support Programme early warning satellite as well as two intelligence satellites, some of which were designed to be boosted into geosynchronous orbit by the Boeing inertial upper stage following release from the shuttle. The military payload specialists would observe satellite deployments and IUS firings, and operate scientific experiments [12].

Delays

On April 4, 1983 during deployment of the first Tracking and Data Relay Satellite from STS-6, the IUS suffered a failure which had serious repercussions on the MSE programme, forcing massive changes in the military payload manifest: STS-10 was immediately cancelled, followed in February 1984 by STS-15 (then designated Mission 41-E) and in April 1984 by STS-16 (Mission 41-H).

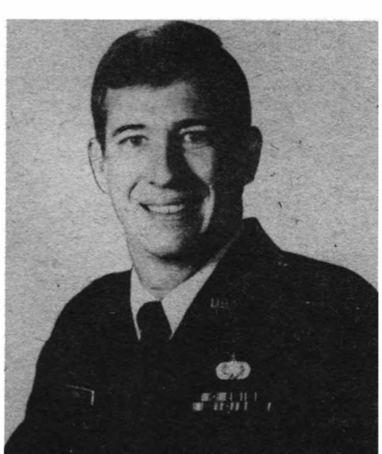
In fact, the STS-10 payload, widely reported to be a TRW/National Security Agency ELINT satellite called Magnum, was configured only for shuttle launch with IUS and could not be cancelled – it had to be slipped from one shuttle IUS slot to another.

Published reports have stated that the original STS-15/Mission 41E and STS-16/Mission 41H payloads were dualconfigured for shuttle or Titan and simply shifted from one system to the other – the 15/41E for a January 1984 Titan, the 16/41H to one launched in December 1984 [13]. Other sources indicate, however, that 15/41E was simply cancelled while 16/41H was postponed indefinitely.

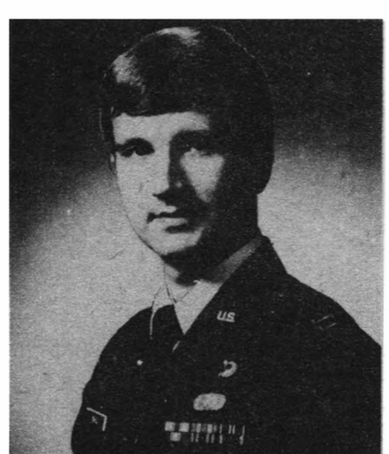
In any case, because of Magnum's importance, the DoD exercised its "launch on demand" option, preempting the next shuttle/IUS spot on the manifest, Mission 51C, which was intended to launch the civilian TDRS-B. TDRS-B was moved to Mission 51E.

The second MSE selection board, in the summer of 1983, confirmed the assignment of Maj. Gary Payton as prime PS and Maj. Keith Wright as bac-

David Thompson



Scott Yaekel



Joseph Carretto

kup PS for what was then STS-15. It also named Capt. Frank Casserino as prime PS with Maj. Daryl Joseph as backup for STS-16.

At this time there was a brief and unsuccessful attempt to place MSEs on "civilian" shuttle missions for which DoD was contributing funds. Commander Vidrine became a candidate for PS "observer" on STS-13/Mission 41C, the Solar Maximum Mission rescue, and even went through flight simulations with the astronaut crew commanned by Capt. Robert L. Crippen (USN).

In March 1984, however, one month before scheduled launch, Maj. Gen. Kulpa's successor as Space Division DCSO, Maj. Gen. Ralph G. Jacobson, refused to authorise Vidrine's flight, claiming it had "no value" to the Air Force, and pulled him from the crew.

A year earlier, in March 1983, Jacobson had summoned Christian and the first cadre MSEs to his office for what came to be known as "the Saturday Morning Massacre". Jacobson was concerned about shuttle launch delays and wanted the MSEs to understand that his mission, i.e., the launch of national security payloads, dwarfed their mission, flights in space by Air Force personnel.

It should be noted that the DoD always intended to choose shuttle payload specialists from other services and commands. Civilian Navy oceanographers Paul Scully-Power and Robert Stevenson were selected in early 1984; Scully-Power went into space that October aboard Mission 41G in place of Stevenson, the original first choice. Stevenson was re-manifested for a series of shuttle missions beginning with STS-15 and was finally assigned to Mission 61K, scheduled for 1986, only to see it cancelled following the "Challenger" disaster.

In late 1985 three officers from the Air Weather Service were selected for another 1986 shuttle flight, the Weather Officer in Space Experiment (WOSE). The Navy also intended to fly a command, control and communications specialist in 1987. These were in addition to MSE and "dignitary" payload specialists such as Air Force Undersecretary Edward Aldridge and Gen. Lawrence Skantze of the USAF Systems Command.

Conflict

The Vidrine incident was just one sign of the continuing struggle within the Air Force over the value of the shuttle versus expendable launch vehicles. Hans Mark and Maj. Gen. Kulpa had championed military man-in-space activities, but their successors, notably Edward "Pete" Aldridge, were doubtful that the shuttle would ever be reliable enough for operational military needs [14]. Aldridge successfully fought for the purchase of 10 additional Titan expendable launch vehicles in 1985 and saw his judgement vindicated when the shuttle "Challenger" exploded, grounding the programme for a lengthy spell.

Even among Air Force space proponents, opinion on the shuttle was sharply divided. Some officers had a clear vision of its usefulness for military activities while others scorned it as a fragile research vehicle. The shuttle also suffered from the "not invented here" stigma [15].

The MSE programme provided a focus for this debate, becoming, in the words of one MSE, "grist". Some senior Space Division officers supported the programme while others did not. Cadre commanders, notably Col. Mart H. Bushnell (who succeeded Vidrine in 1984), lobbied unsuccessfully for additional officers and for SD support with NASA, which had the already noted reservations about the MSEs [16].

In 1983 there was an attempt to give the MSE programme more clout inside the Air Force and NASA with a single stroke when Space Division officials asked astronaut John Fabian, a USAF colonel detached to NASA and veteran of STS-7, if he would consider returning to Space Division to head the group, but Fabian declined [17].

The low point of MSE morale was probably the last months of 1984. In October, the third selection board named Maj. Brett Watterson and Capt. Randy Odle as prime payload specialists and Capt. Michael Mantz as backup for shuttle Mission 62A, the first Vandenberg-launched orbital flight test. Also named were Capts. William Pailes (prime) and Michael Booen (backup) for another DoD launch-on-need payload scheduled to be launched in the autumn of 1985. But no one knew for certain just when these missions would be flown. The Payton/Wright and Casserino/Joseph teams were still on the ground and at least three other payload specialist slots had been permanently lost. Selection of eight or nine new officers for a 1985 third cadre was halted.

Worse yet, Air Force Secretary Vernbe Orr issued a policy statement designed to eliminate "homesteading" – that is, USAF officers should spend no more than four years at one particular station. Officers remaining in one place for greater lengths of time would be penalised when promotions were made.

By this time, of course, all MSEs had been at Space Division for at least four years. Some officers, like Watterson and Sefchek, had spent as many as eight years at SD. Those MSEs without flight assignments immediately made plans to look for other work, and by the summer of 1985, all but Watterson, Casserino and Sefchek had transferred.

Finally, on January 24, 1985, MSE Gary Payton went into space aboard the Discovery on Mission 51C. Nine months later, second cadre MSE Pailes was aboard the first flight of the shuttle Atlantis on Mission 51J.

Just three weeks prior to 51J, in September 1985, Space Division announced publicly that MSE Watterson would fly aboard shuttle mission 62A, the first manned launch from Vandenberg AFB [18]. This was a break in procedure, since Payton and Pailes had

Rob Crombie

Frank DeArmond

(Above) The crew of the first DoD dedicated shuttle mission, STS 51-C. (Kneeling right) Thomas Mattingly, commander, and (kneeling left) Loren Shriver, pilot. (standing left to right) Gary Payton, Manned Space Flight Engineer, James Buchli and Ellison Onizuka, mission specialists.

(Below) The crew that never flew. Mission STS 62-A was to have been the first shuttle flight from Vandenberg Air Force Base. The flight was cancelled following the Challenger Accident. (Front row, left to right) pilot Guy Gardner and mission specialists Richard Mullane, Jerry Ross and Dale Gardner. (Back row left to right) Air Force Undersecretary Edward Aldridge, commander Robert Crippen and Manned Space Flight Engineer Brett Watterson.


MATTINGLY
SHRIVER
ONIZUKA
BUCHLI
PAYTON

only been identified at launch-minus-30 days [19].

The week after Pailes' flight, on October 9, 1985, SD finally disclosed the names of the remaining "active" MSEs:

Capt. Michael Booen
Capt. Larry James
Maj. Charles Jones
Capt. Maureen LaComb
Capt. Michael Mantz
Capt. Randy Odle
Capt. William Pailes
Capt. Craig Puz
Capt. Glenn Yeakel

This list does not include Lt. Col. Payton or Maj. Watterson, who had been publicly identified, or Capt. Casserino, who had not, because these officers were still assigned to Special Projects. They were not formally associated with the MSE programme, though they remained eligible for assignment to shuttle crews. Second cadre officers Armor, Holder, Roberts and Thompson were also assigned to SP.

The question of publicity in itself mirrors the debate over the value of the MSE programme. Officers selected for the first cadre in 1979 were, in some cases, identified through the Pentagon's hometown press service and not instructed to keep their new assignment secret. Maj. Payton's biography, identifying him as a manned spaceflight engineer, was published in Janes' *Who's Who in Aerospace and Aviation* in 1984. The new MSEs were under the impression that the Air Force, as it had with the X-20 and MOL pilots, was going to publicise their existence. "An announcement was to be made 'any day now'", one of them says, "but that day never came". Apparently some men sent out the news with their Christmas cards in December 1979, only to be told to recall them.

Existence of the group (which was originally organised as a Special Project) remained secret, by and large, until late 1982, when various publications ranging from the *Houston Post* to *Aviation Week* disclosed the fact that a "secret cadre" of 13 officers was training as shuttle payload specialists.

The *Aviation Week* story appeared as NASA named an astronaut crew commanded by Navy Capt. T.K. Mattingly to STS-10, then scheduled for launch in November 1983. MSEs Payton and Wright also began to train with astronauts Mattingly, Shriver, Onizuka and Buchli, a fact which was surely known to hundreds of civilian employees of the NASA Johnson Space Center.

MSE Pailes, who found himself frozen out of certain crew functions and forced to invent cover stories to explain his presence at JSC, would later propose a change in security policies to allow for disclosure of the MSE at the same time the NASA crew was announced [20].

In May 1983 Space Division issued a press release confirming the existence of the MSE group and stating that 27 officers had been trained. It was rumoured that SD was now willing to provide pictures and biographies of the MSEs, but, again, no release was made and queries were met with silence (MSE biographies eventually obtained by the author some years later were all dated May 1983).

One MSE suggests that publicity for the group would have implied a greater level of Air Force support for the programme than actually existed. In any case, it was not until reports appeared in the press concerning the Pentagon's secret cadre of "soldier-astronauts" [21] that official clarifications were made.

By November 1985, experience with two successful DoD-dedicated shuttle missions had allowed the Air Force and NASA to reach mutual agreement on dealings concerning security, manifesting and other issues. In addition to the oft-delayed Vandenberg Orbital Flight Test, Mission 62A, five other dedicated missions were scheduled to be flown up to May 1987. The first two launches of Navstar GPS satellites were also scheduled. The fourth MSE selection board met that month and assigned five officers as prime payload specialists for the six new flights: Casserino, James, Jones, Roberts and Puz. Capt. Larry James would make two flights with Navstar. Plans for the selection of a third cadre, cancelled in 1984, went ahead. It appeared that the MSE programme was about to be vindicated.

Then, on January 28, 1986, the shuttle "Challenger" exploded during launch.

Aftermath and The Third Cadre

During the spring of 1986, as the American space programme suffered through a seige of failures and reappraisal, Air Force space managers decreed that MSEs would no longer accompany certain payloads on shuttle launches. This list included TRW Defense Support Program satellites in addition to the previously-mentioned DSCS and Navstar GPS payloads. The primary reason cited was concern for safety. MSEs would continue to train for flights with selected national security payloads, with the Strategic Defense Initiative's "Starlab" (variously known as the Tracking and Pointing Exercise or TPE, PATIE, and Blue Spacelab) and with DoD scientific experiment packages.

Col. Bushnell was reassigned in March and succeeded as Director of Manned Spaceflight Support by Lt. Col. Pailes, the ranking MSE. The five members of the third cadre arrived on April 30, 1986, to begin their initial training. They had been selected from over 500 applicants the previous August:

Capt. Joseph J. Caretto (29)
Capt. Robert B. Crombie (32)
Capt. Frank M. DeArmond (31)
Capt. David P. Staib, Jr. (30)
1Lt. Teresa M. Stevens (25)

Four of the new officers had operational space backgrounds – Caretto and Stevens had worked as shuttle flight controllers with the 1st Manned Spaceflight Support Group at the NASA Johnson Space Center while Staib had been an IUS controller at Cape Canaveral and DeArmond a satellite control officer at Sunnyvale. Crombie was a flight test engineer. They completed training in January 1987.

The revised shuttle programme manifest issued in late 1986 called for five dedicated DoD missions in the first year of resumed operations, presumably providing opportunities for flights by several MSEs. Yet just four weeks later, NASA Administrator James Fletcher announced that the first five shuttle missions, including two DoD flights, would be flown by five-member NASA astronaut crews only. Fletcher further expressed the desire to keep PSs of all kinds off shuttle flights

David Staib

Theresa Stevens

The crew of the second DoD dedicated shuttle mission STS 51–J. (Front centre) Karol Bobko, commander, (front right) Ron Grabe, pilot, (rear left) William Pailes, Manned Space Flight Engineer, (rear right) David Hilmers and (front left) Robert Stewart, mission specialists. *NASA*

for the next 20 missions, "... if not forever" [22]. At the same time, the NASA astronaut office was lobbying for the elimination of payload specialists, with the possible exception of Spacelab-type missions, on which a single PS would be included.

Nevertheless, in April 1987 a new payload specialist selection board named Maj. Craig Puz and Capt. Maureen LaComb as prime payload specialists for the StarLab mission scheduled for 1989 or 1990, a decision which was announced publicly in October. Later in 1987 Space Division finalised plans to send two MSEs into space with a payload consisting of the long-delayed AFP 888 Teal Ruby satellite, the AFP 675 Cirrus 1A package, and the Infrared Background Signature Survey (IBSS) camera.

The Future

In spite of the existence of a handful of flight opportunities, by the end of 1987 the MSE programme had been allowed to wither. Cadre director Pailes returned to operational flying as a rescue pilot at Eglin AFB, Florida, and was not replaced. Following the additional transfers of MSEs Booen, Jones, Mantz and Roberts to other Air Force assignments, and resignations by MSEs assigned to Special Projects, the group consisted of ten officers. No further selections were planned.

And it is far from certain that members of the existing group will go into space even on the Starlab or IBSS missions. For example, the SDI organisation plans to assign its own personnel as Starlab backup payload specialists. Further, in late 1987 the US Air Force conducted a new study of "military man-in-space", intended "to settle a 25-year Defense Dept. debate about the relative usefulness of manned versus unmanned systems..." [23]. Of the 11 scheduled "exercises", a majority would require flights by personnel from the Air Weather Service, the US Navy and the US Army, not the MSE group at Space Division, even though MSEs were to integrate the tests. One official speculates that, ultimately, "Payton and Pailes will be the only MSEs to fly".

Acknowledgements

The author wishes to acknowledge the assistance of the former and current members of the MSE programme who took the time to review and correct certain portions of this paper. Any remaining errors are the author's. It should be noted that information concerning military shuttle payloads comes from open literature identified in the notes.

References

1 For an analysis of the original shuttle design and goals and the Mathematica study, see *Enterprise* by Jerry Grey (New York Wm Morrow & Co, 1979), pages 72 through 79 in particular

2 For a discussion of the relationship between NASA and the Air Force, see *Prescription for Disaster* by Joseph Trento with Susan Trento (New York Crown, 1986), p 122-149

3 Mark, a former (and future) NASA official, was one of the Air Force's few shuttle supporters. As Undersecretary of the Air Force he was responsible for all military space programmes, including secret "Special Projects" in his "black hat" role as head of the National Reconnaissance Office

4. For a more detailed description of the MSE program and training, see *Spacefarers of the Eighties and Nineties* by Alcestis Oberg (New York Columbia University Press, 1985)

5 NASA Official Jay Honeycutt did advise the MSE selection board

6. Memorandum from Gerald D Griffin, Director National Space Transporation Systems Programme Office, NASA, to Manager, NSTS, August 22, 1983

7 The March 1982 NASA Space Transportation System manifest baseline predicted eleven dedicated DoD missions between June 1982 and September 1985

8 From time to time, USAF space managers considered the idea that manned spaceflight engineer training should be prerequisite for all Air Force mission specialist astronaut candidates This idea never received strong support, but several MSEs have been submitted to NASA as potential astronauts James Armor, Daryl Joseph, William Pailes, and Gary Payton were nominated in 1985, Pailes and Maureen LaComb in 1986 (the suspended selection) and again in 1987 Pailes was a finalist for the 1987 mission specialist group.

9 For a description of US military satellite programmes, see *Deep Black* by William Burrows (New York Random House, 1986) and *Guide to Military Space Programmes* by C Richard Whelan (Arlington, Va Pasha Publications, 1984)

10 *Air Force Times* "Officers Needed to Redesign Space 'Control' Experiments," May 24, 1982

11 For a description of the STS-4 payload, see *Aviation Week*, June 4, 1982

12 It has been rumoured incorrectly that some MSEs would have performed EVA. While it is true that members of the group were trained in EVA procedures, including use of the manned manoeuvring unit, US Code presently allows EVAs only by NASA mission specialists and pilots

13 *Aviation Week*, February 13, 1984 See also Anthony Kenden, "US Military Activities in Space – 1984", privately published, 1985

14 See Trento, p 234-235

15 There was a virtual repeat of the Vidrine incident later in 1984, when NASA offered Space Division the opportunity to add a second payload specialist to the crew of Mission 51C SD officials declined

16 In early 1985 SD officials requested a seat for a payload specialist MSE (Capt Scott Yeakel) on Shuttle Mission 51G, then scheduled for June of that year, to operate the MARC-DN camera NASA refused, claiming that payload specialists with "higher priority" were already manifested This elicited a stinging response from SD, since one of PSs was Saudi Prince Sultan Salman al-Saud, a professional broadcaster whose function was strictly that of an observer The issue became moot when other payload manifesting problems delayed the flight of the MARC-DN to Mission 51J, a dedicated DoD flight, where it was operated by MSE William Pailes

17 Ironically, when Fabian finally left NASA in January 1986 he became director of space for the Air Force at the Pentagon, where he supervised the development of military satellites. Trento, p.6, claims this was a Special Projects (National Reconnaissance Office) job, but Fabian reported to the director of research and development, not space systems and C3 The latter job is in the usual NRO chain of command

18 Watterson's fellow payload specialist was to be none other than Air Force Undersecretary Pete Aldridge, Hans Mark's successor, who had assigned himself to the crew, bumping MSE Captain Randy Odle As early as 1983, General Lawrence Skantze, commander of the Air Force Systems Command, had also requested a flight aboard the shuttle and was in the process of being manifested for a 1986 shuttle flight at the time of the "Challenger" disaster

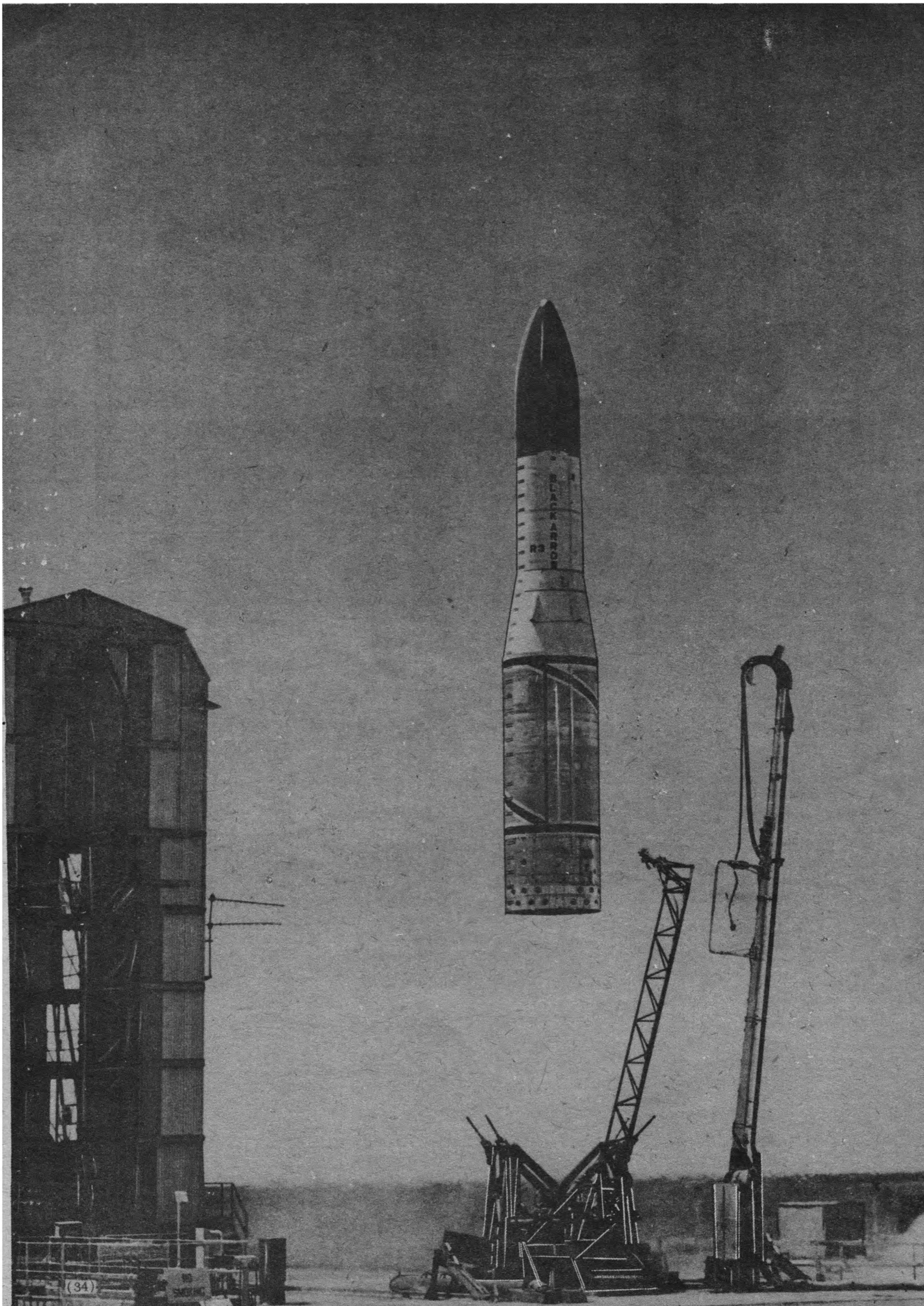
19 Craig Covault, "Military to Withhold Shuttle Lift-off Time", *Aviation Week*, November 9, 1984, p 14 This article also discusses security procedures for military shuttle missions and the "classification" of the Mission 51C crew patch because it contained Payton's name.

20 "51J Postflight Report Some Lessons Learned", William Pailes, October 1985

21 For example, "Space-War Era: It's Already Here", *US News and World Report*, December 17, 1984, p.28

22. Quoted in *USA Today*, January 29, 1987

23. Craig Covault, "USAF Plans Military Exercises on Space Shuttle", *Aviation Week*, January 4, 1988


BLACK ARROW
R3
(34)

Prospero Picture Found

In Correspondence, June 1988, Geoffrey Bowman wrote about his unsuccessful attempts to locate a true photograph of the launch of Britain's first satellite Prospero. Michael Crowe a *Spaceflight* reader in Australia has obtained a copy of the illusive photograph which we have reproduced here in full colour.

Geoffrey Bowman's original letter:

Sir, Following the launch of "Prospero", the first and only all-British satellite, on October 28, 1971, I made numerous efforts to obtain a photograph of the event. I contacted various contractors and government departments without success. They all apologised for being unable to supply "Prospero" launch photographs, and instead sent me numerous photographs showing the unsuccessful Black Arrow launch in September 1970.

On at least two occasions, ***Spaceflight*** has published photographs purporting to show the "Prospero" launch (January 1972, front cover; and April 1986, p.158). In each case the lighting angles and shadows clearly show that photographs of the September 1970 launch have been used. This confusion may have arisen because the 1970 photographs appear to have been issued to the press in anticipation of the launch of "Prospero." One copy in my possession is clearly labelled: "Britain's Black Arrow will launch Prospero from Woomera, Australia."

It would therefore surprise me if ***Spaceflight*** readers (myself included) have ever seen a photograph of Britian's one and only satellite launch, which seems most ironic. Can you now remedy matters, albeit 16 years after the event? If the Society can trace a genuine "Prospero" launch photograph, it surely deserves pride of place in a future issue of ***Spaceflight***.

GEOFFREY BOWMAN
Belfast N. Ireland

Michael Crowe answers Mr Bowman's request:

Sir, As requested by Geoffery Bowman (***Spaceflight***, June 1988, p.527) I have traced a 'genuine' Prospero launch photograph (Negative No:CN71/159).

The lettering on the side of the rocket positively identifies it as being the R3 Black Arrow launch vehicle that placed Prospero, Britain's one and only satellite, into orbit [1].

Without such means of identification one would need to employ the same kind of detective work that Geoffrey Bowman did in trying to distinguish one Black Arrow launch from another.

To lend some credence to his careful scrutiny of the 'Prospero' photographs ***Spaceflight*** has published, (January 1972 and April 1986, p. 158), compare the photograph of the R2 launch with that of the R3. Without the lettering they would be very difficult to distinguish.

In fact, after examining some of the other 'Prospero' launch photographs that have been published [2,3] – incredible though it may be – it seems that all were probably of the R2 Black Arrow launch!

Like the now 'famous' Armstrong-on-the-Moon photograph (***Spaceflight***, December 1987, p. 428 and July 1988 p. 284–285) has the Correspondence page cleared up another historic oversight?

May I conclude by thanking Frank Chapman of the Still Photography Section, Defence Science & Technology Organisation, South Australia, for kindly providing me with these photographs.

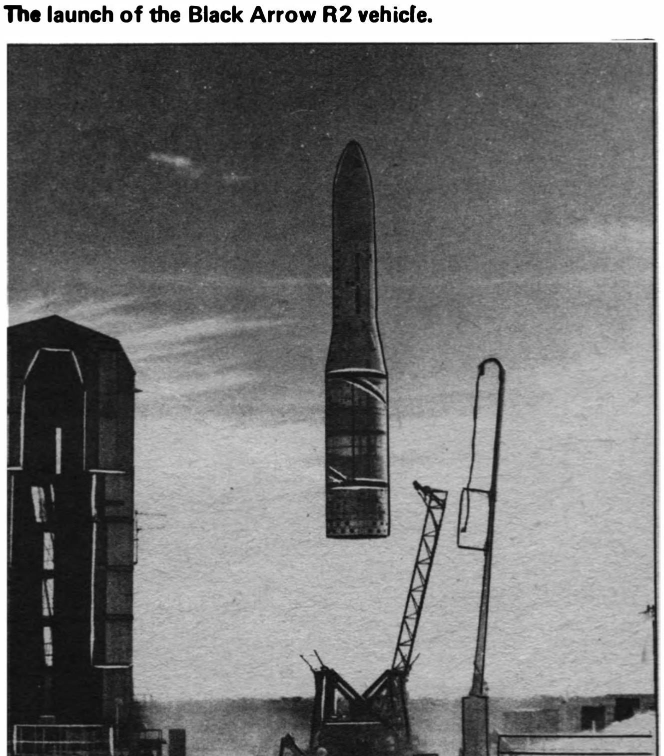
MICHAEL A. CROWE
Waramanga, Australia

References

1 *1971–1972 Annual Report*, Weapons Research Establishment, Salisbury, South Australia Australian Government Publishing Service, Canberra 1972, p 23–24
2 *Jane's Spaceflight Directory*, 1984 p 28
3 *Observing Earth Satellites*, D King-Hele, Macmillan, London 1983, p 8

◂The genuine Prospero launch photograph. The Black Arrow R3 launches Britain's first satellite.

The launch of the Black Arrow R2 vehicle.



The R1 lift-off in March 1970.