spaceflight

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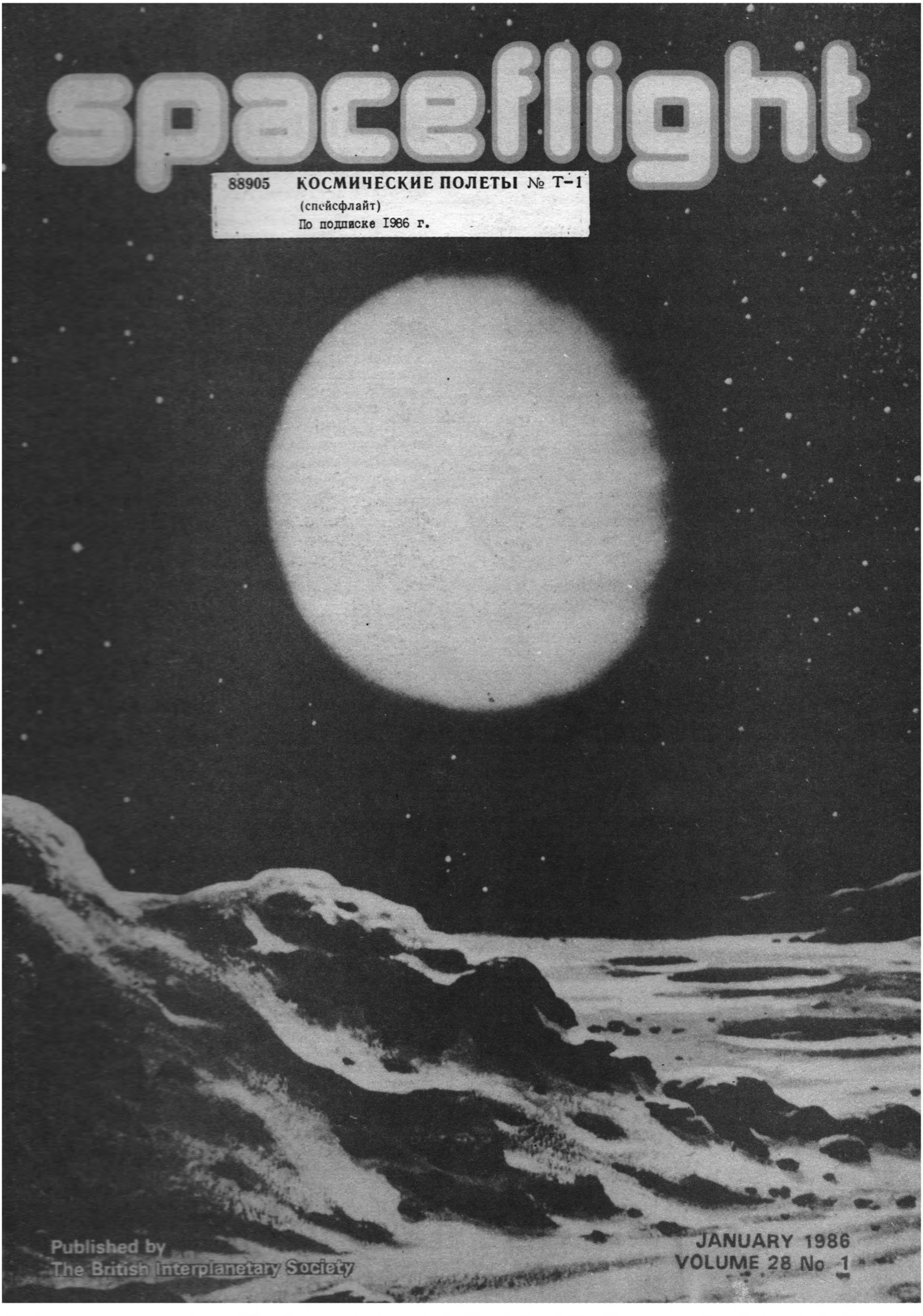

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JANUARY 1986
VOLUME 28 No 1

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This well-illustrated volume will make fascinating reading for any astronomy enthusiast. It begins by capturing the flavour of ancient astronomy with a consideration of historical supernovae and then goes on to divulge a wealth of scientific information on supernovae, pulsars and nucleosynthesis in an entertaining and non-technical way.

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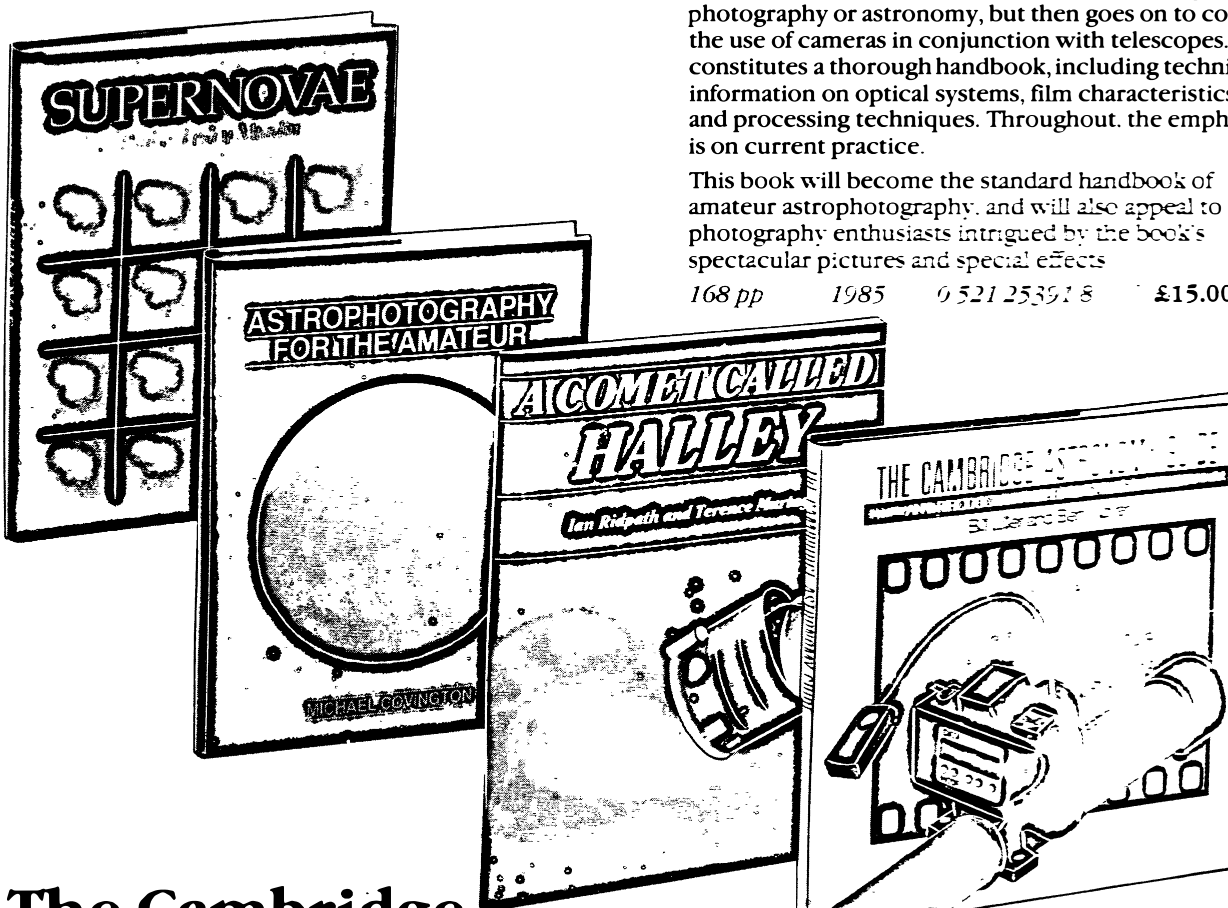
168 pp *1985* *0 521 25391 8* **£15.00 net**



The Cambridge Astronomy Guide

An Introduction to Practical Astronomy

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176 pp. *1985* *0 521 25778 6* **£13.95 net**

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48 pp. *1985*
0 521 31282 5 **Paperback £2.95 net**

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spaceflight

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COVER

Neptune as seen from Triton, a painting by B.S.Fellow David Hardy. *© D.A. Hardy*

BETTER LATE THAN NEVER

The UK Government's move to set up the British National Space Centre, announced on November 20, is to be wholeheartedly welcomed. The Society advocated the need for an Authority to oversee UK Space policy and management in a Special Memorandum to the Government in 1972 and has since repeatedly urged such a course of action. Other voices have joined the call, including that of a Parliamentary Select Committee and the Royal Society. The case for such a move has always been overwhelming.

US space programmes have abundantly demonstrated the need for high-level planning, management, organisation and decision-making in order to realise the potentialities of the Space enterprise: an Authority is needed with ready access to the pinnacle of political power.

In 1958, the NASA was formally brought into being by the US Government and for over 25 years has championed US Space endeavours. In France, the realities of the situation were rapidly grasped leading to the establishment of CNES in 1961. Both NASA and CNES have continued to develop expanding roles as new Space horizons have appeared and new frontiers been reached. They have sponsored the development of new technologies, new areas of science and new applications bringing expansion to industry, particularly their aerospace and computer industries, and in turn benefits to their nations through the effective employment of national resources and skills.

In the UK, Space has been the Cinderella of diverse government Departments each dominated by primarily 'non-space' interests. A little support may have been provided here and there only to be dropped the next time round. Good ideas have readily gone by the board and promising Space initiatives have been started and then petered out in a climate of decreasing interest and lack of political will.

A case in point is the UK 'Black Arrow' satellite launch vehicle which was allocated to the scrap heap on successfully launching its first satellite into orbit. Regrettably, we have seen the spending of a not inconsiderable budget, now running at £100m per annum, with relatively little to show in the way of permanent space achievement and the will to capitalise on it.

The present situation cannot be changed overnight but a start has been made. The newly-appointed Director-General of the British National Space Centre, Roy Gibson, brings with him a wealth of experience from his former position as Director-General of the European Space Agency and a good measure of personal vitality and realism. We wish him every success in his new Office, recognising that much needs to be done and that many complex administrative and technical decisions lie ahead.

The UK now has the opportunity to put its house in order in regard to Space, so that nationally it is fit and equipped to move into the international Space arena with attractive and saleable products. Lost opportunities cannot be regained, but the future is there to be won. The present time is a particularly auspicious one for Space with the US Space Shuttle at operational status, the Space Station programme underway and new advanced ideas, such as HOTOL on the table if not on the drawing board. Opportunities are there to be grasped. Better late than never.

NEW BRITISH SPACE INITIATIVE

The new British National Space Centre is getting down to the business of coordinating the UK's hitherto fragmented space effort. *Clive Simpson* reports on the latest developments.

Mr. Gibson was one of the principal architects of the European Space Agency and became the first Director-General on its inception in 1975.

He was responsible for the management of space programmes amounting to £500m a year and since leaving ESA in 1980 has been a consultant and director of several British and multi-national space companies.

Mr. Gibson is a Fellow of the British Interplanetary Society.

Staff at the UK's new National Space Centre are working on a long term space strategy for the country following the recent appointment of its first Director-General, Mr. Roy Gibson.

Based in London, he will have the help of 30 civil servants to develop the country's first ever coordinated space policy over the coming months.

The British National Space Centre (BNSC) is seen as a counterpart to similar agencies in Germany and France which have already achieved a high degree of success in establishing a sound industrial and policy-making base for their respective countries.

Mr. Gibson, a former head of the European Space Agency (ESA), described his appointment as "a great privilege" and agreed that one of his first tasks would involve drawing up a coordinated space plan for the UK.

"I am convinced that for the amount of money we spend and for the number of people in this country involved in space we can have more impact than we do," he said.

Confirming the appointment of Mr. Gibson in London on November 20, the Minister of Industry and Information Technology, Mr. Geoffrey Pattie, described it as "a very important time" for space, both on the European scene and for the space industry in Britain.

He said the space centre was needed to bring into focus Britain's space activities which were previously the responsibility of separate government departments.

"It is a clear recognition in Government circles of space as a leading-edge technology generator and is an exciting area for Britain to be involved in."

Mr. Pattie cited the need to develop a longer term space strategy, taking into account the needs of industry, science and other civil and defence users of space.

"In Britain, as elsewhere, we have a growing range of such users. As they have become more aware of the benefits offered to them by space it is important to establish a focus to which they can turn for advice and technical support. They will be able to influence the programme of the space centre by making their own financial and in-kind contributions.

"The gains we look for include a better balance between technology 'push' and user 'pull'. The centre will also facilitate the development of joint programmes in areas such as space infrastructure, of interest to the entire space community in Britain," stated Mr. Pattie.

Currently Britain spends £100m a year on space activities, £80m of which goes to ESA. The remaining £20m is channelled through various government departments to the scientific world. But with further ESA participation in the American-led international Space Station programme now likely the BNSC will be looking for a substantial funding increase over the next few years.

Space centre staff are already working on the development of a British space plan to take the country into the 1990's and will be drawing on experts at the Royal Aircraft Establishment, Farnborough, and SERC's Rutherford Appleton Laboratory near Oxford.

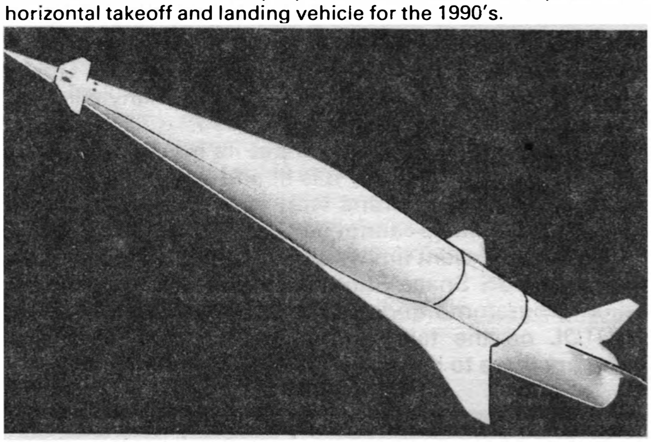
In addition, Mr. Pattie is hoping for a significant input from companies throughout the country which are involved in all aspects of the aerospace business.

One programme which Mr. Gibson and his team will soon have to consider is the proposal from British Aerospace for a horizontal takeoff and landing vehicle, known as HOTOL. Mr. Pattie said discussions were currently taking place with British Aerospace and these were about to address the "proof of concept" stage.

Headquarters for the BNSC will initially be in Millbank, London, and the 30 staff there will be interacting with others at various scientific establishments and with the three major government departments involved – the departments of Transport and Industry, Education and Science, and the Ministry of Defence.

Plans for a national space centre were first announced by the Government in January 1985 after ministers decided there was a need to improve the UK's development of space technology and coordinate policy more effectively.

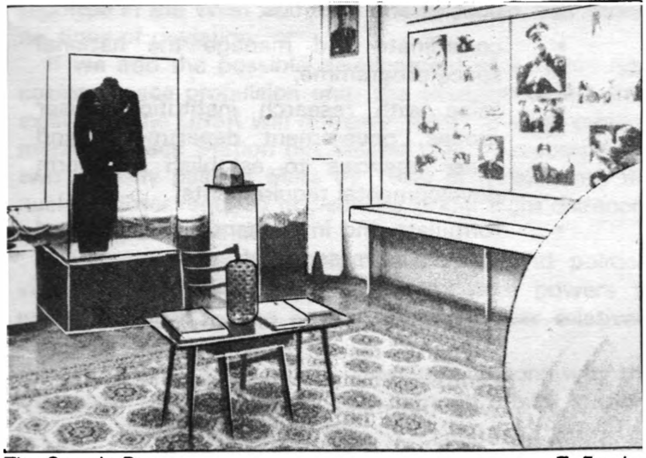
A model of HOTOL, the proposal from British Aerospace for a horizontal takeoff and landing vehicle for the 1990's.



The Gagarin Museum

Sir, My visit to the Gagarin Cosmonaut Training Centre (May *Spaceflight*, p.196) provided a chance to tour the Space Museum in the public area of Star City, dedicated to Yuri Gagarin. About 90,000 people visit it every year and almost 750,000 people have done so since it was opened in November 1967.

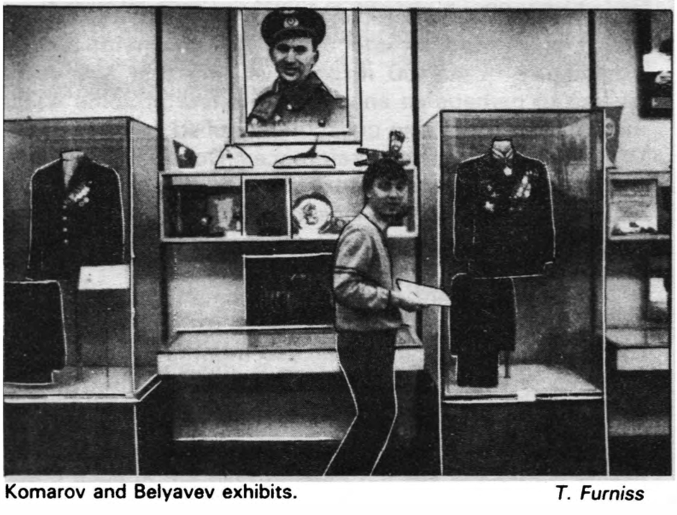
There is an intimate atmosphere in the 'Gagarin Room.' His uniform is adorned with his many medals and awards. Memorabilia include personal documents found at the crash site [the cosmonaut was killed in a 'plane crash in March 1965 -*Ed*] including a photo of Korolev from Gagarin's wallet. There is a small box of soil from where the aircraft came down and photographs of his birthplace.



The Gagarin Room. *T. Furniss*

Another room contains gifts and souvenirs from all the Intercosmos flights; newspapers, badges, flags, stamps, signatures and Salyut items such as notes, memos and food packages. Included are the uniforms of Komarov and Belayev and many of their personal belongings. The flight suits of the Dobrovolsky crew can also be seen. There are watches, medals, a photographic gallery of all the cosmonauts, first day covers, the letters delivered to Soyuz 4 by Soyuz 5 and flight pens. Many items are gifts from the US astronauts, including a tribute from Armstrong and Aldrin, Borman's Apollo 8 watch, Carpenter's Sealab watch, a plaque that went to the Moon, Apollo-Soyuz documents and some books.

Nearby is a faithful reconstruction of Gagarin's office. On his desk are drafts of a speech he was writing, invitations and letters. The diary is opened at 27 March 1968. On the wall there is a photo of his birthplace, Smolensk, taken on the day that he flew into space. In the wardrobe is his military overcoat and cap. The bookshelf is packed with documents. The clock on the wall has been stopped at 10.31 a.m., the time of his death. Before they leave for the cosmodrome, cosmonauts visit his office, which they call their first launch site.



Komarov and Belyavev exhibits. *T. Furniss*

The final museum room contains the first Vostok simulator, spacesuits worn by Gagarin, Titov and Tereshkova, Leonov's EVA suit, the Soyuz 4/5 EVA suits and Romaneknko's Soyuz suit. The Soyuz 4 capsule is here, as are the ASTP docking collar and the drogue 'chute from Soyuz 37. ASTP memorabilia include Leonov's suit and badges, some gloves and space food. There are also photographs from each mission.

TIM FURNISS
Epsom, Surrey

Not Mars?

Sir, I was concerned by the emphasis on a manned Mars exploration mission in the medium term as discussed in the November 1985 issue of *Spaceflight*. It is reminiscent of the Apollo missions which, though technically brilliant, provoked reaction against the huge expenditure for a minumum return. The space programme is often viewed as an expensive toy rather than an investment in the future of humanity. If a space station/transportation system had been attempted *before* Apollo then the expense might have been less and a permanent base built on the Moon, rather than having a few men spend a few days there. It is not enough for space to be exhilarating: we must have rewards and plan for the long term.

It is *much* more important to get a strong presence on the Moon than a man on Mars. It is said that a manned Mars expedition would give an opportunity for international cooperation and that we should go to Mars because 'people want something to look forward to.' We can do both of these on the Moon and get two advantages:

1. a return on capital for Earth now, and
2. a foundation for future missions to build on.

Future deep space expeditions to the asteroids and Jupiter would have similar promise for long term colonisation, by getting materials from the asteroids and water and helium-3 from the Jupiter system. We must avoid thinking of Mars as the prime option when there are many investments that need to be done first. We need the vision of the enthusiast to be combined with a degree of pragmatism to avoid extravagance.

JOHN PAHL
Canterbury, Kent

The 'Soviet' Vegas

Sir, I wish to point out that the Vega craft carry a number of instruments developed and built in countries other than the Soviet Union so they can truly be termed *international*.

MICHAEL BEÖTHY
ing. on telecommunications
Intercosmos Secretary Office
Hungarian Academy of Sciences

A Space Policy for Australia?

Sir, Following the first Australian National Space Symposium in March 1984, the Minister of Science, the Hon. Barry O. Jones invited the Australian Academy of Technological Sciences to form a Working Party to prepare a report on space science and technology for Australia. The report, entitled 'A Space Policy for Australia,' was published last June. The Working Party, chaired by Sir Russel Madigan, made 16 specific recommendations:

1. Australia should, as a matter of urgency, establish a national space policy to facilitate the achievement of an appropriate industrial, technological and scientific structure for Australia's participation in space.
2. In the communications market Australia should, in the near term, concentrate on the ground-station equipment sector.
3. The major market thrust of Australian space activities should be in the remote-sensing sector, involving both hardware and software.
4. Research institutions and educational establishments should arrange to co-ordinate and consolidate their space capabilities in order to contribute effectively to development of Australian space science and technology.
5. The Government should take the leading role in facilitating the development of Australian space science and technology capabilities through the 1980's.
6. Australia should actively pursue the possibility of international collaboration in space and, in particular, of joint space initiatives with countries in the East Asian region.
7. A major component of the national space programme should be government-funded R&D contracts placed within Australian industry.
8. The first phase of the national space programme should have the objective of achieving in industry the capability to participate in complex spacecraft either as a subcontractor or with prime-contractor responsibility for a major system.
9. The space segment of the national space programme should be directed towards development of Earth resources spacecraft equipment suitable for inclusion in other nations' spacecraft or at some future time in spacecraft of Australian origin.
10. Australia should build on its expertise in reception, image processing and analysis of remote sensing data with a view to developing significant exports of hardware, software and ground receiving equipment; and becoming a regional centre for provision of processed data and images, and for training in remote-sensing techniques.
11. The Government should ensure a continuing Australian capability to receive the latest types of Earth observation satellite data and, in particular, should allocate funds at the earliest opportunity to upgrading the Australian Landsat station
12. Space science should be a continuing component of the annual budget for the national space programme.
13. Australia should participate in international space science and applications programmes relevant to Australia's requirements as a means of being involved in state-of-the-art developments.
14. The Government should accept a commitment over the next five years of up to A$100m to finance participation in a number of space projects in which Australia would have a significant design and construction responsibility, and associated basic research, general administrative costs and appropriate support facilities.
15. An independent Statutory Authority, with its own board of Management, should be created to:
    - advise the Government on space R&D policies and priorities;
    - co-ordinate and manage the national space programme;
    - liaise with research institutions, user groups, government departments and other agencies to establish long-term developmental requirements;
    - formulate and implement a co-ordinated and cohesive series of space projects in accordance with the national space policy;
    - place government-funded contracts in industry, research establishments and centres of higher education; and interface with the major overseas space organisations.
16. The national space programme should be reviewed at the end of the fourth year of operation.

The 194 page report is divided into chapters that provide justifications for the above recommendations. More than half of the volume is devoted to appendices with titles such as:

Overseas Space Activities
Current Australian involvement in Space Activities
Future Australian Operational requirements for Space Technology
Review of Australian Industrial Structure and Capabilities in Space-related Industries
Evaluation Methods for Large-Scale R&D programmes
Alternative Organizations Considered.

The next milestone will be dependent on the Australian government and parliament. As the Working Party pointed out, Australia has the technological and industrial potential. It can afford an effective programme with a total expenditure of A$100 million over the first five years leading to perhaps an annual expenditure of some A$60 million. There was one question identified as beyond the Working Party's terms of reference: 'Does Australia have the intellectual capacity to accept that this must be a national effort, all Australians making a contribution?' The politicians are obliged to answer this most fundamental concern.

An announcement on the establishment of an 'Australian Space Technology and Research Authority (ASTRA)' can be expected within the next six months if the Working Party recommendations for a July 1986 hand-over are accepted.

J. SVED
Stevenage, Herts

Soviet Space Station Designs?

Sir, We do not know the extent of knowledge gained from the Soviet Salyut programme but it is clear that the increasingly long periods of time spent in space have culminated in a new (238 day) record for Salyut 7, thus paving the way for yet further extensions to a year or more. Even if this is not possible with Salyut 7, it might be done with Salyut 8 when that is orbited, possibly around 1986-88. By that time the Soviets may have also achieved other goals e.g. orbiting a large Saturn type booster or a manned shuttle.

These underline a long-considered Soviet intent to carry out a full manned space programme *viz* not only to *put* men in space but *keep* them there, i.e. to set up a *permanent* station. This intent has been frequently reported in the West and, over a long period, has shown no signs of deviation.

If we add the possible development of a Nerva-type nuclear space propulsion unit, the situation would then exist that the USSR will not only have a large orbiting manned Space Station but will be able to accomplish a two man fly past of Mars by 1990 or 1992, with the nuclear motor required to clear the longer flight distances pertaining at those dates.

This would amount both to technical and political victories that would be hard for Western powers to match. The US Space Station would appear relatively mundane in comparison.

Thinking over such points underlines reasons why the UK should press for a full-scale manned orbital station, pertinent factors emerging are:

1. Until such a station is built, we cannot establish its uses nor explore its future potential, though it will clearly provide a stepping stone to many new experiments and to manned flight to the nearer planets.
2. Even if the USA and Europe do not embark on such a programme the USSR seems set on such a course. Salyut 8 could easily be a logical step in this. If large enough, it is likely that the USSR will invite other Communist country cosmonauts to take part in long term space experiments - longer in duration than are possible with the Shuttle.

In retrospect, it seems a shame that both the Skylab and the Nerva and Little Nerva nuclear programmes were abandoned just as they were showing signs of success.

If may be that the West is already a long way behind in the Space Station race. Participation by Europe as a whole and particularly by the UK would provide an extremely valuable boost.

A.T. LAWTON

Where is Everyone?

Sir, Articles in the *JBIS* and *Spaceflight* over the past few years have frequently raised the question: 'If there is intelligent life out there, where are they?' Many possible answers have been presented. Most of these, including some contributed by myself, have attempted to explore a possible motivation of alien life either in traversing space or sending messages: I exclude those articles that beg the question by 'proving' that there is no extraterrestrial life. I have in the past pointed out the dangerous fallacy in assuming that aliens will have motivations similar to our own. Reflecting on this, I feel that we might have missed an opportunity in failing to analyse our *own* motivation in wanting to explore space, so I was pleased to note in recent issues of *JBIS* contributions by sociologists and members of related sciences to this question.

The reason for this letter is to encourage us to examine ourselves and our own motivations, on the assumption that they may represent typical reactions of an intelligent species when faced with the prospect of interstellar flight or communication. What drives us and why are we interested? Conversely, what is standing in the way of our immediately starting work on development of probes with interstellar capability? If we can come up with at least partial answers to these questions, we may begin to understand the position of at least that part of the assumed interstellar community who are most like ourselves.

Such an examination might lead us to some hard facts that I suspect would not be pleasing to the majority of humanity; perhaps this is why this subject is so undeveloped. We may not be in a position to develop Isaac Asimov's 'Psychohistory' but we certainly have the statistical and logical tools to derive a few empirical rules about human behaviour! Perhaps this has already been done and I am not aware of it. If so, let's hear from some of the experts!

Some of the items might lead us to a better understanding relative to the inventive process, but it should also include references to those much-berated individuals who take an invention or process and drive it through political systems, laissez-faire and all forms of opposition to make it a practical reality. What is the cause of this drive and how can it be nurtured? Conversely, what is it that makes most of us instinctively feel that a new idea 'won't work,' or actively oppose it? What makes a bureaucrat tick and what distinguishes a good one from a bad one?

Many of us who work in the scientific field realise that, in order to get something done, simply having an idea that will work is a very small part of the whole picture. We have to be able to present it favourably, enlist the aid of bureaucrats, politicians and entrepreneurs with access to money, and drive it through all sorts of institutional obstacles before we even get the chance to prove that the idea is a good one. Is this a particularly human system or does it exist elsewhere?

Knowing the answers would have two benefits. It would allow us to assess more accurately how many civilizations there are in our Galaxy who are actively looking for contact; and it would provide proponents of space flight with a set of rules for most rapidly advancing human endeavours in the direction of active interstellar exploration.

Most advances, I've heard it said, are achieved by less than 10% of the population, the remainder being 'sheep,' content to follow. I've seen nothing to disprove this notion and much in its support.

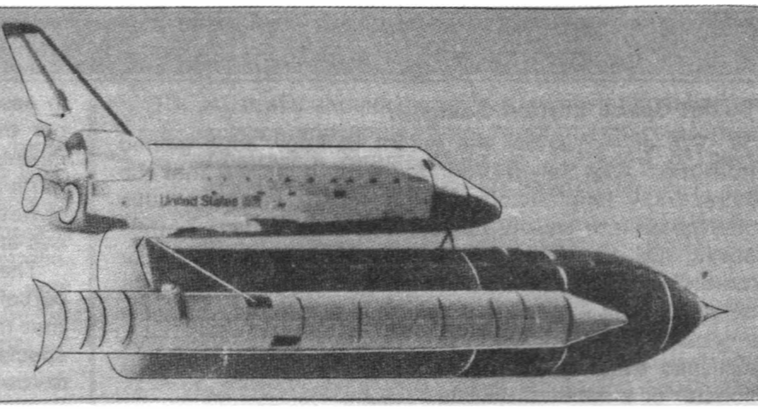
What makes us want to explore space anyway and how do we best go about getting it done?

DR. PETER MOLTON
Washington, USA

The Editor is always interested in receiving items of correspondence, notes, comments, or similar material for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SPACE REPORT

A monthly review of space news and events



COMMUNICATIONS

INMARSAT TAKES TO THE AIR

Trials of a satellite communications system for aircraft—which may eventually lead to passenger telephone services—could begin later this year.

Inmarsat, the organisation which provides communication facilities for maritime and offshore applications, has announced significant steps in the new venture.

It has offered free capacity in its geostationary satellite system to the International Civil Aviation Organisation for tests and demonstrations of possible aeronautical satellite communications services and equipment.

Changes have been made to the international agreements under which Inmarsat operates to enable it to provide aeronautical services alongside those already used by the maritime and offshore industries.

Inmarsat will use trials to assess various aeronautical satellite concepts before committing a future satellite system.

An "initial system description" has already been made available to key organisations in the aeronautical community to support the discussions and for comments.

The document describes a possible aeronautical satellite communications system, providing both voice and data communications and using general purpose communications channels between aircraft and ground. The aeronautical community would be able to allocate different priorities for, and thus accord different treatment to, various types of messages ensuring urgent treatment of high priority messages.

During 1986 Inmarsat expects to have a number of prototype voice and data aeronautical satellite communications terminals available to interested airlines in a cooperative pre-operational trials programme to prove the system concepts and develop new applications, in particular passenger telephone and airline operational communications.

MEXICO SATELLITE AID

The chaos following Mexico City's devastating earthquake last September could have been far worse without the services of a communications satellite developed 18 years ago. NASA's ATS 3, located at 105° W longitude, through its control centre at Malabar in Florida, provided critical communications support for the international rescue and relief efforts of the American Red Cross and the Pan American World Health Organization.

The voice communications link with the outside world was crucial since the earthquake disrupted all other forms of communications in Mexico City. The capital would have been cut off but for the communications capability of ATS 3.

In a direct radio communication from Mexico City, George Manno, director of media relations for the Red Cross, said at the time: "the ATS 3 satellite is providing us with the most critical communications link to the rest of the world. We rely primarily on the ATS as our main communications vehicle." According to Dr. Claude DeVille, of the Pan American World Health Organization: "the ATS 3 satellite is extremely useful in any emergency situation such as the disaster that took place in Mexico."

COMMUNICATIONS TRENDS

Satellites will come increasingly into the orbit of Third World countries by the end of this decade, as more than 300 small Earth stations will be built in a $3,500 million spree to equip underdeveloped Asian, African and Latin American states with modern telecommunications.

Advances in satellite technology such as frequency re-use, on-board switching, special antennae to shape transmission beams and higher power levels have promoted the use of smaller and cheaper Earth stations, which is boosting the satellite market to a "distinct improvement on growth rates in previous payloads" by making hook-ups affordable to states of limited resources. A second factor is the widening practice of satellite system operators to lease transponder capacity to these nations.

Spending on satellite communications by the lesser-developed countries worldwide will reach almost $3,500 million in aggregate between 1985 and 1990, on average a real growth of nine per cent a year in the market. In constant 1984 dollars, the annual market will rise from $566 million in 1985 to a peak of $664 million in 1986, with a decline after the 1986-88 period to $545 million by 1990.

PROBING A THUNDERSTORM

A coordinated series of rocketborne experiments was conducted from NASA's Wallops Flight Facility on 9 September 1985 to study the effects of lightning in the Earth's troposphere. The simultaneous measurements were made from three rocket payloads in the air at different altitudes. Coordinated measurements were also made from a series of ground-based instruments designed to detect the location and characteristics of lightning.

A meteorological data sonde on a small rocket was also launched after the three-rocket series to determine the meteorological characteristics in the upper atmosphere near the time of the other measurements.

The three sounding rockets were launched over a period of about two minutes. A single-stage Orion was followed 70 seconds later by a two-stage Taurus-Orion, with a Nike-Orion after a further 57 seconds.

NEW 'SPACEHAB' MODULES

There is currently a backlog of several hundred funded NASA experiments that cannot fly aboard the Shuttle because of the lack of middeck locker space. This backlog is nearly doubling each year.

As the Space Station programme moves into hardware development and construction during phase C/D, which is scheduled to begin in 1987, NASA's Office of Space Station will require on-orbit testbeds in which to test automated systems, such as liquid transfer under micro-gravity conditions.

Now, the Spacehab company will build a module to fit in the Shuttle cargo bay just behind the crew cabin, accessed *via* the airlock, for astronauts to carry out and monitor many more experiments than is presently possible.

The modules will increase the pressurised living and working space on Orbiters by approximately 28 m^3, almost doubling existing pressurised volume of the crew compartment. Spacehab modules may be configured to contain as many as 100 standard middeck lockers and still provide an additional 20 m^3 of pressurised living and working space. The basic version will rely on payload bay power sources, share environmental control/life support resources with the middeck, and have passive thermal control. The first configuration will provide middeck augmentation for storage and experiments and astronaut sleep stations. Advanced versions will contain major subsystems and complex utilities, fluid loops, hard vacuum access, life support and power augmentation and active thermal control capabilities. Advanced module versions will be designed as Space Station testbeds and for use in Space Station construction, logistics and operations support.

Spacehab Incorporated will provide users with comprehensive payload services that include module volume lease, module/Orbiter integration (for full-module users), payload integration and payload mission support.

Costs for individual active and passive middeck locker accommodations, cost to lease dedicated Spacehab modules and the costs for specific Spacehab payload services will be determined during the Phase-B study, which will be completed during the first quarter of 1986.

Spacehab estimates that the cost of leasing dedicated basic modules will be about $5 million per flight. The cost of leasing the space of individual lockers for middeck type experiments will be a small fraction of the cost of leasing a dedicated module.

The plan is to have the first of the three modules ready for flight before the end of 1987, with five missions a year being possible by 1990.

HALLEY'S COMET MISSION

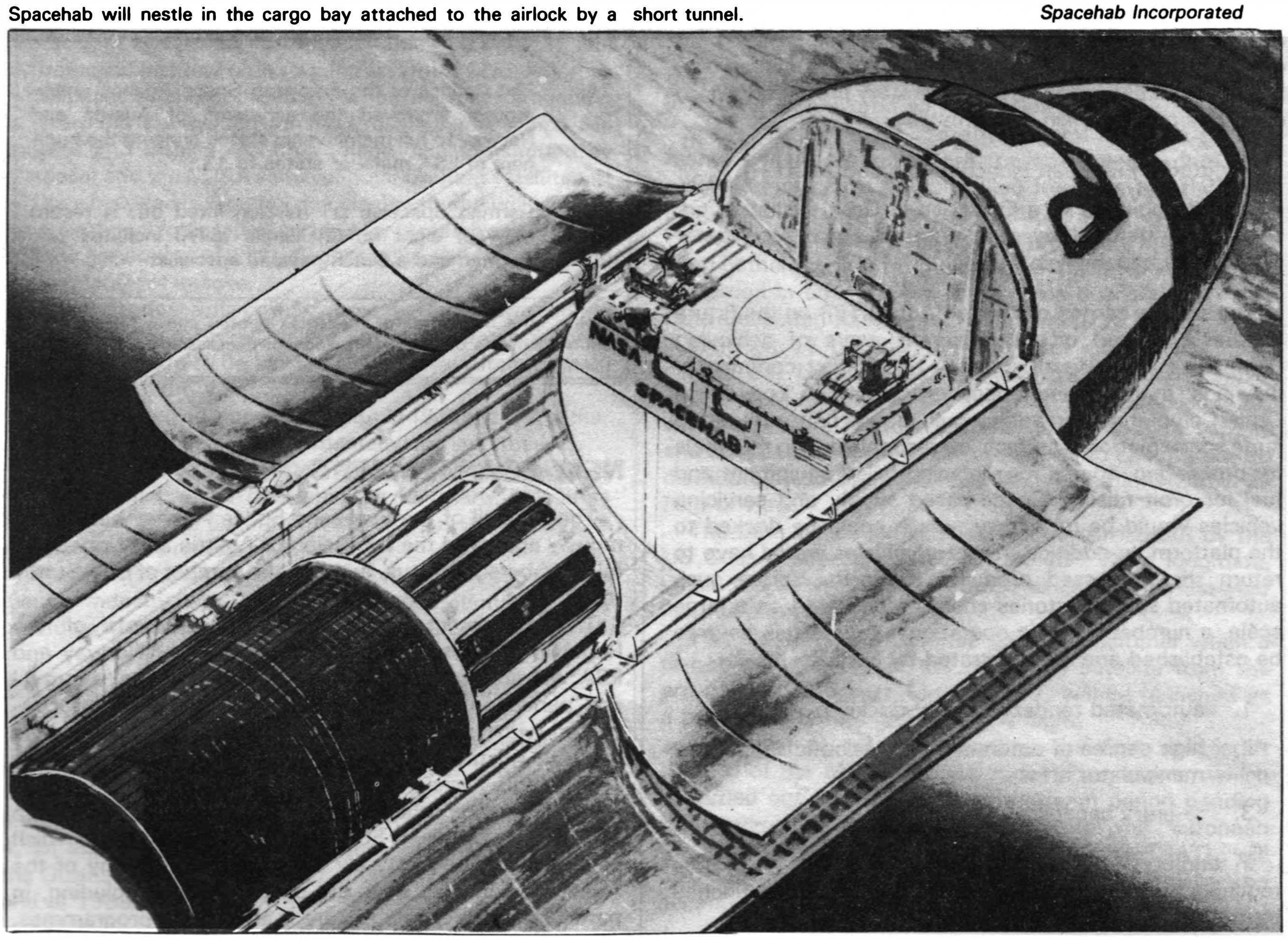
Astronomers Samuel Durance and Ronald Parise have been named as payload specialists to fly on Shuttle mission 61E in March.

Their objective will be to study Halley's comet and other celestial objects using three ultraviolet astronomical telescopes and a visible light, wide field camera.

The launch, using Columbia, is scheduled for 6 March and the seven member crew will be in orbit for eight days.

Durance is a research scientist at Johns Hopkins University, USA, and Parise is manager of advanced astronomy programs for the Computer Sciences Corporation, USA.

Spacehab will nestle in the cargo bay attached to the airlock by a short tunnel. *Spacehab Incorporated*



SOVIET SPACE AGENCY

A civilian Soviet space agency has been formed by the USSR to act as a counterpart to the American NASA and other national space agencies.

Called Glavkosmos — an acronym for the Main Administration for the Creation and Use of Space Technology for the Economy and Scientific Research — its primary function will be to manage Soviet space science, space applications and co-operative international space ventures.

WATER ON MARS

Ice, snow, flowing rivers and vast lakes could have played a major role in shaping the ancient Martian surface and climate, a panel of scientists reported in early October. According to these new ideas, a thick layer of snow might have girdled the Martian equator in the planet's early years. Melted water running from beneath this snowpack could have carved out 'rivers,' the extensive winding channels imaged originally by Mariner 9.

In addition, huge ice-covered lakes might have formed in canyons near the equator early in the planet's history. Primordial Mars might have been warm enough to support flowing rivers and lakes on its surface.

ESA'S LONG TERM PROGRAMME

To prepare for the major decisions needed for European space transportation elements of the 1990's, ESA Member States have entrusted ESA with a Long Term Preparatory Programme (LTPP). Within this, a number of industrial studies are being made to identify projected STS user requirements, performing preliminary concept definitions of candidate STS elements and providing preliminary cost estimates. This preparatory programme concentrates on two main elements:

1. future European launchers beyond Ariane 4,
2. the build-up of a European In-Orbit Infrastructure (IOI) that will eventually permit Europe to master new capabilities.

The studies carried out so far in the LTPP on the future IOI have centred on the different ways of achieving European independent capability to conduct commercial missions; in particular, space processing in Low Earth Orbit. Complete automation would require fully automated large space platforms, which are resupplied with materials for processing, spares for replacing failed equipment and fuel for orbit raising. Space-based supply and servicing vehicles would be necessary, which could be docked to the platform. In addition, re-entry vehicles would have to return the processed products to Earth. Before such automated space factories could be operated on a large scale, a number of basic operational capabilities have to be established and demonstrated by Europe:

1. automated rendezvous and docking,
2. high degree of automation and robotic support by manipulator arms,
3. re-entry capability.

In addition, periodic manned intervention would be required, performed by the crew of a spaceplane launched by the future European launcher.

MILESTONES

September 1985

21 Hughes withdrew the Leasat 5 communications satellite from the Shuttle 61C manifest in December, pending further investigations into the Leasat 3 and 4 failures.

October 1985

2 Cosmos 1686 docks with Salyut 7. It is described as a star module, similar to Cosmos 1267 and 1443.

3 Military Space Shuttle mission 51J, using the new orbiter Atlantis, established a Shuttle high-altitude record of 320 miles (515 km) shortly after launch from Kennedy Space Center.

8 The tenth Navstar global positioning system navigation satellite is orbited by an Atlas E. Future launching will be made with the Shuttle and PAM DII upper stage.

15 Japan scheduled the first launch of its large H-2 vehicle for 1992. Development costs, including the first flight, total $800 M.

16 Shuttle orbiter Challenger is rolled out to the pad for the Spacelab D1 mission.

17 ESA's first pre-operational meteorological satellite, Meteosat F1, launched in November 1977, finally ran out of hydrazine fuel and drifted away from its position in geo-stationary orbit. It had originally been designed for a three year life.

23 NASA agreed with the Californian-based Scott Science and Technology company (headed by Gemini/Apollo astronaut David Scott) to provide assistance for a new Shuttle upper stage, the Satellite Transfer Vehicle. Most of the development work is being carried out by British Aerospace.

24 The Council of the European Space Agency unanimously approved the accession of Austria and Norway to full membership status bringing the numbers of ESA member states to 13.

30 German Spacelab D1 mission lifted off. A record crew of eight on Challenger (61A) included two German and a Dutch payload specialist.

Please note that some of the dates quoted above refer to the announcements of the events and not necessarily to the events themselves.

NEW ESA MEMBERS

The Council of the European Space Agency has unanimously approved the accession of Austria and Norway to full Membership status, bringing the number of ESA States to 13.

The agreement between the governments of the Republic of Austria and of the Kingdom of Norway and ESA will now be put forward for governmental approval and parliamentary ratification in the two countries concerned with the goal of achieving full Membership status for both Austria and Norway on 1 January 1987.

With this decision European cooperation in the space field will be strengthened. It comes after a period of close cooperation between ESA and the two countries which have, in fact, been closely associated with many of the Agency's activities over the past 20 years including, in particular, the Spacelab, Marecs and ERS-1 programmes.

HERMES COMPETITORS JOIN FORCES

France's two main aerospace companies — Aerospatiale and Dassault-Breguet — will jointly develop the country's Hermes manned mini-shuttle.

In a dual contract award Aerospatiale has been given the prime contractor role and Dassault-Breguet named delegate prime contractor with responsibility for aerodynamic design.

CNES, the French national space agency will retain authority as overall prime contractor and eventually hopes to share production with other countries agreeing to help finance the programme.

Ideally it would like Hermes adopted as a programme of the European Space Agency, within the framework of plans which also include the Ariane 5 launcher and the Columbus manned space station.

UK DATA SYSTEM FOR SWEDEN

A British firm is developing a meteorological satellite data processing system for the Swedish Meteorological and Hydrological Institute under a contract worth £225,000.

Software Sciences, based at Farnborough in Hampshire, is designing the system for the Prosat project which will process and display real-time image data transmitted by Meteosat and the NOAA series of polar orbiting satellites.

Once installed in Sweden one display station will be used for operational forecasting and one for research applications and the generation of a library of satellite scenes to assist in interpretation of images.

In another deal Software Sciences has been awarded the Project Definition Study for the Earth Resources Satellite (ERS) Data Centre to be located at the Royal Aircraft Establishment, Farnborough.

ERS 1 is due to be launched by ESA in 1989 and will gather data on the oceans and, experimentally, the land masses.

National centres, being established to collect and process the data, will provide data analysis for many industries including shipping, fishing, forestry and oil exploration, as well as scientific reseaarach.

The UK ERS Data Centre is being funded by the Department of Industry and is expected to be operational by 1989, providing a service to industry and nations around the world.

ARIANESPACE LAUNCH CONTRACT

Arianespace and Inmarsat have signed a contract for the launch of the Inmarsat 2 F2 satellite in 1988.

Built by British Aerospace as prime contractor, it weighs around 1140 kg and will be put into orbit by an Ariane 4, an improved version of the European launcher, from the Guiana Space Center, Kourou, French Guiana, by the end of 1988.

Inmarsat, the 44 member country maritime satellite organisation, provides communication facilities for maritime, offshore and other mobile applications.

This order increases the total launch service contracts obtained by Arianespace to 35 satellites, out of which 23 remain to be launched for a value of about 6.5 billions French francs (or about $600 million dollars).

ARIANE READY TO GO

Europe's Ariane launcher should be back in operation in January with the launch of Ariane V16 from the Kourou site in French Guiana.

Missions were halted last year after the failure of an Ariane third stage on September 12 — the rocket was carrying a dual satellite payload both of which were destroyed.

Recommendations by an official inquiry have now been acted on and Arianespace — the commercial operator of Ariane — has announced the resumption of launch operations.

Mission V16, an Ariane 1 rocket carrying the French Earth observation satellite Spot and the first Swedish satellite, Viking, is scheduled for launch on January 11.

Ariane V17, due for launch on February 14, will be the first vehicle to use the new launch pad, ELA 2, at French Guiana. This version, an Ariane 3, will be carrying telecommunications satellites for the American GTE Spacenet Corporation and for Brazil.

Intelsat V is currently scheduled for launch during the second half of March 1986 on mission V18 and in addition Arianespace has plans for five further launches during the remainder of 1986.

MISSION ACCOMPLISHED

ESA's first pre-operational meteorological satellite Meteosat F1, launched in November 1977, has finally run out of hydrazine fuel and drifted away from its position in geostationary orbit to the extent that it is no longer "visible" from the Michelstadt (Federal Republic of Germany) ground station where the spacecraft's data was received, nor can it be controlled from the nearby European Space Operations Centre (ESOC).

Meteosat F1, designed for a three-year lifetime, has been gathering data from platforms which are either fixed or carried in balloons, on ships or on-board aircraft (the Data Collection Mission) over the last eight years.

As from 11 October the Meteosat mission has been carried out by Meteosat F2 (launched in June 1981) which, from its orbit at 0° longitude above the equator, will continue to produce pictures of the Earth's surface and cloud cover in the visible and infrared spectra and to distribute these images to user ground stations within its field of view.

The Data Collection Mission will be carried out by the US Goes-4 spacecraft, located at 43° West longitude, which has been "lent" to Europe since May of last year for this purpose.

This situation will continue until this summer when a re-furbished version of the prototype satellite from the pre-operational series, Meteosat P2, will be launched as a passenger on the first Ariane 4 flight.

According to present planning, the first spacecraft (MOP1) of the Meteosat Operational Programme, which is carried out by ESA during the interim period pending the ratification of the Convention of the European Meteorological Satellite Organisation (EUMETSAT), will be launched in summer 1987, to be followed by the second and third units respectively in 1988 and 1990.

TOWARDS NEPTUNE

By C.E. Kohlhase, R.V. Frampton and J.W. Gerschultz

A new chapter in the remarkable journey of Voyager 2 is about to be written during the forthcoming flyby of Uranus and in three years' time with an encounter of Neptune.

Introduction

The interplanetary exploration of Voyager 2 has already been the journey of a lifetime, stretching the imagination by an order of magnitude and providing valuable information about the two largest planets of the Solar System, Jupiter and Saturn.

Unlike its sister craft, Voyager 1, which is now heading towards the edge of the Solar System, Voyager 2 is on course for two further planetary encounters before it, too, follows a trajectory that will take it into the depths of space.

Voyager 2 will flyby Uranus in late January and, although its instruments were not optimised for encounters with planets beyond Saturn, impressive pictures and data on the system are expected.

Likewise, three years later, in 1989, the spacecraft will set another remarkable 'first' with an encounter of distant Neptune.

This article provides an insight into the Voyager 2 spacecraft and examines these exciting mission encounters.

Approaching Uranus

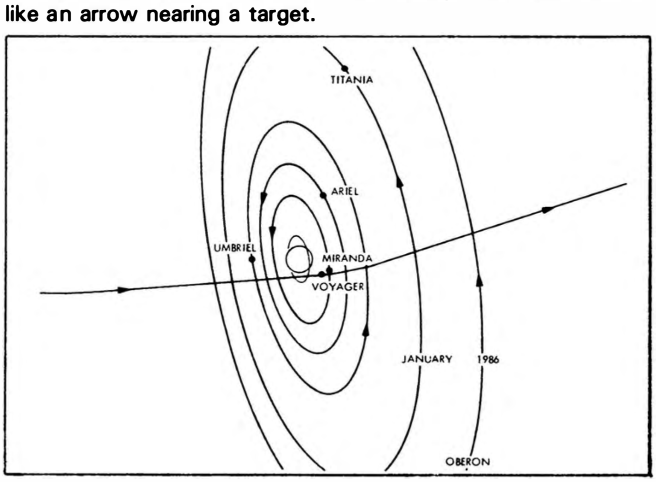
Relative to an observer on Uranus, the Voyager 2 spacecraft is approaching from approximately the same direction as the Sun appears in the sky, at a speed of about 53,000 km/hr.

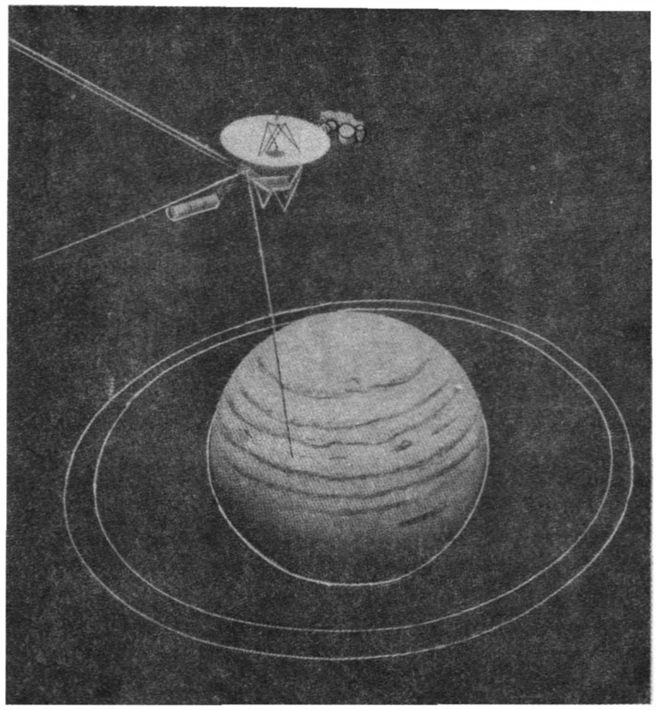
Uranus itself is orbiting the Sun at a mean distance of 19 Astronomical Units (1 AU = Earth-Sun distance) and, although travelling at some 24,000 km/hr, it still takes 84 years to complete just one orbit.

By the Uranus closest approach time of 18:00 GMT on 22 January 1986, Voyager 2 will have travelled more than 33 AU along its heliocentric path since leaving the Earth more than eight years ago.

Relative to an observer on the spacecraft, the Uranian system, with its five known satellites and nine known rings, resembles an enormous bulls-eye target almost 1,200,000 km across. This expanse is over three times the Earth-Moon distance.

Uranus is tilted on its axis, so that Voyager will approach it like an arrow nearing a target.





An artist's impression of Uranus encounter.

Uranus itself is truly a giant planet, with a diameter of 52,500 km, compared to the Earth's 12,700 km, representing a diametric ratio of four to one and a volumetric ratio of 69 times that of the Earth.

It is significant to note that the path of Voyager 2 must pass slightly within the orbit of Miranda, a Uranian moon, in order for Uranus to provide the proper gravitational deflection to continue on to Neptune. The exact encounter timing of 18:00 GMT was selected to optimise the geometry for Miranda coverage using image motion compensation.

At the time of closest approach radio signals will take 165 minutes to reach Earth, meaning that data transmitted at the time of closest encounter will not be seen until 20:45 GMT.

Fifty five minutes prior to the Uranus closest approach, Voyager will pass Miranda at a range of 29,000 km.

Spacecraft Instrumentation

The basic structure of the spacecraft, called the bus, is decagonal (ten sided) and the whole vehicle is designed to roll about its axis of symmetry, known as the z-axis, by firing hydrazine jets. Normally the spacecraft is aligned so that the z-axis points at the Earth.

Each of the ten sides of the bus (numbered clockwise 1-10) houses various electronic assemblies. For example, Bay One contains the radio transmitters.

To give the spacecraft full manoeuvrability, two further turn axes are incorporated into the basic design: x-axis (pitch) and y-axis (yaw).

Most spacecraft have small, steerable antenna dishes attached to the spacecraft bus but Voyager is different. It could be said that the spacecraft bus sits on the High Gain Antenna (HGA). The reason is that to establish acceptable communications between itself and the Earth over such vast distances the antenna must be very large, in this case 12 ft.

A high degree of accuracy is also required because the antenna focuses the radio energy into a concentrated, narrow beam. It operates at only half power after deviating by as little as 0.5 degrees off axis for the X-band frequency and 2.3 degrees for the S-band.

The X-band frequency, 8.4 GHz is used for the

transmission of science and engineering telemetry data at rates varying from 4.8 to 21.6 kilobits per second. The S-band channel is configured to contain only engineering data on the health and state of the spacecraft at the low rate of 40 bits per second.

Attitude Control

Voyager 2 is three-axis stabilised, controlled by an onboard computer known as the Attitude and Articulation Control Subsystem (AACS). It also controls movement of the scan platform.

Voyager has two ways of maintaining its attitude: by gyro control and by celestial control. Gyro control is used for special purposes and short periods (up to several hours at a time).

In celestial control mode, Voyager maintains its fixed attitude in space by viewing the Sun and a bright star. Should it drift from its proper orientation by more than a certain angle (known as the deadband), the AACS will issue commands to fire the tiny thrusters and bring it back on line.

Instruments used to track the Sun and star are the Sun Sensor, mounted on the HGA, and the Canopus Star Tracker, so named because Canopus is usually the preferred star in the sky because of its brightness.

On occasions during planetary encounter, when Canopus might be obscured by the spacecraft bus or the planet itself, an alternative in the opposite side of the sky is used.

To accomplish this, a Stellar Reference Change manoeuvre is carried out, thus meaning it is possible to maintain the spacecraft in the most favourable attitude at all times for photography and the gathering of data.

Scan Platform

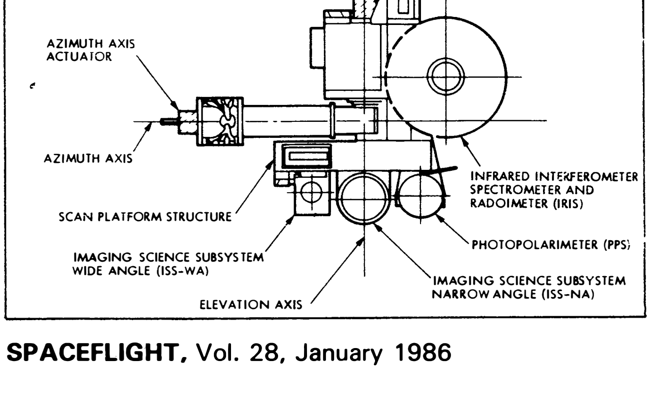
The scan platform is one of several appendages attached to the bus and it is here that most of the science instruments are located, including those that need to be pointed at the target body.

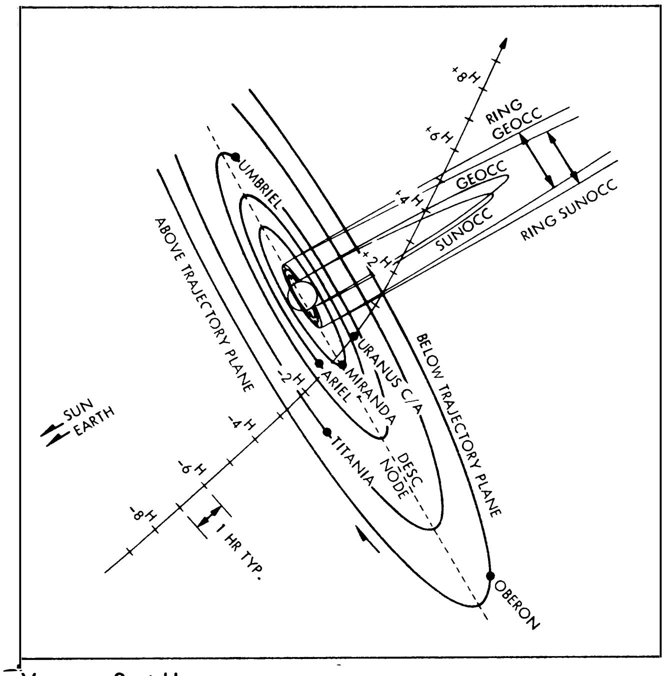
A long boom is used because of the advantage this gives the instruments in being able to look backwards at the planet or moon in question immediately after the closest encounter. The platform itself has motors and gears (called actuators) that slew it to point in various directions.

Almost 100 minutes after the Voyager 2 closest approach of Saturn in 1981, the azimuth motion of the scan platform unexpectedly halted, causing the loss of valuable science data from instruments that required pointing.

The seizure was due to the heavy use of the high-rate slews, causing a vital lubricant to migrate away from a tiny shaft-gear interface (spinning at 170 rpm), which then expanded slightly with the additional heat, finally leading to a seizure. Attempts to resume normal scan platform operation took two days.

The scan platform.





Voyager 2 at Uranus.

As a result, the faster slews will not be used during the Uranus encounter and a contingency near-encounter sequence has been prepared just in case prior testing indicates the likelihood of the scan platform motion sticking again.

Spacecraft Power

Spacecraft electrical power is supplied by three Radioisotope Thermoelectric Generators (RTG) which are miniature nuclear power plants, converting about 7,000 watts of heat into some 400 watts of electricity. These lie along the RTG boom, away from the spacecraft bus and opposite the scan platform.

At launch the power output from the RTGs was 475 watts and this has decreased by about seven watts per year, due mainly to the half-life of the fissionable plutonium dioxide and degradation of the silicon-germanium thermocouples.

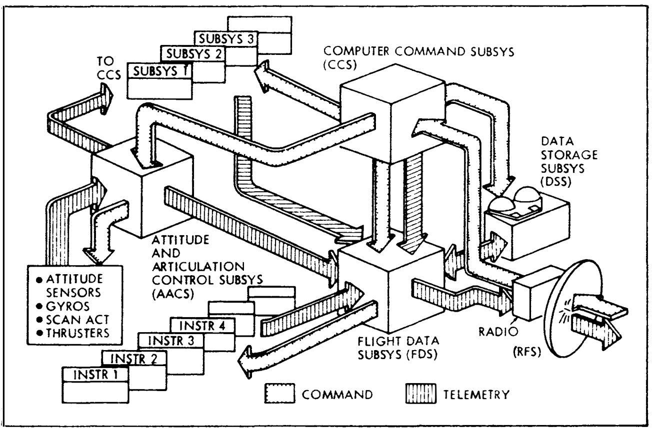
Power output for the previous two planetary encounters was 448 watts for Jupiter and 429 watts for Saturn, with an expected 398 watts for Uranus and projected 372 watts for Neptune.

The power requirements are constrained to be less than the RTG output and excess power is dissipated through the shunt regulator as heat. The difference between the available power and that used is known as the 'power margin' and since there is substantially less available for the Uranus encounter great care has been taken in planning a power management strategy.

For example, the S-band high power state cannot be used regularly and several other key power loads have to be turned off at some risk to use the S-band high-power state for the Earth Occultation Experiment.

On occasions when Voyager cannot immediately send science telemetry data to Earth, such as during a manoeuvre when the HGA is not pointed at Earth or during a time of occultation, the Digital Tape Recorder (DTR) is available to store the data for later playback to Earth.

However, data management is still a demanding task because it is important to get data played back as quickly as possible so the tape recorder can be filled again – and this must be balanced against the interface caused with science gathering.



Voyager's three computer subsystems.

The Computer Command Subsystem

The CCS, consisting of two identical computer processors, their software algorithms and some associated electronic hardware, is the central controller of the spacecraft. It has two main functions: to carry out instructions from the ground to operate the spacecraft, perform housekeeping functions and to gather science data; and to be alert for a problem with or malfunction of any of the subsystems and to respond to it.

The latter of these functions is carried out by a series of software routines called Failure Protection Algorithms (FPAs), which occupy approximately ten per cent of the CCS memory and make the spacecraft semi-autonomous and able to act quickly to protect itself.

Its other function, storing and processing commands from Earth, allows the spacecraft to act as an intelligent robot to carry out its science gathering functions in strict accordance with the carefully developed mission plan.

Science Instruments

There are 11 science instruments on Voyager 2 and all but four are located on the scan platform or its supporting boom. Of these four, the Magnetometer uses its own boom; the Planetary Radio Astronomy (PRA) experiment shares the 'rabbit ear' antennae with the Plasma Wave Subsystem (PWS) and the Radio Science Subsystem (RSS) uses the radio beams from the HGA.

Four instruments on the scan platform require accurate pointing: the Imaging Science Subsystem (ISS) wide and narrow-angle cameras, the Ultraviolet Spectrometer (IRIS) and the Photopolarimeter Subsystem (PPS).

The remaining three instruments on the scan platform boom, all fields and particles experiments, are the Cosmic Ray Subsystem (CRS), the Low Energy Charged Particle (LECP) experiment and the Plasma Subsystem (PLS).

All of these experiments, except for the RSS, send their observational data to the Flight Data Subsystem (FDS) for formatting into telemetry.

To Neptune and Beyond

The Voyager 2 encounter with Neptune during August 1989 will be the fourth and last swingby on this epic grand tour of the four giant outer planets. It will be a fitting occasion to celebrate the 12th anniversary of its launch.

To ensure that Voyager 2 will be able to complete its final planetary tour at Neptune, mission planning for the 'Voyager Neptune Interstellar Mission (VNIM)' started several months ago.

It was necessary to allocate critical spacecraft resources jointly for both the Uranus and Neptune encounters. Fortuitously, there appear to be adequate consumables to accomplish this task with little penalty extracted at either encounter, although some operational design margins (such as power) will be slim by earlier standards.

Other spacecraft performance limits that become critical are telecommunications (because of the greatly increased range to Earth) and imaging smear – because of the very long exposure time required with light levels 900 times fainter than those on Earth. Talking with the spacecraft will become more of an operational burden as well, because of the 8.2 hour two-way communication time.

Neptune, some 30 AU from the Sun, is truly at the outskirts of the Solar System, taking 165 years to complete a single orbit.

Despite being the fourth largest planet in the Solar System it is invisible to the naked eye and was discovered in 1846 based upon mathematical calculations of Uranus' orbit perturbations.

Triton, Neptune's largest moon and comparable in size to our own Moon, was discovered only days after the planet itself, but even with today's powerful telescopes little new information has been obtained, except for recent observations of partial rings just inside three Neptune radii from the planet centre.

Neptune should appear as a slightly oblate bluish-green ball with a diameter of 48,600 km, or nearly four times that of the Earth. Because of its largely gaseous nature, the mass is only 17 times that of Earth and its polar axis has only a moderate tilt of 28 degrees. It is estimated that the rotation rate of the outer atmosphere is about 18 hours.

Neptune and Triton Encounter Planning

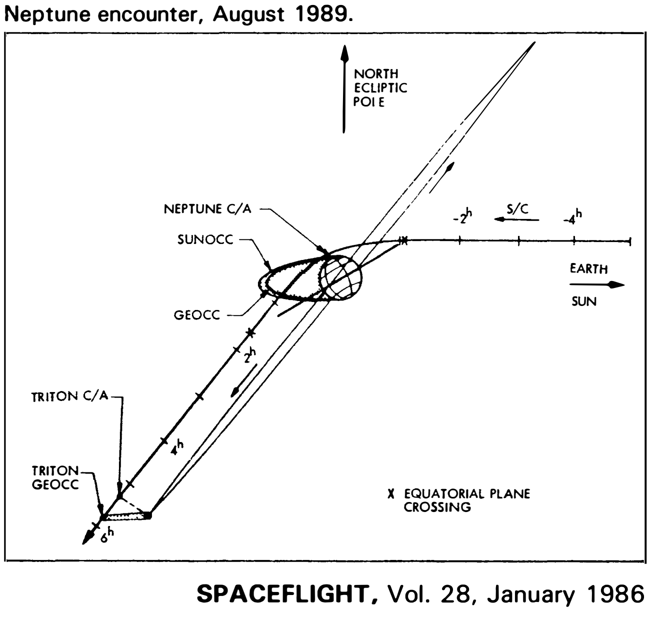
Without the availability of a gravity-assist corridor to continue to Pluto, a large number of trajectory options were studied in order to assess the relative science value of spacecraft observations made from each potential Neptune flyby mission.

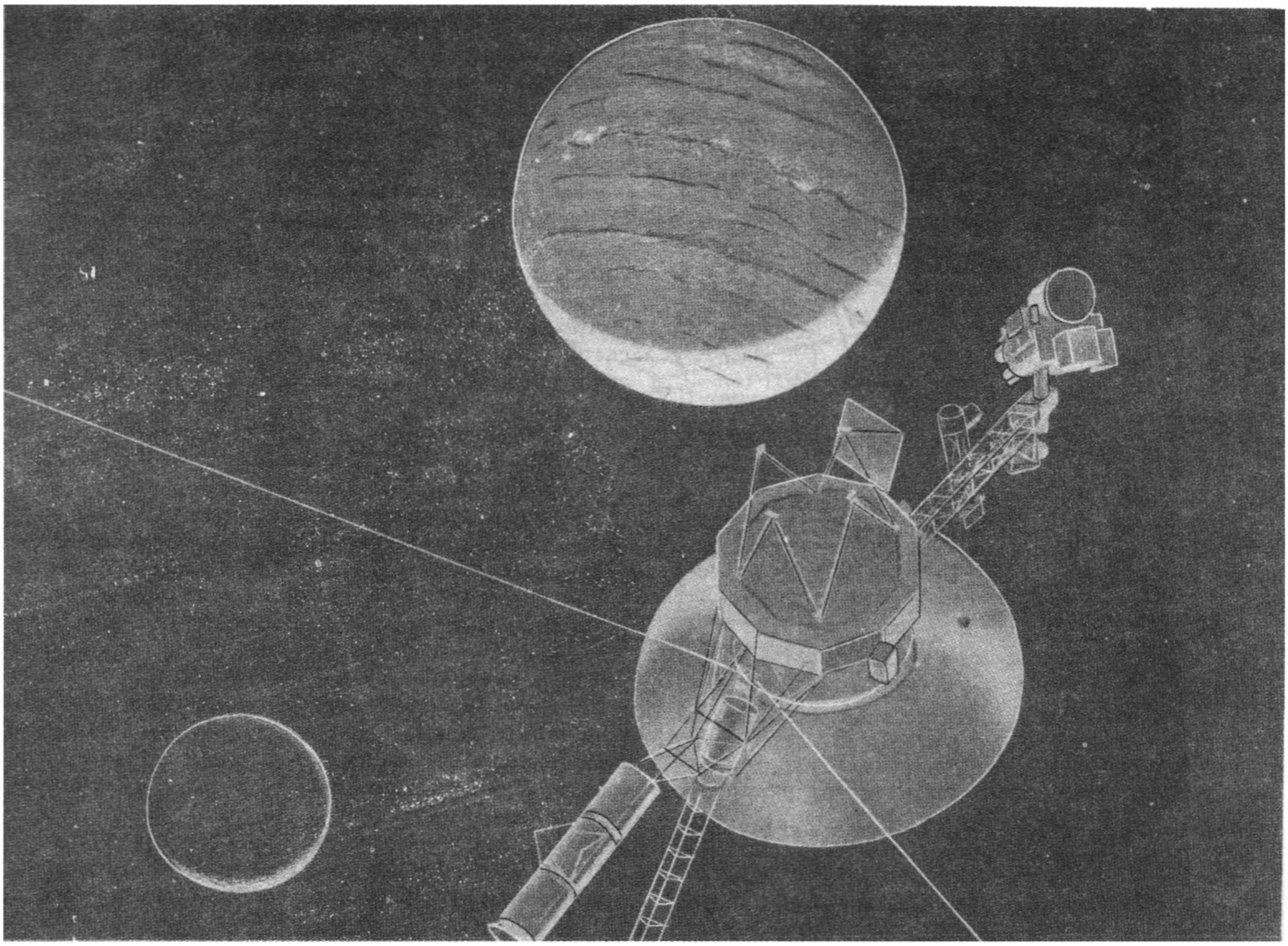
In the end, after months of debate, scientists agreed that a dual close encounter with both Neptune and Triton would be most desirable, especially since the satellite geometry would permit a reasonably good Earth occultation at Triton.

The resulting trajectory involves a special spacecraft velocity-change manoeuvre, just after the Uranus encounter, that will advance the arrival of Voyager 2 at Neptune in order to allow for proper phasing with Triton.

If all goes as planned, the spacecraft will skim over the north pole of Neptune a mere 1,300 km above the gaseous surface on 24 August 1989. The gravitational force of

Neptune encounter, August 1989.





An artist s impression of Neptune encounter.

Neptune will cause Voyager to veer sharply downwards, through both Earth and solar occultation regions by Neptune and out towards the orbit of Triton. About five hours and ten minutes after the Neptune closest approach Voyager 2 will pass within about 8,200 km of Triton's surface.

Although Triton may have a thin atmosphere of methane and nitrogen, the surface is expected to be visible to Voyager's cameras, allowing detection of surface features, including possible oceans of liquid nitrogen that have been suggested by some Earth-based observations.

Shortly after Triton closest approach, the spacecraft will pass behind the satellite to create the Earth occultation so highly valued by radio science investigators. This occulation will provide information about Triton's thin atmosphere as well as an accurate measurement of the large moon's diameter.

Post-Neptune Cruise Science

Following exploration of the Neptune system, the spacecraft will have completed an unprecedented series of encounters with the four giant outer planets and will have gathered valuable interplanetary information in addition.

At the conclusion of the VNIM on 31 December 1989, Voyager 1 will be at approximately 40 AU and 33 degrees north ecliptic latitude and Voyager 2 will be at approximately 31 AU and slightly south of the ecliptic plane. Both will continue to escape from the Solar System toward the solar apex and communications could be maintained as long as they continue to function. Logically, an extended mission should be conducted in anticipation of penetrating the boundary between the solar wind and the interstellar medium, allowing measurements to be made of the interstellar fields and particles unmodulated by the solar plasma.

It is expected that both Voyager 2, and its predecessor, Voyager 1, will remain alive for many years to come unless some unexpected failure were to occur.

Thanks to advance planning, there is no immediate concern about limited onboard resources, and the Voyagers (together with the Pioneers) will be the first spacecraft to continue their voyages into the outer reaches of the Solar System, to the heliopause and beyond.

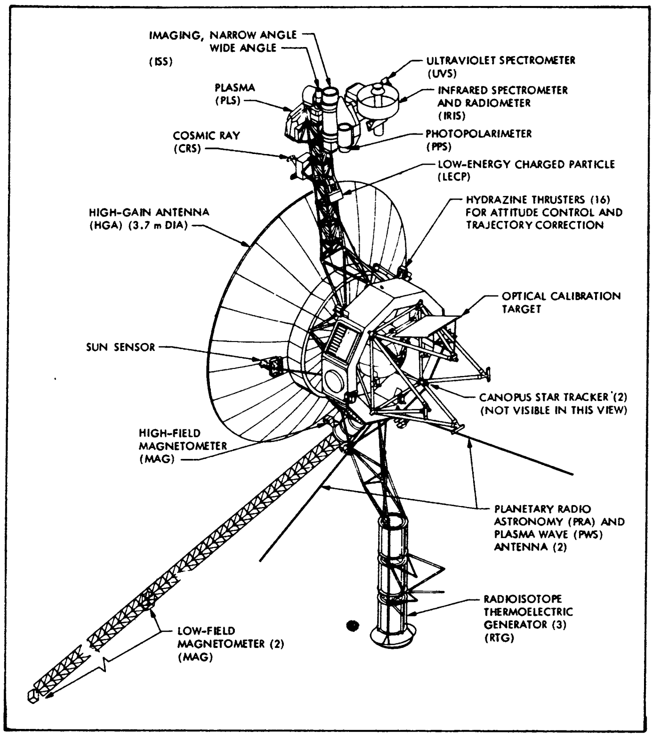
Obviously, this represents a unique opportunity to continue to extend the scientific charting of our Solar System as well as to gather new information about ultraviolet emissions from galactic sources.

With a little luck, one or perhaps even both of the Voyagers may be alive and well at the crossing of the heliopause boundary, where the interstellar medium restricts the outer flow of the solar wind and confines it within a magnetic bubble called the heliosphere.

This is a key scientific objective stated in the VNIM Project Plan. The exact location of this boundary is not known and it will most likely vary as a function of solar departure direction. However, it is believed to be located between 50 and 150 AU in the direction of travel for both Voyagers and Pioneer 11.

The Sun sensor might be the first resource limitation to occur at about 80 AU in the year 2001 for Voyager 1 and 2006 for Voyager 2, although there is an excellent chance it will continue to function well beyond 80 AU.

Thereafter, declining hydrazine reserves and/or minimal power requirements of 230 watts would be reached in about the year 2015 when the Voyager 1 and 2 spacecraft would be at heliocentric distances of 130 and 110 AU, respectively.



The Voyager spacecraft.

Typical scientific objectives to be addressed by interplanetary observations are:

1. Characterisation of the solar wind evolution with distance from the Sun (MAG, PLS, LECP, CRS).
2. Observation and characterisation of the Sun's magnetic field reversal (MAG, PLS, LECP, CRS).
3. Search for low-energy cosmic rays (CRS, LECP).
4. Characterisation of particle acceleration mechanisms in the interplanetary medium (MAG, PLS, LECP, PWS).
5. Search for evidence of interstellar hydrogen and helium and an interstellar wind (UVS, PLS).
6. Observation and characterisation of the heliospheric boundary where effects of the solar wind terminate (MAG, PLS, LECP, CRS, PWS).

In addition, interplanetary observations will be made (on a target-of-opportunity basis) to:

1. Search for radio emissions from the Sun in an environment well removed from planetary sources (PRA, PWS).
2. Search for and characterise galactic sources of extreme ultraviolet emissions (UVS).
3. Improve astrometric parallax measurements for selected stars using the substantially longer Voyager-Earth baselines (ISS).

To the Stars

The Solar System does not end at the orbit of Pluto, the ninth planet. Nor does it end at the heliopause boundary, where the solar wind can no longer continue to expand outward against the interstellar wind. It extends over a thousand times farther out where a swarm of small cometary nuclei are barely held in orbit by the Sun's feeble gravity (at that great distance).

The two Voyager robots will race past the orbit of Pluto by the end of this decade and barring random electronic failures they may even survive until several years after the turn of this century.

But even at speeds of 53,000 km/hr it will take nearly 20,000 years for the Voyagers to reach the comet swarm and by this time they will have travelled a distance of one light year, or nearly a quarter of the way to Proxima Centauri, the nearest star.

After the Voyagers have left the remote realm of comets they will make their way slowly to other star systems.

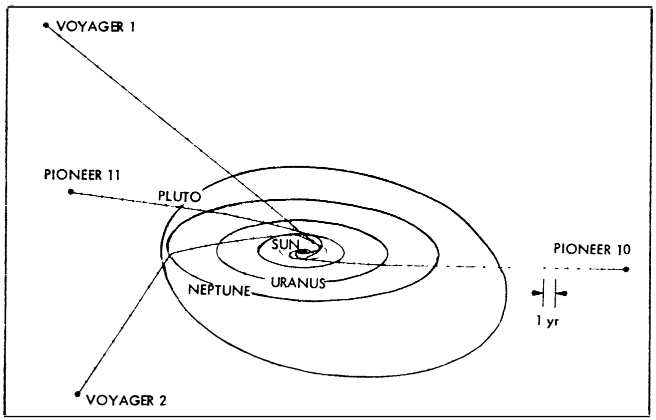
Affixed to each robot emissary from Earth is a gold-coated copper phonograph record designed by Carl Sagan and a small group of scientists and friends. The choice of a record was motivated by its ability to hold a large amount of information, and by the launching of the Voyagers during the 100th anniversary of the invention of the phonograph record by Thomas Edison.

Each record contains 118 photographs of our planet, ourselves and our civilisation; almost 90 minutes of the world's greatest music; an audio essay of special sounds; and greetings in almost 60 languages. An aluminium protective cover should ensure survival of the record for 100 million years against the occasional impacts from interplanetary and interstellar dust grains.

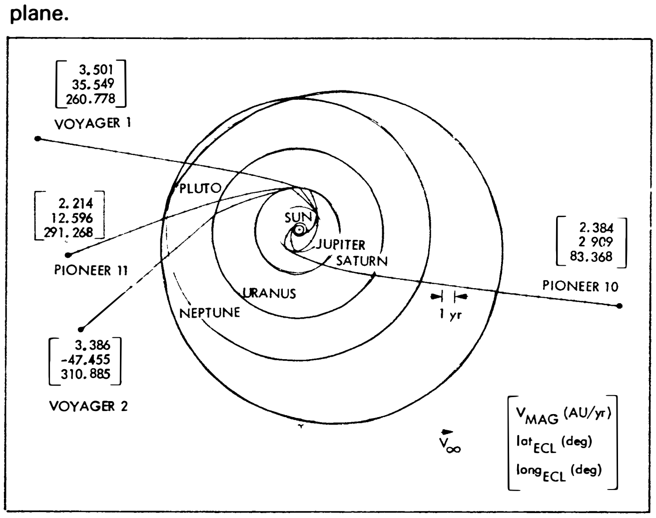
Though appealing to the human imagination, the possibility is extremely low that an extraterrestrial being will discover one of the Voyagers, rendezvous with it and play out the contents of the record. But it is still exciting to calculate the Voyager flight paths into the distant future, searching for close encounters with other star systems.

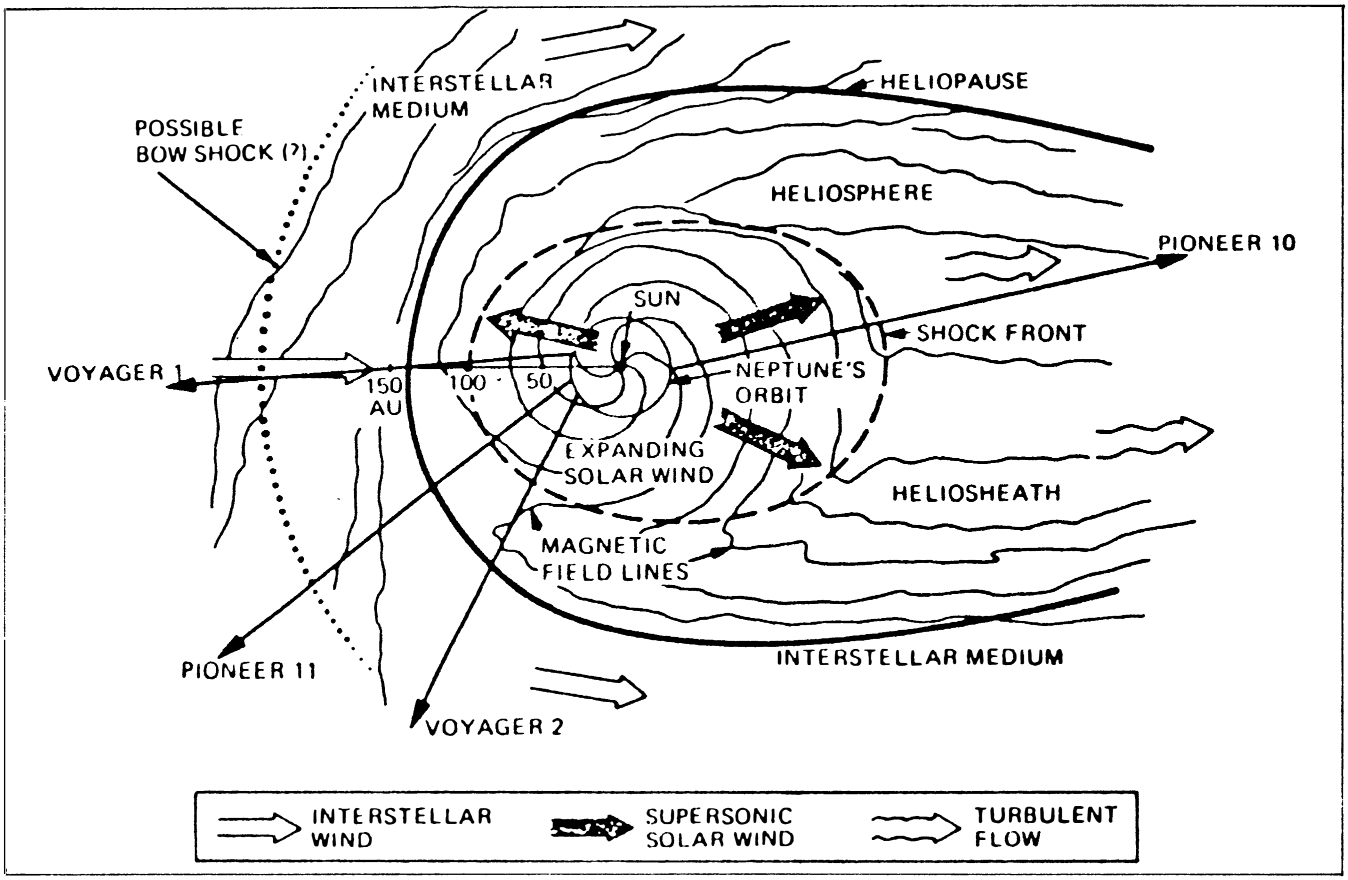
As the Voyager and Pioneer spacecraft travel out of the Solar System they will eventually attain their asymptotic

An ecliptic plane projection of the Voyager and Pioneer paths.



Gravity assist will deflect both Voyagers out of the ecliptic plane.





Departing the heliosphere.

departure directions, as seen on the sky of the current epoch.

Because the Voyager 2 flyby of Neptune will be over the north pole the departure trajectory will be deflected substantially south of the ecliptic and Earth equator, into the south polar area of the celestial sphere.

Plotting the departure trajectories against the background stars on the celestial sphere immediately suggests that, in the future (distant in human terms, close in geologic or astronomical terms), the trajectories of these four spacecraft may carry them past several other stars. Because of the slow speeds of the spacecraft (compared to the stellar distance scale) and the resulting long time intervals, and because of the space velocities of stars during this interval, it would not be expected that stars currently located in the direction of the outgoing asymptote would be the most likely candidate for stellar flybys. In order to determine if specific stellar flybys occur for these four spacecraft, it is necessary to propogate both the spacecraft positions and the star positions in order to search for future "close" encounters.

In about 40,000 years, Voyager 1 will pass within 1.6 light years of AC+79 3888, an aging star in the constellation of Camelopardus, at the boundary near Ursa Minor. Though only one third the size of our Sun, it could harbour planets. Also in 40,000 years, Voyager 2 will fly within 1.5 light years of Ross 248, a small star in the constellation of Andromeda. Radiation bursts from Ross 248 suggest unfavourable conditions for life-bearing planets.

Voyager 2 is not doomed to sail the cosmic seas in an eternal trek of absolute solitude. For, in 285,000 years, it will pass within 3.5 light years of Sirius, the brightest star other than the Sun in Earth's heavens. The dog star and its white dwarf pup, in the constellation of Canis Major, will appear as a bright beacon to the deceased robot craft.

It is evident that the Voyager spacecraft are travelling far too slowly for even a modest penetration of interstellar space within our lifetimes.

In the 21st century follow-on deep space missions will make use of new propulsion technologies, such as Nuclear Electric Propulsion, and these new spacecraft could develop Solar System exit velocities of 8-13 AU a year compared to Voyager 2's 3.4 AU/yr.

But even that is slow, so are we captive of an aging Sun that drifts about the Milky Way Galaxy at a mean distance of 1.7 x 10^{12} AU with a period of only 245 million years?

Only time will tell, but we must press forward and hope that a technological breakthrough can be achieved so that one day we can join a community of galactic civilisations.

Acknowledgements

The Voyager quest is a team effort and many people contributed to this work in a variety of ways. It is part of a larger effort originally published as JPL Document 2580, dated 15 August 1985. Regarding the original version, special thanks are in order for W. J. Kosmann, R. A. Neilson and S. H. Plagemann, who authored other sections of the document than those excerpted here; for L. F. Whyman, who provided invaluable typing and review assistance; for R. C. Dumas-Thibodeau, who prepared the artwork and layout design; to D. M. Wolff, who provided an exceptional review of the overall product, and to Clive Simpson who prepared this edited version.

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TV IN SPACE

By Michael Engle

The use of television systems in carrying out space work is becoming increasingly important. The author, an engineer at NASA's Johnson Space Center who helped to train astronauts to use the Shuttle's TV system, discusses their present value and what they might achieve in the Space Station and beyond.

Introduction

Now that the Shuttle is operational, its closed circuit television system is becoming increasingly important. Whereas, in the past, TV cameras were used mainly for public relations, people involved with the Shuttle are finding many and varied uses for the Orbiter's TV system. This trend, fuelled by advances in 'telepresence,' will become increasingly important in space, especially for Space Station operations.

The Orbiter TV System

The Orbiter closed circuit TV system consists of cameras, lens, onboard monitors, pan/tilt units, a video tape recorder and associated electronics. An Orbiter normally carries four payload bay cameras (two each on the fore and aft bulkheads), two cabin cameras, two monitors and a video tape recorder. If a remote manipulator arm is flown two more cameras are carried, on the wrist and elbow joints.

The TV camera consists of a silicon intensified target vidicon tube and a lens assembly. The image tube, combined with automatic light control circuitry, provides excellent low light level performance, with a dynamic range of about five million to one. The cameras can use any one of three lens versions:

- monochrome lens
- colour lens (a monochrome lens with a colour wheel)
- a wide angle lens, with a wide field of view and a colour wheel.

The crew can see only black and white on their monitors. The videotape recorder used by the astronauts carries a 30-minute cassette.

In training, crews are taught with a variety of simulators, using both mockups and computer-generated views. In addition, a 'Photo/TV Checklist' is carried on each flight to help the astronauts set up the TV system, achieving proper fields of view and collecting video data for payloads.

Operational Use

The Orbiter TV system was originally designed as a Class III system, i.e. it was not critical to mission safety or success. As the Shuttle became operational, however, it became increasingly important to mission success (i.e. Class II). An example is the repair of the Solar Max satellite on flight 41C in April 1984. Without the TV system, berthing and repairing the satellite would have been extremely difficult, if not impossible. The arm wrist camera proved invaluable when astronaut Terry Hart performed the complex 'rotating grapple' to capture the wobbling solar observatory.

Another example, following the failure of both Payload

Astronaut Bob Crippen works on the Shuttle during STS-7 in June 1983. Behind him is a TV camera. *NASA*

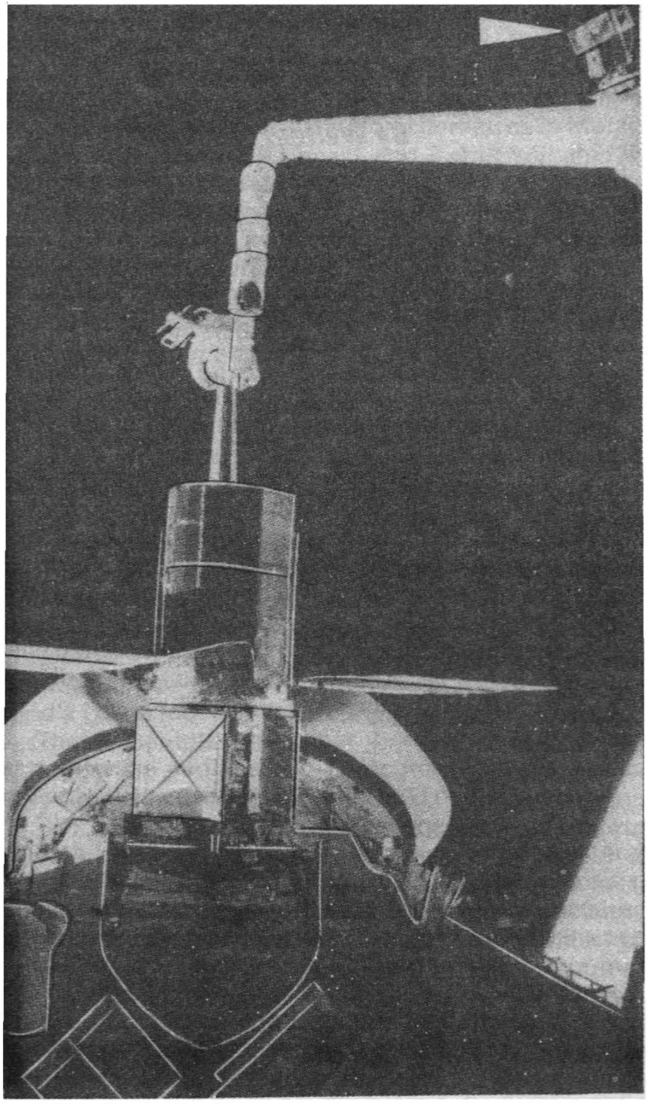
Assist Modules on flight 41B in February 1984, was the addition of an operational requirement to view the motor burn on all flights carrying these modules. Videotapes will then help engineers to analyse future performance.

As satellite servicing assumes a larger role in Shuttle operations, the role of TV will grow correspondingly. Real time visual data are essential for vehicle inspections, payload deployment and retrieval, extravehicular activity support and spacecraft repairs. Eventually, space servicing will become analogous to marine salvage operations where divers performing on-the-spot servicing are complemented by team-mates on the surface monitoring the work *via* television.

Payload Support

Shuttle users are beginning to realise the potential of using the Orbiter's TV system for data collection and operational support. An example is the experiment called 'Experimental Assembly of Space Structures (EVA)/ Assembly Concept for Erectable Space Structures,' better known as Ease/Access, which will use the television system to record spacewalking crewmembers manually assembling simple structures. Using the resultant video recordings to conduct a time and motion study, an accurate model of human productivity during EVA construction may be developed.

Another payload that relied heavily on the TV system



The repair of the Solar Max satellite in April 1984. The 'elbow' camera on the manipulator arm is arrowed. *NASA*

for data collection was OAST-1, an extendable, 32 m long solar array mounted in the cargo bay and carried on 41D in June 1984. The dynamic performance of the extended array, with visible targets, was recorded and monitored for later analysis.

On Spacelab 3 early this year, TV will be used to view and record auroral activity. 'Astro' is an ultraviolet astronomy payload that will observe Halley's comet in February 1986; TV will be used to help Astro point its instruments in the right direction.

In the future, the Orbiter's TV system will continue to play an active role in operations and payload support. Possible changes include using lighter, smaller cameras with better colour capability, higher resolution monitors and voice-operated controls. Such changes will also pave the way for the sophisticated TV monitoring and telepresence capabilities required for the Space Station.

Space Station TV Systems

Following President Reagan's directive in January 1984 to begin work on the Space Station, NASA is undertaking a myriad of studies. There is the potential to design a sophisticated and flexible Space Station TV system, benefiting from experience gained with the Shuttle.

Video systems will prove invaluable in conducting routine operations and maintaining the psychological health of the crew. The station will probably include several free-flyers, independent, co-orbiting platforms containing experiments or production facilities. These platforms will need to be monitored with the minimum of disturbance; the best way is *via* a closed circuit TV system. Space station performance and integrity must also be monitored visually, necessitating some sort of TV system. A dual transmit/receive and closed circuit TV system could provide crews with entertainment (films, games, etc), as well as allowing private conversations with family and friends on the ground (the latter has been a feature of Soviet Salyut missions).

An important function of the Space Station will be traffic control. It will not only monitor and control the free-flying platforms but will also serve as a staging post for payloads bound for different orbits. Like an airport control tower, the station will coordinate payload arrivals and departures, maintain separation and provide maintenance and refuelling services. It will require very sophisticated electronic ranging and monitoring instrumentation. Traffic control will probably be accomplished by both laser and radar, as well as visually. A visual capability, *via* both windows and TV monitors, will serve as a complementary method of traffic separation, as well as backup to the avionics.

Extravehicular activity will be an important part of Space Station operations. Initial construction of the station will involve extensive spacewalks and subsequent operational activities and will, routinely, depend on EVA. TV monitoring will be necessary to support such operations, both to monitor crewmembers' safety and to help them in their work.

In the long term, the visual monitoring of today will be replaced by telepresence, intimately involving the human operator in a robotic control system. Future teleoperator systems will meet and even exceed the capabilities of the human eye. In the not-too-distant future such technology will, as George von Tiesenhausen of NASA's Advanced Systems Office puts it, allow you to 'do things in space as if you were really there.' As this field develops, more and more EVA tasks will be performed by crewmembers inside the station *via* teleoperator devices. NASA believes that telepresence capabilities will equal human EVA abilities by the 1990's. Initially, stereo black and white televisions will be used on the teleoperators but these cannot match the capability of the human eye. Eventually, NASA hopes to have teleoperator cameras with both colour and wide fields of view - these require a far higher number of communication bands than are now available. Such camera systems will match and perhaps exceed the resolution of the human eye.

A Space Vision System, built by the Canadian National Research Council, flew on the Shuttle in late 1984 aboard mission 41G. It might prove to be the forerunner for Space Station TV monitoring systems. It uses either a natural or laser light beam, interfacing with an onboard computer, to provide depth perception when manoeuvring or grappling payloads with the Orbiter's manipulator arm. A Canadian payload specialist, Marc Garneau, monitored the TV image aboard the Orbiter. In the future, such computerised vision systems will be an important tool in building the Space Station and other large space structures.

There appears to be no insurmountable obstacles to building and operating a TV monitoring system for the Space Station. The environment does not pose a problem, as the station will not be exposed to excessive radiation (which could damage a camera's silicon tube) and thermal control can be achieved by using methods such as shading, thermal blankets and strip heaters. The greatest problem is providing camera cooling during long periods of continuous operation.

Space News and Commentary

From the US Capital

By Walter Froehlich

CATCHING UP WITH A COMET

Halley's comet has been seen on its periodic visits to the vicinity of the Earth for more than 2,000 years. But it has never had a more enthusiastic welcome than it is currently getting from NASA and other space organisations.

Records describing the comet have survived for each of its last 29 appearances at intervals of 75 or 76 years from 240 BC to 1910, except for the year 164 BC. During many of these appearances the comet was regarded an evil omen — a heavenly harbinger of doom — even though its travels near the Earth have been accompanied and followed by as many auspicious events as detrimental ones.

This time around, the comet's arrival is considered by many scientists to be a once-in-a-lifetime research opportunity, and they are going at it in a big way. Research equipment has vastly improved in the 75 years since the comet's last visit in 1910. For the first time it can now be inspected from above the obscuring atmosphere. Ground and aerial observations are being supplemented by an array of spectacular space missions:

- NASA is sending its sparkling new astronomical observatory "Astro-1" on its maiden flight aboard the Shuttle's cargo bay on March 6. During their seven days in orbit, the Shuttle crew will be assigned to use Astro-1's three ultraviolet telescopes and two wide-field cameras almost exclusively for observations of the comet.

- Earlier, on a January Shuttle mission, a "Spartan" experiment package containing automated research instruments is to be released into a free-flying orbit for 48 hours and then retrieved so that its recorded comet observations can be analysed upon return to Earth.

- NASA's Pioneer Venus Orbiter, which has been circling Venus since 1978, will swivel its ultraviolet spectrometer toward Halley's comet. The craft will be in a unique position on the opposite side of the Sun from Earth. From that unusual vantage point the craft will be able to examine the comet during its closest approach to the Sun. At that time the comet will not be be visible from the Earth because the Sun is obscuring it. The craft will observe gases and dust emanating from the comet.

- The US Solar Maximum Observatory, which made history in 1984 when it became the first disabled spacecraft restored to service by an in-flight repair crew aboard the Shuttle, will also turn its instruments towards Halley's comet. The craft's coronograph that had been designed particularly for its Sun studies will produce images of the comet and its spectrometer will examine the comet's nucleus.

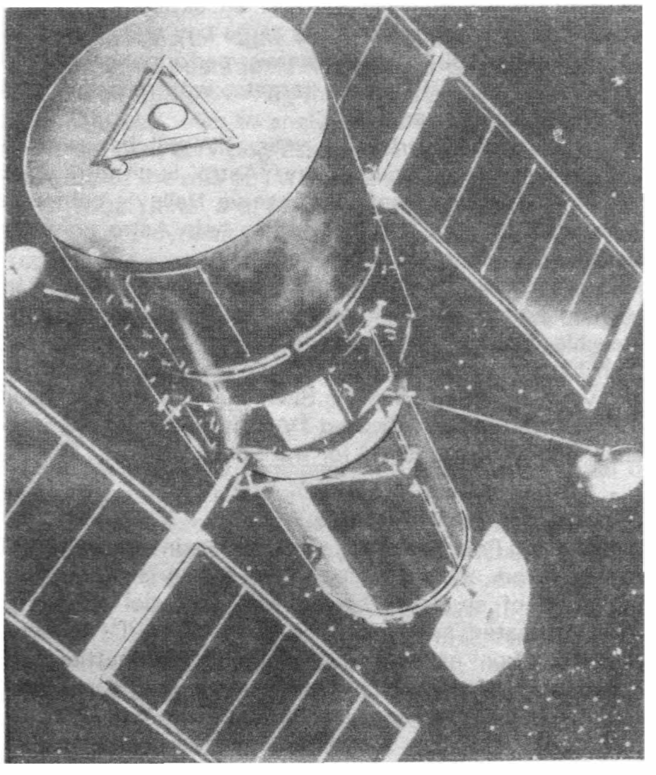
- The International Sun-Earth 3 Explorer (now renamed ICE, for International Cometary Explorer) which has been in a high-altitude orbit for solar wind monitoring since 1978 will make spectrographic analysis of Halley's components. That craft already made history in September 1985 after its course was altered and it became the first human-made object to come close to a comet.

The experience gained during that encounter is proving helpful to US Halley watchers as well as to the ground crews of spacecraft of other nations.

All of this extensive comet research comes, ironically, after NASA had been subjected to severe criticism within the United States for allegedly failing to take full advantage of the appearance of this most famous of all comets. The critics have been charging that NASA, for budgetary reasons, assigned only already existing research equipment rather than designing a new mission dedicated solely to Halley's comet explorations as some other countries are doing.

Thus, the European Space Agency launched its Giotto spacecraft on July 2, 1985, on a path which is to

The Hubble Space Telescope, due for launch during 1986.



take it, after course refinements, to within about 500 km of the comet's nucleus on March 13, 1986. Japan launched its first two interplanetary spacecraft — "Planet-A" and "Sakigake" — to look at the comet from distances of several million kilometres in March. And the Soviet Union Vega 1 and 2 craft will also fly within a few thousand kilometres of Halley's comet for observations early in March.

NASA is playing a vital part in these multi-national observations through its co-sponsorship with West Germany of the International Halley Watch (IHW).

The twin headquarters for the IHW, staffed by scientists from many countries, are located at NASA's Jet Propulsion Laboratory in Pasadena, California, and West Germany's University of Erlangen-Nurnberg.

A YEAR FOR SPACE SCIENCE

NASA's activities pertaining to Halley's comet are part of an array of projects which have motivated NASA to declare 1986 as "A Year for Space Science." NASA is arranging exhibits and other public education programmes which vividly show how space exploration continues to drastically expand humankind's vision into our cosmological neighbourhood.

These exhibits and other programmes also call attention to some of NASA's other major science activities planned for 1986:

- The January fly-by of Uranus by the US Voyager-2 spacecraft. It will be history's first close-up examination of that planet which is more than twice as distant from the Earth as any object ever examined in such detail.

- The launch of the first explorations, late in 1986, with the revolutionary Hubble Space Telescope which NASA Administrator James M. Beggs has called perhaps the most important scientific instrument ever flown, and which some scientists have hailed as "the scientific instrument of the century".

- The launch in May of the Galileo spacecraft on an 18-month journey to Jupiter where the craft will release a 1.5 m diameter entry probe that is to descend into and analyse the planet's atmosphere.

- A possible close-up inspection of the asteroid Amphitrite. No decision has yet been made on whether to undertake that historic mission by steering the Jupiter-bound Galileo spacecraft on a detour to the vicinity of that 200 km planetoid in the middle of the asteroid belt about two and a half times as far from the Sun as is the Earth. If the decision is made to divert Galileo on the side trip, the craft's arrival at Jupiter would be delayed by about three months.

Scientific exploration has always been a major objective of the US space programme and NASA's 1986 projects promise to become particularly productive. They encompass the experience and technological knowhow accumulated over more than a quarter of a century of operations in space.

As they extend humankind's view, these projects will undoubtedly add substantially to our knowledge about the solar system and the laws and workings of nature that govern everything within it and in the universe beyond.

News Bulletin

COSMONAUT ILLNESS FORCES EARLY RETURN

Cosmonauts onboard the Soviet Salyut 7 space station unexpectedly returned to Earth in late November after the commander, Vladimir Vasyutin, fell seriously ill.

This was the first time in the history of manned space activity that a mission has been curtailed by either the Soviets or the Americans for such a reason.

First news of the cutting short of the unfinished programme after 65 days came on November 21 when Tass announced that the three cosmonauts from Salyut 7 had returned safely to Earth in their Soyuz 14 craft.

Doctors were on the scene at touchdown in Kazakhstan, a Central Asian Soviet Republic, to examine the commander but no details of his illness were released.

A subsequent Tass statement said: "Vasyutin's condition is satisfactory. We cannot say any more than that as we have to make a thorough check-up. It is only clear now that, as we expected, he needs hospital treatment."

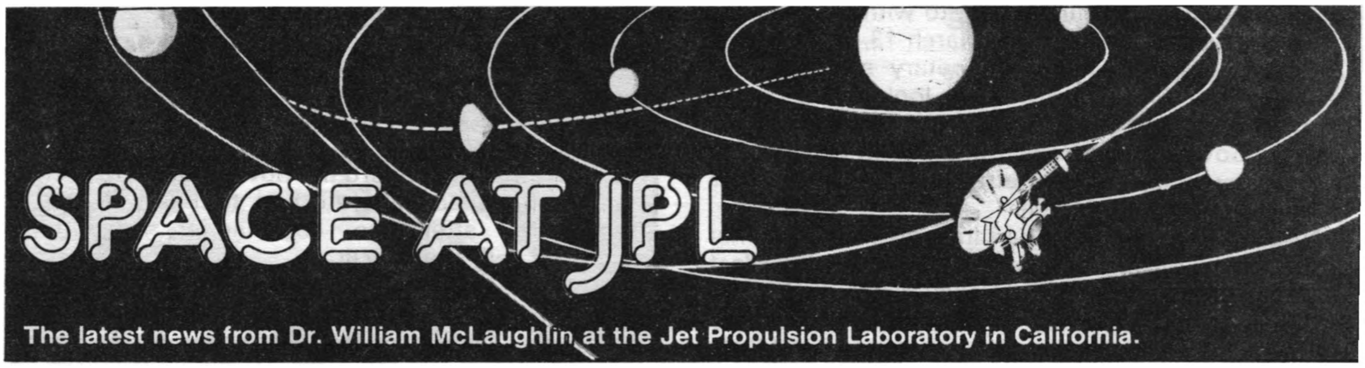
Vladimir Vasyutin

Vasyutin (33) went into space on September 17 with two other cosmonauts, Georgi Grechko (flight engineer) and Aleksandr Volkov (researcher-cosmonaut), carrying out a joint eight day mission with the cosmonauts already there, Dzhanibekov and Savinykh. Grechko and Dzhanibekov returned to Earth in Soyuz T-13 on September 25.

Since then the remaining three cosmonauts had been working on an extensive scientific programme which included taking pictures of six million square miles of Soviet territory for use by scientific and other bodies.

Vasyutin was assigned to the cosmonaut detachment in 1976 at the age of 24, completing test pilot school the following year. He was on his first space mission, although had previously been a member of training programmes on four back-up crews.

No immediate indication was given by the Soviet authorities about how long the commander had been ill before the decision to abort the mission was taken.



MARS AERONOMY ORBITER

In the July-August and December 1985 editions of 'Space at JPL,' two candidates for the second mission in the Planetary Observer series were examined: the Lunar Geoscience Observer (LGO) and the Near Earth Asteroid Rendezvous (NEAR). The first mission in the series is the already-approved Mars Observer project; this month a third candidate to follow that mission will be reviewed: the Mars Aeronomy Orbiter (MAO).

The dictionary defines aeronomy as a 'science that deals with the physics and chemistry of the upper atmosphere of planets.' Following the advent of radio in the late 19th century, Heaviside and Kennelly postulated in 1902 that transmissions were accomplished by the reflection of radio waves from a layer of charged particles in the upper atmosphere. These particles were detected in 1924 by the British physicist Sir Edward Appleton (1892-1965). The structure of this region of charged particles, the ionosphere, varies greatly with solar activity and has seasonal and daily patterns of fluctuations, as anyone who listens to radio can attest. The ionosphere extends from approximately 50 km to 1000 km above the Earth and can be divided into three distinct regions.

Research into the structure and dynamics of the Earth's upper atmosphere has been greatly facilitated by the use of sounding rockets and satellites. The first US satellite, Explorer 1, resulted in the discovery of the Van Allen belts, whose reservoirs of trapped protons and electrons gird our globe. The interaction of the solar wind with the Earth's magnetic field continues to be an active area of research.

Aeronomy investigations for the other planets are in their infancy. The Pioneer-Venus (1978) mission has begun that service for Venus. In the case of Mars, the emphasis to date by NASA has been on geology, biochemistry and properties of the neutral atmosphere.

The scientific goals for MAO are to characterise the magnetic field of Mars, the interaction of the planet with the solar wind and the structure and dynamics of the upper atmosphere. More specifically, daily and seasonal variations of the upper atmosphere are to be determined; the question of whether Mars has an intrinsic magnetic field is to be addressed; and the present escape ratio of hydrogen, oxygen and nitrogen from the atmosphere are to be measured. These last data would have important consequences for the study of the evolution of that atmosphere.

In order to accomplish these goals, three different experimental methods have been identified: (1) *in situ* measurements of atmospheric constituents, (2) optical remote sensing of the atmosphere, and (3) measurements of plasmas and electromagnetic fields. The first set of measurements can be done through the use of mass spectrometers, while the second set would require interferometers. Several instruments, including a magnetometer, electric field detector and solar wind plasma analyser, would implement the third item.

A possible launch date for MAO is September 1992, with a one-year flight time to Mars. Then, starting in the autumn of 1993, MAO would collect data for about one Martian year (approximately two Earth years).

The orbit of MAO about the planet would be highly eccentric so that the instruments could sample a wide range of atmospheric levels. It would also be highly inclined to the Martian equator to allow measurements to be taken at most latitudes. The period is planned to be greater than 20 hours. During this period data are gathered at three different rates. In the high regions of the orbit (that is, around 'apoareon'; the suffix is derived from 'Ares,' the Greek equivalent of the Roman Mars) data are collected at 512 bits per second and put on to the spacecraft's tape recorder. As the spacecraft draws closer to Mars, entering the ionosheath region, the data rate doubles to 1024 bits per second. Then, 15 minutes before periareon, the data rate doubles again to 2048 bits per second. At these rates, more than 80 million bits are generated each day and played back in a 4.5 hour daily downlink.

The mission could be accomplished with several spacecraft designs. The one that is selected, should MAO be chosen as the second Planetary Observer, would be influenced by the spacecraft for the Mars Observer. If that prior mission employs a dual-spin spacecraft, then MAO would probably follow suit. But if the Mars Observer is three-axis stabilised (does not spin), then MAO might go to a different design. A low-cost alternative would be to spin the entire spacecraft for stabilisation; fields and particles experiments thrive in this type of environment.

A fourth Planetary Observer candidate, in addition to MAO, LGO and NEAR, is the Comet Coma Sample Return. That mission will be reviewed in a later edition of this column.

KECK TELESCOPE GROUNDBREAKING

The Keck 10 m telescope, scheduled for completion in 1991, will be placed on top of a 4,150 m dormant volcano, Mauna Kea, in Hawaii. On 12 September 1985 ground was broken at the site in a ceremony attended by some 150 officials and guests. The Keck Telescope should be the largest in the world at the time of its completion (see the June 1985 edition of this column).

The telescope will be constructed from a $70 million grant from the W. M. Keck Foundation to Caltech (Caltech operates JPL for NASA). The California Association for Research in Astronomy (CARA) is a corporation that has been formed by Caltech and the University of California for the purpose of building and operating the Keck Telescope. The two institutions will share viewing time equally and also provide access for the University of Hawaii, from

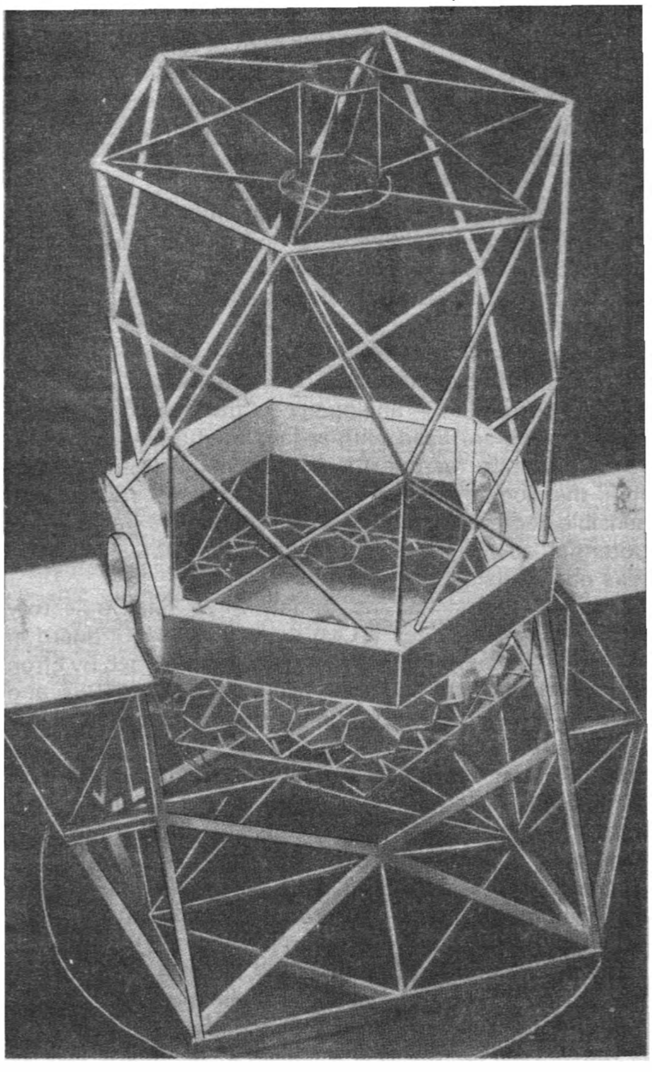
which the observatory land is being leased. The estimated $87 million in construction funding will be provided by Caltech, the bulk of this funding comes from the Keck grant, while the University of California will provide funds for instrumentation of the telescope and operation of the facility for 25 years.

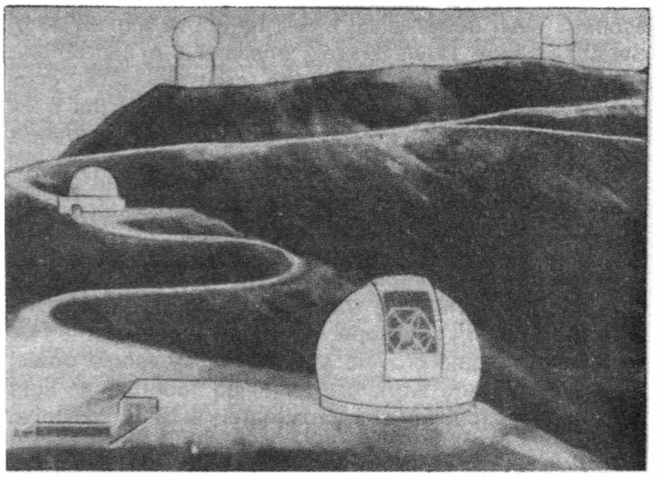
At the ceremony, Dr. Marvin Goldberger, the President of Caltech, said, "Every time an instrument has been introduced into modern science that enables us to explore hitherto inaccessible regimes, we have been shocked and humbled by the unexpected. It is just such a quantum jump in observational astronomy that we will be embarking upon as we break ground for the W. M. Keck Observatory."

Dr. Edward Stone is the Chairman of the Department of Physics, Mathematics and Astronomy at Caltech and also serves as the Project Scientist for JPL's Voyager Project. He gave a talk on the design, construction and potential of the Keck Telescope to an audience at JPL on 2 October 1985.

Stone pointed out that Caltech's 5 m Hale Telescope at Palomar is still the premier instrument in astronomy even though it was designed 50 years ago (it went into operation in 1948). For a scientific instrument to dominate its field for so long is unusual in modern science. One reason is the fact that it represents the end point of a certain technology: the massive, large mirror held together by mechanical strength. It would be difficult to build and support mirrors significantly larger than the 5 m slab of glass.

The 10 m Keck telescope will be built by Caltech and the University of California, to be placed atop Mauna Kea, Hawaii for the start of observing in 1992. The Palomar telescope has a 5 m main mirror.





In this artists s concept, the dome of the 10 m Keck Telescope on Mauna Kea, Hawaii is shown in foreground. Other existing international facilities in the background combine to make the area on top of the 4150 m dormant volcano one of the major astronomical sites in the world. *CARA*

The segmented Keck mirror will consist of 36 hexagonal mirrors, each of which can be relatively thin and light since it rests only in its own support. Stone said that two fundamental items of technology had to be addressed prior to undertaking the 10 m mirror:

(1) Devising a method for shaping each of the 36 constituent mirrors; unlike a mirror for a single-mirror telescope, they will not be axially symmetric. Most methods apply to the symmetric case.

(2) Developing an accurate way to monitor and control the position of each of the individual mirrors so as to coordinate their light-gathering activity into the formation of a sharp image.

Both problems were solved by Dr. Jerry Nelson and his associates at the University of California. Nelson is the Project Scientist for the Keck endeavour, while Jerry Smith of Caltech is the Project Manager. Smith formerly managed the development of NASA's 3 m Infrared Telescope Facility and the Infrared Astronomical Satellite (IRAS). See the April 1984 'Space at JPL.'

The 1.8 m mirrors will be shaped by 'stress mirror polishing.' In this method, levers applied to the perimeter of each mirror distort its shape in such a way that it can be polished with axially-symmetric methods and then, when the levers are released, voila! – the mirror's shape slithers into the desired, non-axially symmetric configuration. Of course, the method requires iteration through several stressing, polishing and measuring steps.

The second piece of technology employs two displacement sensors on each mirror edge (168 in total). These sensors, accurate to 1/200 of the wavelength of light, measure the positions of the individual 7.5 cm thick mirrors and report their results to a controlling computer. The computer controls three motor-driven screws per mirror and effects positional corrections, accurate to 1/50 wavelength, every second.

The performance of the Keck Telescope, according to Stone, is a function of both its size and its location. For example, compared to the 5 m telescope at Palomar, it will be 16 times more effective in stacking up photons. A factor of four is obtained from the doubling of mirror diameter and a second factor of four results from the improved seeing (perhaps 0.5 arc second compared to 1 arc second) on Mauna Kea, which has only 10% of the water vapour and 60% of the atmosphere at sea level.

Of course, the seeing for NASA's Hubble Space Tele-

scope is even better since it will be above almost all of the atmosphere. However, this smaller 2.4 m instrument, scheduled for launch into Earth orbit in 1986, does not have the raw light-collecting capability of the Keck telescope. It will excel in producing high resolution images free from atmospheric smear. The Keck telescope will collect photons from faint galaxies, over 12,000 million light years distant, allowing spectroscopy to be performed for these far objects.

A site has been prepared adjacent to that of the Keck Observatory in the hope that future funding could result in a second 10 m telescope. Operating together, the two instruments would provide a facility of awesome power for interferometric work or, conjoined together as light buckets, the capability of approximately a 15 m telescope.

ICE BISECTS GZ

It was a time for superlatives. On 11 September 1985 the International Cometary Explorer (ICE) successfully accomplished the first encounter with a comet as it passed through the tail of Giacobini-Zinner (GZ). The set of fields and particles instruments (no imaging) onboard ICE registered dramatic changes during passage through the ion tail, estimated to be 15,000-20,000 km in diameter at the (central) chord of crossing.

The story of how this NASA/Goddard mission was diverted from its original functions in the Earth-Moon system to go off to a comet is one of the most dramatic tales in astronautics history (some of the earlier history is contained in the November 1984 writeup in *Spaceflight*). The comet mission was the idea of Dr. Robert Farquhar of the Goddard Space Flight Center, who combined intelligence with persistence to bring about the final result.

One of the components of this success was the accurate navigation of ICE to the centreline of the tail 8000 km from the nucleus. Missions such as Voyager and Galileo supplement radiometric tracking data, acquired by the antennae of the Deep Space Network, with optical images of the target (satellite, planet) taken from the spacecraft. The latter data type is extremely important for these deep space missions, which would not be possible without it, since the camera images establish the relative location of spacecraft with respect to target. With no onboard camera, ICE was denied this data type. Closer to Earth than Voyager or Galileo, ICE had a chance to recoup using Earth-based measurements. Thus, the ICE navigators were faced with the necessity of accurately determining the ephemerides of both the spacecraft and the comet in order to bring them together.

When the comet was recovered by Earth-based telescopes early in 1984, as it approached the Sun in its 6.5 year orbit, its positional uncertainty was on the order of 100,000-200,000 km. Since, at that time, the tail of GZ was thought to be only 5000 km in diameter, the navigators clearly had their work cut out.

Dr. Donald Yeomans of JPL led the effort to improve the orbit of the comet and Dr. Leonard Efron, Chief of the ICE navigation team at JPL, was responsible for determining the orbit of the spacecraft. We will examine these efforts in turn.

Yeoman's task began with the recovery of GZ in April 1984; now Earth-based telescopes could supply positions of the comet as measured against the background of stars.

The optical tracking network was assembled under the auspices of the Astrometry Network of the International Halley Watch and eventually supplied 814 data points from 61 observatories from GZ recovery up to 6 September 1985, five days before the encounter. Major observatories, e.g., Lick in California, worked along with amateur astronomers in a world-wide endeavour to characterise the motion of GZ. Not only were careful astrometric measurements necessary, but they had to be done with respect to a special set of accurately-known stars prescribed by Yeomans (essentially stars from the fundamental AGK3 catalogue).

Time became the essence as the day of encounter approached. Many observers took their observations, reduced the data and telexed the results to Yeomans immediately. He cites as an outstanding example Brian Manning of Stakenbridge Observatory in Worcestershire, England, who used a 26 cm reflector to generate an expeditious and accurate stream of data.

The determination of the orbit of GZ came from folding these observations into a mathematical model of the comet's notion. A particular problem surfaced in the case of GZ. Not only is the motion of the comet shaped by the gravitational attraction of the Sun and planets, but also by non-gravitational forces that change relatively rapidly, on a time scale of months or years. Non-gravitational forces exist for Comet Halley too, but they generally vary only slightly over a period of centuries. One model that would explain the rapid variation of non-gravitational forces on Comet GZ postulates a very flattened cometary nucleus that wobbles or precesses. Then, sites of expulsion of mass from the nucleus would change their inertial direction of force on the nucleus as it wobbles. Expulsion of mass generates forces on the comet by Newton's Third Law.

Yeomans fed GZ ephemeris updates into the ICE navigation process throughout the mission. The last update was sent to Goddard the morning of Friday, 6 September. Over the next day, manoeuvre analysts at the NASA centre computed the last engine burn of ICE and executed it on Sunday, 8 September, three days before encounter. Yeomans estimated that he had determined the final orbit of GZ to within 500 km, relative to Earth. Later analysis of additional cometary observations indicated that his accuracy might have been even better.

The second part of orbit determination for the ICE mission, spacecraft location, proceeded in parallel with the cometary ephemeris improvement. The raw materials for this process were two-way doppler data (S-band) and range data. These data measure the velocity and distance of the spacecraft relative to the observer on Earth and are used in conjunction with a mathematical model of the craft's motion – analogous to the way that optical observations are used with regard to the comet's orbit. A complication for the ICE mission came from the fact that the comet's mass was too small to affect, to a sensible degree, the motion of the spacecraft – so another potential source of comet/spacecraft relative location was not available.

As ICE approached its target, three final trajectory correction manoeuvres (TCM) were done by Goddard in response to the navigational information provided by Efron and Yeomans. The first took place on 7 June 1985 and allowed Efron's team to monitor the performance of the spacecraft's engine. Utilising this experience, they were able to assist controllers at Goddard in tuning the burn parameters while the second burn was in progress, on 9 July. This action was possible because the TCMs were each done in segments, with time between each.

The final TCM, as noted, took place on 8 September. Efron estimates that it delivered the spacecraft to within 50 km of its targetted position relative to Earth. Then the relative position of ICE and GZ was inferred from each of their separately determined positions relative to Earth. Fitting the spacecraft and comet together in this manner is reminiscent of the civil engineer's 'blindfold' trick of

steering two tunnel drillings together under a mountain.

Efron was present at the control centre at Goddard on the day of encounter. He describes the event: "Everyone anxiously scanned visual displays monitoring antenna signal-to-noise ratios and spacecraft solar panel output current (reflecting concern for comet dust coating the panels). Cautious optimism turned into elation as 11.06 GMT came and passed. We knew the instruments had been recording notable levels of activity for some time, but smiles now spontaneously appeared when spacecraft survival had become a reality... a comet had been encountered."

LIFE IN THE COSMOS

From time-to-time in these pages, the subject of SETI, the search for extraterrestrial intelligence, has been discussed. This topic is only one in a broadly-based set of investigations that are now taking place concerning the fundamentals of biological science.

At the coarsest level of resolution one can distinguish three areas of research: (1) the formation and distribution of chemical precursors of life, (2) the origin of life, and (3) the mechanisms of evolution. The first subject has been addressed in a recent NASA publication, *The Cosmic History of the Biogenic Elements and Compounds* (NASA SP-476 edited by John Wood of the Harvard-Smithsonian Center for Astrophysics and Sherwood Chang of the NASA Ames Research Center), and will be reviewed here. A recent theory of the origin of life, due to A. G. Cairns-Smith, will also be examined. Although the theory of Darwinian evolution is itself undergoing a period of rapid evolution, space here does not permit an adequate progress report; the interested reader should consult an article by G. L. Stebbins and F. J. Ayola in the July 1985 *Scientific American.*

When it all began, at the Big Bang, the expanding Universe that was created consisted mainly of hydrogen and helium, with very little of the heavier elements in evidence. In particular, the biogenic elements carbon, nitrogen and oxygen were absent. Thus, the first generation stars that formed were composed only of hydrogen and helium, and we would not expect these systems to be abodes for life as we know it. This type of first-generation (or early generation) star can be found populating globular clusters. Somewhat more than 100 of these ancient objects form a spherical halo about our Galaxy – each is composed of approximately 100,000 stars.

During its prime, a first generation star produces energy by nuclear fusion reactions that convert hydrogen into helium. Later in the life of the star, the helium itself becomes a fuel and nuclear reactions turn into heavier elements, including carbon and oxygen. Some of the biogenic elements are then present in the Universe but are seemingly sealed in the interior of their source of origin. Fortunately (for us), processes exist that break the seal and distribute the elements for general use, including the needs of biology. The most dramatic of these processes is the sudden expulsion of large amounts of material by the star if it becomes a supernova or a nova. A second, more gentle method of distribution is by continuous mass loss through stellar winds (flows of energetic ions that depart from the star). The solar wind is a prominent feature of our environment and has been intensively studied by numerous space missions, including the recent AMPTE project.

The second generation stars that form from the interstellar medium have available to them from the star heavier elements. This fact allows more complex nuclear reactions to proceed and, as a result, the biogenic element nitrogen is produced and eventually disseminated into the interstellar medium by the processes discussed above.

The interstellar medium is not a homogeneous collection of atoms. This breeding ground for stars contains ions, dust and molecules of some complexity, along with atoms. The interstellar medium is, in addition, segregated into rather dense molecular-cloud regions and almost empty intercloud regions. The latter regions are not favourable for the development of complex molecules because ultraviolet radiation from nearby stars continually breaks chemical bonds. The interstellar clouds do not provide a hospitable region for molecular building programmes, and many species have been detected through astronomical observation in recent years.

A star is created by gravitational collapse and heating in part of an interstellar cloud. However, not all of the collapsing material feeds into the star-to-be. An accretion disc can form; it consists of material lying nearly in a plane and rotating about the protostar.

For later generation stars, such as the Sun, the accretion disc will contain biogenic elements and their compounds. If planets subsequently form in the accretion disc (called the solar nebula in the case of the Sun), some will be stocked with the raw materials that life-as-we-know-it requires.

The material from the now-vanished solar nebula is still available for study; it has been locked into comets. As Wood and Chang express it, "Comets are the repositories of the most primitive, best preserved, but most fragile nebular and presolar materials still surviving. We study them from afar with intense interest, and yearn for the opportunity to send spacecraft missions to them."

In the 1920's the Russian A. I. Oparin and the Englishman J. B. S. Haldane formulated the 'warm pond' theory of the origin of life. Given biogenic materials discussed above, and some additional chemical evolution in the waters of the early Earth, life arose as increasingly complex organic molecules developed and learned to replicate themselves. This scenario, considerably amplified by biochemists over the years (there is a journal *Origin of Life* devoted to this and allied topics), is still the most widely accepted theory explaining how life arose on Earth.

However, some biologists have felt that the probability of molecules arranging themselves by chance in the intricate patterns required by even primitive life is too small to provide credence to the warm pond theory.

A. G. Cairns-Smith, a chemist at the University of Glasgow, takes issue with the conventional theory of the origin of life. His book *Genetic Takeover and the Mineral Origins of Life* (Cambridge University Press, 1982; see also his article in the June 1985 issue of *Scientific American*) proposes that life did not start with carbon chemistry. It came into being from highly ordered crystal structures, perhaps in certain clays, which themselves were capable of reproduction and only later became 'filled in' with what we recognise today as organic compounds.

The crystals of Cairns-Smith are clay minerals like kaolinite and can store the information that life needs through 'defects' which inhabit almost all crystals (thus, a defect can be a virtue!). Crystal growth and cleavage provide ways in which this information can be propagated through time. In a word, Cairns-Smith has functionally outlined a gene but not one made of DNA. The clay 'scaffolding' was gradually taken over by what we describe as organic molecules and the normal processes of Darwinian evolution could begin.

The theory of Cairns-Smith will have to be tested in the scientific arena, but it clearly has some attractive features and, if correct, may bolster the position of ETI theorists who believe in the abundance of life in the Universe.

PRESENTATION TO THE SOCIETY

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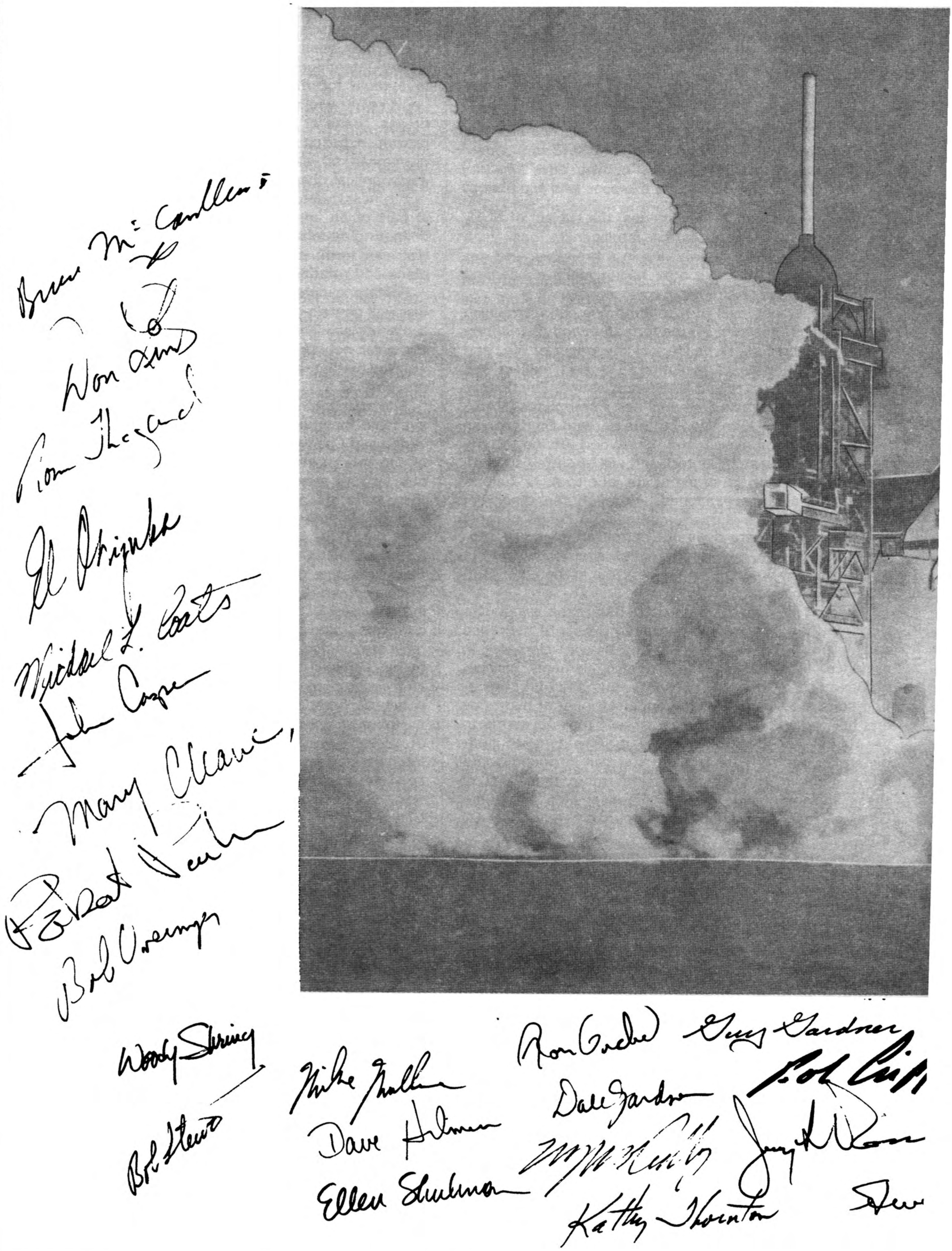
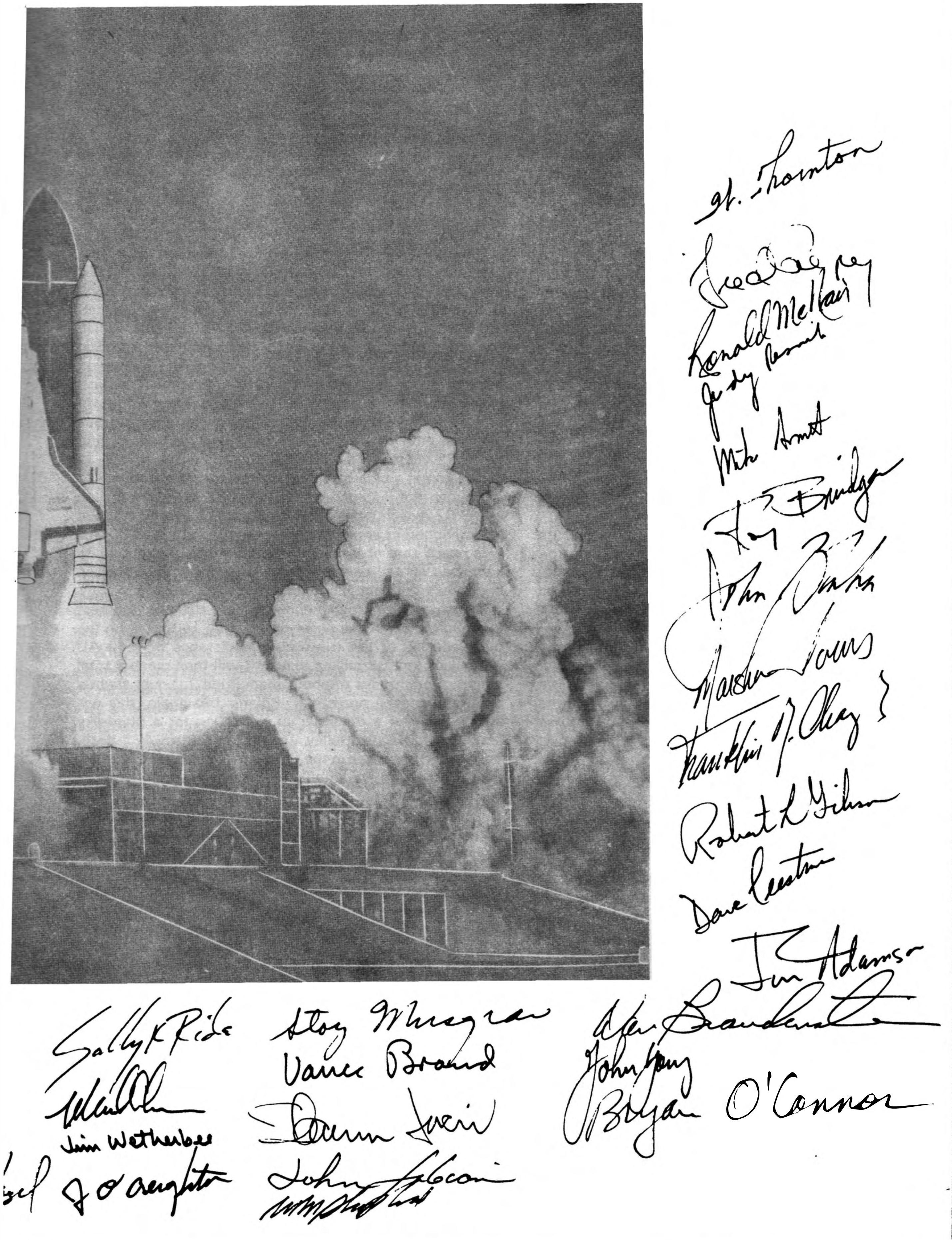


...eatly honoured to receive the Shuttle launch picture reproduced below. It bears the signatures of 46 US astronauts. ...thers, unavoidably absent at the time, have asked to be associated with the gift. The Society expresses its grateful ...naut individually, and to Tony Smith who dealt with the matter so magnificently on our behalf.



Compiled by L. J. Carter

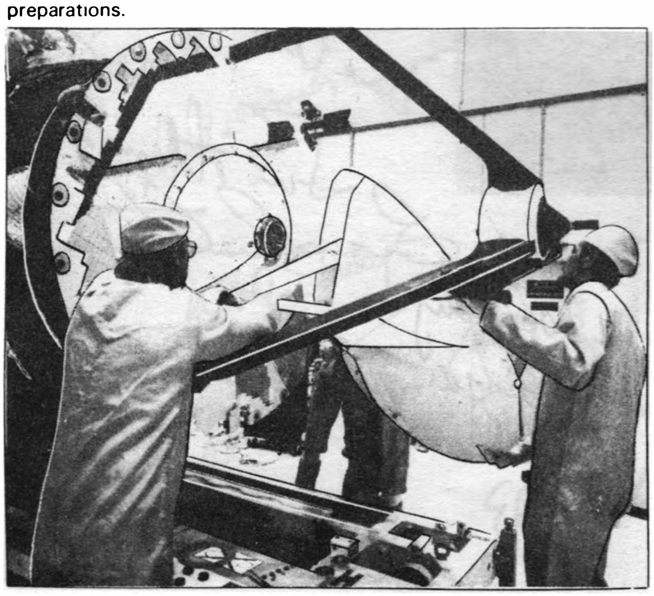
WELL ON THE WAY

Halley's comet has been on the inbound leg of its journey round the Sun since its aphelion in 1948. At that point it was 35.25 AU (5,270 million km; 3,275 million miles) from the Sun, well beyond the distance of Neptune and moving at only 0.91 km/sec. (2,000 mph). Perihelion, the point of closest approach to the Sun, will occur on 9 February 1986. The comet will then be only 0.5781 AU (87.8 million km; 54.6 million miles) from the Sun, well inside the orbit of Venus and moving at 54.55 km/sec (122,000 mph).

The comet was first observed on its return to the inner Solar System on 16 October 1982 in images obtained by Caltech astronomers G. Edward Danielson, David C. Jewitt and co-workers using the 200-inch telescope at Mount Palomar Observatory.

By early autumn 1984, observations showed that its coma - the bright halo of dust and gas surrounding the nucleus - had already begun to develop, with astronomers now questioning why it began to exhibit this feature so far from the Sun. Early observations also showed that Halley's brightness was fluctuating, again to their puzzlement. Even so, viewing conditions for this 30th recorded appearance will not be as good as those during the last apparition in 1909-1911 because of the different relative positions of the Sun, Earth and the comet. In fact, the comet this time will appear much less spectacular than at any other during the past 2,000 years. Estimates of Halley's brightness during earlier returns are based on the comet's closest passage of Earth and the assumption that it behaved as it did in 1909-1911, when it reached a total apparent brightness of about magnitude -1 and passed within about 0.15 AU [23 million km; 14 million miles] of Earth.

Installation of the dish antenna on the Giotto spacecraft during launch preparations.



Comet Halley moves backward (opposite to Earth's motion) around the Sun in a plane tilted 18° to that of the Earth's orbit. This retrograde motion is unusual among short-period comets, as is its aphelion distance beyond the orbit of Neptune. Its period averages 76 years, which corresponds to an orbital circumference around the Sun of 12,200 million km (7,600 million miles). The period actually varies from appearance to appearance because of the gravitational effects of the planets. Measured from one perihelion passage to the next, Halley's period has been as short as 74.42 years (1835-1910) and as long as 79.25 years (451-530).

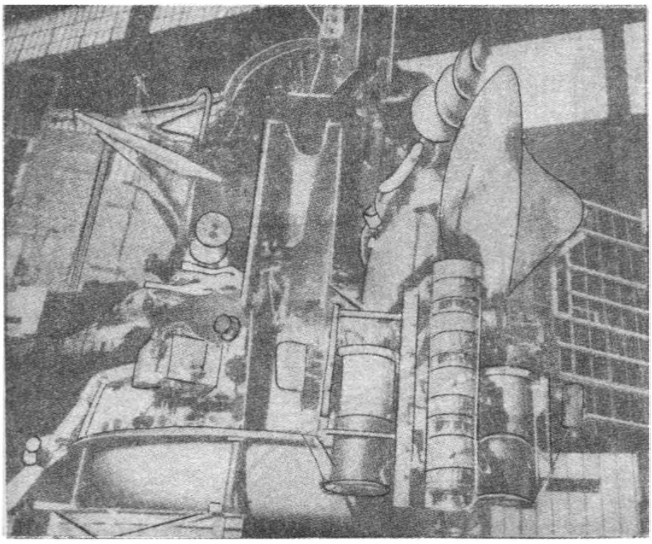
The comet's closest approach to Earth occurred in 837 AD, when the distance was only 0.033 AU (4.94 million km; 3.07 million miles). On 10 April 837, Halley reached a *total* apparent brightness of about magnitude -3.5. This was nearly that of Venus at greatest brilliance though its light was spread over an extended area and its surface brightness thus actually fainter.

During the current appearance, Halley's nearest approach to Earth will occur on 11 April 1986, i.e. on the outbound leg of the trip and at a distance of 0.42 AU (63 million km; 39 million miles). It will then reach a total apparent brightness of about magnitude 2.0, just slightly brighter than the north star, Polaris, but again, this will be spread over a much larger area than for a point-like star. On that date, Halley will be far south (-47° declination) and best seen in the Southern Hemisphere, actually passing through the zenith for observers at 47° south latitude. The comet will be very low in the sky. Inbound to the Sun, Halley will make a close approach to Earth on 27 November 1985, at a distance of 0.62 AU (93 million km; 58 million miles).

Among short-period comets, Halley is judged to be large. Its nucleus is believed to be an irregularly shaped sphere, roughly 6 km (4 miles) in diameter, rotating approximately every 2.2 days. The axis of the nucleus is tipped perhaps 45° to the orbit plane. The estimated mass is 100 million million kg.

During the peak of spacecraft activity, on 10 March 1986, the nucleus is expected to produce gas at a rate of 8 x 10^{29} molecules per second; of this, some 80% is expected to be water. Seen another way, this production is equal to 3,000 kg/s (6,600 lb/s). Estimated dust production on that date: general, 600 kg/s (1,300 lb/s) and, in jets, 900 kg/s (2,000 lb/s), for a total of 1,500 kg/s (3,300 lb/s).

The dust emitted by the nucleus will extend roughly 100,000 km (60,000 miles) in the sunward direction and twice that distance perpendicular to the sunward direction in mid-March 1986. Various gases will extend far beyond these distances, but the *visible* gas coma will probably be no larger than the dust coma. The visible gas is largely composed of C_2 (molecular carbon) with small



The Soviet Vega probe.

contributions from many molecular fragments containing such elements as carbon, hydrogen and nitrogen (C_3, CH and CN, for example). Various visible coma structures will be the product of dust jets.

The ion and dust tails of Halley should become fairly well separated. In mid-March 1986, the ion tail should extend about 15° - representing a maximum length of about 80 million km (50 million miles) - in the direction opposite the Sun. At that time, the dust tail will appear to be spread out like a fan, rather than edgewise as in 1910. It will appear to the north of the ion tail as a sort of heart-shaped blob, 2° in length, with its point at the coma. (For scale, the Moon is about half a degree in diameter). Both tails will be visible only in clear, Moonless skies far from any city lights and air pollution, looking like faint, misplaced pieces of the Milky Way.

With each orbit around the Sun, the comet loses an estimated 1-3 m (3-10 ft) of material from the surface of its nucleus. Thus, as it ages, it dims in appearance and may eventually lose all the ices in its nucleus. The tails disappear at that stage and the comet finally evolves into a dark mass of rocky material or dissipates into dust.

It is estimated that an average periodic comet lives to complete about 1,000 trips around the Sun. Halley has been in its present orbit for at least 16,000 years but has shown no obvious signs of aging in its recorded appearances.

The NASA Hubble Space Telescope, scheduled for launch in August 1986, will track Halley on its way back out of the inner Solar System, perhaps all the way to its point of aphelion, 3,280 million miles from the Sun.

All properly documented Halley data obtained from Earth and from space will be stored and then published by the International Halley Watch in 1989 as an archive for use by researchers until the comet next returns in 2061. Data will appear both in book form and on digital videodisc for easy computer analysis.

INTERNATIONAL MEETING

Representatives of the space agencies of Europe, the Soviet Union, Japan and the United States met in Washington DC from 10-12 September to continue discussions on a broad range of cooperative activities in the investigation of Halley's comet. A unique aspect of this meeting was the opportunity to follow NASA's ICE (International Cometary Explorer) spacecraft encounter with the Comet Giacobini-Zinner on 11 September. This was the first time

COMETS GENERALLY

Our knowledge of comets is limited, even for those seen in recent years. This is because the nucleus - which is the real comet and the source of the visible coma and tails - is too small to be seen other than as a point of light. Only our knowledge of cometary motions is on reasonably firm ground.

Comets are believed to have condensed from the solar nebula at the same time that the Sun and planets formed, about 4,500 million years ago. Most are thought to reside in the furthermost reaches of the Solar System, 30,000 to 70,000 astronomical units from the Sun. This distant aggregation from which comets are gravitationally 'pulled' is known as the Oort Cloud, after the Dutch astronomer Jan J. Oort (1900-), who originated the idea, though recent evidence suggests that the region from 1,000 to 30,000 AU might also be heavily populated.

It is believed that comets remain far from the Sun until they are disturbed by the gravitational perturbations of passing stars and forced into closer orbits. Because of their small size and normally great distance from the Sun, they are believed to be the most pristine, unaltered samples of the early Solar System. Planets, moons, even some asteroids, by comparison, have undergone various changes as a result of melting, volcanism and other processes. This is one reason why there is so much interest in comets. Their unique status may hold many clues to a better understanding of the origin and evolution of the Solar System.

Long-period comets are those with orbits stretching from 200 to many millions of years. They are usually the most spectacular. Aphelion (their most distant point from the Sun) is often more than 50,000 AU away.

Short-period comets are those with orbits of less than 200 years. Most reach aphelion near the orbit of Jupiter. Of about 100 well-known short-period comets, Halley is the brightest and the most famous. Actually, it belongs to a group now called 'intermediate' period comets, i.e. not short enough to be regularly influenced by Jupiter but still with periods less than 200 or so years.

All comets have two tails. The first is formed when solar heating causes neutral molecules to be shed from the nucleus. These molecules are given an electric charge by solar UV and X-radiation. When they encounter the solar wind and its magnetic field, the then-charged molecules are carried outward to form a tail that may stretch millions of miles through space. This is known as the ion tail, 'ion' being the general term for atoms and molecules that carry an electric charge.

Gases streaming from the nucleus also carry off a fine dust. This dust, blown away from the Sun by the pressure of solar wind, forms a second tail. It is seen by reflected sunlight and is known as the dust tail.

When the two tails are superimposed on each other, as seen from Earth, the comet appears to have only one tail. This happened in 1910 for Halley. For smaller, less active comets, one or both tails may be too faint to be seen or even photographed and the comet will appear simply as a fuzzy blob of light. All comets appear this way when far from the Sun. Tails usually begin to become visible only within about 1½ AU of the Sun.

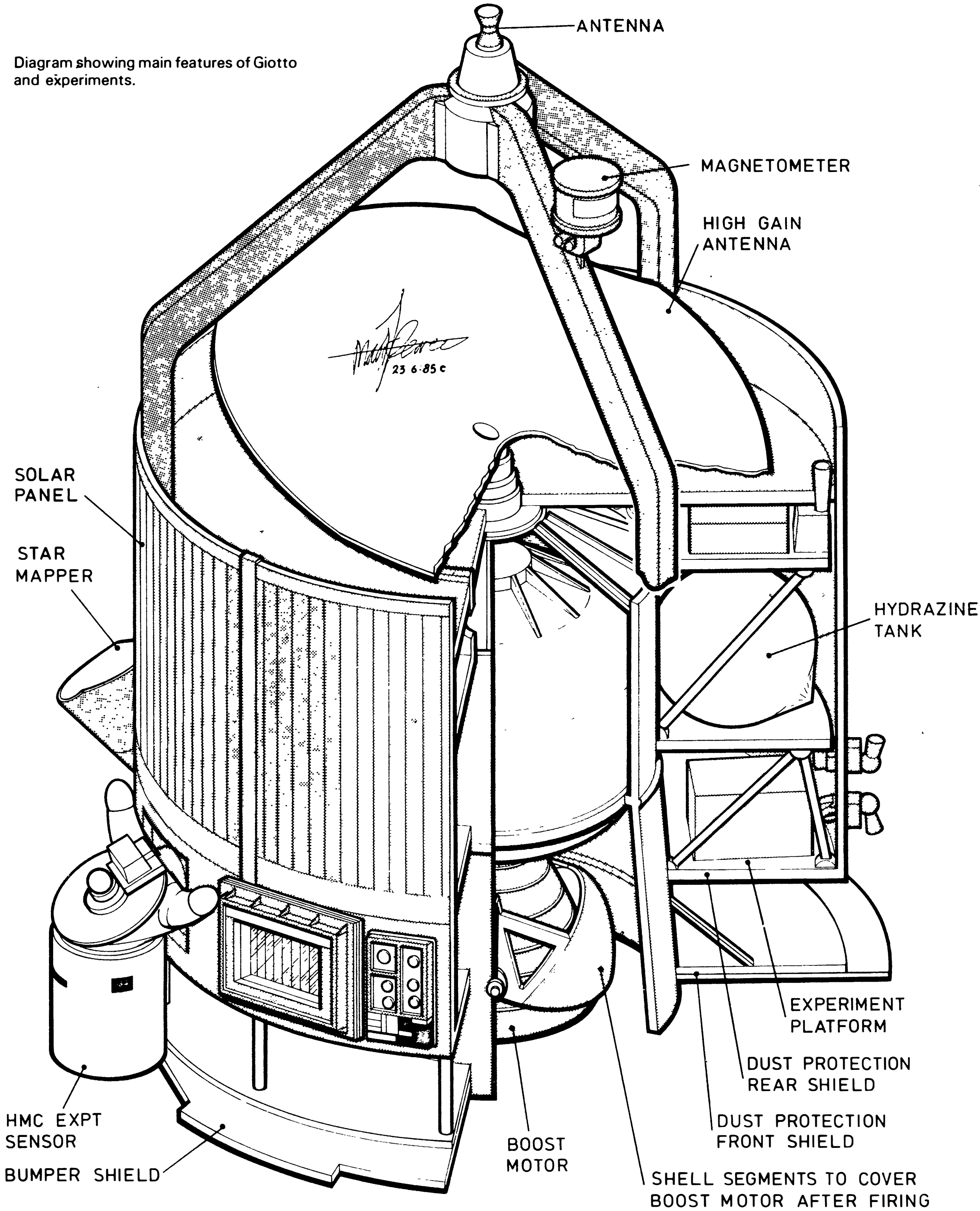
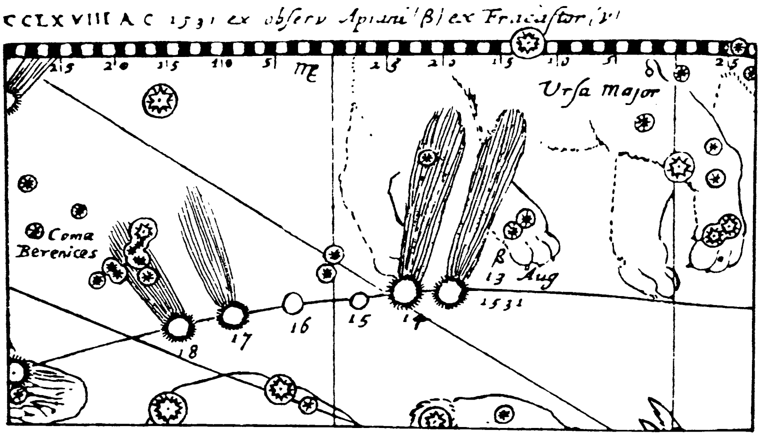


Diagram showing main features of Giotto and experiments.

in history that a spacecraft had flown through, and taken measurements in, a cometary coma and ion tail. The representatives were surprised by the high level of activity displayed in plasma physical processes and by the extent of the solar wind/comet interaction region. These factors are being taken into account in planning mission operations for the March 1986 encounters.

One of the focal points of the coordination is the 'Pathfinder' concept, the joint navigational effort involving ESA, the USSR and NASA. Giotto, which will be the last to fly by the comet, will benefit from data on the position of the nucleus (which is too small to be seen from Earth even with the best telescopes) transmitted by the cameras on-board the two Soviet Vegas which will encounter the comet 7 and 4 days before Giotto. These data will be used to reduce Giotto's targetting error from 300-500 km to about 150 km. NASA will assist in the Pathfinder activities by providing Vega with tracking support from its 64 m deep space antennae in California, Australia and Spain.

On Giotto, 8 out of 10 experiments had been switched on by mid-September for testing and to obtain cruise and science data and also, partially, in support of the Giacobini-Zinner encounter. The remaining two experiments (Dust Mass Spectrometer, Dust Impact Detection System) were switched on in early October.



Observations of Halley's comet in 1531 by Peter Apian.

WATCHING GIOTTO'S HEALTH

Engineers have been monitoring the health of Giotto since launch with a British computer designed primarily to provide advanced communications for large business systems. Information Technology Ltd's Momentum 9000 supermini-computer at the European Space Operations Centre is processing and distributing vast quantities of telemetry data at high speeds despite having only 0.75 megabytes of main memory. This feat is possible because of Momentum's advanced communications architecture, developed to provide fast response for large numbers of varying types of Input/Output devices, such as on a 150-terminal commercial computing system.

Momentum is feeding continuous data on 2,000 Giotto and experiment parameters through an ITL Cablestream Local Area Network selectively into 10 other computers, from Apples to DEC PDP-11s. Momentum's selectable multi-colour synoptic displays of each sub-system also makes satellite and experiment status visible and adjustable without mountains of printouts. Momentum was used as the development base for ETOL, the European space programming language, which allows scientists and engineers to programme their applications without needing to be computer specialists. Cablestream is a range of ITL equipment that makes up Europe's most popular broadband cable local area network (by numbers of installed ports) and is used by many industrial and commercial giants.

RADIO OBSERVATIONS

As Halley's comet approaches the Sun, increasing temperature will cause the sublimation of ices in its nucleus, thought to be really nothing more than a giant dirty snowball. Water molecules liberated and then dissociated by the ultraviolet light will cause it to emit radio spectral lines at 18 cm wavelength by a maser process. The 18 cm lines will appear either as emission or absorption lines depending, in a complicated way, on the exact velocity of the comet relative to the Sun.

Radio observations of the 18 cm lines of OH from Comet Halley will be used to study the production rate of OH, the outflow of gas from the comet, the magnetic field (which may cause a detectable Zeeman splitting of the OH lines), and to test theories of the mechanism of the maser.

A worldwide network of radio telescopes will be observing the comet during its apparition. Jodrell Bank plans to use its 80 m Mk IA telescope to study the comet in January/February 1986, near perihelion. Radio observations will then be particularly useful as the comet will be too close to the Sun for sensitive observations in most other wavebands. During this period, the OH maser is expected to switch several times between emission and absorption, as the comet's heliocentric velocity changes.

HALLEY AND FLAMSTEED

Although Edmond Halley is greatly honoured nowadays, it wasn't always so. A bitter wrangle occurred between Halley and John Flamsteed, the First Astronomer Royal, which was never resolved. Halley had much that was derogatory to say about Flamsteed: the latter responded (in a letter to Abraham Sharp) by called Halley 'a malicious thief.'

Their differences were not due solely to temperament e.g. Flamsteed was brought up on rigorous lines whereas Halley was somewhat intemperate, but to Flamsteed's wish to hold back on publication to enable him to extend and improve his observations.

On the other hand, both Newton and Halley wanted to see his observations and put them to use, the dispute culminating in the appearance of a 'spurious' edition of Flamsteed's observations, edited by Halley, to which Flamsteed responded by buying up as many copies as he could and burning them!

Newton was not above all this. For a long time he was Flamsteed's friend but the dispute grew so bitter that, by reason of his own interest in using Flamsteed's material, he became similarly embroiled.

Review

La Cometa di Halley
P. Maffei, Arnoldo Mandadori, Informazioni Stampa, 20090 Segrate, Milano, Italy, 1985, 418pp.

Those who understand Italian will much enjoy this work. Though a paperback it affords a heavyweight introduction to Comet Halley which is not only well illustrated and well printed but which includes many fascinating illustrations, some in colour.

After the general introduction, the book gets into it stride with ancient and medievel accounts of earlier returns, in most cases accompanied by maps showing the paths of the comet across the celestial sphere. More recent returns are written up extensively, culminating in the 1985/86 apparition which is dealt with in considerable detail and which includes the appropriate star maps and similar information to enable the comet to be readily discovered.

It is greatly to be hoped that the book will also appear as an English edition.

HALLEY'S COMET IN 1910

By H.J.P. Arnold

As Halley's comet speeds toward the inner Solar System, it is understandable that the events of the last 'apparition' in 1910 should be receiving considerable attention. Since that visit was the first to take place in the era of mass newspapers, the manner in which the event was presented to the public, together with the public's reactions, is of particular interest.

Introduction

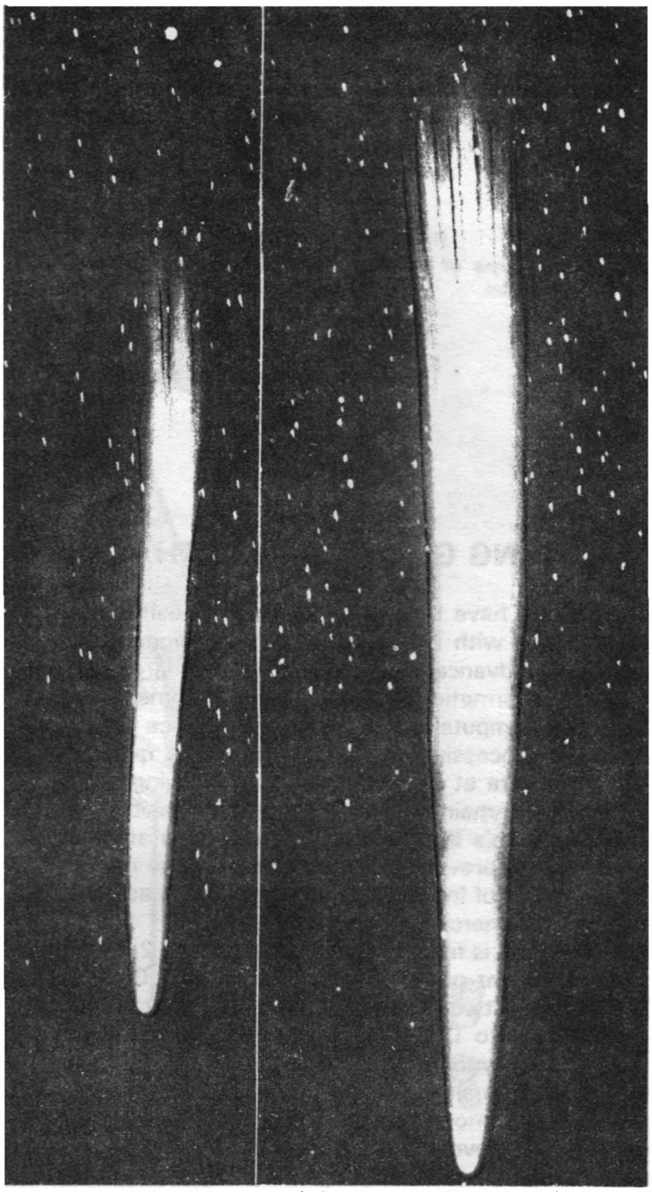
Until now this line of research has tended to concentrate on *national* newspapers and magazines, with the result that the provision of information and reactions at the 'grass roots' level have received little attention. This brief account makes such a local evaluation - for Portsmouth in Hampshire - drawn largely from the pages of *The Evening News,* the area's daily newspaper. In 1910 Portsmouth (chiefly famous for its Royal Navy dockyard which for some years had been leading the *Dreadnought* capital ships building programme), was a large city with a population of more than 230,000. *The Evening News* had a circulation of about 60,000 and the price was 'One Halfpenny.'

An Unexpected Visitor

Paradoxically, the story starts in January 1910 with news of another and totally unexpected comet: the discovery of what came to be called the Great January or Daylight Comet. Following two brief announcements on 19 and 20 January, *The Evening News* of the 22nd went into some detail and reported sightings from around the country and locally. Under the heading 'The New Comet. Where to Look...,' it quoted Mr. Victor Pink of the local company Pink & Sons as having seen the comet from Cosham (near Portsmouth) the previous evening 'below Venus and a little to the right at around 5.30 p.m. while returning home from Horndean on the light railway.' The report then went on to quote authoritative comment from members of the Royal Greenwich Observatory, something that it did consistently in the next few months. E.W. Maunder of the Observatory (a solar specialist but also a great popularizer of astronomy), in a report drawn from the previous day's *Daily News,* stated that 'It is unusual for a comet to be readily seen by the naked eye, even at night; but it is extraordinary for one to be visible in full daylight.'

In subsequent issues, the position of the comet was helpfully given to readers, together with details of observations from around the country as well as the Portsmouth area. On Monday 24 January, a report described the comet as being 'very beautiful' and resembling the 'gorgeous tail of a bird of paradise.' It had been seen by many Portsmuthians on the previous Saturday evening when 'Quite a large crowd gathered on Fratton (railway) Bridge about half past five and had a remarkably good view of the visitant in the western sky. The comet was likened to a falling rocket (but) one lady exclaimed to her husband, who had occupied five minutes in directing her gaze at the wonder "Is that all!" '

In the same story, comments by Sir Robert Ball, Lowndean Professor of Astronomy and Geometry at Cambridge University, were neither academic nor dry. He concluded 'And the wonder of it all is that in a few days more the



Two images of Halley's comet (12 May left; 15 May right) acquired from Honolulu. The tail in the right image stretches some 40°
Hale Observatories

(Daylight) comet would go back to infinity, never to appear again. We do not know whence it comes, nor whither it is going.'

A.C.D. Crommelin at Greenwich (a comet specialist and one of the two men who had done excellent work in calculating the orbit of Halley's comet for the 1910 apparition) took the opportunity to bring the subject around to that more famous (if potentially less spectacular) visitor in *The Evening News* of 27 January by advising 'all observers to be very watchful, because it (Halley's) was rapidly approaching the Sun and at any time it might develop a tail... It will not be visible to the general public until towards the end of April and the beginning of May.'

Of even greater help to the general public was an article that had appeared in *The Evening News* on 21 January which, among other points, cautioned readers that 'The new comet is not to be confused with Halley's comet, which is still a faint telescope object and will not be conspicuous to the naked eye until the last fortnight in May. Bright comets, with the single exception of Halley's, are always unexpected visitors, and the new comet is a further example of the rule.'

As February approached, the stories became quite technical and one - on 3 February - reported that the

comet's orbit had finally been computed accurately but that 'Comet 1910A' - its official astronomical designation - was 'growing fainter.' But it had been spectacular and so far as the general public was concerned its brilliance was to compound the disappointment felt at the appearance of its more illustrious successor.

The Arrival of Halley's Comet

The coverage of the Halley's comet visitation in *The Evening News* can be divided conveniently into the period up to the middle of May 1910, when the newspaper published extremely detailed and well-informed stories on the comet's progress but with limited local content; the period just after the middle of the month at the time of the comet's transit (passing in front) of the Sun and the possible passage of the Earth through its tail; and then the period from the second half of May into early June when coverage remained extensive with interesting local reaction. Throughout this coverage the newspaper combined expert comment (usually from members of the Greenwich Observatory quoted in national publications) with reports from around Britain and the world, again normally quoting correspondents of the national and international press.

The Hampshire Telegraph (a weekly sister paper of *The Evening News*) described an early local observation on 7 May when Mr. M.J. West of Gosport (on the west side of Portsmouth Habour), who was 'much interested in the science of astronomy,' wrote that having failed to locate Halley's comet on several mornings over the previous fortnight, he finally found it with the naked eye between 3.10 and 3.20 a.m. on Tuesday (3 May) from the Recreation Ground at Gosport. 'I also saw it through a low power telescope and although it appeared much larger than when I got my first telescope view of it on 9 February, it did not show much of a tail, which was not surprising in consequence of its low altitude and the approaching dawn...'

Mr. West in Gosport was evidently an experienced observer and an early bird in more senses than one so far as anybody but the professional astronomers was concerned. Crommelin at Greenwich was again quoted in a lengthy article on 10 May. This gave an outline of Halley's history and in particular the quite unjustified association with disasters of one kind and another. On the current apparition, he told his audience at the Victoria Institute in London that, in the last ten days of May, the comet would 'give a fairly good display as an evening star, though it was only right to warn those who saw the great comet of 1882 that Halley's would not compare with it from a spectacular point of view.' (Oddly, Crommelin does not seem to have referred to the brilliant daylight comet a matter of just a few weeks earlier). He went on to add that the ancient records of the brilliance of Halley's comet 'led him to believe that it had declined as the centuries passed.'

Public Alarm

By this time the alarm felt at possible death and destruction resulting from the visitation, and especially the allegedly poisonous effects of passing through the tail, was in full flow. This has been extensively treated in the Halley literature but *The Evening News* gave additional insights. On 13 May, for example, it carried a delightful item quoting Padre Alfani of the Ximenes Observatory who, in a lecture at Florence, sought to ease his audience's worries ('the chances of (the comet) doing any damage to the Earth were a hundred thousand millions to one') and went on to quote the case of 'A man (who) came to him on the previous day to implore him to give a written statement that the comet was harmless, so that he might calm the fears of his mother-in-law.'

The comet and Venus as they appeared from the Lowell Observatory in Arizona on 13 May 1910. The exposure was 36 minutes.

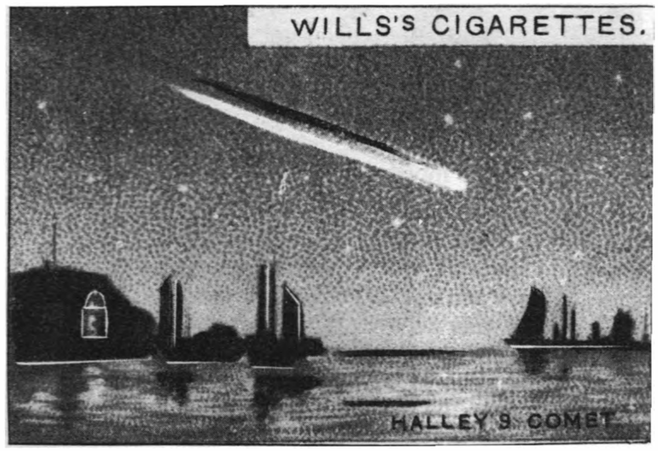
On 14 May (the longest reports appear to have been on Saturdays) the newspaper devoted its story partly to the alleged menace of the comet, partly to scientific reports. Thus the plan of the International Commission for Scientific Aeronautics in the UK to send instruments aloft in balloons 'in view of the possible passage of the Earth through the tail... on the early morning of the 19th' (one of the balloons was due to be launched from a location in Hampshire) was reported, as were accounts of the comet being seen at locations abroad such as Berlin, Aix-la-Chapelle and Odessa. The brightness was quoted as varying from magnitude 1 to 3 - the last (and least bright estimate) being accompanied by the comforting if somewhat puzzling comment that 'this fact now tends to allay the nervous apprehension of the people.' An *Express* report from New York leaned in the same direction. It quoted spectrograms obtained at the Lowell Observatory in Flagstaff, Arizona as showing that the 'dreaded cyanogen gas,' which was supposed to be one of the constituents of the comet's tail, was confined to the head. 'Hence there is no danger of the poisonous gas reaching the Earth.'

Comet's Vapours like 'Kirsch Liqueur'

Also intended to put people's minds at rest were comments attributed in the same *Evening News* story to a report in the *Standard* from Paris of a letter laid before the Astronomical Society there by Camille Flammarion, director of the Juvisy-sur-Orge Observatory and a well-known populariser of science, especially astronomy. Flammarion appears to have adopted a rather quixotic role during this period, starting as many scares as those he attempted to scotch. However, on this occasion he described wild predictions about the comet as being 'only worthy of barbaric ages' and criticised the 'necromancers and such like charlatans (who) were driving (sic) a great trade just now (while) many educated people who ought to know better were sealing up their windows and doors... to protect themselves against the dreaded tail of the coming visitant.' Flammarion predicted confidently that inhalation of any of the comet's diluted vapours 'would resemble that of a glass of Kirsch liqueur and would be simply exhilarating.' Quite why the comet should be associated with a spirit distilled from the fermented juice of a black cherry was not explained!

While the death of King Edward VII early in May doubtless provided the doomsayers with further evidence of the comet's malevolence, *The Evening News* on 18 May (the day of Halley's transit of the Sun) adopted a bantering tone. Its story was sub-headed 'Twixt Earth and Sun to-night' and began 'To-night Halley's comet passes between the Earth and the Sun, and we are looking forward to being whisked by the end of its tail.' It stated that the tail was now about 14,500,000 miles long and that 'we may just be flicked by it between midnight and three a.m.' *The Evening News* advised its readers that after the transit the comet would become an evening star but that for a few days it would be too close to the Sun to see. '... (For) the first popular view for people who object to leaving a warm bed at half-past two in the morning, and going to a high place, we shall most likely have to wait until Saturday.'

Very lengthy coverage on the following day (19 May), while briefly quoting a Greenwich Observatory official on the chances of seeing the tail from Britain, concentrated on foreign reports under the sub-heading 'Serious and Comic Results.' The San Remo correspondent of the Paris *Journal* reported that one man had jumped into a well and drowned and that another 'not wishing to wait for the comet, killed his wife with a hatchet and afterwards



Halley's comet continued to be a popular astronomical theme long after the 1910 appearance. This is a cigarette card issued c.1928.

hanged himself from a tree.' But mostly the touch was light. In France the subject was being treated 'in a spirit of light hearted banter' while Germany was indulging in 'popular festivities.' In Rome it was like New Year's Eve with cafes and restraurants remaining open all night. Most people in Spain were celebrating the transit 'with great joy' and in Madrid 'to the sounds of guitar and tambourine' they were going to 'elevated positions to view the comet which however will probably not be visible as the sky is overcast.' This last report continued: '(Far) from being... the subject of superstitious terror, the passage of the comet and its terrible tail close to our planet forms, on the contrary, a cause of mirth and of entertainment, gastronomic as well as astronomic, for families can be counted by the hundred who, the better to observe the vagabond orb, have laid in plentiful supplies to fortify them in their vigil.'

There was some serious scientific comment on 19 May (and an indication of good weather in the USA at least) when the distinguished Professor Barnard of the Yerkes Observatory was quoted as saying delightedly that the comet was 'a most striking object, brighter than any portion of the Milky Way and it could be traced a distance of 107 deg...' Whimsy, however, was never far away and another story described strange happenings in Southfields (London) the previous night, where 'myriads of tiny crystals... covered the pavement in all directions and sparkled in the moonlight like hoar frost.' It was a warm night, *The Evening News* observed, yet 'whether the phenomenon had anything to do with the comet, however, is an open question.' More prosaically, but not to be entirely outdone, it reported that in Portsmouth on the same night 'it is stated that the Northern lights were very much in evidence.'

Strange Smells

On Saturday 21 May, *The Evening News* headed its lengthy coverage 'Have we Brushed the Tail?' and quoted conflicting and abstruse arguments by scientists around the world. (In fact, there is still no agreement on whether the Earth passed through the tail in 1910.) While the comet had been a 'magnificent spectacle for many nights' on Mahe in the Seychelles, the Geneva correspondent of the *Daily Chronicle* wrote that 'crowds of tourists, Alpinists and Swiss Scientists have been disappointed as Halley's comet was invisible owing to the clouds.' Camille Flammarion also reported bad weather and more particularly that a watch of five observers at the Juvisy Observatory on the night of 19/20 May noted no instrumental effects of passage through the tail but that 'at about half-past two, four of the observers had certain olfactory

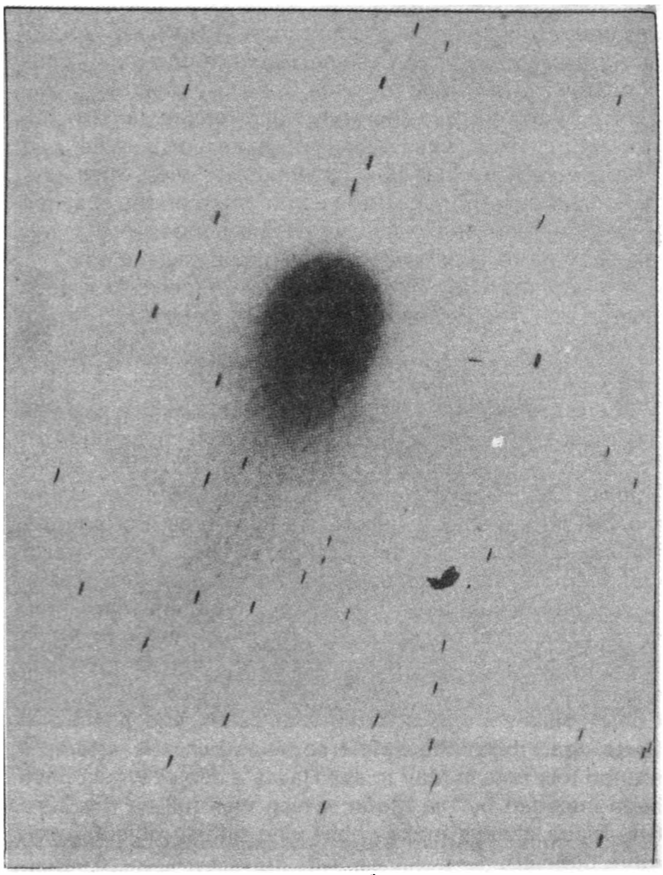
experiences which are described variously as a smell of burning vegetables, of a marsh, or of acetylène. During the night, the nightingale was silent...'

The Evening News writer, however, appeared more taken with the experience of a South Wales magistrate and amateur astronomer who had gone out to observe the comet and was confronted by a detective, who asked what he was doing. 'I am looking for the comet.' 'That's all very well, but I have been watching you for some time now and your movements have been very suspicious.' The detective remained incredulous 'until invited into the house.'

Local Observers

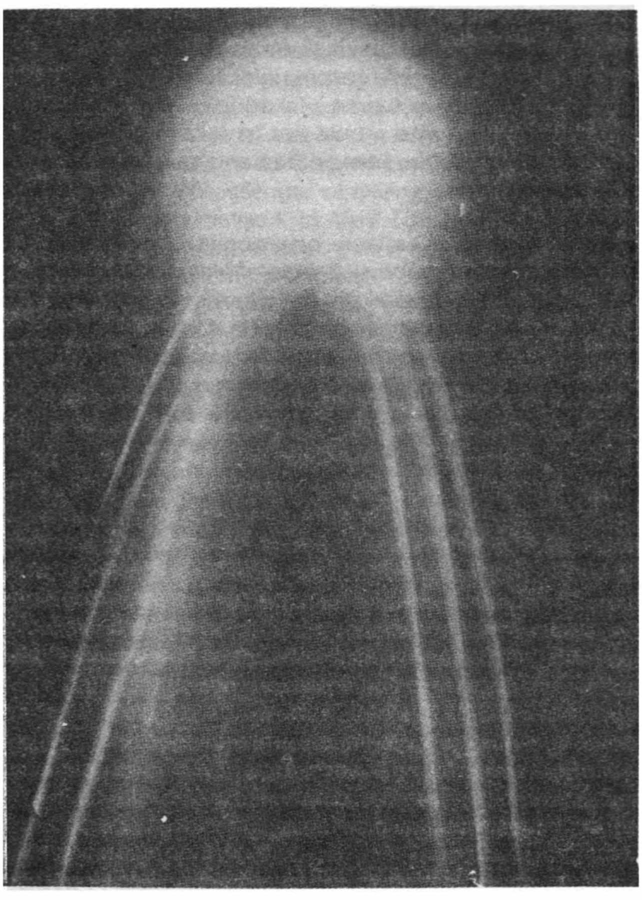
More seriously, there appeared in the 21 May issue a letter from Annie M.H. Sturdee of Southsea, dated 19 May. Miss Sturdee was clearly a keen student of astronomy and wrote how terribly disappointed she had been on the previous night not to see anything of Halley's comet. There had been thunder and lightning and then 'flashes from a searchlight every now and again between 1 and 2 a.m. (which) were unappreciated under the circumstances.' Earlier in the evening, however, she had seen a fan in the sky 'alternate rays of light and dark slightly north of west' which were quickly obscured by cloud but which she was convinced were due to the proximity of the Earth to the tail of the comet. 'The interesting spectacle compensated me for my long and uneventful morning vigil.'

The Evening News obviously believed it had a capable local astronomer in Miss Sturdee since it quoted her on 23 May as saying that 'the last phase (sic) of Halley's comet may be seen early from the (Southsea) Common... between the hours of 9 and 11 p.m. provided the western sky is free from clouds.' She sketched the location of the comet in the sky on the previous evening 'though the clouds prevented a good view' and went on that each night 'the comet will appear a little higher up and further away from Mars as if steering for Regulus (in the constellation Leo). 'Amateur observers will do well,' the perceptive Annie Sturdee continued 'to keep as far away as possible from the electric lights, which are not helpful to star gazers.'



A 20 minute exposure taken with the 75 cm reflector at Khedivial Observatory, Helwan, Egypt captured Halley on 3 June 1910 as it headed back out into the Solar System. (Negative image).

One of the more frequently reproduced pictures of the Comet is this Hale Observatory image produced on 8 May 1910.
Hale Observatories



In this same issue, and that of 25 May, while splendidly clear conditions for observing the comet were reported around the world from Johannesburg to Constantinople, Britain had to be content with very patchy visibility to say the least. Good views had been had from Dover and 'glorious visibility' for over an hour and a half at Brunscombe but generally the story was gloomy. London was disappointed in the comet as 'not much to look at,' while to a local Portsmouth correspondent who saw the comet briefly on Sunday night (22 May) from the top of Portsdown Hill (to the north of the city) it appeared rather as 'a blurred star with a diffuse light. As the clouds separated for a second or so, a faint tail could be seen pointing upwards and to the south....It was not nearly so conspicuous as the Daylight Comet.' On 24 May the comet had been just visible to the naked eye from Totland (Isle of Wight) but for the 'large numbers of people... eagerly looking for the comet, the sight they obtained was evidently disappointing.'

The Flammarion story of strange smells published in *The Evening News* of 21 May was taken up in a letter from 'M.G.W' in the issue of 26 May. This quoted a lady of Bembridge Crescent (Southsea) waking up between two and three o'clock on the morning of 19 May 'with a painful sensation of suffocation.' The room was filled with the smell of some noxious gas and 'a lady in Victoria Road also gave me an exactly similar account... It was not a pleasant experience of the comet.' Today, perhaps,

this would be the signal for an avalanche of letters but only one response to the account from M.G.W. was found during a search of *The Evening News* at this time. One Monckton Hoffe writing from the Queen's Hotel, Southsea reported waking up in the early hours of the same night in a room which 'seemed full of fumes of sulphur' - a room, moreover, that had its windows wide open and looked out over the sea. Hoffe commented on the absence of any mention of the subject in the London press and queried whether the incident had any Earthly explanation. 'I am sure the *Daily Mail* could have made quite a nice column on "The Suffocating Citizen of Southsea".'

The Comet: 'A Fraud'

Scare stories and strange happenings aside, perhaps the most comprehensive and despondent description of Portmouth's experience of Halley's comet in 1910 appeared in *The Evening News* of Thursday 26 May. Under the heading 'Halley's Comet. Disappointed Portsmouth Amateur Observers' the author wrote: 'After much watching and the exercise of the patience of Job, Portsmouth has at last seen the comet... Nothing more than an insignificant starry smudge in the western sky to which those whose enthusiasm was not altogether damped (sic) cheerily added a tail. To those who had seen the Daylight Comet, Halley's was a fraud, a delusion, and a snare...' Quite apart from the indifferent weather, the attempts around this time in May to see Halley's comet would have been impeded by the Moon, which was full on the 23rd (the Moon always makes observing diffuse objects even more difficult).

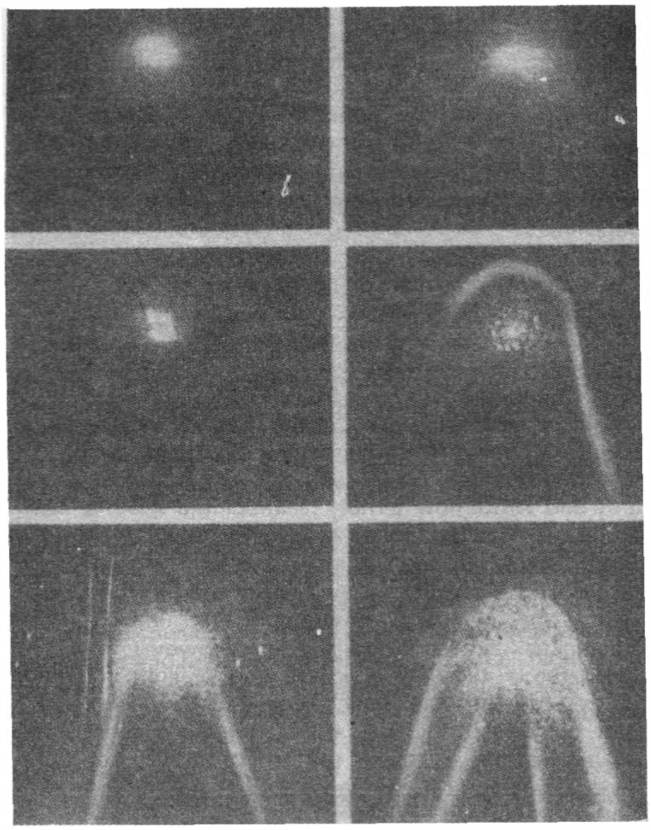
In the same issue, E.W. Maunder of the Greenwich Observatory in a talk to the British Astronomical Association, gave a more balanced and less emotional evaluation. So far as Londoners were concerned he admitted that 'Halley's comet had gained for itself a bad reputation. Most Londoners looked upon it as a distinct fraud but really that was the fault of our positon. Drawings and photographs from other parts of the world showed a far different looking object.'

And that was one of the last mentions of the comet in *The Evening News.* On 3 June a claim by E.S. Grew in the *Graphic* that comets might originate on Earth and that the Krakatoa explosion may have created a small comet, was reported, mercifully without comment. Subsequently there were further reminders of the very unstable weather of the period and a story published on 8 June was headlined 'Thunderstorm Fatalities' and 'Deaths by Lightning.' No doubt some blamed it all on the comet which, so far as the general public was concerned, was now fast disappearing back into the far reaches of the Solar System from which it is now returning.

Conclusions

A number of general conclusions may be drawn from this piece of local research.

1. The coverage by *The Evening News* was extensive, informative and lively. Any person who read the newspaper carefully would have had a good knowledge of the main events of the apparition - but (and this is a reflection on the limited astronomical knowledge of the time rather than a criticism of the newspaper) they would not have gained much of an idea of *what* a comet was. While *The Evening News* coverage in 1910 was in depth and frankly lengthier than may be the case in 1985/6, there was an absence of feature articles presenting a general description and analysis of the apparition. At this time, too, the newspaper reproduced few photographs and there were no images of the comet.



Computer enhancement of two original images (at top: 7 May 1910 left; 8 May right) highlight finer structure. *S. Larson*

2. Quotations attributed to foreign astronomers and (more frequently) to members of the Greenwich Observatory were helpful and were, for example, quick to warn the general public in this country that their sight of Halley's comet would not be as impressive as that of some earlier comets. (It is a sad fact that the prospects for the 1985/6 apparition are even worse.) In addition, a regular and attentive reader would not have confused Halley's comet with the unexpected and earlier Great January Comet.

3. While the skies were occasionally clear and there were some good sightings of Halley's comet, it is evident that generally the weather was poor in the UK at the critical times. Thus, the Portsmouth experience may be regarded as fairly typical of much of the country. This was a major contributory factor to what was obviously the considerable disappointment felt by the general public. This leads to a final conclusion:

4. People still alive today who remember seeing a comet in 1910 or having one pointed out to them would have been, in most cases, between about five and ten years old at that time. It seems certain that most would not have seen Halley's comet but its brilliant and unexpected predecessor.

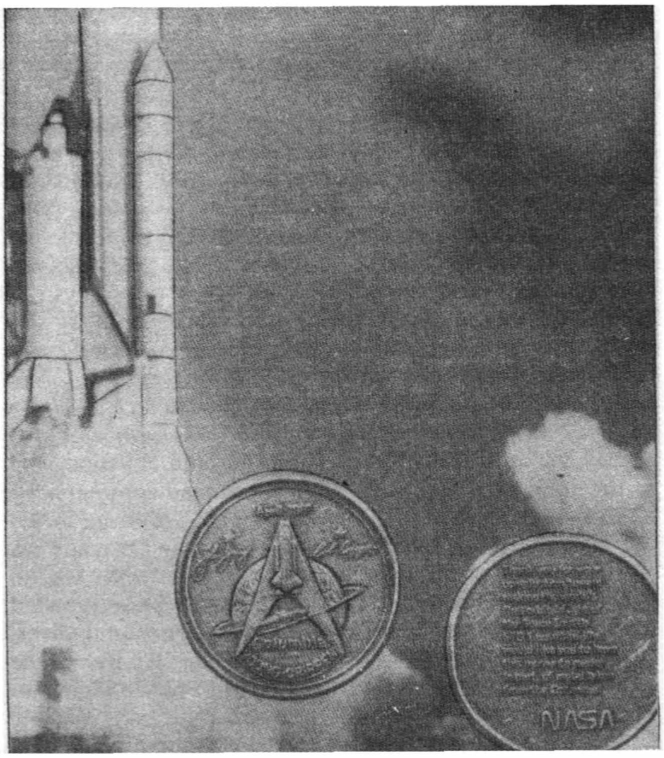
Acknowledgements

The author would like to thank Ms Pamela Towlson of the Royal Astronomical Society Library; the staff of the local history and newspaper sections of the Central Library, Portsmouth, as well as the staff of the Havant Library; and Mr. A.W. Garrett for their valuable help.

SPACE MEDALLIONS

By L.J. Carter

Coins and medallions have long been used to commemorate historical events. Among those of great historical interest are many concerned with the appearance of comets - formerly regarded as harbingers of pestilence and death. Most are in the hands of museums or private collectors. Nowadays, however, medallions are available at modest cost to commemorate every significant step in the space age. They are of great intrinsic merit and interest and can form the basis for a most intriguing collection.



A medallion issued by NASA to mark the first flight of the Space Shuttle, 12 April 1981. *NASA*

Coins and Medallions in History

Coins depicting comets were issued in Roman times, struck after the death of Julius Caesar by the Emperor Augustus, Julius' adopted son. There are a number of variants. One shows the head or bust of Julius Caesar with a "hairy star" (the comet of 44 BC) above, the usual representation of a comet in those days. Other Augustinian coins are similar though relating to the appearance of a comet in 17 BC, thought to be a reappearance of the soul of Julius on the occasion of the Saeculer Games (held normally every 110 years) arranged by Augustus, as shown by the herald on the reverse of many of these coins.

Up to and including the Middle Ages a number of spectacular comets appeared which coincided with dire events on Earth and thus found their way into medallions. For example, the great comet of 1558 "unquestionably announced" the death of the Holy Roman Emperor, Charles V that year, according to contemporary writers e.g. "the death of Charles was foretold by a Comet. At the beginning of his sickness it inclined to the North, at the end it became fixed over the monastery itself and disappeared when Charles was dying."

Stories surrounding medallions concerned with such events make fascinating reading e.g. the Comet of 1664-5 which was seen by Newton and Hevelius. The common people insisted that it was in the form of a fiery sword, pointing to the doomed City of London. It was widely thought to be a Messenger of Divine Wrath. Their worst fears were soon realised. In May 1665 the plague broke out and before long almost every household door bore the long cross and the inscription "Lord have mercy upon us" which told of the plague within. There were no domestic animals left. No dog bayed and no cat walked at night, for 40,000 dogs and 200,000 cats had been killed in the belief that they had conveyed the plague. No infants lived that year. The dead were interred in great trenches with many, no doubt, sharing a like fate though still alive. Out of a population of nearly half a million, at least 100,000 died though, without reliable estimates, it could have reached twice that number.

Scarcely had the plague gone than another terrible disaster befell London. This time it was the Great Fire. The medallion issued in 1666 commemorates this doleful story in depicting a flaming background, dead trees and an air of general desolation.

Recent Comets

With the rapid discovery of more and more comets in the 20th century - but none really spectacular - little has been done to commemorate them. As far as is known, the first medallions commemorating Halley's comet were for its 1910 apparition and were minted mainly in Germany. Several have already appeared in anticipation of its 1986 return and many more will probably emerge. A medallion appeared to commemorate Comet Kohoutek but is now hard to find.

Medallions on general astronomy topics, too, are hard to find though three types of medals, designed by William Andrews, were struck by the Royal Mint in gold, silver and gilt-bronze, respectively, to commemorate the tercentenary of Royal Greenwich Observatory in 1976. These were the only official medals of the tercentenary but there may have been others. The obverse of all three depict Flamsteed House, with reverse designs of an armillary sphere (for astronomy), Harrison (for time) and Ramsden's sextant (for navigation). All are 5½ cm in diameter; the gold medals are 22 carat and weigh approximately 155 g; the sterling silver medals approximately 90 g. Both are hallmarked at Goldsmith's Hall, London. The issue was limited to a maximum of 100 each of the gold set, 1,000 of the silver and 3,000 of the bronze.

Tokens

Further variation took the form not so much of medallions but of tokens or inscriptions. Superstitions, too, had not died out. The wine of the years when a great comet appeared was said to be excellent e.g. the comet 1811 gained further fame on the grounds that its appearance coincided with an unusually good port wine, while the wine in 1858 was also said to be better than that of any others "because of the influence of the comet." The comet, therefore, became a favourite brand or trademark for wines - particularly champagne wines from Europe. Most were impressed upon the bottles themselves but at least one supplier struck a very neat tiny medal to hang around the necks of the bottles.

Strangely, no comets are depicted in any of the wide range of tradesmen's tokens issued in the UK in the 17th, 18th and 19th centuries. Some thousands of designs were created on almost every topic imaginable but the only tokens remotely concerned with an astronomical

topic are those showing Sir Isaac Newton, issued in Cambridge in the 19th century.

Space Medallions

Many medallions have been struck to honour individual contributions to space developments though most have been of a "one off" variety. This category includes, for example, the gold medals awarded by our own Society to Yuri Gagarin, Valentina Tereshkova and all three Apollo 11 astronauts, Neil Armstrong, Edwin Aldrin and Michael Collins. Others have appeared with more general circulation, e.g. the medallion issued to participants at the 1976 IAF Congress. An even higher number of Soviet medallions have been struck honouring Gagarin, Tsiolkovsky and others, though few are available in the West.

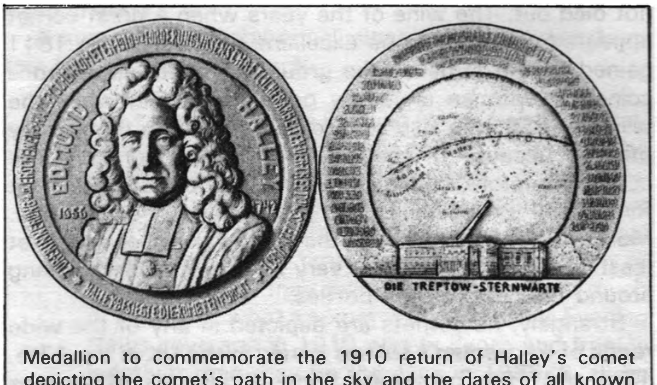
Space medallions really came into their own with the advent of the American manned programme. Practically all of the hundreds of different types produced commercially were issued in America. Only a few were produced in the UK but others appeared in France, Spain and Guyana, to name but a few. Members of the Society who visited Cape Kennedy during the Apollo shots were regailed with collections of medallions, both in bronze and silver, depicting all the Mercury and Gemini flights, since extended to include Apollo, Skylab and Shuttle flights to date, including the Spacelab mission.

The commemorative space medallions most easily and inexpensively acquired are those of solid bronze, usually packed in a plastic display case with a simulated velvet background. The normal price is around £2, which puts them well within the pocket of nearly everyone. Practically all are extremely well-designed and suitable to collect, though are probably not subsequently displayed as much as they deserve owing to competition from the more colourful decals (gummed stickers), mission patches, etc.

Even more space-related are a variety of medallions produced by NASA or their contractors for specific space events e.g. the approach and landing tests of Shuttle *Enterprise* in 1977 or coins handed out at anniversary dinners. Those issued by NASA contain many made from alloy mixed with a small part of the structure of the particular spacecraft commemorated, with the result that each medallion, presumably, contains minute specks from the actual craft. Some 200,000 were issued for the Apollo 8 flight; the same for Apollo 11 and more for the ASTP mission.

The Apollo 11 medallions contained metal from both *Eagle* (lunar lander) and *Columbia* (Command Module). Another 100,000 were struck in the case of Skylab, for issue on 14 September 1974, the flown metal being from a camera bracket weighing a little over ½ kg. These medallions were made of aluminium, with a reeded edge. They were 4 cm across and weighed 4.7 grams. For STS-1, 98,000 medallions were struck under a US Government contract and distributed to all employees on the first Shuttle launch on 12 April 1981. Each medallion contained a particle of metal carried aboard *Columbia's* first flight. A related example was the 25th Anniversary coin given to all NASA employees on 1 October 1983. In the case of dinners, a small piece of ASTP flight material was used in the metal for producing souvenir medallions distributed to 2,000 attendees at an Annual Goddard Memorial Dinner. A National Space Club medallion contained material from Apollo 8, Apollo 11, Skylab, Apollo-Soyuz and even from an early rocket built and flown by the late Dr. Robert H. Goddard. This was a bi-centennial medallion (1776-1976). The front depicts a space helmet, one of Goddard's early rockets and the then projected Space Shuttle. Practically none are on the market at present but, in years to come, a fair proportion will undoubtedly find their way into the hands of dealers from whom they may be purchased.

The French mint struck this medal to commemorate the discovery by Jules Janssen and Norman Lockyer of the method of observing solar prominences without waiting for solar eclipses.
(By kind permission of the Cambridge University Press, from Gingerich, 'Astrophysics and Astronomy to 1950').



Medallion to commemorate the 1910 return of Halley's comet depicting the comet's path in the sky and the dates of all known earlier returns (German).

Coins

Flights to the Moon were also commemorated by an American Silver dollar (actually made of copper and nickel) issued in 1972. This shows a representation of President Eisenhower on the obverse and the Apollo 11 Eagle above the lunar surface on the reverse. 62 million were issued. One of the three dollar coins minted to mark the American bicentennial (1776-1976) also showed President Eisenhower on the front and the Liberty Bell on the reverse but with the Moon also appearing in the background. Versions in both silver and bronze appeared.

Last year the USSR issued a rouble depicting Valentina Tereshkova, the first woman to orbit the Earth. Nearer to home, the Shuttle appears on a crown issued in the Isle of Man in 1983 as part of a set of five to commemorate the bicentenary of Manned Flight.

The 500th Anniversary of Copernicus saw the issue of commemorative coins in Poland and East and West Germany.

[The Society will be interested to receive details of coins or medallions that members come across relating to Halley's comet which appear overseas. Collecting such medallions will prove just as rewarding now as in the past.]

HERMES: THE FRENCH SHUTTLE

By Martin Sénéchal

France intends to press ahead with its Hermes mini-shuttle even if the project does not become part of ESA's programmes. In the light of recent announcements the author looks at competitive studies carried out by Aerospatiale and Dassault-Breguet.

Characteristics

Basic specifications as set by CNES (Centre National d'Etudes Spatiales), the French Space Agency, call for a delta-winged, reusable spaceplane, 15-18 m long with a wingspan of 9-11 m. The weight has to be limited to 13-17 tonnes, imposed by the choice of Ariane 5 as the launch vehicle. The launch weight includes 2.5 tonnes of propellant for orbital insertion, in-orbit manoeuvres and reentry. A payload of 4-5 tonnes could be carried in the payload bay, which has a diameter of about 3 m and a volume of 35 m^3.

Hermes would be used as a service vehicle for space stations, transporting crew and cargo. Missions include the assembly of space structures and scientific and applications experiments. In-orbit maintenance, repair and refurbishment of unmanned satellites and platforms could provide some after-sales service for Ariane-launched vehicles. NASA has repeatedly cited this as a major advantage of the US Shuttle launches over the unmanned Ariane.

A typical mission would take the craft to a circular 400 km orbit inclined at 0-30° with a crew of two pilots and up to four scientists or engineers. The duration would be eight days but that could be extended to 30 days with a smaller crew, and to 90 days when docked to a space station. Sun-synchronous orbits are also possible at altitudes of 500-800 km with a payload of only 1.5-2.5 tonnes and a crew of 2-4.

Hermes will land on a runway at the Ariane launch site in Kourou, French Guiana, or at a specially-prepared site in Europe. A landing will be possible after only one revolution, even in a near-polar orbit, with a cross-range manoeuvring capability of 2,500 km over a reentry trajectory of 9,000 km. This capability has a considerable effect on the design of Hermes.

Ariane 5

Hermes will be launched atop the expendable Ariane 5, a heavy-lift booster. Development of Ariane 5 was approved during the European Space Agency's Ministerial-level Council meeting in January 1985. The current design focusses on a configuration called Ariane 5P which has a central body with an HM60 large cryogenic engine with two side-mounted strap-on solid boosters. The HM60 is currently under development as a separate ESA programme. Ariane 5P will be developed for launching satellites but will be reliable enough to be man-rated.

Ariane 5P's cryogenic motor and boosters would be ignited on the pad to ensure that the propulsion system is functioning before liftoff. Sea-level thrust of the HM60 is to be 770,400 N, with a thrust at altitude estimated at 1,004,400 N, the engine burning for 500 seconds. The solid boosters would be 19 m long and 3 m in diameter, carrying about 170 tonnes of propellant and burning for approximately 117 seconds. The Ariane would be able to lift a maximum of 13 tonnes into a Sun-synchronous transfer orbit or the Hermes spaceplane into low Earth orbit. The first flight of the rocket is expected during 1994, with operational missions beginning a year later.

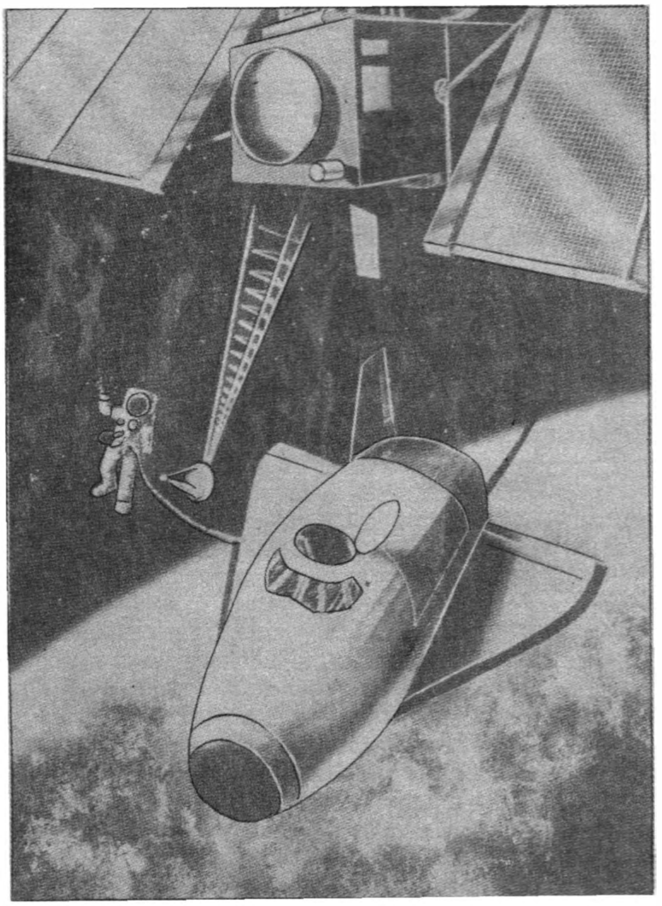
The Aerospatial Hermes design. *CNES*

The initial flight of Hermes would occur during the second half of the 1990's. Full scale development would start in 1988, enabling the first flight to be conducted during 1997. Intermediate milestones on the CNES calendar include production of demonstration and engineering test models in 1990, followed by systems testing between 1993 and 1996. Development costs through the initial two test flights are estimated at £1,050 million, with £9 million provided for Hermes studies in 1985-86 and £15 million in 1987.

European Cooperation

Since France wants Hermes to become an ESA programme, CNES gave a project-briefing to member states before the top-level ESA meeting in January 1985. Reaction from other members was encouraging and the final resolution of the Ministerial-level meeting states that the French decision to undertake the project, in association with other European nations if possible, was noted with interest. France and her partners were asked to keep ESA informed of the progress made in Hermes studies with a view to including this programme in the Agency's plans as soon as is feasible.

France is determined anyway to continue development and will seek bi-lateral agreements with other European nations if this route is adopted. In 1977, when the SPOT Earth-resources satellite was not accepted as an ESA project, France pressed on alone before being joined by Belgium and Sweden. A number of countries, including Belgium, Sweden and Italy, have already shown interest in CNES' plans and could join France, who would provide 50% of the funding. Other participating countries could enter the programme after CNES has chosen a prime



Hermes in orbit. *CNES*

contractor - a decision expected in the autumn of 1985.

The prime contractorship was the issue of sharply-contested competition between two leading French aerospace companies, Aerospatiale and Dassault-Breguet, with both finishing preliminary studies in March 1985.

The Aerospatiale Proposal

Aerospatiale has used its experience gained from working on missiles and reentry vehicles, the Ariane launcher, communications satellites and civil aircraft such as Concorde and the Airbus series. Their proposed mini-shuttle is 15.5 m long, with a delta wing and small, vertical stabilisers at the wing-tips. Wingspan will be 11 m. A large, centreline vertical stabiliser is located behind the payload bay above the orbital manoeuvring engines. The payload bay has a volume of 35 m^3 and there is a docking/EVA port between the bay and the cockpit area.

Hermes will be an unstable 'plane during most of the reentry and approach stages, when it is slowing down from orbital speed (7 km/sec) to the landing speed of 300 km/hr: Hermes will thus have to be controlled by fly-by-wire under the command of computers and sophisticated software. Here, the work done by Aerospatiale on Concorde (the first transport aircraft with fly-by-wire controls) and the Airbus A-320 (the first with sidestick mini-controllers and fly-by-wire controls) is important.

Sidestick flight controllers are used in the Hermes cockpit, which is clearly inspired by that of the Airbus. One of the two sidesticks controls rotation, while the other commands movement along the three translational axes. The lack of centre-mounted control sticks allows pull-out tables to be installed in front of each pilot. The main instrument panel is fitted with five cathode-ray tubes displaying orbital, navigational and systems data, along with trajectory information required for reentry and landing. The pilots' seats are placed on the forward floor section of the cockpit and are raised to maximum height during the final approach to give sufficient dowards visibility through the windshield. Seats for the remainder of the crew will be located behind the pilots and will have sufficient room between them to add two more seats for astronauts being transferred to or from a space station. These additional seats could be stored on the space station itself or placed under the experimenters' seats when not in use. All seats can be folded out to allow the crew to sleep. Cockpit volume is approximately 26 m^3, which is far more than the minimum requirement set by CNES at 3 m^3 per astronaut. An additional space of 6 m^3 is available under the floor for avionics and life-support equipment.

Propulsion into orbit after Hermes separates from its launcher will be provided by two 20 kN engines mounted in the rear fuselage. Attitude control is provided by a system of eight vernier thrusters on the forward and aft fuselage and these are similar to those already used on Aerospatiale's satellite designs. Dissipation of excess heat from the systems on-board (several kW), the crew (130 W per man) and the variable heating from the Sun will be necessary once orbit is reached. Radiators on the inner side of the payload-bay doors assure the necessary heat loss, circulating cooling fluids through pipes in the radiators.

The cockpit in Aerospatiale's design is an independent, light alloy structure fixed to the interior of the main airframe at four points. This method was dictated by weight and environmental control considerations but also results in less risk of leaks from meteor strikes and gives improved crash protection. Power could be provided by fuel cells, solar panels or thermo-electric generators. All three possibilities are under study.

Experience in thermal protection has been gained by Aerospatiale through its research on carbon materials used as protection for missile reentry vehicles.

The Dassault-Breguet Proposal

Dassault-Breguet has used the expertise acquired from work on its Mirage, Jaguar and Alpha Jet military aircraft and their related avionics and electronics systems. This design bears less resemblance to the American Shuttle than does that of Aerospatiale. It also incorporates a delta wing with modified winglets as vertical stabilisers but has a more slender appearance and there is no large vertical stabiliser in the centre of the rear fuselage.

The crew compartment is equipped with six cathode-ray tube displays, with two touch-screens to facilitate dialogue with the complex on-board systems, and mini-sidestick controllers. The possibility of voice-control of the craft has also been studied.

In 1972-74, the company worked with Grumman on thermal protection for the American firm's Shuttle proposal and produced a system that proved, during tests, to be able to resist around a 100 simulated reentrys at 1,200°C, similar to Hermes' requirements.

Crew safety will be assured by ejection seats, as used in military aircraft; Dassault proposes the system already used in the Falcon 50 prototype. This is usable even at very low altitudes and could, for instance, be used in the case of a failed landing approach.

HERMES UP-DATE

Since this article was written CNES has named Aerospatiale as prime contractor for the programme, with Dassault-Breguet assuming delegate prime contractorship for aeronautics design of Hermes. See *European Rendezvous,* page nine of this issue.

THE INDUSTRIAL SPACE FACILITY

By Dr. Michael Sheehan

The US Space Station will not be operational until the mid-1990's but before the end of this decade a large man-tended space processing platform could be in orbit.

Introduction

On 20 August 1985 NASA opened a new era in the commercial exploitation of space when it signed two agreements with the small Houston-based firm of Space Industries Inc. (SII), which will allow the company to deploy its Industrial Space Facility (ISF) from the Space Shuttle. The ISF is the world's first privately-owned, commercial space platform. NASA Administrator James Beggs declared on signing the agreement that, 'we hope the ISF will be the first of many such platforms to be built by private industry to complement the permanently manned space station and lead, eventually, to an industrial park in space' [1].

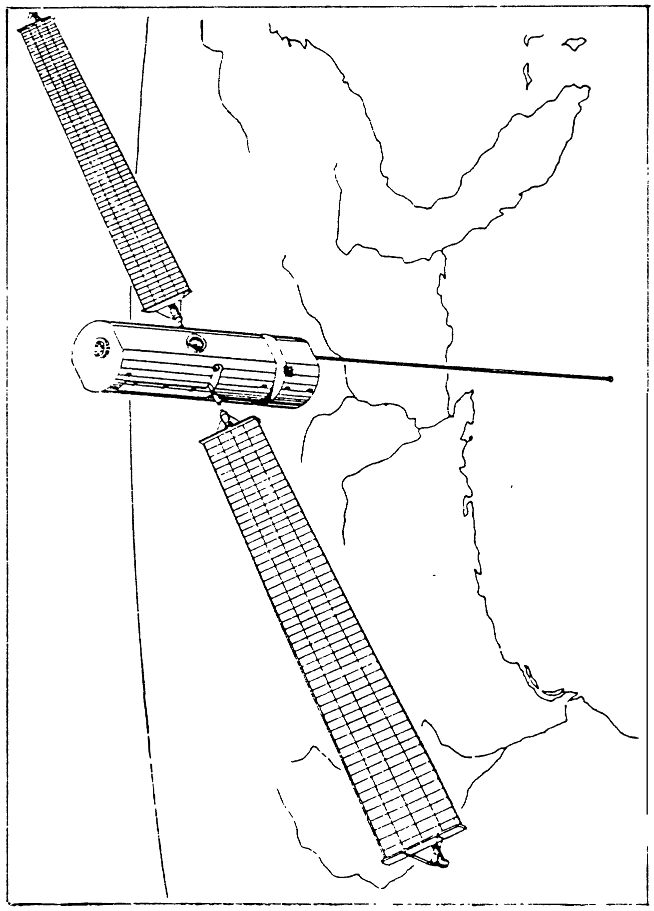
NASA, in fact, seems to have gone out of its way to be helpful to Space Industries. The total cost of the project is likely to be approaching $500 million by the time initial deployment occurs in 1989. That is an enormous financial undertaking for a small, three-year-old company, so some sceptics have raised doubts about its ability to finance the venture. NASA has given the company a considerable helping hand by deferring payment for the 2½ Shuttle missions that will be required to get the facility functioning in orbit. NASA's normal arrangement is to be paid in advance for such launches. The deferred payment arrangement is expected to save Space Industries some $200 million in 'front-end' expenditure. The company will, instead, pay for the flights with the income produced by renting the facility to companies interested in exploiting the commercial potential of near-Earth orbit.

The generous NASA terms appear to be one of the first fruits of the new American policy for the commercial use of space announced by President Reagan in July 1984. The policy was aimed at encouraging and accelerating private sector investment and involvement in space-based business.

Modular Concept

The Industrial Space Facility will be modular in concept and will measure some 10.7 m by 4.4 m. Attached to the facility will be a 3 m supply module capable of being routinely replaced so that products can be returned to Earth and the facility restocked with key expendables. Supply module exchange will be accomplished using the Shuttle's Remote Manipulator System. Visits for facility resupply are currently planned to occur as often as every three to four months.

The ISF is not designed to be permanently manned but rather to provide a habitable environment for astronauts while on-board equipment resupply and servicing is taking place. Shuttle and, eventually, Space Station crews will be able to enter through the Shuttle-ISF docking mechanism or 'berthing adaptor.' Once on board the Facility Module, the astronauts would be operating in a comfortable 'shirt-sleeve' environment while they carried out such tasks as repairs, equipment changeovers, servicing adjustments, the harvesting of completed products and cleaning and restocking of production apparatus. Each



The ISF, a man-tended space processing platform, which could be in operation by the end of the decade.

facility module will have 71 m^3 of pressurised internal volume. Between Shuttle visits, the facility would operate automatically as a 'free-flyer,' though once the Space Station is in operation, one or more facility modules could be attached to it.

The design emphasises ease of maintenance and replacement of parts, as well as updating them over time. The basic modular approach is meant to facilitate this. Wherever possible, the design incorporates proven existing technology and the emphasis throughout is upon simplicity. Most repairs and replacements can be carried out by astronauts from inside the modules but where this is not possible the design facilitates operations by astronauts in pressure suits. Extensive failsafe redundancy is another prominent feature.

This approach of designing the facility around the needs of its users and maintainers is very much the method of Dr. Maxime Faget, the President of SII. Faget has a lifetime's experience of spacecraft design behind him. Between 1962 and 1981 he was responsible for supervising the design, development and testing of NASA's manned spacecraft projects. Officials at NASA feel that if anyone could be said to be the 'father,' in engineering terms, of the Gemini, Apollo and Skylab programmes, it would be him. He is well placed to appreciate the technical and human limitations of the NASA facilities the ISF will depend on and able to design the facility in such a way as to make NASA's job as easy as possible.

Faget has said that he plans to use 1975-class technology for the most part. This use of proven, off-the-shelf technology is a major reason why both NASA and American private industry seem confident that the ISF will succeed. It is not dependent upon future technological breakthroughs but rather is the product of engineers and technology that have already proved themselves in earlier US space projects. Once in orbit, the ISF modules should

be robust enough to remain there almost indefinitely. They are not expected to return to Earth, though this can be done if necessary. In order to maximise servicing efficiency, the first two facilities will be docked side-by-side. The ISF will operate in a circular 230 nautical mile orbit inclined at 28.5°.

ISF and the Space Station

Both Space Industries and NASA envisage the ISF as complementing America's Space Station. The modular approach means that the ISF embodies the capacity for growth in both size and function as business becomes more aware of its potential uses. The facility will be placed into an orbit compatible with that of the Space Station and once the latter becomes operational, probably around the year 1994, the ISF will benefit from operational economies brought about by the frequent Shuttle missions servicing the Space Station. According to Phillip Culbertson, Associate Director for NASA' Space Station office, 'There are characteristics of the ISF and the Space Station that are similar. They both provide habitable work space, are Shuttle-dependent, and essentially autonomous. For these reasons there may be some aspects of the two programmes that are of mutual interest and use to both NASA and SII' [2].

If the ISF is successful, NASA would benefit directly in a number of ways. The NASA-SII agreement gives the Houston company the go-ahead to develop the Shuttle's first docking module. This is primarily designed to enable the Shuttle to dock with the ISF but the same hardware will be available for use as the Space Station's docking mechanism.

NASA will also benefit from the second part of the August 1985 agreement, which provides for a mutually beneficial exchange of information during the definition and preliminary design phase of the Space Station. It is likely that a similar information exchange will be agreed upon for the Space Station development period, scheduled to begin in mid-1987.

A further gain for NASA is that the ISF will be launched four to five years before the Space Station is orbited. The interaction with the ISF will thus provide NASA with valuable operational experience in docking the Shuttle to orbital structures and, more generally, in the basic operations required for manned servicing of permanent orbital facilities.

Potential Uses

The ISF is designed to reach operational status with a single Shuttle launch. Once the first 'facility module' is in orbit, more can be added. When asked how many units SII intend to orbit, Faget commented 'as many as we can sell.' Each facility will have two 30 m solar arrays (similar to those deployed on Shuttle mission 41D) capable of providing up to 12 kW of sustainable power. Other research and production requirements such as cooling and telemetry are also organic to the facility.

Space Industries see their enterprise as essentially a 'real-estate' project catering for prospective space manufacturers. They would provide the environment in which other companies could actually produce. In the words of a company spokesman, 'We provide power, a safe harbour with docking facilities and a base to work in. Our success depends on the aggregate market.' There ought to be no shortage of customers for the ISF. NASA currently has contracts with a large number of companies who use the Shuttle to carry out experiments in space, while the ISF has a number of advantages over the Shuttle in terms of research, development and production facilities. Shuttle flights have an average duration of about a week - a major constraint on the types of experiments that can be usefully carried out in orbit. In contrast, the ISF can run automated experiments for a minimum of three months between Shuttle servicing visits. Moreover, whereas the Shuttle is not designed specifically for such experimentation and therefore possesses limited space capable of being utilised for R&D purposes, as a purpose-built facility virtually all the ISF's 71 m^3 of interior space is devoted to R&D or manufacturing. In addition, manufacturers using the Shuttle must continually launch their hardware into space, whereas ISF payloads remain on station far longer, dramatically reducing the manufacturer's transportation costs.

The advent of the ISF represents a major boon to companies wishing to investigate the potential of space-based manufacturing because it will give them an orbiting facility to operate in even before the Space Station becomes operational. The kinds of manufacturing which the ISF is designed to facilitate include:

- Pharmaceutical products for the treatment of diabetes, emphysema, multiple sclerosis and various blood diseases.
- Pure, exotic crystals for use in high-speed computers.
- New homogenous alloys comprised of mixtures that cannot be produced on Earth because of gravitational effects.

The facilities design also gives it a great deal of versatility. Space Industries argue that it can provide an ideal environment for life-science and material processing experiments, that it is an ideal test-bed for use by US government agencies wishing to develop space-related equipment and procedures and that it can be employed as an 'orbiting warehouse' for R&D equipment, repair parts and logistic supplies [4].

Potential users of the ISF have already been coming forward. A number of American and Japanese companies have expressed a firm interest, while discussions have been held with the European companies involved in the Columbus space station project [5]. The potential for space commercialisation is already being realised. NASA itself has agreements with 20 companies and is negotiating with 24 others interested in the commercial exploitation of space. The first 'made-in-space' products have already gone on sale: polystyrene spheres, each 0.01 mm in diameter and each perfectly round. In July 1985 the US National Bureau of Standards began marketing them as a calibration tool for scientific instruments and as a standard to measure such tiny particles as red blood cells. The NASA-SII agreement represents a major step forward in the utilisation of space. According to NASA Administrator James Beggs, 'One of NASA's top priorities is to expand the economic frontier of space. We view it as a three-pronged effort: working with industry to help identify products that can't be made on Earth; helping business to apply space technology to Earth-based manufacturing techniques; and transferring space-based applications to the private sector. We are beginning to use space to change the stamp of nature on our lives for all time.'

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2. NASA News, No. 85-119, Washington D.C., 20 August 1985, p.2.
3. *Houston Business Journal,* 26 August 1985.
4. *The Industrial Space Facility,* Space Industries Incorporated, (Houston, 1985), p. 1.
5. *Aviation Week and Space Technology,* 2 September 1985, p.26.

SATELLITE DIGEST–188

Robert D. Christy

Continued from the December 1985 issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

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

COSMOS 1678 1985-77A, 15997

Launched: 1015, 29 Aug 1985 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1681.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 258 x 272 km, 89.88 min, 82.33°.

COSMOS 1679 1985-78A, 15999

Launched: 1140, 29 Aug 1985 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1681.
Mission: Military photo-reconnaissance.
Orbit: 172 x 342 km, 89.67 min, 64.87°, manoeuvrable.

COSMOS 1680 1985-79A, 16011

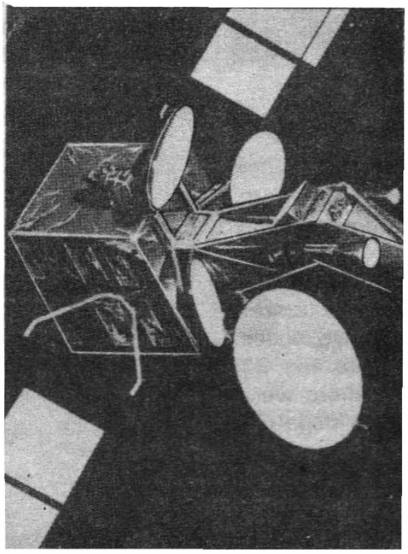
Launched: 0708, 4 Sep 1985 from Plesetsk by C-1.
Spacecraft data: Possibly a cylindrical, solar cell-covered body, 2 m long and 2 m diameter with mass around 700 kg.
Mission: Military communications using a store/dump technique.
Orbit: 784 x 807 km, 100.82 min, 74.06°.

COSMOS 1681 1985-80A, 16018

Launched: 1045, 6 Sep 1985 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit, and a supplementary package of instruments at the forward end. Length 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package, recovered after 13 days.
Orbit: 219 x 226 km, 89.02 min, 82.33°.

SOYUZ T-14 1985-81A, 16051

Launched: 1239*, 17 Sep 1985 from Tyuratam by A-2.
Spacecraft data: Near-spherical orbital compartment, conical re-entry module and cylindrical instrument unit with solar panels. Length approx 7.5 m, diameter (max) 2.2 m and mass around 7000 kg.
Mission: Crew and spacecraft exchange for Salyut 7. The three man crew consisted of Vladimir Vasyutin, Georgi Grechko and Aleksandr Volkov. Soyuz T-14 docked with the rear port of Salyut 7 approx 1415, 18 Oct 1985. Grechko returned to Earth with Vladimir Dzanibekhov on 26 Sep (see Updates – below).
Orbit: Initially 196 x 223 km, 88.63 min, 51.62°, then by way of a transfer orbit of 272 x 326 km, 90.45 min, 51.63°, to a docking with Salyut in an orbit of 338 x 353 km, 91.38 min, 51.63°.



Intelsat 5 satellite

COSMOS 1682 1985-82A, 16054

Launched: 0132, 19 Sep 1985 from Tyuratam by F-1.
Spacecraft data: not available but several tonnes mass.
Mission: Electronic reconnaissance over ocean areas.
Orbit: 429 x 443 km, 93.31 min, 65.03°, maintained by a low thrust motor.

COSMOS 1683 1985-83A, 16056

Launched: 1010, 19 Sep 1985 from Plesetsk by A-2.
Spacecraft data: as Cosmos 1681.
Mission: Military photo-reconnaissance, recovered after 15 days.
Orbit: 356 x 414 km, 92.30 min, 72.87°.

COSMOS 1684 **9185-84A**, 16064

Launched: 0118, 24 Sep 1985 from Plesetsk by A-2-e.
Spacecraft data: Possibly based on the Molniya satellites with a cylindrical body surmounted by a conical motor section with power provided by a 'windmill' of six solar panels, length 4 m, diameter 1.6 m, mass around 2000 kg.
Mission: Missile early warning satellite.
Orbit: Initially 583 x 39334 km, 709.12 min, 62.90°, then raised to 580 x 39762 km, 717.51 min, 62.90° to ensure daily ground track repeats.

COSMOS 1685 1985-85A, 16088

Launched: 1115, 26 Sep 1985 from Plesetsk by A-2.
Spacecraft data: as Cosmos 1681.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 356 x 416 km, 92.31 min, 72.87°.

COSMOS 1686 1985-86A, 16095

Launched: 0842, 27 Sep 1985 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with power provided by two panel solar array. Length 13 m, diameter (max) 4.15 m, and mass around 20 tonnes.
Mission: Carrying of supplies to, and enlargement of, the Salyut 7 station, Cosmos 1686 docked with Salyut's forward hatch at 0916, 2 Oct 1985.
Orbit: Initially 172 x 301 km, 89.18 min, 51.62°, then by way of a transfer orbit of 284 x 318 km, 90.49 min, 51.63° to a docking with Salyut at 336 x 353 km, 91.37 min, 51.63°.

INTELSAT 5A(F-12) 1985-87A, 16101

Launched: 2330, 28 Sep 1985 from Cape Canaveral AFB by Atlas-Centaur.
Spacecraft data: Box-shaped body, 1.66 x 2.10 x 1.77 m with attached 4 m aerial mast and a 15.9 m span solar array. The mass before apogee boost motor firing was 2013 kg, reducing to 1096 kg on total depletion of fuel. The vehicle is three-axis stabilised by momentum wheels and station keeping is by the use of gas thrusters.
Mission: Communications satellite providing the equivalent of 15000 telephone channels at C-band and L-band.
Orbit: geosynchronous.

COSMOS 1687 1985-88A, 16103

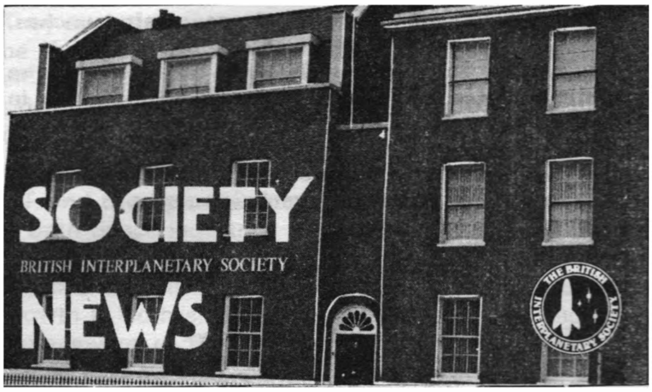
Launched: 1923, 30 Sep 1985 from Plesetsk by A-2-e.
Spacecraft data: as Cosmos 1684.
Mission: Missile early warning satellite.
Orbit: Initially 609 x 39194 km, 706.62 min, 62.98°, then raised to 610 x 39732 km, 717.51 min to ensure daily ground track repeats.

COSMOS 1688 1985-89A, 16107

Launched: 0902, 2 Oct 1985 from Kapustin Yar by C-1.
Spacecraft data: not available.
Mission: Possibly a military radar calibration satellite.
Orbit: 347 x 548 km, 93.47 min, 50.68°.

COSMOS 1689 1985-90A, 16110

Launched: 0550, 3 Oct 1985 from Tyuratam by A-1.
Spacecraft data: Cylinder with two, Sun-seeking solar panels, length about 5 m, diameter (max) 2 m and mass around 1500 kg.
Mission: Earth resources remote sensing.
Orbit: 573 x 657 km, 97.06 min, 97.97°.



SPACE STATION MEETING

The Society held its latest Space Station symposium in its HQ Conference Room on 25 September 1985, with a full audience hearing a range of presentations on the theme of "Space Station Applications."

Capt. Robert Freitag, a long-standing Fellow of the Society and Director of NASA's Policy Plans Office (Space Station), described the current status of the US space agency's studies. NASA was 5½ months into the 21 month Phase B (definition) stage and finding there were very difficult decisions still to be made. A major depature from previous programmes was the extensive international element, with ESA, Canada and Japan all making significant contributions. Japan has organised a very efficient industrial team headed by Mitsubishi, Canada was concentrating on the servicing aspect but there was a feeling that Europe was being somewhat slower in producing its detailed requirements and intentions.

Dr. George Peters of ESA described the Columbus programme, indicating that Phase B studies should be completed by early 1987. The deadline for responses to a call for new mission proposals for projects using the Space Station/Columbus was due on 29 November 1985. Columbus will initially be directed at Space Station participation but the eventual goal is to create European space autonomy, possibly based on a free-flying Columbus and the Hermes mini-shuttle.

From the UK point of view, of course, the Space Platform - particularly the polar orbiting aspect - is of considerable interest. Dr. Robert Parkinson of BAe described four platforms under consideration, two co-orbiting with the Space Station and two in polar orbit. The polar versions will be concerned mainly with remote sensing in morning and afternoon orbits, whereas the two co-orbiters have evolved because of the mutually exclusive requirements of astronomical and microgravity payloads. The European far infrared/sub-millimetre telescope (FIRST) is being used to provide a basis for establishing the astronomical platform requirements; its need for frequent slowing would clearly impact the low microgravity condition required by materials processing.

Dr. Don Hardy, of the Royal Aircraft Establishment, discussed the UK's approach to defining user requirements since this will eventually decide the format of the platforms. A core team is heading 13 expert panels on remote sensing, microgravity, astronomical, management and so on, with extensive consultations due to continue until October 1986. A series of open workshps, funded by the government, will be held over the next year to provide a forum for free discussion.

The afternoon session concentrated primarily on applications, with papers considering astronomical, materials research and communications aspects. Dr. Brian Derby of the University of Oxford pointed out that space materials processing, while a highly promising field, was still at an early stage. Of course, the 'g-jitter' produced in the Shuttle, Spacelab and eventually the Space Station by internal movement, demands that materials work must be carried out aboard free-flying craft. Present work is highlighting the feature that removal of Earth gravity allows secondary effects, such as Marangoni convection, to come to the fore. Some features are still poorly understood.

Dr. A.J. Dean of Southampton University provid' an excellent example of one discipline that will be pro,elled forward by the advent of the Space Station: gamma-ray astronomy. By its very nature, this branch of astronomy requires its detectors to be as large as possible and so will be more suited to the main station than smaller free-flyers. In addition, it is not really affected by movement or outgassing by its host.

Claus Toksvig, member of the European Parliament.

As space spokesman for the European Parliament's Committee on Energy, Technology and Research, it gives me great pleasure to send greetings to the British Interplanetary Society.

The European Parliament tries very hard to be a catalyst in all manner of fields. The decision to draw up a report on European Space policy was one of our first major initiatives after the elections in June 1984.

A year's intensive work has resulted in a report to be considered by the Parliament in its October session. The major conclusions are as follows:

1. The French Eureka initiative needs a space centrepiece. We suggest either a permanent Moon base or an autonomous European space station in low Earth orbit.
2. The need for education in the space fields could be met through use of the EEC social fund and through the creation of a European Space Institute which would set the qualifications needed for a European doctorate or MA or BA degree in astronautics.
3. Money should be made available to conduct appropriate studies of space-related data already available to us. In particular, the needs of the Third World in climatology and in mass education should be considered high priorities.

The work on the report has benefitted from close contacts with ESA and others. The need for democratic control in this vital field is stressed. My own hope for the future is that my committee will continue to monitor space developments in Europe and that this early contact with your Society will become closer.

CLAUS TOKSVIG

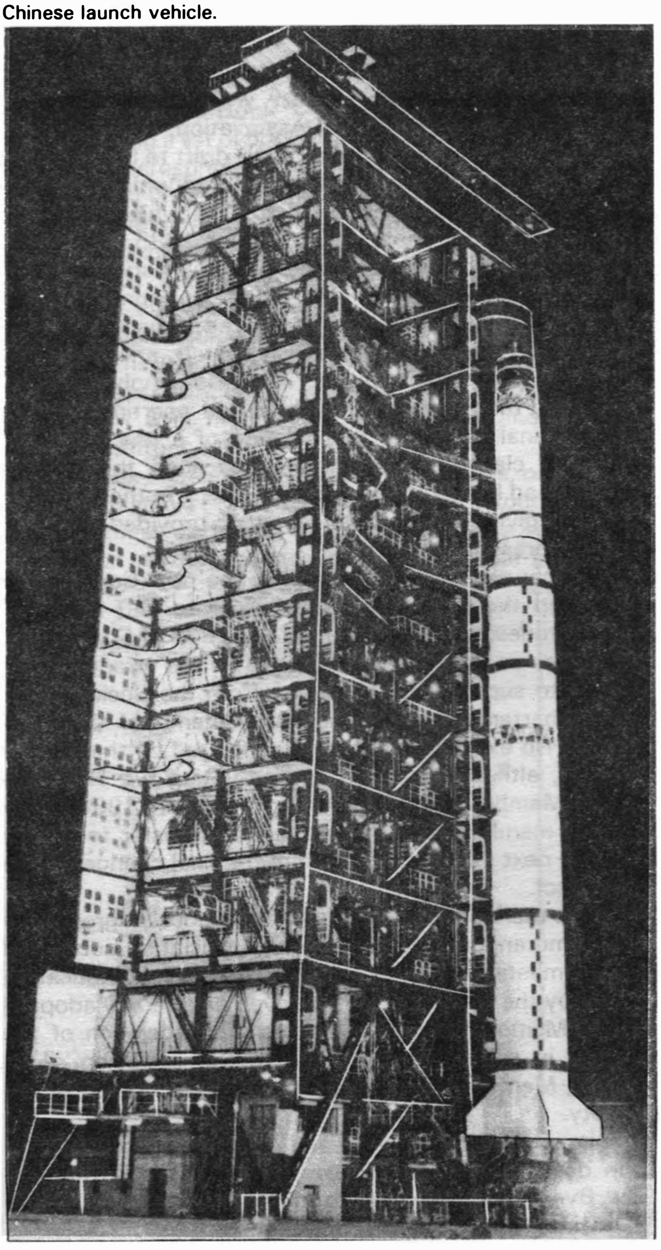
CHINESE SPACE TOUR

Prior to representing the Society at the jointly-sponsored 'Towards Columbus and the Space Station' symposium in West Germany on 3-4 October 1985, Roy Gibson spent two weeks in China at the invitation of the Ministry of Astronautics. After talks with the leading ministry official and those of the technical centre (CAST) in Beijing, he visited aerospace installations in South China, including Kunming not far from the border with Vietnam.

He was impressed by the continued progress being made in the Chinese space programme and, particularly, by the increasing contacts with the aerospace industries and the USA and Western European countries. However, in spite of a cooperative agreement between China and the UK, few signs were to be seen of a British contribution to Chinese space activities.

The visit took place shortly after the Chinese decision to halt the procurement of a direct broadcast satellite system. It was clear that the Chinese authorities were fully aware of the damages of alienating the aerospace industry but there appeared to be substantial reasons for the action, though with reason to expect a resumption of the procurement exercise - in a modified form - in the not-too-distant future.

Chinese launch vehicle.



NASA APPOINTMENT

Richard Barnes, a Fellow of the Society, has been appointed Director of the International Affairs Division of NASA Office of External Relations, after completing four years as NASA European representative based at the American Embassy in Paris. In that capacity he was responsible for liaison with the European Space Agency and the national space agencies of Western Europe on agreed cooperative projects and for identification of potential future joint space projects. He joined the NASA International Programs Office in 1961, serving in various capacities, including Deputy Director of International Affairs before his Paris assignment.

DEATH OF GERHARD ZUCKER

We are sorry to record the death of Gerhard Zucker, an early pioneer of the postal rocket, who died in Duren, Germany, on February 4, 1985, at the age of 76.

Zucker was best-known for his rocket mail experiments carried out between 1933 and 1935, in which he collaborated with a number of BIS members.

He carried out further postal experiments in the years 1956-64 though these attracted little attention.

REPORT OF THE 40TH ANNUAL GENERAL MEETING

The President (Mr. C.R. Turner) welcomed members to the 40th Annual General Meeting by pointing out that, although 1983 marked our 50th Anniversary, this had continued into part of 1984 and one had only to look back on the year to see how much had been accomplished during that time. For example, a wide range of meetings had been held, Society publications maintained at an enhanced level and membership increased by 10%.

Some of these matters would be discussed again later but he wished to express his thanks to the retiring President (Mr. A.T. Lawton), to colleagues on the Council, the Members of Committees and to the Society's staff for all the work that had been done. It was astounding that so much had been achieved in the space of a single year.

The matter of the Society's accounts for the year to 31st December 1984 was introduced by the Executive Secretary who pointed out that, with a successful year behind us in many respects, much was still to be desired on the matter of a satisfactory annual financial surplus for this held the key to our future. It was only by building up surpluses that sufficient funds could be accumulated to enable the Society to undertake the wide range of activities which lay ahead. The accounts disclosed a mixture as before. If one looked at the year itself one could contemplate a very satisfactory period of activity. On the other hand, if one looked to the future, one could see an overwhelming need for even greater effort and greater financial strength if further opportunities were to be grasped.

The report and accounts were agreed unanimously.

The President continued by remarking that, on the matter of Council elections, interest in the work of the Society was undoubtedly reflected by the fact that eight candidates were standing for election. As this was in excess of the four vacancies, the matter would be determined, as usual, by postal ballot. Ballot forms would be

sent to every member of the Society for completion and return by 31st January 1986.

The meeting then proceeded to hear a number of individual reports.

One of the most important and of wide general interest were the arrangements for Space '86, to be held at Brighton on 26-28 September with the theme of 'Space - Profiles of the Future.' Although this represented the third occasion for such a venture, the presentation and arrangements were as exciting as ever. This time the theme had crystalised, almost of its own accord, into papers that presented a continuous thread, beginning with one setting the theme and another that expanded it to the space scene overall, and then continuing with a series reflecting our position poised on the edge of the Universe, looking outwards. The following session was concerned with the input of material i.e. the down-link in information technology and not only on data about the Earth but also about the stars. The question was one of size and enormity, with every sign of it far dwarfing anything we had hitherto experienced.

After contemplating how one could cope with this enhanced flow, two further sessions considered our position in a practical sense i.e. by the construction and utilisation of space stations, including the potential UK involvement, with Europe, and a review of how this might develop. The final session concerned both future means of transportation, including the use of HOTOL, and the problems of living and working in space.

The programme would include a Banquet and Reception, as before, and also a tour of the Royal Pavilion for the Ladies.

Fuller information would appear in both magazines, with registration forms becoming available almost immediately.

Space '86 was only one of a number of fascinating symposia planned for 1986. Another of great importance was the third in our series on the Development and Utilisation of the Space Station, to be held on 21 and 22 May 1986, followed by one on Space Transportation on 19 November 1986. These were additional to the symposia on Soviet Astronautics and Space History, the IAF Congress and the European Space Symposium, among others. In fact, the work involved in making such arrangements had become so continuous as to evoke the description of 'wall to wall Symposia.'

A further matter concerned arrangements for the 1987 IAF Congress. The Society had been involved in detailed arrangements for many years now, for this was a most complicated event requiring substantial funding and considerable organisation. Practically all of the preliminary work had been accomplished and there was every indication that the invitation from the Society to host the International Astronautical Congress for 1987 would be accepted. Fuller details, again, would be published as soon as possible.

The Library had continue to grow, albeit slowly, and give considerable satisfaction to members. The arrangements for combining Library facilities with meetings had worked exceptionally well and produced high praise. The Library Committee, itself, was hard at work in most difficult circumstances, endeavouring to enhance the Library in every possible way. Much of its work, including its frustrations no doubt, were fully reported to members in the pages of our magazines both in the form of Library Reports and From the Secretary's Desk items, as well as in other ways.

One such example of its work concerned the articles that had appeared concerning the Society's unique copy of *Uranometria* which, if all went well, would be offered to members as a facsimile edition. Present plans involved preparing a fully-detailed brochure which would be issued to members shortly to enable them to place orders for advance copies. Those doing so would receive a special discount so this was clearly a useful thing to know. Work on evaluating *Uranometria* was still underway. A computer program had also been secured to enable more detailed studies to be undertaken of the observations themselves. This, it was hoped, would form the basis of a fourth contribution as soon as the work had been done. In the meantime, the articles themselves had proved of considerable interest. Those members who had responded with further comment or additional information may be assured that their interest is greatly appreciated.

Another matter of particular interest and concern to the Society lay in the area of Space Policy. In this field the Society had been particularly active, advocating courses of action and providing technical and similar information on a wide variety of levels. This was something it had undertaken for many years now but which was being accelerated. Members, themselves, could find a valuable supporting role in this work. Letters and articles in newspapers and magazines, both local and national, all helped to create a more favourable space climate. It is important that this work be undertaken as fully, as completely and as energetically as possible. Opportunities are immense, not only to advance UK involvement in space but also to advance the Society itself. Please, however, do not write to the Society itself advocating such matters. The need is to preach to the uncommitted, not to the converted!

The final item of business concerned the Extraordinary Resolution whereby the Society was to adopt a new Memorandum and Articles of Association.

The President pointed out that the draft to be approved was one held and signed by himself and which, in every material respect, was essential to that which appeared in *Spaceflight* for September/October 1985. The slight differences that emerged resulted from misprints (two), the omission of a word or two and the updating of all the sections of the Companies Act referred to because, since our new Constitution had been prepared, another Companies Act had been passed. This was simply a matter of deleting the old section numbers and inserting the new ones. A final item was the deletion of a few words to update a clause in the Articles because the original wording had been superseded by wording in the new Act.

A list giving these changes was provided to each member present for clarity.

The only matter of substance in the new Constitution concerned the introduction of Corporate and Non-Corporate grades, already set out on page 378 of *Spaceflight.* This arose as a direct consequence of the arrangements needed to support an application from the Society for a Royal Charter and meet the requirements of the Privy Council. No existing member was affected by the change because, although election as non-voting (*viz* Non-Corporate) Members would apply from 1 January 1986, every existing member would be eligible to transfer to Fellow over the next 10 years, i.e. before the final changes came into effect.

It was therefore proposed and unanimously agreed that the Memorandum and Articles of Association submitted to the meeting and, for the purposes of identification signed by the President, be approved and hereby adopted as the Memorandum and Articles of Association of the Society in substitution for and to the exclusion of all existing Memorandum and Articles of Association of the Society.

This was put to the vote and carried *nem con.*

In declaring the result, the President added that the new Bye Laws stemming from the changes would also come into effect from 1 January 1986

FROM THE SECRETARY'S DESK

Comet Collectobilia

Finding suitable material for the Society's special collection on comets is becoming harder, with each enquiry invariably bringing the response that the object wished for has already been disposed of. The puzzle is, who *buys* all these things?

Light on the subject was recently shed by G.W. Kronk in his book *Comets,* which disclosed that he had amassed no less than 7000 pamphlets over the last few years. Another example appears in the book *Halley's Comet* by J. Metz, which is almost wholly concerned with describing the collection of an amazing range of items relating to the 1910 return.

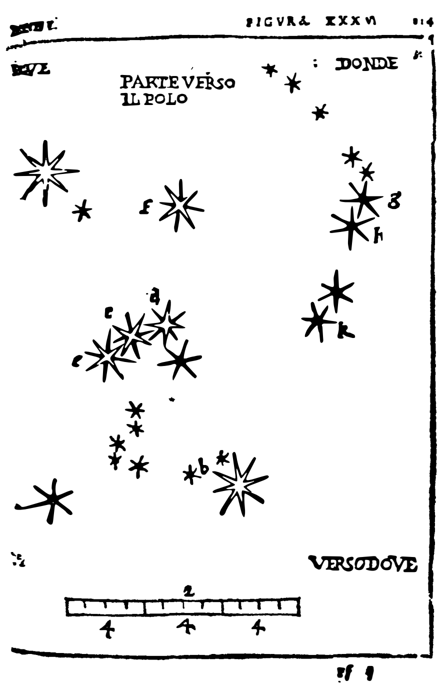
The Chelsea Antiques Fair last September expanded things yet further by listing over 60 items of Comet Jewellery for sale, all collected over the past decade. Apparently such jewellery was worn as amulets or charms, and commemorated not only Halley's comet but others such as Beila in 1846, Donati in 1858, Coggia's of 1874 and the Great Comet of 1881.

Turn-Up for the Book

Examining a list of books for sale the other day disclosed a most interesting volume. It was *De le Stelle Fisse...,* bound with (as is often the case) *Della Sfera del Mondo... (The Sphere of the Universe)* - both by Alessandro Piccolomini and published at the same time.

The first edition (1540) contained the first printed star atlas ever to appear, as opposed to the simplified constellation figures in earlier works. In fact, Piccolomini initiated the use of letters, in his case using consecutive Latin letters, to identify individual stars, a practice later adopted - with modification - by Bayer and so by all modern astronomers.

His book contains 48 woodcut star charts, one for each of the Ptolemaic constellations, depicted in four categories of brightness each with its own scale of degrees and an indication of the direction of the equatorial pole. Since the book was printed in Venice there is every indication that it was probably a most valuable navigational adjunct for the Captains of the Venetian galleys of those days.



But where had I seen it before? A quick mental run-through gave the answer. We already *had* a copy! Ours was a 1561 edition, acquired almost by accident some time ago with the purchase of other items. At that time we were not sure what we had actually obtained but took it 'on spec' in view of its date. Its star charts, prepared without background constellation figures, are very like those that any amateur astronomer might prepare today.

Progress, but in which direction?

Avenging angels have pointed out that *Pilgrim's Progess* was written by John Bunyan and not by John Buchan, as inadvertently stated on p369 of the Sep-Oct 1985 issue of *Spaceflight.* By way of assurance, the error was neither a reincarnation for Lord Tweedsmuir nor cause for John Bunyan to turn in his grave. It was simply an unspotted typesetting mistake.

Referring to the same page Charles Tharratt points out (not for the first time) that his work was only on Black Knight (*not* Black Arrow i.e. the composite craft which included both Black Knight and satellite) as inadvertently stated.

It's true, but Charles deserves the greater glory.

Why do my sins bring instant retribution when those of others are put back, as far as I can see, to Judgement Day?

Society Headquarters

I am frequently asked both by new members and by visitors to talk about our HQ and to explain how we came by it. Interest in the Society and its achievements is most intense but, although this can be satisfied on the spot, those unable to make the journey tend to be overlooked. To rectify this, the following notes provide the gist of what happened.

For many of the prewar years, following its foundation, the Society had no regular HQ at all. It remained an amateur body operated from the private homes of many individuals, not least Arthur C. Clarke who used his 'digs' at 88 Grays Inn Road for Society correspondence and his Somerset address as the 'final frontier,' no doubt to be memorised and then eaten by those members of the Society involved who, hopefully, survived the war and sought to use it as their rallying point when hostilities ceased.

It was effective. Although the Society numbered about 100 Members pre-war, not many of whom reappeared, sufficient emerged to form a solid nucleus on which the Society could be re-formed and re-built.

After a short period, during which it received an exotic accommodation address at Albemarle House, Piccadilly, it reverted to the more mundane address of my own home. There it survived for a number of years, growing rapidly and beginning to take on the shape of a professional body.

After only a few years, it outgrew the capacities of a private home and ventured to find its new offices. These consisted of one (later two) L-shaped rooms at 12 Bessborough Gardens, SW1. At that time the Society was so ill-known that the landlord refused to grant a

lease to the Society but insisted, instead, that it appear in the name of a 'Member of Means.' Subsequently, all went well and the lease was transferred into the Society's name.

From that point the Society continued to grow, based on the labours of one full-time staff member and several volunteer helpers. Fortunately, this occurred during a most fruitful period in the Society's history which saw the establishment of regular lecture programmes and the appearance of *JBIS* as a leading space periodical.

This period, too, saw the extensive groundwork undertaken that led to the foundation of the International Astronautical Federation and its major Congress in London, which set the pattern for future Congresses for many years.

However, the problem of accommodation soon loomed large once more because the Society had continued to grow and its rooms could no longer accommodate its vital paraphanalia which flowed out along the corridors and up the stairs and into every alcove. Accommodation, indeed, became a limiting factor. Not only was more space needed but the problem of ever-increasing rents had to be faced, a position made all the more acute by the fact that we were in an area ripe for development.

As a calculated risk, the Council agreed to surrender the Society's lease and to accept a monthly tenancy on the understanding that no rent increases would be made. This would operate substantially in our favour should development be delayed but be disastrous if early development occurred. In the event, development was held up for some years during which time we stayed at Bessborough Gardens at a purely nominal rent and were thus able to build up a modest surplus against the 'great day' when we would have to move.

Development delays added up to give us a breathing space of four years. Throughout this time we scoured London looking for suitable accommodation, being painfully made aware of three main facts in the process:

1. Even if current rents seemed manageable, there was every chance that these would be increased at regular intervals and the Society's future jeopardised by an ever-increasing commitment.
2. There was no way in which a property could be purchased. For one thing the capital cost was well above any figure we could raise and the interest charges on the balance would represent a cost to the Society even more onerous than the rental.
3. The building we were seeking didn't seem to exist!

As time passed the position became more acute and the Council became more and more concerned about where the solution lay. We were already scouring vacant properties outside the London area when, incredibly and quite fortuitously, a curious thing happened.

Stage I

I normally had to travel through an area that had been largely bulldozed for a road widening scheme at Vauxhall. It lay on the South side of Vauxhall Bridge, just as the Bessborough Gardens address lay on the North side. It was also adjacent to the recently-built Victoria line, with its fast connections to North and Central London, and by Vauxhall Station (British Rail) with frequent connections to the main line stations at Waterloo and Charing Cross.

All that was left of the area, after the road widening scheme, was the old Dalton's Weekly building, a garish construction from the 1920's with a bright yellow and green facade together with the semi-ruins of an adjacent house, vandalised and derelict. The area had actually been bought up by a property speculator with a view to a major redevelopment scheme. Unfortunately, the property boom was just about to collapse, and so did he! I continued my unmolested walks to and from Bessborough Gardens until a sign appeared *en route* indicating that the property was available for purchase.

Enquiries were soon under way and freehold of both properties acquired, though the house, by then, had been listed as a Grade 2 protected building and could only be restored i.e. there was no possibility of flattening the lot and starting again. However, the reinforced framework of the old Dalton's Weekly building was still intact which meant that, at least, some very modest structure could be placed on it on a temporary basis and thus ensure the Society's continued existence. After much heart-searching, perhaps even heart-rending, discussions, the following plan of campaign was agreed:

1. To tackle the building as a ten-year project. Each stage would be divided into a 'module' and added as funds permitted. It would begin with the absolute minimum i.e. just sufficient to provide office space to enable essential activities to continue.
2. At the same time a fund-raising Appeal would be started.

This period, in many ways, turned out to be the most excruciating and yet most productive. The problems of building an office, step by step and, at the same time, running the Society's affairs, which were already almost too large to handle - placed an intolerable burden on staff who, for over two years, had to cram both into their lives, with Society work predominating for most evenings and practially every weekend during the entire period. This was not made easier by a yet further burden, the whole of the preparation and typesetting for the Daedalus Report.

Fortunately, this work brought great rewards. Members became interested in the Trojan work being undertaken and the need to make a 'quantum jump' in the Society's affairs and gave unstinting support. Funds rolled in with Daedalus, too, adding to our coffers. When added to other money-raising plans, the total enabled us to enlarge the single module first envisaged and, as success continued, go the whole hog and have both buildings refurbished and connected together with a new front entrance and thus become a single entity. It wasn't possible for all this to be done on the grand scale of course, but certainly enough to allow us to meet all our objectives on a minimum basis.

Astonishingly, the essential programme was met, and in a space of only two years.

Stage II

Life inside the new HQ building, at first, was very Spartan, with voices echoing, rooms empty and facilities minimal! During the first year of occupation much had to be accomplished in providing much-needed equipment and jettisoning some that had seen better days. Even some carpeting appeared but, before more could be done, the economic ravages of 1980 took their toll. The Society faced a grim prospect. Not only was it £35,000 in debt, representing the money needed for the completion of the building work, but an enormous increase in publication costs had made it impossible for it to run on its normal income.

Severe economies had to be made to match incoming bills, successfully as it turned out while, at the same time, even more effort had to go into trying to whittle down the £35,000 indebtedness. Considerable inroads were made into the problem and by 1981 they were laid to rest when the building was finally paid off.

Space Garbage
J. Meadows, George Phillip, 12-14 Long Acre, London WC2E 9LP, 160pp, 1985, £7.95.

Asteroids, meteorites, comets, meteors and interplanetary dust is the space garbage referred to, in other words all the matter left over after formation of the planets and the satellites.

Although, even in aggregate, these bodies seem insignificant when compared with the Sun and planets, they may hold vital clues to the origin and evolution of our Solar System, apart from being responsible for some of the most dramatic astronomical events seen from Earth, ranging from meteor showers and, aurorae displays to the occasional devastation caused by impact of one of the larger meteorites.

Professor Meadows regards astronomers as divided in to two groups, the 'Lords of Creation' who survey the whole Universe and the pickers-up-of-trifles who potter around in the Solar System, adding that, somewhere in the basement of the latter group, come astronomers interested in the small lumps of matter described. Indeed, it wasn't so long ago that one of the so-called Lords regarded minor planets, for example, as 'vermin of the skies,' which well illustrates the point.

Fortunately, Professor Meadows has produced a most interesting book which, coupled with the present outpourings on Halley's comet, should do much to redress the balance. The author devotes a chapter to the comet though his net is spread very wide and even takes in the passing of the dinosaurs.

The Planets
Heather Couper with Nigel Henbest, Pan Books, Cavaye Place, London SW10 9PG, 1985, 144pp, £6.95.

From the dawn of history the planets have fascinated mankind and been essential to our unfolding knowledge of the cosmos. With the space-age, we have been able to examine the planets in uncompromising close-up and thereby unravel some of the complex mysteries of the Solar System. In fact, more has been learned about the planets in the last two decades than in the whole previous history of mankind.

This book looks at each planet from an historical, cultural and scientific point of view, explains how our ideas about each one have evolved, how they have influenced life on Earth and what the latest probes have revealed. It also contains practical information on how to observe the planets with little or no special equipment, how to observe comets and meteors, (a list of annual meteor showers is included) and a guide to planetary movements over the next five years.

The Story of the Earth
P. Cattermole and P. Moore, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1985, 224pp, £12.95.

This book describes the complex history of our planet from its formation to the emergence of Man and his subsequent influence on the planet and its environment.

The Earth evolved from a primeval solar nebula, endured a long period of bombardment by cosmic particles and has been subjected to continental drift and the formation of mountains and oceans. In between, it has seen numerous ice ages.

The book approaches the subject in a roughly chronological order, beginning with some of the methods used by geologists, physicists, chemists and biologists to determine the processes which have contributed to the internal makeup and to the present external appearance of our planet.

Accounts are included of many dramatic events which still, albeit slowly, are continuing to change the face of the Earth.

This is a fascinating story and one which is bound to enthral.

Stargazer Pack
George Phillip, 12-14 Long Acre, London WC2E 9LP, 1985, £4.95.

This pack includes several old favourites *viz* a 10 inch planisphere, a wall chart of the stars and paperback book called *Signposts to the Stars*, all of which form an excellent introduction for the beginner to astronomy. Armed with these, little difficulty should be met with in finding one's way among the constellations.

As an added attraction, the publishers have included a small 'Halley's Comet Leaflet' which gives the positions of the comet among the stars during its 1985/6 appearance, though it must be added that the leaflet is really little more than a token compilation.

For a general guide to the stars, however, the planisphere, chart and booklet are ideal.

The Challenge of Space
R. Kerrod, Collins, 8 Grafton St., London W1., 1985, 96pp, £6.95 (h/c) £5.85 (s/c).

This basic volume, written by a BIS Fellow (and acknowledged as such), is an excellent introduction for the juvenile end of the market to space travel and its vast range of possibilities. Eight chapters, many with full-colour illustrations, take the reader from the origins of modern astronautics with Goddard, Tsiolkovsky and von Braun, through to the farther reaches of the Solar System. The Space Shuttle, the extensive uses of satellites, space stations and the astronauts themselves are all covered.

The Crab Nebula and Related Supernova Remnants
Eds. M.C. Kafatos and R.B.C. Henry, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1985, 285pp, £25.

The Crab Nebula is the single most important supernova remnant in the sky. There are many properties which make it of special interest e.g. with a well-studied central pulsar, helium-rich gaseous filaments, a synchroton nebula and its association with the supernova of 1054. Progress in instrument capacity in the X-ray and radio spectral regions over the past 15 years has led to the discovery of close relatives with the result that it is, apparently, no longer an anomaly but a prototype of a sub-class of remnants.

More than a decade has passed since the last international discussion on this important object though the advent of digital detectors and advances in X-ray and radio astronomy has produced a flood of high-quality spectral and morphological data which has formed the basis for several theoretical advances. Even so, our knowledge of the Crab's composition is still somewhat unclear though ultraviolet data from the Space Telescope will obviously fill in more gaps.

This book brings together the most recent and theoretical and observational work, based on a meeting held in October 1984. New ideas covered include the Crab-like remnant in the Large Magellanic Cloud; the magnetohydrodynamic model of Crab radiation and the Crab Nebula jet. Also included are data from the International Ultraviolet Explorer and the Infrared Astronomy Satellite.

Solar Radiophysics
Eds. D.J. McLean and N.R. Labrum, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 1985, £35.00 ($59.50).

A vast new body of observational information has become available in recent years about the Sun. In particular, clear and detailed knowledge has emerged about the sizes, positions and motions of the sources of radio bursts. High-quality observations with satellite-borne instruments have helped materially in enabling radio emissions to be related to other solar phenomena.

This volume presents aspects of present-day solar astronomy at metre wavelengths i.e. the radio astronomy of the solar corona. Accordingly, detailed discussion of the important topics of decimetre and micrometre radio astronomy have been omitted.

Extraterrestrials: Science and Alien Intelligence
Ed. E. Regis Jr., Cambridge University Press, The Edinburgh Building, Shaftesbury Rd, Cambridge CB2 2RU, 1985, £25.00.

If extraterrestrials *do* exist, what are the prospects for contacting them or them contacting us? Indeed, how would or could such contact be made and would such messages even be intelligible to us?

Speculation on such topics is popular nowadays. Although belief in beings from other worlds goes back to ancient times, it is only recently that it has become capable of being verified or falsified by test.

Should we one day discover that intelligent aliens exist, what would be the result: would it alter our view of ourselves, or our ways of thinking to any substantial degree, or would we go on just the same as before?

There are many strands to the problem. Chemists have pondered over requirements for the origin of life, biologists have considered whether and how life-forms might develop, physicists have calculated the rates at which interstellar cultures might populate the galaxy, and philosophers have tried to say something about its significance in the large scheme of things.

The present volume contains contributions from a number of sources on various aspects of such problems, starting with the possible existence and nature of extraterrestrial intelligence, if it exists, and its detectability, with several papers on possible consequences of making contact.

The moral aspect will surely concern us greatly, not least whether we may be able to maintain our present ethical values in the face of completely different rules. Past history tells us that changes will inevitably result.

Space Law in the United Nations
M. Benko, W. de Graaf and G.C.M. Reijnen, Martinus Nijhoff Publishers, P.O. Box 989/3300, AZ Dordrecht, The Netherlands, 1985, 256pp, £31.95.

This is the first detailed treatment of the economic, political and technical backgrounds of those Space Law matters under discussion in the UN. It covers such topics as remote sensing, delimitation of outer space in view of the problems stemming from Privatisation, Nuclear Power sources, Demilitarisation and the proposed legal structures applicable to each.

The authors' acknowledge that a number of important matters are not dealt with e.g. protection of the Earth's environment, the establishment and use of Space Stations (a matter of pursued energetically elsewhere but one which has not yet found its way to the UN) and only partially on private enterprise aspects. They concern themselves mainly with projects and problems under debate within the UN at the present time together with some of the solutions currently offered. For this reason, too, the matter of the origin and early history of the UN Outer Space Committee, itself, leading to the six international agreements already signed, is also omitted.

Although, as might be expected, problems concerned with preventing an arms race in outer space loom large, results are as far off as ever. Even so, the authors put on as brave a face as is possible in the circumstances.

Space, The Next Ten Years
Ed. T.W. Jensen, *et al*, Univelt, P.O. Box 28130, San Diego, CA 92128, USA, 176pp, 1985, Soft Covers $25.

Many notable in the space scene have contributed to this volume which covers such topics as space commercialisation and industry, space education, Congressional views, DoD and the military in space, arms control, space law, civil and international space, space policy, science and technology and space after 1994.

The material is based on talks and presentations given at the First Annual Space Symposium sponsored by the United States Space Foundation, held November 1984.

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Chronology of Eclipses and Comets AD 1-1000
D. Justin Schove (In collaboration with Dr. A. Fletcher), Boydell & Brewer Ltd., P.O. Box 9, Woodbridge, Suffolk, IP12 3DF, 356pp, 1984, £19.50.

Eclipses and comets were recorded in early chronicles because they were believed to account for events that were still in the future; today we find these records help us to date events in the past. Both can be precisely dated by modern astronomical techniques and are therefore an invaluable aid in checking the chronology of historical records. This study covers the whole world for the period AD 1 to 1000. It opens with an analysis of the types of historical record which mention eclipses or comets, showing how such records may be unintentionally or intentionally falsified, particulary in order to associate the appearance of an eclipse or comet with a major historical event. It indicates how an investigator can unravel such distortions.

The body of the book provides a list of eclipses and comets and the sources for each event, with diagrams showing any problems which relate to their observation. The object was not to analyse each eclipse and comet scientifically but to identify and list them in chronoligical order i.e. with the main aim of providing a scientific chronology.

Space Commerce
N.C. Goldman, A Ballinger title distributed by Harper and Row Ltd., 28 Tavistock Street, London WC2E 7PN, 186pp, 1985, £26.50.

Visions of robots mining the Moon for rare minerals and orbiting factories producing pharmaceuticals and semiconductors for consumption on Earth are likely to become realities in the relatively near future, thus forming the basis for this analysis of their economic, business and policy implications.

The author argues that space will become economically and commercially important once private enterprise asserts itself and takes the plunge, assuming that Governments create the right atmosphere to define and regulate national and private interests. One big problem, of course, is whether policy-makers will be able to overcome an urge for over-regulation, something which would undoubtedly stifle private development in infancy.

In this book the author looks towards the longer-term far-reaching implications of space enterprise and discusses how these might subsequently integrate into domestic economies and what impact they might have on Earth-bound developments.

DO YOU REMEMBER?

25 Years Ago...
5 January 1961. McDonnell officials proposed a one-man space station to NASA consisting of a Mercury capsule and cylindrical laboratory. The station would be capable of supporting the astronaut for up to 14 days in a shirt-sleeve environment.

20 Years Ago...
16 December 1965. Gemini 6 astronauts Schirra and Stafford return after a day in space. The flight included rendezvous and station-keeping with Gemini 7, closing to within 30 cm of each other.

15 Years Ago...
25 December 1970. The Soviet Union launches the 17th Molniya 1 communications satellite into a 12-hour highly elliptical orbit. Molniya 1 satellites played a major part in linking distant regions of the USSR with Moscow.

10 Years Ago...
15 January 1976. Helios 2, a German solar probe, is launched by Titan/Centaur from Cape Canaveral into heliocentric orbit. Its first close approach to the Sun takes place in April.

5 Years Ago...
29 December 1980. Space Shuttle *Columbia* is rolled out from the Vehicle Assembly Building at the Kennedy Space Center in preparation for STS-1, the first orbital flight test. 6½ hours later the Shuttle is in position on the launch pad.

K.T. WILSON