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SPACE FLIGHT NEWS

Mission Report

EURO LAB

WHAT THE INFRA-RED EYE SAW!

Where the USA is going wrong: Gene Cernan

Progress: Soviet Workhorse

Romanenko Record

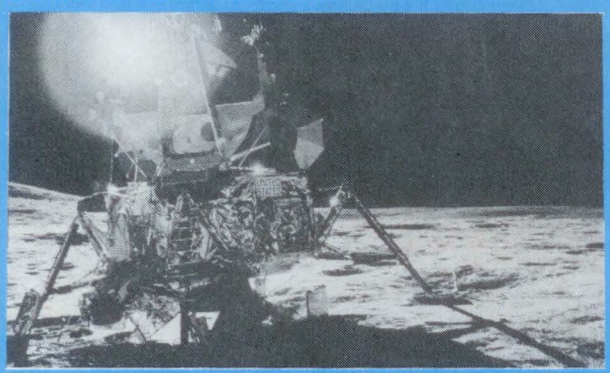
NASA's FLEXIBLE F-111

COMING ..... NEXT MONTH

LUNAR MODULE

On six occasions manned spacecraft touched down on the surface of the Moon. The spacecraft in question were known as Lunar Excursion Modules, or LMs.

Dave Shayler tells the story of the LMs' development, and explains how these curious-looking machines were built and flown.



CHAMPION CHASE-PLANE

Our regular guest-columnist, ex-astronaut Robert Overmyer, relates his experiences flying NASA T-38 jetplanes in support of Space Shuttle operations.

SPACE'S MEDICINE-MAN!

Pharmaceuticals and other high-quality products may one day be manufactured in orbit.

Charlie Walker of the McDonnell Douglas company has flown three times aboard the Space Shuttle to conduct important medical research work in low-Earth orbit. He takes advantage of our newly-inaugurated OPEN SPACE *column to summarize his results and present his view of the way ahead.*

FINALLY, DON'T FORGET...

SPACEFLIGHT NEWS *is now published on the* FOURTH TUESDAY *of every month. Our March 1988 issue will therefore appear on the news-stands on Tuesday 26 February.*

DON'T MISS IT!

CONTE

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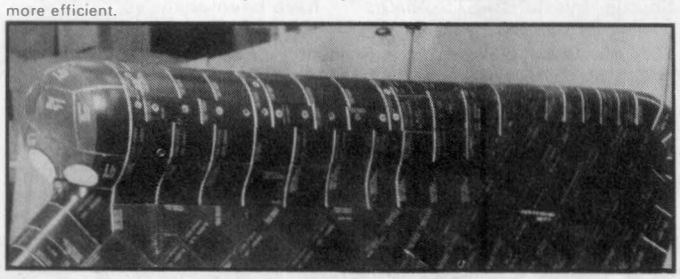

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FRONT COVER:
The launch of *Columbia* at the start of mission STS-9 forms the centerpiece of this month's front cover. Inside the reusable spacecraft's cavernous payload bay on this occasion was the Spacelab 1 laboratory module, in which four scientist-astronauts worked in shifts around the clock for ten days.

Turn to pages 34/42 for our exclusive *SHUTTLE MISSION REPORT* on this epic flight.

The inset at bottom-right shows NASA's very special F-111 test airplane. It is equipped with wings which mimmicks those of a bird's by altering their shape in flight to suit varying conditions. Full story on pages 24/27.

COMMENT

PREPARE FOR ACTION!

The rousing call above is double-edged. We'd like you to prepare for some real action-packed photos further on in this very issue, but we also want you to get ready for a big announcment we'll be making in next month's issue . . .

The pictures are the work of Soviet photographer Aleksandr Mokletsov, and their appearance demonstrates the unique relationship* SPACEFLIGHT NEWS *has with the Soviet Union.

We can rightly claim to be the first magazine in the West to release a full series of views showing cosmonaut Yuri Romanenko's triumphant return to Earth after 326 days in space.

With stunning clarity you'll see the area around the Soyuz TM-3 capsule transformed into a hive of activity as Romanenko and his compatriots Aleksandrov and Levchenko are lifted back onto terra-firma and escorted to their waiting helicopter, where preliminary medical examinations begin.

Not that these are the only pictures we're proud of this month. There's the usual feast of views from the United States, where both astronautical and aeronautical developments get their just share of coverage.

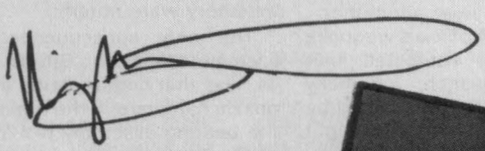
And our important announcement?

That will have to wait until next month, although we can say two things to give you a taste of what's coming.

First; we aim to give YOU an opportunity to play a real part in advancing space exploration. Running a magazine with a truly worldwide readership, we frequently find ourselves being called upon to act as a catalyst for action.

Starting next month, there will be the means to do just that.

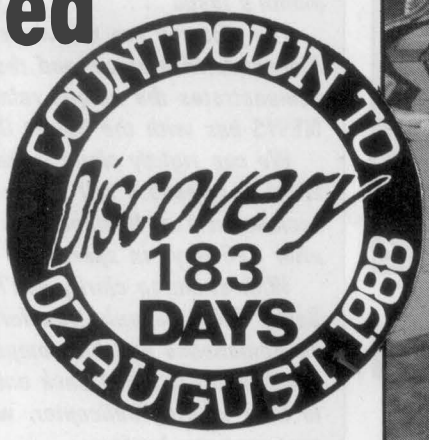
Second; the announcement's appearance will make next month's issue of* SPACEFLIGHT NEWS *the most important one yet. So important, in fact, that I'm urging you this month to get pen and paper at the ready.



NIGEL MACKNIGHT
Editor/Publisher
'Spaceflight News'

EDITED BY DR. DAVID WHITEHOUSE

Setback as Shuttle launch is delayed



THE MOST recent test-firing of a redesigned Shuttle solid rocket booster (SRB) has revealed a fault in an aft nozzle component, causing a setback to the drive to put America's reusable space-plane back into action.

The test, designated DM-9 (Demonstration Motor-9) took place on 23 December and was a full 120-second-duration firing of a complete booster fixed in a horizontal position to a special support structure at manufacturer Morton Thiokol's Brigham City, Utah plant.

Initial post-test inspections gave rise to optimism when they indicated that the redesigned field joint (the area where the fatal flaw developed on mission 51-L) had performed properly.

However, closer examination of the aft nozzle area, where the searingly-hot combustion gases are expelled, revealed that a component known as the 'outer boot ring' had broken at some stage in the test-firing.

The outer boot ring is a component fabricated from plies of carbon-composite material. It holds in place a flexible 'boot' which protects a critical component in the booster assembly from heat damage; the bearing which enables the whole aft nozzle to gimbal in flight for steering.

Apparently, the insulative boot itself was also damaged during the firing, a large area of material being burned away altogether.

Senior NASA officials we spoke to last week estimated that *Discovery's* launch, originally scheduled for 2 June, would be delayed by approximately eight weeks.

Soon after the DM-9 test, *SPACEFLIGHT NEWS* spoke to the NASA astronaut who, until very recently, was assigned to oversee the Shuttle SRB redesign and test-firing program; Robert 'Hoot' Gibson, whose duties have just been taken over by fellow astronaut Steve Oswald.

The reason? Gibson has been assigned as the Commander of the second Shuttle mission in the resumed flight program, the military STS-27/*Atlantis* mission now slated for November.

'Hoot' scotched rumors that the flaw revealed in the DM-9 test would cause a significant delay to the STS-26/*Discovery* mission previously scheduled for 2 June. He was also emphatic that, had the failure seen in the DM-9 test been experienced in flight, the consequences would not have been fatal.

In fact, he said, such a failure has occured in flight on one (51-J) occasion, and no adverse effects on the Shuttle's ascent trajectory were noted.

The only consequences of such a malfunction , Gibson told us, was that certain items of aft nozzle hardware in the region of the bearing assembly would be damaged beyond reuse on a subsequent flight.

● **Full story next month.**

The full-scale Shuttle solid rocket booster (SRB) used in the DM-9 test-firing is readied for ignition at manufacturer Morton Thiokol's Brigham City, Utah plant. A component failure discovered after the tests will delay the launch of* Discovery *by about eight weeks.

Discovery may have 'new' landing site

WHITE SANDS Space Harbor, New Mexico (formerly known as Northrup Strip) has been designated as an alternative landing site for the next three Space Shuttle missions; STS-26/*Discovery,* STS-27/*Atlantis* and STS-28/*Columbia.*

NASA says White Sands would be used if weather conditions precluded a normal end-of-mission recovery at the primary landing site, the dry-lakebed runways at Edwards Air Force Base, California.

Future landing-site options will be considered after the next three flights, when data on the improved Shuttle braking system and some other technical issues have been analysed.

White Sands has been used only once for a Shuttle landing, when *Columbia* returned there at the close of mission STS-3, the third Orbital Test Flight (OTF), on 30 March 1982. The New Mexico site was selected even before launch, because heavy rains had flooded Edwards.

'Let's explore Mars

THE USSR has suggested that NASA's Mars Observer spacecraft, to be launched from the payload bay of the Shuttle in 1992, be modified to act as a data-relay platform for information gathered on the Martian surface by two heavily-instrumented Soviet balloons due to be drifting across the 'Red Planet' at the time the U.S. probe is in action.

The balloons are being constructed jointly by the USSR and France as part of a 1994 Mars mission.

Apparently, the Soviet suggestion is being taken seriously in Washington, because it would represent a cost-effective form of U.S./Soviet collaboration and would significantly enhance the scientific return of the balloons, in turn increasing information

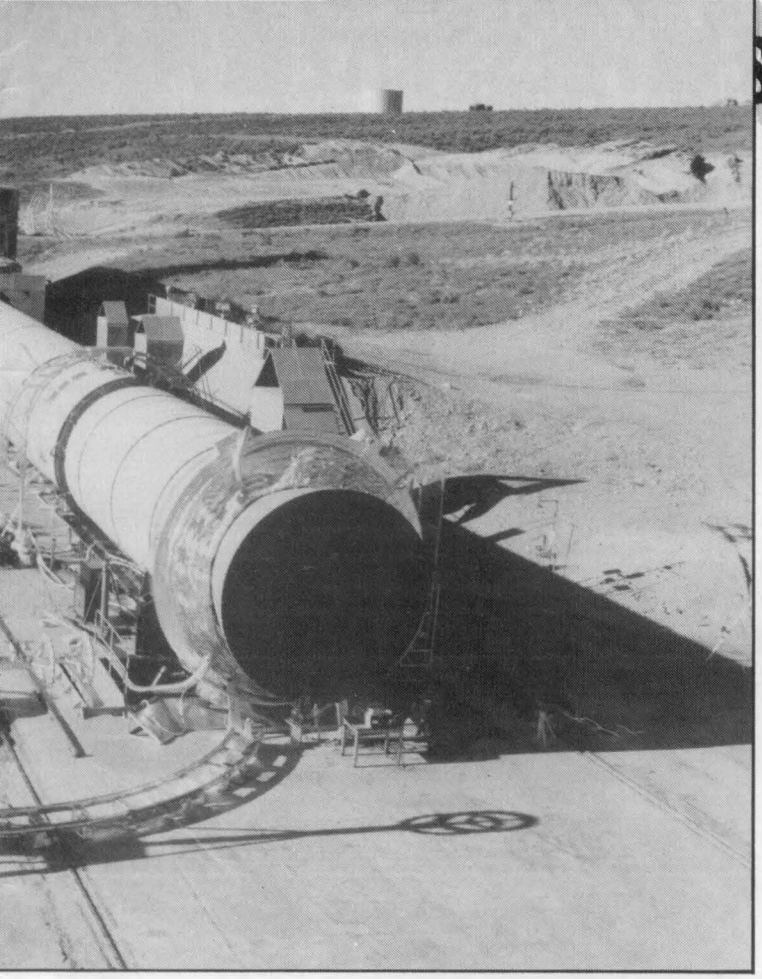
PRESS.... STOP PRESS.... STOP PI

On the night of 20 January, we received official word that the Soviet Shuttle's long-awaited first launch is imminent. The announcement came during a Moscow press conference hosted by Aleksandr Dunayev, head of the national space organization, Glavcosmos.

Lift-off will take place as soon as what are termed *"final preparations"* are completed. The reusable craft will be orbited by the world's most powerful booster, the Energia (Energy) vehicle, which is capable of carrying payloads of up to 100 tonnes.

● The Progress 34 cargo ferry was launched to the Mir space station complex at 10:46am GMT on 20 January.

● It's been announced that the Soviet/Afgan joint mission to Mir will take place this August.



Rare criticism from Soviet space chief

EX-COSMONAUT Vladimir Shatalov, now Chief of the Yuri Gagarin Cosmonaut Training Center ('Star City') near Moscow has had some critical comments to make about the Soviet space program. His critisisms came during a recent interview, in which he stated that, apart from the program to make detailed observations of the Earth from space there was a *"lack of purposefulness and consistency"* in the space program.

He continued by saving that, although a lot of the work being conducted in space could potentially lead to considerable 'spin-off' benefits back on Earth, the crews *"will bring the results back and everything will disappear down a hole."*

Responding to a question about crewmember creature-comforts in space, Shatalov stated that *"relaxation onboard the craft is the Achilles' heel of spaceflights . . . it is necessary to have good collections of books, video cassettes, tape-recordings and regular televisual contacts with families. Sometimes you also need to be alone in your cabin.*

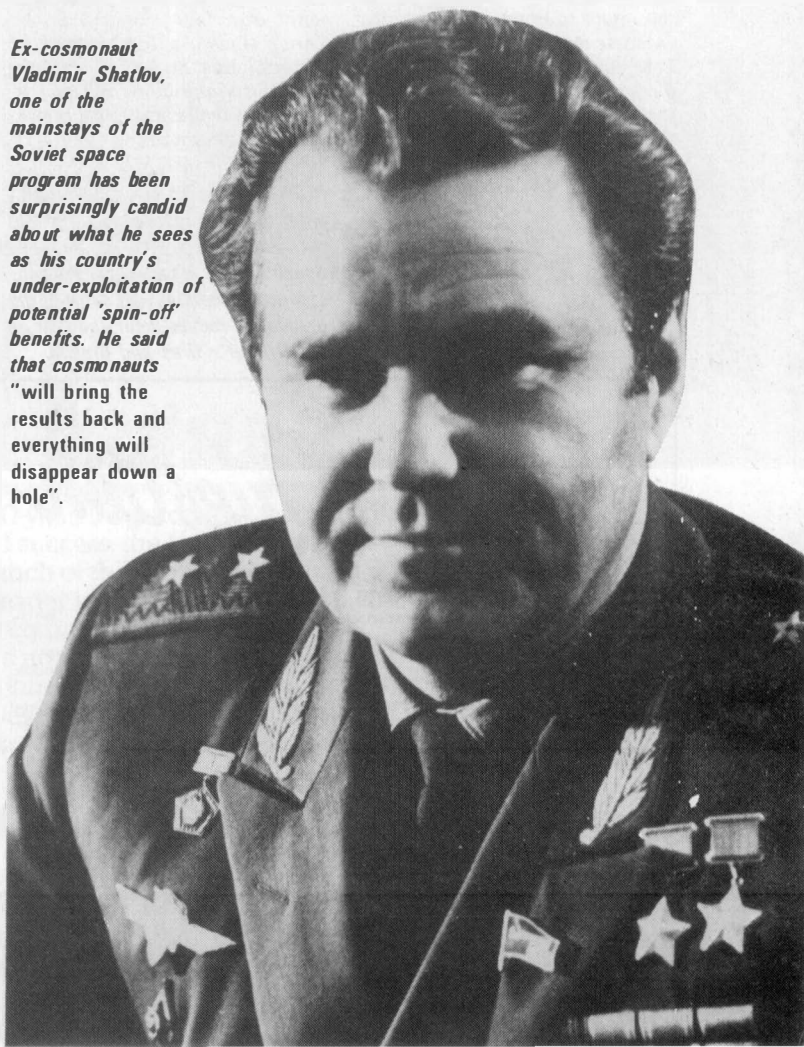
"As the (space) *stations are improved, so the opportunities for relaxation will also increase . . . it is very important to switch from today's psychological crew support which, like it or not, is weak, to permanent psychological contact between the cosmonaut and Earth."*

Canada signs up

CANADA has signed a Memorandum of Understanding (MoU) with the United States on participation in NASA's Space Station program, thereby becoming first international partner to do so.

Canada's main contribution will be the important mobile servicing center that will help construct the Space Station as well maintain it.

Signing of the MoU was well-timed. Almost exactly 25 years ago, the first Canadian satellite, Alouette, was placed into orbit by a NASA rocket.



***Ex-cosmonaut Vladimir Shatlov, one of the mainstays of the Soviet space program has been surprisingly candid about what he sees as his country's under-exploitation of potential 'spin-off' benefits. He said that cosmonauts* "will bring the results back and everything will disappear down a hole".**

Aussies upgraded

THE Australian element of the NASA-operated Deep Space Network (DSN) has been upgraded. The diameter of the large radio dish at Canberra has been increased from 64 meters to 70 meters as part of preparations to receive the weak radio signals returned by the distant Voyager 2 spacecraft as it makes its historic encounters with the planet Neptune and its mysterious moon Triton in August 1989.

In addition, all three DSN tracking stations – the other two are in California and Spain – are to be modified to receive data from the USSR's twin Phobos spacecraft, due to be launched later this year (see separate story).

'COUNT US IN' SAY ITALIANS

LUCIANO Guerriero, director of the Italian national space organization, has said on a visit to Washington D.C. that Italy will participate in the U.S./International Space Station program even if the European Space Agency (ESA) cannot come to an agreement with NASA on the terms of its collective cooperation.

Italian scientists are already cooperating with their U.S. counterparts on a Tethered Satellite System (TSS) that will be reeled out on a cable over 100 kilometers from an orbiting Space Shuttle to 'trawl' the Earth's upper atmosphere for science data. They have suggested that such a tether could also trail experiment packages below the Space Station, possibly releasing small capsules to return certain materials back to Earth.

together'

about the planet the Americans themselves will want to land on one day . . .

● Soviet space program officials have revealed that they have plans to launch a radar sounding spacecraft to probe the Martian surface between the 1988 Phobos missions and the 1994 Franco-Soviet balloon mission.

Quicker Contact!

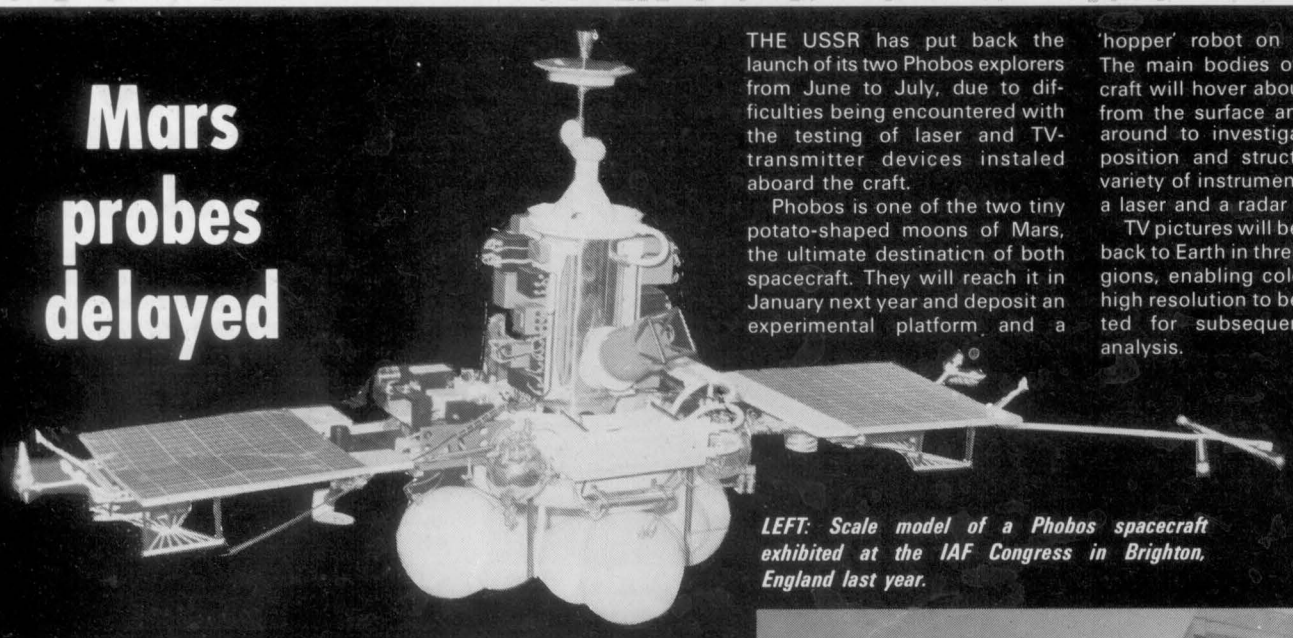
As of 7 January, *SPACEFLIGHT NEWS* has been equipped with both FAX and Telex communications facilities. The respective numbers (which henceforth will appear in our publishing-data panel on pages 2/3 are as follows:-

FAX: (0780) 57261.

TELEX: 265871 MONREFG.

We ask all our friends and contacts to make a note of these numbers and to use the new facilities whenever it helps speed the flow of information to our pages.

Mars probes delayed



THE USSR has put back the launch of its two Phobos explorers from June to July, due to difficulties being encountered with the testing of laser and TV-transmitter devices instaled aboard the craft.

Phobos is one of the two tiny potato-shaped moons of Mars, the ultimate destinatıcn of both spacecraft. They will reach it in January next year and deposit an experimental platform and a 'hopper' robot on the surface. The main bodies of the spacecraft will hover about 50 meters from the surface and manouver around to investigate its composition and structure using a variety of instruments, including a laser and a radar sounder.

TV pictures will be transmitted back to Earth in three spectral regions, enabling color images of high resolution to be reconstructed for subsequent scientific analysis.

LEFT: Scale model of a Phobos spacecraft exhibited at the IAF Congress in Brighton, England last year.

Cape to smooth its grooves!

ALTHOUGH Shuttle missions planned for the foreseeable future will terminate at either Edwards Air Force Base in California or White Sands in New Mexico, the recommencement of landings at Kennedy Space Center, Florida will be the next logical step in the return to normal flight status.

However, the runway surface at Kennedy has apparently caused severe wear and degradation to the tyres and braking system of the Orbiter vehicle, and NASA engineers at Langley Research Center in Virginia have been investigating the problem.

The runway of the Shuttle Landing Facility (SLF) at Kennedy has thousands of grooves running at right angles to each other to provide grip in wet conditions. Research work conducted at Langley shows that if the grooves in the region of the runway where the Orbiter first touches down are smoothed a little, then tire and brake mechanism wear will be considerably reduced.

Of the 24 Shuttle missions completed thus far, only six have terminated at Kennedy Space Center due to a combination of uncertainties about the highly-dynamic weather conditions in Florida and the general conservatism built into the early STS missions.

RIGHT: This machine cut over 8,500 miles of grooving into the surface of the Shuttle runway at Kennedy Space Center. Now, NASA are considering smoothing-out some of the grooves to reduce wear and tear on the Orbiter's tires and brakes.

OVERMYER'S Question Corner!

IN HIS article for our December 1987 issue, former Shuttle Commander Robert Overmyer posed another one of his tricky questions. He asked:-

"Who will be the Pilot on the second Shuttle mission of renewed flight operations – the military STS-27/Atlantis mission?"

Answer

"The Pilot for mission STS-27 has been named as Guy Gardner."

Winners

Ernie Willems of Hoboken, Belgium
Steve Morris of Leamington Spa, Warwickshire, England
Gareth Sims of Standens Barn, Northampton, England.
Rosy Steuperaert pf Deinze, Belgium
Carsten Doig of Inverkip, Greenock, Scotland

All five will receive an autographed color portrait of 'Shuttlenaut' Robert Overmyer

Question

Now here is this month's question. The conditions and prizes are the same as before, but we now permit only ONE entry per person; we will select the first five correct answers pulled from the postbag and the Editor's decision is final

Send your answers on a postcard please, to reach us not later than noon on 8 April 1988. Address: *OVERMYER'S QUESTION CORNER,* Spaceflight News, P.O. Box 100, Stamford, Lincolnshire PE9 1XQ, England.

"How many Shuttle Training Aircraft (STAs) does NASA have on strength at the present time?"

(The correct answer to this question, and the names of the five winners, will appear in the May 1988 issue).

USSR 94, REST OF WORLD 13

THE USSR achieved more satellite launches in 1987 than she did in 1986. Cosmos 1907, launched on 29 December, took the total number of Soviet launches to 94, compared to 91 last year.

In stark contrast, only 13 satellites belonging to other nations were placed in orbit thorughout the course of 1987.

BRAZILIAN SPACE LABORATORY SET UP

PRESIDENT Sarney of Brazil has officially inaugurated the new space laboratory of the Space Research Insitute in Sao Jose dos Campos. In this speech, Sarney said the laboratory was *"the cornerstone that irreversibly sets in motion Brazil's complete space mission, the objective of which is to launch into orbit and to operate four Brazilian-made satellites. The first satellite is in an advanced stage of development and is due to be launched in 1989."*

President Sarney also promised that no matter what problems or difficulties his government faced, Brazil's national space program would go ahead.

CHINA TO LAUNCH SWEDISH PAYLOAD

THE PEOPLES' Republic of China has confirmed that she will launch a Swedish scientific and telecommunications satellite called Fleza into orbit in 1991. The satellite will be launched by a Long March 2 rocket, which can put a payload of up to 2.5 tons into low-Earth orbit.

Until now, China has launched her own geostationary satellites from Xichang, and her indigenous remote-sensing Earth-observation satellites from the Jiuchuan complex. However, she is currently building a third national satellite launch complex south of Peking and says that this site, and the Xichang facilities, will be devoted to launching satellites for commercial purposes.

Later this year the Long March 3 booster is set to launch two U.S. telecommunications satellites, as well as China's fourth geostationary comsat.

SPY-SAT DETECTS ENERGIA ACTIVITY

REPORTS coming in from sources at the Pentagon say that the U.S. KH-11 spy-satellite photographs show considerable activity on the complex that will be used to launch the second flight of the Soviet Energia (Energy) heavy-lift booster rocket.

The prototype Energia flew successfully on 15 May last year, although the rocket stage of its piggyback payload pod malfunctioned, resulting in the payload failing to reach orbit. Extensive damage was apparently also caused to the launch pad facilities. A few months after that first test-flight, another Energia was erected on the same launch pad at Baikonur and later removed.

An unmanned test of the Soviet Shuttle is expected to take place before long, with the reusable spaceplane mounted atop an Energia vehicle.

BACK ISSUES

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India hosts conference

AN INTERNATIONAL Space Conference was held recently in Bangalore, India and attended by representatives from Great Britain, the USSR, the USA, West Germany and the host nation. The conference considered the prospects for further international co-operation by the major scientific organizations and institutions.

Opening the meeting, Professor U.R. Rao, Chairman of the Indian Space Research Organization (ISRO) said that the meeting would make a contribution to the further development of international co-operation between scientists, which is a major factor in fostering peaceful uses of outer space to promote social and economic development.

The Indian government has drawn-up a program around the space goals it wants to achieve during its next five-year plan. Details were submitted by the Minister of State for Science and Technology, Kocheril Roman Narayanan, to India's lower chamber of Parliament.

Early in 1988 there will be a second attempt to launch the Indian ASLV booster that failed one minute into its maiden flight in 1987. India also plans to deploy satellites to improve the monitoring of its terrain and the efficiency of its land use.

The Indian government is reported to be keen on an idea proposed by USSR premier Mikhail Gorbachev during a visit to India in November 1986. He talked about the creation in India of an international center for joint research and development of space technology, including a school for the training of cosmonauts and specialists from other developing countries.

THE GOAL IS MARS

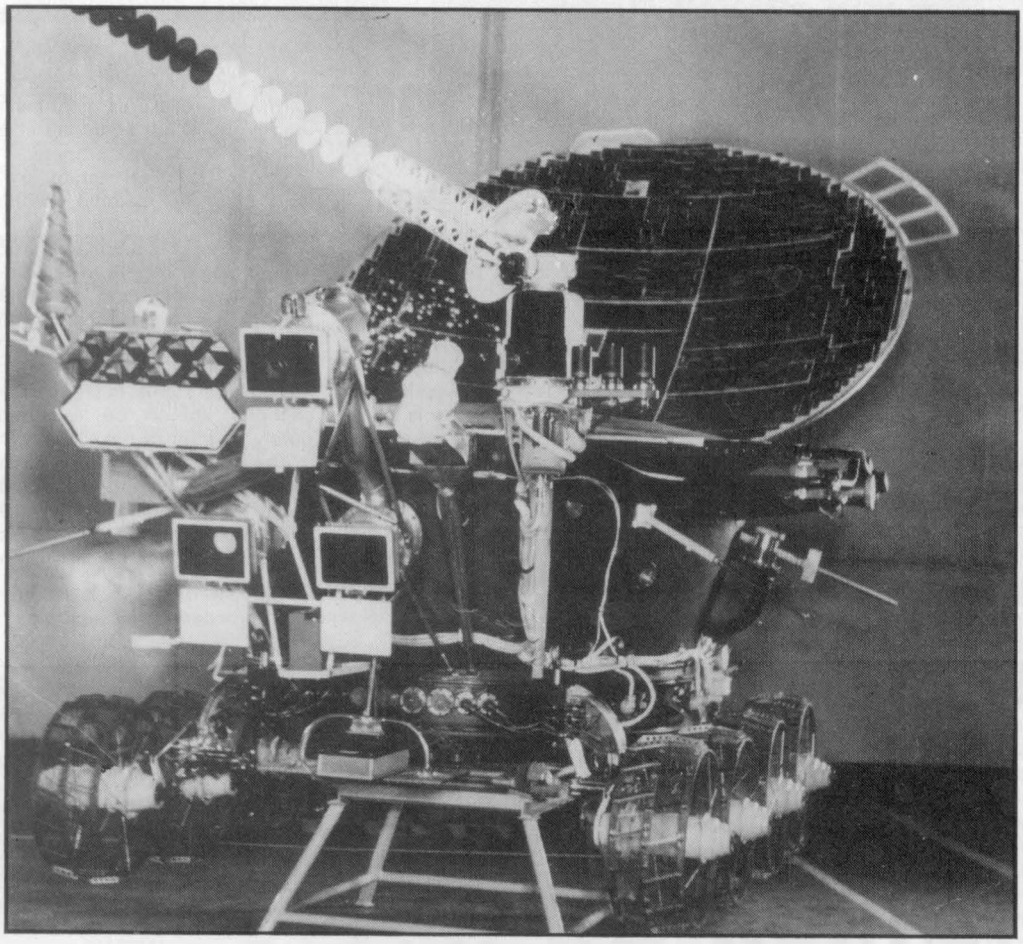
FOLLOWING cosmonaut Yuri Romanenko's 326-day sojourn in Earth orbit, Vyacheslav Balbebanov, Deputy Director of the Soviet Academy of Sciences' Institute of Cosmic Research, told the military newspaper *Krasnaya Zvezda* that one of the main goals of the nation's space program over the next five years will be gathering information about Mars to prepare for a manned mission.

Balebanov said that new modules to be attached to the Mir (Peace) space complex will study the Earth, its atmosphere and the Pacific Ocean.

COMING UP...

Welcome to our listing of imminent launches . . .

DATE	LAUNCH SITE	MISSION	VEHICLE	PAYLOAD
February 1988	Cape Canaveral, USA	SDI	Delta 181	Classified ('Star Wars')
February 1988	Plesetsk, USSR	Cosmos	F-2 Tsyklon	Cosmos oceanographic studies satellite
February 1988	Baikonur, USSR	Gamma	A-2 (Soyuz)	Gamma 1 astrophysics observatory
February 1988	Vandenberg, USA	AC-?	Atlas 63E	NOAA
February 1988	Tanegashima, Japan	–	H-1	CS3A
March 1988	San Marco, Indian Ocean	–	Scout S-206C	San Marco science payload
March 1988	Kourou, French Guyana	Ariane V21	Ariane 3	Spacenet 3R/Geostar RO1 comsat + Telecom 1C comsat
April 1988	Kourou, French Guyana	Ariane V22	Ariane 4	Meteosat P2 weather satellite + Amsat comsat + Panamsat comsat

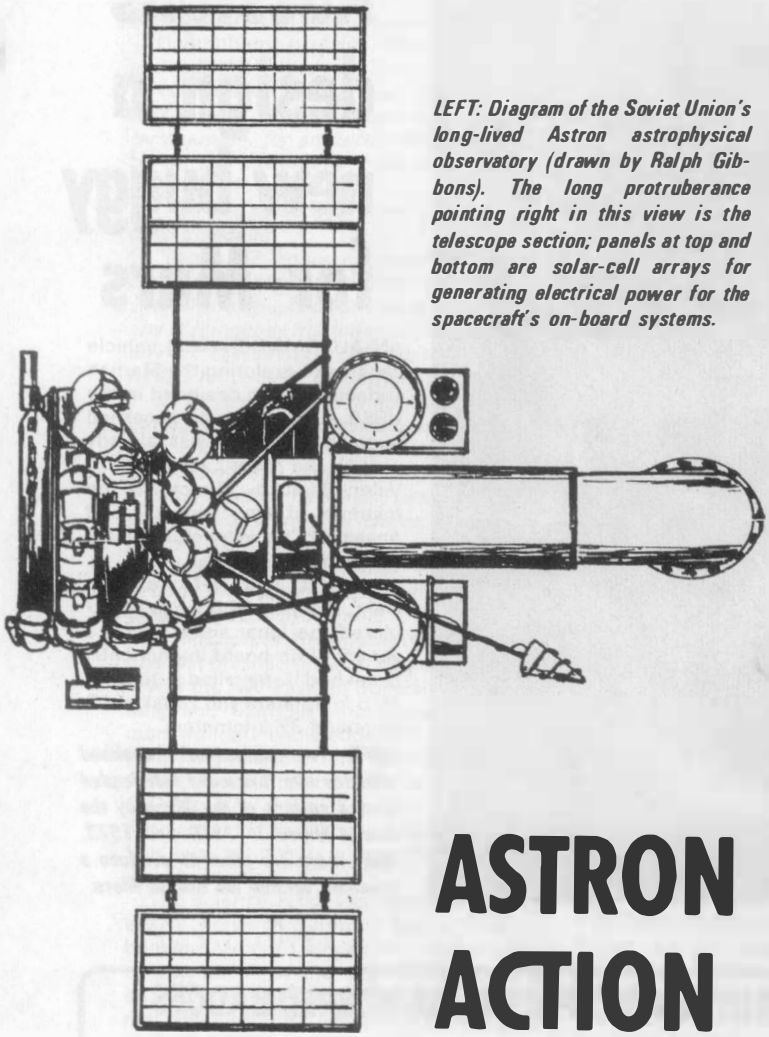


Russians design a new buggy for Mars

AN AUTOMATIC roving vehicle capable of exploring the Martian surface is being designed in the USSR. It is based on the Lunakhod buggies the USSR has already sent to the Moon, according to Valery Barsukov, Director of the Institute of Geochemistry and Analytical Chemistry of the USSR Academy of Sciences.

In 1970 and 1973 respectively, two Lunakhod rovers explored the lunar surface with a variety of on-board instruments. Lunakhod 1 travelled a total of 10.5 kilometers and Lunakhod 2 traversed 37 kilometers.

LEFT: Two unmanned Lunakhod vehicles like this ware soft-landed on the surface of the Moon by the Soviet Union in 1970 and 1973. Now thare are plans to produce a modified version for use on Mars.



LEFT: Diagram of the Soviet Union's long-lived Astron astrophysical observatory (drawn by Ralph Gibbons). The long protruberance pointing right in this view is the telescope section; panels at top and bottom are solar-cell arrays for generating electrical power for the spacecraft's on-board systems.

ASTRON ACTION

THE ASTRON astrophysical observatory, launched nearly five years ago by the Soviet Union, is continuing to return valuable data. It contains a detector to observe the Universe in X-rays, as well as an ultraviolet telescope; the largest of its kind ever placed into orbit.

Astron's planned operational lifetime was just one year. A larger replacement is currently under construction and will be launched during the next few years.

The Royal supporter

PRINCE CHARLES, in a recent speech to the Stock Exchange in London, called for increased support for the HOTOL spaceplane project, although he didn't actually mention the craft by name and merely spoke of the possibility of the nation losing a *"brilliantly simple"* aerospace concept to foreign interests.

Earlier, it had been revealed that Prince Charles wrote to Roy Gibson, former Director General of the British National Space Center (BNSC), asking for his comments on the British space situation in light of recent government announcements to the effect that funding will not be increased to match increases committed by the other European Space Agency member-nations.

PIONEER BIRTHDAY

OVERSEERS of America's Pioneer 8 science satellite recently celebrated 20 years of operational use. Pioneer 8 was launched by a McDonnell Douglas Delta rocket on 13 December 1967 and was placed in an elliptical solar orbit to make measurements of interplanetary space.

Of its eight instruments, only one is now functioning, but that isn't so surprising when one considers that the craft was originally designed to operate for just 6 months!

Pioneer B's sister ship, Pioneer 6, has now entered her 22nd year of operation and is the oldest functioning satellite in interplanetary space.

Buy land on Moon!

WHERE could you buy a five-acre plot of land for just £14, or U.S. $30?

While you're thinking it through, bear in mind that the plot has no water or electricity supplies and that, although the view is good, you'll find yourself about a quarter of a million miles from the nearest supermarket!

Rick Walter, a U.S. estate agent (realtor) is offering to sell plots of land on the Moon through his company Lunar Land Company. He says he is trying to do it as legally as is possible on Earth, and reassures customers who worry about someone else trying to claim their property.

Under U.S. real estate law, land must be claimed in the county where it's located.

To sound a cautionary note, we ask eager buyers to remember that selling land on other planets has been tried before and that, just like the service that offers to name a star after you, it has no legal status. In short, transactions should be regarded purely as a bit of fun.

The United Nations states that space, including the Moon and the planets, belongs to no-one and that no-one can claim it. We wonder how long that noble sentiment will last . . .

CHRISTMAS QUIZ ANSWERS & WINNERS

There has been an overwhelming response to our first *SPACEFLIGHT NEWS CHRISTMAS QUIZ*, announced in the December 1987 issue. As advertised, the list of correct answers, and the names of the lucky winners, appear in the February 1988 issue – this issue!

Readers will recall that the quiz was split into two prize-winning categories, and one non-prize-winning 'just-for-fun' category. The answers to the 50 questions posed by spaceflight historian Eddie Pugh in this latter category appeared elsewhere in the December issue.

Now here are the prize-winning results you've all been waiting for. . .

FIVE FACE CHALLENGE

In this section of the competition, we presented five 'mug-shots' – photos of astronauts and cosmonauts, past and present – and asked you to identify them.

The answers are as follows:-

F1. *Boris Volynov* (Soviet Union)
F2: *Robert Stewart* (USA)
F3: *Dimitry Prunariu* (Romania)
F4: *Ken Mattingly* (USA)
F5: *Anne Fisher* (USA)

WINNER

Peter Rees of Bridgend, Mid-Glamorgan, S. Wales.

Peter will receive a very exclusive prize: a copy of Melvyn Smith's *ILLUSTRATED HISTORY OF THE SPACE SHUTTLE: U.S. Winged Spacecraft from X-15 to Orbiter.*

Very aptly, this excellent book has been autographed for our lucky winner by former Shuttle astronaut and X-15 rocket-plane test pilot Joe Engle!

PLANETARY POSERS

In this section of the competition, ten very tricky questions on the subject of unmanned space exploration were posed by Andrew Wilson, the author of the newly-published *JANE'S SOLAR SYSTEM LOG.*

The correct answers are as follows:-

P1: *Luna 3*, the Soviet probe, returned the first pictures of the Moon's previously-unseen far side. It did so in October 1959.
P2: *Luna 10* became the first spacecraft to enter orbit around the Moon. The year was 1966, the month April.
P3: *Venera 4* became the first successful Soviet mission to Venus. It delivered an instrumented capsule into Venus' atmosphere in October 1967.
P4: *Luna 16, Luna 20 and Luna 24* were the first three spacecraft that returned lunar soil samples to Earth.
P5: *August 1989* is the month America's Voyager 2 probe will make its historic encounter with the planet Neptune.
P6: *Venera 9* returned the first picture from Venus' surface. This was in October 1975.
P7: *Mariner 10* from the United States is the only spacecraft to have reached Mercury. It made three flybys of the planet.
P8: *Pioneer 10*, the U.S. probe, was the first operating spacecraft to cross the Asteroid Belt. It did so *en route* to Jupiter.
P9: *Six* spacecraft have gone into orbit around Mars thus far. They will soon be joined by the Soviet Union's two Phobos probes.
P10: *1978* was the year in which the United States launched its last planetary mission. The craft was Pioneer Venus 2, also known as the Pioneer Venus Multiprobe.

WINNERS

Philippe Ancia of Leige, Belgium
P.Y. Layt of Thetford, Norfolk, England.
Barry Smith of Skegness, Lincolnshire, England.
Lars Worm Andersen of Frederikssund, Denmark.
Keith Wilson of Blackwood, Lanarkshire, Scotland.

Our five winners will each receive a copy of *JANES SOLAR SYSTEM LOG* autographed by author Andrew Wilson.

LOOK OUT FOR OUR 1988 CHRISTMAS QUIZ!

It's certainly been fun for us running the *CHRISTMAS QUIZ* – and quite a challenge of those of you who had a crack at winning. Would you believe, only one reader came up with all the correct answers?

It's true! Our hearty congratulations go to Keith Wilson of Blackwood in Lanarkshire, Scotland.

CHINA ACTS ON SPACE PICTURES

THE Peoples' Republic of China is the only country other than the USA and the USSR to master satellite recovery techniques and she is now using photographs taken in space and returned to Earth in re-entry capsules to improve understanding of the nation's terrain, thereby boosting some sectors of the national economy.

The Shoudu Iron and Steel Company has used satellite photographs to prospect some 160,000 square kilometers of land around Peking, discovering seven prospective mineral deposits in the process.

Another satellite photograph revealed that the site planned for an electric power station in Shanxi lay in a geographical fault zone, so the station was built elsewhere!

Satellite photographs have apparently helped in planning for the double-tracking of the Canton-Hengyang railway line, and have shown that some sections of the Baoji-Chengdu railway line crossed other fault zones.

● Two agreements between the Peoples' Republic of China and West Germany covering research into the effects and potential uses of microgravity in space were signed recently in Peking.

Under the agreement between the China Great Wall Industrial Corporation and the Ministry of Research and Technology (MRT) of the FRG, MRT will conduct research into protein crystal-growth in space in 1989 using Chinese capsules capable of returning to Earth.

Another agreement reached between China's State Science and Technology Commission and the West German MRT states that the two countries will co-operate in research covering a dozen fields, including materials-science and life-sciences.

Both agreements were signed after 16 West German space scientists and other officials visited research institutes in China recently.

● West Germany is to jointly build with China a biological research satellite, launched atop a Chinese Long March booster.

The names have been announced of both crews for the forthcoming Soviet-Bulgarian joint mission. Here we see Bulgarian cosmonaut Aleksandr Alexandrov and his Soviet (presumed prime-crew) Commander, cosmonaut Anatoli Solovyev, at a press conference held in Moscow on 25 December. Off-frame is Viktor Savinikh.

THE SOVIET UNION has named the crews involved in the joint Soviet/Bulgarian mission to Mir, due to be launched on 21 June.

Two three-man crews are in training. One (we believe this to be the prime crew) is led by Soviet cosmonaut Anatoli Solovyev, accompanied by cosmonaut-researcher/flight engineer Viktor Savinkh.

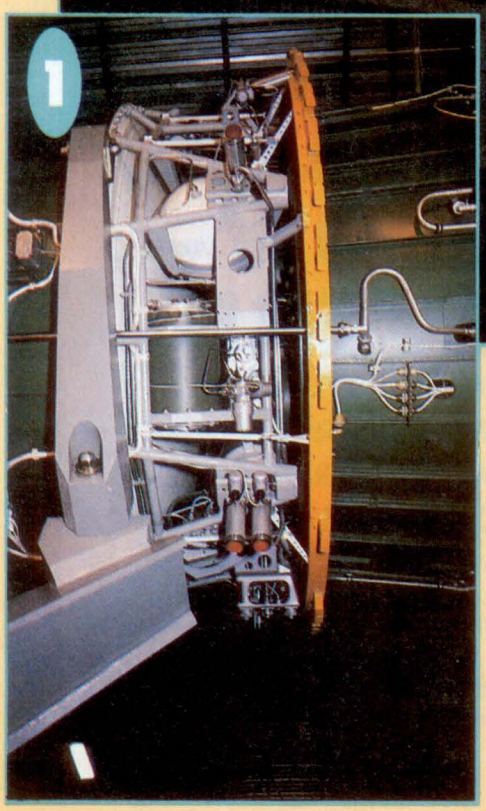
Savinkh is a well-travelled spaceman (he flew on the Soyuz T-4/Salyut-6 mission and the Soyuz T-13/Salyut-7 revival mission), while Solovyev has not flown before. Both men trained as the Soviet element of the backup crew for the 1987 joint Soviet-Syrian mission.

The third crewmember is Bulgarian Aleksandr Alexandrov – no relation to the Soviet cosmonaut of the same name.

The other crew is headed by ex-Salyut cosmonaut Vladimir Lyakhov (Soyuz-32/Salyut-6 and Soyuz T-9/Salyut-7, teamed with a new Soviet face, Andrei Zaitsev and Bulgarian cosmonaut Krasimir Stoyanov.

A ten-day mission, with eight days aboard Mir, is planned.

PEE
PRO



Having already published a series of intimate close-up views of the Soviet Union's Mir (Peace) space station and Soyuz-TM manned spacecraft in our December 1987 and January 1988 issues respectively, we are 'completing the set' this month by showcasing similarly explicit views of the Progress unmanned cargo-carrier.

The photographs are the work of Robert Christy, who also wrote the caption comments.

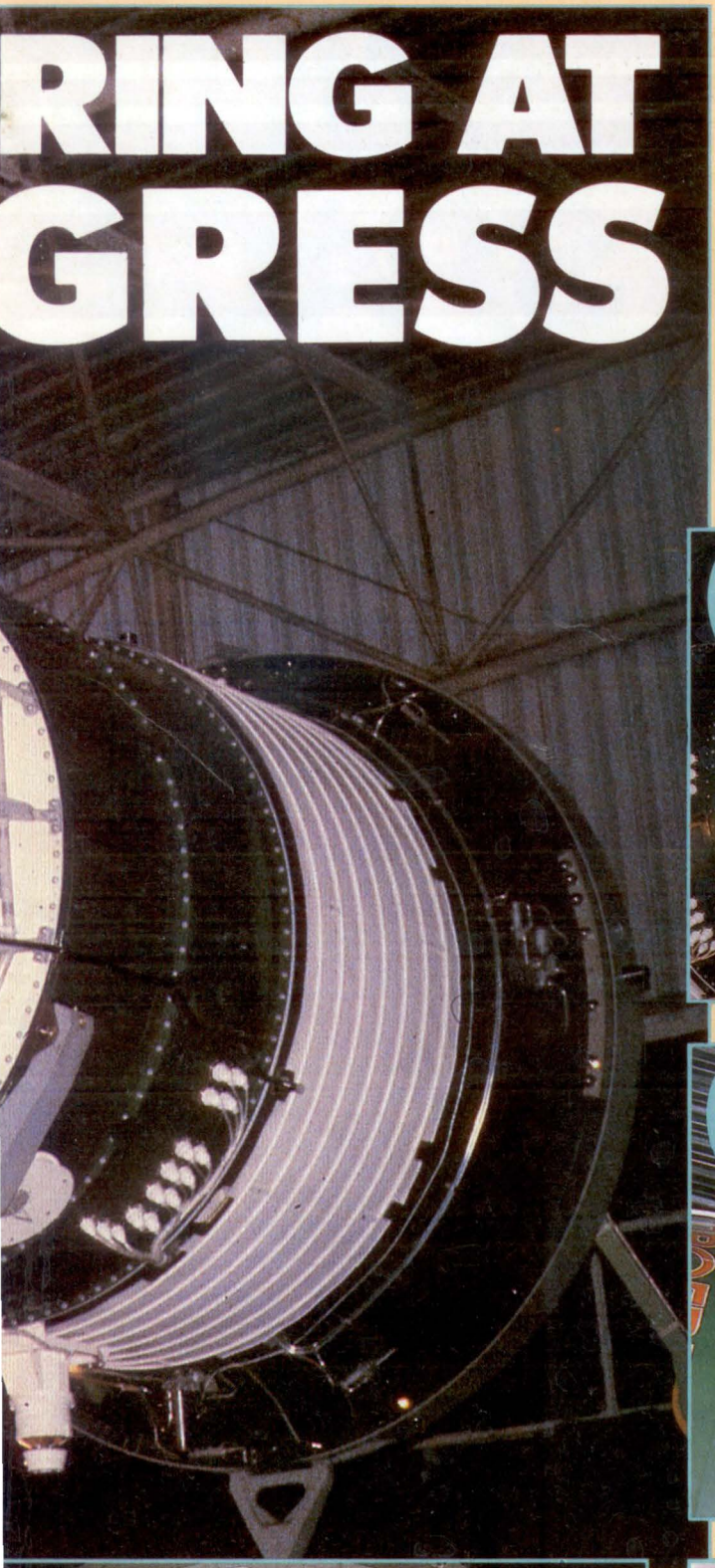
1 *Viewing from the opposite side to that seen in the main picture, the camera peers at equipment crammed into the interface between the instrument unit and the tank section (right). Easily visible are tha red-painted interiors of the attitude-control nozzles. The gray-colored girder is part of a display stand and is not part of the spacecraft itself.*

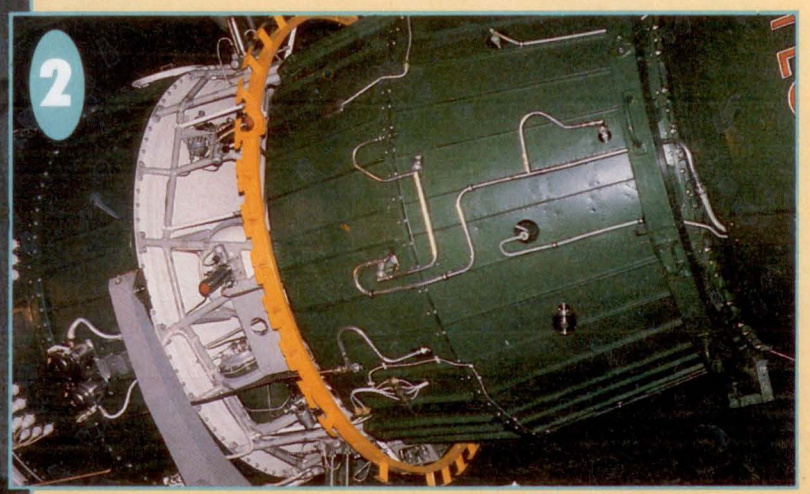
2 *Taken from a vantage point slightly to the right of that for photo (1), the camera captures some of the intricate plumbing on the exterior of the tank section. The prominent yellow ring supports a plethora of slot dipole antennae for Earth communications.*

3 *Yellow-colored protective cover on one of the antennae of the spacecraft's automatic approach control system (used for rendezvous and docking with Mir).*

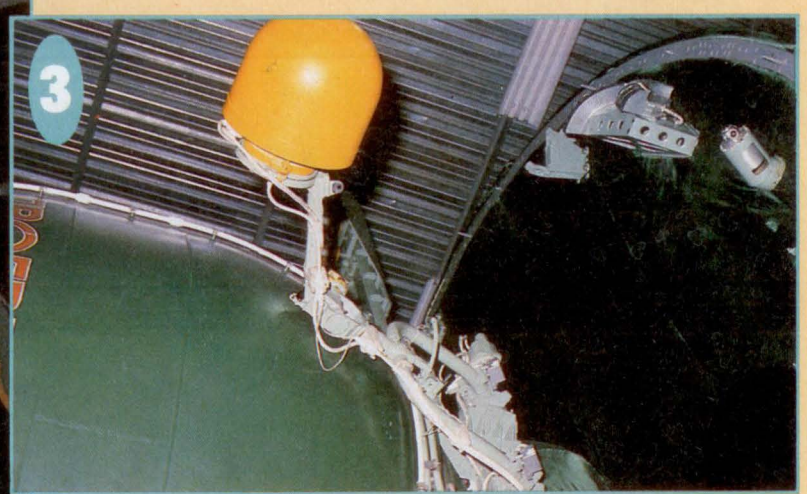
RING AT GRESS

LEFT: Striking overall view of the Progress 'automatic cargo spacecraft', to use the Soviets' prefered description. Based on the Soyuz manned spacecraft design shown in these pages last month, Progress consists of the same orbital module (the bulbous section nearest the camera) and instrument unit (the section aft of the yellow ring assembly amidships). The Soyuz crew cabin section at center, however, is replaced by an enclosed tank section, used to ferry fresh supplies of fuel and drinking water for transfer to Mir's own tanks after docking.

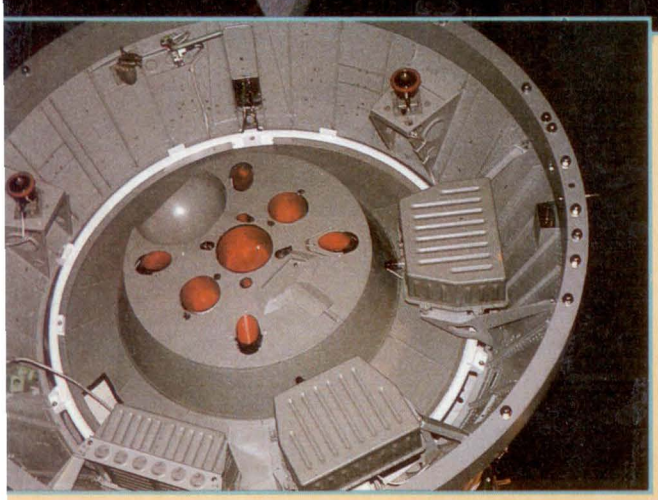


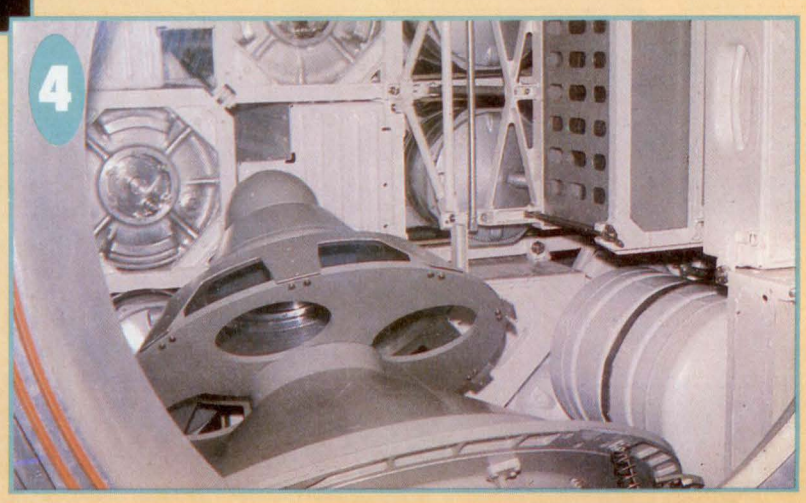


Cosmonaut's-eye view of the orbital module's interior. The hefty gray conical object at center is the docking probe attached to the 'front door', which has been hinged open for access. Normally, it would plug the circular 'doorframe' in the immediate foreground. Equipment racks in the background house removable containers filled with cargo.



Close-up of the main engine hardware, situated at the rear of the instrument unit. Although Progress is displayed publicly in this form, actual flight hardware is probably equipped with the same single main-chamber unit and pollution cover shown in photo (1) of our **SNOOPING AT SOYUZ** *photo-sequence last month.*





New Series

OPEN SPACE

NOW SPACE

RIGHT: Pictured in his days as Apollo 17 Commander, when he became the Last Man on the Moon, Gene Cernan is our second OPEN SPACE *guest-columnist.*

Last month's SPACEFLIGHT NEWS *featured the publication of our first* OPEN SPACE *column, marking a new departure for us – our first foray into a form of journalism known as 'opinion editorial'. Each month from here on in,* SFN *will invite a prominent space person to air his or her views on a topical subject with which they have close connections.*

Our first guest was Englishman Alan Bond; the man who conceived the radical HOTOL spaceplane propulsion concept, with its claimed ability to reduce the cost of placing payloads in low-Earth orbit by a factor of five.

This month, our guest is Eugene Cernan; veteran of three Gemini and Apollo flights and immortalized as the Last Man on the Moon. Cernan maintains that the United States' space program is not a program at all – "it is a series of events".

Read on, as he elaborates on this contention.

GIVE US A REAL PROGRAM says Moonwalker Gene Cernan

My sitting here to write this *OPEN SPACE* column started with a chance remark I made to *SPACEFLIGHT NEWS's* Editor Nigel Macknight on the eve of a party held in Houston to celebrate the 15th Anniversary of my Apollo 17 mission to the Moon.

I said something to the effect that the U.S. space program was not really a 'program' at all in the accepted sense of the word – it was *"a series of events"* – and that in recent years those events have included the Apollo-Soyuz orbital link-up with the Soviets, the first few flights of a reusable spaceplane (the Shuttle), the *Challenger* disaster, and – coming soon – the return-to-flight STS-26/*Discovery* mission.

Now that I'm putting pen to paper, I want to broaden that theme and say that Mercury, Gemini and Apollo were a single program to all intents and purposes, built with a single goal in mind – landing a Man on the Moon.

Without Mercury, or without Gemini, Apollo never would have been.

Going even further, I'd say that without any one of those flights within that program, a major link in the chain towards accomplishing the goal President Kennedy set for us would have been severely impacted. If you pull out any one flight towards those lunar landings,whether it be Gemini 9 or Apollo 7 or whatever, the whole program would have been jeopardized.

Indeed it was. When we had the Apollo 1 pad fire in January 1967 we had to delay and experienced a considerable impact on the program as a whole.

The series of 'programs' (and I use the term very loosely) that followed Apollo were closed-in. Skylab wasn't going anywhere. There was a piece of excess hardware and three spacecraft that we didn't use going to the Moon, so we decided we were going to use this hardware to have an orbiting laboratory and learn something about staying in space for longer periods of time.

But that wasn't a program. that was just a limited utilization of what turned out to be surplus Apollo hardware. What the Russians are doing today, we've already done with Skylab back in 1973-74; on a smaller scale duration-wise, but on a larger scale spacecraft-wise.

And then we came along with the joint U.S./Soviet Apollo-Soyuz Test Program flight the following year, and nothing emanated from that. There was no far-reaching co-operation between East and West of the type originally envisaged.

ASTP was a test-case, granted– but it was a single event nonetheless.

Then on we went to the Shuttle, and other than the first four test flights – which were a program to get the Shuttle 'operational'–you could pull out any mission from the series over the last year or two before the *Challenger* disaster and it wouldn't have made any difference.

As a matter of fact, several of those Shuttle flights got leap-frogged over others because of intervening factors, such as the availability of crews or the availability of hardware, and it didn't make any significant difference to the whole.

There's not a common goal. There's a Space Transportation System – the Shuttle – that's been developed, and is being developed, and it's got nowhere to go.

It's not tied to a far-reaching goal.

Critics of my viewpoint will no doubt argue that, surely, the thing about the Shuttle once it became 'operational', was that it wouldn't need to be part of a cohesive program *per se,* because each flight had its own self-contained objectives; maybe the deployment of some satellites, or the rescue and repair of some other spacecraft, or a spacewalk to perform some task or another outside the spacecraft.

> ***'Where is the space program going to be in the year 2000?'***

But that's just the point!

Each flight was merely an event, and if that event didn't occur, then all that happened was that a given satellite was not deployed into orbit. In other words, that flight was not part of a far-reaching program geared to the needs of the future; it was an end in itself.

Again, some people will argue the case for having a Space Transportation System 'routinely' performing tasks in orbit for no other purpose that to get those tasks done. They'll point to the value of having a reusable vehicle that deploys satellites, and serves as an orbital laboratory for distinguished scientists such as Charlie Walker working the McDonnell Douglas EOS device, capable of manufacturing pharmaceuticals in space.

To them I'll reply: *"Okay, we have a Space Transportation System. But for what purpose? Going where? To do what?"*

The benefits they can list are in my opinion useful only to a very limited degree and don't represent a cohesive program. Granted, the McDonnell Douglas EOS experiments were tied together and each had a specific purpose. Each flight Charlie Walker made represented a step forward for that particular program.

But I'm talking about the direction of the national space program *as a whole.*

What's the next big event in the American space program? It'll be the STS-26/*Discovery* mission in the summer. After it flies and it's successful (and it will be), then what?

You tell me what the U.S. space program is geared to; what are our long-term plans? Where are we headed? How are we going to get there? What are we going to do when we *do* get there?

When I fired these questions at your Editor, he played devil's advocate and said that now the United States had developed the tools to do the work, we were at last getting out and *doing* that work. We could do things like launch the Hubble Space Telescope, allowing us to see 350 times more volume of space than we have ever seen before and making significant discoveries in the process.

He said we could do a host of other things, like go launch the Navstar GPS satellite constellation, and pave the way for Space Station by assembling experimental structures like NASA spacewalkers Jerry Ross and Woody Spring did during their 61-B Shuttle mission in late-1985.

In effect, he said, the result was a gathering-together of all of the knowledge that had been gained in space thus far with a view to putting it to work.

My reply? That's wonderful. And if you want to describe that as a program called 'putting space knowledge to work', that's fine. The Shuttle is taking things up into space and I'm all for this – don't get me wrong.

But I'm thinking bigger than that. *Those are still events.*

Let's look out into the future. Where is the space program going to be in the year 2000? What do we plan to have happening, and what are we doing it for? What is the purpose of a Space Station? I mean, is it just to put something up there and put people in it, or is it a link in a chain?

In short; is it a step that's necessary to get beyond, like Mercury was to Gemini, and Gemini was to Apollo?

My view is that Space Shuttle *is* a step. It's a link in a chain. Unfortunately, no-one knows what the rest of the chain looks like.

No-one has defined that. No-one in this country has made a commitment to look into the future and to make that a national objective, rather than a political objective geared to just the four-year period of office of the Presidency.

The famous Ride Report on America's future in space, and the earlier report by Thomas Paine, were really all that was necessary to start with, and they're fine. A lot of hard work went into them, and a lot of

● **Continued over the page**

good people spent a lot of time on them.

But who's read them?

And who's responded to them? Has Congress responded with a plan or any kind of support? Has the Reagan Administration, even to this day, endorsed it – or so much as *countermanded* it? Or done anything?

The point I'm making is that no-one seems to have had enough time even to pay any attention to it.

In my view, it's not important whether you agree with the schemes put forward in these reports or not. What *is* important is the fact that nobody in a position of leadership in the country has given it any thought.

Some people might say that's because we don't have a President who is really in favor of the space program like we used to in the old days. On the contrary, I think we have a President who *is* in favor of the space program.

I think the problem lies in the fact that he puts too much in the hands of the people who advise him within the Administration, and they think too politically.

You need a President who can overrule his staff. A President who is visionary.

It's in the nature of politics in this country that people just make decisions based upon political expediency; doing what's going to be good tomorrow and the next day rather than in the long-term.

Congressmen, unfortunately, have to spend the years that they're in office trying to get re-elected, and if space is not an issue in their court, then they're not going to spend time on it. If it's not going to get them votes, and if it's not going to get them re-elected, they're either going to support it or not, but it's not going to be an issue and they're not going to bring it out front.

In American election campaigns that are going on right now, I have yet to hear anybody on *either* side make an issue out of space. Either for or against it. Other than SDI, of course, because 'Star Wars' has got a lot of play and they can get their nickle there. But I'm talking about real technical high-risk exploration of space – manned spaceflight.

Now I think we need the vision of a man who can look beyond and over the people that are advising him and say – like Kennedy did – *"Guys, we're going to the Moon. Now you get your act together and figure out how we're going to get there."*

That's what we haven't had, because of the political staff that stand between the President and the space program. It doesn't make any difference whether it's this Administration, or the last one, or the one before that. They don't think that far ahead because there's nothing (politically) for them to gain by doing that.

But for a *President,* there is!

Another problem lies in the fact that NASA itself does not have a leader who is capable of really taking his case to the public – or maybe he just isn't willing to do that.

In my view you need a guy like James Webb, who was NASA Administrator during the important years of the Apollo program. Someone who can take it straight up to Congress and the public and make something go

Gene Cernan stands on the surface of the Moon during Apollo 17.

beyond the next term of Office.

I'm not saying the present NASA Administrator isn't trying. It's just that he doesn't have the right personality.

Having identified the problem, I'm not going to pretend I have all the solutions, other than to say that the people who really believe in high-risk space technology research and development have got to get out and get the visibility to explain to the American people the little-to-zero cost of spacefaring compared to the other things we do in this country and make them aware of the significance of space to the future.

Only that way can they get the kind of support that is needed to break this perpetual chain of governmental disinterest.

Even NASA is to blame here to some extent. Here we are with the 15th Anniversary of the last time a Man walked the Moon. Forget that was me; it's just a significant event in history that, if you were a good P.R. man, you would make something out of.

If you want a good press you find good things to talk about. This happens to be a good thing to talk about – but nobody's talking about it.

We need to take our case to the public; and the public influences Congress. And the only way you can get to the public is through the media. Unfortunately, however, most of us sit by and watch while events in other fields dictate what people are going to read.

I heard a story yesterday where someone said to a little kid, *"What would you do if you were head of NASA?"*, and he said *"Well first I'd build a Space Station and then I'd get a program to go to the Moon, and then I'd plan a program to land an American on Mars"*.

The question came back, *"But how are you going to get Congress to support something like that today?"*, and the kid's answer was, *"Well* you're *Congress may not – but my Congress will!"*

In other words, the constituency of kids, and the awareness that kids are developing for the significance of space, is going to change the way things happen in the future. The only problem is, if we keep dragging our heels, those kids are going to have a hell of a road-block to overcome.

Since I'm getting to the end of this piece, I'd like to close with this comment in answer to those who ask, *"Why should a government commit itself to expenditure in a high-risk field like manned Solar System exploration in today's economic climate?"*

My country has evolved, certainly over the last 100 years, into the leader of the Free World because of its willingness to muster its resources and take a risk at being a leader in research and technology. That has effected our economy tremendously and we get respect for it.

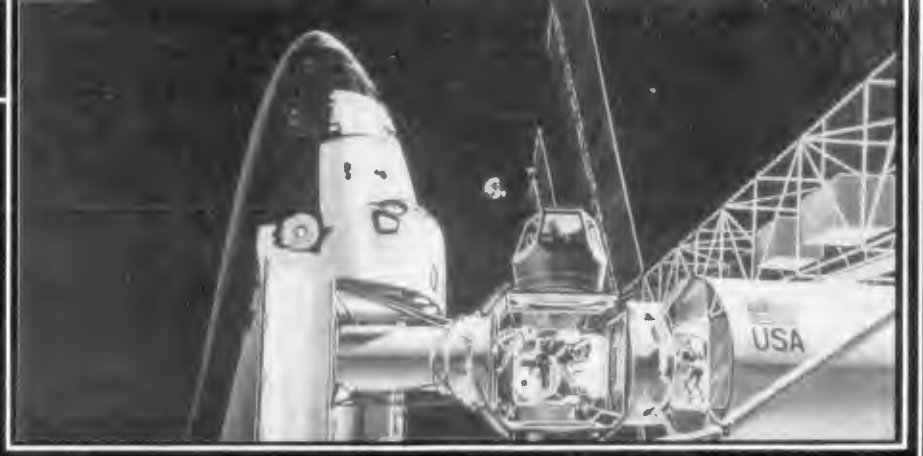
If you look at what's happened around the world – to where the competition is these days – you can see that we can't afford to abandon that approach. We can't afford to be second.

The future of our leadership in the world depends upon it. There are no alternatives.

Gene Cernan

Earth seen from Apollo 17 in 1972.

GENE CERNAN ON THE SOVIET PROGRAM



Everybody in the Free World, and especially in the United States, ought to realize that there's a Soviet space station (Mir) flying over our country several times a day, and that we are ten years away from putting a similar station in space.

The Russian program is good because it's based upon a commitment. They have a plan and they have a firm commitment to that plan. You can argue about how unsophisticated their plan is, or how unsophisticated their spacecraft are, or how much more hi-tech we are than they are, but that's not the point.

They are there and we are not, and we could have the most sophisticated flying machine that Mankind has ever seen, but if it's not in space what good does it do anybody?

The Soviets have got a good, solid, legitimate program. However, we should remember one important point that a lot of people tend to overlook. They have a single space program, and it's run by their military. Call it what you will, it's a military rocket program.

They may be doing civilian scientific experiments, but nonetheless, nothing's changed.

We have two space programs in this country. We have the civilian NASA space program and we have a military space program also, although it's not a manned military space program in the way that the Soviet one is, other than a few Shuttle flights now that are dedicated to the needs of the Department of Defense.

In the case of our civilian space program; unlike the Soviets, we have been able to share every item of detail with the entire world from beginning to end; the results of every single experiment.

I think that's important.

Having stated earlier that it will be ten years before we can put a space station into operation that will allow us to match the capabilities being demonstrated aboard Mir, I happen to think there'll at least be an American space station of some description in orbit before the big U.S./International Space Station is assembled in the mid-to-late 1990s.

It'll be Space Industries' Industrial Space Facility, or ISF.

I believe very strongly that the ISF will be up there in the early-1990s. It will be placed in orbit by the Shuttle and enlarged by attaching further components in space. Also, it has the capability to be man-tended – and will be.

That program will materialize because we need it to materialize, and it's a good example of what the American private sector can do – in co-operation with Government, because it does need the Shuttle to get up there, and was designed for that from the outset.

CERNAN'S BACKGROUND

Eugene Cernan was born in Chicago, Illinois on 14 March 1934 and grew up in what he terms *"a blue-collar family in the western suburbs of the city"*.

After attending college, he graduated with an electrical engineering Degree from Purdue University, via whose ROTC unit he went on to fulfil a lifetime's dream by earning a living flying jet airplanes off aircraft carriers for the U.S. Navy.

A period spent acquiring a Degree in aeronautical engineering from Postgraduate school at Carmel, Monterey, California was followed by selection to the NASA space program. Selection was based on earlier recommendations from the Navy, despite the fact that Cernan was at this time too young to meet all the astronaut selection criteria.

Cernan became a fully-fledged member of the astronaut corps at Johnson Space Center, Houston in January 1964, his first assignment being to the propulsion system programs for the Agena upper stage and the Gemini launch vehicle, the Titan 2.

Although assigned (with Tom Stafford) to the back up crew for the Gemini 9 mission, this was to become Cernan's first spaceflight when the original prime crew of Elliot See and Charlie Bassett were killed in a jet-plane accident.

Cernan remains the youngest American ever to have flown in space.

Being the second of the fourteen Group 3 astronauts to fly, Gene Cernan then qualified for inclusion in the backup crew for the first manned Apollo mission, Apollo 7 (prime crew Schirra/Eisele/Cunningham). This assignment was followed by Cernan's naming to the Tom Stafford-led crew for Apollo 10, which at one time was scheduled to be the first mission to land on the Moon.

It took Cernan and Stafford to within 47,000 feet of the lunar surface, and paved the way for Armstrong and Aldrin's momentous Apollo 11 mission two months later.

Captain Eugene Cernan is today a highly-respected aerospace consultant and President of the Cernan Corporation of Houston, Texas.

Next, Cernan backed-up Al Shepard, prime crew Commander on Apollo 14, further whetting his appetite to gain a place in that coveted left-hand seat; *"I think perhaps having an opportunity to take on the responsibilities of Commanding my own crew was as important to me as being able to cover that last 50,000 feet and land on the Moon."*

"To have the opportunity to do both was my real goal."

Both objectives he ultimately accomplished as Commander of the Apollo 17 mission, when he spent three days on the lunar surface with Harrison Schmitt, bringing the Moon-landing program to a triumphant climax.

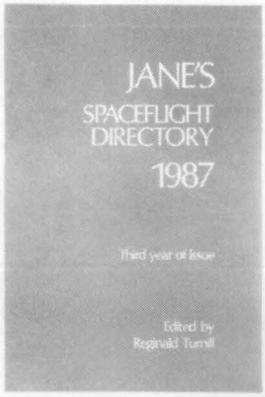
Looking back at that sequence of events", he says today, *"how could anyone feel left out, and not feel like he was the luckiest guy in the world?"*

During preparations for the joint U.S./Soviet Apollo-Soyuz mission of 1975, Eugene Cernan 'wore two hats'. He was Deputy Program Manager to Glynn Lunney on the administrative side, and also worked closely with the flight crews.

After participating in the very early days of the Shuttle program by working on the simulator development program, Cernan came to a turning point in his professional life. With a 20-year Naval career behind him, he felt the time had come to move into the civilian sector and see if he could make use of his talents there.

Having completed a spell in the international energy consulting business, Cernan is now very successfully involved in aerospace consultancy work and is President of the Cernan Corporation, headquartered in Houston.

B·O·O·K·S



JANE'S SPACEFLIGHT DIRECTORY 1987
Edited by Reginald Turnill
Without doubt the most comprehensive (550 pages) and up to date (most has been re-written since the second edition last year) book on space, it provides extensive details of worlds space programmes, the military use of spore, launchers and spacemen. Plus a space contractors section and their current programmes.
£6?

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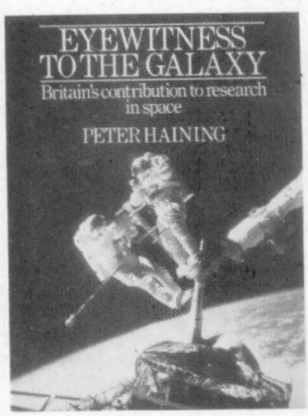

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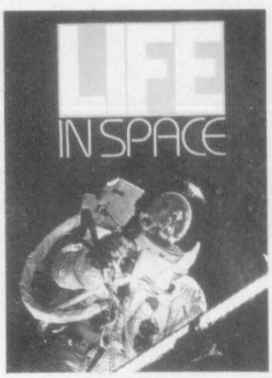

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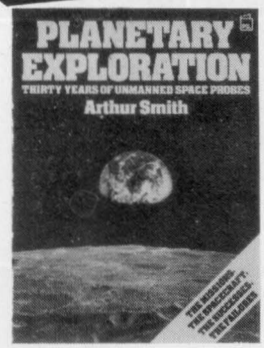

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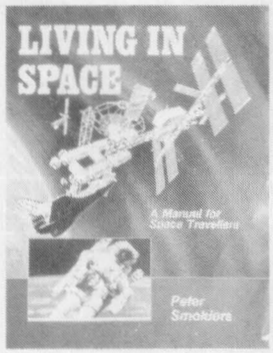

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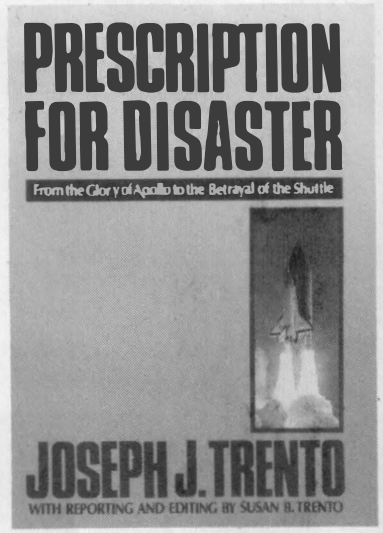

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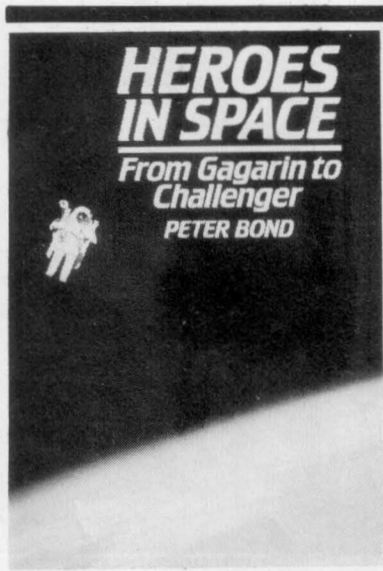

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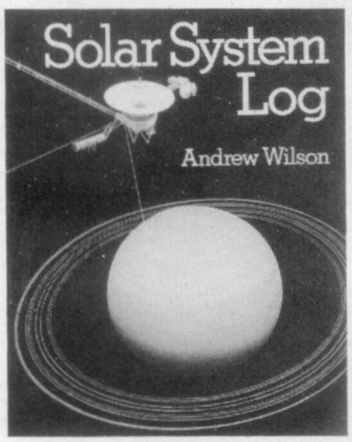

REVIEWED IN THIS ISSUE

NEW

HEROES IN SPACE
From Gagarin to Challenger
by Peter Bond

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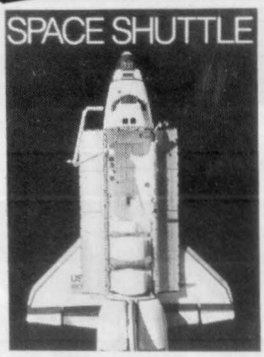

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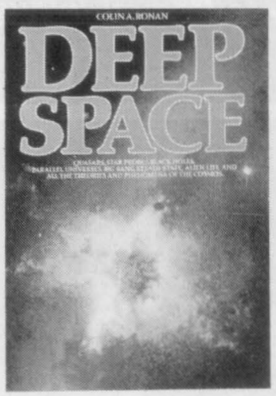

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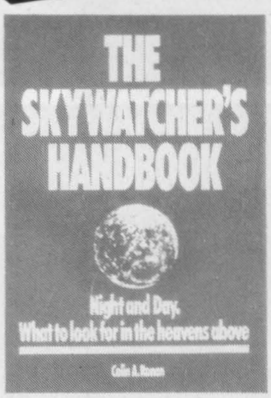

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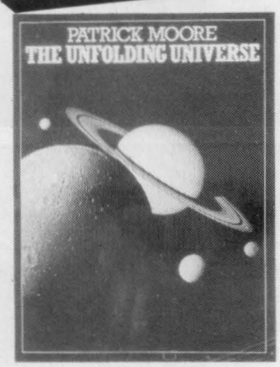

THE UNFOLDING UNIVERSE
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by Tony Osman
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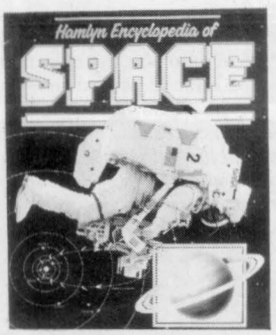

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S·P·A·C·E Relations

In July 1975, the United States and the Soviet Union linked spacecraft in Earth orbit and performed a short but significant joint mission; the Apollo-Soyuz Test Project, or ASTP.

Here, the two cosmonauts on board, Alexei Leonov and Valeri Kubasov, describe those historic events from a unique Soviet viewpoint.

The day of 15 July 1975, which was unusually hot even for Baikonur, has gone down in the history of space exploration. The blast-off of the Soviet spaceship Soyuz-19, scheduled for 3:20 Moscow-time, was to mark the beginning of joint work in orbit by Soviet and American crews.

Precisely at the preset hour, the representatives of the Soviet and American sides, scientists and journalists, gave their farewell applause to Alexei Leonov and Valeri Kubasov as they departed on their space mission. Soon after that, an American Apollo spacecraft with Thomas Stafford, Vance Brand and Donald Slayton on board took off from the American continent.

Their joint work was followed with keen attention by people in all countries.

"The road traversed by the participants in the Soyuz-Apollo program from its conception to the brilliant success of the mission, was both long and difficult. The Soviet and American specialists had to settle quite a few problems and overcome many technical difficulties.

"And then it is no secret either that the joint mission had its ill-wishers and even direct opponents in the U.S.".

This is how the general results of the mission were assessed by Academician B. Petrov, who was the chairman of the Intercosmos council at that time.

"We particularly remember the minutes when our two ships closed upon each other and docked in a near-Earth orbit", say Leonov and Kubasov. *"Both ourselves and the American crew had been anxiously looking forward to that moment, which had been preceded by three long years of pre-flight preparations.*

We were glad to receive fellow-astronauts Stafford, Brand and Slayton on board our ship. And then we worked together with them on board their spacecraft. Let us put it straight: throughout the mission our working partnership was close and well-coordinated.

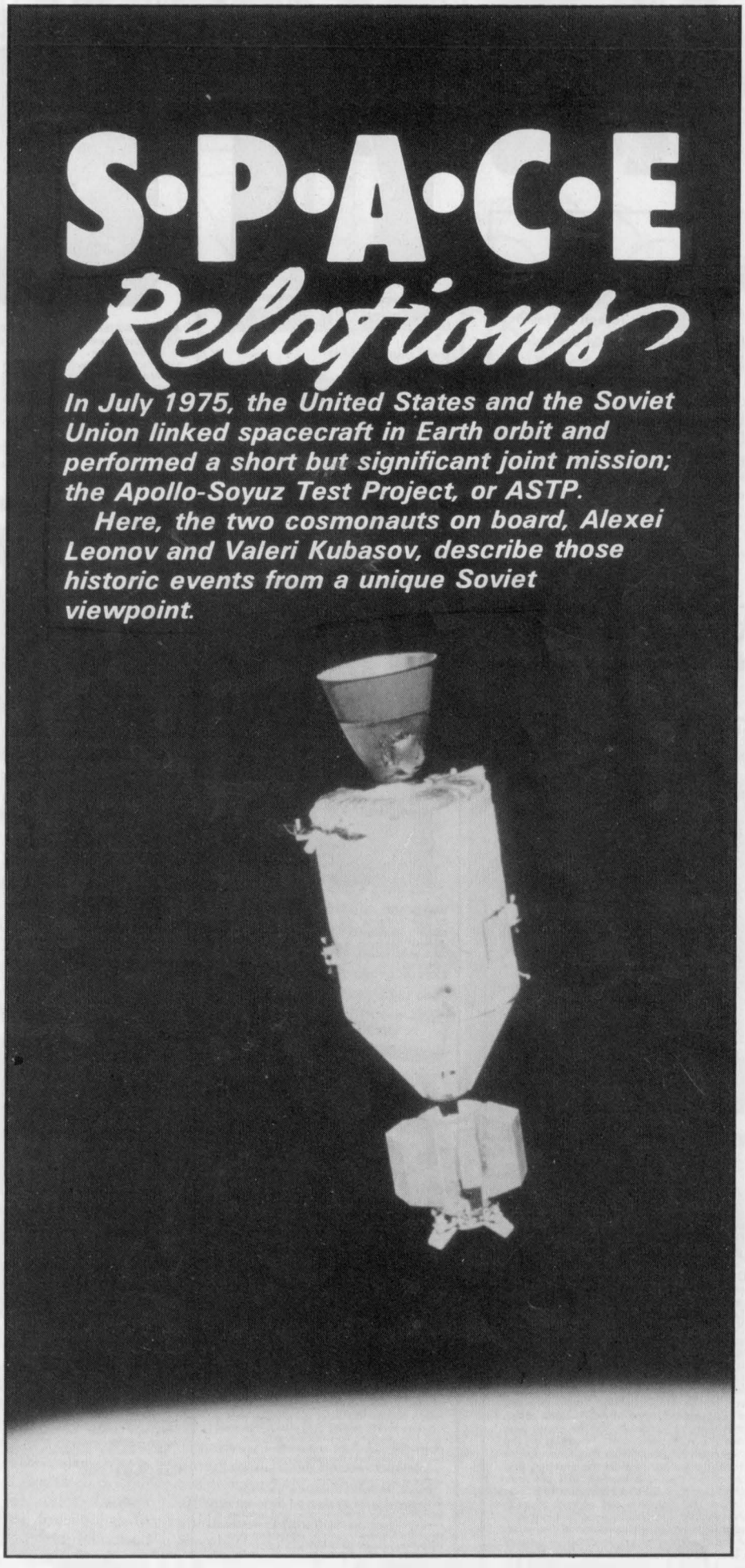
"This is because our mission was based on the noble idea of setting the stage for mutual understanding in outer space".

I talked to Alexei Leonov and Valeri Kubasov on the eve of their departure for the United States at the invitation of NASA, where they were to mark the tenth anniversary of the joint Soyuz-Apollo mission.

"This is not our first trip to the United-States", said the Soviet cosmonauts, *"and our American colleagues have visited the Soviet Union on several occasions. After the flight, together we made a joint tour of our country and of the United States.*

"That was the year when the Soviet people were marking the 30th anniversary of the Victory in the Great Patriotic War. The American cosmonauts were greatly impressed by their visits to the Piskarevskoye cemetery in Leningrad and to heroic Volgograd."

by A. Pokrovski



RIGHT: This rare photograph allows us to gain a Soviet prespective on the Apollo-Soyuz joint mission. Here, the Apollo Command and Service Module (CSM) closes in on its Soyuz counterpart prior to the bumpy docking operation. The rectangular-shaped object at the lower tip of the American spacecraft is the "special passage module" cosmonaut Valeri Kubasov refers to in the accompanying article. The module reconciles the two different atmospheres within the docking spacecraft.

APOLLO-SOYUZ MEMORIES — BY COSMONAUT VALERI KUBASOV

The first international spaceflight in the history of cosmonautics, known as the Soyuz-Apollo Test Project (ASTP), became possible thanks to *detente* and to a mutual Soviet-American striving for wider scientific and technical cooperation. A large number of people in both countries were engaged in work on this ambitious venture.

The chief aim of the flight was to test in orbit the compatible means for spaceship docking. These means could enable the Soviet Union and the USA to render mutual aid to spacecraft in a difficult position or in time of disaster.

Besides that, the flight was to carry out five large scientific-technical experiments in space physics, materials technology, medicine and biology.

The ASTP participants had to solve a number of complex problems, and the first among them was the language barrier. It was of particular significance to the spacemen. The crews had to understand each other well when acting in orbit.

The spacemen themselves found a way out. They decided that each crew would speak the language of the other side in flight. Such an approach, from our point of view, best solved the problem of mutual understanding, and one must say that it fully acquitted itself.

"We decided that each crew would speak the language of the other side in flight."

ABOVE: Cosmonaut Valeri Kubasov, who describes his experiences in his own words for **SPACEFLIGHT NEWS** *readers, is pictured hard at work in the orbital module of the Soyuz-19 spacecraft.*

BELOW: The Commanders of the American and Soviet spaceships meet in Earth orbit. Left is Tom Stafford; right Alexei Leonov who, ten years earlier, performed the very first spacewalk.

Preparing for the flight, the spacemen had to study not only their own equipment, but also the craft of the other side. Joint rendezvous and ship docking manouvers, mutual transfers of crewmembers from one ship into the other and common experiments were ahead, meaning that one needed at least some knowledge of the potentialities of the other side's ship and of how to handle it.

Alexei Leonov and I had the honor of being the members of the primary crew of the Soviet ship; Thomas Stafford, Vance Brand and Donald Slayton constituted the American crew. Besides that, standby crews on both sides had prepared for the flight.

All of we Soviet cosmonauts had repeatedly gone to the USA for joint training and, in our turn, received the American crews in the USSR.

Apart from the development of compatible docking means, other technical tasks had to be solved in the course of the realization of the project. One of them, specifically, was that the Soyuz and the Apollo had different artificial atmospheres. The Soyuz used a gas mixture close in composition to the normal air, whereas the Apollo utilized pure oxygen.

To enable the spacemen to pass from one ship into the other, a special passage module was developed and produced. It was there that a change of atmosphere took place.

A number of measures were implemented securing the compatibility of ground facilities for flight support. The technical director of the project for the Soviet side was Corresponding Member of the USSR Academy of Sciences Konstantin Bushuyev, with Glynn Lunney for the American side.

The Soyuz was to blast-off from Baikonur on 15 July at 14:20 hours. About seven hours later the Apollo would follow suit.

We were in an elated mood before the launch. Everything had gone without a hitch. We had daily got in touch with Houston, exchanging information on launch preparations. In the last days before the start, as had been agreed upon, communication had worked every other hour. We knew that on Cape Canaveral everything was also going according to plan . . .

It was very hot in the last few days at Baikonur: 46 degrees Centigrade in the shade. Breathing was difficult in the street – only the air-conditioned hotel provided relief. Only here was it possible to work calmly with documentation, which had to be looked through again and again before flight.

U.S. Ambassador Walter Stoessel, with his wife, arrived at the cosmodrome. We had a meeting with them shortly before lift-off. We, already in our spacesuits, sat partitioned-off by glass. On the other side were the ambassador and his wife. We conversed in English. At the end of the conversation, Alexei Leonov presented the ambassador's wife with a mirror – the exact copy of those fixed on our spacesuits.

As always, we arrived at the launching site

two-and-a-half hours before launch. We took out seats in the craft and began checking the on-board systems. Five minutes before the start of the engines we fastened our safety belts. Exactly at the appointed time we heard their roar. Slowly but unreluctantly the rocket detached itself from the Earth.

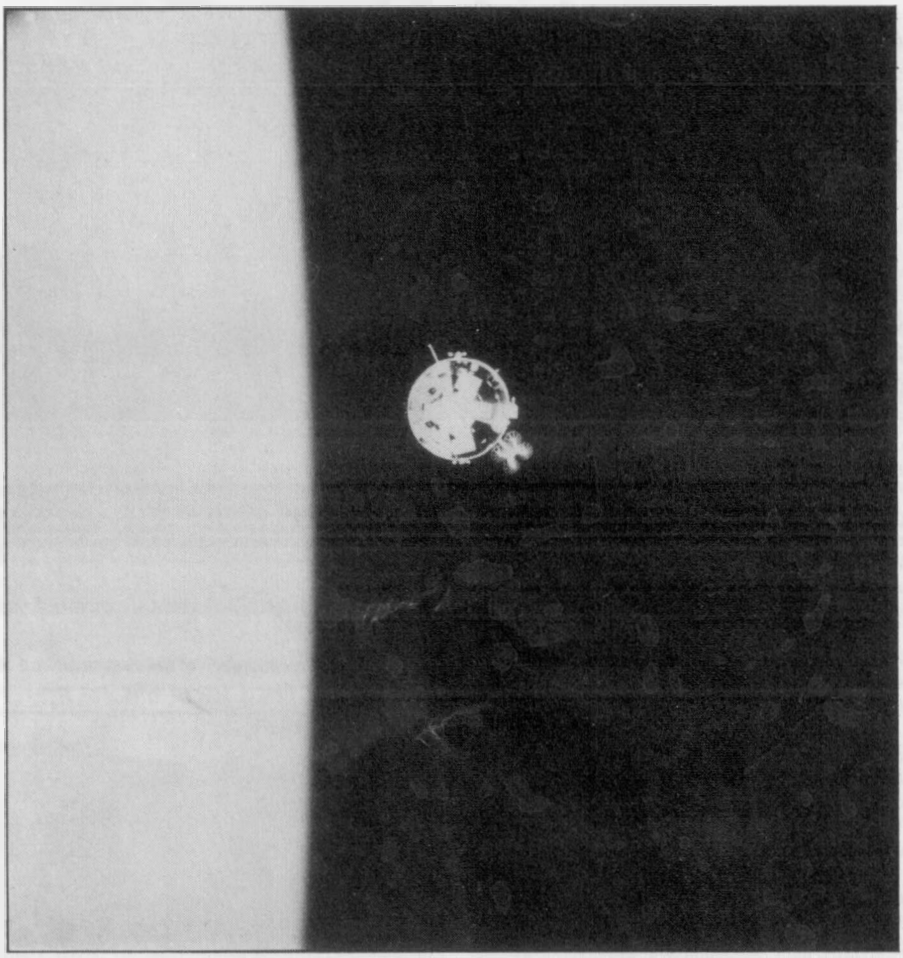
The famous Gagarin *"We're off!"* again sounded on the air.

And so Soyuz-19 was in orbit. After the separation of the third stage, our solar-cell panels, antennae and a docking target unfolded. We reported to the Flight Control Center: *"Everything's okay. The compartments of the ship are airtight, we feel fine . . ."*

The flight had started, and we were waiting for the Apollo's launch. Alexei and I were elated, though there was one vexing detail. The television image from the ship did not reach ground control. The Control Center asked us why, and we confirmed that a malfunction of the television system had been discovered. Ground control experts did not have to rack their brains over what had happened for long.

Very soon they located the cause of the trouble. The switch through which image transfer was to be effected had become inoperative.

Though the preparation of the Apollo had been going according to plan, nevertheless we were concerned. The weather in Florida is erratic at this time of the year. It was known that a thunderstorm front was approaching the launching site over there. But then by the moment of launch we were told that the sky had cleared up and that the thunderstorm had missed the place.



LEFT: Another unusual Soviet angle on the ASTP mission, this time showing the Apollo spacecraft pointing directly toward its Soyuz sister ship. Note the cluster of four communications antennas protruding from the spacecraft's lower-right side in this view, and the tiny trumpet-shaped attitude-control nozzles at top and bottom.

The Apollo was launched on time.

On the first day Alexei and I had vigorously worked on board for about nine hours and were already going to have a night's rest, having forgotten about television. But suddenly ground control reminded us: *"Stop, boys. The repairs are needed."* And point after point they instruct us on what is to be done.

As a result, we slept for only four hours, but we did repair the TV system.

From Moscow came a report that the American crew was having its own problems with the docking unit, and they also went to bed an hour-and-a-half later than had been planned.

There are moments in one's life which one waits for with great excitement. To us such a moment was the first docking. It had been agreed upon that the Soviet and American ships, while over the Atlantic, would come up to each other as close as 50 meters and equalise their velocities– *"begin soaring,"* in our terminology.

In this position the ships were to have continued movement in the direction of Soviet territory. It was already over Soviet territory that the crews were to have reported on the condition of on-board systems and, after receiving the go-ahead, got down to docking.

In reality, things went somewhat differently. Though the soaring did start over the Atlantic, when we were flying over Spain (where there is a point for communication with the Mission Control Center at Houston) the operator, upon inquiring about the state-

"I felt a pang, thinking that the Apollo module might go to pieces. . ."

of-affairs on board the craft and learning that everything was well, wished us a successful docking at the end of the talk.

Only by the extreme strain of the crews can one probably explain the fact that the ships after this wish began the rendezvous. A soft touch followed. And the docking!

When on our approach to the Crimea we were asked how things were, I replied that the docking had already been completed. A long pause followed. Obviously ground control could not at once realise what had happened. Only a while later did they ask us to tell our story.

Unnerving quite a bit was also the second docking, with the docking module of our Soyuz now being active. The ships softly touched each other. I watch the screen and see that the Apollo suddenly goes off abruptly to one side. I felt a pang, thinking that the module now might go to pieces . . .

But here the Apollo reached the edge of the screen and began to move back. It meant that the module withstood, and that the usual oscillating process was now over. I felt relieved.

Later we learnt that after the mechanical grip of the ships, the Apollo's side engines had started working accidentally.

When the entire flight program was successfully completed and we returned to the Earth, then we traditionally chalked a big-lettered *Spasibo! (Thanks!)* on a side of the landing module and signed beneath.

All the participants of the Soyuz-Apollo Test Project worked cooperatively on its realisation. The peoples of the world hoped that it would serve – and it did serve – the cause of improving the relations between states; not just between the USSR and the USA, but also throughout the planet.

One can only regret that this beautiful example of cooperation did not find a worthy continuation later on. Everybody knows that this occurred not through the fault of the Soviet Union. Now a very complicated, dangerous situation is taking shape in space affairs – the 'Star Wars' program – but I would like to hope that a sensible way out will be found, leading not to a new round of the arms-race, but to a sequel to the line which was commenced by the Soyuz-Apollo program.

The Soviet Union has repeatedly declared its resolve to work for the prevention of an arms-race in outer space and to end it on Earth. Well known are the concrete initiatives taken by our country in this direction.

It is necessary that other states, and the USA above all, should show an equally sincere striving for the attainment of this historic goal, for only on this road will Humanity be able to make real progress.

BOOK REVIEW

HEROES IN SPACE

From Gagarin to Challenger

by Peter Bond
Published by Basil Blackwell Ltd, Oxford, England & New York, USA.
467 pages
Price £14.95 (hardback)

As time goes by, it becomes increasingly difficult to find a fresh approach to a well-documented topic. However, in his book *Heroes in Space*, newcomer Peter Bond does seem to have found a formula which works.

Seeking to, as he himself puts it, *". . .write. . .a tribute to the courageous pioneers. . .",* Bond deliberately chooses to humanise the events, detailing the technical aspects of the missions only when they add to the general understanding. In doing so, he finishes up with a book that contains enough substance for the 'space buff', yet still remains light enough to be entertaining to the casual reader.

Prefacing the actual missions with a chapter on the early history of spaceflight and the problems associated with placing humans in a fundamentally

According to Peter Bond's book, Sergei Korolyev – the famous 'Chief Designer' – suffered heart problems prior to Gagarin's epic flight.

alien environment, the author continues with some fascinating descriptions of the flights themselves. Each starts with a brief biography of the astronaut concerned, before going on to reveal such details as; the famous 'Chief Designer', Korolyev, suffered heart problems before Gagarin's flight; and, *Columbia*, the Command Module on Apollo 11, was struck in lunar orbit by a piece of space debris. . .

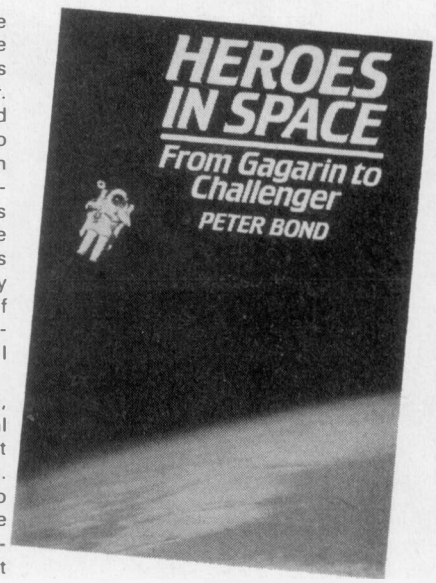
Particularly pleasing is the way that the book resists the temptation to follow the flights through in chronological order. Instead, Bond has grouped together related flights, so making it easier to gain an overall picture of a given program. The early Moon missions are separated from the more scientific 'J'-class lunar missions that followed, and the early failures with the Soviet family of Salyut space stations are contrasted with the more successful occupations of Salyuts 4 to 7.

There is one small criticism, though this is purely personal and in no way detracts from what is a very readable volume. Twenty-six photographs in two sections illustrate the text. Some are familar, and some less well-known. But how much better it would have been to use color pictures instead of mono.

In ***Heroes in Space*** Peter Bond most certainly achieves his stated aim of chronicling the courage of the pioneers of President Kennedy's 'Last Frontier'.

I recommend it as a worthwhile addition to any bookshelf.

EDDIE PUGH



ALL THE BOOKS FEATURED IN OUR *REVIEW* SECTION CAN BE OBTAINED DIRECT FROM THE *SFN* BOOK SERVICE – SEE PAGES 18/19.

NASA'S FLEXI-WING!

PART ONE

NASA and the U.S. Air Force have teamed-up to develop and test-fly a very special research airplane called AFTI, which mimmicks the actions of a bird, altering the shape of its wings in flight to suit its manouverings.

Curious to get a closer look, **SPACEFLIGHT NEWS** *travelled to Edwards, California and talked to chief test pilot Rogers Smith and AFTI program manager Lou Steers.*

ABOVE: NASA's wing-flexing AFTI F-111 captured high over the California desert with her wings swept well back. From this vantage point we can clearly see that the wing has been considerably curved by the on-board computers driving hydraulic rams within to improve the airplane's low-speed handling characteristics. Also apparent is the extreme smoothness of the wing surface, devoid of the drag-inducing hinges and actuators which protrude into the airflow on other aircraft.

TOP RIGHT: With its radar-toting nose cone removed for servicing in a hangar at Edwards, beautiful signwriting spells-out the AFTI's formal title, and logos proclaim allegiance to the three primary program participants; Boeing, who converted the original General Dynamics-built airframe to its present radical form, NASA and the U.S. Air Force.

LEFT: Another maintenance shot, this time showing the ability of the wings to sweep fully forward, and again highlighting the ultra-clean lines of the wing surface — a unique feature of this exotic airplane. Note also the gold-colored wing pivots amidships.

RIGHT: These two men took the AFTI airplane on its maiden flight and have conducted the majority of the flight-testing thus far. On the left is NASA's Rogers Smith, whom **SPACEFLIGHT NEWS** *interviewed for this article. To the right, Lt. Col. Frank Birk of the USAF, who has recently moved on to another program.*

NASA has operated airplanes with wings of almost every shape in its pursuit of excellence in the air. Most have had conventional swept-back wings but one, the Grumman X-29, has wings which sweep forward. Then there has been the X-5 sweeping-wing design, and the tilt-wing Bell XV-15.

A newcomer to the inventory, the part-helicopter/part airplane Sikorsky RSRA, has a radical X-shaped wing that can also serve as a main rotor, while the 'manned lifting bodies' of the late 1960s and early 1970s had *no wings at all!*

A test program NASA is deeply engaged in at the present time involves an airplane fitted with yet another revolutionary wing concept – a wing that can *alter its shape in flight*. Such a device is called a mission-adaptive wing', because its aerofoil profile changes to suit the task or mission being undertaken at a given point in time.

AFTI is the name given to the program geared to testing this concept. The initials stand for Advanced Fighter Technology Integration.

The concept of the mission-adaptive wing has been around the world of aeronautics for a very long time. Designers have long envied the capability of a bird to alter the shape of its wings to suit differing flight conditions. They could visualize the tremendous increase in efficiency that would be possible if the aerofoil section of an airplane's wing could similarly alter its shape all the way from leading to trailing edge in flight.

Theoretical calculations held out the alluring promise of enhanced performance but, as is often the case, the technology simply did not exist to support such a concept through the transition to hard reality. Highly-advanced computer technology would be required to effect the required wing-profile variations in flight (via hydraulic rams buried within the wing), in rapid response to ever-changing aerodynamic conditions.

The on-board computers would also have to cope with the constant control inputs of

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the pilot as he manouvered about the sky.

As well as the computational advancement that would clearly be needed before a mission-adaptive wing could fly, special materials would have to be developed; materials capable of flexing as the wing altered its shape in flight, yet maintaining a smooth surface that the airflow could cross with the minimum disturbance, thereby reducing aerodynamic drag levels.

In short, unless a mission-adaptive wing could be built properly, and controlled by a suitably 'smart' computer set-up, there was no point in building it at all.

The program leading to the construction of the present AFTI airplane began when an extensive variable-camber wing design study was initiated at NASA's Langley Research Center in Hampton, Virginia in the late-1970s. Later, engineers and aerodynamicists conducted a highly-encouraging series of wind-tunnel tests and concluded that the most suitable testbed to facilitate evaluation of a mission-adaptive wing would be a high-performance airplane already being operated by the agency.

That airplane was a standard General Dynamics F-111 fighter-bomber which had already been modified by the addition of the world's first 'supercritical' wing as part of the TACT (Transonic Aircraft Technology) program being conducted in the 'seventies. A supercritical wing is tailored to optimize the efficiency of an airplane flying at speeds just under and just over the speed of sound; the so-called 'transonic regime'.

In 1980, a contract was finally awarded to the Boeing Military Airplane Company, through the U.S. Air Force project office assigned to the mission-adaptive wing venture and headquartered at Wright-Patterson Air Force Base in Ohio, to modify NASA's General Dynamics F-111 jetplane with the addition of a variable-camber wing and associated control and monitoring systems.

Responsibility for conducting the flight-testing program would fall jointly on the Air Force Flight Test Center and NASA's Ames-Dryden Flight Research Facility, both based at Edwards Air Force Base, California, leaving two disappointed bidders for the F-111 conversion contract, Grumman and – ironically – General Dynamics themselves, to disappear from the picture.

Most of the F-111 remained at Edwards during the modification program. Only the wings of the big twin-engined jetplane left the legendary California test site when the time came for Boeing to implement the transformation that woud turn the original TACT supercritical-wing testbed into the current variable-camber-wing prototype we see today.

The rebuilding operation took place at the Advanced Development Center of Boeing's Seattle, Washington plant. Each wing 'box' (or main spar structure) was retained, but the leading and trailing edges were replaced with their ingenious variable-camber equivalents and a multitude of hydraulic servo-mechanisms (mechanical actuators which move the wing panels under commands from the on-board computer) were instaled and connected-up electrically.

After this internal instalation work was completed, both wings were covered with sheets of a special fiberglass-like material to ensure that a smooth surface is presented to the passing airflow. Consequently, there are no protruding hinge-lines or other breaks in the wind-cheating lines of the upper wing surfaces, although there are some neat sliding surfaces beneath the wing.

A study in superiority. The big F-111 scythes through the air high above the craggy terrain, its test pilot occupants gathering yet more flight data. Note the air-to-air refuelling port behind the cockpit canopy glazing.

These accomodate the movements that take place as the internal hydraulics cause the wing leading and trailing edges to be pulled down to suit certain flight regimes.

NASA aeronautical research programs often help the commercial aircraft manufacturers to improve their products, but this time some of the technology went in the *opposite* direction. The smooth fiberglass-like wing-covering material had originally been developed by Boeing for the Kruger flaps fitted to its 747 jetliners!

Other modifications to the F-111 visible from the outside are the slight alterations to the wing/fuselage interfaces and the line of tiny 'sights' fitted along the wing leading edges, which are targeted by a special 'eye' peering through a small window set into the fuselage side. This is an instrument which takes measurements of the wing's flexing characteristics in flight and records data for subsequent analysis.

Beneath the skin, as one might expect, the airplane is a mass of computer wizardry, state-of-the-art flight-control equipment, and telemetry apparatus for relaying technical data back to controllers on the ground.

As those of you with an interest in military aviation will already know, even standard F-111s have a swing-wing configuration; the wings can be swept forward to improve low-speed handling characteristics for landings on short, unprepared airstrips, or they can be swept right back to bestow Mach 2.5 performance.

The swing-wing capability is retained on the NASA F-111, as is the supercritical-wing concept of the original TACT testbed. This means that the AFTI airplane effectively combines a first-generation variable-camber wing with a second-generation supercritical wing.

Duly modified, the F-111's wings were transported by land back to Edwards for mating to the fuselage, after which a series of rigorous ground-tests were conducted. The first flight of the machine in its new MAW (Mission Adaptive Wing) guise took place from the hot desert test facility in October 1985.

To gain a better understanding of the AFTI program, *SPACEFLIGHT NEWS* travelled to Edwards just before Christmas

NASA'S FLEXI-WING!

With its wing smoothly curved to provide maximum lift at the low speeds encountered before touchdown, the NASA/USAF Mission Adaptive Wing (MAW) F-111 looks every inch a winner.

to meet with NASA Project Pilot Rogers Smith and NASA Program Manager Lou Steers (both have USAF counterparts on this joint program).

The visit also allowed us to take a first-hand look over the sleek F-111 and some of its elaborate internal workings.

Steers came directly to NASA from college, where he was an engineering student seconded-out to the agency between 1966-70 on a six-months-on/six-months-off basis. He worked on the exotic X-15 and manned lifting body rocketplane research programs in the early days of his career, before joining NASA full-time in February 1971.

This was followed by participation in flight-test programs on the YF-17 fighter prototype and NASA's Vought F-8 Crusader supercritical-wing testbed, before Steers started working with the F-111 airplane that is today known as the AFTI 'flying laboratory'.

His personal relationship with this machine now stretches back over ten years, during which time he has seen it flown by such distinguished NASA and Service pilots as Fitzhugh Fulton, Einor Enevoldson, Bill Dana and, poignantly, future astronaut Dick Scobee, who perished at the helm of the Shuttle *Challenger* . . .

Steers explained to us what happened after that October 1985 first flight of the F-111 in its new mission-adaptive wing configuration: *"The AFTI program was built around a projected two-year flight-test program; one year with the airplane flying in the manual mode, and one year flying in the automatic mode.*

"NASA and the Air Force completed the manual-control first phase between October 1985 and November 1986. Operating in this mode entailed making fairly basic wing-profile changes in flight by means of controls actuated by the pilots in the cockpit, rather than by the on-board computer.

"From November 1986 to last summer, AFTI was grounded while the automatic flight control system was instaled. The first flight with that system instaled took place in August 1987, since which time extensive testing of the airplane's performance characteristics in its computer-governed mode have been underway.

Two of the airplane's four automatic modes have already been flight-tested, and performance characteristics in the remaining two automatic modes will be evaluated between now and 31 July 1988."

On that date, the AFTI program will have reached a critical crossroads – and possibly the end of the line.

Lou Steers: *"Right now, we are trying to evaluate how much of the required data we will have gathered by that time. We then need to decide whether we should push for further funding, or whether we can say that we have basically proven what we set out to prove within the original timeframe.*

"We already know we will not have accomplished everything we wanted to, but we're evaluating whether we have enough to transfer the technology into future airplane design."

Assuming that transfer of technology will ultimately take place whether the AFTI program continues beyond 31 July 1988 or not, just who will benefit from all the dollars and effort the Air Force and NASA have expended these past two years on evaluating these unique variable-camber wings?

Lou Steers has some interesting answers: *"There is both military and commercial applications. One of the things we're looking at is take-off and landing performance. We're also looking at cruise performance and manouvering performance – so there's applications across-the-board.*

"NASA is looking at some of the materials involved on this airplane, and we are developing our own research 'tools' which will help us with advanced airplane concepts of the future; not just airplanes with supercritical or variable-camber wings, but all kinds of airplanes.

"The Air Force side of our program, of course, is looking at the airplane's performance from a military standpoint, but that doesn't mean that the potential benefits of this type of configuration are restricted purely to military airplanes.

"Commercial airliners of the future might well benefit from the kinds of technologies incorporated in the mission-adaptive-wing F-111."

The inevitable question. Hopes and dreams aside; is an airplane fitted with a variable-camber wing more efficient than an airplane fitted with conventional wings?

"What we've got to date from our flight research is that the mission-adaptive wing concept works on a full-scale tactical fighter. We have also shown that the performance data that we've gathered in flight agrees very well with our wind-tunnel data and analytical results.

"We have verified that we do get a performance improvement of the type prediced prior to the commencement of the flight-test program.

"Depending on what aspect of the performance you're looking at, we've measured improvements of between eight and 20 per cent over the performance figures attained by this same F-111 when it was in its original TACT configuration."

And what of NASA's trusty F-111 testbed? Will it undergo yet another metamorphosis and re-emerge onto the Edwards ramp resplendent in fresh paint, clad for further battle with the aerodynamic unknown?

Sadly, it seems not. The 20-year-old machine could end its days in a museum.

At very least, those fine wings should be preserved to await the dawn of another age of aviation. They just might prove to have been the start of something big . . .

APRIL ISSUE: PART TWO – THE PILOT'S VIEW!

BELOW: Yuri Romanenko is stretchered to a waiting Soviet Air Force Mi-8 helicopter at the Soyuz TM-3 landing site near the central-Asian town of Arkalyk.

SPACEFLIGHT NEWS EXCLUSIVE!

THE RETURN OF ROMANENK

Count on *SPACEFLIGHT NEWS* to bring you the very latest reports and pictures! This month, we're the first magazine in the West to present a full series of pictures showing Soviet cosmonaut Yuri Romanenko's triumphant return to Earth after a record-breaking 326-day stay in space.

SOYUZ TM-3's descent module, with the world endurance record-breaking cosmonaut Yuri Romanenko of the Soviet Union inside, touched-down 80 kilometers from the central-Asian town of Arkalyk on 29 December 1987, returning him to a hero's welcome just in time for the national New Year holiday.

It was ten years since he and cosmonaut Georgi Grechko had become the first Soviet crew to celebrate New Year in orbit. Between December 1977 and March 1978, the pair spent 96 days in space as the first visitors to the Salyut-6 orbital labora tory. The longest-duration space mission before then had been that of America's Skylab 4; 84 days in 1973/4.

The picture on the left shows the descent capsule of Soyuz TM-3, with the three cosmonauts still inside. Members of the recovery team and a television crew cluster around the exit hatch and stretchers lay nearby.

Some interesting details can be discerned on the base of the capsule, exposed when the protective heat-shield was jettisoned at altitude shortly after re-entry. On either side of the *CCCP USSR* legend we can see pairs of blackened nozzles. These are the solid-propellant rocket engines which soften the landing impact.

They are triggered into action at the instant three downward-pointing probes make contact with the ground (two are visible here, bent back at the moment of touchdown; the third has presumably been broken off).

The radio antenna protruding at 45 degrees broadcasts a signal from Soyuz-TM's recovery beacon. There are also some flashing strobe-lights on the spacecraft, but they are not visible from this angle.

Wording stenciled onto the base of the capsule explains in Russian and English, alongside a sequence of four diagrams, how members of the public can help the cosmonauts to climb out. They also warn against potential injury or contamination from various on-board pyrotechnic devices.

We were fascinated by some of the symbolism on the spacecraft's base. For example, we noticed the triangular-shaped international symbol denoting the presence of radioactivity just above the letters *CCCP*. The familiar 'wine glass' symbol indicates that careful handling is required. An arrow nearby means, quite literally, *THIS WAY UP*...

Close inspection of indentations in the snow indicate that the capsule has moved from its original position, either under the influence of the high winds on its billowing parachutes, or with the aid of recovery team muscle-power.

The craft has clearly slid to a halt (note tracks in the snow to right), been rolled clockwise, then rolled part-way back into its final resting place (the presence of compacted snow on the capsule's near-side bears out this observation).

The last three months of the Soyuz TM-3 flight had been busy ones for Romanenko and fellow-cosmonaut Aleksandr Aleksandrov. October was spent unloading the Progress 32 un-

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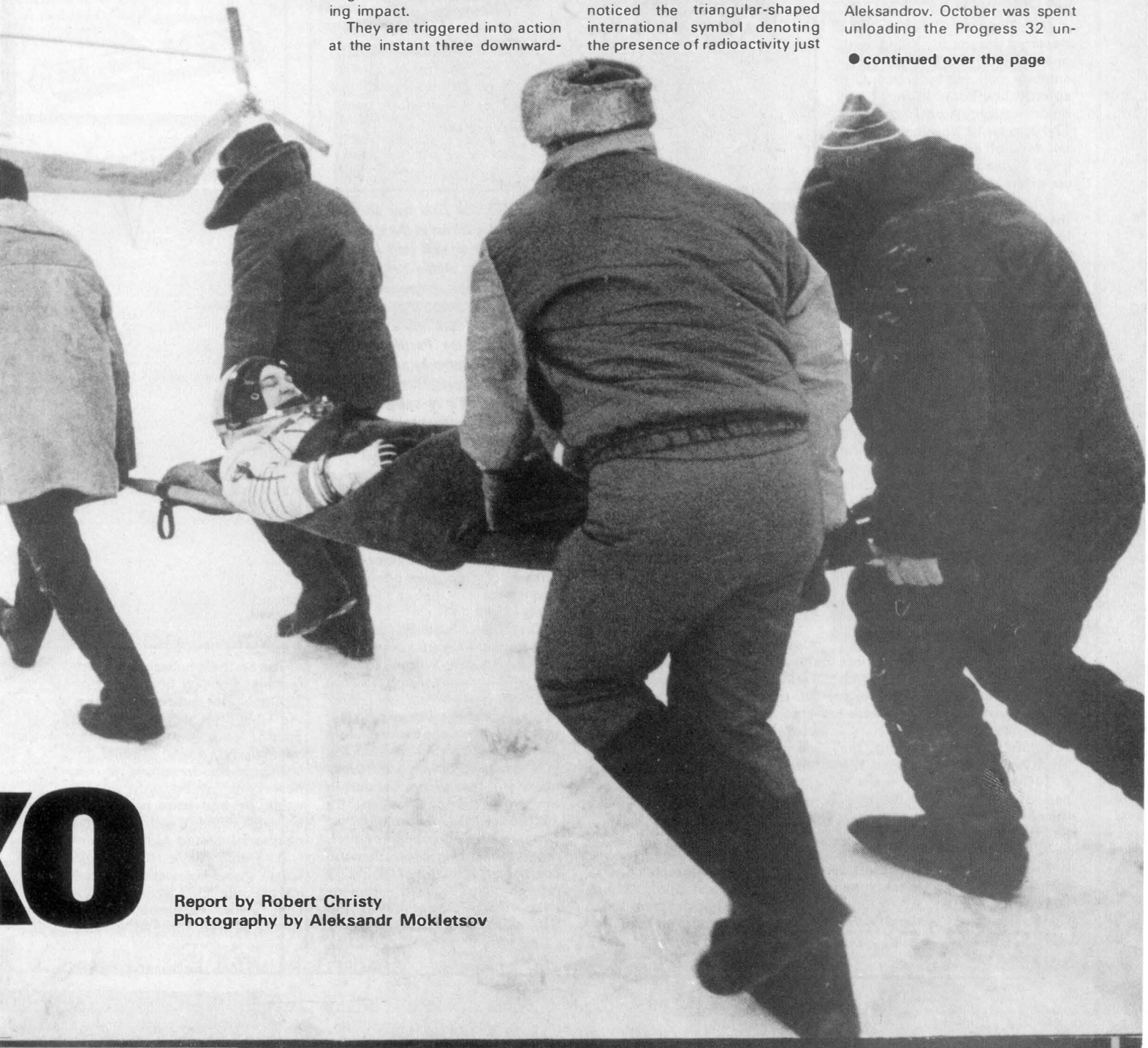

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Report by Robert Christy
Photography by Aleksandr Mokletsov

THE RETURN OF ROMANENKO

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manned cargo-carrier, launched at 11:44pm GMT on 23 September (2:44am Moscow time on 24 September). Two days later it had approached the Soyuz TM-3/Mir/Kvant complex and, at 1:08am GMT on 26 September, hitched-up to the Kvant end of the orbital 'train'.

Progress 32 was used to test some new control and stabilization software programs which had been loaded into one of Mir's computers by the crew. At 4:09am on 10 November, as part of those tests, it undocked and drew away to two-and-a-half kilometers distance and then moved back to re-dock at 5:47am.

At 7:25pm on 17 November it departed for good. Filled with garbage Romanenko and Aleksandrov had loaded aboard, it spent a few hours in free flight before retrofire was initiated at 12:10am on 18 November. Three-quarters of an hour later, Progress 32 burned-up in the Earth's upper atmosphere.

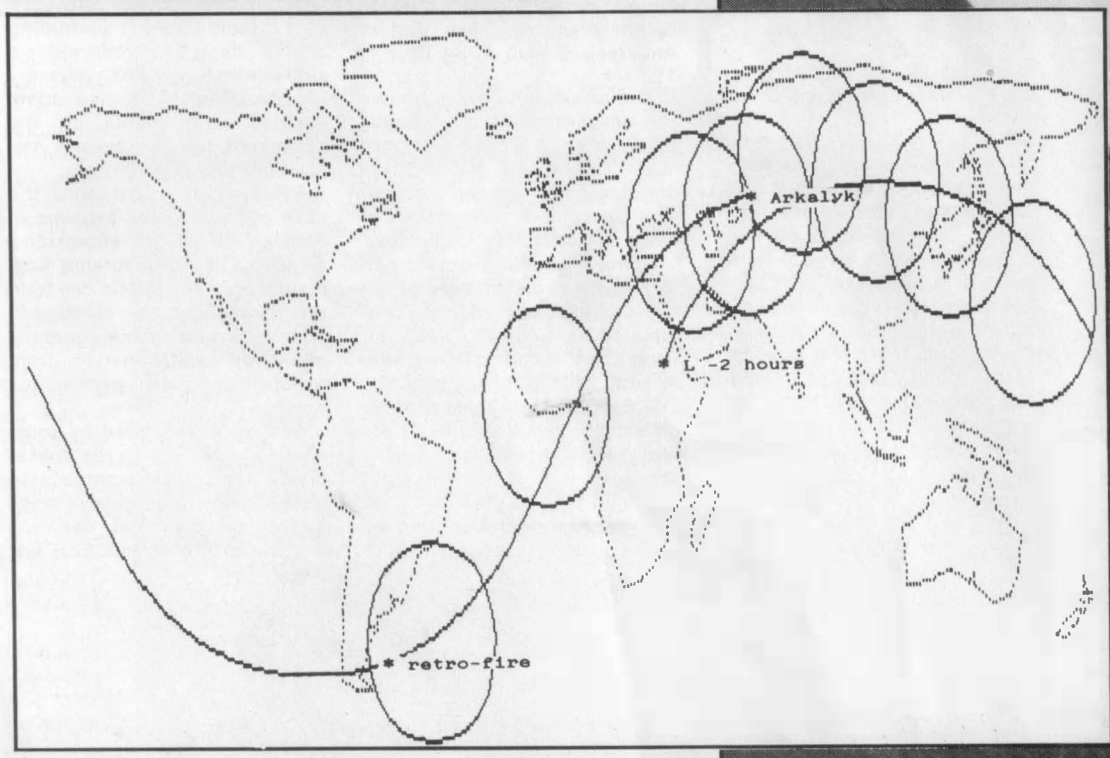
After official announcements that the end of Romanenko's long-duration mission was approaching, the next event came almost as a surprise. Progress 33 left Baikonur at 11:47pm on 20 November carrying fresh supplies to the station. It spent the routine two days chasing Mir and then, right on-cue, attached itself to the back of the Kvant module at 1:39am on 23 November.

With Progress 33's launch came the Soviet Union's first major foray into the space-souvenir market. Packed in a special container in the vehicle's cargo hold were 1,000 stamped, franked envelopes for later sale to the stamp-collecting public.

Another month was taken to unload Progress 33 completely, and its manouvering engine was put to use at around 3:00pm on 12 December, when it was used to raise the orbit of the whole complex and establish launch 'windows' for Soyuz TM-4, which by this time was being prepared for lift-off.

Before the engine-firing, the Mir/Kvant complex was in a 325 x 340-kilometer orbit, with a period of 91.13 minutes. After the adjustment, the heights were 334 x 360 kilometers, and the period 91.42 minutes.

The first indication that a manouver had taken place came later on in the day, when radio signals monitored by the *SPACEFLIGHT NEWS* team in Lincoln, England, came slightly later than expected. The manouver set-up a series of 'windows' on the remaining odd-numbered days of December (see *STOP PRESS* item in our January 1988 issue, page 4).



ABOVE: This computer-generated map illustrates the final two hours of Soyuz TM-3's flight on 29 December. After crossing Africa at the end of its last-but-one orbit, Soyuz TM-3 passed from west to east (left to right) across the USSR. During that time it came, in turn, within range of the major ground stations at Tblisi, Dzhusaly (near Baikonur), Kolpashevo, Ulan Ude and Ussuriysk. As it headed out over the Pacific Ocean it passed over one of the standard tracking-ship stations off Japan, then into a zone outside radio-cover. After Soyuz TM-3 had crossed the Pacific and the southern tip of South America, its retrofire was monitored by another ship in the south-Atlantic. Control then passed to another waterborne tracking station in the Gulf of Guinea, before the spacecraft's re-entry into the atmosphere and the standard radio black-out period. Landing came near the town of Arkalyk, north-east of the Aral Sea and Baikonur, from where Yuri Romanenko's journey had started ten months earlier.

On 9 December, Major-General Aleksei Leonov, deputy head of the Yuri Gagarin Cosmonaut Training Center, presented two full-trained crews to the press. Experienced cosmonaut Colonel Vladimir Titov was named Commander of the first crew, teamed with flight engineer Musakhi (Musa) Manarov, and cosmonaut-researcher Anatoli Levchenko, a test pilot.

Crew number two consisted of Colonel Aleksandr Volkov, Aleksandr Kaleri and Aleksandr Shchukin, another test pilot. Leonov said that a final decision as to which team would be launched would be made shortly before lift-off.

According to Radio Moscow, all six men would fly to Baikonur the following day for launch in a further *". . . ten days or so . . ."*, making 21 December the most likely date.

On 19 December, Soyuz TM-4 and its rocket were taken out to the launch pad. A final decision on which crew would fly the mission had *"still to be made"* (which means, more accurately, that the crew allocations were still to be *confirmed)*, so the individually-tailored cosmonauts' seats still had to be instaled in the craft. Launch was set for 11:18am GMT (2:18pm Moscow Time) on 21 December, as anticipated, and news came that the cosmonaut-researcher would be returning to Earth with Romanenko and Aleksandrov in the Soyuz TM-3 vehicle.

The State Commission (a flight-readiness review board) met on 20 December and confirmed that the Titov crew would be aboard Soyuz. Yuri Romanenko may have heaved a sigh of relief, for although the handover to the new crew would only take a week, he had been spared the ordeal of working with *four* other people all named Aleksandr!

It would have been even worse than his experiences during the July 1987 Syrian cosmonaut visit, when he had to choose between *three* Aleksandrs;

LEFT: A remarkably happy-looking Yuri Romanenko gives his first impressions of the 326-day flight and landing to journalists on the snow-covered Turgai steppe.

Cosmonaut Anatoli Levchenko, who had spent only seven days in orbit, makes his way toward the waiting helicopter, his chores far from over. Romanenko and Alaksandrov were taken straight home, but Levchenko was tasked with taking a Tupolev Tu-154 jetliner on a 3,000-mile mock spaceplane 're-entry and landing' – proof positive that the Soviet Shuttle is on its way.

Aleksandr Laveikin, Aleksandr Viktorenko and Aleksandr Aleksandrov.

Soyuz TM-4 lifted off exactly on schedule before a live television audience. Nine minutes later it was in low-Earth orbit, to start the 48-hour 'Mir chase'. Four firings of the Soyuz-TM main engine would be needed to bring ferry and space station together at the correct speed.

Six hours after leaving Baikonur, Soyuz TM-4's path carried it over Great Britain (and, later in the day, over the United States), where observers were treated to the sight of a parade across sky led by Mir/Kvant, some forty minutes ahead of Soyuz TM-4, which was preceded by a twinkling, tumbling final-stage rocket casing.

Radio Moscow's report of the launch contained the intriguing snippet of information that Levchenko's work involved "... *testing control techniques for reusable spacecraft ...*"

Observers were left to speculate as to the precise meaning of the phrase. Was Levchenko's flight simply to allow him to get his 'space legs', or was there more to it?

At 12:28pm, Soyuz TM-4 arrived alongside Mir. It then spent seven minutes moving around to the Kvant end of the complex before completing the docking manouver at 12:51pm (Progress 33 had departed that docking port at 8:16am on 19 December, to meet a fiery end a few hours later).

At 2:20pm, the hatch was opened and the new crew floated through into the complex where, if all goes to plan, they will remain until the end of 1988, setting a new duration record and breaking the psychological 'one-year-in-space barrier'.

Following a six-day handover period, Romanenko, Aleksandrov and Levchenko were ready to depart. Their final task, after packing the Soyuz descent module with logbooks, experimental results, the newly-franked postal covers and their personal belongings, was to move Levchenko's tailored couch from Soyuz TM-4 to Soyuz TM-3.

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THE RETURN OF ROMANENKO

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Romanenko had some terse remarks for ground controllers when he felt they were trying to push his last-minute packing along too quickly . . .

On 29 December, the journey back to Earth began with undocking at 5:49am. At 8:20am retrofire was completed and Soyuz TM-3 was on an irreversible downward course, set to plunge into the atmosphere above central Africa. Following a radio-blackout period, caused by the white-hot sheath of plasma generated by frictional heating between the spacecraft and the surrounding air during the 7-kilometers-per-second plunge, the cosmonauts were once again in contact with their colleagues on the ground.

BELOW: A doctor takes Romenenko's pulse during a preliminary medical examination inside the helicopter en route to the permanent medical facility.

At 9:00 precisely the parachute unfurled, although there was still over 100 kilometers to go. At 9:02 the range was down to 25 kilometers. Finally, at 9:16am GMT, the descent capsule touched down on Mother Russia.

Romanenko was home at last – after orbiting the Earth 15½ times a day for 326 days, 11 hours and 38 minutes.

Aleksandrov's flight had been shorter; a matter of 'only' 161 days, 7 hours and 17 minutes, but this was no mean feat in itself, as only four previous manned space missions (if we exclude Romanenko's) had been of a longer duration.

Helicopters had difficulty landing near to the descent module, which was lying on its side. They were being buffeted by near gale-force wind gusts of over 60 miles per hour.

Physically, flight had taken its toll on the men. Romanenko and Aleksandrov had to be carried from the descent capsule. Because of the high winds, it was impossible to erect the usual tent at the site, so the two cosmonauts were taken directly to a helicopter; then, after a preliminary medical check, back to Baikonur.

ABOVE: Cosmonauts Aleksandr Alexandrov (left), Yuri Romanenko and Anatoli Levchenko smile for Aleksandr Mokletsov's camera in the cabin of the Mi-8 helicoptar that transported them away from the landing site.

Levchenko was afforded less luxury. It appeared that his mission was not quite over! He was transported by helicopter from the landing site to a nearby airfield where a Tupolev Tu-154 airliner was awaiting him. The meaning of the Soviets' earlier reference to Levchenko's work involving *". . . . control techniques for reusable spacecraft . . ."* suddenly became very clear . . .

With Levchenko at the controls (and possibly with his back-up, Alexandr Shchukin, at his side) the aircraft flew to Moscow. Then, after a short stop, Levchenko flew it back to Baikonur. He had completed a round-trip of about 5000 kilometers, some five hours of flying time.

Only then was his 'space mission' finished.

He had simulated, under genuine spaceflight conditions of weightlessness, an eight-day shuttle-type mission, complete with an approach and landing at an airfield on Earth, fully proficient behind the controls of a winged manouverable craft.

Soviet officials later confirmed that Levchenko's exercise had been a test of a man's ability to spend time in orbit and then make a safe airplane-type landing, and that this was indeed a pathfinder for future operations with the long-awaited Soviet Shuttle.

Back up in space, one further task had to be completed before the new long-stay crew could settle down to their year-long mission. The day after Soyuz TM-3 departed, Titov and Manarov climbed aboard Soyuz TM-4, undocked it from the Kvant module, waited for the complex to complete a half-somersault, then redocked it at Mir's axial (forward-facing) hatch.

The whole manouver was competed in nineteen minutes, and left the way open for the next unmanned Progress cargo-carrier to dock with Mir/Kvant/Soyuz TM-4 in mid-January 1988.

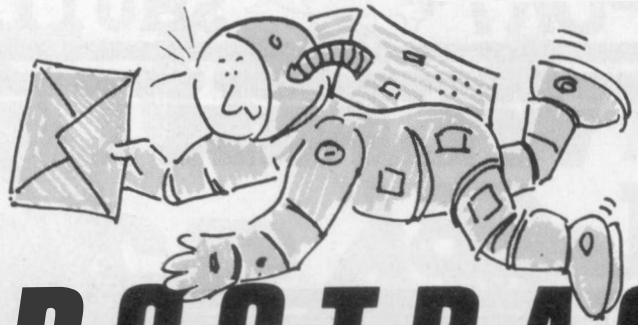
Look out for news of its arrival in our *PRESS SITE* pages.

Statistics

Romanenko's record-breaking flight

- Mission duration: 326 days, 11 hours, 38 minutes
- Orbits competed: 5,149
- Distance covered: 135,717,300 statute miles
- Average speed: 17,229 mph
- Average altitude: 212 statute miles.

BELOW: Now that Romanenko is back on Earth, Colonel Vladimir Titov is the new Commander of the Mir (Peace) space station. He is a veteran of the ill-starred Soyuz T-8 mission of April 1983 and a survivor of the original Soyuz T-10 mission that September, which came to an abrupt end when a fire on the launch pad precipitated emergency ejection of the two-man crew. Titov celebrated his 40th birthday aboard Mir on 1 January, just a few days after getting on-orbit.



POSTBAG

Write to Postbag, Spaceflight News
P.O. Box 100, Stamford, Lincs PE9 1XO, England.

AUTOGRAPH-HUNTER EXTRAORDINARY

Dear *SFN,*
I AM writing to tell you and your readers about my collection of astronaut autographs and space memorabilia, some of which are put on public display from time to time in my workplace, the Glengormley branch of the Ulster Bank.

To start with, I have the autographs of practically every American to have flown in space. These include Neil Armstrong, Gene Cernan, the late Donn Eisele, Senator Jake Garn and Anna Fisher. Sadly, my collection also includes the autographs of four of the seven victims of the *Challenger* disaster; Dick Scobee, Judy Resnik, El Onizuka and Ron McNair.

On the brighter side, I have the autographs of two of the five STS-26/*Discovery* astronauts; Rick Hauck and 'Pinky' Nelson.

There are some particularly rare autographs hidden amongst the familiar names. Do you recall John Llewylln, who would have become the first British-born astronaut had he not left NASA in 1969? I have his autograph, and also that of the man who so nearly made it to the 'first-Britisher-in-space' title in 1986, Nigel Wood.

Other rarities; I have the autographs of Shuttle astronaut Linda Godwin, who has yet to fly in space, the Canadian Payload Specialist (another yet to fly) Roberta Bondar, and Soviet cosmonauts Yuri Gagarin, Gherman Titov, Valentina Tereshkova, and Vitaly Sevastyanov.

Aside from the autographs, I also have some interesting items of space memorabilia, and even actual 'hardware'. There's a sketch of *Friendship 7* drawn (and signed) by John Glenn, a vial of polyester material processed on Shuttle mission STS-6 *(Challenger's* debut flight), a piece of insulation from the Skylab space station, recovered from debris which rained down on Western Australia in July 1979, an Order of Service from the *Challenger* disaster memorial service held a few days after the accident, and one of the now-famous First Day Covers flown aboard *Challenger* on mission STS-B in mid-19B3.

These items, and my many autographs, are my pride and joy. When I discovered that I was one of the winners in an *OVERMYER'S QUESTION CORNER* quiz held in *SFN* recently, and later received my prize of an autographed color portrait from your astronaut guest-columnist Robert Overmyer, my friends in the Irish Astronomical Association simply remarked; *"Trust you!"*

Derek Heatly,
Newtownabbey, Co. Antrim,
N. Ireland.

Autograph-hunter Derek Heatly of Northern Ireland has the autographs of (left to right) Neil Armstrong, Yuri Gagarin, Valentina Tereshkova, Anne Fisher and many other spaceflight notables . . .

CHRISTMAS QUIZ

Dear SFN,
IN addition to the small error in the December 1987 issue's *SPACEFLIGHT NEWS CHRISTMAS QUIZ,* which you noted on page 6 of your January 1988 issue, I am writing to say that there is one more.

In Section 1, *The Ten Commanders,* question 4 asked which was the first space mission commanded by Al Shepard. The answer is given as *Skylab 3,* but Shepard never *went* to Skylab!

In addition, I was appalled to see your reference to *"Cape Kennedy"* on page 10 of the January 1988 issue. The name was changed back to *"Cape Canaveral"* 15 years ago.

Ray Ward,
Sheffield, England.

Dear Ray,
YES, you're right about Al Shephard never having flown to Skylab. What the wording should have said was Al Bean, *not Al Shepard!*

With respect, we did not refer to the Cape Canaveral geographical area as "Cape Kennedy" *in error as you suggested. If you look back over previous issues of* SFN, *you'll see that we do occasionally use the words* "Cape Kennedy", *even though – strictly speaking – the Cape was renamed many years ago.*

The reason for this very deliberate usage is that we feel the whole area embracing Kennedy Space Center and Cape Canaveral Air Force Station is still, spiritually, "Cape Kennedy" *– whatever the pedants would have us call it.*

I think we are better-off adopting the principle that titles, like rules, were coined for the obeyance of fools and the guidance of good men.

Cape Kennedy – here's to the next 20 years!

BOOK FOUND

I AM writing in reply to Canadian reader Mary Macphee's query published in the December 1987 issue.

Mary described a book she'd seen somewhere but couldn't identify. From the description she gave, I'd say it sounds like a book I have in my possession. It's entitled *Moments in Space* and is published by Gallery Books, an imprint of W.H. Smith Publishers, Inc., 112 Madison Avenue, New York, NY 10016, USA.

A. Angelidis,
Northcote, Victoria,
Australia.

Giggle

by Russ Brown

MISSION REPORT

Overleaf we continue our series of* SHUTTLE MISSION REPORTS *written prior to the appearance of the first issue of* SPACEFLIGHT NEWS *in October 1985 . . .

HEAVYWEIGHT SPACELAB!

Spacelab, at long last, has had its first taste of space! The European Space Agency-built orbital laboratory, which was designed from the outset to occupy a berth in the Shuttle's cavernous payload bay, was four years late in getting there. Nevertheless, its debut flight has been deemed a success by all but the most cynical observers.

Lasting over ten days, the joint NASA/ESA STS-9/Spacelab 1 flight was the longest Shuttle mission to date. The presence of the Spacelab 'long module' and a single experiment-bearing pallet in the cargo hold made this the heaviest Shuttle stack ever to get away from the launch pad.

Under legendary Commander John Young, a six-man crew established a new benchmark as the largest ever flown into space on a single mission. It was a crew of contrasts. Young was making a record-breaking sixth spaceflight, while his Pilot, Brewster Shaw, was notching-up his first. Two Mission Specialists flew on this occasion; Dr Owen Garriott (53), adding this flight to his 59-day Skylab 3 stint in 1973; and Dr Robert Parker (46), like Shaw, a space 'rookie'.

A particularly noteworthy feature of STS-9 was that it became the first mission to fly the new breed of astronauts known as Payload Specialists; career-scientists NASA has brought into the Shuttle program to enhance the scientific gain from each mission.

The Payload Specialists in question were biomedical engineer Dr Byron Lichtenberg (35) of the United States and materials-science specialist Dr Ulf Merbold (42) of West Germany – the first non-American to fly on an American manned mission.

Merbold, born in East Germany incidentally, was seconded to NASA for this flight by ESA. His selection from the corps of Euro-astronauts may (quite rightly) have had something to do with the fact that West Germany contributed 55 per cent of the $850 million development costs of Spacelab.

Homing in on the action as we are wont to do, *SPACEFLIGHT NEWS* interviewed two of the STS-9/Spacelab 1 astronauts post-mission. They were Owen Garriott and Byron Lichtenberg, both of whom spent the majority of their time working experiments inside the Spacelab module.

Lichtenberg told us he had wanted to fly in space *"ever since I was a kid and read a lot of science fiction"*. His career path took him into the U.S. Air Force. He flew F-4 Phantoms on 138 combat missions in Vietnam, including 43 over North Vietnam, garnering two Distinguished Flying Crosses and eleven Air Medals.

On leaving the Air Force, Dr Lichtenberg entered the civilian scientific sector. He attended the internationally-known Massachusetts Institute of Technology (MIT) where, along with some Canadian co-investigators, he found himself drawn into a proposal whereby some space motion-sickness experiments be flown aboard the inaugural Spacelab mission.

CREW:
(left to right, ABOVE)
OWEN GARRIOTT (MS1)/
BYRON LICHTENBERG (PS2)/
BREWSTER SHAW (Pilot)/
JOHN YOUNG (Commander)/
ULF MERBOLD (PS1)/
ROBERT PARKER (MS2)

ORBITER: *Columbia* (OV-102)

LAUNCH:
16:00:00 GMT/28 November 1983
Kennedy Space Center, Florida.

LANDING:
23:47:24 GMT/08 December 1983
Edwards, California.

ORBITS: 167

DISTANCE: 3,755,424 nautical miles.

MISSION ELAPSED TIME:
10 days, 7 hours, 47 minutes, 24 seconds (247 hrs, 47 mins, 24 secs).

WEIGHTS:
Take-off/4,515,296 pounds
Landing/220,027 pounds

This was back in 1976. Lichtenberg and his colleagues had been investigating why some people succumb to spacesickness, and how the brain changes its function in space; how it takes in different sensory information and deals with this new information.

By 1978, Lichtenberg had been selected, along with Dr Michael Lampton from Berkeley, California, to train as a Payload Specialist for Spacelab 1. Only one year before lift-off was a decision taken as to which one would actually fly and who would back him up.

Since making his epic Skylab 3 flight in '73, our second 'featured astronaut', Owen Garriott, has been far from idle. After completing his Skylab mission, he transfered from the Astronaut Office to become first Deputy Director, and then Director, of the Space Science and Applications office at Johnson Space Center in Houston, Texas.

After several years at Houston, Garriott began a one-year government Fellowship at Stanford University renewing his academic credentials: *"I didn't specialize, I purposely followed a number of different disciplines as broadly as possible, just to get reacquainted with the academic community"*.

Following that, Garriott resumed duties with NASA as Assistant Director for Space and Life Sciences, again at JSC, but in 1978 he returned full-time to the Astronaut Office to get ready for STS-9/Spacelab 1.

That's five years preparing for one space mission, but there was a lot to do, as Garriott himself recounts: *"We were following the development of the Spacelab hardware in Europe. We had a number of our early training activities there for the experiments that were flown on Spacelab 1, and we also followed the completion of the hardware development and some of the testing of it at Bremen and other European locations."*

Because he had performed three spacewalks on his Skylab 3 mission, Garriott was a natural for selection (with John Young) to the two-man team assigned to contingency-EVA training for STS-9. Such training takes place before every Shuttle mission. It ensures that there is a second line of defense in the unlikely event of a mechanical failure necessitating the manual stowage of the payload bay doors prior to re-entry.

LAUNCH

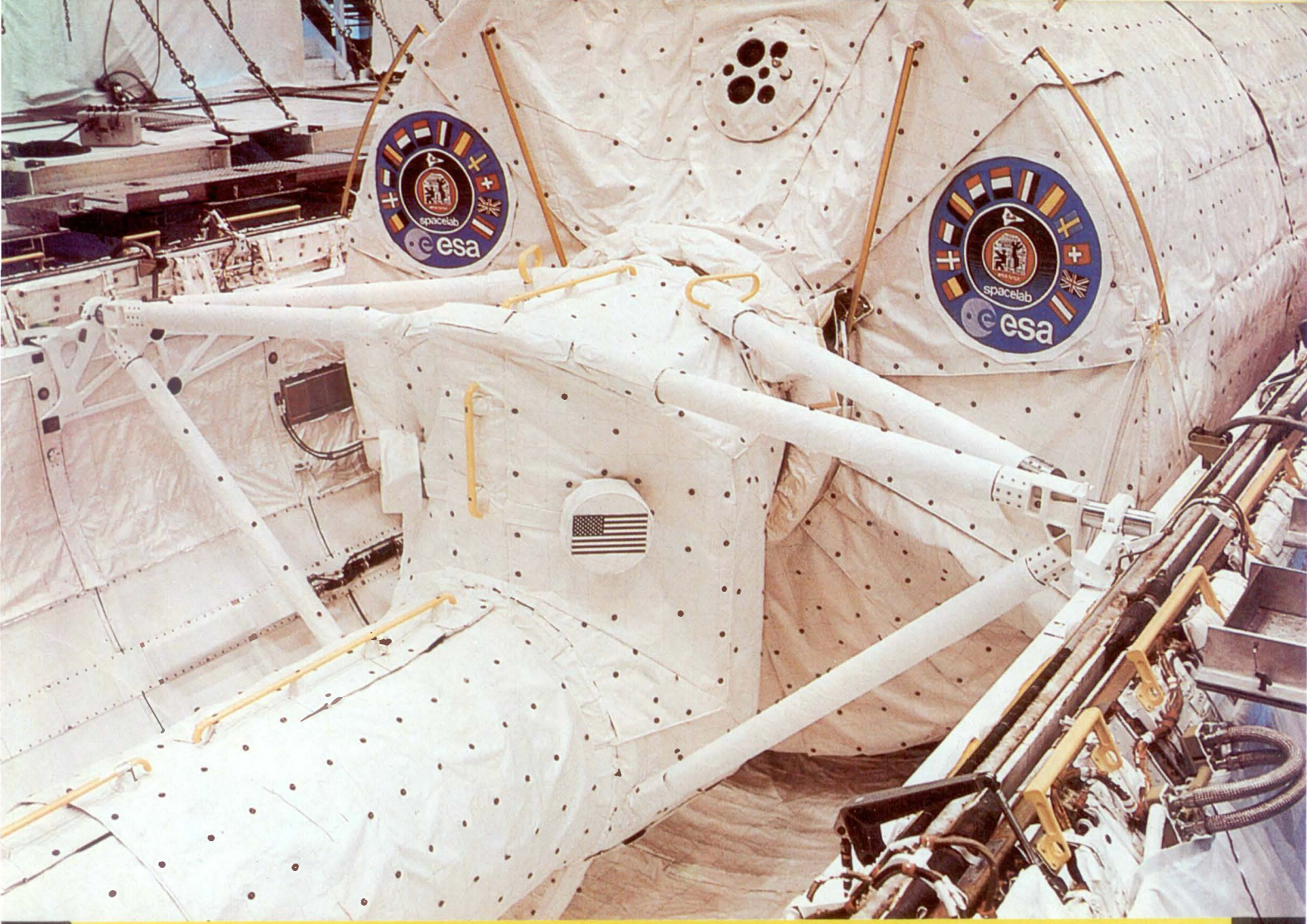
The launch of STS-9/Spacelab 1 was delayed, first to September, then to October, and finally to late-November, by a combination of problems with the TDRS tracking and data relay satellite system which supports Shuttle missions, and concerns awakened by analysis of the solid rocket boosters recovered from the ocean after the 30 August launch of STS-8/*Challenger*.

On close inspection, the three-inch-thick

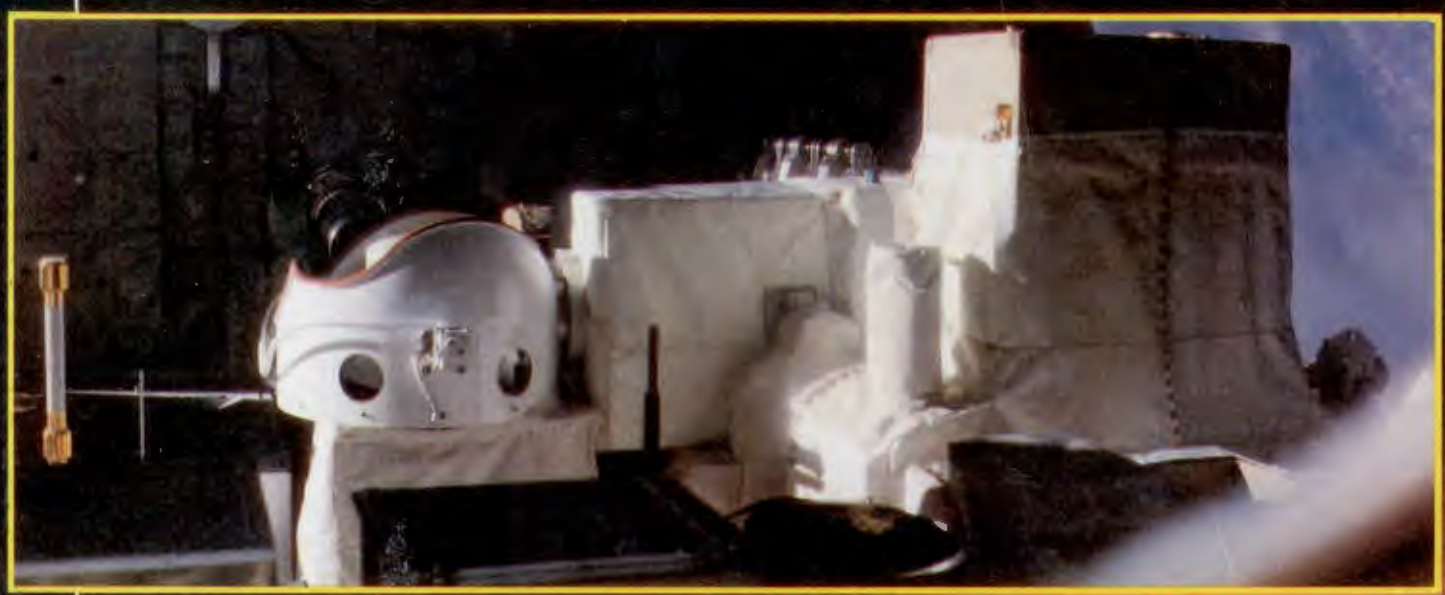
CONTINUED ON PAGE 39

UPPER RIGHT: Spacelab exterior; the manned 'long module' is seen positioned in* Columbia's *payload bay prior to the spacecraft being rolled out to the launch pad. The hinge lines of the payload bay doors are visible on either side of the module, as is the Z-shaped deviation built into the tunnel connecting the laboratory to the Orbiter mid-deck which is off-frame to the left.

LOWER RIGHT: Spacelab interior. Both of the 'featured astronauts' interviewed by* SPACEFLIGHT NEWS *for this article are pictured hard at work inside the laboratory module. They are Payload Specialist Byron Lichtenberg (left), and Skylab 3 veteran, Mission Specialist Owen Garriott, both of whom were on the 'Blue' shift with Pilot Brewster Shaw (the latter was up on the flightdeck when this photo was taken).


spacelab
esa
spacelab
esa


SPACELAB MISSION 1
NASA
esa
ASTRONOMY · SOLAR PHYSICS · SPACE PLASMA PHYSICS · ATM
MATERIAL SCIENCES · TECHNOLOGY · LIFE SCIENCES · EARTH



ABOVE: Alaska action! The Aleutian Range volcano Veniaminof was not previously thought to be active, but this striking STS-9/Spacelab 1 photograph shows that it is. A fumarole (a vent in or near a volcano from which hot gases, especially steam, are emitted) and its shadow are clearly visible above the snowcovered crater.

MAIN PICTURE: Columbia *appears to hang upside-down in space in this eerie shot, in which a cross-section of the Earth's atmosphere is illuminated by the gathering sunrise. The port wing appears at top left, and the tall tailfin and bulbous OMS pods catch the golden sunlight. The outline of Spacelab, with its circular ESA logo barely visible, can be discerned in the Shuttle's cavernous payload bay.*

TOP LEFT: A 'gathering of the clan' in the aft end cone of the Spacelab module, as the STS-9/Spacelab 1 crew take advantage of weightlessness to strike a star-like pose for an automatic camera. Clockwise from the bottom are Parker, Young, Merbold, Garriott, Shaw, and Lichtenberg (grasping his knees).

LEFT: Behind the manned Spacelab 'long module' was a pallet loaded with experiments. It is seen here in a photograph taken by one of the astronauts peering through the laboratory module's aft viewing port.


Columbia
NASA

CONTINUED FROM PAGE 34

insulation layer lining one of the boosters' aft nozzle assemblies was found to have been almost totally burned-through by the 5,800-degree onslaught of propellant combustion.

The aft nozzles earmarked for STS-9/Spacelab 1 were therefore replaced, delaying the launch beyond the already-slipped target date considered optimum for science data-gathering. Launching towards the end of November inevitably meant that there would be some diminishing of Spacelab's capabilities.

Earth-observations would be hit by the very low-elevation sunlighting angles in the northern hemisphere at this time of the year. Furthermore, an unfavorable Sun-Moon-Earth disposition would result in far-from-ideal orbital conditions for astronomy observations, and experimentation in the realms of space plasma physics and upper-atmospheric physics.

Those negative factors notwithstanding, launch and ascent into orbit went perfectly, *Columbia* crackling into the cold Florida sky with a sprightfulness belieing her considerable weightlifting feat.

First-time spacefarer Byron Lichtenberg simply describes the ascent experience as: *"The neatest thing in my entire life."*

ON-ORBIT

With *Columbia* soon configured for orbital activities, with her payload bay doors gaping open and her bank of computers loaded with the appropriate software packages, the serious work of space science could begin. One of the early activities for the astronauts upon getting on-orbit was to take medical measurements pertaining to their initial responses to weightlessness.

This data would ultimately be correlated with measurements taken both *pre*-flight (for many months before launch, right up to within a few days of it) and *post*-flight, in order to build up a complete picture.

A total of 72 scientific investigations had been planned for the mission. They originated from eleven European countries, plus the United States, Canada and Japan. Of the dozens of experimental packages crammed into the Spacelab module, two in particular are worthy of mention in this summarized account.

One came from the European Space Agency (ESA), and was essentially two standard 19-inch-wide Spacelab experiment racks mounted side-by-side and outfitted with such a welter of equipment as to form, in effect, an entire materials-science laboratory.

This ESA 'double-rack' payload represented what Byron Lichtenberg describes as *"the first really concentrated materials-science effort in space"*. Isothermal and gradient furnaces were being used to perform a variety of metal preparations, while a mirror-heating furnace melted silicon rods and recrystalized them into a single rod in zero-gravity under the watchful eye of deft experimenters.

An Italian fluid physics module incorporated into the ESA double-rack was designed to nurture long free-standing columns of liquid to study the effects of zero-gravity on them. A special chamber alongside it created ultra-high vacuum conditions to aid studies into the adhesion of metals, one to the other.

The second of the two particularly noteworthy science payloads aboard the Spacelab 1 manned module was another double-rack, this time dedicated to life-sciences experimentation. It featured a plant-growth unit with two miniature centrifuges that produced an artificial gravity of 1 g; the same gravitational environment as that on Earth.

In these conditions, small sunflowers were left to grow for two or three days just as they would on Earth.

The sunflowers were then abruptly removed from their 1 g environment and put into a chamber, where they were photographed to see how they behaved both immediately upon being exposed to zero-gravity, and for the ensuing 24 hours.

That life-sciences double-rack also facilitated a series of human experiments. The astronaut-scientists performed a series of blood pressure experiments, drawing each other's blood on orbit and conducting related studies under laboratory conditions.

The rack also supported neuro-vestibular experiments extending directly from the work Lichtenberg and his colleagues have been conducting back on Earth at MIT, studying how the human brain adapts to weightlessness.

Byron Lichtenberg: *"We had a large rotating dome that you put your head in. With the dome rotating, after a while you feel like it's you that's starting to spin and the dome is slowing down. We took pictures of the eyeball to study this phenomena, and also had the people under test move joysticks so that we could see that person's own sense of the motion he was undergoing."*

This wasn't the only human-adaption instrument to fly on Spacelab 1.

An exotic ESA-developed 'sled' device was denied a place on this mission two years ago because the extra weight would make an undesirable contribution to the Spacelab-laden Shuttle's already-marginal center-of-gravity disposition, but an effective lightweight version was flown instead.

It took the form of a seat, in the outdoor lawn-chair fashion, which could be folded neatly away when not in use. Once comfortably seated, the test-subject occupant could be moved by hand by the other crewmembers (rather than by a heavy electric motor), as his responses to these movements in weightlessness were monitored by a camera directed at the iris, and measured by electrodes stuck to the skin covering the small muscles around the eye sockets.

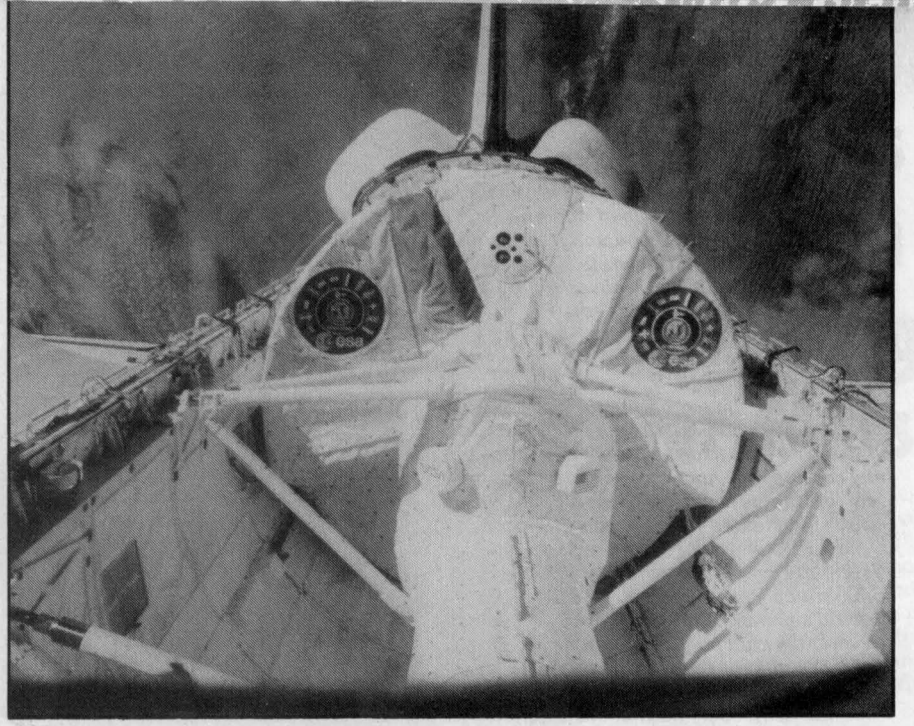
When attached to a pivot set in Spacelab's floor, the seat could be caused to rotate its occupant either in pitch, roll or yaw. Alternatively, it could be removed from the floor pivot and moved, again by hand, in a linear (back-and-forth) motion.

Lichtenberg: *"The bottom line from the space motion-sickness experiments is that, in three to four days – maybe five days – if you're sick at all you will adapt and feel just fine.*

"Once you do adapt, you can do anything you want on-orbit in terms of somersaults and flips, and turning upside-down and making all kinds of head motions and performing activities that tended to make you sick those first few days."

The STS-9 crew operated a shift system to ensure that the payloads aboard were constantly put to work. By splitting the crew straight down the middle, each 12-hour shift could conveniently comprise one Pilot to keep an eye on things up on the flightdeck, and one Mission Specialist and one Payload Specialist to attend to the experiments in the lab module.

The 'Red' shift comprised John Young, Bob Parker and Ulf Merbold, while the 'Blue' shift was made up of Brewster Shaw, Owen Garriott and Byron Lichtenberg. Shaw, Garriott and Lichtenberg had adjusted their circadian rhythms in the days prior to lift-off,



An STS-9 astronaut using a handheld 70mm camera aimed through one of the aft windows on* Columbia's *flightdeck captured this excellent view of Spacelab nestled in the payload bay, with a cloud-covered Earth backdrop.

UPPER LEFT: After spending more than 10 days in Earth orbit, the STS-9/Spacelab 1 crewmembers exit* Columbia *to be greeted by NASA's Director of Flight Operations, George Abbey. First in line is Commander John Young, followed by Brewster Shaw, Bob Parker, Euro-astronaut Ulf Merbold, Owen Garriott, and Byron Lichtenberg (who was another record-maker on this mission; America's first non-career-astronaut to join a NASA crew in space).

LOWER LEFT:* Columbia *in repose during closeout activities at dusk on Edwards' Runway 17. She was later transported back to Florida atop NASA's Boeing 747 Shuttle Carrier Aircraft (SCA).

which resulted in the odd spectacle of one half of the crew enjoying lunch while the other half ate breakfast at the traditional pre-launch astronauts' dining session.

Lichtenberg explains how the system worked: *"We were timelined down to five-minute blocks of time, and some activities had to happen almost down to the second; for example, for an Earth-observation pass or for an astronomy pass or an upper-atmospheric physics pass.*

"You had to be right there and do things on the second.

"Those 12 hours of timelined, or pre-programed, experiment operations left us virtually no time to do any troubleshooting or any contingency malfunction procedures, or any of the reworks of experiments that hadn't functioned properly the first time.

"If an experiment didn't work properly during the timelined period, and it was not time-critical, we sort of put it in the background and then came back to it for a second try after the shift handover, when you turned over the timelined activities to the next person – Ulf, in my case.

"That way, our normal 12-hour work periods in reality became working days of more like 15 or 16 hours."

In most cases, the Mission Specialist who had just finished his shift could call it a day. It was the two Payload Specialists, Lichtenberg and Merbold who, because of their more intimate knowledge of the experiment hardware, had to extend their working days to fettle recalcitrant equipment.

Fortunately, the Spacelab module is spacious enough to accomodate three, even four, busy astronauts without too much jostling for position.

The science tasks were distributed fairly evenly between Garriott, Parker, Lichtenberg and Merbold, since all four were trained to operate all of the experiments with an appropriate level of competence under normal circumstances. However, some division of labor did take place on the grounds of specialist expertise.

For example, Ulf Merbold tended to take the lead on materials-science activities and was scheduled fairly heavily on the ESA materials-science double-rack. Byron Lichtenberg's biomedical engineering background put him in the hot seat on many tasks associated with that discipline, while astronomer Bob Parker usually got to grips with stars and related matters.

Electrical engineer Owen Garriott more often than not took a lead on the upper-atmospheric physics experimentation, with which he is well acquainted. He, like the other astronauts busily engaged inside Spacelab, had little time to peer out the window, but he did make this interesting observation: *"We were flying at 57 degrees inclination on this flight, of course, and the high latitudes made the opportunities for looking at the Earth beneath us of even greater fascination.*

"We could see both northern and southern latitudes much better than even on Skylab at 50 degrees."

Although the two Mission Specialists had responsibilities relating to the day-to-day operation of the Orbiter vehicle's systems, when these were working normally (which they did for most of the time), they could devote their efforts solely to advancing the research activities going on in the Spacelab module alongside their Payload Specialist cohorts.

Owen Garriott: *"Operation of many of the experiments required two people working together as a team, particularly in the life-sciences area. You would perform a test on one person, and then you would reverse the roles and they would perform that test on you.*

"Experimenter and subject, and vice versa."

ABOVE: This clever composite photo shows STS-9 Commander John Young (left) and Pilot Brewster Shaw preparing for* Columbia's *re-entry into the Earth's atmosphere. Young, who wears glasses for some activities as this picture shows, was establishing a new world record by making his sixth spaceflight, having now notched-up two Gemini missions, two Apollo missions and two Shuttle missions.

Byron Lichtenberg was full of praise for one particular advancement represented by STS-9/Spacelab 1: *"It was the first time we've ever had direct contact between scientists on board a spacecraft and scientists on the ground. Always in the past, all of the communications had gone through an astronaut on the ground – the CAPCOM, or Capsule Communicator.*

"Also, in the past NASA hasn't really had active practising scientists on board its spacecraft; it had always been a scientist that had been selected by NASA and then spent from three to 15 years being a NASA astronaut and not being a true scientist.

"On Spacelab 1, the concept of having practising scientists in direct voice and video contact with their peers on the ground was a major step forward. I think we were able to be a lot more productive in the fact that we could talk our scientific jargon amongst ourselves.

"It's a shorthand, if you will, in the same way that the pilot astronauts up on the flightdeck have their own form of shorthand communication going with the CAPCOMs."

The voice and science-data downlink from *Columbia* to Houston operated via the TRDS-1 tracking and data relay satellite, and went direct to the newly-opened Payload Operations Control Room (POCR) at Johnson Space Center. There, under the management of NASA's Marshall Space Flight Center (who took primary responsibility for Spacelab 1 crew training, payload integration and payload flight operations), teams of international scientists involved in the development of the various experiments could interact with their colleagues aloft and monitor the inflow of data.

The vast majority of scientific returns from a mission like STS-9/Spacelab 1 bear fruit only when the accumulated data has been painstakingly analysed during the weeks, months and even years which follow. Some discoveries, however, are made in 'real time' aboard the spacecraft and these naturally caused great excitement in the POCR and inside Spacelab itself.

Particularly noteworthy in this regard were a couple of life-sciences and materials-science discoveries; the former involved observation in zero-gravity of reflex human eye movements previously thought to be attributable purely to gravity-induced influences; the latter involved the Italian fluid physics module, and saw the first formation in space of large columns of fluid without a container.

During our interview, Byron Lichtenberg described how various 'off-the-cuff' hardware lash-ups were necessary to help these and other science activities on their way: *"As much as we thought we understood the processes on the ground, and as much as we thought we'd got experiment hardware that would work, when we got up into space we found that some things were not as well-defined and as easy to do as they were here on Earth.*

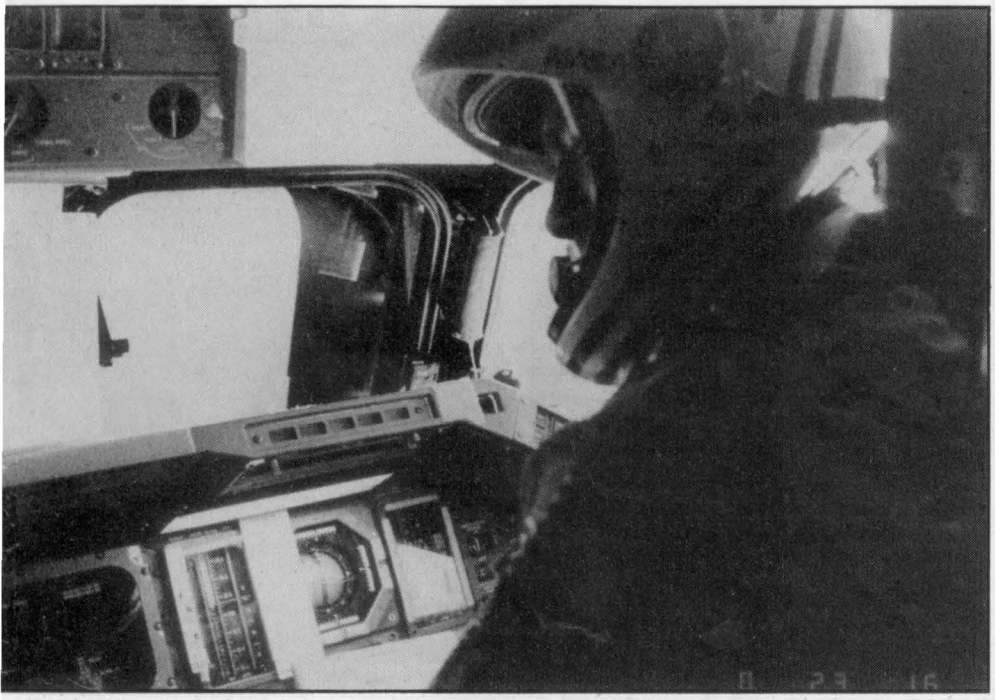
"As a result, we had to do some refitting and devise makeshift experiment set-ups from time to time."

Hardware idiosyncrasies of a different kind caused the crew to have quite a 'moment' on Day 3 of the mission. Lichtenberg: *"We were in the module working away, when all of a sudden we heard a big 'Kaboom!'. I had my feet in footloops on the floor at the time and it felt like the whole floor had just lifted up.*

"It was a scary moment for us. We all stopped, held our hearts and looked at each other and didn't say a word, because we were waiting for all the alarm bells to go on. We didn't know whether it was a micrometeorite impact or a minor explosion, or just what had happened.

"After a while, when we didn't hear any alarm bells, we thought, 'Well, we're probably still alive!'.

"We talked to Brewster up on the cockpit



and he said that he had checked every display on the computers and there was nothing wrong – and yet he had heard and felt this disturbance, too.

"We thought about that a while and it happened several times more within the succeeding hours. It turns out to be a thermal expansion phenomena associated with us changing our attitude profile, although the engineers only pinpointed the exact source of the noise after we got back to Earth.

"We had been in an attitude where our tail was pointed towards the Sun – the so-called 'cold-test attitude' – and then very abruptly we'd turned so that the entire payload bay was facing the Sun. That tended to warm-up the entire vehicle, and it created an effect you can probably understand a little better if you think about the expansion joints incorporated in steel bridges back on Earth.

"There is a slip-joint in the tunnel that connects the Orbiter mid-deck to the Spacelab module. That slip-joint is supposed to absorb the movements caused by the differential expansion rates of the Orbiter and the Spacelab, but apparently the joint was too tight.

"As a result, a lot of stress would build up in there, until it gave out a great oil-can-like 'Kaboom!' as the forces stored up in there were abruptly relieved."

Hardware bumps-in-the-night gave way to software heart-stoppers towards the end of the mission. A Reaction Control System (RCS) thruster-firing was followed by the complete failure of Computer 1. Although Computer 2 took over its tasks, as is normal with a back-up (or 'primary redundant set') system of the type instaled aboard the Orbiters, a second thruster-firing caused this computer too to shut down.

BELOW: West Germany's Ulf Merbold looks to be taking his work very seriously in this pre-flight training shot, taken at Johnston Space Center. On STS-9/Spacelab 1 Merbold, seconded to NASA by the European Space Agency (ESA), became the first non-American to fly on a U.S. space mission. His backup was Dutchman Wubbo Ockels, who may himself fly on a future joint NASA/ESA Shuttle mission.

"I was asleep when all this happened," Byron Lichtenberg told *SFN* later. *"Those of us on the 'Blue' shift were just finishing-up our sleep period and the plan was for us to get up and prepare to re-enter early in the morning California-time, landing about eight o'clock.*

"It was, I guess, about 4.15 in the morning, when the computers were going through a sequence to fire the various thrusters to make sure everything was working okay prior to re-entry. When they fired the big 870-pound primary RCS thrusters, there was a tremendous booming sound and the whole spacecraft just shook like someone had hit it with a sledgehammer.

"They fired those a couple of times, and that woke me up, so I said, 'Well, it's about time to get up anyway'. As I was getting out of my bunk, Bob Parker was coming down from the flightdeck and he said, 'We did not lose just one, but we lost both of the computers they were operating – they just dropped right off the line!'

"So I said, 'That's not so good!'. He said, 'No, well they just got one of them going again, but for a while there we were in free drift mode while they fixed it. Nothing was controlling the ship'.

"I went up to the flightdeck, and of course everybody was talking to ground control. We spent the next five or six hours trying to troubleshoot it; trying to find out what happened."

Although the Orbiter has a total of five on-board computers, a generic failure like this, which could easily be common to all five, is cause for the utmost concern. STS-5/*Columbia* Pilot Robert Overmyer, working in the Mission Control Center, told *SPACEFLIGHT NEWS: "We were scared windless, quite frankly."*

John Young, up on the flightdeck, confesses that his *"legs turned to jelly"*. A lot of hard work went into finding a fix.

Eventually, Young and his crew pulled it all back together again, but from a science point-of-view the computer problem had a fairly serious impact on the data-gathering activities that had been scheduled for the immediate hours following touchdown. Instead of returning early in the morning, the crew made five extra Earth orbits and did not get down until late-afternoon.

By that time, after a 20-hour stint, the 'Red' shift were deemed too exhausted to face what had originally been scheduled as an entire day of medical tests in an impressive new facility that had been built for the purpose back at the Edwards landing site.

More about that later. . .

RE-ENTRY & LANDING

For re-entry, Lichtenberg and Garriott exchanged the places they had occupied for lift-off, with the former downstairs in the mid-deck, and Skylab veteran Garriott enjoying his first view of this extraordinary event from a proper cockpit, rather than from a hurtling 'backs-first-look-out-for-the-parachutes' space capsule.

I asked him to compare the two re-entries; Skylab and Shuttle.

"I had a window. Looking up, I could see

through a bit of the overhead windows, too. You see the interesting colors, oranges and pinks as you come down through the more and more dense layers of the atmosphere.

"We were flying at a lower altitude on Spacelab 1 than I flew on Skylab. Although the orbital velocities are about the same, in that you're travelling a little over seven kilometers per second in any of these lower altitudes, the angular rate at which the nadir moves by is about twice as high when you're at half the altitude.

"That means the ground beneath you appears to move by about twice as fast, which is certainly one noticeable difference."

Down on the mid-deck, Byron Lichtenberg was soaking-up his own experiences in the closing stages of a rewarding mission: *"For me, it was like your first flight in anything; you need to learn what's going on and some of the ways the vehicle reacts are new to you.*

"John made an excellent job of touchdown, but when the nose came down it really slammed very hard on the runway. That was due to the Spacelab being in the payload bay, giving the whole Space Shuttle a more forward center-of-gravity than usual.

"It felt like the nose-gear was going to come right up between my feet!"

If only Lichtenberg had known the full facts, the thump of the nose wheels contacting the runway would have sounded like sweet music. *Columbia* was on fire!

Smoke streamed from the tail area during rollout, prompting some concerned exchanges over the intercom. Post-flight inspection revealed that a ruptured fuel pipe had caused two of the three Auxilliary Power Units (APUs) to explode and start a smouldering fire. . .

As aforementioned, the STS-9/Spacelab 1 crewmembers were supposed to disembark from *Columbia* and go straight into a new life-sciences data-collection facility that had been set up at Edwards' Dryden Flight Research Center. It is extremely well-equipped, even featuring a giant-sized version of the 'sled' device instaled aboard Spacelab.

The object of the tests was to establish what physiological and psychological state the astronauts were in immediately after re-entry to the Earth's gravity field (this is termed 'baseline data-collection'), and then look at the way they adapted back to 1g over the next five or six days.

Some of the very critical data-points were to have been obtained during those first few hours following after landing. However, the 'Red' shift crewmembers had been awake almost 20 hours at that point, prompting the NASA hierarchy to decree that no tests would be performed on them after all. They would be sent straight to bed and the first series of medical tests conducted in the morning on their awakening.

"We in the 'Blue' shift had been up only about 10 hours, I guess, at that point," says Byron Lichtenberg. *"We agreed to go through about six or seven hours of medical testing that day and then get some rest. We got to bed about midnight on the day of our landing."*

Having spent many years studying the effects of prolonged zero-gravity on the human body, Dr Lichtenberg offers *SPACEFLIGHT NEWS* readers a revealing insight into the after-effects:

"Even during a ten-day mission like ours, your muscles start to atrophy. They don't have to work against gravity anymore, so they tend to lose muscle mass and they become weaker; primarily your legs and your back.

"Coming back to the Earth and being caught in the Earth's gravity field again, you notice that when you stand up, it takes more of a conscious effort to stand up and walk around. The day after landing, your muscles are quite sore – especially your leg muscles.

"It's been described like running a marathon race the day afterwards. You're pretty sore.

"There are other side-effects. What happens is that your blood volume actually decreases by 10-20 per cent during the course of five to seven days in orbit, because you just don't need that much circulating. When you come back to Earth you're like an automobile that's a quart low, so to speak. It's like somebody that's been bedridden for a while; if you're not careful, you feel a little bit lightheaded, a little bit dizzy.

"What we do is, we take some countermeasures to try and help those things out. We do a thing called 'fluid loading', where we will drink several quarts of water and take some salt tablets just prior to re-entry, in order to build up the plasma levels and compensate for this blood loss.

"Another thing that happens is that your brain has adjusted to weightlessness and once you come back to the Earth's gravity, it's not sure what to make of this thing called 'down' anymore. So if you try and stand up with your eyes closed immediately after landing, you tend to fall over.

"Your balance mechanism is off and it takes several days for that to re-establish itself.

"So, coming back in initially, you realize there's some inappropriate things happening; it's a fairly significant change in the body and there's some physiological stresses on you. The point is, we know about these and we have ways of counteracting them."

Owen Garriott's closing remarks summed-up the essence of this historic Spacelab debut mission: *"I think the key element of this flight was its multi-disciplinary nature. There was no single experiment, no single discipline, that monopolized the majority of the time.*

"Spacelab 1 was intended to show how well all disciplines could make use of the Orbiter as a laboratory in space."

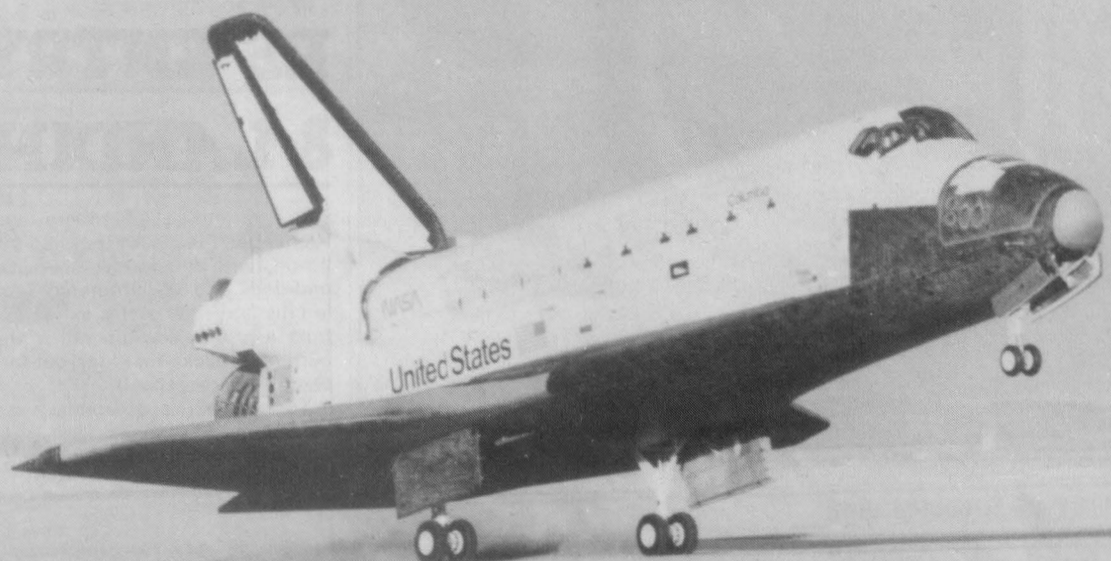
And Byron Lichtenberg? *"For me, it was the experience of a lifetime. It was just fantastic."*

MISSION REPORT
by Nigel Macknight

Statistics

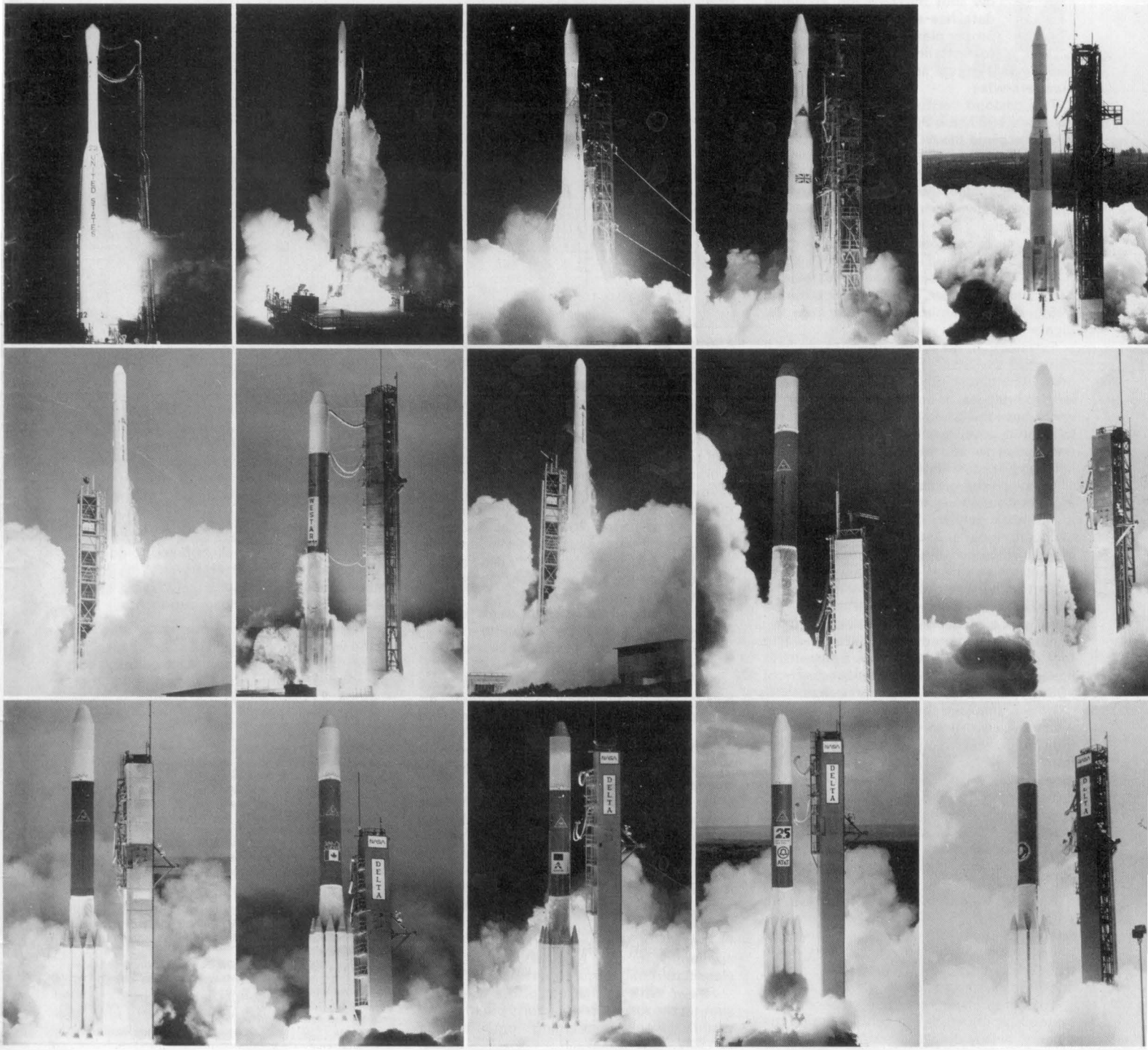
SHUTTLE MISSION
STS-9/*COLUMBIA*

- 94th manned spaceflight
- 40th U.S. manned spaceflight
- 9th Space Shuttle mission
- 1st flight by European-built Spacelab orbital laboratory
- 6th flight by Orbiter *Columbia*
- 1st six-person crew to fly in space
- 1st U.S./International manned spaceflight. Ulf Merbold became first non-U.S. citizen to fly on a U.S. mission.
- 1st Shuttle flight to carry Payload Specialists
- John Young became first person to make six spaceflights
- Brewster Shaw, Robert Parker and Byron Lichtenberg became joint 128th people in space; joint 63rd Americans
- Owen Garriott became 54th person and 24th American to make two spaceflights.
- Ulf Merbold became 1st West German in space and 2nd West European in space
- Longest Space Shuttle mission to date; 10 days, 7 hours, 47 minutes, 23 seconds to main gear touchdown.



BELOW: The presence of Spacelab in the payload bay made* Columbia *a real heavyweight on this occasion. She tipped the scales at 220,027 pounds as she terminated her mission on Runway 17 at Edwards Air Force Base, California. Although it is not visible in this shot, a stream of smoke trailed from the tail section after a smouldering fire caught hold in the region of a ruptured fuel line. Two of the Orbiter's three Auxilliary Power Units (APUs) also exploded.

NOTHING SUCCEEDS LIKE SUCCESS.



No booster can match Delta's 10-year, 98 percent launch success rate. Confident of Delta's continued success, the U.S. Air Force chose our new, more powerful Delta II for launch of the Global Positioning System satellites. Delta also became the leader in the U.S. commercial launch industry by landing the first commercial launch contracts.

Confidence borne of success. There is no more compelling reason for you to select the Delta II. If you need satellite launch services in the early '90s, contact: Space Transportation New Business Development Office, McDonnell Douglas Astronautics Company, 5301 Bolsa Ave., Huntington Beach, CA 92647.

MCDONNELL DOUGLAS

Robert Christy

IN ORBIT

SFN's monthly update on comings and goings between Earth and space.

Now that most of the available data has settled down into its proper place, this is a good time to cast an eye back on what 1987 has left us space-watchers with, numbers-wise.

The payload carried on the last orbital launch of 1987, the Soviet satellite Cosmos 1907, received the NORAD catalog number 18720. The payload carried on the last launch of 1986 was numbered as 17264.

At surface value, these two figures suggest that the worldwide total of launches in 1987 placed about 1,500 more officially-logable objects in space, but in fact that's not quite the case.

Although many of the newly-cataloged items did result from launches made during 1987, a large number emanated from the flights of previous years . . .

For example, the Ariane V16 rocket which launched the SPOT 1 and Viking satellites on 22 February 1986 broke-up in orbit and left 363 pieces of trackable debris, all of which have received official catalog numbers as ground-based radars confirmed the presence of more and more, and smaller and smaller pieces drifting through space.

Although the official system for cataloging items put into space is rather complex, it is perhaps worthy of a more detailed explanation here, since a fuller understanding of it will greatly enhance your enjoyment of space-watching.

Getting back to that Ariane V16 mission, because it's an excellent case-in-point; the latest piece of debris to receive a catalog number is designated 1986-19TU, meaning that it is the 451st trackable fragment to have emanated from the 19th launch of 1986, which is what Ariane V16 was.

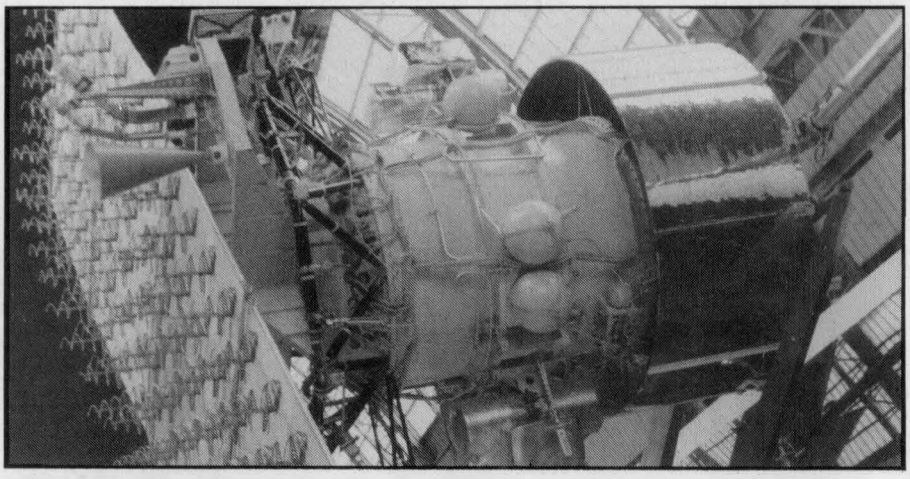
Under the current cataloging system, which uses two-letter suffixes for identifying individual payloads and fragments resulting from a given launch, the last possible combination, 1986-19ZZ, would represent the 576th fragment, then the number of letters would have to be increased to three and begin with 1986-19AAA, 1986-19AAB, and so on, as more items of debris were picked up by radar and allocated individual catalog numbers.

Readers should beware that this system employs only a 24-character alphabet, rather than the full 26-character A-Z version, because the letters *I* and *O* are never used, lest they be confused with the numbers *1* and *0*.

To deal briefly with another aspect of the system's application, we can again use the piece of Ariane debris refered to above as a working example. The first official entry of the fragment designated 1986-19TU appeared in NORAD's main catalog on 17 December 1987. However this does not mean 17 December 1987 was the date on which NORAD actually *discovered* the fragment.

Rather, 17 December 1987 was the date on which the fragment's designation number was transfered to the main catalog from a subsidiary listing; in this particular case, NORAD's catalog of so-called 'temporary objects'. This temporary catalog contains lists of unconfirmed, or even dubious, items in orbit.

As NORAD gets enough data to either confirm or deny their existence, so they are either transfered to the main listing or just deleted altogether.



ABOVE: An Ekran (Screen) television-relay satellite of the type orbited by a Soviet Proton rocket on 27 December (see entry 1987-109A on facing page): the 'bedsprings' are transmission antennas.

Having got all that straight, we should just mention that not many individual launches produce such large fragment-counts as Ariane V16 (451 at the present time, including the two satellite payloads themselves). Many make nearly 200 as launch vehicle stages or satellites break-up for a variety of reasons, the explosion of residual fuel trapped in piping and propellant tanks being the most common factor.

When the upper rocket stage of the Nimbus 4 satellite (catalog number 1970-25) exploded, at the last count at least 350 fragments resulted.

Sometimes, the destruction of a satellite is initiated deliberately. One reason for deliberate destruction might be fears that parts of a satellite about to re-enter the Earth's atmosphere might survive the fiery onslaught and crash to the ground, posing a threat to lives and property.

On other (rarer) occasions, objects in orbit have met their end as unsuspecting targets of ASAT (anti-satellite) missiles under test. A good example was the Solwind military science satellite, which was shot down by an ASAT missile unleashed from a McDonnell Douglas F-15 Eagle flying high over California.

The result was yet more space debris appearing in the NORAD catalog; 278 classifiable fragments to date.

Phew! With all that out of the way, let's sum-up the results of the efforts put in by the world's satellite-launching organizations in 1987.

1987 LAUNCH SUMMARY (BY SITE)

Launch site	Launches	Satellites	Still in orbit on 31 December
Tyuratam, USSR	46	50	29
Plesetsk, USSR	48	65	47
Kapustin Yar, USSR	1	1	1
Cape Canaveral, USA	3	3	3
Vandenberg, USA	5	9	9
Kourou, Guyana (ESA)	2	3	3
Jiuquan, China (PRC)	2	2	0
Tanegashima, Japan	2	2	2
Kagoshima, Japan	1	1	1
TOTALS	110	136	95

USSR DOMINATES

As usual, the USSR accounted for the majority of launches. During the twelve months, they launched 96 rockets into space, delivering 117 satellites to orbit, including three Soyuz-TM manned spacecraft. Of this total, three failed publicly. In January, controllers had to destroy a Cosmos military photo-reconnaissance satellite to prevent its re-entry vehicle from dropping back to Earth and falling into 'enemy' hands.

Then two Proton rockets failed to deliver their cargoes to correct orbits (a communications satellite in January and a triple GLONASS navsat payload during April).

Proton was back into its stride by the end of the year, with a series of six launches over a four-month period (see the introduction to last month's *IN ORBIT* listing, and the Raduga 21 and Ekran 17 entries in this

POSTSCRIPT:

- Cosmos 1836 (1987-33A), a Soviet military reconsat, finished its mission and re-entered the atmosphere on 2 December after 230 days in orbit.
- Cosmos 1865 (1987-58A), another Soviet military reconsat, finished its mission and re-entered the atmosphere on 14 August 1987 after 37 days in orbit.
- Soyuz-TM 3, (1987-63A), a Soviet manned ferry serving Mir, undocked at 5:55am on 29 December. It landed near Arkalyk, Khazakhstan (carrying cosmonauts Romanenko, Aleksandrov and Levchenko) at 9:16am, following completion of a retrograde rocket-firing at 8:23am.
- The entry for Cosmos 1890 (1987-86A), a Soviet navigation satellite, in the November 1987 edition of *IN ORBIT*, has an incorrect launch-time. It should have read *9:48pm*.
- Cosmos 1893 (1987-89A), a Soviet military reconsat, finished its mission and re-entered the atmosphere on 16 December after 55 days in orbit.
- USA-27 (1987-90A), a KH-11 reconsat listed last month, has catalog number 18441.
- Cosmos 1894 (1987-91A), a Soviet communications and data-relay satellite, is now on-station at 24.5 degrees west longitude. Its orbit is 35750 x 35811 kilometers, 1435.7 minutes period, 1.2 degrees inclination.
- Cosmos 1896 (1987-93A), a Soviet military reconsat, finished its mission and re-entered the atmosphere on 25 December.
- Progress 33 (1987-94A), a Soviet unmanned cargo freighter, undocked from Mir at 8:16am on 19 December. A few hours later, a retrograde rocket-motor firing led to a destructive re-entry over the Pacific Ocean.
- USA-28 (1987-97A), a Defense Support Program (DSP) satellite listed last month, was launched from Cape Canaveral AFS, not Vandenberg AFB as stated.
- Cosmos 1899 (1987-99A), a Soviet military reconsat which was still in orbit when last month's list was prepared, returned its cabin section to a landing on 21 December as expected.

SOVIET LAUNCH TOTALS
(Tyuratam and Plesetsk sites)

	1983	1984	1985	1986	1987
Tyuratam	32	33	33	35	47
Plesetsk	62	62	62	56	48
TOTALS	94	95	95	91	95

NAME,INT'L DESIG'N (CATALOG NO.)	LAUNCH TIME & DATE (GMT)	LAUNCH SITE & VEHICLE	PERIGEE (KM)	APOGEE (KM)	PERIOD (MINS)	INCLINATION (DEGREES)
Raduga 21 1987-100A (18631)	11:30am 10 December	Tyuratam, USSR D-1-e (Proton + added stage)	35770 geosynchronous – 128 degrees east	35790	1435.7	1.5
Communications satellite near the Statsionar 15 location, serving the Orbita-2 system within the USSR, with telecommunications links at C-band (6/4 GHz). Single transponders support each of the K-band (14/11 GHz) Luch system, and the L-band (1.6 GHz) Volna maritime and aeronautical communications system.						
Cosmos 1900 1987-101A (18665)	7:10am 12 December	Tyuratam, USSR F-1 (Scarp)	257	271	89.8	65.0
Nuclear powered, radar-carrying surveillance satellite observing naval movements. Frequent operation of a low-thrust rocket motor is used to maintain orbital height against air-drag.						
Cosmos 1901 1987-102A (18666)	11:30am 14 December	Tyuratam, USSR A-2 (Soyuz)	174	355	89.8	64.9
Military photographic reconnaissance satellite carrying several return capsules for periodic recovery of film. Its height is maintained against air-drag by a manouvering engine which can also be used to position the orbit ground track over a photographic target.						
Cosmos 1902 1987-103A (18668)	1:32pm 15 December	Plesetsk, USSR C-1 (Skean)	368	411	92.3	65.8
Small military satellite, possibly to be used as a calibration target by ground-based radars.						
Soyuz TM-4 1987-104A (18699)	11:18am 21 December	Tyuratam, USSR A-2 (Soyuz)	168 255 333	243 296 359	88.6 90.0 91.4	51.6 51.6 51.6
Carried a crew of three to the Mir/Kvant complex, consisting of its commander– Col Vladimir Titov, flight engineer– Musakhi Manarov, and cosmonaut-researcher–Anatoliy Levchenko. It docked with Kvant at 12:51pm on 23 December and the crew transferred to Mir/Kvant some 89 minutes later. At 9:10am on 30 December, the day after Soyuz TM-3's departure, it undocked from Kvant (with Titov and Manarov aboard), awaited a 180-degree turn by the Mir/Kvant comlex, and then re-docked with Mir's forward-facing port at 9:29am. Orbits shown are the initial one, the transfer orbit and the orbit after docking with Kvant.						
Cosmos 1903 1987-105A (18701)	10:35pm 21 December	Plesetsk, USSR A-2-e (Soyuz + added stage)	586	39759	717.6	63.0
Satellite in Molinya-type orbit, carrying rocket-launch detectors and acting as part of the Soviet Union's missile early-warning system.						
Cosmos 1904 1987-106A (18709)	8:23pm 23 December	Plesetsk, USSR C-1 (Skean)	968	1009	105.0	82.9
Polar-orbiting navigation satellite with radio beacons operating at 150 and 400 MHz.						
Cosmos 1905 1987-107A (18711)	8:45am 25 December	Tyuratam, USSR A-2(Soyuz)	207	273	89.3	70.4
Recoverable, manouverable satellite based on the Vostok design, carrying out military photo-reconnaisance, due for recovery on 8 January 1988.						
Cosmos 1906 1987-108A (18713)	11:30am 26 December	Plesetsk, USSR A-2 (Soyuz)	178	224	88.8	82.6
Recoverable, manouverable satellite based on the Vostok design, carrying out Earth-resources photography, due for recovery on 9 January 1988.						
Ekran 17 1987-109A (18715)	11:25am 27 December	Tyuratam, USSR D-1-e (Proton + added stage)	35716 geosynchronous – 99 degrees east	35851	1435.8	1.6
Television-relay satellite with a high-powered transponder operating at 714 MHz and serving community aerials in the more remote areas of the Soviet Union.						
Cosmos 1907 1987-110A (18720)	11:40am 29 December	Plesetsk, USSR A-2 (Soyuz)	356	415	92.3	72.8
Recoverable, manouverable satellite based on the Vostok design, carrying out military photo-reconnaissance, due for recovery on 12 January 1988.						

issue).

Europe and the United States both started to rebuild their launch vehicle programs during 1987 after the terrible losses of 1986. Following modifications resulting from the official investigation into the Ariane V18 failure in May 1986, Arianespace launched three payloads with a brace of launches towards the end of 1987.

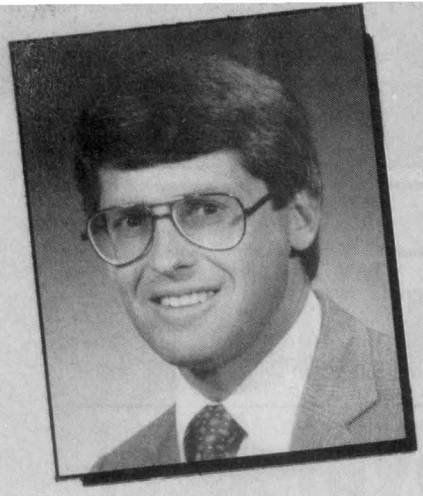
The United States conducted two successful Titan 34D missions in 1987; one of each of the 'east-coast' and 'west-coast' versions of the Martin Marietta-built vehicle, from Cape Canaveral in Florida and Vandenberg, California respectively. The difference between the two variants is that for Cape Canaveral launches, the Titan 34D is fitted with an inertial guidance system to allow it to find its way out to sea and into orbit, whereas for launches from Vandenberg, the rocket flies on a trajectory parallel to the west coast of the USA, allowing ground-based radio stations to take care of automatic guidance functions.

Other contributors to the year's grand total, as shown in the accompanying panel, were the Peoples' Republic of China (who launched two recoverable satellites) and Japan, who launched one scientific satellite, one remote-sensing satellite, and one technology experiments satellite (Ginga, Momo and Kiku-5 respectively).

One point worthy of special note before we close this summary of 1987, is the fact that the Soviet launch site at Tyuratam achieved its largest-ever annual launch total; 46 missions. The previous record (41) was held jointly by the years 1965 and 1982.

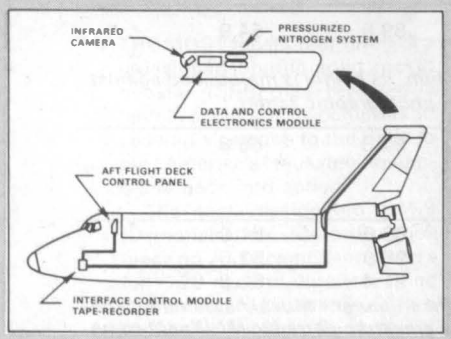
Overall, the USSR's total for the year is on a par with the past few years, so the increased activity at Tyuratam was balanced by a reduction in the number of launches from Plesetsk. This may be a 'one-off' situation, but on the other hand it could represent a balancing-out of work between the two locations. Whatever the reason, it's been twenty years since these two Soviet sites matched launch rates so closely, and even then it was only because parts of the facility at Plesetsk were still under construction.

Could we see a reversal in the relative status of the two sites during 1988? *Watch this space...*



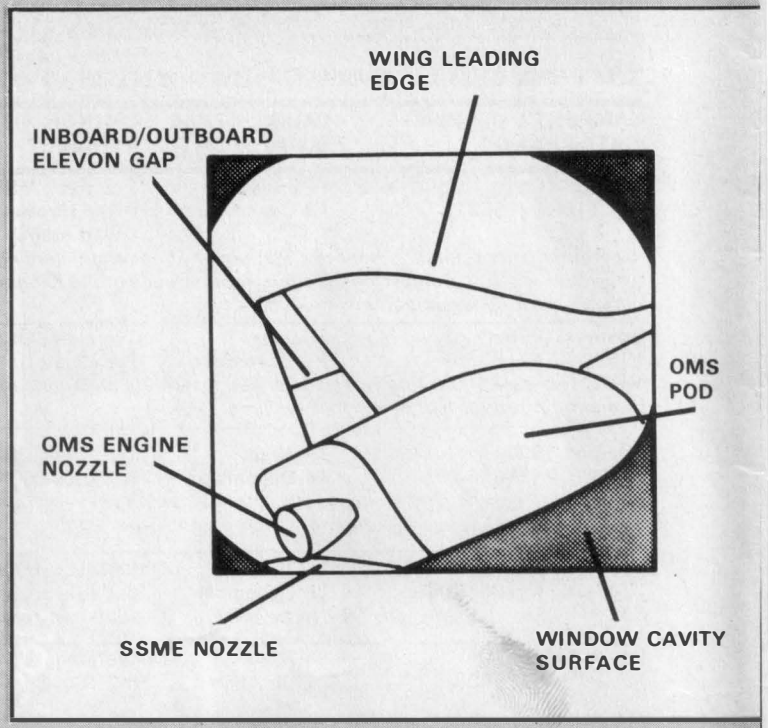
LEFT: NASA Langley's David Throckmorton explained the SILTS system to **SPACEFLIGHT NEWS.**

RIGHT: The black-and-white diagram helps clarify the detail in the actual color image captured during re-entry by the infrared 'eye' as it peers through the oblique-pointing window atop Columbia's *tailfin. We see the extreme heat levels (represented by the white coloring in this computer-enhanced picture) being experienced by the leading edge of the port wing. Also, a vicious dagger of heat is finding its way through the narrow gap between the inboard and outboard elevon control surfaces on the wing trailing edge.*



BOTTOM RIGHT: View witnessed through the forward-facing window by the 'eye' some 11 seconds later. As the diagram shows, our vantage point is from the same position atop the Orbiter's tailfin, but this time we are looking straight down onto the upper fuselage and the leading edges of the wings where they join the fuselage.

LEFT: Diagram showing the relative positions of infrared 'eye' system hardware aboard Columbia.



INFRARED EYE!

Think of how much you could learn about the performance of the Shuttle Orbiter's heat-resisting tiles if you could look down on them with an infrared 'eye' during the searingly-hot re-entry sequence! As Nigel Macknight explains here, that's just what NASA did – and they came up with these startling shots. . .

When *Columbia* blasted away from Kennedy Space Center's Pad 39A on 12 January 1986 for what turned out to be the last full Shuttle mission (61-C) for a very long time, she carried a host of sensors to measure the flight conditions she encountered, thereby assisting future reusable spacecraft design studies.

Atop *Columbia's* tall tailfin was a particularly intriguing sensor package called SILTS (an abbreviation for Shuttle Infrared Leeside Temperature Sensing experiment), and to learn more about it *SPACEFLIGHT NEWS* spoke soon after the 61-C mission ended with David Throckmorton, Assistant Head of the Aerothermodynamics Branch of NASA's Langley Research Center in Hampton, Virginia.

But this is where our plans to run an article on the SILTS experiment and its results in the spring of 1986 ran up against a brick wall. The problem was two-fold; first, Throckmorton (who, with co-investigator Vince Zoby, is SILTS program 'mainman') called to explain that his team had discovered a hardware malfunction within the SILTS experiment, making interpretation of its data extremely difficult and time-consuming.

Second, it was suggested by a higher authority that public release of color-enhanced infrared images derived from that data might present what are termed 'technology-transfer' problems; the leaking of commercially-valuable information to foreign nations.

So it was that *SFN* began a two-year waiting game, eager to publish the pictures and the story behind them, but frustrated by technical and political constraints.

Then, in December, the long wait came to an end. NASA, having solved its data-interpretation problems, released two SILTS infrared images, both of which appear on the opposite page with accompanying diagrams. The images have not been released in their fullest form for reasons of commercial proprietary, and the remainder will stay under wraps.

So just what does SILTS do?

Imagine if you could somehow stand on top of the Shuttle Orbiter's tailfin during re-entry, viewing the play of heating effects across the upper (leeside) surfaces of the vehicle as it comes down. Measurements taken from such a vantage point could provide detailed temperature-profile 'maps' of immense benefit to the designers of future winged re-entry vehicles.

This is where technology-transfer concerens come to the fore. Why should America work long and hard, and spend vast sums of money developing the world's only operational reusable spacecraft, then hand all the benefits of that effort on a silver platter to her competitors overseas?

Consider some of the background. Despite exhaustive computer-simulation exercises, there were large uncertainties in the Shuttle designers' understanding of the heating processes which would take place over the Orbiter surfaces during re-entry. After all, such flight conditions could not be duplicated in wind-tunnels and test chambers here on Earth, and advanced computational techniques capable of creating such an environment artificially were simply not available in those days.

As a result of their uncertainties, the Shuttle's designers added more thermal protection material than was probably required. With human lives at stake, it was only proper to err on the side of safety. There is a significant penalty, however, because carrying additional thermal protection means having less weightlifting capacity left for payloads.

Larger reusable spacecraft of the future might potentially incur an even greater penalty, because they will carry a correspondingly greater weight of thermal protection materials. Therefore, although it was too late to do anything about the existing Shuttle design, NASA determined that the next-generation shuttlecraft which might ultimately replace the current one would benefit from an improved understanding of the dynamics of re-entry vehicle hypersonic heating profiles.

An opportunity to make such an advance in knowledge came with the original idea for the SILTS concept by Langley's James Dunavant some 13 years ago.

The fruit of Dunavant's inspired thinking is the present SILTS configuration, in which the top section of *Columbia's* vertical tail has been replaced with a 20-inch-diameter Rockwell International-built pod housing an infrared camera and some associated control equipment. The camera's field-of-view is 40 degrees which, by way of comparison, equates the SILTS infrared 'eye' with a camera of the type you may have at home, fitted with a wide-angle lens.

SILTS's camera can rotate to look through either of the two 2½-inch-diameter infrared-transparent 'windows' set into the dome-shaped forward end of the pod; one forward-facing, the other oblique. One window looks straight down toward the fuselage and the leading edges of the Orbiter's wings at the point where they meet the fuselage. The base of the tailfin is also visible through this window.

The other window, being set at an angle to the Orbiter fuselage centerline, permits most of the port wing and the port Orbital Manouvering System (OMS) pod to be viewed.

A constant supply of nitrogen gas at room-temperature flows across the windows during re-entry to provide an insulative cushion from the onslaught of extreme temperatures caused by the friction between the Orbiter and the surrounding atmosphere. If this was not done, the sensitive infrared

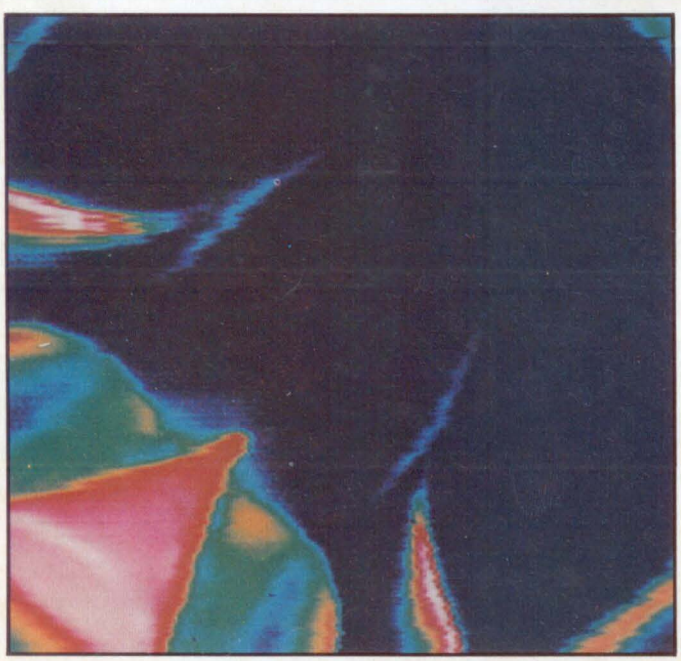
Close-up shot of the forward section of the SILTS pod atop Columbia's *tail-fin, the leading edge of which can be seen disappearing into the lower left-hand corner of the picture. The white circle to the left is the forward-facing window of the infrared 'eye', which looks straight down onto the upper fuselage. The circle to the right is its oblique-looking counterpart, which scans out across the port wing.*

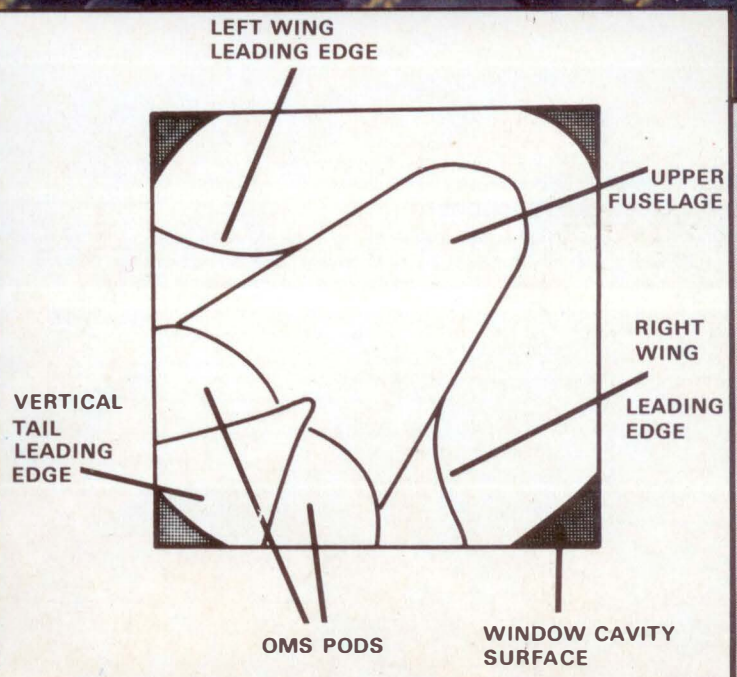
'eye' would only see the windows themselves, rather than what lies beyond them.

On Shuttle mission 61-C, the only operational use of SILTS thus far, the infrared 'eye' came into action at an altitude of 400,000 feet, when *Columbia* (travelling at 16,700 mph) issued an automatic computer command to eject thermal-protection plugs off the two tail-mounted window ports. At that point, the infrared camera started operating, alternately viewing the port wing and then the fuselage every eleven seconds until the Orbiter had dropped to a height of about 80,000 feet and slowed to a speed of about 1,500 mph.

In this 20-minute period of operation, over 110 pairs of infrared images were captured and stored on the on-board OEX (Orbiter Experiments) tape-recorder for subsequent processing and analysis.

We are priviledged indeed to view one set here, and hope that we might learn more about the benefits reaped by the SILTS experiment when it flies on *Columbia's* next mission, STS-28 in February 1989.





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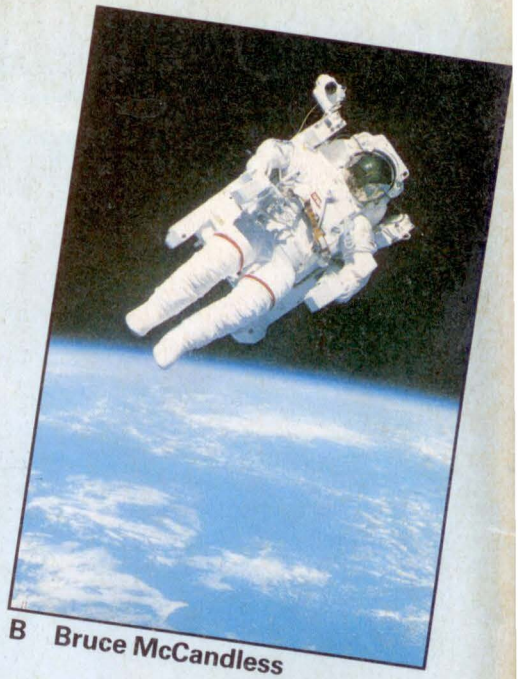
A Challenger



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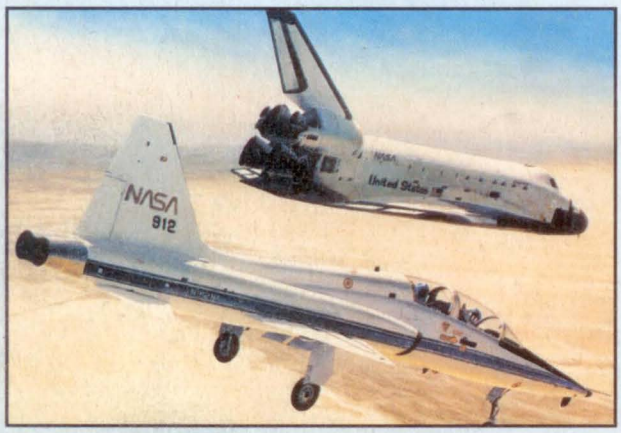
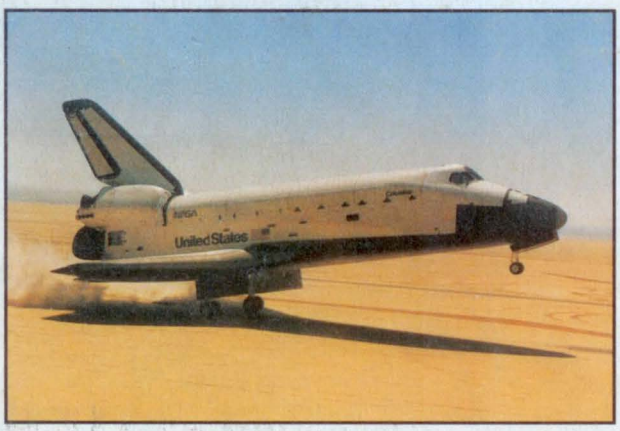
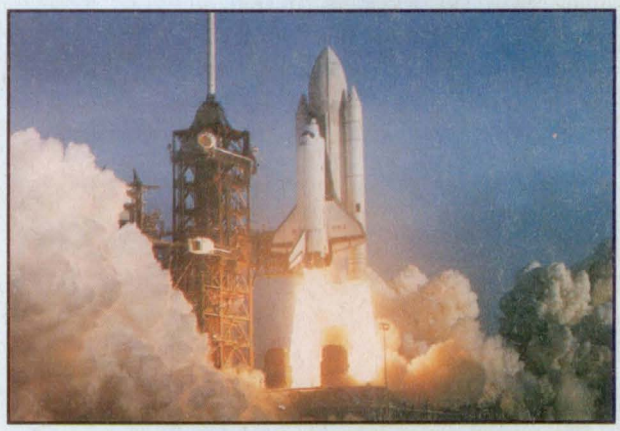


C Columbia & T38

D Enterprise and SCA



E Columbia touchdown



F Columbia launch

KEY TO POSTERS

(A) Shuttle Orbiter *Challenger* thundering skywards from Kennedy Space Center's Pad 39A carrying Space Laboratory 51-F, July 29th 1985.

(B) NASA astronaut Bruce McCandless tries out the MMU (Manned Manoeuvering Unit) for the first time during Shuttle Mission 41B in February 1984.

(C) Space Shuttle *Columbia* descends towards Edwards Air Force Base California at the end of its maiden flight accompanied by a NASA T38 chase plane.

(D) Space Shuttle Orbiter *Enterprise* atop NASA's Boeing 747 SCA (Shuttle Carrier Aircraft)

(E) Astronauts John Young (Commander) and Robert Crippen (Pilot) land America's first Space Shuttle STS-1 *Columbia*, Edwards Air Force Base, California, April 14th 1981.

(F) STS-1, the first Space Shuttle blasts off from Pad 39A, Kennedy Space Center Florida, April 12th 1981.

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