spaceflight

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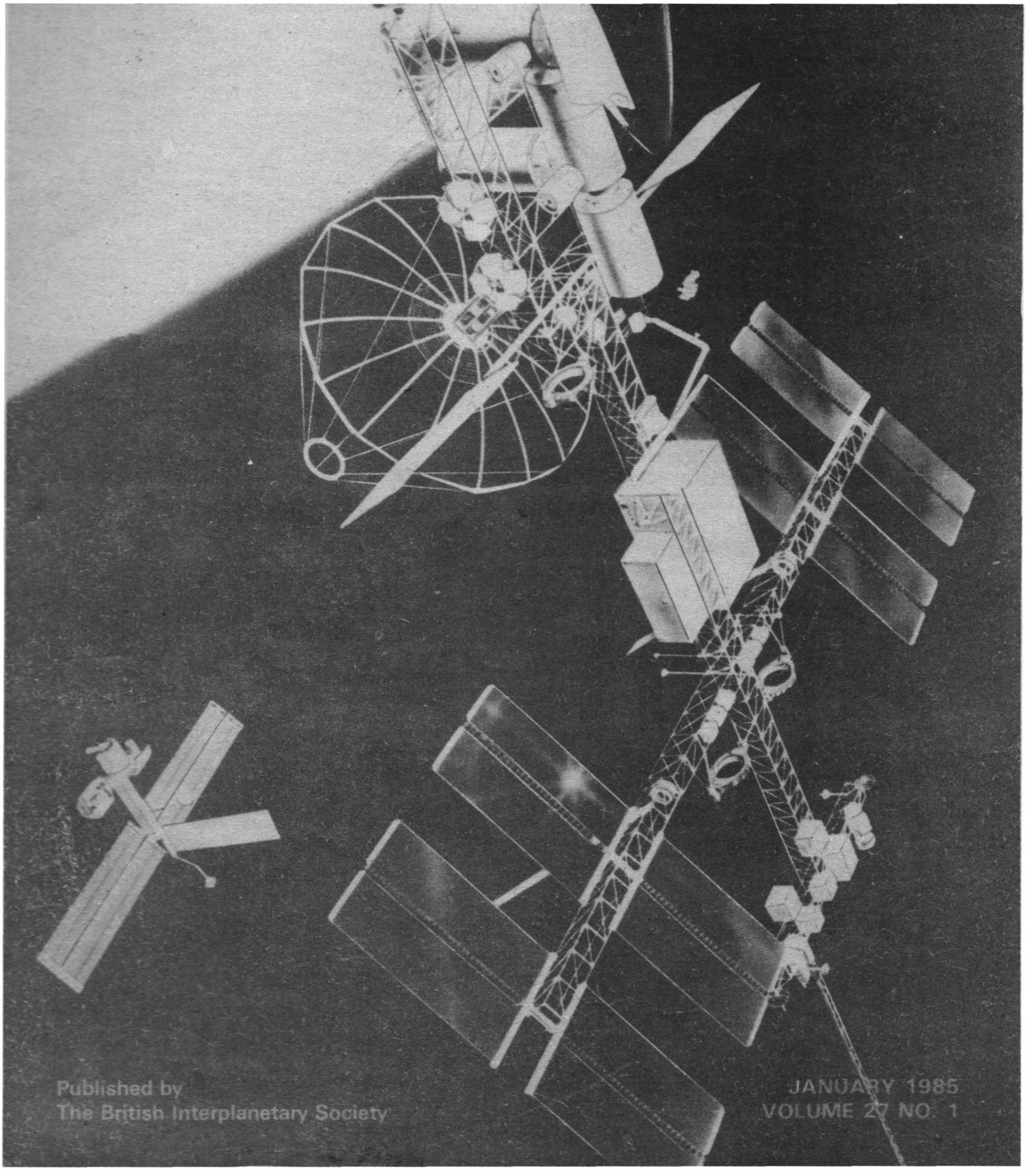

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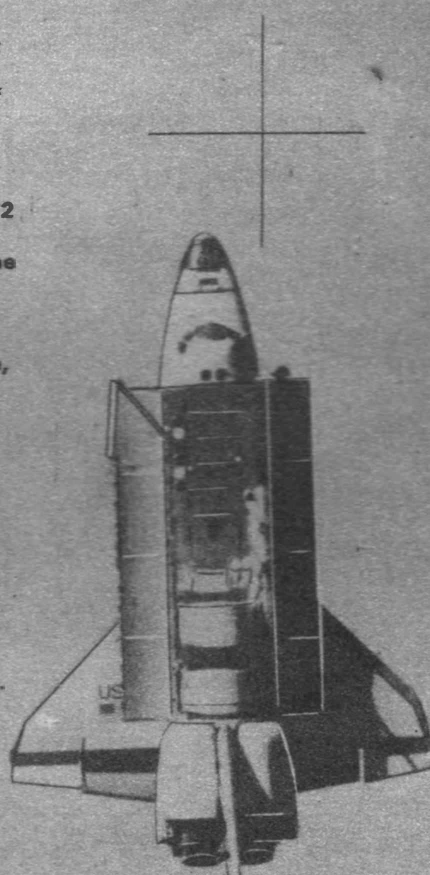
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project-Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($11.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($11.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

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Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($9 .00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

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THE CASE FOR A NATIONAL SPACE AGENCY

On 21 February 1960 the Society placed before HM Government recommendations on the course of a British/European space programme. Among its many far-reaching proposals was one for setting up a National Space Agency, as it was clear even then that the implementation of a plan involving so many diverse interests, some of them conflicting, required a high degree of coordination and monitoring not only to achieve what was best in our national interests but also to ensure that this would be maintained. It was perceived that a policy of uncoordinated endeavours and the fragmentation of activities would inevitably lead to a loss of direction, urgency and purpose, and fractionise our national resources.

This single central agency was to represent all government interests in space and to have the following objectives:

1. To be seen as the UK focus for space activities.
2. To establish basic objectives and to hold the balance between differing activities and interests.
3. To provide direction, coordination and cohesion.
4. To oversee space activities generally and to act as our national authority in international space ventures.

Throughout the last two decades, however, there appears to have been no conscious discussion of the pros and cons of such a step for, arguably, there might be reasons against it as well as for it. The need, clearly, is for an open discussion to enable all the relevant points to be aired and a balance struck. The fact that objections existed in responsible quarters cannot be denied. Problems of policy, administration and economics are clear enough. Nonetheless, official inaction at this stage will be tantamount to real death of UK space hopes, so the time is now opportune to raise the matter again and pose it as one for serious deliberation by those holding the power of decision in our land.

By way of background we reiterate the following real areas of concern.

Firstly, we underline the point that now is the best opportunity the UK has had for more than a decade to get right into the field of space technology once more. If it is missed, another chance may not emerge for decades.

Secondly, no space programme should be isolated from the rest of the nation. Its purpose should be to raise the whole level of our scientific and industrial capability. The money is spent, least of all, 'up there.' It goes into knowledge, facilities and expertise 'down here.'

Thirdly, it follows that, e.g. the role of the smaller company needs to be very carefully evaluated. A plethora of companies

Continued overpage

COVER

NASA'S 'power tower' Space Station reference concept. About 150 m in total length, five pressurised modules will provide living space for six to eight occupants. A co-orbiting platform serviced by the station is seen in the background; this would carry experiments and instruments undisturbed by manned activity. *NASA*

involved in a project raises all sorts of problems of coordination, management and synchronisation - the frustration level can be high. On the other hand, recent history tells us all too plainly that many smaller companies may possess an expertise that can be extremely valuable. Many appropriate supporting roles of this sort spring to mind, e.g. those in the field of data management and information technology generally.

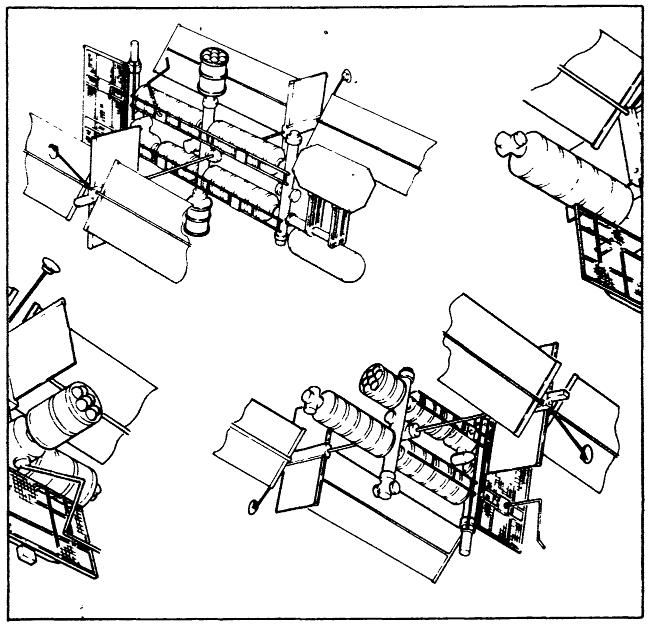
Fourthly, matters like this involve detailed and expert appraisal of projects over a wide area. How this should be done is a problem. ESA, for example, adopts the aim of returning to each participating country an equivalent allocation of contracts for its home industry. This is undoubtedly fair and convenient, but still leaves exposed the question of whether it is best able to provide the support needed. The problem revolves around whether one adopts a global view, i.e. the best interest of the *project* or, basically, tries to accommodate the problems of sociology and economics in individual countries.

To turn now the main task. We have to face the fact that the reasons why President Eisenhower formed NASA are as cogent here as in America two decades ago. First, there was the matter of reducing competition and misunderstanding between various arms of government and the services and, second, the need to set up a *competent* agency. Both reasons impelled the President to pull in a nucleus from outside, in order to overcome the bureaucracy. We have two even more essential reasons. Not only do we need to revitalise whole sections of British industry by spreading new concepts, directives and techniques among companies and organisations large and small, but we also have a need for a visionary approach to build up our people's morale. We have the technological personnel today, but where is "Next Generation Britain?" Major developments in the history of mankind are now taking place and yet few of our populace appear to be aware of it. The media rate it just a few lines, while blowing up trivia out of all proportion. Do they take this attitude simply because they discern a lack of space interest in Government quarters? A national space agency, by its very nature, provides the stamp of authority the subject deserves. The Space Station is a project that promises both opportunity and incentive. If we grasp it we will be much better equipped to bridge the industrial chasms *opening up today* before the aerospace and electronics industries.

A National Space Agency will make it easier for ESA, NASA and all other agencies to negotiate with us, besides creating a competent position to proffer advice to the Government on a rapidly expanding and developing area frought with opportunity and promise but which requires the most continuing and comprehensive study.

What would be the major practical steps to be taken the minute a National Space Agency appeared? They can be identified at once, i.e.

1. Establish its own core programme.
2. Settle its priorities. We are looking for a continuing UK space policy, so it should set up a long-range programme, say, over a 15 year span, rather than the five year periods currently preferred.
3. Establish its users and provide user-participation.
4. Establish its relationships with industry, i.e. both in contractual development and exploitation and commercial operation.
5. Provide a coherent voice on space matters, seeking a comprehensive rather than a fractional approach and establish its lines of presentation to, and in association with, the public and groups of all sorts.
6. Consider, very carefully, its role in education and in public policy, and be sure to provide an adequate contact point both with the media and the public generally.



A good deal of this is open to further comment and argument and, provided that this is well-founded and informed, rather than prejudicial and serving self-interest, this could be most useful. For example, the provision of a competent Director and staff, the access points for technical and scientific input and preventatives against an inbuilt ostrich-like approach are all vital to the success of the idea. In such an enormous field and one where past heights of personal glory may have little relevance, a problem could arise on the choice of Director alone. Traditionally, such plums go to the older dignatory or to a personality honoured in other fields. For a newly-created space agency this could prove a disaster.

Again, it may be argued that questions of policy will not be solved simply by setting up a National Space Agency. This is undoubtedly true, and desirably so, but, at least, our country would have a better chance of getting off on the right foot with such a body to deliberate and advise, and answerable both to Parliament and to the public itself.

An even more cogent problem concerns funding. There are the matters of not only how much a National Space Agency will cost (and will it earn its keep?) but will it demand more from the national cake than we can afford, and at a time when taxation is at throat level and with a Government expenditure already grabbing probably more than 60% of our entire nation's output.

From the point of view of the scientist, who, in many cases may represent the initial 'user' of space facilities, the needs are for an easy route of access into space, with funding and management clearly identifiable and also the recognition that much space work actually has to be done here 'on Earth' - with robotics as a current prime example.

These are all arguments for deliberation. Nothing can be gained by over-simplifying recommendations but these are all points that can be deliberated over and overcome. The response 'We will do it - but not now!' is no longer satisfactory. We need an unequivocal 'We will *do* it.'

The matter is now ready to be fully aired and a decision taken.

REFERENCES

1. The case for a United Kingdom Space Programme, *Spaceflight*, 8(10), October 1966, pp.347-354.

SPACECAB II: A SMALL SHUTTLE

By David M. Ashford*

The full exploitation of space depends on the reduction of launch costs. The author describes a proposal for such a concept developed from earlier *Spaceflight* and *JBIS* contributions.

Introduction

An earlier article on Space Tourism [1] described a new type of launcher, called Spacebus, intended to meet the requirements of regular passenger transportation to and from space hotels. Spacebus is of advanced design since it requires standards of safety, comfort, reliability and costs approaching those of today's airliners. Its development would clearly benefit other space enterprises. Mention was made of a step-by-step development strategy for Spacebus involving, firstly, a rocket-powered research aeroplane and, secondly, a partially-reusable small shuttle called Spacecab [2].

Since then, Spacecab has been reconfigured as a fully reusable concept, scaled down from Spacebus. The new concept, called Spacecab II, is much more attractive and probably more relevant to short-term European space transportation requirements.

Spacecab II Description

Spacecab II is a two-stage vehicle of roughly the same size as Concorde and not unlike some of the 1960's Eurospace Aerospace Transporters in appearance. However, it has been designed for minimum development cost and makes full use of developments since the earlier studies.

The Booster stage is a medium sized supersonic aeroplane. Four Olympus turbojets are used for take-off, acceleration to Mach 2, flyback and landing. Two complete Ariane second stages are buried in the rear fuselage to accelerate from Mach 2 to the separation speed of Mach 4.

BOOSTER			
	Span, m	28.3	
	Length, m	64.8	
	Engines		
		4 x Olympus to M = 2	Concorde
		2 x Viking IV to M = 4	Ariane 2nd Stage
	Separation Speed	M = 4	
	Weights, Tonnes:		
	Empty	74.0	
	Payload	41.0	
	Fuel	66.0	
	All-up	181.0	Concorde
ORBITER	Span, m	16.3	
	Length, m	16.8	
	Engines	6 x HM7	Ariane 3rd Stage
	Weights, Tonnes		
	Empty	6.1	
	Payload (and crew)	1.0	
	Fuel	33.9	
	All-up	41.0	

The Orbiter stage has a blunt swept configuration dominated by the liquid hydrogen tanks, which make up about 65% of the stage volume. The payload bay is behind the two man cockpit and has a useful volume of 6 m^3, which is similar to that of a medium-sized van. Six Ariane third stage engines (HM7) are fitted. The Orbiter is partially buried in the Booster to protect it from air loads during the boost phase and to reduce the supersonic wave drag penalty. As a result, the Booster/Orbiter combination is as clean as Concorde.

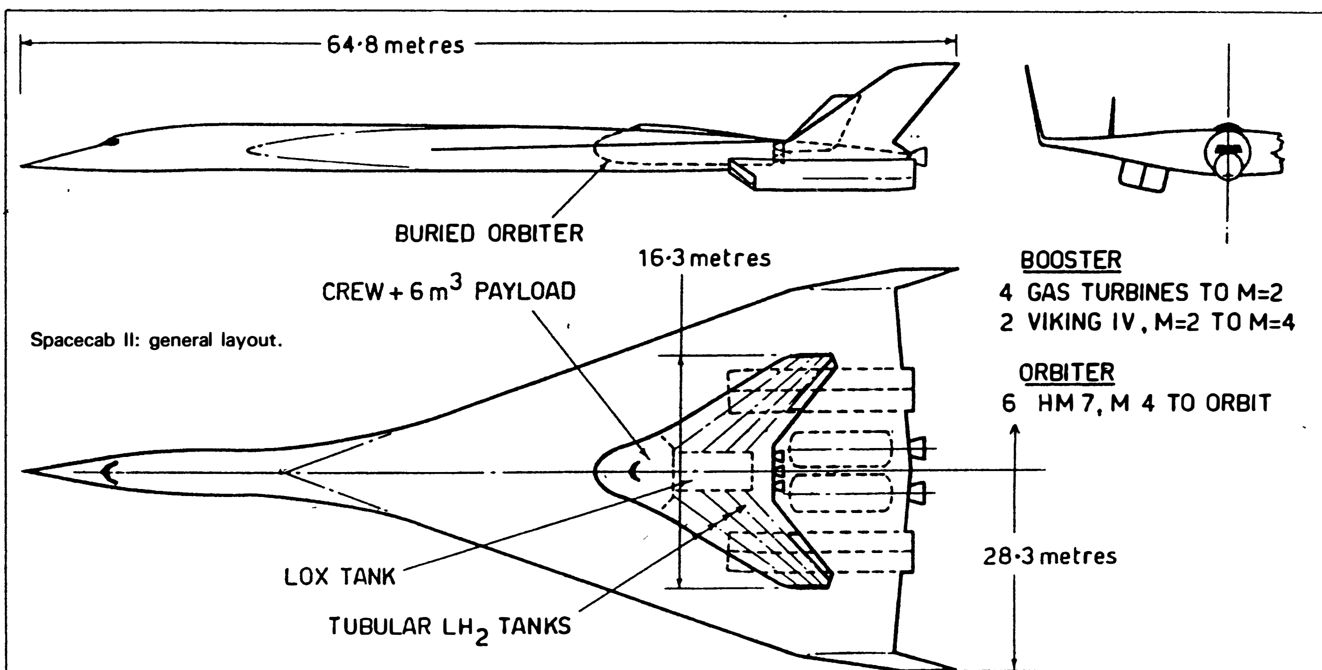
Leading data, derived from first order sizing calculations, are given in the table.

Spacecab II Uses

As a fully reusable vehicle operating like an aeroplane from existing airfields, Spacecab II would be suitable for the passenger transportation segment of an embryonic space tourism industry. However, its small size (six passengers) would limit its use to the pioneering phase. It would also serve as a technology development vehicle for the larger and more efficient Spacebus. However, its most important early use would be as a general purpose launcher suitable for small (about 750 kg) manned payloads to low orbit.

Existing or planned launchers are not well suited for this

* British Aerospace Dynamics Bristol. Note: The views expressed are those of the author and not necessarily those of British Aerospace. (Spacecab II was described in a paper on Space Tourism presented at the BIS Space Transportation and Space Station Symposium, 11 April 1984).



Spacecab II: general layout.

purpose. NASA's Shuttle is designed for large payloads to low orbit and Ariane is optimised for large unmanned payloads to geostationary orbit. Ariane 5 as planned could launch a small manned payload, Hermes, to low orbit, but at very high cost because of the throw-away booster elements. The fully reusable Spacecab II could therefore be the most efficient vehicle for smaller manned payloads to low Earth orbit. As such it would be ideally suited for carrying:

- Rescue crew
- Mechanics and spares for satellite repair.
- Construction crews for large space structures.
- Small experiments.
- Mechanics for in-orbit assembly of payloads for onward transportation to geostationary orbit.
- Military payloads.
- Space station re-supply payloads.

The last mission listed is probably the most relevant to present European plans. The vehicle scenario emerging for the 1990's is of a large US space station, NASA's Shuttle and derivatives, an ESA successor to Ariane 4 and a small European space station called Columbus. In this context a small reusable shuttle like Spacecab II would be invaluable for complementing the much larger NASA Shuttle for supporting the large US space station and Columbus. It would be ideal for small support payloads not requiring the large capacity of the NASA Shuttle, such as crew replacement, spares, consumables, VIPs, repair crew, medical emergencies, replacement modules and returned samples or processed products. For small payloads of this nature, Spacecab II would be much cheaper to operate than NASA's Shuttle, which would still be used for launching the space stations and for re-supply missions requiring a large payload. Spacecab II would therefore be a most useful complement to existing or planned space vehicles and could be an ideal European contribution to the NASA/ESA programme for the 1990's.

Development Costs

At first sight it might seem that Spacecab II would cost several £Billion to develop and, indeed, further study might show this to be the case. If so, then Spacecab II would have to take its chance as a possible major European project of similar cost and management complexity to Ariane or Spacelab. However, the Spacecab II concept has several features that *raise the possibility* of a demonstrator prototype that could be developed as an aeroplane rather than as a manned spacecraft, leading to a factor of 10 reduction in costs up to the first orbital flight. This would put it within the financial reach of the UK alone. These features are as follows:

Complete Reusability: Spacecab II is completely reusable and has weight margins adequate for a robust structure with long life and low maintenance cost. In terms of cost per flight the advantages of reusability speak for themselves. All spacecraft so far have involved expendable launcher components - the fundamental reason for the exotically high cost of space transportation to date.

In terms of development cost, reusability allows an aeroplane-like test flight programme in which the flight envelope and systems operation are progressively explored, starting with subsonic flights and working through supersonic, hypersonic and sub-orbital flights until orbit is achieved. Spacecab II, although a manned space vehicle, can therefore be man-rated as an aeroplane. By contrast, previous manned spacecraft have been launched by vehicles with expendable stages. The resulting very high cost per flight has drastically reduced the affordable number of test flights. The spacecraft were therefore launched to the near extreme of the flight envelope (orbit) after very few flights, leading to very expensive ground testing, reliability demonstration, redundancy and quality control to ensure astronaut safety.

Existing Engines: Both the Booster and Orbiter use derivatives of existing engines, namely the Olympus turbojet and the Viking IV and HM7 rocket motors from Ariane.

Buried Orbiter: The Orbiter is partially buried in the Booster. This permits an ascent trajectory in which the air loads on the Orbiter are not a design factor (which they are for existing launchers). This enables the shape and structure to be optimised for re-entry, abort and landing. The result is a swept blunt configuration with a very low re-entry wing loading, thereby minimising re-entry heating. Moreover, the structure can be designed for a low equivalent airspeed, allowing a lightweight design to be adopted.

Existing Technology: Spacecab II involves *no* technology, hardware concepts or operating techniques that have not already flown on aircraft or spacecraft, with the possible exception of the Orbiter structure in which multi-cell pressure-stabilised propellant tanks also form the wing structure. This is a simple enough concept that has been proposed for numerous launcher projects but not actually built.

Taking the above features into account there is *no obvious reason* why the development cost of the Spacecab II Orbiter and Booster to first orbital flight should each be much more than that of a demonstrator prototype advanced aeroplane. The going rate for such prototypes is in the region of £50 to £200 million. Taking the upper end of this range, the Spacecab II cost to first orbital flight *could* be as low as £500 million (twice £200 million with extra because the cost of engine spares will be high until the engine life evolves to tens of hours rather than tens of minutes).

Conclusions

A reusable small launcher, Spacecab II, has been described which would be a very useful complement to planned space transportation vehicles. Its main purpose would be logistic support of a large NASA space station and a small ESA one. It would also be ideally suited for rescue, satellite repair, carrying the construction crew for large structures, small experiments, in-orbit assembly and military purposes. It would also be suitable for passengers and could therefore be the next step towards a space tourism industry, perhaps using a derivative of Columbus as a space hotel.

By adopting certain design features and a particular development strategy it seems *possible* that Spacecab II could be developed as an aeroplane, rather than as a manned spacecraft, leading to development costs that could be afforded by the UK alone, as a contribution to the ESA/NASA programme for the 1990's. This possibility seems sufficiently attractive to justify further study.

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1. D.M. Ashford "Space Tourism: Key to the Universe," *Spaceflight*, **26**, 1230129 (1984).
2. D.M. Ashford, "Project Spacecab: A Minimum Cost Orbital Taxi," *JBIS*, **34**, 3-9 (1981).

Nothing is New

Sir, Your nine points (*Spaceflight* editorial, November 1984) have a familiar ring. They remind me of Fray Hernando de Talavera's objections to the proposed voyage of Columbus, which ran as follows:-

1. A voyage to Asia would require three years.
2. The Western Ocean is infinite and perhaps unnavigable.
3. If he reached the Antipodes he could not get back.
4. There are no Antipodes because the greater part of the globe is covered with water, and because Saint Augustine says so.
5. Of the five climatic zones, only three are habitable.
6. So many years after the creation it is unlikely that anyone could find hitherto unknown lands of any value.

On the basis of these recommendations, in 1491, the entire project was rejected. Just as he was about to give up he found one more friend, who caused the decision to be reversed and so allowed Columbus to set out on his epoch-making trip the next year.

It is interesting to reflect that, although it took Columbus several years to get his enterprise accepted, he was able to complete the project relatively quickly once he had the go-ahead. In fact, the equipment to perform his new mission was already in existence: the problem was simply to develop an understanding of how far it could be pushed and what wonders were left to explore.

To adopt a more latter-day economic argument, it was only in 1962 that President Kennedy proposed forming the Comsat corporation. At that time the feasibility of geostationary satellites had not been demonstrated, let alone their value perceived. It took a gamble on a 15 year economic horizon to allow the programme to go forward. The UK stepped in during the early 1970's as a 'fast second' and benefitted accordingly, but this may not always be possible. Once in a while, one must gamble on a '15 year horizon' instead of the usual '5 year horizon' common to today's industry.

According to a TRW study the US Government nowadays collects more taxes *each year* from users, builders and sellers of communications satellites and services than the total NASA R&D Investment in Comsats during the 1960's!

CAPT. R.F. FREITAG
Virginia, USA

Superior Intelligence, or Inferior Argument

Sir, I recently had an opportunity to discuss with Dr. Logsdon, personally, his appearance in the BBC *Horizon* programme which was the subject of the editorial in the November 1984 issue.

His comments can be summarized as follows:

1. He was given no idea of the framework nor where he was going to be in the programme.
2. He was simply asked a series of questions.
3. In general, he remains absolutely convinced that he expressed himself very positively as "one of the stronger allies" of the space movement. *In no way had he expected to be regarded as an* "anti."
4. His contribution had been to set up an accusation and then knock it down (i.e. a Devil's Advocate), though remaining adamant that the idea of selling the space station concept solely on the basis of short-term commercial returns is not feasible.
5. He believed that the BBC had been seeking someone specifically to "counter" the offical NASA position.

It seems clear from this that those of his remarks deemed most appropriate were clipped out of the interview, used out of context and passed off as an authoritative opposition.

This, in my view, is one of the most easy and most unsavoury methods of deception.

L.J. CARTER
Executive Secretary

Ignorance Still Rules

Sir, I agree totally with your hard-hitting editorial in the November 1984 *Spaceflight*. It hits all the old anti-space arguments and knocks them out cold, though there will always be those people who denounce such things as space research as a waste of money so long as poverty, etc exist on Earth.

I recall an "Any Questions" (BBC Radio 4) programme during the height of the Apollo Moon flights, in which a well-known trade union leader answered a question on space research expenditure. His answer was that the only benefit was the invention of non-stick frying pans!

CHRISTOPHER ALLAN
Stoke-on-Trent

SNIPPETS

Sir, Re the *Spaceflight* editorial (November 1984 issue) on the James Burke programme, if robots are so damned good, why don't scientists on the ground replace themselves with robots in their laboratories?

I agree that robots should be used for the automated, repetitive functions and thus leave the rest of us free to use our intellect.

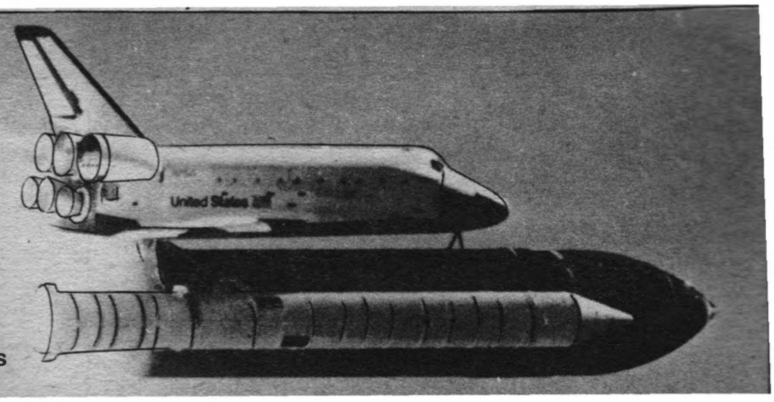
P.R. FRESHWATER
Oxon

Sir, It has been three long years since I last received an issue of *Spaceflight*. When I was forced to give up membership (those dreaded finances) it took a while to get used to the idea of not receiving that monthly welcome addition to my library.

Well, the prodigal returneth. I have always held the BIS in the highest esteem and on those occasions when one hears mention of it on TV or reads of reference to it in the press I think, "I used to be a member of the BIS." I wish to be able to say, "I am a member of the BIS" again. To achieve that end, I respectfully request details of membership dues and conditions again.

RICHARD BARANIAK
Australia

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews 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.



ASTRONOMY

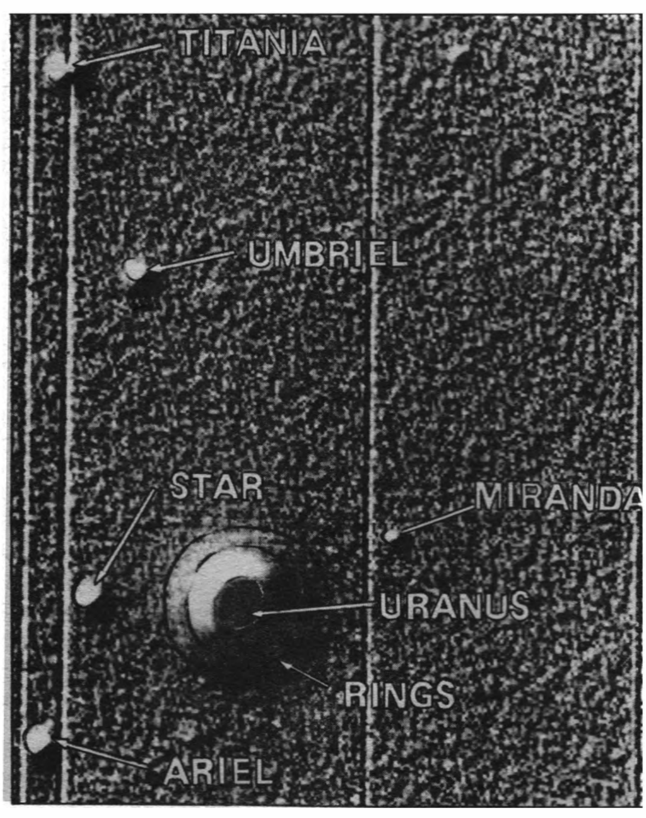
RINGS OF URANUS

Astronomers have clearly photographed the rings of Uranus for the first time, showing them to be made of particles that are possibly the darkest found in the Solar System. Drs. Richard Terrile of NASA's Jet Propulsion Laboratory and Dr. Bradford Smith of the University of Arizona used a charged-coupled device camera system at the Carnegie Institution's Las Campanas Observatory in Chile to record the images last April.

Photographing the rings is difficult because they are darker than charcoal and close to the much brighter Uranus. Computer processing was performed to make the rings visible.

The rings can be seen as a circle of material concentric around the nearly pole-on view of Uranus. (Uranus orbits with one pole facing the Sun; the rings girdle the planet's equatorial region, giving the Uranian system its bullseye-like appearance). The five known moons can also be seen, along with several background stars.

The rings were discovered in 1977 when they blocked out the light of a distant star just before and after Uranus passed in front. The known nine rings are very narrow, with the widest of them, called the epsilon ring, having an average width of about 50 km.



Analysis of the new photographs shows the rings reflect back only about 2% of the sunlight falling on them, making them possibly the darkest material found in the Solar System. This raises the question as to their composition. Two possibilities have been suggested. Evidence from meteorites and observations of asteroids suggests that dark organic material is prevalent in the outer Solar System; another possibility is that they are made of frozen methane, another common material in these regions. Methane ice, which is normally bright, can be darkened by radiation, either by high-energy particles from the Sun or from trapped radiation around Uranus (similar to the van Allen radiation belts around the Earth).

Studies of the rings are particularly important because they will contribute to preparations for the encounter of Voyager 2 in January 1986.

SIRTF INVESTIGATORS

NASA has selected the scientists who will form the Science Working Group for the Space Infrared Telescope Facility, the next generation of Earth-orbiting observatories for infrared astronomy. The scientists were chosen following a review of proposals solicited from the scientific community in 1983. Investigators were sought in several different categories: focal plane instrument investigators, facility scientists and interdisciplinary scientists.

The SWG, in concert with the NASA Ames Center project team, will now help to guide the detailed definition studies for the observatory and its instruments.

SIRTF has a high scientific priority within NASA. According to Dr. Burton Edelson, NASA Associate Administrator for Space Science and Applications, SIRTF is planned as a 1988 'new start.' "As the discoveries of the IRAS mission have shown us, the field of infrared astronomy is a very rich area for scientific discovery. We have great confidence that SIRTF will produce great science by following up on these important discoveries."

Since SIRTF is designed to detect light in the infrared region of the electromagnetic spectrum, it must be cooled to minimise the amount of infrared (heat) radiation emitted by the telescope itself. The optics and interior surfaces will be cooled to a few degress above absolute zero (-273°C). Placing the observatory in space also eliminates the infrared radiation from the Earth's atmosphere.

The reduced background infrared radiation will allow astronomers to study much fainter and more distant infrared sources.

SIRTF will study a variety of objects, ranging from solar system type dust around nearby stars to forming galaxies at the edge of the known Universe. SIRTF's sensitive

infrared observations will advance our understanding of many important astronomical problems. It will build upon the results of the recently-expired Infrared Astronomical Satellite (IRAS), which successfully carried out the first all-sky survey at infrared wavelengths. During its 300 days of operation, IRAS made many discoveries, including seven comets, a ring of solid material around the star Vega and bands of dust around the Sun between the orbits of Mars and Jupiter.

SIRTF will be about 1000 times more sensitive than IRAS and will study a range of infrared wavelengths that extends almost ten times further in each direction (both shorter and longer) than observed by IRAS. The spectral resolution (the ability to discriminate very fine 'colour') will be between 100 and 1000 times that of IRAS. It will also have much greater capability for providing images of infrared sources with fine spatial detail.

SOLAR OBSERVATORY STUDY

British Aerospace is leading an international team in the study of a unique solar observatory spacecraft for the European Space Agency.

The observatory, called SOHO (Solar Heliospheric Observatory), will be placed in a special orbit around the Sun inside that of the Earth's where the gravitational attractions are equal and opposite. The satellite will thus remain fixed on the Sun/Earth line, some 1.6 million km from Earth.

SOHO will make continuous observations of the solar surface, corona and the solar wind. One of its key measurements will be to detect oscillations of the surface. Such measurements, like those obtained on Earth by terrestrial seismologists, will give important clues on the structure of the interior.

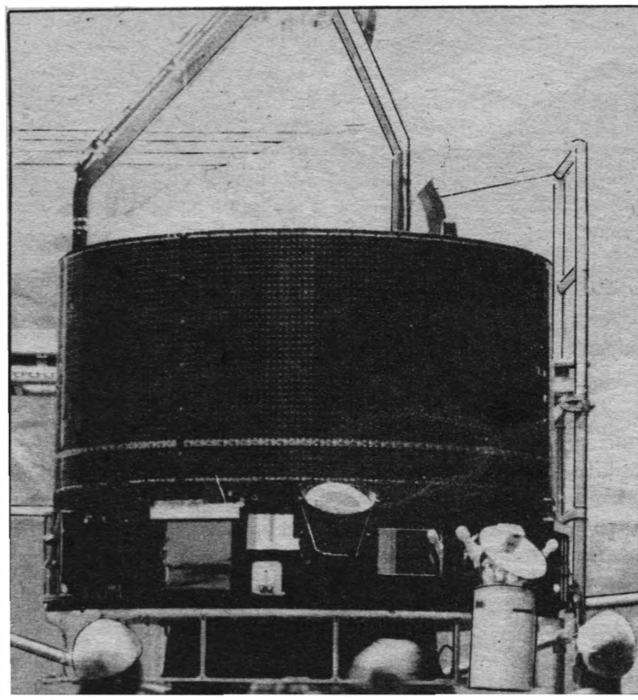
The observatory is planned for launch in 1992 and will participate in an international programme of Sun/Earth studies involving the US, Europe and Japan.

ASTEROID DISCOVERY

A new fast-moving asteroid to add to the 3000 already catalogued has been discovered as a temporary neighbour of the Earth, Venus and Mars. The asteroid, designated 1984QA, was found on 30 August in a path that periodically crosses the orbits of Earth and Venus, and approaches Mars. The gravitational influences of these planets on the 1 km diameter body make its orbit unstable, so 1984QA must be a recent arrival.

Calculations show that the asteroid's close planetary encounters will gradually change its orbit so that sometime during the next 10,000 years it will either hit one of the planets or be ejected from the Solar System completely.

1984QA has a semi-major orbital axis closer to the Sun than that of the Earth (1984QA = 0.989 AU, Earth = 1.0 AU by definition). This places it in the Aten class, named after the first of this type of asteroid, discovered in 1976. This is only the fourth Aten known. All were discovered by JPL scientist Eleanor Helin during her asteroid search programme sponsored by the World Space Foundation. The asteroid is only very rarely observable from Earth. The time it takes to go around the Sun is so little different from the Earth's one year that the discovery circumstances are repeated only about once every 60 years. While not observed at the time, the asteroid came closest in August 1983, passing less than 6½ million km away.



The European Halley's comet Giotto probe, due for launch next July, is seen being installed in the French Toulouse facility in preparation for a solar simulation test.

1984QA continued to be visible through large telescopes to the end of October and it will become more difficult to observe over the next few years until 1986, when it will disappear from our view. It will not be in an observable position again until around the year 2040. Additional observations are being made while it is still visible in order to determine more precisely its physical characteristics and orbital dynamics. Radiometric measurements made from the Infra-Red Telescope Facility in Hawaii give a preliminary indication that the object may be silicaceous, or similar to the Earth in composition.

COMMUNICATIONS

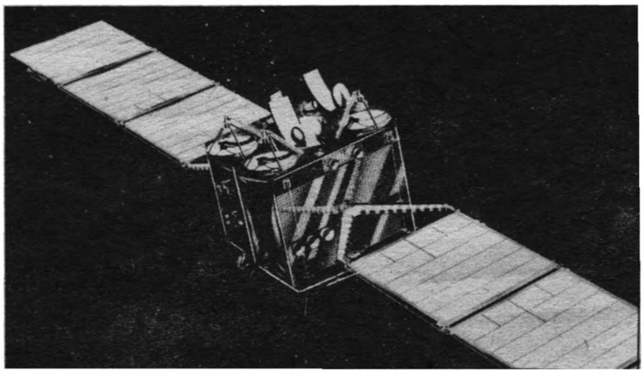
ACTS CONTRACT

NASA has awarded a $260 million contract to a team headed by RCA's Astro-Electronics Division for the design, development and construction of the Advanced Communications Technology Satellite, due for launch by the Shuttle in 1989. A primary goal is to develop advanced satellite communications technologies, including satellite switching and processing techniques and multi-beam satellite antennae, using the 20 and 30 GHz bands. These technologies will be needed for the increased satellite capacity of the mid-1990's.

ECS-2 ACCEPTED

On 12 October 1984 the European Space Agency handed over the ECS-2 satellite to the European Telecommunications Satellite Organisation (Eutelsat). Following its successful launch by an Ariane 3 on 4 August 1984, ECS-2 underwent a number of in-orbit tests before being officially declared operational. Although ESA continues to control the satellite for Eutelsat, acceptance of the satellite will mean that ownership will pass to Eutelsat and the satellite will then be re-named 'Eutelsat I-F2'.

The satellite was brought into service on 1 November. The regional European system was thus completed, with two operational spacecraft in orbit (Eutelsat-F1 was laun-



ECS-2 is now operational.

ched in June 1983). Services include TV distribution to cable networks, telephony, data transmissions and the Satellite Multiservice System (SMS), a system of international links for business services in which the Eutelsat space segment combines with the international space segment of Telecom 1. With SMS, Eutelsat is offering a variety of links in Europe for video-conferencing, high-speed data transmissions, fast facsimile and remote printing.

The European Broadcasting Union (EBU) is using two transponders for the services it provides to its members as part of Eurovision.

The ECS series evolved from ESA's successful experimental satellite OTS (Operational Test Satellite), launched in 1978. They will provide communication services until the early 1990's and ESA is already studying more advanced systems. The third ECS might be launched next August on another Ariane rocket.

SOVIET EARTH STATIONS

Two Soviet coast Earth stations began operations with the Inmarsat international maritime satellite communications system on 17 October 1984. The stations, located at Odessa on the shores of the Black Sea, will provide high quality communications links between ships, other maritime facilities such as offshore drilling rigs and the international telecommunications network.

Owned and operated by Morsviazsputnik, the Soviet Signatory member of Inmarsat, each has a 13 m parabolic antenna, transmitting at 6 GHz and receiving at 4 GHz. One is focused on the Marecs, a satellite operated by Inmarsat in geostationary orbit 36,000 km over the Atlantic Ocean. The other uses facilities aboard an Intelsat 5 satellite over the Indian Ocean. The coverage of the Odessa stations, the first two co-located antennae in the Inmarsat system, therefore extends to almost two-thirds of the Earth's surface.

SPACE SHUTTLE

SHUTTLE TANK DELIVERED

The first Shuttle External Tank for use at the Vandenberg Air Force Base in California arrived in late October after an 8,000 km journey, marking a major milestone in the activation of the West Coast space launch complex. The first launch from there is expected next October.

Most of the major facilities at Space Launch Complex 6 have been completed, including the facility for storage and preparation of the Tank. The US Army Corps of Engineers has been responsible since 1979 for building and facility construction while Martin Marietta Aerospace has had responsibility since 1975 for design, procurement, installation and checkout of Shuttle ground support systems.

The ground support systems consist of 13 new or modified groups of facilities. Major structures, besides the Shuttle Assembly Building, include a launch control centre, payload preparation facility, a mobile tower to take payloads to the vertically-mounted Orbiter, an access tower for the mounted Orbiter and a mobile service tower for access prior to liftoff.

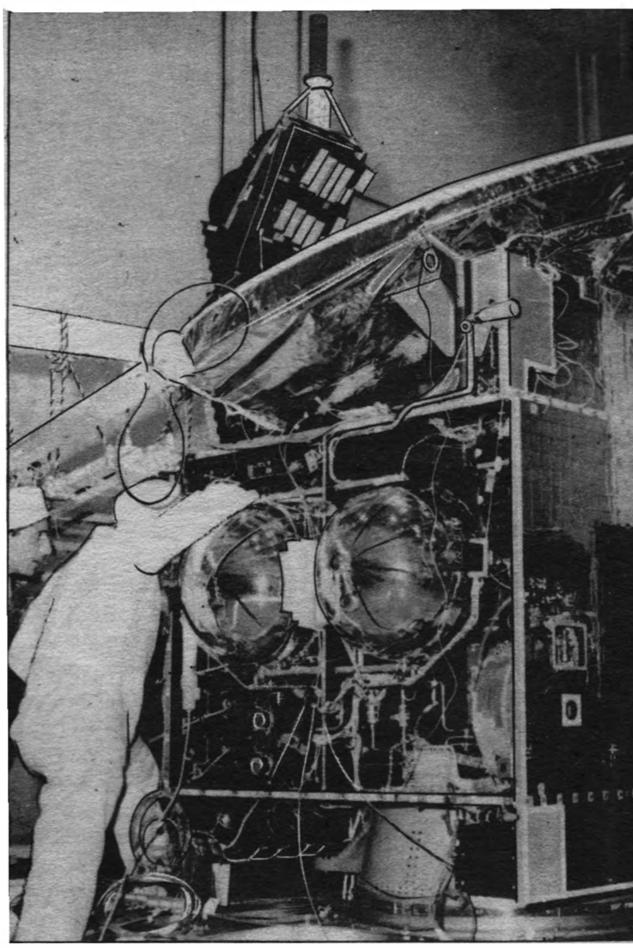
For its journey to Vandenberg, the Tank was mounted on a transporter at Michoud in New Orleans and shipped on a covered barge formerly used to tow Saturn segments to the Kennedy Space Center in Florida. It will be mated with two inert Solid Rocket Boosters and the Orbiter *Enterprise* for compatability testing.

SHUTTLE UPPER STAGES

The Orbital Sciences Corporation in the US are developing a series of four upper stages for use with the Space Shuttle, writes Nicholas Steggall. Based on a modular design, the stages are designed to give increased performance, high reliability and low cost using space-proven hardware. The four stages are: the Transfer Orbit Stage (TOS), a shortened version (TOS-S), the Apogee and Maneuvering Stage (AMS), and a two stage combination vehicle (TOS/AMS).

The TOS, TOS-S and AMS will boost satellites from low altitude 'parking' orbits of the Shuttle to higher orbits,

The Spacenet 2 communications satellite was launched by Ariane VII in November, together with the Marecs B2 maritime communications satellite. The 1995 kg Spacenet and 1050 kg Marecs were both successfully sent into geostationary transfer orbit by the second Ariane 3 launch. *RCA*



such as the elliptical transfer orbit leading to a final geostationary orbit used by communications satellites. The two stage TOS/AMS will be able to place satellites into elliptical transfer orbits, circularising the orbit and changing its orbital plane when final orbital altitude is achieved. The TOS will be ready for its first flight by November 1986, TOS/AMS by April 1987 and the AMS by mid-1987.

ISRAELI SPACE PROGRAMME

The Government of Israel recently formed the Israeli Space Agency (ISA) to plan and implement a series of space projects, writes Joel Powell. In the short term, the Israelis will fly a life sciences experiment involving a hornet's nest aboard the Shuttle by 1985. ISA also intends to fly an Israeli-made astrophysical X-ray sensor aboard NASA's Spartan platform from the Shuttle within the next few years. In the long run, plans include a low Earth orbiting satellite by 1988 to carry environmental and Earth resources instruments. By 1993 ISA hopes to develop a weather satellite and communications satellite (or at least to buy several transponders on a foreign spacecraft). ISA would also like to develop a national satellite launcher, but this is by no means certain.

ASTRONAUTS ASSOCIATION

Following discussions at a meeting in July, the astronauts of Western Europe have formed an Association of European Astronauts (AEA). The declared aims are to encourage meetings for the exchange of views on their training experience and the projects concerned. All European astronauts who have either flown or have been selected to train for a specific mission are eligible to join. The first working meeting was scheduled for 5/6 October 1984 in Maastricht, The Netherlands.

The AEA began with seven members; three ESA astronauts, Claude Nicollier, Ulf Merbold and Wubbo Ockels; two French astronauts, Patrick Baudry and Jean-Loup Chrétien; two German astronauts, Reinhard Furrer and Ernst Messerschmid. Ulf Merbold has already flown on the Shuttle during the first Spacelab mission and Chrétien was on the Soviet Soyuz T-6/Salyut 7 mission. The others are assigned to flights that will take place during 1985. In addition, new members from Italy and Britain are being invited to join the association.

During the working meeting it was planned to discuss plans for Europe in manned space flight, including Columbus, ESA Long Term Planning, US Space Station and German Spacelab preparation.

MATTINGLY LEAVES NASA

Astronaut Tom Mattingly has been named as the Director, Space Program of the Naval Electronic Systems Command, effective early next year, NASA and the US Navy have announced. Becoming a NASA astronaut in April 1966, he flew as command module pilot of Apollo 16 in 1972, and as commander for STS-4, the fourth Shuttle flight, in 1982.

NASA Administrator James Beggs said of Mattingly: "America's civil space programme has profited immensely from having on tap the skill and expertise of military career people like Ken."

October 1984

8 NASA has tentatively given approval for the Galileo probe to fly past an asteroid on its way to Jupiter. A final review still has to be made. Launch is due by Shuttle/Centaur in May 1986.

8 NASA has submitted a new Shuttle pricing policy to the President for approval. Until Oct. 1988, they will charge $71 million for a full cargo bay and after that might charge up to $100 million.

8 China will now launch satellites for other nations on a commercial basis, it is reported. The new liquid oxygen/hydrogen booster, Long March 2, comparable to the US Delta, can handle 400 kg into geostationary orbit from the new launch centre in the southwest at 28°N/100°E.

8 British Aerospace is leading a team of companies in studies for the European SOHO solar obseratory satellite.

10 Astronomers have directly photographed the rings of Uranus for the first time. Using a charge-coupled device camera and image processing, they were found to reflect only 2% of incident sunlight, making them the darkest known objects in the Solar System.

11 The second NOVA US Navy navigation satellite is launched by Scout from California.

12 Iran becomes the 41st member of Inmarsat, the maritime communications satellite agency.

13 Shuttle *Discovery* lands at Kennedy Space Center, Florida at end of mission 41G. The imaging radar experiment might be reflown because of 60% lost data. The Large Format Camera appeared to be completely successful.

16 The 4 m Anglo-Australian Telescope in Australia reaches 10 years of operation.

20 Astronomers have photographed a disc of material around the star Beta Pictoris.

21 The first Space Shuttle External Tank arrives at the Vandenberg Air Force Base in California for the first launch into polar orbit, due next October.

22 The orbits of the Palapa and Westar satellites are being lowered using onboard thrusters for the Shuttle rescue mission in November.

22 The US Congress has approved $15 million funds for the USAF to study a new expendable booster to supplement the Shuttle. Possibilities are now Titan and Atlas Centaur versions, and a new vehicle based on the Shuttle solid boosters.

22 A new asteroid, 1984QA, has been discovered in an unstable orbit crossing the paths of Earth and Venus.

25 A countdown demonstration test is concluded for Shuttle 51A (*Discovery's* second flight).

29 NASA's second TDRS communications satellite is due to be delivered on 8 Dec. for launch next Feb.

31 It is estimated that space losses this year (including the Palapa, Westar and Intelsat 5 communications satellites) have cost insurers $300 million.

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

TWENTY YEARS IN SPACE

British Aerospace embarked on its journey into space 20 years ago. The Company's heavy launcher, Blue Streak, was establishing its faultles series of firings and, in 1964, the Company received its first satellite contracts - for the design and construction of the first all-British spacecraft, Ariel 3 (launched in 1967) and for the first scientific spacecraft of the European Space Agency, Esro 2 (Launched in 1968). Both were designed to collect scientific data in space for one year, but went on working long beyond their design lifetimes. As BAe looks ahead to the next 20 years, it is timely to review what might come about with two major projects.

Introduction

In the two decades of its space career, British Aerospace has been the prime contractor for 13 launched communications and scientific satellites without a single failure in orbit. The company has also been involved as a major subcontractor in 27 other satellites that have been launched for scientific and communications purposes, again without a single failure in orbit.

Today, in the ever-expanding world of space communications, reliability, performance and cost are of prime importance to those who buy satellites, those who operate them and those who use them. Twenty years of designing and building satellites of increasing mass, power and complexity, exploiting new technologies and employing an ever-widening range of sophisticated test facilities has put BAe into the position of European leader in space communications and the chosen supplier of European commercial communications spacecraft.

Space Platforms

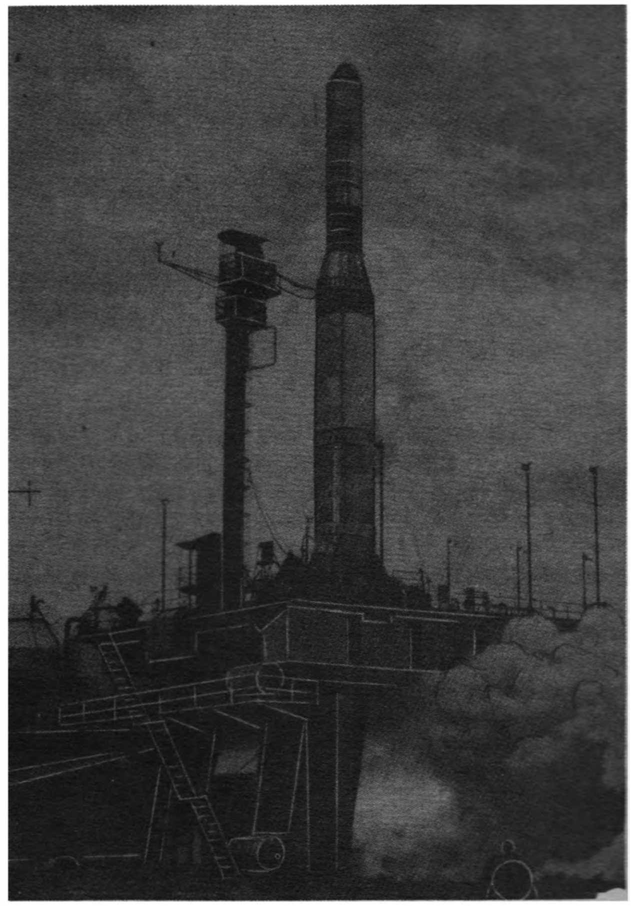
Designed to operate in conjunction with the NASA manned Space Station of the 1990's, the BAe Space Platform would provide a wide variety of unmanned missions at Space Station altitude. It would be taken into orbit on a single Shuttle launch for manned assembly *in situ*.

The unmanned platform is proposed as a key element for European participation in the US Space Station programme. Analysis of operating costs indicate that launch and facility costs for payloads attached to the Platform will be about half of those for payloads flown on retrievable carriers such as Eureca or multi-mission spacecraft.

The Platform will be a multi-user facility, offering power, cooling, data services and orbital control in a contamination-free environment with very low residual accelerations, unaffected by the presence of man. In orbiting in proximity to the manned Station, it will take advantage of manned operations for servicing and payload exchange.

As a permanent facility, it will offer the advantages of requiring only the launch of payloads for different missions, avoiding the need to launch complete spacecraft. Payload retrieval costs will be reduced as well. Again, being a permanent facility, it will not suffer periods of inactivity during which the support equipment of retrievable spacecraft has to be serviced on Earth.

In orbit mass would be around 11 tonnes, with an array width of 54 m providing 35 kW at beginning of life with 12 kW available to the payloads and a thermal rejection capability of 15 kW. Operating altitude can vary from 400 to 800 km. Six berthing points on the 16 m long payload beam could carry up to six full pallets, each containing about 4000 kg of mixed payloads.



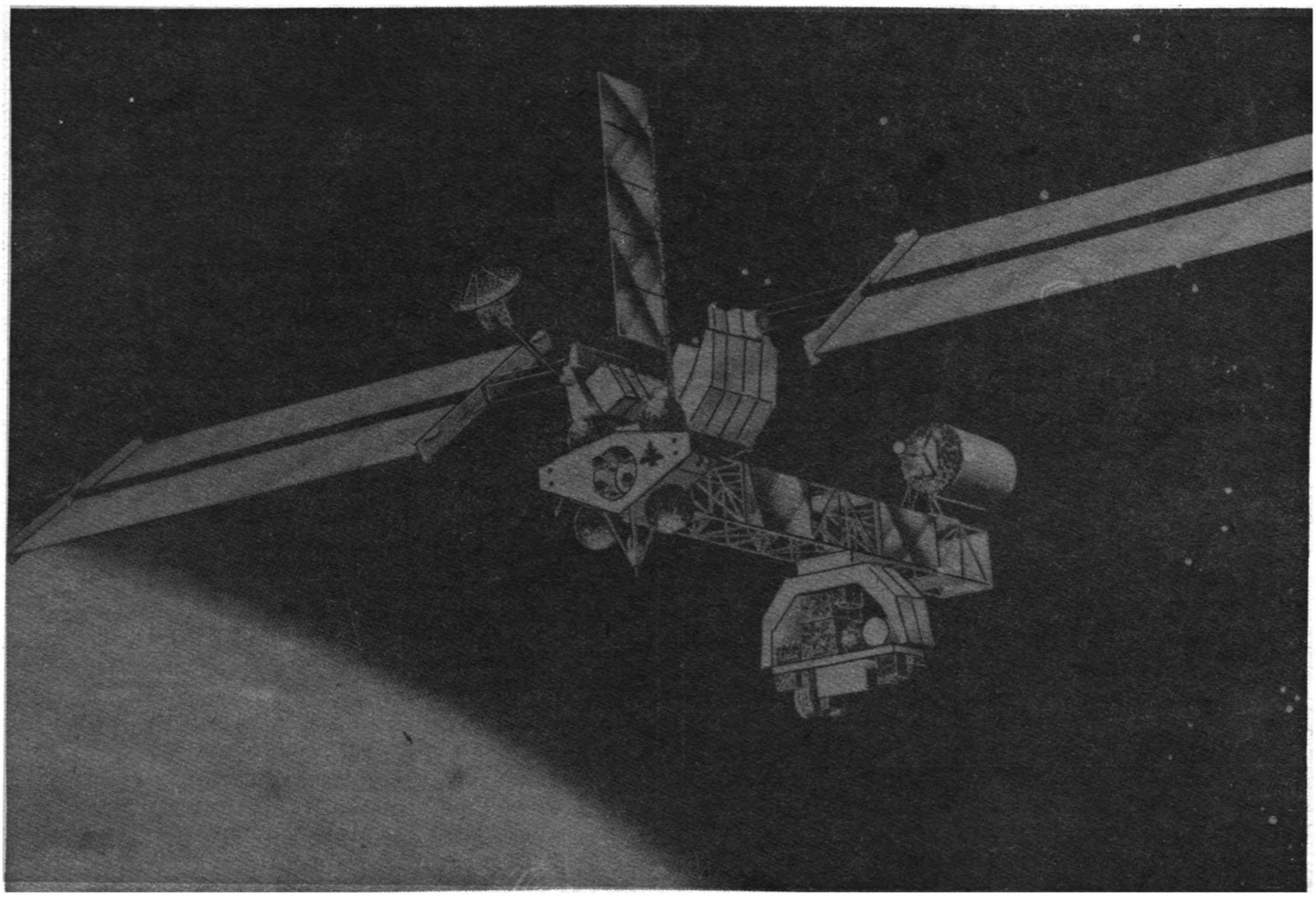
Blue Streak as the first stage of Europa.

Communications

British Aerospace, with its partners in Europe and Canada, is now building Olympus 1 for ESA. This satellite will be the precursor of the Olympus class, the most powerful communications satellites in the world. Olympus 1 will generate 3.5 kW from its solar arrays to provide a variety of broadcasting and telecommunications for Europe in the Ku and Ka bands. Later versions will develop up to nearly 8 kW of power that will enable the satellite to offer up to 12 full power direct TV channels for the US or up to 100,000 telephone circuits or their data equivalents.

Olympus is based on the classic three-axis stabilised form of spacecraft, exemplified by the British Aerospace OTS, ECS, Marecs and Eurostar classes and by the communications satellites of most other world manufacturers. When DC power requirements reach 4 kW, spinning satellites become too large; three-axis stabilised craft can reach up to 8.kW. An input of 8 kW means that about 5 kW must be dissipated as waste heat (because of the inefficiences of the electronic equipment carried inside the body) and the three-axis body can dissipate this heat only through the two faces that do not 'see' the Sun - 'north' and 'south' faces on which the solar arrays are mounted. The size of these faces are constrained by the capacity of launchers.

It is this limitation that has led to the form of spacecraft that will be required in the 1990's and into the next century, before the huge space stations of that century come into being. British Aerospace believes that the basic



The British Aerospace Space Platform could be launched by a single Shuttle.

concept must change - neither the three-axis nor the spinner will be able to handle the ever-increasing traffic demands through each orbital 'parking slot,' but at the same time the new satellites must still be capable of being lifted into orbit by future launchers.

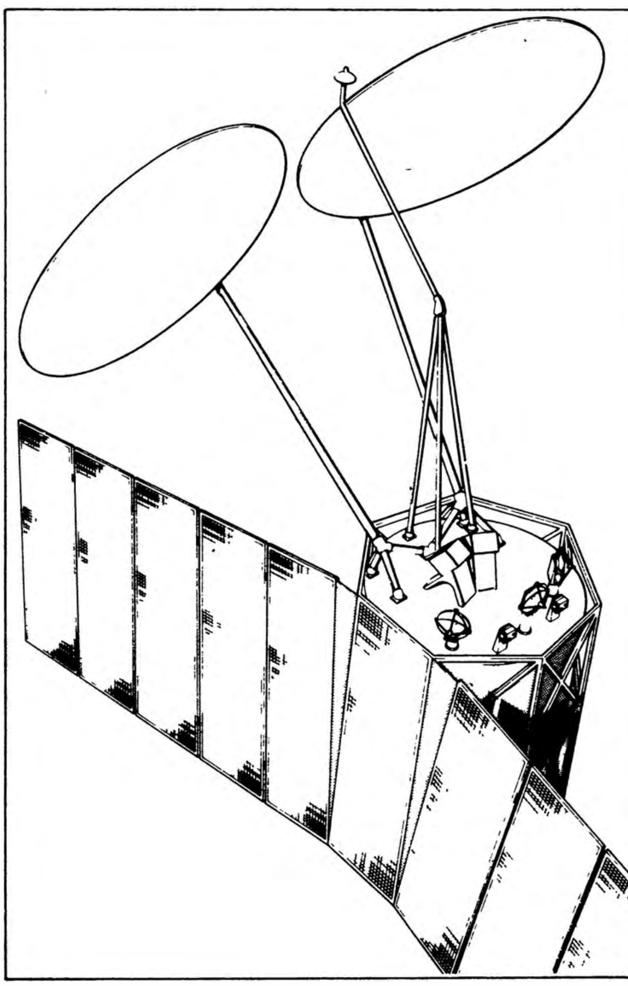
Unlike today's conventional spacecraft, the body of the 'Big Communicator' locks permanently towards the Sun. The first change, therefore, is that there are no rotating bearings and power transfer devices between the body and the solar arrays.

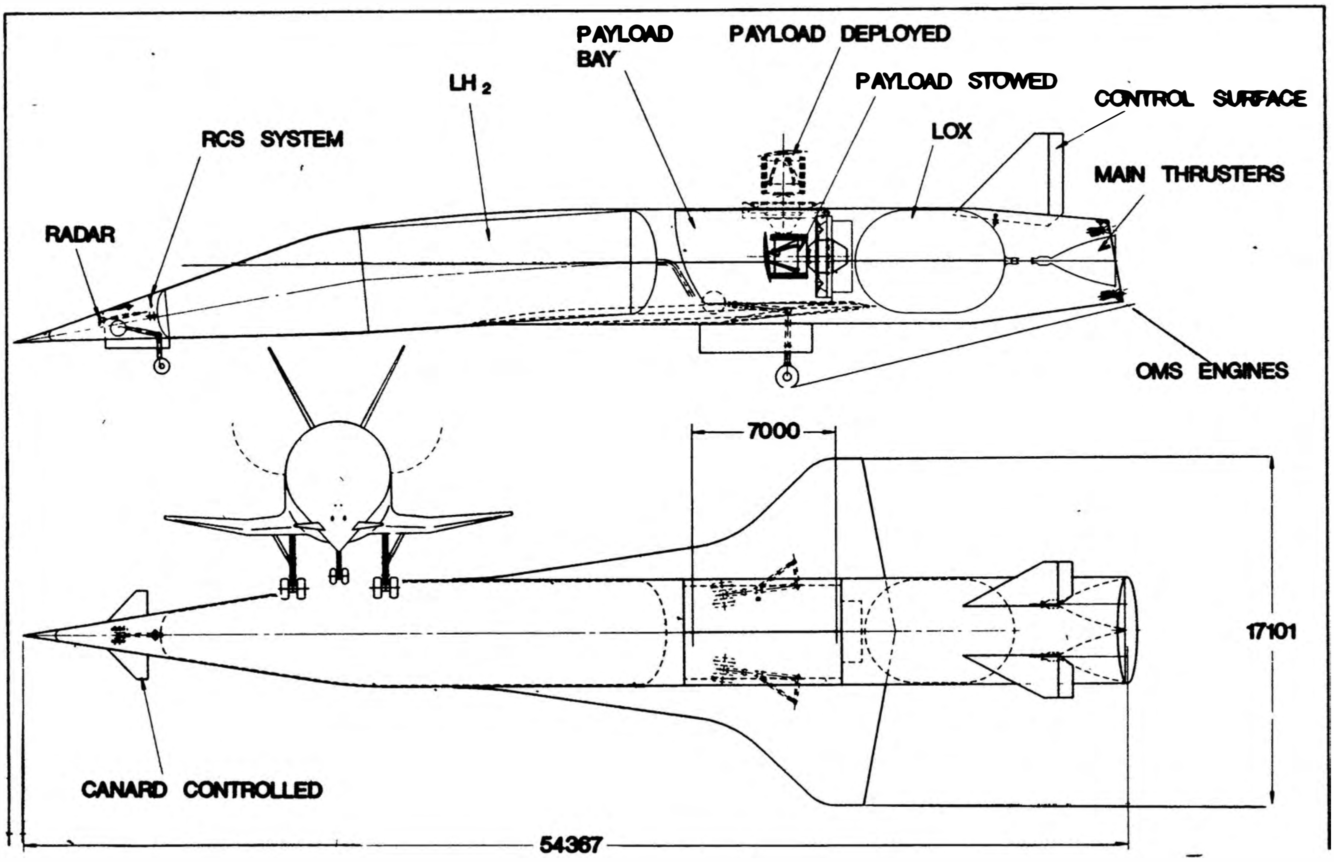
The body itself consists of an open framework, into which is inserted a drum that rotates once per day. This drum, mounted on a bearing, carries all the antennae and communications equipment for the mission and is locked towards the Earth.

The principal advantage is that of thermal capacity. Unlike spinners and conventional three-axis designs, the Big Communicator puts the payload drum permanently in shade. Thus, for a given volume of spacecraft, more heat dissipation can be handled from a larger payload. In comparison with today's satellites, the payload/body mass ratio of the Big Communicator shows on improvement of nearly 2 to 1.

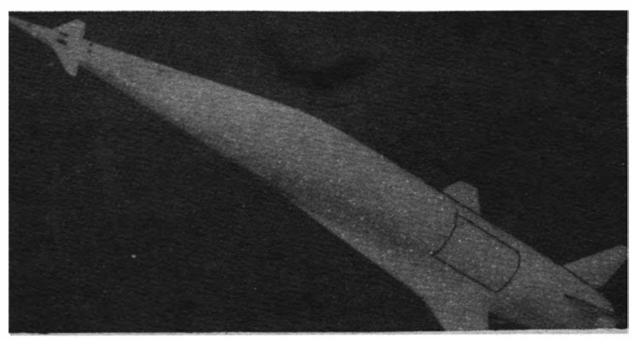
A secondary advantage arises from a reduction in the number of bearing and power transfer assemblies from two to one. The one that *is* used has to carry only the power associated with the payload and not the additional power required by the satellite body.

Adjacent column: A Big Communicator showing the body and arrays locked onto the Sun. The body has an open structure containing a drum that rotates once per day and radiates excess heat from the payload through its structure. The communications equipment, antennae and inter-satellite links are mounted on the drum. The arrays are given "anhedral" to provide a clear line of sight for the antennae when they are looking along the plane of the arrays and for balancing torques.





The British Aerospace Hotol concept, capable of handling up to 7000 kg to low Earth orbit in its 9 x 4.5 m cargo bay. Rolls-Royce are contributing to the propulsion studies. (Dimensions in mm).



The open-framed body is seven sided, one to act as the mounting face for the arrays and the others to provide a symmetrical mounting for the wrap-around array panels. The number of panels can be varied from six (three on each side) to 22 (11 on each side) to provide a DC power range from 4 kW to 15 kW. In each case, power in transfer orbit is provided by the central body-mounted array panel and by those wrap-around panels that expose cells when wrapped. In cases where multi-wrapping is used (more than three panels on each side), the total number of panels is chosen to ensure that not less than two panels expose cells when wrapped. Thus, in the maximum case of 22 panels, wrapping occurs four times, but the last wrap contains only two panels, leaving two of the previous wrap exposed.

Stabilisation is achieved by twin momentum wheels with a common axis on the Sun-pointing axis, controlled off-Sun sensors with automatic compensation for variations in Sun angle between solstices. The payload drum is driven off its central bearing, which is controlled by Earth sensors on the drum and by radio frequency pointing when required.

The body carries all the satellite service functions, including attitude and orbit control thrusters, fuel supplies, batteries and telemetry and is configured at its base to mount on to the Ariane 4 or on to a liquid-propellant perigee stage for the Shuttle.

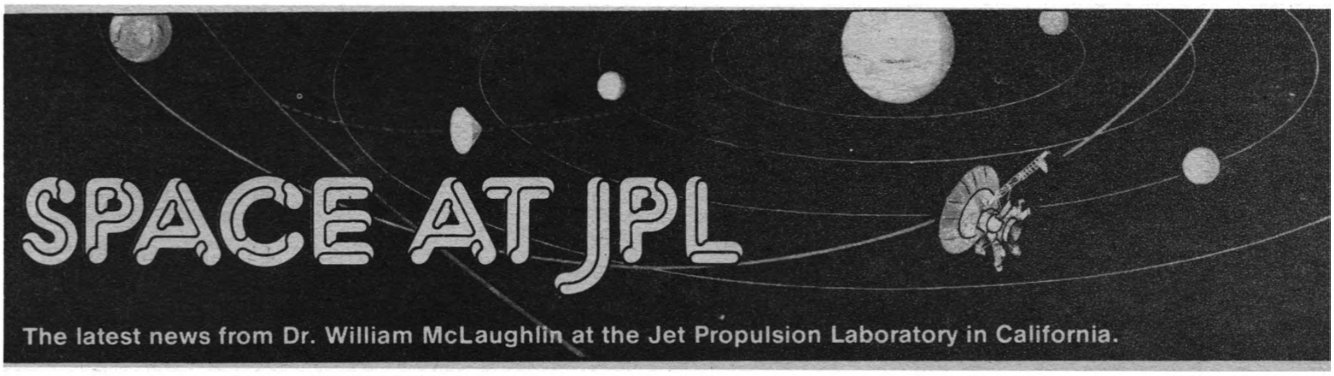
Thermally, the payload drum, which is mirrored and which exposes most of its surface to space at any one time, provides a benign environment for the payload, with increased mounting areas available for high-dissipation elements and for batteries that are sensitive to high temperatures.

The design needs to be flexible to accommodate the various services that the Big Communicator will provide: fixed, mobile and broadcast services. Differences between these three types are seen in the array power and the antenna configurations. The principal difference in comparison with today's satellites will be the use of inter-satellite links in Big Communicator clusters and between clusters. This will permit clusters to be accommodated in orbit above land masses, providing total coverage of those areas, with communications between clusters by carbon dioxide laser links. Thus, the traditional configuration of satellites over oceans to interconnect continents, with the inevitable limitation on continental coverage, will be replaced by laser-linked clusters of Big Communicators over each continent.

Typically, with its improved mass-carrying capacity and with new communications technologies, a Big Communicator will be able to handle ten times the capacity of an Intelsat 5. With it will come other new concepts by British Aerospace:

STV: A new, high-efficiency, liquid-propellant upper stage for Shuttle, to lift satellites of the Olympus and Big Communicator classes from lower Earth orbit to geostationary orbit.

HOTOL: A new concept for a Horizontal Take-Off and Landing launcher which will provide more efficient and more economic means of launching than today's vertical take-off rockets (described in detail in November 1984's *Spaceflight* 'Space Report' section).



COLOURS OF INFRARED STARS

The ancient Greek astronomers Hipparchus and Ptolemy arbitrarily graded the visible stars into six brightness classes in their two famous catalogues. The stars in the sixth class were just barely visible to the naked eye, while the 20 or so brightest stars occupied the first class.

Nineteenth century astronomers quantified this classification and defined a first magnitude star to be 100 times brighter than a sixth magnitude star. Now, it is a curious physiological fact that the human eye converts equal *ratios* of brightness into equal *intervals* of perceived (psychological) intensity. So, since there is a difference of five magnitudes between a first magnitude star and a sixth magnitude star, each magnitude class is brighter than its neighbour by a factor equal to the fifth root of 100, or approximately 2.5 Thus, a first magnitude star emits about 2.5 times more photons per second than does a second magnitude star.

Modern astronomy has extended the concept of stellar magnitude in two directions: (1) to include stars fainter than sixth magnitude (and, also stars brighter than first magnitude; Sirius has a magnitude equal to *minus* 1.4), and (2) to measure the brightness of a star at different colours.

With regard to extension (1), Halley's comet was recovered with the 5 m telescope at Palomar in 1982 when it was a very faint object, at magnitude 24.3, which is more than 20 million times fainter than one of Ptolemy's sixth magnitude stars.

Ptolemy did make a comment in his catalogue on the colours of six stars, calling them *hypokirros,* or yellowish. Modern photometric techniques employ filters of various colours, i.e., filters that pass only selected wavelengths of light and then measure the magnitude of the star in question at that colour. By comparing the magnitude of a star at one wavelength (colour) with its magnitude at another, the star can be better characterised than by quoting a single magnitude to represent it.

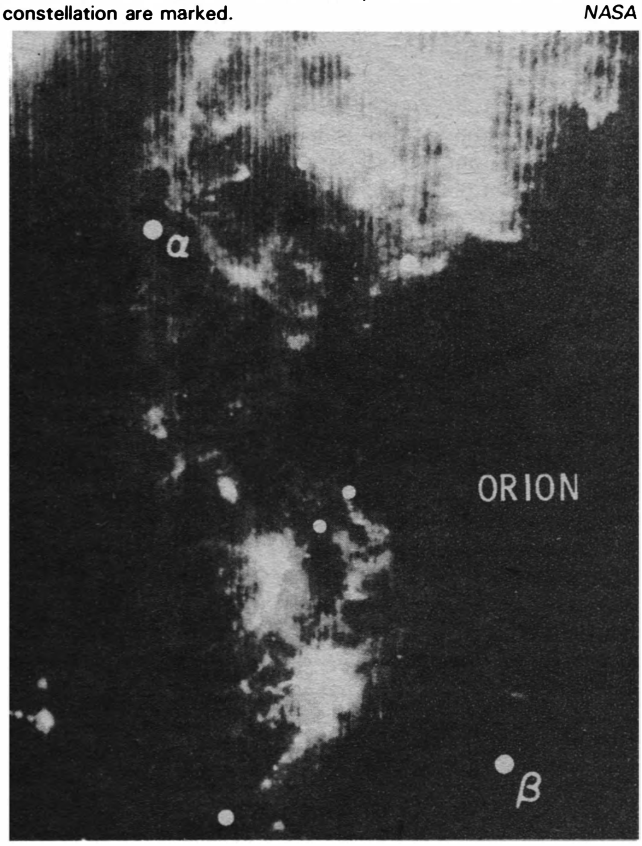
During its 10 month mission in 1983 to survey the entire sky at infrared wavelengths, the Infrared Astronomical Satellite (IRAS) catalogued some 250,000 stars, measuring both their positions and brightnesses at several wavelengths (colours). Visible light extends from a wavelength of about 0.4 microns to 0.7 microns (a micron is one millionth of a metre); IRAS recorded energy in the infrared region from 8 microns to 100 microns.

Dr. George Aumann of JPL and a member of the IRAS flight team in England was making what he describes as some 'rather mundane' measurements on 10 stars that were being used for inflight calibration purposes. During this activity he noted that the star Vega was considerably brighter at 60 microns than expected. Intrigued, Aumann and his colleague Dr. Fred Gillett of the Kitt Peak National Observatory examined in detail the immediate region about Vega. The rest is history (see the December 1983 edition of this column).

They found that Vega possessed an extended structure about it on the order of 100 astronomical units in diameter. Calculations showed that this structure consisted of particle-sized objects rather than mere dust or gas. It could not be determined whether or not planets are present in this cloud of material. Later, a second star, Fomalhaut, was also found to have particles orbiting about it (see 'Space at JPL' in the April 1984 issue). Fomalhaut is also brighter at 60 microns than it is at 12 microns, due to the cooler, orbiting material; cool objects like particles emit longer wavelengths than hot objects like stars.

With these examples in mind, Aumann searched the IRAS data, recording the difference between the magnitudes of stars at 60 microns and at 12 microns and concluded that 10% to 20% of nearby main sequence stars are at least one magnitude brighter at 60 microns than they are at 12 microns. Vega was two magntidues brighter between these two infrared 'colours.' One star, Beta Pictoris, was over five magnitudes brighter at 60

The Orion Nebula as seen in infrared by IRAS. The main stars of the constellation are marked. *NASA*



microns. The term 'main sequence star' is an astronomical classification that distinguishes these stars from the so-called 'red giant or supergiant stars.' Our Sun is a typical main sequence star.

No extended structures have been determined to exist around these stars with infrared excesses at 60 microns other than, of course, Vega and Fomalhaut. However, the phenomenon is suggestive and Aumann speculated at an International Astronomical Union meeting in Boston in July that the infrared excesses could be indicative of a certain stage of stellar evolution. It is possible that a small-particle stage could precede the production of planets; theorists presently believe that it took our Solar System a few hundred million years to accrete its outer planets. (The Solar System, if observed from afar, would not show a significant infrared excess, because the planets, compared to a swarm of small particles, do not have sufficient surface area to be detected in this way).

Further observations and analysis must be conducted before the evolution of other stellar systems can be understood; but see Paul Weisman's interesting conclusions about possible comets around Vega, as reported in the November 1984 issue of this column.

If the 10-20% of the stars with infrared excesses do eventually prove to be protoplanetary systems, Aumann concludes that, logically, the places to look for planets would be those main sequence stars that do not exhibit excesses, i.e., stars that have, possibly, already given birth to their planets.

HERSCHEL, URANUS AND INFRARED

In 1781 the musician and astronomer William Herschel (1738-1822) made the first addition to the set of six planets known since prehistory. Observing from his residence in Bath, England, he discovered the planet that eventually came to be known as Uranus.

Herschel detected its non-sidereal nature by the existence of a sensible disc and a subsequent motion from night to night. Writing in the *Philosophical Transactions* of the Royal Society, he describes the process of discovery: 'On Tuesday the 13th March, between ten and eleven in the evening, while I was examining the small stars in the neighborhood of H Geminorum, I perceived one that appeared visibly larger than the rest...' At this time Herschel thought he had detected a comet, as evidenced by the title of his paper: "Account of a Comet."

In addition to Uranus, Herschel effected the first extension of the electromagnetic spectrum beyond the visible region when he found and explored the infrared in 1800. To accomplish this he split sunlight into its constituent colours using a prism and then placed a thermometer adjacent to the red portion of the spectrum, where no colour was apparent to the eye. The indicated temperature rose above ambient conditions in the room; the infrared had been discovered.

Two current programmes at JPL are directly dependent upon Herschel's discoveries. Voyager 2 is on its way to a January 1986 closest approach to Uranus, and IRAS data are still being analysed after that satellite's all-sky survey in the infrared conducted in 1983.

The City of Bath is a marvel of Georgian architecture and has extensive Roman archaeological discoveries to interest the visitor. However, none of Bath's attractions exceeds in scientific significance the Herschel House and Museum at 19 New King Street. The house itself was built in 1766 and from its garden Herschel discovered Uranus. The William Herschel Society, formed in the City of Bath in 1977, has restored the house and reproduced in its interior the flavour of Herschel's research and 18th century bath.

Herschel was a professional musician and composed for and played the organ in the Octagon Chapel in Bath, as well as performing in Bristol and other towns. A musical display in the Herschel House commemorates this aspect of his life in addition to astronomical and personal memorabilia of Herschel and his sister and colleague, Caroline. Miss Herschel was a musician (singer) and astronomer in her own right. She discovered eight comets and was awarded the gold medal of the Royal Astronomical Society in 1828.

It is a thrill not to be missed by the devotee of astronomy and space exploration to stand in Herschel's garden where the known Solar System suddenly expanded by a factor of two on a winter night in 1781.

THE POWER OF PHOTONS

Potential applications of specular (or mirror) reflection in space missions were examined in the November edition of this column. There it was shown that solar photon management with carefully positioned mirrors could transfer information over large distances across the Solar System. The advanced concept review for this month returns to the subject of photons but concentrates upon their ability to exert force.

The physics underlying the use of photons to transmit force relies upon the fact that they possess momentum and that, upon striking an object such as a spacecraft, some momentum gets transferred to that object. In principle, it is no different from transferring momentum from racket to ball in a game of tennis. In space navigation the force of 'solar pressure' exerted by photons from the Sun is significant. If neglected in trajectory computations it would result in errors of thousands of kilometres for interplanetary flights.

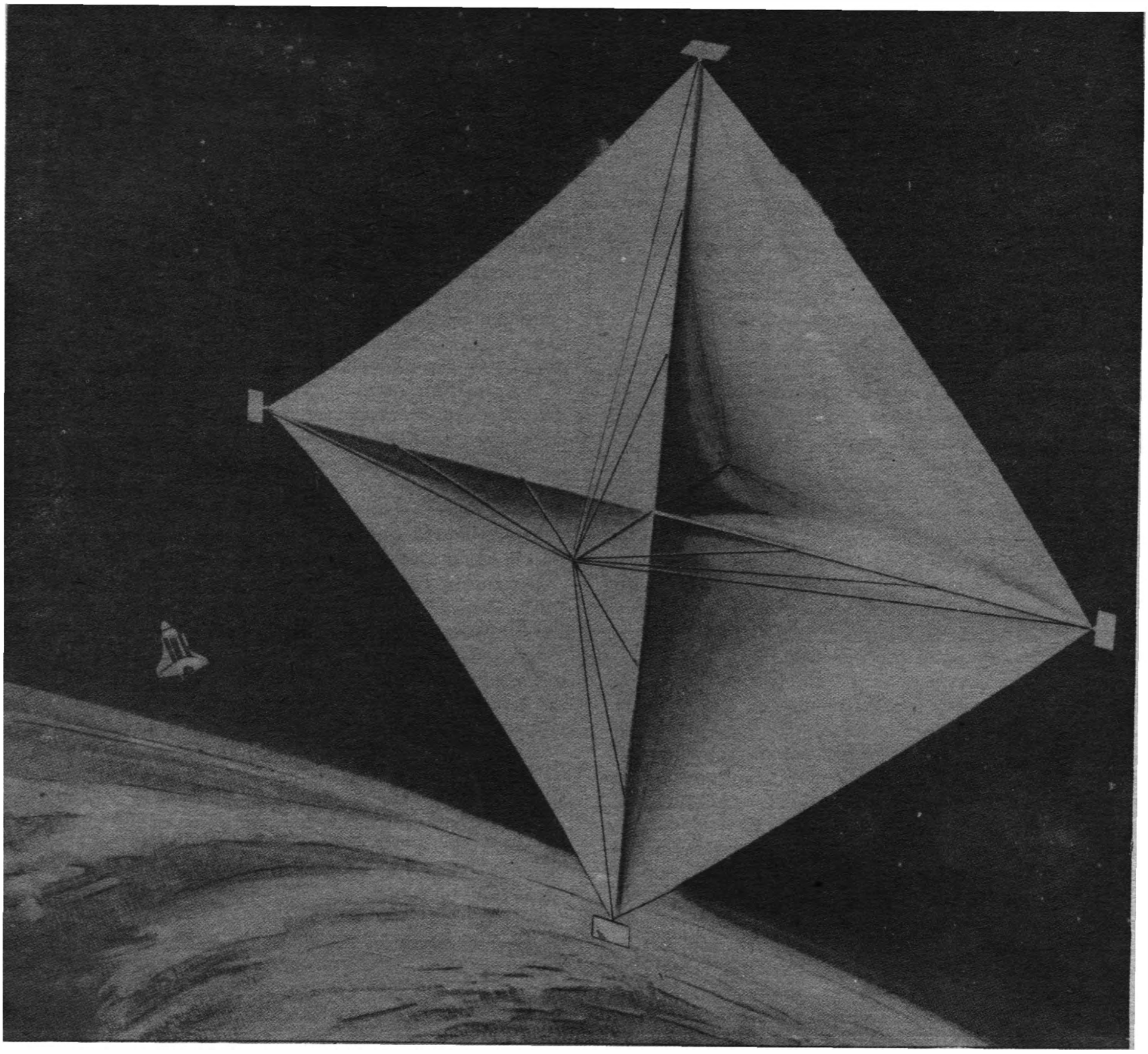
It is possible to use the photons in an active manner to control the attitude (orientation) of certain spacecraft. The Mariner 4 Mars probe and the more recent Insat communications/meteorology satellites of India carried solar vanes. By adjusting the position of these vanes, rotational forces could be generated to control attitude. This method of control reduces or eliminates the usual reliance upon small rocket thrusters for attitude control.

The most successful use of this method occurred during the Mariner 10 mission to Venus and Mercury. Mariner, launched in 1973, was running out of propellant for its attitude control subsystem and so a plan was devised to use its solar panels (normally used only to convert sunlight to electricity) as solar vanes. Without this, it would not have been possible to accomplish the three successful flybys of Mercury.

One of the most exciting applications of solar pressure will be to propel spacecraft: solar sailing. The concept in modern times goes back to 1946 when an Italian, Luigi Gussalli, suggested a variant of what is currently conceived as solar sailing (Tsiolkovsky, as usual, was earlier in thinking of the idea).

The use of a solar sail was seriously considered for a rendezvous with Halley's comet, a mission (never funded) that the Jet Propulsion Laboratory was designing in the late 1970's. However, the solar sail eventually lost out to solar electric propulsion.

Numerous other applications of the solar-sailing technique have been proposed in the literature. For example, Robert L. Staehle has suggested that Solar Sail Cargo Vehicles could play a useful role in a mission to Mars (see his article in the January 1983 issue of *Spaceflight*). The first actual solar sail mission could be the World Space



A 1976 NASA concept for a 700 m square solar sail for Halley's comet.

Foundation's planned engineering development mission scheduled for 1987 or 1988. The primary objectives for the Earth-orbiting mission are to understand the dynamics of the sail and the control of the spacecraft.

Robert L. Forward has proposed an extension of the solar-sail concept that could be applicable to interstellar flight: a sail driven not by solar photons but by a bank of powerful lasers in solar orbit (and drawing their power from the Sun - see the October 1976 *JBIS* for his analysis).

Perhaps the ultimate use of photons for propulsion would occur with the construction of a photon rocket in the more distant future. It certainly would have a high exhaust velocity!

Going beyond photon rockets, one can speculate on the possibility of tachyon rockets. Tachyons are hypothetical particles that travel at speeds greater than that of light (a photon's pace). The nomenclature for particles of various speeds is rather amusing: tardyons (less than the speed of light), luxons (at the speed of light, i.e., photons), and tachyons (greater than the speed of light). Readers interested in the vagaries of tachyons should consult Martin Harwit's book *Astrophysical Concepts* (Wiley, 1973).

ULYSSES MISSION

The International Solar Polar Mission, a joint ESA/NASA project, has been renamed 'Ulysses.' The new name arose as the result of a contest and was the suggestion of Bruno Bertotti of Italy who will be the principal investigator for a gravity-wave experiment on the mission.

The relationship to solar exploration comes from a late medieval tradition which tells of a last voyage of Ulysses beyond Gibraltar into 'an uninhabited world behind the Sun,' as described in the 26th Canto of Dante's *Inferno*. The new name and the Ulyssean traditions of exploration that cluster around it 'could help in framing our technical work in a broader poetical and philosophical background' according to Bertotti.

The unique feature of the Ulysses mission is that it will explore both poles of the Sun from a position far out of the plane of the ecliptic, or orbital plane of the Earth. Most previous space missions have been confined to a narrow band about ± 7.5° centred on the ecliptic (see 'Space at JPL' in the March 1983 issue). The primary objectives of the Ulysses mission are to investigate, from

its advantageous position, the properties of the solar wind, solar flare X-rays, cosmic gamma ray bursts, the heliospheric magnetic field, the interplanetary magnetic field, cosmic rays and cosmic dust. In addition there will be the previously-mentioned gravity-wave experiment as well as some radio science investigations.

The 370 kg spacecraft was built by Dornier Systems of West Germany and is currently in storage at the ESTEC facility in Noordwijk, The Netherlands. It entered storage in December 1983, resulting from a delay in the original launch date of 3 February 1983. It will be removed in March 1985, when it will be re-integrated with the scientific instruments which are stored separately at the institutions of the principal investigators.

After launch in 1986 from a Shuttle/Centaur G' combination, Ulysses will first head to Jupiter in order to receive a gravity assist that will fling it far out of the ecliptic and in a direction back toward the Sun. The first solar encounter will begin when Ulysses reaches 70° solar latitude, in either October or December 1989, depending on the final trajectory chosen. It will spend about four months above that latitutde at a distance of just over two astronomical units from the Sun (an AU is the mean distance from Earth to Sun: about 150 million km). Polar passage is scheduled to take place in either December 1989 or February 1990, again depending on the trajectory.

Bending down toward the ecliptic, it will cross that plane in July 1990 and begin its climb to the opposite pole which will be overflown in October 1990 or January 1991. The end of mission is 27 March 1991. Whether Ulysses passes the north or south pole of the Sun first has yet to be decided; a south-first polar passage is currently favoured but the final selection may not be made until as late as six months before launch.

Since both Ulysses and NASA's Galileo mission will head to Jupiter in 1986, they must share the 'Jupiter window' for that year. The combined possible launch period for these two missions is contained between 15 May and 8 June, inclusive. Nominally, Ulysses will be launched first. Galileo will become the prime mission for launch on 20 May. Even though the two will go up from different pads at the Kennedy Space Center (39A for Ulysses and 39B for Galileo), a 64 to 112 hour reset period must be allowed between launches for operational considerations, a factor that would assume significance if the Ulysses launch were to be delayed for some reason.

In addition to supplying the craft, four of the nine instruments and elements of the mission design, ESA will lead mission operations (from JPL). NASA will provide the Shuttle/Centaur launch vehicles, part of the mission design, five instruments, the RTG power source for the spacecraft, the operations facility and tracking and navigation functions.

The US project manager for Ulysses is Willis G. Meeks of JPL, and Derek Eaton is the European project manager.

SIMULATING VOYAGER

The Space Flight Support building at JPL (more commonly known to the natives as Building 264) houses, as the name implies, several of the Laboratory's flight projects: Voyager, the Venus Radar Mapper (VRM), the Extreme Ultraviolet Explorer (EUVE), the proposed oceanographic satellite Topex and the Ulysses mission. In the northeast corner of the fifth floor of the building is a large room filled with computers and supporting equipment. The purpose of this apparatus, the Capability Demonstration Laboratory (CDL), is to provide a realistic simulation of the Voyager spacecraft in order to test the effect of new computer programs upon the spacecraft. The CDL allows us to determine whether or not Voyager will respond to its computer instructions as anticipated.

The generation of one one of these computer programs was considered in December's issue (see 'Keeping Voyager Current' p.448). This month the story is continued by looking at the role that the CDL plays in confirming the correctness of new flight software, in particular the software employed in the Flight Data Subsystem (FDS) computer onboard Voyager. Recall that this computer (really 'these computers;' there are two of them onboard Voyager 2) is charged with the tasks of (1) commanding the 11 instruments of the spacecraft in their task of taking scientific data, and (2) processing these data into a form suitable for transmission back to Earth.

The operator of the CDL facility is Stuart de Jesus. After receipt of computer code, on a tape, from the developers of that code, he proceeds to the conduct of his tests. The CDL is operated in two modes. In the first, the full spectrum of supporting equipment is arrayed together with a faithful replica of the computer, which has been loaded with the program or portion of a program that is being tested.

Supporting equipment includes, for example, models of the other two types of computers onboard the spacecraft; the Sun sensor and star tracker which, together, help to keep the spacecraft properly oriented; and the motor and gear train that is used to drive the platform upon which are located several of its instruments, including the two cameras (the platform assemblage is not included in the CDL).

The output of the test is in the form of spacecraft telemetry, i.e., the stream of scientific and engineering data normally sent to the ground. Some of the telemetry is checked by de Jesus himself, some is checked automatically by a controlling computer in the CDL, and some may be turned over to the experts on the Voyager spacecraft team for their evaluation.

If problems are uncovered during this process, then the computer program is referred back to its developers, Dick Rice and Ed Blizzard, for correction. In the case of testing extensive revisions of the computer program it is not unusual to perform several iterations of the test-and-correction procedure.

The second mode in which the CDL is operated, and this is the most frequently invoked alternative, dispenses with the supporting equipment and substitutes in its place another computer. Thus, in this mode the Flight Data Subsystem computer with its resident program-to-be-tested is imbedded in the world as simulated by another computer. One computer creates an illusion to sustain another computer!

As the Voyager spacecraft recede further into the outer reaches of the Solar System, they will need new computer capabilities to assist them in coping with their changing environment. Therefore, it is expected that continued program development and associated testing in the CDL will accompany Voyager to Uranus, Neptune and interstellar space.

Thanks are due to R.J. Rice, E.M. Blizzard and S.R. de Jesus for their tutorial time with regard to these discussions on Voyager. The Voyager project is managed by JPL for NASA's Office of Space Science and Applications. Richard P. Laeser of JPL is the Project Manager.

SPACE GREENHOUSE

Astronauts may one day use the traditional skills of farming in the decidedly unfamiliar environment of space. Boeing Aerospace Company researchers are now studying design concepts under a $95,000 NASA contract for a Space Station greenhouse that would allow astronauts to grow their own food.

Introduction

Manned space flights to date have used two methods of supplying their occupants with water, air, waste management and food: storing all consumables onboard before the initial launch and holding all of the waste products as they are generated, and resupplying consumables *via* transportation vehicles and returning the waste products (much as the Progress craft do with the Soviet Salyut space station).

A biological regenerative closed system would supply all essential materials by recycling waste products back into reusable materials. A study completed for NASA in 1983 examined the initial cost and feasibility of transporting a Controlled Ecological Life Support System (CELSS) to be used aboard a spacecraft or a remote land base, such as a lunar station. The current study being undertaken by the life sciences group is examining the actual concept design of such a system.

The Greenhouse

What form would a CELSS greenhouse take and what could be grown and harvested in such a unique environment? Mel Oleson, a life sciences analyst with Boeing, says that several designs are being studied. Each must take into consideration power, mass, volume, cost, reliability, maintainability, accessibility, training ease and safety. But can large quantities of vegetables be grown in zero gravity or a partial gravity state? Oleson admits there are no guarantees.

"We think that some plants will grow in zero gravity and that some will grow in partial gravity," he said, "but until actual experiments are conducted we don't know for certain whether any sustained growth will occur in those environments."

Meanwhile, a list of plants that might reasonably fit their criteria for an operational space greenhouse is being developed.

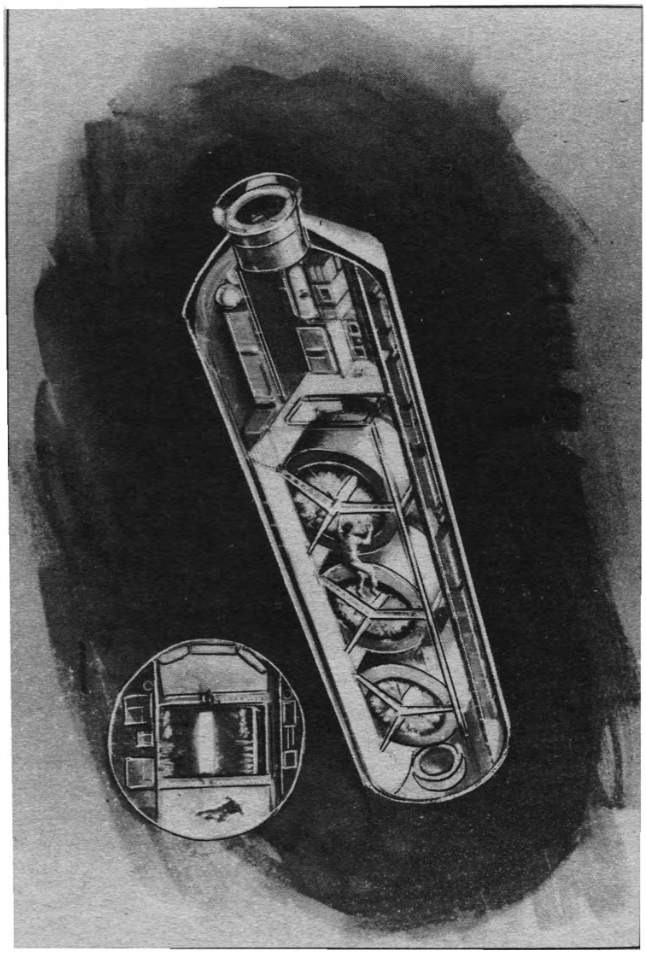
The Soviets, he noted, are rumoured to have experimented with their own 'space garden' of onions, tomatoes, marigolds and celery.

A Space Station astronaut's diet composed entirely of products from a CELSS greenhouse would obviously be vegetatian, though the process, which starts with the planting of a seed and ends with consumption of the grown product, is an involved and complicated one.

"After we decide what we will grow, then we ask, 'Do we grow seeds in space, or do we use cuttings or cloning?" Oleson wonders. "That is a bioengineering research question."

Plant growth systems is next on the list of questions to be answered. Growth might require periods of simulated gravity, such as that provided by a rotating drum system, while light might be optimised by the use of cylindrical plant trays surrounded by fluorescent lamps.

Researchers are designing prototypes for a food processing centre where harvesting and washing could be accomplished. Methods of harvesting would differ; a picking sequence for food such as strawberries would need to be devised while plants such as wheat would need to be mass harvested.



This concept of a pressurised Controlled Ecological Life Support System shows how rotating drums would simulate gravity to grow plants in space. A light source is shown in the middle of each drum. In the circular drawing, a cutaway of one of the drums is depicted with plants growing in the interior. *Boeing*

Nothing would go to waste in the process. Waste products (human, plant and inorganic) would be recycled into a nutrient solution used to feed the plants.

Once the plants have been harvested they would have to be stored on a long-term basis. "We're looking into traditional freezing, dehydration and dry and wet storage techniques," Oleson said.

Solar panels extended from the growth module would power artificial lighting of the support system. Water and oxygen would be recycled by biological processes. Plants give off oxygen, which would then be used to resupply the air in the closed environment.

In a system in which 97% of a person's needs is supplied by the greenhouse, such a diet might include the following plants: lettuce, tomatoes, carrots, cabbage, potatoes, green beans, dry beans, wheat and melons. Other plants that could be considered include soy beans, mustard greens, peanuts, rice, corn, kale, turnip greens, chick peas, oats and broccoli.

A permanently occupied Space Station holding four people and operating for longer than six years, regenerating 50% of the diet, would appear to be less costly than resupplying the required food and oxygen and storing the waste products.

A Space Station operating more than eight years could economically produce 97% of the diet rather than resupply an equivalent amount of consumables. The initial research project estimated that a savings of at least $68 million over a 15-year Space Station lifetime could be realised.

PERSONAL PROFILE

ERIK QUISTGAARD

The previous Director-General of the European Space Agency, Erik Quistgaard, held the post from May 1980 to August 1984. His tenure at ESA saw the Ariane rocket reach operational maturity and Spacelab establish itself as a valuable contributor to space science.

Introduction

Since Man first looked up at the heavens and wondered, space has been a challenge. But without vision, without the faith to turn dreams into reality, space cannot be conquered. The dreams are many and they are individual to each of us, often depending on our early experiences. For me, such dreams go back as far as I can remember.

Born in Copenhagen, I spent my first six years with my family on the top floor of an apartment building. Every day, as I looked out of the east-facing window, I could see flying machines taking off from a nearby airport. Even today I can sense the thrill and excitement a small boy experienced as he watched those tiny biplanes perform all kinds of loops and other daring manoeuvres. Through the other windows to the west, I looked down on the harbour and the ships unloading their cargoes of coal, timber and other goods from all over the world. I could visualise the many countries of origin as the docks swarmed daily with sailors from China, Africa and other far-off places.

Then, at the age of six, I was suddenly transplanted into the fertile Danish countryside of Southern Jutland. The day that I found my father's 1928 Chevrolet parked unattended in the courtyard is still vivid in my memory. Of course, like any normal boy, I climbed in and took my place behind the wheel, pretending to be the driver. As I stamped my foot down, I hit the starter button and, to my utter astonishment, the motor roared into life and the car began to move. I had not realised that my father had left the keys in with the ignition on! Fortunately, I had watched carefully when he had taken me for rides, and after some yards of dreadful driving I managed to stop. I had received my first lesson to the effect that, with the right know-how and techniques, man can control complicated technical machines and processes.

Mr. Quistgaard meets Mrs. Thatcher at ESTEC in September 1983. *ESTEC*

Mr. Quistgaard with Her Majesty, Queen Beatrix of The Netherlands at the celebrations in May 1984 to mark 20 years of European space cooperation. *ESTEC*

It is little wonder then that, as a young engineer, I was designing cars at the Chrysler works in Detroit and later at Volvo in Gothenburg, where I was fortunate enough to be one of those who helped to build up that company at the beginning of the 1950's. Being in on the ground floor gave me a very useful insight into how a technically-based company grows and operates. I was able to use that knowledge later in a totally different field: ship building. In 1973 we grossed 1.6 million tonnes deadweight (tdw) from one dock, a success born of good systems concepts and good engineering practices. In 1975, however, the world shipping slump arrived and large vessels were no longer in demand. In one jump we went from ships of 500,000 tdw to 500 tdw each. By technical know-how and a strong control over operations, such changes can be made.

Then the Danish Delegation to ESA asked me if I would be willing to take on the challenge of European space cooperation. Fortunately for me, the other Member States of this fine organisation followed suit.

Head of ESA

So, in May 1980, I started in Paris, only five days before the second experimental Ariane rocket fell into the sea. I, too, had been dropped in at the deep end! It was not long before I realised that the real challenge lay not only in continuing the European space effort but in giving it new momentum. My first and very difficult task was to understand what it was all about: the mechanics of space, the physical conditions for satellites and launchers, what was needed to guide and control spacecraft and their launchers, how to get the instruments to work and how to transmit the signals. Then there were the unusual

aspects of space technology: how to achieve reliability for something that is subjected to the space environment for years without the possibility of maintenance or repair; how to preview and develop technology for space engines that are not yet conceived and will be produced only in 5 to 15 years' time. All these technical considerations are beyond the capacity of one brain alone to accommodate.

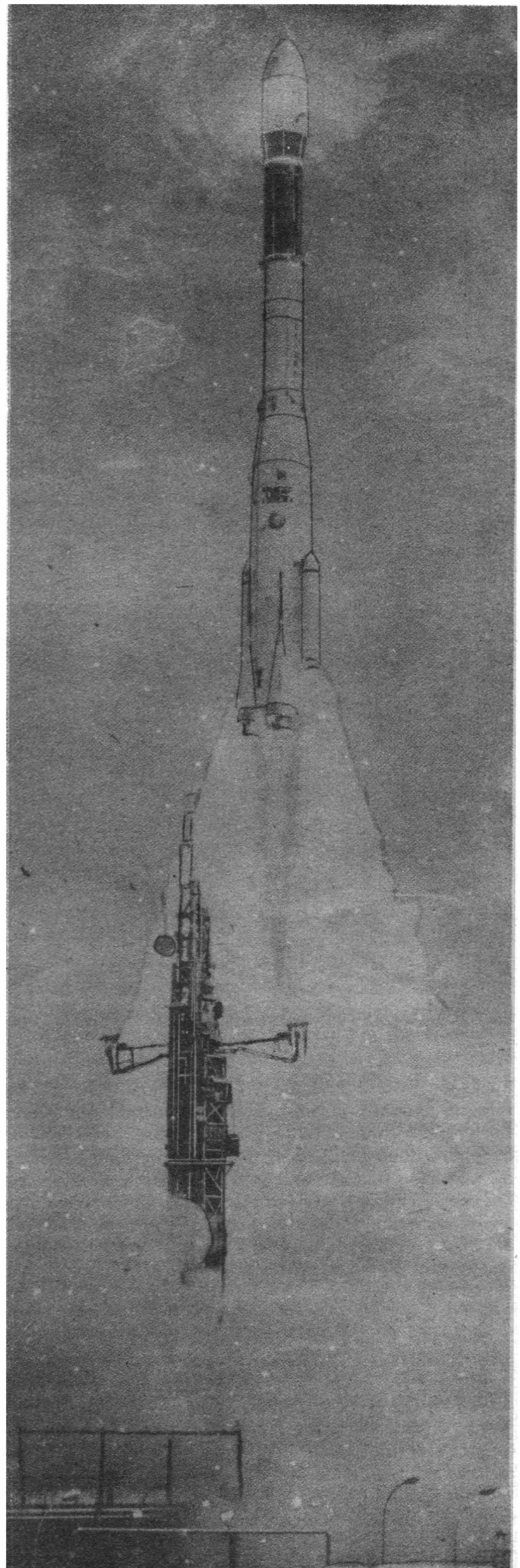
Space, being the domain of dreamers, can be tackled only by people with ideas but it has also to be supported by those with the political will to succeed.

Space costs money and a considerable intellectual output. It is to Europe's credit that it was realised from the beginning that there were critical financial and intellectual thresholds that could only be crossed by concerted cooperation between nations. Here, again, understanding the political objectives of the member states was a 'must.' It was necessary for me and my collaborators in ESA to spend a great deal of time talking to those people in Europe who were politically influential and had an interest in space.

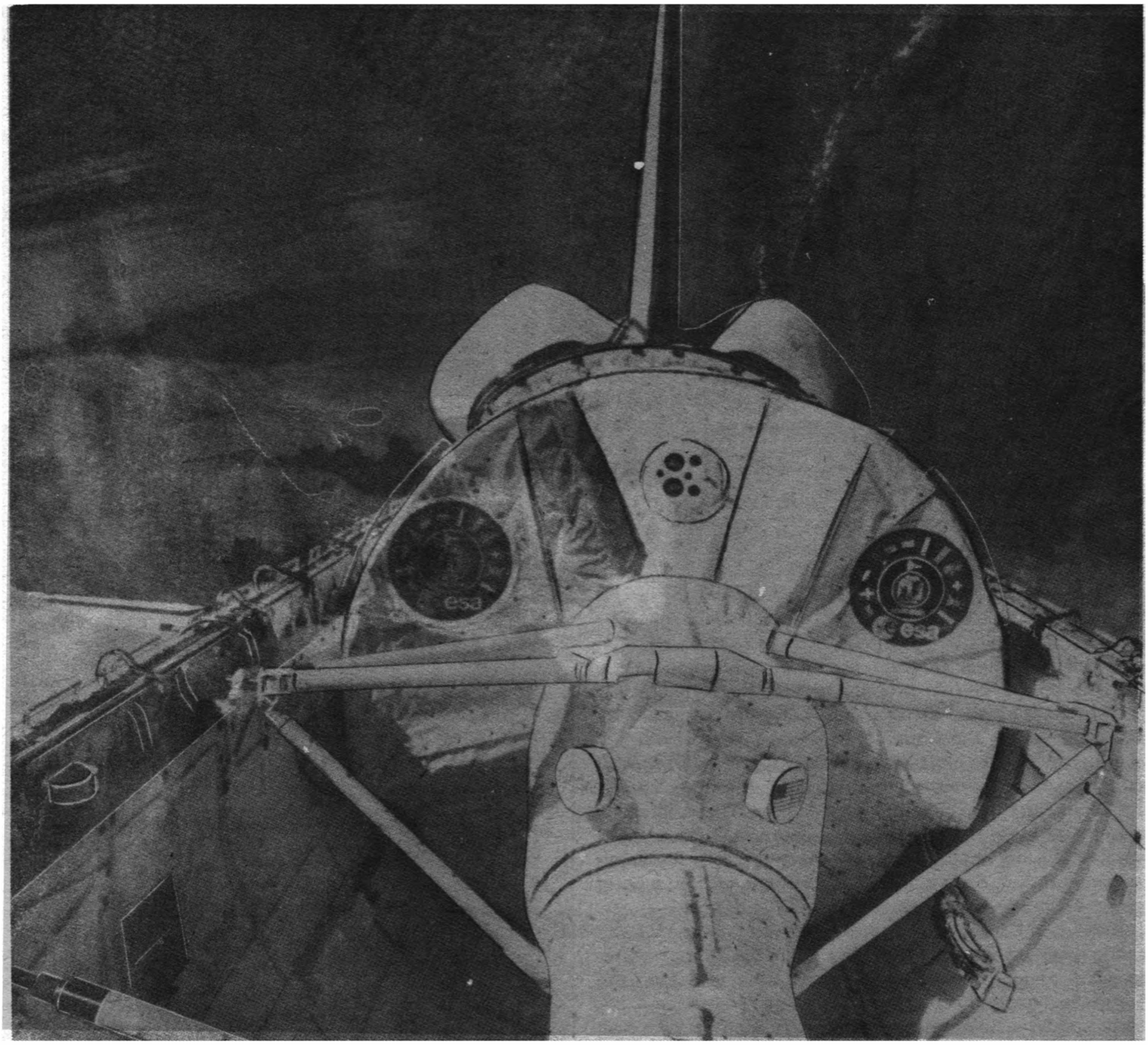
Politicians certainly need technically sound, good and unbiased guidance in such a difficult subject. To be really honest in approach and convincing in argument, one should have a better knowledge oneself. For me, these years in European high technology and in a difficult political environment have been the best of my life. It takes a particular type of person to be a project manager or to have a responsible role in a project, knowing that even after battling through a difficult definition phase there is only a certain probability that the satellite will perform as planned. Then one must carry the responsibility and keep alight the hope for a decade or so before it eventually flies. The type of people one works with in space must be both dreamers and strong believers; intellectually they must be outstanding. The politicians one meets must match this endeavour within their mandate. It is a big challenge to get the two on to the same wavelength but, once in a while, it works and then a good future for European space cooperation is assured.

But we in Europe are not alone. When I came into the space business we were still very much the junior partner to our American friends in NASA. NASA had helped the European space effort along - let's not forget it. All our early satellites were launched by American rockets and we learned a great deal during Spacelab development. However, it is better not to remain as the junior partner and it so happened that the relationship changed during my four years at ESA. Matters came to a head over ISPM (International Solar Polar Mission - now renamed Ulysses), the joint NASA/ESA programme in which it was planned that two satellites would pass simultaneously but in opposite directions over the poles of the Sun, exploring space well outside the ecliptic plane for the first time. Suddenly, in January 1981, NASA withdrew their satellite, an apparently crippling blow to the mission. Subsequent negotiations did not reinstate that probe but paved the way for a more respectful and, finally, cordial cooperation between the two agencies. The next major event was very positive. The first Spacelab flight on STS-9 in December 1983 succeeded beyond all expectations. The Europeans had made an important contribution to the US space transportation system - and it worked. Europeans had shown to the world that they had reached maturity in the space business.

Ariane is now a strong force among the world's launchers. I saw the first launch of an Ariane 3 in Guiana, when two European communications satellites were injected into precise transfer orbits. Both satellites, the



Facing column: despite some early setbacks, the Ariane European launcher is now established as a competitive space launcher. *ESA*



The flight of Spacelab 1 in November/December 1983 demonstrated that Europe is now capable of manned space flights. *NASA*

European ECS-2 and the French Telecom 1A, are performing perfectly in orbit. Exosat, launched last year, is the world's foremost X-ray observatory. Meteosat has become a household word, its images received by millions on television. Marecs and ECS-1 are both working well. I have seen Europe grow to maturity in space science and space technology, with the European aerospace industry and ESA working together as a team. The new technology is here and we know where and how to use it.

The Future

Naturally things do not stop now. There are new dreams and new objectives to be met if we are to maintain and further European space cooperation as a world force. A plan for the European space engagement up to the end of the century and beyond has been presented to the ESA Council and the technical and political work is in progress to have the plan endorsed during the next 15 months.

I see Europe gaining independence in space, step by step. The launcher is there and Europe's rôle in manned space flight will be consolidated. We have demonstrated our ability to develop and exploit telecommunications by satellite; further development will bring us in to a leading world position. Earth observation, the newest European discipline, is only just beginning but the omens are good. What can be done in microgravity is exciting and will be exploited.

Looking ahead, I believe that our space science programme, which has been so successful despite the limited funding available, will be granted a much-needed financial increase. In 1986 Europe will play an even more prominent rôle when the Giotto probe passes close to Comet Halley. Europe is a world leader in space science and we will continue to accelerate. It should be remembered that it is in the scientific satellite projects that Europe has been most daring in its use of technology. Through the space science programme not only scientific but technical dreams have become reality. Quality, rather than quantity, has been our password.

I have worked in the space community now for four years. I had my initial ideas and dreams when I started and now, as I leave ESA, I must confess that these have been more than rewarded by the many successful European space events of that period. I shall watch the future with keen interest in the knowledge that I helped to build it.

FROM THE SECRETARY'S DESK

Visit of JSC Director

We were delighted to welcome to HQ recently Dr. Gerry Griffin, Director of the NASA Johnson Space Center which is now primarily responsible for the fabrication of the Space Station.

Gerry returned to Houston in 1982 as Director when Kris Kraft retired. Almost immediately, his No. 1 job was to secure Space Station approval from the US Congress besides keeping an eye on the Shuttle to make sure it stayed on course - up to then it had flown only four test flights. Gerry sees his task as really trying to build up a space infrastructure. He likens the present space scene as being rather like a railway without any stations, sidings or wayside buildings i.e. consisting solely of lines from A to B.

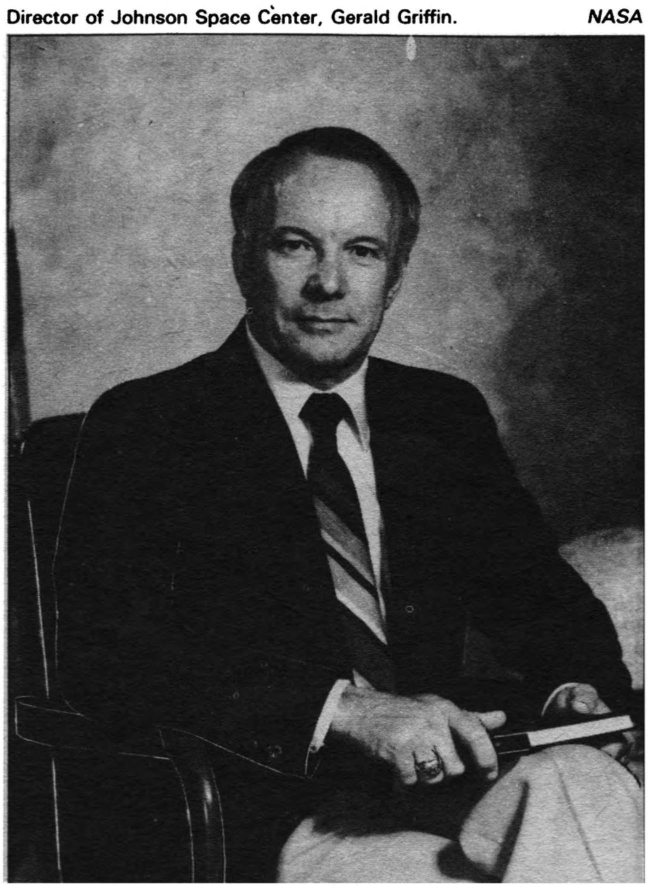
The US space station project, undoubtedly, owes its existence to President Reagan. His attitude of "It's time to have some vision and look to the future" won the day. Had he not been personally involved, the Space Station would probably still be in the administrative jungle - a lesson that could apply to this side of the Atlantic also.

Replying to the argument that funds are spent either on science or space projects i.e. they are competing, he said that NASA experience contradicted this, with science flourishing *because* of major programmes. During the Apollo development years, for example, scientific budgets increased all along the line i.e. they actually *grew* then. Many American scientists today now realise this.

Gerry grinned ruefully when he reflected on how much time and effort had been spent by the press recently discussing the Shuttle waste management system. "Here," he said, "we have this large, highly complex manoeuvrable Shuttle system, yet at a recent press conference between one and 1½ hours was spent answering questions from the media solely on the "potty." The Shuttle programme must be successful, he added, if this was the main topic! Actually, the flight of *Discovery* went so well that there probably wasn't much left to talk about. Gerry was genuinely surprised to learn how sparse had been the UK media coverage of such an incredibly sophisticated and important event and wondered if the key lay in the lack of UK space involvement.

It undoubtedly does.

Director of Johnson Space Center, Gerald Griffin. *NASA*



Welcome Visitor

We were delighted to welcome to HQ John Hodge, Deputy Director of the NASA Interim Space Station Project Office, an emigre Englishman who has made a great success abroad.

John left Vickers Armstrong at Weybridge in 1952 to go to Avro, Canada, joining NASA just as its manned programme got under way. He recalls sitting around a table, with companions, designing the Control Center-to-be at Houston. Like all good concepts, it first appeared on the back of an envelope!

NASA has been trying for 25 years to put a Space Station programme together. Now, with the aid of John's inspired team, a second giant leap for Mankind daily becomes more likely.

The World of Comets

We recently obtained a small booklet called "Tractatvs de Cometis" by D. Roccamora, published in Rome in 1670 and dealing specifically with the comet of 1664. My first instinct was to check it against the Catalogue of the Crawford Library of the Royal Observatory of Edinburgh, probably the Bible of all interested in comets. This Collection contains most of the works on comets prior to 1921 - no less than 1,261 items all told - without taking into account additional material held in pamphlet form! The earliest item listed is dated 1473, with another seventy manuscripts from the 16th century and a further 350 from the 17th century.

Surprisingly, our own modest possession wasn't listed.

Have we acquired something lacking from this world-famous collection?

Job Spec

Space Education is full of advice to those seeking space-related jobs, even up to becoming an actual astronaut. Sadly, little seems to relate to us even though we are right in the middle of the astronautical scene, as must be only too apparent from our publications and announcements.

Years ago, an employer looked for knowledge of the three R's (reading, writing and 'rithmetic) as a sound basis but the things we seek are second sight, thought transference and the ability to use a divining rod.

When it comes to education I recommend the study of navigation: This is essential if one wants to miss the multitude of traps and snares.

The acquisition of actual knowledge comes rather low. Everyone around already claims to know more than I do, whatever the subject.

Bigger and Better

I commend to all members the latest Council initiatives to secure a greatly enlarged Society membership. A total of 10,000 is not beyond our grasp. The latest offer (reproduced elsewhere in this magazine) is to ask members to publicise our special one-year introductory first-time membership for the specially-low rate of £16.

This is a real saver and one that ought to help to boost our membership substantially.

STS-9/SL1 Presentations to the Society

The Society was greatly honoured to receive the signed montage of pictures and crew patch (reproduced below) from the STS-9/Spacelab 1 crews. Astronauts Young, Shaw, Parker and Garriott signed at Houston during April-May 1984: the payload specialists added theirs subsequently *viz* Ulf Merbold signed in May and Byron Lichtenberg in June. The patch was one which actually flew on the Shuttle and circled the Earth 166 times.

The montage is particularly interesting not only because Ulf Merbold was the European Space Agency's first man in space but also because this marks the first flight of Spacelab and Europe's entry into manned space flight.

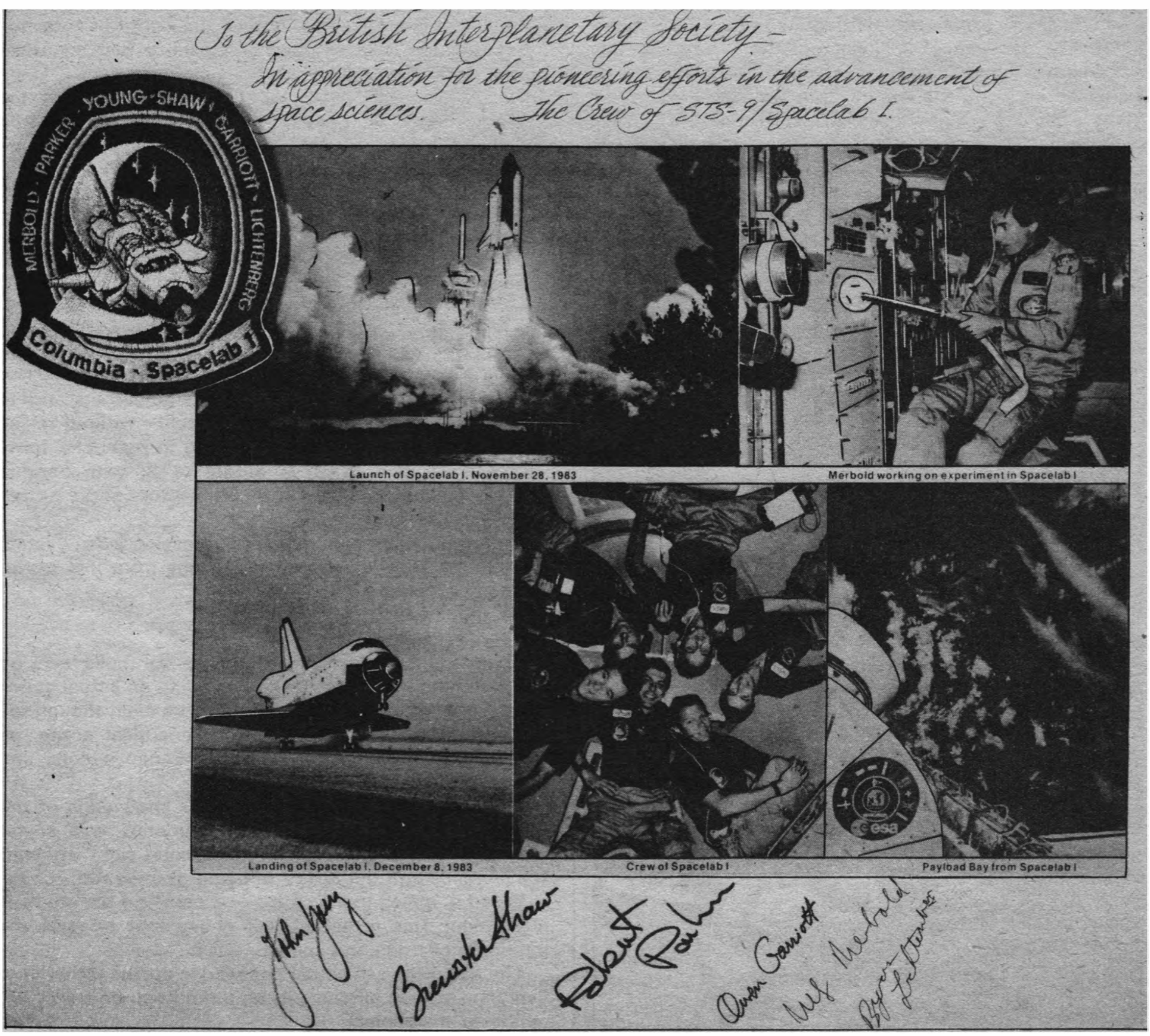
Besides demonstrating that Europe can produce first-class flightworthy hardware, Spacelab opened up completely new opportunities for performing space science in orbit in quite a different way. For example, by using the POCC and TDRS, it became possible for experimenters-on-the-ground to be part of experiments on board - *via* video and sound links and the payload specialist.

The Society is happy to record, in this way, the emergence of Spacelab as a stepping stone towards Europe's space goals.

Deeds of Covenant

I cannot urge too strongly upon those members liable to UK tax to take out a Deed of Covenant, if they havn't already done so. There is an estimated £10,000 in additional funds which the Society could secure simply by this means.

The Deed itself has only to be signed and dated and witnessed. Thereafter, it is returned to the Society for processing and the member sees no more of it. Deeds are valid for four years i.e. they represent a promise by each member to pay his subscriptions for four years though, in practice, the Inland Revenue doesn't insist on this where the Deed is not continued for some good cause e.g. falling on hard times, illness, etc. The financial impact of the Deed upon each member, most of whom join us for life, anyway, is therefore almost nil. If desired, the Deed can be continued on an annual basis after the first four years for as long as each member wishes.



THE BIS IN SPACE

By Dr. L.R. Shepherd

The rôle of the British Interplanetary Society as a promoter of space activities is as important now as ever, for there is still a great deal of work to be done in convincing the world of the value of astronautics.

Valentina Tereshkova, the first woman in space, proudly displays the BIS medal presented to her in 1964 The Society also recognised the supreme achievement of Apollo 11 and presented each of the three astronauts – Neil Armstrong, Edwin Aldrin and Michael Collins – with a gold medal.

Introduction

The emergence of Man from the confines of his native planet marks the beginning of a new and fundamental stage in human evolution. He has broken the bonds of gravity and ascended from the depths of the pit in which his species evolved, to a plane that has no perceptible boundary. His accessible environment is now virtually infinite in its extent and his freedom of movement is restricted only by the fetters of time, his short life and the enormous distances to be traversed.

Where destiny will take him in ths immensity of space is yet beyond his imagination but it is barely conceivable that, having made the initial ascent from the pit, he should remain forever loitering at its brink and there his destiny should end, close to the bounds of Mother Earth. On the contrary, logic dictates that, following his first leap into space, Man should be destined to explore and occupy an expanding domain within his, new, unbounded environment. However, logic does not necessarily determine the *development* of human affairs. Many factors could work to deter or limit Man's advance into space, or hinder progress to the extent that the prospects of further achievements, within the foreseeable future, might disappear.

The development of new technologies is constrained, not so much by the magnitude and complexity of the technical problems to be surmounted, however formidable, as by the difficulties of securing adequate funding and the allocation of sufficient resources to overcome them. Sadly, the wealth and resources of this planet are limited though the demands upon them grow ever, greater. Space technology has to compete with countless other demands for the resources it needs for advancement. Considerable effort is required on the part of those who endorse the human venture into space if it is to receive the priority and financial support adequate to ensure its continuation.

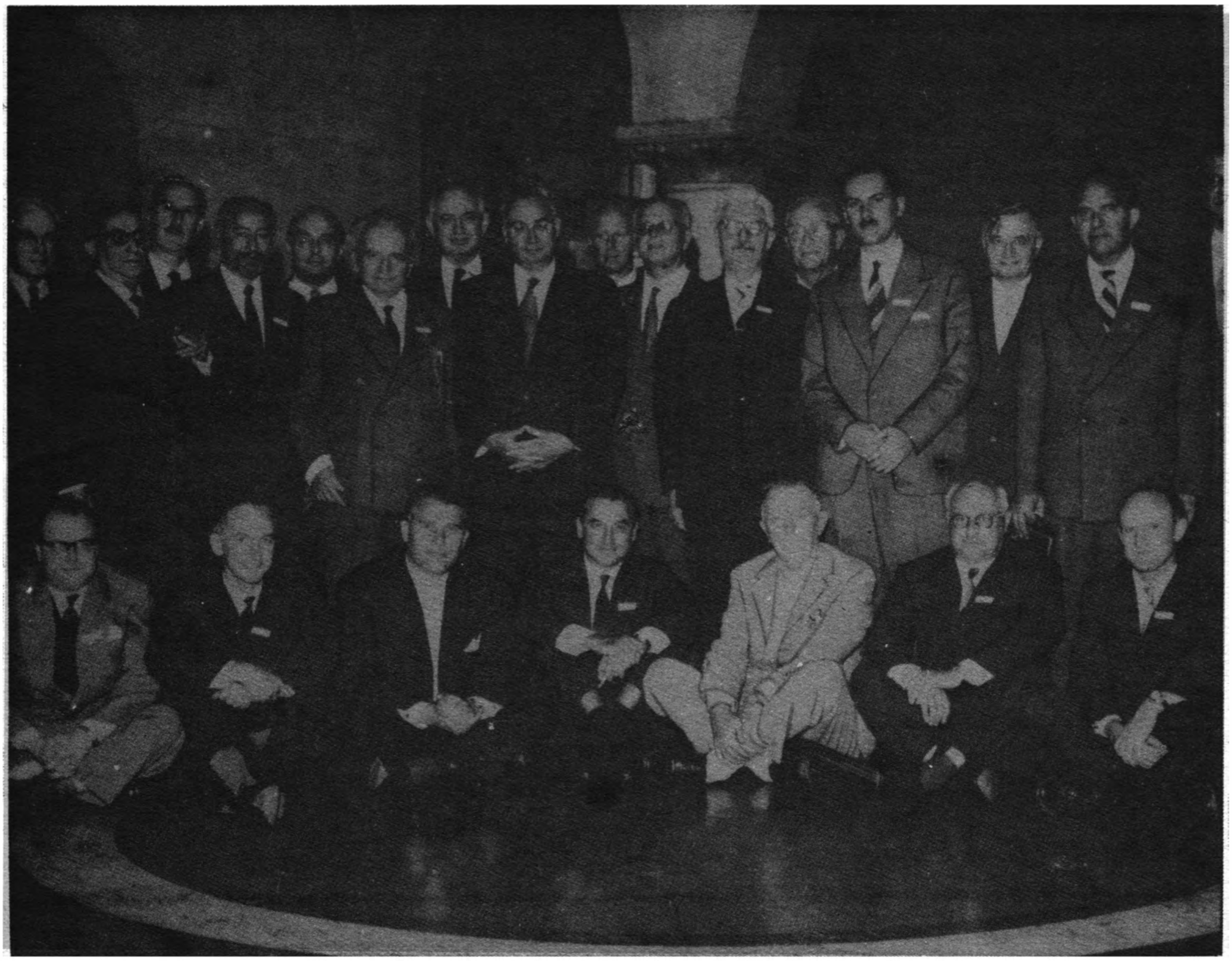
This is why, in a generally unfavourable economic environment, the case for the expenditure of money and resources on space projects has to be argued with great conviction against many other demands of seemingly more immediate concern. Besides that, except where established applications (such as communications satellites) are involved, the extremely high level of funding required for space projects goes beyond that available from normal commercial sources, particularly in view of the obvious absence of early financial benefits. Consequently, governmental investment, on a national or international basis, is essential. Sponsorship of space technology by governments, in the initial stages, has been obtained largely by virtue of military considerations or through the desire to enhance national pride and prestige. More recently, commercial incentives have come into the picture and there has been a limited governmental recognition that the pursuit of pure scientific research in space must also merit some support.

The Future and the BIS

If Man is to proceed to the next stages in his conquest of space, then there needs to be a continuing acceptance of the importance of the purely scientific motive and, above all, a far-sighted realisation that new and advanced developments in space technology, going beyond the prospects of immediate commercial benefit, must receive a reasonable measure of support. This clearly indicates that the main rôle of the astronautical societies is to engender, in the minds of the public and governments, a recognition of the fundamental significance of space flight and an acceptance of the need to fund long term space technology adequately.

Most nations justify military expenditures, which often go far beyond their economic capacities, on the grounds of state security. It may be argued with even greater force that the funding of non-military long-range developments in space might prove vital to survival. Such arguments rest upon the facts that the opening of the space frontier should enormously enhance the resources available to Man and that the dispersal of humankind over many worlds will provide a safeguard against both natural and self-inflicted disasters. Astronautical societies have the responsibility to argue such fundamental points to the utmost of their ability.

From the outset, the British Interplanetary Society has seen its rôle in this light. Founded in 1933, when all aspects of space flight were treated with derision by the great majority of the established scientific community, the designation "Interplanetary" left no element of doubt



The BIS was instrumental in the formation of the International Astronautical Federation. Pictured here are a few delegates of the Stockholm Congress in 1960. BIS Fellow Hermann Oberth, who celebrated his 90th birthday last June, is standing sixth from the right. The author is seated second from the left, to the right of the late BIS Fellow Wernher von Braun.

as to its ultimate aims and convictions. Many arguments were put forward during its early years to set the Society's sights lower, reflected by a more mundane name. These were all rejected. Today, after men have set foot on the Moon and numerous spectacular interplanetary excursions have been made with robot spacecraft, the name is now far from fanciful. Even so, it still has to be interpreted as meaning that our Society is not one with limited horizons.

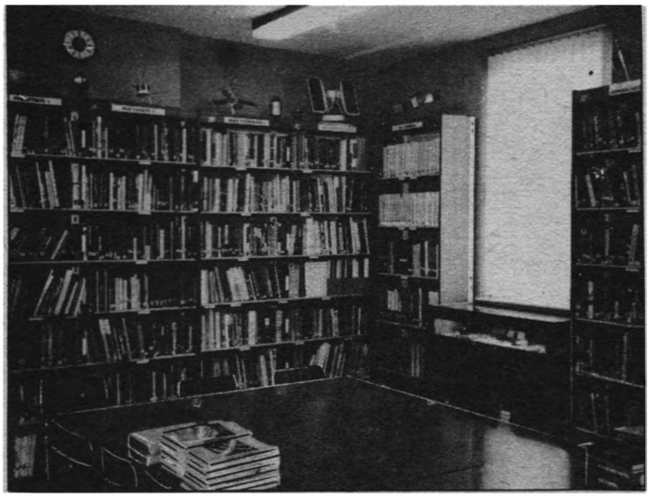
A principal function of any society is to provide the medium for the dissemination of new information and knowledge in its specified areas of interest. It also should be concerned with the *propagation* of knowledge, not just in a specialised form for the serious student, but in a more popular form for the benefit of others. These responsibilities are normally discharged through publications and the organisation of lecture programmes, symposia and conferences. Those societies that are politically inclined may also try to promote their fields of activity by appeals for sponsorship to governments and other potential sources of support.

Over all these broad areas of astronautics, the British Interplanetary Society has been active in every respect. It assigns the highest priority to regular publications in both popular and specialised forms. It has matched this by attention to the organisation of meetings ranging from single lectures to large conferences and it has always seen, as one of its main tasks, the need to make appropriate representations to all areas of Government, for the support of space technology.

On the matter of publications our Society, *within three months of its foundation*, produced the first issue of its Journal (*JBIS*), dated January 1934. It was no more than a pamphlet of six pages, *albeit* properly printed on good quality paper. During the succeeding six years to September 1939, when all activities of the BIS were suspended for the duration of hostilities, 12 issues of the Journal were published, at irregular intervals but expanded to 28 pages - small format (140 mm x 220 mm). Now, 50 years later, it is a monthly magazine of, typically, 48 (A4) pages.

Over its first 20 years, *JBIS* carried a mixture of papers, some of a technical character and others of purely popular appeal. In the mid-1950s however, with governments in both the USA and USSR proclaiming their intentions to build and launch orbital space vehicles, there was a clear need to publish more information for the benefit of the general public. The BIS considered that, for its part, it could not meet the new situation with a single publication so a popular style magazine, *Spaceflight*, was introduced to serve the growing public interest, leaving the Journal to meet the needs of those with a serious professional concern in astronautics. The first issue of *Spaceflight* appeared in October, 1956, as a quarterly publication. After four years it was published bimonthly and, from 1966, it has seen 10 issues a year in the same A4 format as the Journal.

In strict terms, the Journal is not a single publication but is subdivided into a number of distinct series, each



The Society's Library.

devoted to a particular area of interest. These areas range from the immediate applications of space technology to the very long term possibilities that are covered in the Interstellar Studies series. They reflect the concern of the Society with the broad implications of astronautics rather than a narrow concentration on matters of immediate practical significance.

From time to time the BIS has published material in the form of single issues or books and, recently, introduced another magazine *Space Education*.

In the information field, the Society has not confined its activities to printed publications, but, from the earliest days, has organised lectures, not only for its own members, but also for other bodies including schools, clubs and professional societies. Increasingly, over the past 30 years, these meetings have included symposia and exhibitions, often extending over more than one day. In many cases these meetings have been organised in collaboration with other national societies or on an international basis with its contemporary astronautical institutions overseas. In this last connection, particular reference should be made to the stress placed by the BIS on the desirability of organising astronautical ventures on an international basis and its consequent interest in promoting cooperation between the many national space societies that now exist around the world. The BIS has played an important role in securing such collaboration.

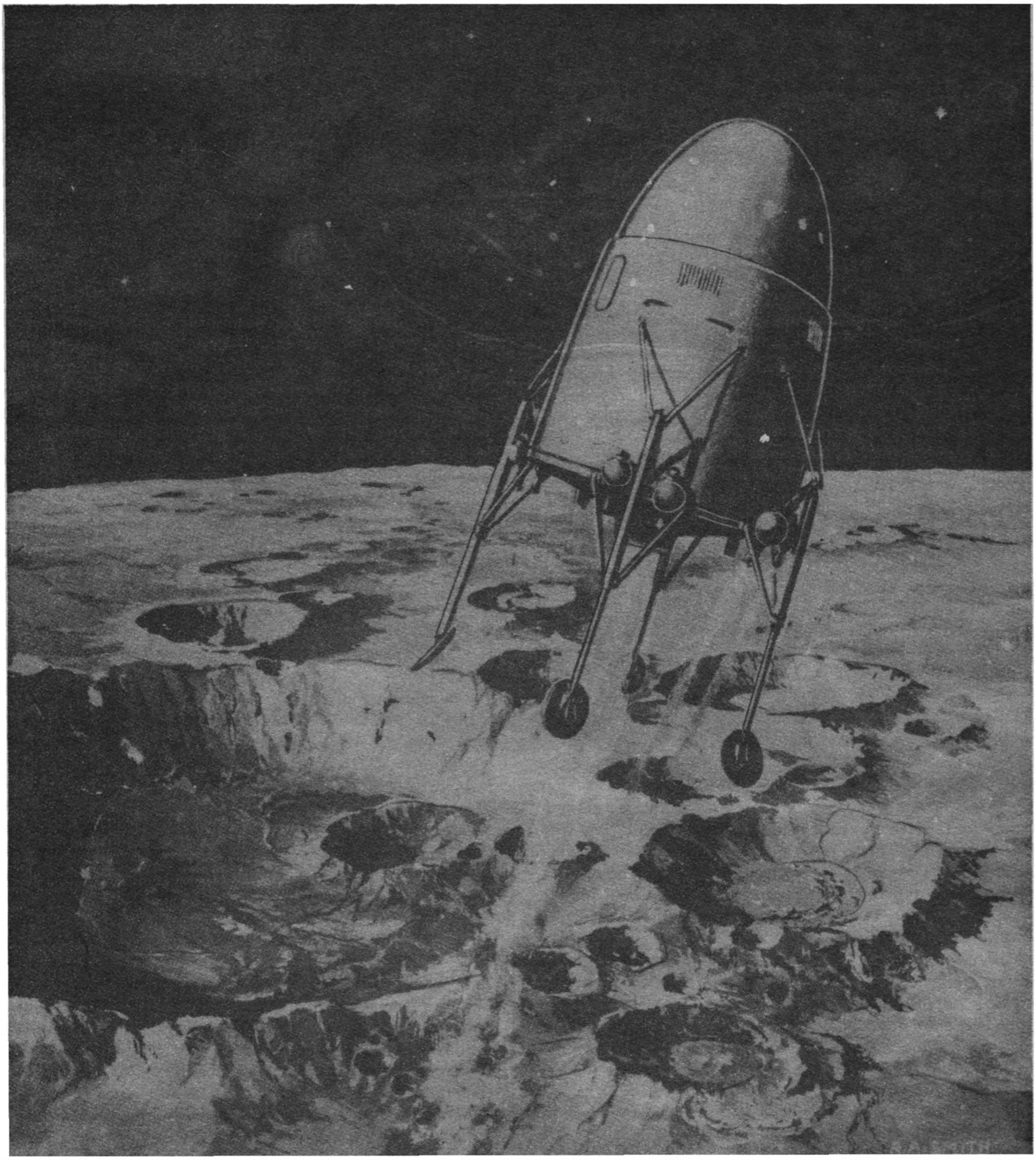
The outstanding example of the part played by the BIS in promoting cooperation between the world's space societies was its significant role in the foundation of the International Astronautical Federation. In 1949, the Gesellschaft fur Weltraumforshung, based in Stuttgart, suggested that the BIS should organise, in London, a meeting of the various national astronautical and rocket societies in order to explore avenues of collaboration leading to the establishment of some form of association between them. The BIS responded enthusiastically and proposed that the London conference should be held in 1951. In the event, an earlier meeting was arranged in Paris by the Groupement Astronautique Francais, at the end of September 1950, between respresentatives of eight societies, from Argentina, Austria, Britain, Denmark, France, the Federal Republic of Germany, Spain and Sweden, where the conclusion was reached that some form of association should be created and that its inauguration should take place at the larger London meeting in the following year. The BIS was charged with the responsibility for organising the London conference and for coordinating proposals specifying the form and constitution of the intended association, in correspondence with the other founding bodies. This task was duly discharged and at the London meeting, which was held at Caxton Hall, Westminster, during the first week in September 1951, the International Astronautical Federation was brought into being, the founding societies consisting of those from the countries that had been represented at Paris, joined in London by astronautical societies from the Netherlands, Italy, Switzerland and the USA. One of the principal functions of the Federation was to be the holding of an annual International Astronautical Congress and it was agreed that the preliminary meeting in Paris and the London conference should respectively, be, designated as the First and Second of these Congresses.

The BIS rôle as a founder member of the IAF did not end there. In September 1959 it played host to the Tenth International Astronautical Congress, at Church House, Westminster, on which occasion the sister organisations of the IAF; the International Academy of Astronautics and the International Institute of Space Law were founded. It might be regarded as fitting that these three world-embracing astronautical institutions should have been born within the precincts of the "Mother of Parliaments."

In a narrower international sphere, the BIS joined with its sister societies in France, West Germany and Italy and with Eurospace, the industrial European space forum, to establish the European Space Symposium. The first of these Symposia was organised by the BIS in London in 1961 and was devoted to papers assessing the problems of re-usable launch vehicles. Later, the American Astronautical Society joined the group to broaden the scope of the Symposia.

The activities of the BIS have extended beyond the more orthodox pursuits outlined above. From its foundation, it was the intention that the Society should make original contributions to the technology of space flight. In the pre-war years most of the contemporary astronautical societies shared this purpose and generally attempted to satisfy their aspirations by conducting primitive experimental programmes in rocket propulsion. The founders of the BIS examined this option but considered it impracticable and concluded that the creative urges of the Society ought to be fulfilled in some other manner. They decided on a course that was both realisable and potentially useful *viz* to conduct technical assessments that would identify the feasibility of space missions and, perhaps, provide useful guidelines to future technologists with the material resources to carry them through. In modern technology, of course, all major projects are preceeded by years of "paper studies" with precisely this purpose. They can vary in scope from long range speculative investigations, far ahead of likely application, to the large and expensive assessments and design studies that immediately preceed the actual commitment to a project. Activities in the latter category require the resources of research and development centres but the more conjectural preliminary assessments fall within the capacities of small groups and even individuals who have little more than their enthusiasm; adequate professional knowledge; access to the technical information involved and, today inevitably, their own microcomputers and electronic calculators.

In those early days the Society, therefore, set up its first technical committee to organise groups to conduct assessment studies of a conjectural, but nevertheless serious, nature. At that time, the electronic aids to computing had yet to be developed and background information in space technology was virtually non-existent, but there was no lack of enthusiasm or volunteers ready to devote their leisure hours to this activity. The first study thus conducted, in the pre-war era, was an assessment of a manned lunar flight. In the event, this was removed



The BIS paved the way to the Moon in its lunar lander studies of the 1930's and 1940's. The full story is told in the Society's book "High Road to the Moon", available at £6, post free, from the Society.

by a mere 30 years from the actual realisation, but in terms of technology it was an age removed from possible achievement. It may be said of this study that, while in terms of propulsion and launch vehicle engineering it was far from the mark, it depicted with remarkable accuracy the techniques of landing and take-off from an airless body like our Moon. In fact, the lunar landing vehicle of the BIS study, which was illustrated in *JBIS* soon after the war, bears an uncanny resemblance to the Apollo Lunar Module.

When the Society was reformed in 1945, it resumed activities in the sphere of technical assessment and such studies have now become a tradition of the Society. This is why a technical committee structure has been maintained, to solicit or encourage studies by individuals or groups, with much of the space in *JBIS* devoted to the resulting reports. A result of this policy has been that the *JBIS* has become a medium of international repute for the publication of serious speculative investigations in the forward areas of astronautics. These have come increasingly from authors outside the Society's own study groups, often describing work conducted in governmental and other astronautical research centres.

Technical assessments may be of a short, medium or long range character, depending on the state of the technology demanded for their realisation. The first category would involve projects that can be achieved by established technology. Since they are based on known

engineering principles, these assessments may be made in sufficient detail to enable reasonable cost estimates to be included. Indeed, one reason for carrying out an assessment might be to demonstrate that the foreseeable benefits from a project would amply justify its cost. Medium range assessments, on the other hand, look ahead towards projects dependent upon technology yet to be demonstrated, but nevertheless describable in meaningful terms. Cost evaluations, in such cases, may not be of much significance for the purpose of the assessments would not be that of securing immediate project funding, but, rather, to point the way ahead and justify investment in the development of the basic engineering involved. Finally there are the long range projects dependent upon technologies still beyond Man's scientific capabilities but conforming, nevertheless, to established scientific principles, so that the assessments are raised above the fictional level. The object in carrying out assessments in this category are largely philosophical but very useful in exploring the far frontiers of Man's environment and understanding the problems that have to be confronted in extending them.

Of course, there are no clear demarcations between the categories of assessments described. Broadly speaking, the manned space stations now projected come into the short range class, as would the next stage of lunar exploration by Man and the programme of unmanned planetary missions. On the other hand, manned expeditions to the planets and the establishment of bases on the Moon and Mars must be assigned to the medium range category for, although their accomplishment can be described in terms of existing basic technology, they lie at present outside the scope of practicable engineering. Interstellar exploration, in the full sense of its meaning, falls far into the long range category.

The astronautical interests of the BIS are wide-ranging and comprehensive. Its publications endeavour to cover every aspect of the subject, from the early history to the far frontiers of interstellar flight. It does not seem appropriate, however, for an astronautical society to try to conduct technical assessments of a short-term nature. With space already a commercial area, such studies are of little serious value unless they made in considerable detail, thus requiring a scale of effort available only in well-funded centres. In its internal assessment activities, therefore, the Society is concerned more properly with medium range developments that do not yet demand detailed analysis and, beyond these, with the long term possibilities which are of fundamental signficiance. As far as the short term is concerned, the rôle of the Society is more that of a reporter, educator and supporter. Such is its attitude, for example, with respect to the now imminent development of manned space stations.

The BIS was founded with the principal objective of promoting the development of space flight with special interest, of course, in getting such work underway in the UK. This attention to the political side of astronautics has been maintained and widened through its association with contemporary societies in other countries. The present surge of activity in space is heavily concentrated in the hands of the USA and USSR which, together, constitute only 11% of the human race so there is a need for a much greater involvement by the other 89%, not only by the industrially advanced countries of Europe, Japan and Oceania, but also by the poorer countries that make up three quarters of the world's population. Because of its geographical location, the BIS, naturally, is intimately concerned with European countries: Simply expressed, it sees the need for a programme in the ESA countries commensurate with that of NASA in terms of the proportion of the Gross Domestic Products involved (0.5% in USA, but only 0.05% in ESA countries). Within ESA, it would wish to see the UK contribution raised to match that of its major partners, instead of falling far short as it presently does.

BIS President A. T. Lawton displays the congratulatory plaque received from the International Academy of Astronautics to mark the Society's 50th Anniversary in October 1983. Behind is a further plaque, presented by NASA.

Nearly all the activities of the Society, (publications, lecture programmes, symposia, exhibitions etc) contribute to this political purpose and in the long run these day-to-day pursuits may prove to be the most effective ways of bringing the importance of investment in space to the notice of government and the public. In addition, the BIS has taken actions of a more specific character in the form of letters and memoranda to the government of the day. The first of these was a document, submitted to the Macmillan Government in 1960, which proposed that the Blue Streak and Black Knight liquid propellant rockets (developed for an abandoned military purpose) should be adapted as a satellite launch vehicle. The document also recommended, among other things, that studies should be conducted into the technical feasiblity and commercial significance of communications satellites and that research should be done on winged re-entry vehicles. In the event, Blue Streak was embodied into the ELDO Europa launch vehicle and Black Knight became the base stage of the Black Arrow launcher, which was abandoned after placing one small satellite in orbit, a typical fate for successful British projects! Communications satellites are now a major part of the UK space-related programme, but the other recommendations of the Society, in this memorandum produced little action.

Subsequent memoranda to government placed the main emphasis on the need for a Western European space authority which would be responsible for the ongoing developing of launch vehicles and other aspects of space activity, including manned space flight. Such a recommendation to the Wilson Government in 1965 met with no positive response but a second, along similar lines, to the Heath Government in 1972 served to reinforce a growing feeling in official circles that a unified Western European space programme was desirable and, within two years, the European Space Agency was set up. It is the purpose of the Society to generate such official and public receptiveness through its day-to-day activities.

HALLEY'S RETURN

Many members have asked us for the important dates and events in the 1985/86 apparition of Halley's comet. Dr. John Davies of the Space Science Dept. of the University of Birmingham has compiled the table below to provide a key list of the highlights.

1984
Mid-Dec: Launch of two Soviet Vega probes to Halley *via* Venus (arrive Venus June 1985).

1985
Jan: Launch of MS-T5 (Japanese Halley mission pathfinder).
Jan: Halley crosses Jupiter's orbit.

May 5: Eta Aquarids meteor shower at maximum; best seen from southern hemisphere; Halley debris.

Jul 10: Giotto (ESA Halley probe) launch from Korou, South America, by Ariane.

Aug: Halley might be visible to large amateur telescopes from this month onwards.
Aug 14: Launch of Planet A (Japanese Halley probe).

Sep 5: Giacobini-Zinner perihelion Sept 5.26, 1.03 AU from Sun, 0.47 AU from Earth.
Sep 11: ICE spacecraft (US) encounters comet Giacobini-Zinner at relative velocity of 20.7 km/sec.

Oct 10: Draconid meteors at maximum.
Oct 20/1: Orionid meteors at maximum.
Oct 31: Sun/ICE/Halley in alignment, detect response to solar wind.

Nov 28: Halley crosses Mars' orbit.

Dec: Halley visible to naked eye from Britain.

1986
End Jan: Halley lost in evening twilight.

Feb 9: Halley perihelion (not visible to naked eye).
End Feb: Halley reappears in morning sky, too far south to be seen from Britain.

Mar 8*: Japanese Planet A spacecraft flys past Halley.
Mar 9*: Soviet VEGA 1 flypast of Halley.
Mar 13/14: Giotto intercepts Halley about midnight GMT.
Mar*: Soviet VEGA 2 flypast of Halley.
Mar 31: Sun/ICE/Halley in alignment, detect response to solar wind.

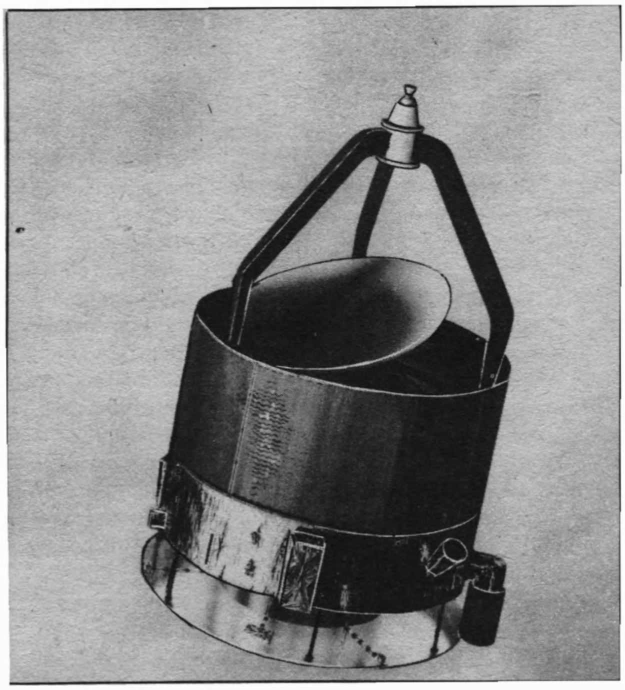
Apr: Most spectacular views of comet (from southern hemisphere).
Apr 11: Halley at closest to Earth, 0.42 AU.
Apr 23: Halley crosses Mars orbit outbound.

May 5: Eta Aquarid meteors at maximum, Halley debris.
Mid May: Halley fades below naked eye visibility.

Jul 1: Halley now faded to 10th magnitude, good amateur telescope needed to see comet.

Orbital Information (1986 return)
Period: 76 years.
Aphelion: 35.29 AU = 4831 million km.
Perihelion: 0.587 AU = 87.82 million km.
Perhelion date: Feb 9.44 1986.

* Dates of spacecraft encounters may change slightly.



Giotto nears the nucleus. *Bae*

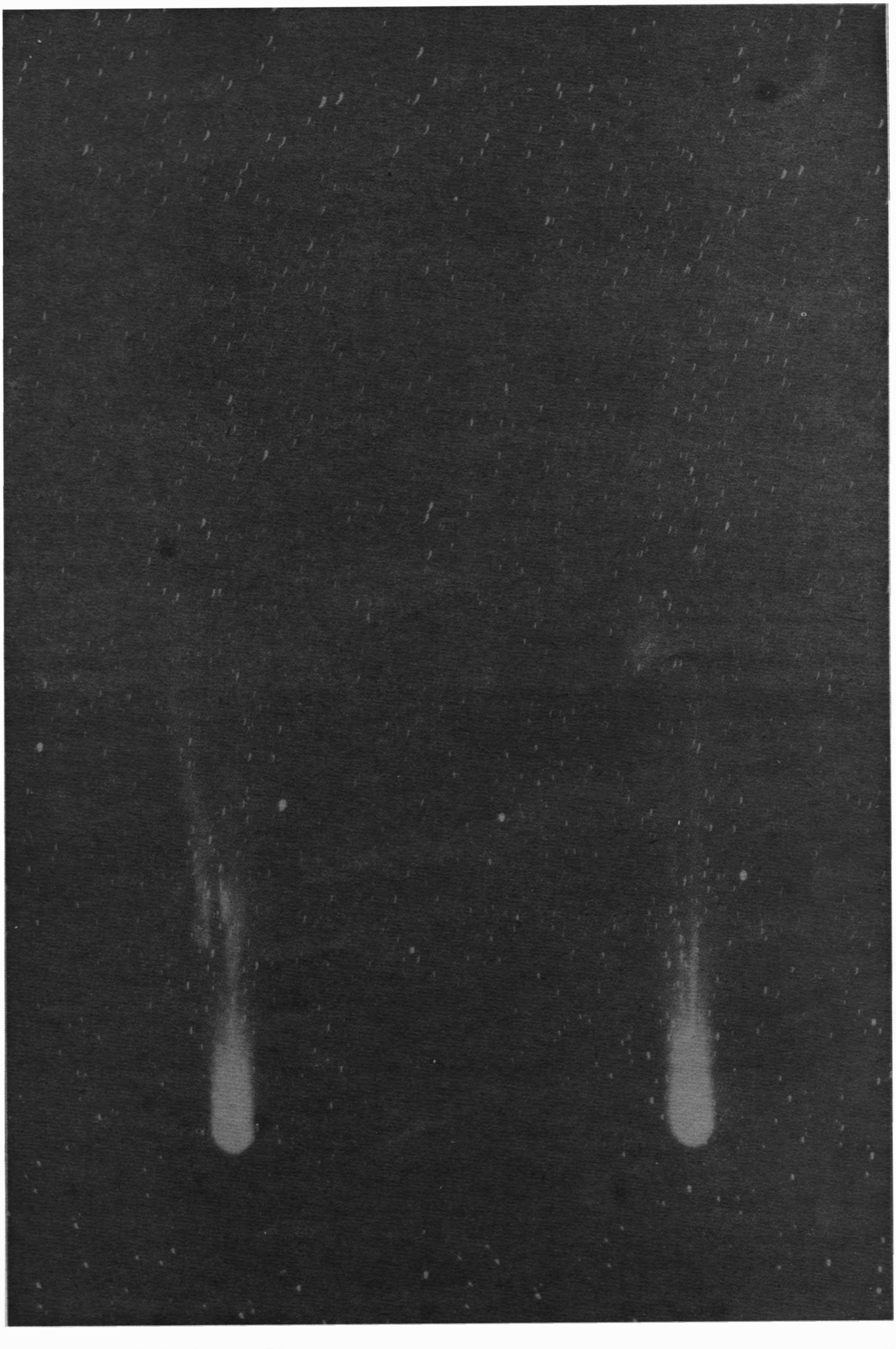
Closest approach to Earth: Apr 11 1986 Distance 0.42 AU = 62.83 million km.
Inclination of orbit: 162.24° (Retrograde Orbit).
Heliocentric velocity at Aphelion: 0.91 km/s.
Heliocentric velocity at Perihelion: 54.55 km/s.

Physical Information
Estimated diameter of nucleus: 5 km.
Estimated density of nucleus: 1 gm/cc.
Estimated rotation rate: about 10 hours.

Historical Information
240BC First recorded observations (by Chinese astronomers).
837AD Closest recorded approach to Earth, 5.99 million km (April 11).
1066 Seen by Harold before battle of Hastings, incorporated into Bayeux tapestry.
1301 Seen by Giotto de Bondone, included in his work "The Adoration of the Magi."
1682 Seen (not discovered) by Halley.
1705 Halley predicts return of comet in 1758.
1742 Halley dies, aged 86.
1758 Comet rediscovered by Johann Palitzsch on Dec 25th.
1835 Second predicted return, observed extensively.
1910 Third predicted return, first photographs of Halley's comet taken.
1982 Recovered at Mt Palomar Oct 16 at magnitude 24.2.

Glossary
Aphelion: Furthest point of orbit from Sun.
AU: Astronomical Unit = 150 million km.
ESA: European Space Agency.
ICE: International Comet Explorer spacecraft (formerly ISEE-3).
Perihelion: Closest point of orbit to Sun.

Facing page: two images of Halley's comet from the 1910 apparition. *Lick Observatory*



COMMERCIALISING SPACE

Dr. David Stephenson

Space technology has progressed to the point where it will soon be possible to use space vehicles to advertise commercial products to millions on Earth. Here the author expresses his personal conception of one way in which this could occur.

Introduction

As part of the global image management industry, advertising is one of the world's most potent economic and social forces. One global fast food chain spends over $250 M per annum on advertising; in Britain 0.3% of the G.N.P. is spent on TV advertising.

Commercial inserts within audience-attracting TV programmes are the most powerful tools available to the image manager today. But, by the end of this century, the TV audience will have been severely fragmented by advances in video recording, cable and satellite broadcasting and interactive video systems.

The night sky is by far the most boring form of entertainment available today. The rare occasions when this tedium is relieved (for example, by the passage of a comet) generates a surge of public interest that demonstrates clearly the communications potential.

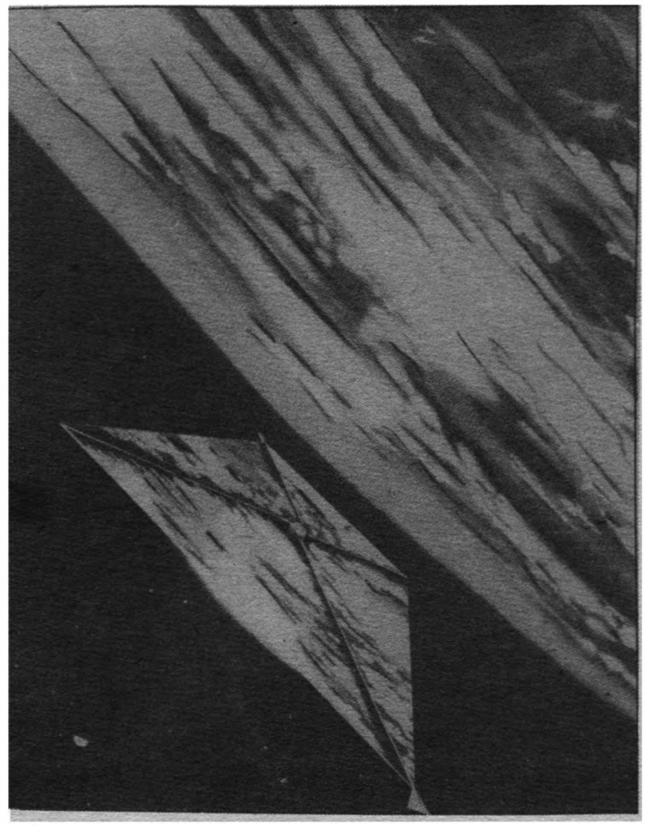
One of the unwritten rules of image management is that presentations should not conflict with the expectations of the target population, but rather should enhance and expand those expectations (to the benefit of a client). Space technologists can now seize the opportunity offered by the fragmenting TV audience and, by the end of the century, offer a service that creates flexible format, artificial constellations of bright star-like objects in the night skies of the world's cities.

System Definition

What the image management industry will probably expect from a space display system are artifical constellations in the form of logos and short brand-names bright enough to over-ride modern urban lighting over the cities and resort areas of the world. These constellations of up to 50 'stars' will have to be available for at least an hour during the late night shopping hours between 6 and 10 pm local time but, within that time, can be re-targeted several times to avoid adverse weather and to adjust to local variations in commercial activity. Although the message will not change during the display period it must be flexible to suit the requirements of many sponsors and should move to circumvent the obscuring effects of buildings and landscape. Political licencing and line-of-sight effects demand that the illuminated area on the ground will have to be strictly defined, and the display modules or artificial stars must not be so bright as to risk injury to the eyes of people in rural areas.

Lights in the Sky

Ehricke [1,2] has published extensively on using large plane mirrors to beam light and power from orbit. A small plane mirror reflecting the Sun's rays from space appears as a point source of light with a beam divergence equal to the apparent diameter of the Sun (0.00931 radians at the orbit of the Earth). Thus the minimum



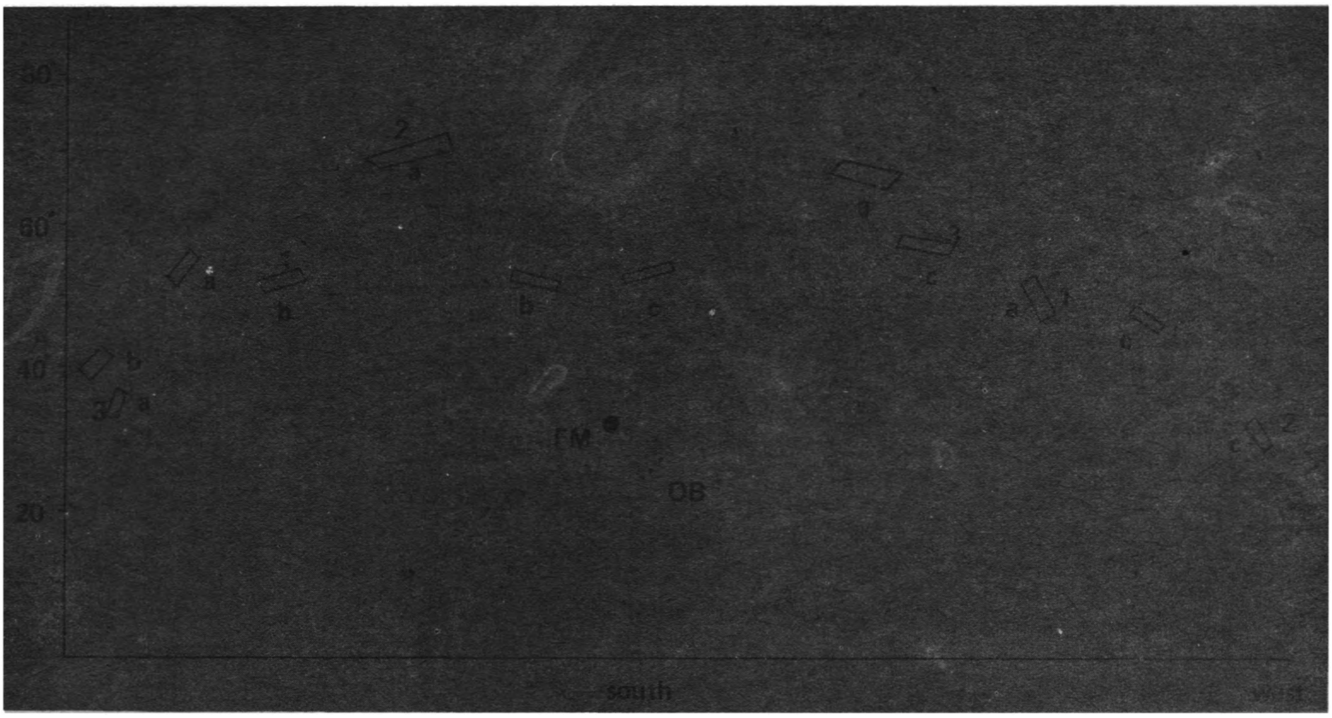
Mirrors similar to this solar sail concept of the World Space Foundation could be used to reflect sunlight to Earth. *WSF*

linear dimension of the illuminated area on the ground is 0.93% of the orbital altitude. Thus a plane mirror in orbit fulfills two of the requirements of space displays: a well defined target area and, since the light is not reflected over a wide angle, the intensity inside that area is high.

The concept of orbital mirrors has been promoted to aid the development of the less developed countries that certainly do not have the resources to support major space activities. If the mirrors displayed commercial logos for multi-national corporations then the services of the mirrors would, like those of American commercial TV, be available at no cost to the recipient. The less developed countries with their dark night skies and largely illiterate (i.e. symbol-orientated) populations, enhanced by free-spending tourists, must be a major target. During the development and deployment phases the response of the developed economies is going to be crucial.

In practice, an imperfect mirror away from the local zenith creates an illuminated ellipse surrounded by a halo of scattered light. But, even though the incident brightness would be reduced, because the human eye responds logarithmically a small mirror would still appear as a very bright star-like object in almost any part of the night sky of the target area.

The major markets of the world are between 22° and 55° N latitude and separated by 120° of longitude. If reflecting satellites presented displays during only one sector of an orbit then, from an eight hour orbit, they could be aimed at all market zones in sequence. For example, a display over Las Vegas would be seen eight hours later from a city in South Korea. This orbital period would optimise the use of a limited life-span capital investment and would attract clients with world-wide interests and identities. An eight hour circular orbit implies an altitude of 13,900 km and a minimum target zone dimension of 130 km. This closely matches the area of major conurbations and their dormatory suburbs, but is small enough to limit the effects on the sensitive and



Space display seen from Los Angeles at 34° N, 118° W. Orbit: 8 hour circular, median inclination 22°. Display Format· inclination ±0 5°, 3° sector. Numbers are times in hours from equator crossing at 18.00 hr LA time: a. Optimum Orbit, node above 14.00 hr local time; b. Non-optimum, −45° from optimum, node above 17.00 hr local time; c. Non-optimum, +45° from optimum, node above 11.00 hr local time. Orion's Belt and Full Moon shown to same scale.

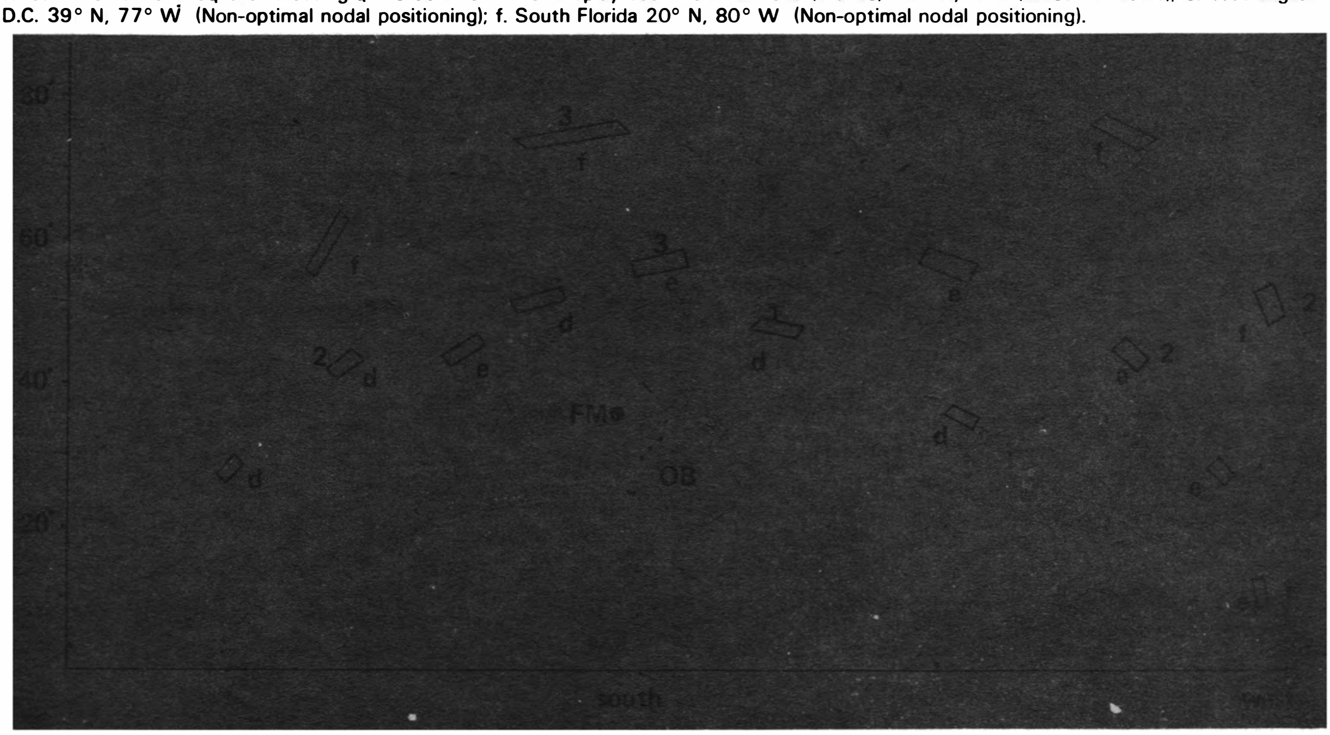
politically effective pseudo-rural halo of commuting professionals.

At 13,900 km altitude a 400 m^2 mirror seen overhead from the equator at 18.00 hours local time would appear like a star with a magnitude of −6.2; that is two magnitudes brighter than Venus at its brightest. Even when only 20° from a setting Sun the mirror would be as bright as Jupiter. A modern commercial logo would demand a constellation of up to 50 stars giving a total display brightness equal to the full Moon.

The formation for a two dimensional display will have mirrors distributed along a limited sector of a family of eight hour orbits with slightly differing inclinations. At the nodes the formation would briefly form a line, before opening out over two hours and then collapsing and inverting after the next node.

Launched from Cape Canaveral, the Space Shuttle enters an orbit with an inclination of 28.5° that is almost ideal for displays to the northern hemisphere. The prime market for space-based advertising is the 'Sunbelt States' of the south western USA. This is an area with a booming high technology-based economy, blessed with some of

Space display seen from other targets. Orbit: Optimum orbit for viewing from LA. Display Format: inclination ±0.5°, 3° sector Numbers are times in hours from equator crossing at 18.00 hr LA time. Display seen from: d. Paris (France) 49° N, 2° E (times - 8 hours); e. Washington D.C. 39° N, 77° W (Non-optimal nodal positioning); f. South Florida 20° N, 80° W (Non-optimal nodal positioning).



the clearest skies in the world and having a long tradition of untrammelled free market economic activity. Therefore an orbital inclination of 22° was used when calculating the examples shown in the diagrams to prevent the displays approaching the zenith when viewed from this area. The rectangular format with an inclination spread of ±0.5° and distributed along a 3° orbital sector shows how the display would appear from various major targets around the world. Individual display modules could be positioned freely within the display structure, so presenting a Latin letter, would need 10 modules or less. Showing the display during peak viewing times is equivalent to an ascending node above 14.00 hours local time, but two examples of non-optimal node positioning are also presented.

Despite the distortions introduced by the linear-linear scales of the figures it is apparent that up to two hours of display time would be available on each orbit. To show the impressive potential of this space technology the full Moon and Orion's Belt are included on the same scale. Line of sight distortions will occur as the modules move around their orbits but the effects are similar to those seen when driving past a conventional billboard.

Spacecraft Characteristics

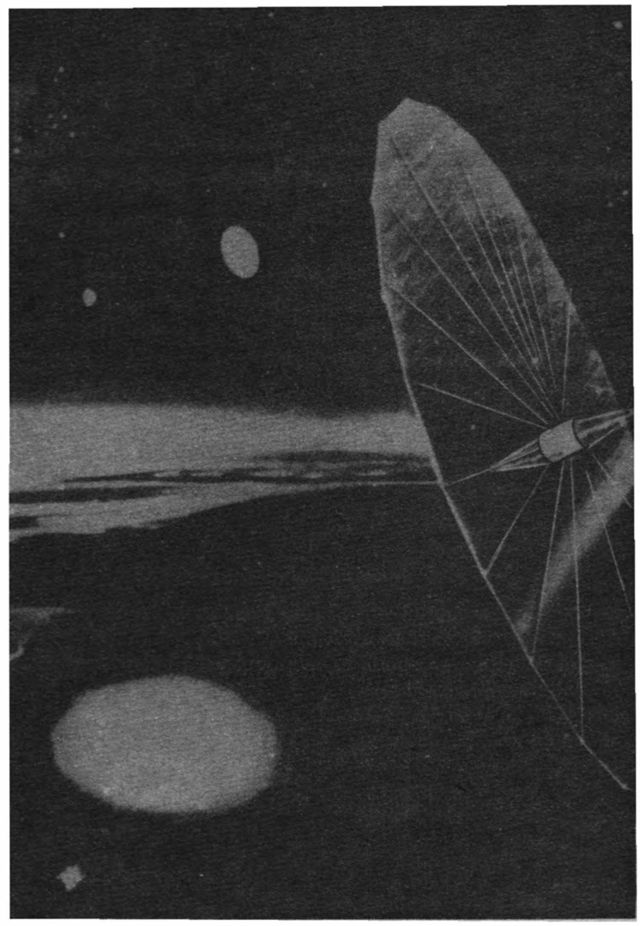
The main element will be a deployable mirror with an area of over 400 m^2, which may resemble the solar sailing craft shown on the front cover of the September/October 1983 issue of *Spaceflight*. Designs like this suggest that a display module should have an in-orbit mass of about 200 kg. The displays will demand a pointing accuracy of 2' while tracking at 22' per minute for a precision of 10 km on the ground. Morris [3] has reported that handling clusters of communications satellites has already been investigated and this work may be invaluable for the operators of space displays.

During the six hours when displays are not possible internal computers will have to perform fine manoeuvres to correct for drifts between the modules. Every few days the complete formation will have to be changed to suit the needs of many sponsors. This will be a complex procedure and considerable effort will be needed to optimise the algorithms and spacecraft systems that control the manoeuvring. Finally, every month, the complete display will have to move its nodes to compensate for the 1.2° sidereal motion of the Sun.

Some form of low-thrust high-efficiency propulsion system would seem to be most suited to the requirements of this mission. Solar sailing will be unavoidable, but probably will not be adequate for all purposes. Ion and electro-thermal motors could provide the required thrusts, but need substantial areas of solar cells to generate their electrical power. A practical design would probably be a hybrid that used solar radiation pressure for angular momentum budgeting and fine station keeping, while an electrical thruster would change formation and node position. This latter could also be used to insert the module into the eight hour orbit from the low Earth orbit reached by the Shuttle.

Costs

The proposed service would be unique and can only be compared with broadcast advertising. Thirty seconds at weekends on LBC (a local London radio station) costs £3000 and local urban TV commercials cost over $10,000 per minute. Since a space display would have to show the same logo to markets around the world for at least a day, a minimum daily contract of $100,000 would seem to be a target that would attract interest from potential sponsors.



Mirrors in orbit could be used to provide illumination for cities at night - especially valuable during the winter. *NASA*

An estimate of the operating costs of a 25 star display would be (in millions of dollars):

STS launch: (25 x 400 kg)	23.5
25 Mass Produced Display Modules	200.
5 years' operations	50.
	273.5

Continuous operation for six hours per day for five years	657,000 mins.
Less 20% maintenance	525,600 mins.

Provided that alternate targets are available to avoid adverse weather this gives a daily running cost of $190,000. Development costs and profit implies a final cost to the customer of $400,000 a day. This is currently too high, but not outrageously so. Launch and equipment costs are coming down and advertising budgets are increasing, so sometime around the end of the century 'spacevertising' should become a commercially viable proposition.

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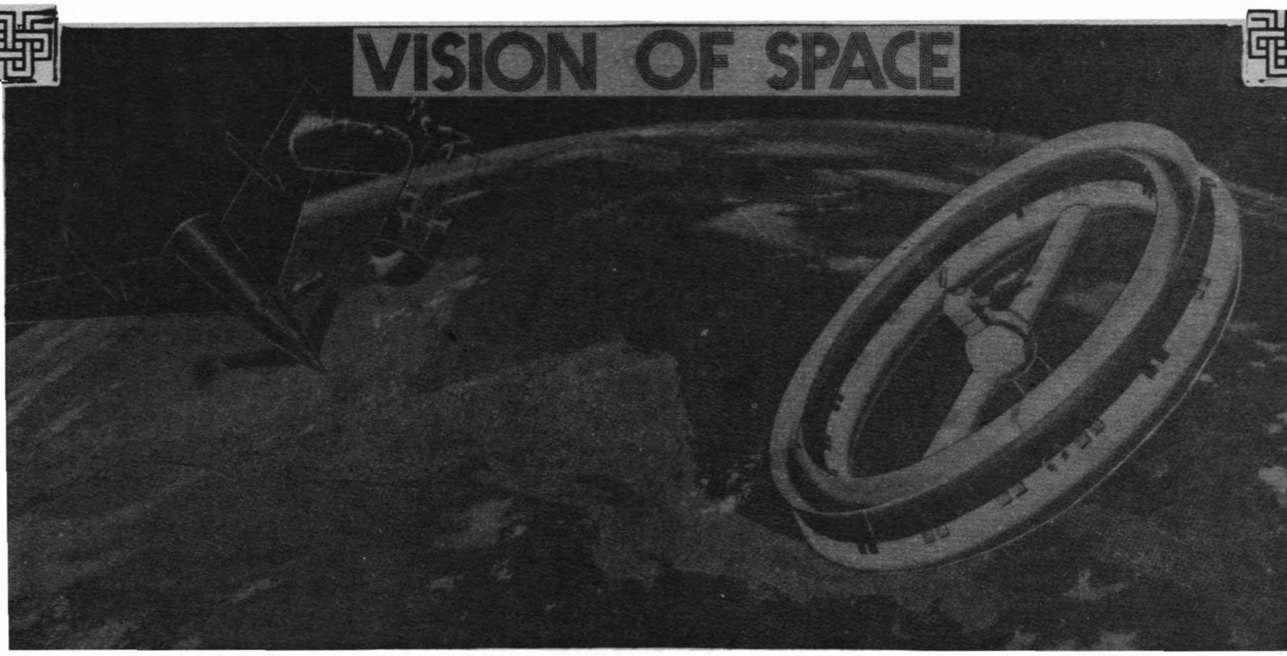
VISION OF SPACE



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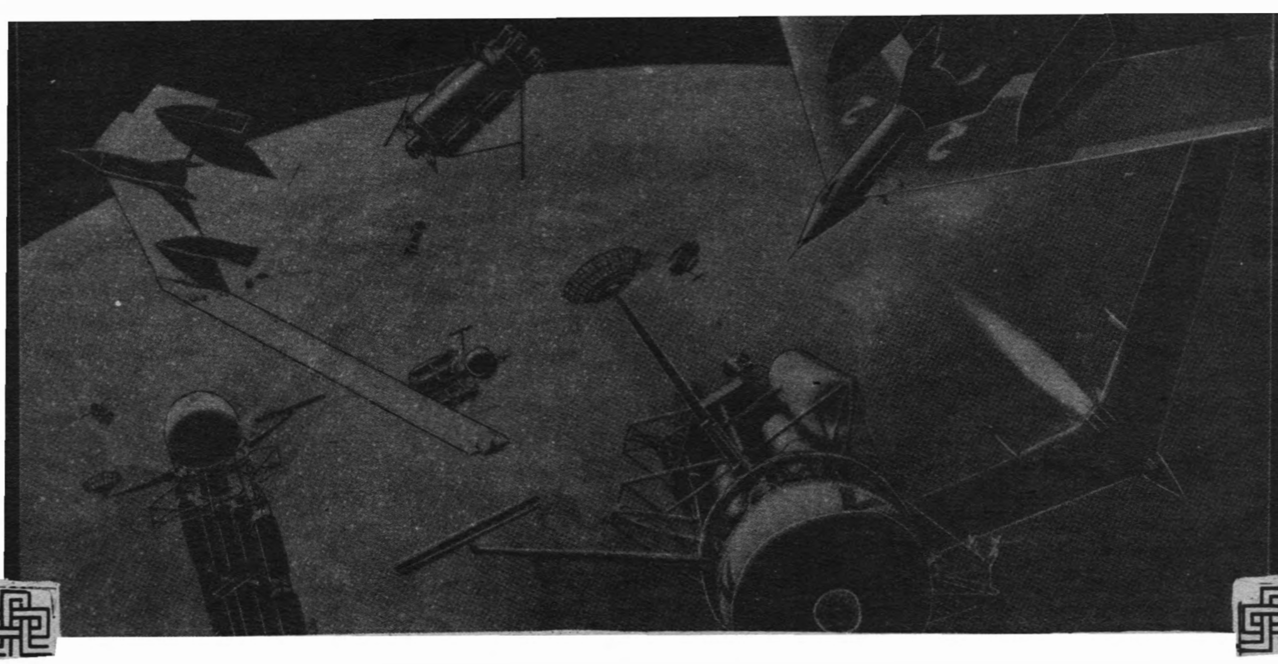
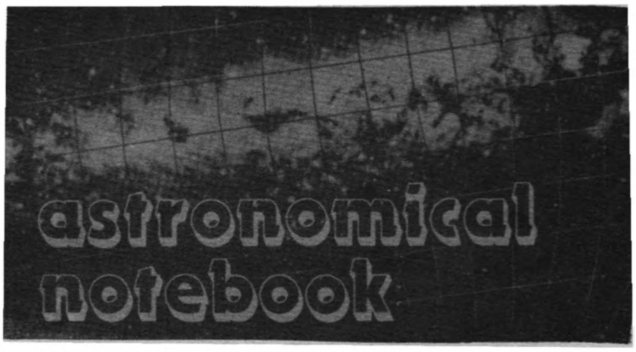




By Prof. John Griffith
of Lakehead University,
Ontario, Canada.

GALAXIES UNDERLYING QUASARS

As time progresses it appears more likely that quasars are unresolved Seyfert I galaxies. The same active galaxy that at low redshift would be classified as Seyfert would be considered a quasar at a redshift larger than 0.1 to 0.2, when the surrounding galaxy would be too faint to be easily recognised. M.A. Malkan of Palomar Observatory, B. Margon of the University of Washington and E.A. Chanan of Columbia University, writing in "The underlying galaxies of X-ray-selected quasar," *Astrophysical Journal* **280**, 66-78, 1984, obtained deep red images of 24 X-ray selected quasars, using the Palomar 1.5 m telescope. Over half yielded resolved structures centred in the pointlike quasar nucleus, with the light from the extended region being starlike. The host galaxies are usual normal spiral galaxies.

H.K.C. Yee of the Dominian Astrophysical Observatory and University of Arizona, and R.F. Green of the University of Arizona, in their paper "An imaging survey of fields around quasars. II. The Association of galaxies with quasar," *Astrophysical Journal* **280**, 79-90, 1984, analyse the properties of galaxies in small fields around quasars with redshifts from 0.05 to 2.05. They find that compact, high-central-density groups or small clusters of galaxies are the preferred sites for quasar activity.

These researchers, again using the Palomar 1.5 m telescope, obtained images centred on 108 quasars of control fields, 1° north of each equator.

They confirm the cosmological nature of quasar redshifts and find an overall excess association of galaxies with quasars. The excess galaxies appear to be situated at the same cosmological redshifts as the quasars. High redshift quasars do not have visible associated galaxies, presumably because they are too distant (and hence too faint) to be detected. The rate of detection of a nebulous component around the quasar decreases with distance.

There is a high galaxy density near quasars. The authors are undertaking more work on the properties of the associated galaxies to bring about a better understanding of the effects of global environment on the formation, maintenance and properties of quasars.

EXTRAGALACTIC RADIO SOURCES

Recently, the types of emission from extragalactic radio sources have been increased from the two well-known classes to three. Extended radio components with steep spectra and typical sizes over 100 kpc were one of the well known types, with compact nuclear components, sizes less than 1 pc and flat spectra the other. The third class are intermediate between the first two in size (around 1 kpc) and have steep radio spectra. Their size makes them smaller than a typical galaxy (which is of the order of 25 kpc).

This new source has been christened steep-spectrum cores (SSCs) and sometimes occur in combination with very extended and/or compact radio emissions. Nearly all SSC's are associated with relatively gas-rich galaxies, such as Seyferts; peculiar galaxies with rotating gaseous disks and dustlanes and/or neutral hydrogen; or cooling X-ray coronae. In several of these cases there is direct evidence of interaction between the SSCs and their environment.

More distant quasar-SSCs may be more powerful, but otherwise similar, objects. The properties of SSCs may often be explained in terms of jets propagating through a dense interstellar medium.

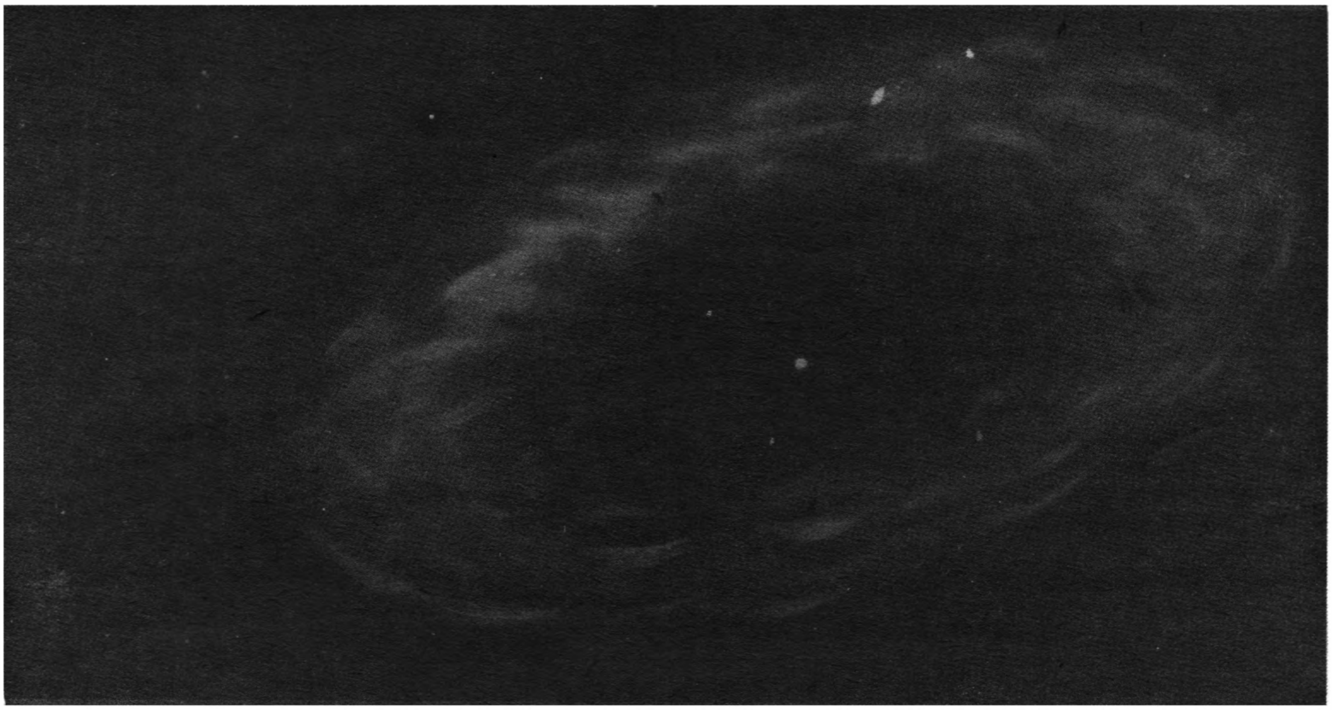
Using the VLA (Very Large Array at the US National Radio Astronomy Observatory) W. van Breugel of Steward Observatory, G. Miley of Leiden Observatory and T. Heckman of the University of Maryland obtained high resolution maps of the structures and polarization distributions of some of a sample of 23 powerful SSCs (mostly quasars). In their paper "Studies of Kiloparsec-scale, Steep-spectrum radio Cores. I. VLA maps" in *Astronomical Journal* **89**, 15-22, 1984, they list such items as positions, sizes, flux densities and polarization parameters, together with giving contour maps.

From analysis of the observations they suggest that these objects contain relatively dense ionized gas and that, generally, SSCs are embedded in dense gaseous environments. They seem to be due to jets propagating through dense and inhomogenous stellar material. The jets collide with clouds, heating and accelerating the ambient gas. This would account for the bright radio emission (shocks in the jets), wide emission lines (accelerated clouds), depolarization (entrained clumpy gas), the steep-spectrum turnover and the distorted structure/bending of jets by rotating gas or collisions with massive clouds.

Further study is suggested.

POPULATION III STARS

Traditionally, two populations of stars have been recognised. Population I stars are younger, typical of the spiral arms with relatively high abundances of metals, having formed from hydrogen contaminated by the debris from supernovae. Population II stars are older, typically found in the galactic halo and with a very low abundance of metals. Population III stars would be even older, perhaps pre-galactic in origin. They may be as massive as 100 solar masses. The cosmological consequences of the existence of such stars is discussed by B.J. Carr of the Institute of Astronomy, Cambridge; J.R. Bond of Stanford University and W.D. Arnett of the University of Chicago in "Cosmological Consequences of Population III stars," *Astrophysical Journal* **277**, 441-469, 1984, where they point out that pre-galactic very massive stars would leave black hole remnants. The effect of these remnants is discussed and could provide the 'missing mass.' Distortions in the 3 K background radiation are expected and the consideration of the associated effects places strong constraints on the mass spectrum and formation epoch of Population III stars. In particular, observations



Large amounts of material were observed by the Infrared Astronomical Satellite orbiting several stars, among them Vega. The IRAS resolution was not high enough to detect planets.

of spectral distortions in the 3 K background, the far-infrared background spectrum, the lower bound in the metallicities of Population III stars, various abundance anomalies and a gravitational wave background would enable a better determination of the possible existence and characteristics of Population III stars to be made.

STAR FORMATION

Stars form in molecular clouds but, as a consequence of the heavy obscuration, it is difficult to observe the initial stages of stellar formation in optical wavelengths. Using radio wavelengths, the flux from the associated HII regions may be observed and the Lyman alpha output obtained. From this the spectral type and luminosity of the ionizing stars may be obtained. V.A. Hughes of Queens University (Canada) and J.G.A. Wouterloot of Sterrwacht, Leiden used both the Westerbork Synthesis Radio telescope and the National Radio Astronomy Observatory's Very Large Array to observe the molecular cloud Cepheus A. Their work is reported in 'The star-forming region in Cepheus A,' *Astrophysical Journal* **276**, 204-210, 1984, where they describe a cluster of about 14 compact HII regions contributing to the total radio flux from the eastern source of Cep A. The radio peak is displaced from the infrared peak, where a number of pre-main sequence objects, incapable of ionizing their surroundings, appear to exist.

The formation and elongation of the HII regions is along a line and the authors propose that the collapsing cloud led to a prolate spheriod with the magnetic field aligned along the axis. A field of 3.5 milligauss has previously been reported; such a field could contain various HII regions. There are two strings of HII regions, each about 0.1 pc long. If the stars are equivalent to main sequence stars, the 14 regions can each be attributed to a B3 star, of age around 1000 yrs, separated in some cases by as little as 1000 AU. Binary stars are predicted, with some stars coalescing into more massive stars. Further star formation is expected.

RAPID QUASAR VARIATIONS

Albert D. Grauer of the Louisiana State University, using the 91 cm reflector at Kitt Peak National Observatory, reports in his paper "Evidence for Rapid Optical Variations of the Quasi-stellar Radio Source 4C 19, 45" (*Astrophysical Journal* **277**, 77-81, 1984) that this object of apparent magnitude 17 displays rapid brightness variations on the order of 0.02 days or less. This, in turn, implies a size of the emitting region of the order of 30 light minutes. A model of a 10^7 solar mass black hole surrounded by an accretion disk 30 light minutes in radius and a mass of 10^6 solar masses appears to fit the observations.

GRAVITATIONAL IMAGING

Most of the visible matter in the Galaxy appears to be located in superclusters of galaxies. These are long, thin filaments separated by voids of similar extent. Their length ranges from 10 to 100 Mpc. In their paper "Gravitational Imaging by Superclusters," (*Astrophysical Journal* **278**, 291-294, 1984), R.H. Sanders, T.S. van Albada and T.A. Oosterloo consider the effects of the gravitational lens effects of such thin filaments.

They point out that the importance of gravitational imaging by superclusters is critically dependent upon properties of the superclusters which are, at present, uncertain. Until the typical perpendicular scale height and mean line density are known, we are unable to predict their effects accurately. However, we may be able to estimate the unknown parameters from specific examples of gravitational imaging.

There are already several possible examples available, ranging from groups of three quasars and three radio sources to the general tendency of extended radio sources to be parallel if they lie within 10° of each other.

The presence or absence of galaxy or radio source alignments will constrain the properties of superclusters.

41D: THE DEBUT OF *DISCOVERY*

By John A. Pfannerstill

Following the excitement of Spacelab, the first Manned Manouvering Unit flights and the repair of Solar Max on the previous three Space Shuttle missions, the twelfth Shuttle flight, designated Mission 41D, was to be a return to the 'routine' business of delivering satellites and flying scientific and technological payloads. On the agenda was the deployment of one satellite, the testing of a new, ultralight solar array, Earth photography and commercial drug processing.

Introduction

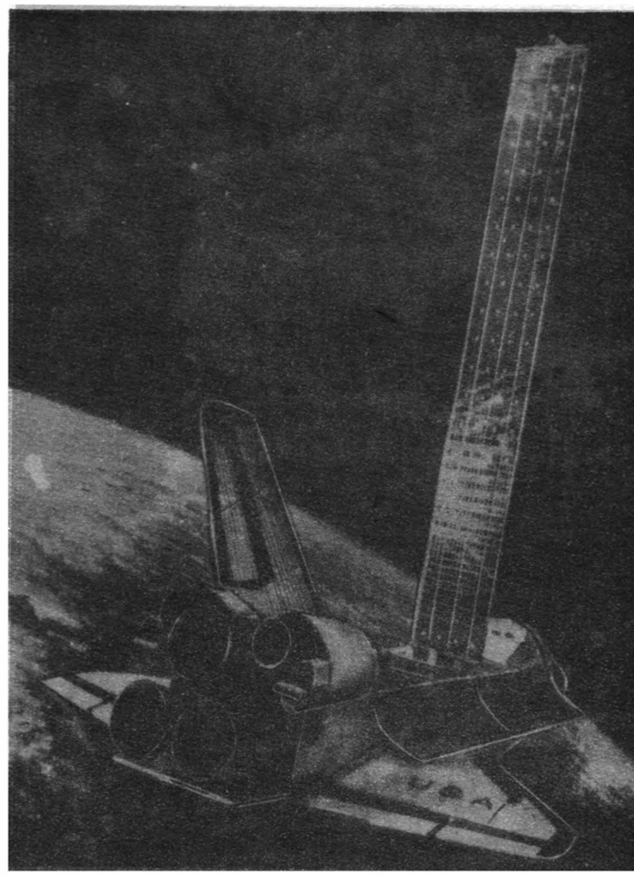
Mission 41D marked the inaugural flight of Orbiter OV-103, *Discovery*. Although it looked almost identical to its sister ships, *Discovery* was much improved. Over 3,000 kg less massive than *Columbia* and 300 kg lighter than *Challenger*, it had weight-saving fabric thermal protection system blankets covering most of the upper fuselage and wings, replacing many of the heavier tiles of its predecessors. To shave off more weight, *Discovery* also used graphite epoxy structural elements in its main body construction instead of the more massive aluminium beams. Its unfuelled and unloaded weight was 67,100 kg.

In addition to being the first flight of a new Orbiter, 41D also marked the first time that a commercial paying passenger was included on a crew. McDonnell Douglas requested that one of its engineers, Charles D. Walker [a BIS Fellow-*Ed.*], went along to operate its new improved version of the Continuous Flow Electrophoresis System (CFES). The CFES was carried on an experimental basis on four previous Shuttle missions, processing only small quantities of test materials but, since its last flight, the 288 kg unit went through major modifications, enabling it to produce large amounts of medicines and vaccines which Johnson & Johnson and Ortho Pharmaceuticals Corporation hope to market commercially by the late 1980's. Its operation was expected to take up a considerable portion of crew time and so McDonnell Douglas argued successfully that time and money would be saved by sending one of its own engineers along. As one of CFES' designers, Charlie Walker was the obvious choice. McDonnell Douglas was charged $80,000 by NASA to finance his basic Shuttle training, which included instruction in emergency procedures and operation of the Orbiter's living accomodations. For Walker, it was a once-in-a-lifetime opportunity and, as training progressed, he quickly became less a part of the payload (which he technically was) and more a member of the crew.

The NASA crew was made up of four 'rookies' and one veteran. Henry W. Hartsfield, who previously flew in June 1982 on STS-4, headed the team as mission commander. His crew included USN Commander Michael L. Coats, the Pilot, as well as three Mission Specialists: Lt. Col. Richard M. Mullane (MS-1), Dr. Steven A. Hawley (MS-2) and Dr. Judith A. Resnik (MS-3). Resnik was to become the second American woman to go into orbit, alongside Hawley, the husband of the first US space woman, Sally Ride.

For the first mission, *Discovery* carried a varied payload:

1. Syncom IV-1 communications satellite;
2. NASA's Office of Aeronautics and Space Technology (OAST-1) payload;
3. Large Format Camera (LFC-1);
4. Continuous Flow Electrophoresis System (CFES-BLOCK III);
5. Cinema-360 and IMAX motion picture camera payloads;
6. One Getaway Special (GAS) payload;
7. One Shuttle Student Involvement Project experiment;
8. Two science and technology experiments, the Vehicle Glow Experiment and the Clouds Experiment.



An artist's impression of the Solar Array Flight Experiment. NASA

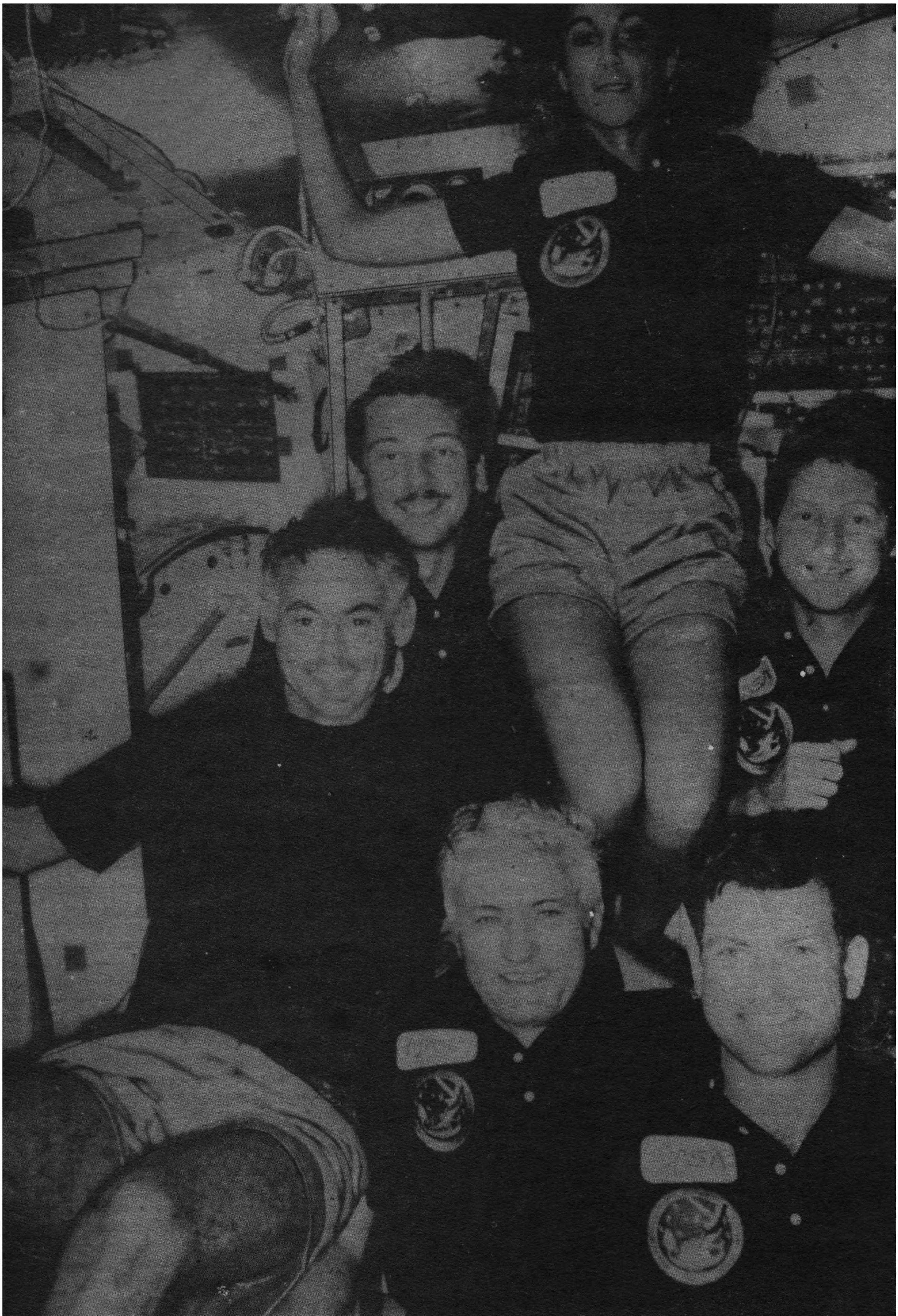
The mission was planned to last for seven days with a landing at Edwards Air Force Base in California. Launch was scheduled for 25 June 1984.

False Starts

The countdown began at 07:00 GMT (all times GMT) on 23 June and went extremely well. The targetted launch time was 12.43 on 25 June with a 45 minute launch window dictated by deployment constraints on the Syncom satellite.

On the morning of 25 June, *Discovery's* first crew went through the familiar launch-day route of breakfast, the ride to the pad and boarding the Orbiter. Everything was going strictly by the book until shortly before launch when a problem was noted in *Discovery's* backup computer. Engineers studied data from the computer in the hope that the trouble could be resolved, but it could not. The

The 41D crew pose in *Discovery's* middeck. Clockwise from top they are, Judith Resnik, Steven Hawley, Michael Coats, Henry Hartsfield, Richard Mullane and Charles Walker.



mission was scrubbed for the day at 12:35, just eight minutes away from the scheduled liftoff.

The disappointed astronauts were taken out of the Orbiter and the propellants were drained from the External Tank. Technicians then went out to Pad 39A to check the computer and found that the suitcase-sized unit had suffered a hardware failure. A replacement was 'cannibalised' from *Challenger* and installed in time for a launch attempt the next day.

On 26 June, the crew went through exactly the same routine a second time. As they strapped themselves in, the only problem was the weather. At daybreak the pad was completely enshrouded in thick fog, making the Shuttle completely invisible to the spectators at the press site but as the Sun came up, the mist began to lift and, as the 12:43 launch time approached, there were hazy blue-white skies overhead.

The countdown passed the critical point at which the backup computer failure had occurred the day before and everything was in fine shape as launch control commentator Mark Hess counted down the final seconds.

'Ten... we have a GO for main engine start... seven, six, five... we have main engine start... we have a cutoff... we have an abort by the on-board computers of the Orbiter *Discovery!*'

Observers saw a brief puff of steam from the Shuttle main engine exhaust, accompanied by a gasp-like roar that quickly died away. The smoke and vapour slowly drifted off, leaving *Discovery* sitting forlornly in the morning sunshine.

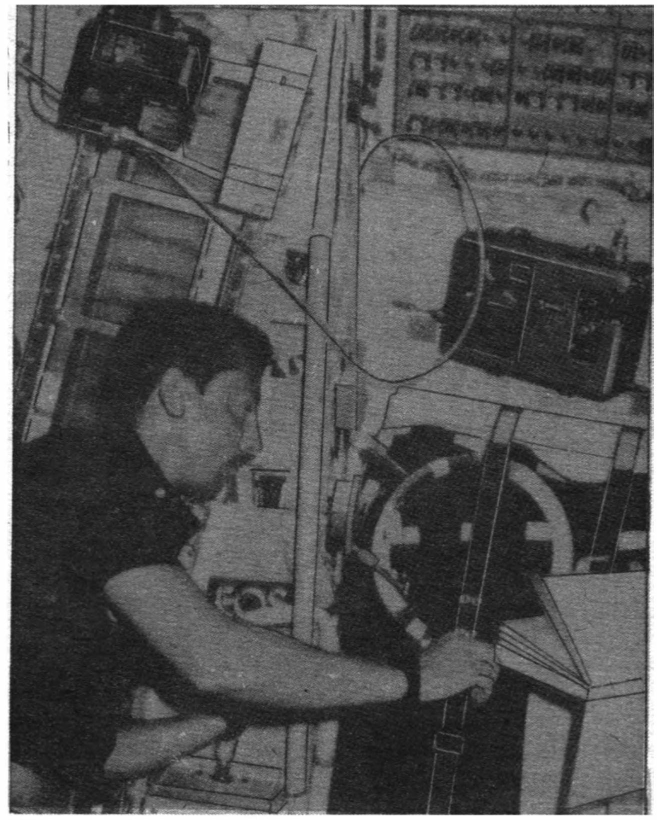
Up in the cockpit, the astronauts felt vibrations as the main engines lit up, accompanied by audible engine malfunction alarms in their headsets. Veteran commander Hartsfield said later, "I knew we weren't going anywhere."

It became apparent that two of the three main engines ignited in the normal one-at-a-time 'ripple-fire' sequence employed on all flights. However, before the third could fire up, *Discovery's* computers sensed that something was amiss in one of the two engines already firing and so they called an automatic halt to the countdown, shutting everything off at the T-4 sec mark. This was exactly what the computers were programmed to do and they performed their function flawlessly.

At this point, Hartsfield said later, the crew's main concern was making sure that the Solid Rocket Boosters would not ignite accidentally. Unlike the main engines, once the SRBs ignite they cannot be shut down. In such a situation, *Discovery* would *have* to lift off, main engines firing or not. The spacecraft would probably ditch far downrange in the Atlantic. As it turned out, however, there was no reason for concern. The computers continued to do their job, automatically saving the SRBs and putting *Discovery* into a condition in which nothing could accidentally start.

Suddenly, just as controllers were starting to relax and take stock of the situation, TV monitors showed a fire burning on the underside of the Orbiter's tail, near the body flap. Fire detectors at the pad subsequently confirmed the blaze and an effort was made to put it out using high-pressure water nozzles. The flames were doused and the water was turned off. The fire started up again and the water had to be switched back on. This happened three times.

Controllers were faced with a highly dangerous situation. The External Tank was still fully loaded with over 700,000 kg of propellant capable of exploding within seconds if touched off by the fire. Hartsfield, as well as Launch Director Bill Sieck, considered an emergency evacuation of the Orbiter. This would involve the six astronauts quickly leaving *Discovery,* running across the Orbiter Access Arm to a cab mounted on a slide-wire, and then riding in the cab to the ground a few hundred metres away. From there, they would be quickly driven out of the area in an armoured vehicle. In the final analysis, Hartsfield decided to sit tight. There was the possibility that toxic gases might be present around the Orbiter. In that event, it would be safer for the crew to stay aboard as long as there was no immediate danger.



Payload Specialist Charles Walker hard at work with his CFES equipment in *Discovery's* middeck.

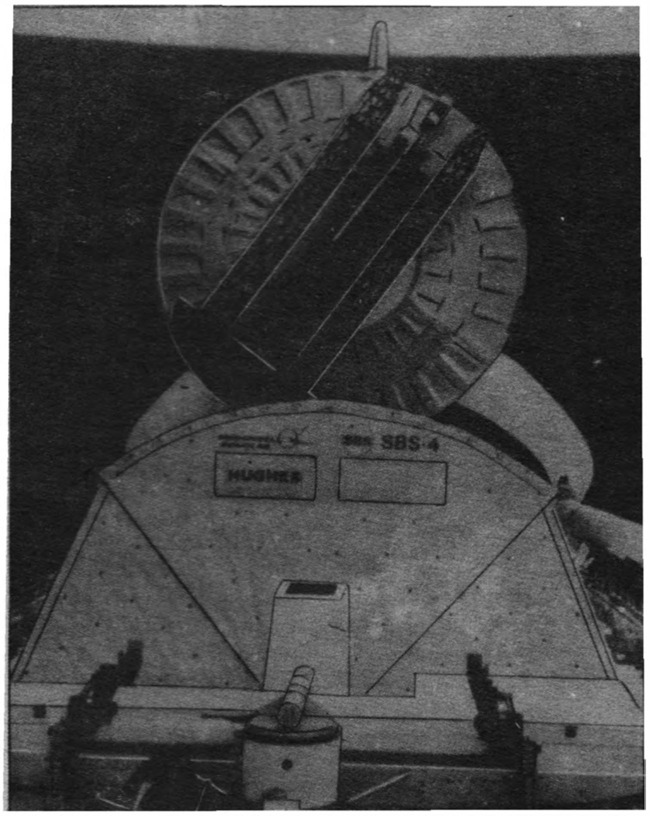
As soon as it was deemed safe, a crew of technicans went out to the pad to get the astronauts out of the Orbiter. Some of the crew members looked visibly shaken and tense as they emerged from *Discovery's* hatch some 40 minutes after the incident. There was no milling around. The astronauts rapidly doffed their helmets and were led quickly out of the White Room.

With everyone safe, Shuttle managers set off on the difficult task of trying to determine what had gone wrong. It was obvious that there had been a very serious malfunction and that there would probably be a delay on the order of several weeks. The astronauts returned to Houston while engineers and technicans converged on *Discovery.*

Regrouping

The first order of business was to understand exactly what had happened. In a normal Shuttle main engine start sequence, Engine 3 ignites first, followed by 2 and then 1. As soon as the Orbiter's computers confirm that all three engines have reached full thrust, the SRB start command is given and the Shuttle is on its way.

In the 26 June abort a problem developed in Engine 3. It was theorised that when it went through its start sequence at T-6.6 seconds, pieces of microscopic contamination caused the Main Fuel Valve in the engine to malfunction. In the meantime, Engine 2 started normally and the computers were just about to send the ignition command to Engine 1 when they noticed the problem



Lying on its side with its top toward the camera, Syncom IV-2 is launched 'Frisbee-style' from *Discovery*.

in No. 3. As programmed, they shut everything down immediately, leaving the count in a hold at T-4 seconds. Meanwhile, the excess hydrogen in the area following the brief engine startup was deemed to be the cause of the fire seen at *Discovery's* tail. The only damage to the Orbiter was that some of the vulcanising material used to treat the tiles on the body flap was burned off and had to be re-applied. The ET and SRBs came through unscathed.

The main problem facing the engineers and technicians was how to deal with Engine 3. They attempted to duplicate the failure in ground tests, but were unable to do so. As a result, instead of simply replacing the faulty valve it was decided to replace the entire engine. The changeout was done at the pad and completed on 5 July.

Shuttle programme scheduling presented mission managers with still more problems. At the time of 41D's originally scheduled launch, NASA was planning a rather ambitious programme of four more flights before the end of the year. This hectic pace was severely affected by 41D's failure. The planners decided to combine most of 41D's original payload with some of the items scheduled to fly on *Discovery's* second mission, 41F, which was then set for the end of August. Thus, plans proceeded to fly 41D in the late August time slot with Hartsfield's crew and the following D/F hybrid payload aboard:

1. Syncom IV-2 communications satellite (from 41F);
2. Satellite Business Systems (SBS 4) communications satellite (from 41F);
3. Telstar 3 communications satellite (from 41F);
4. NASA's OAST-1 payload (from 41D);
5. Continuous Flow Electrophoresis System (CFES-BLOCK III) (from 41D);
6. IMAX Motion Picture Camera system (from 41D);
7. One Shuttle Student Involvement Project experiment (from 41D);
8. Two science and technology experiments, Vehicle Glow and Clouds (from 41D).

To make room for these additions from 41F, Syncom IV-1, the LFC, Cinema-360 and the GAS payload were all dropped from the mission to be re-assigned to flights some months down the line. Likewise, the remainder of the 41F payload, as well as astronauts Bobko, Williams, Seddon, Hoffman and Griggs, were given other assignments. Mission 41F was formally cancelled.

Discovery was rolled back to the Vehicle Assembly Building on 14 July where it was de-mated from the ET and transferred to the Orbiter Processing Facility. There it underwent modifications to its payload bay to permit the cargo changes. The re-stacked vehicle was then moved back to Pad 39A on 9 August where its new payload was installed two days later.

Thus outfitted with a new cargo and a slightly different mission, *Discovery's* second countdown began on 27 August, aiming toward a 12:35 liftoff on 29 August.

Further trouble cropped up late on 28 August that caused a 24 hour postponement. The problem consisted of a timing error in *Discovery's* Master Events Controller, a device that commands many critical vehicle functions during flight. There were fears, that if gone uncorrected, the timing discrepancy could have prevented the SRBs and ET from separating during ascent. Johnson Space Center computer experts designed a software 'workaround' and the launch was re-scheduled for 30 August at 12:36.

Mission Day 1: 30 August 1984

A year after *Challenger* began its third mission by lighting up the night sky in the first after-dark Shuttle launch, *Discovery* leaped off the same pad to start its maiden voyage. Liftoff came at 12:41:50, having been delayed nearly seven minutes by a stray Piper Aztec aircraft that had wandered into the restricted airspace around the Kennedy Space Center.

Because of the lightweight structure, the new Orbiter's computers programmed an ascent profile that put less stress on the wings and tail. Throttling of the main engines was done in steps and a more gentle angle of attack was selected. Main engine performance was good and after cutoff and two Orbital Maneuvering System burns, *Discovery* and her crew found themselves in a 296 km circular orbit inclined at 28.45° to the equator.

As on all Shuttle flights, the first order of business was getting the payload bay doors open again. As *Discovery* was a new Orbiter, extensive door opening tests were conducted. This also marked the first flight for a new Remote Manipulator System (RMS) arm, so Mission Specialist Judy Resnik unlimbered it and put it through its paces about 3½ hours after liftoff. "The arm works super," she concluded. Some initial checks of the CFES were also done, handled entirely by 41D's passenger, Charlie Walker.

The main order of the day, however, was the deployment of SBS 4, an operation taken care of by Mike Mullane and Steve Hawley. The 3,349 kg cylindrical satellite spun up and out of *Discovery's* payload bay at 20:40 in a precision deployment that was followed 45 minutes later by an equally exact 85 second PAM engine burn. The astronauts used one of the RMS television cameras to observe the manoeuvre from their vantage point 20 km away.

There had been concern about how well the PAM would perform. The two satellites were lost on Mission 41B in

February 1984 because of failed PAM engines but there was no cause for alarm this time. The solid propellant stage worked perfectly, putting SBS 4 into a good geostationary transfer orbit. An engine aboard the satellite itself later fired on 1 September, putting SBS into a stationary position over the equator some 35,880 km high.

The only problem noted with *Discovery* involved a faulty Cathode Ray Tube screen on Pilot Mike Coats' side of the cockpit, but plans were being developed to replace it with a tube from the aft payload control console. It was planned to make the change just before entry, so that Coats would have it available for landing.

Mission Day 2: 31 August 1984

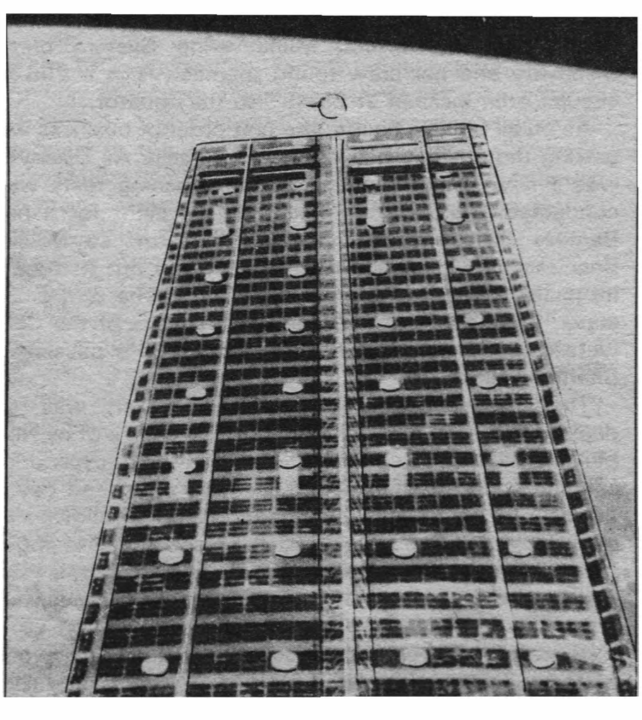
Awakening to the strains of 'Anchors Aweigh,' the US Navy theme song, the crew began their day by getting ready for the second satellite deployment.

The deployment of Syncom IV-2 was to be very different from that of SBS 4. Much of the difference lay in the fact that Syncom was of a radically different design. Built specifically to be launched from the Shuttle, the satellite rested on its side at the far end of the payload bay. Instead of being spun up inside the bay and then pushed out vertically as SBS has been, Syncom was designed to be flung out of the bay on its side at a very slow rotation - much like the popular 'Frisbee' flying disc. In fact, NASA officially referred to it as the 'Frisbee Deploy' method. Nor did Syncom use a separate upper stage to boost it into geostationary transfer orbit. It carried its own self-contained propulsion unit and could travel itself all the way from the Shuttle's 296 km orbit up to geostationary altitude.

Again, Mullane and Hawley were in charge. At 13:10, Hawley threw switches to retract the pins holding the satellite in the payload bay. Three minutes later, Mullane commanded the deployment. The Orbiter was flying upside down and in the views transmitted from the RMS television cameras, Syncom IV-2 appeared to be dropping 'down' toward the Earth in a slow 2 rpm rotation as it left the bay at 0.46 m/s.

The astronauts watched the satellite depart against the beautiful blue background of the Earth. They were able to observe Syncom's omni antenna mast extension some 80 seconds after deployment and about five minutes after that they were able to see the satellite increase its rotation rate to 33 rpm by using small hydrazine thrusters.

The OAST-1 solar array at nearly full extension.



At 13:28, Hartsfield and Coats made a small OMS burn to put *Discovery* at a safe distance in preparation for Syncom's perigee kick manoeuvre at 13:58. The satellite's modified Minuteman 3 engine worked perfectly, burning the full 59 seconds and putting it on target. Three additional manoeuvres, all performed by the liquid propellant engine, were planned over the next few days in order to place Syncom in position over the equator at about 100° West longitude.

The second day of the flight also marked the start of payload specialist Charlie Walker's processing work with the CFES. However, less than one hour into his 80 hours of planned work, the large drug processor automatically shut itself off after exhibiting 'wildly divergent pressures.' Walker started it back up only to have to stop it manually a few minutes later when the pressures again started to fluctuate. He tinkered with the unit for some time, along with experts on the ground who studied other data in an effort to find out what was wrong. McDonnell Douglas engineers promised to keep working overnight, hoping to pass a solution up to Walker in the morning.

Mision Day 3: 1 September 1984

Shortly after the crew awoke, Walker was on a communications headset talking to McDonnell Douglas' deputy CFES programme director David Richman. Richman gave him some recommendations, but there was no clear-cut resolution. The CFES continued to operate erratically in the automatic mode. Walker eventually resorted to manual operation, which required a great deal more work on his part, but by the end of the day things seemed to be going well and Walker appeared to be making up much of the lost time.

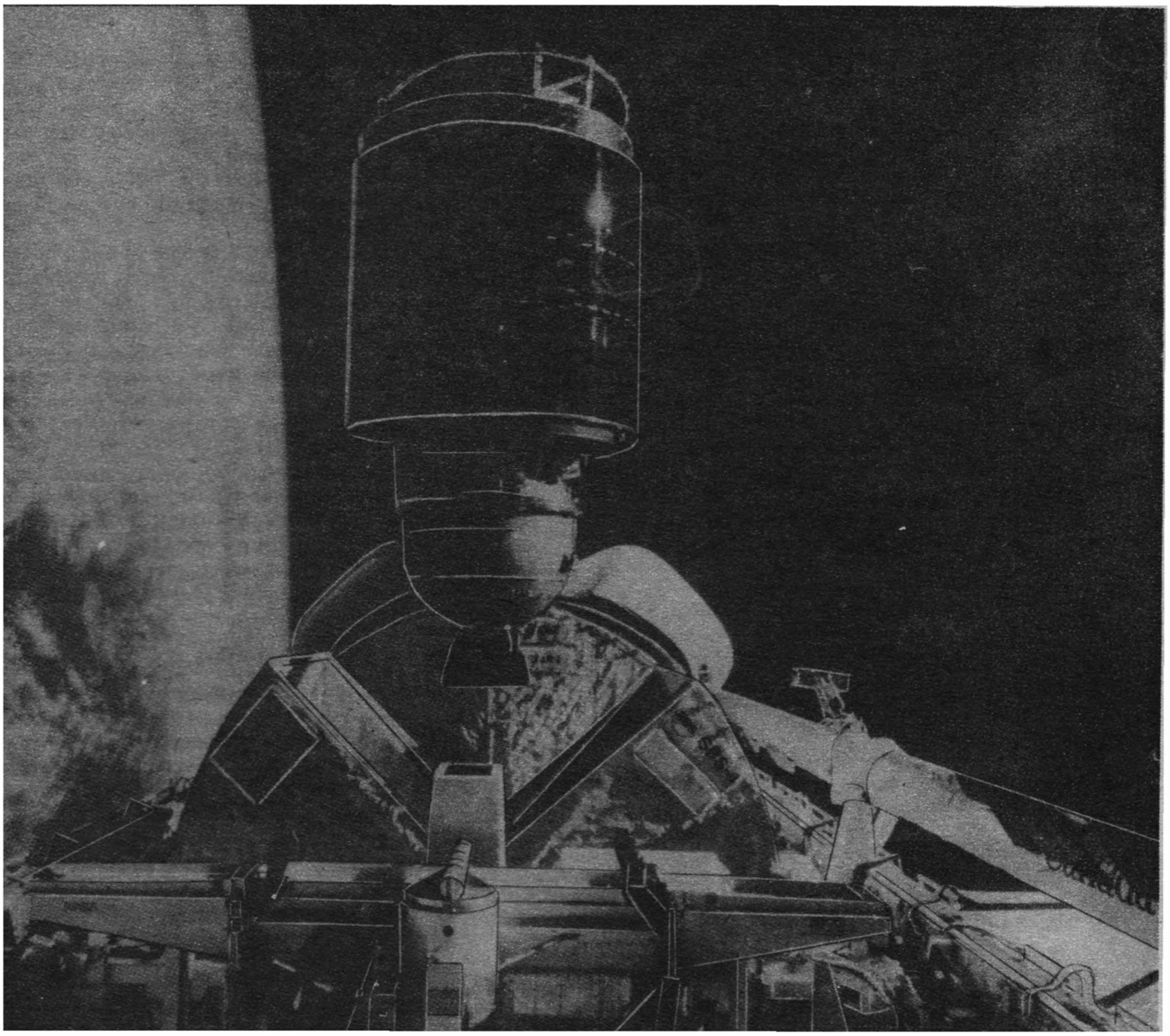
The other astronauts also had a busy day ahead. Resnik planned to begin operations with the OAST-1 Solar Array Experiment and Hawley and Mullane had their third and final satellite to launch.

The Telstar 3 satellite, set for deployment during *Discovery's* 33rd orbit, was almost a twin of SBS 4. The astronauts started Telstar spinning at 50 rpm and then threw switches to spring it vertically out of the payload bay at 0.9 m/s. Final departure took place at 13:24. Once again, Hartsfield and Coats backed *Discovery* away to a safe distance from which the PAM perigee burn could be observed by the RMS cameras. The solid stage ignited right on time at 14:09 and burned perfectly for the full duration. *Discovery's* satellite delivery mission was now complete. The crew had achieved a perfect 'three for three' record and it was time to move on to other activities.

On the agenda for the remainder of the day were two extension tests of the large 31 m solar array that was part of the OAST-1 package. For these first two deployments, however, the wing would be raised only to 70% of its full length (about 22 m).

Resnik began the first extension at 17:30 as *Discovery* passed over Hawaii on its 36th orbit. The ultralight wing was folded up accordion-style inside a shallow box only 18 cm high. It was slowly pulled out of the box by a lightweight fibreglass mast that extended at a rate of 3.8 cm/s. The principle was much the same as that employed by portable home movie screens.

Hawley observed that the 84 plastic panels making up the array seemed to stick to one another as they emerged from the stowage container. He assumed that this was due to the many weeks that they had been folded since



The SBS 4 satellite rises out of the payload bay on the first day of the mission.

their last ground test deployment. The sticking was not observed on subsequent extensions.

The panels pulled apart properly, however, and after 9 minutes the wing towered 22 m over the Orbiter's payload bay. 'It's up and it's big!' Resnik exclaimed, adding that the array was 'very steady and stable.' After a few minutes, Resnik retracted the wing to make sure that it would fold properly, which it did. She then initiated a second extension to the 70% position, this time to observe how it would behave when shaken by *Discovery's* thruster firings. The wing appeared to be very stable. It swayed somewhat but the astronauts said that the action of deploying it actually shook it more than did the thruster bursts.

The tests concluded a very busy day for the crew, who bedded down for their third night in space shortly after the wing was re-stowed in its box.

Mission Day 4: 2 September 1984

Day 4 was a little more relaxed. Mullane and Hawley took advantage of some of the free time to make and fly zero-g paper aeroplanes down in the middeck area. One of them had even brought along a Frisbee and the two mission specialists played a weightless game of 'catch' for the benefit of the TV audience on Earth.

It was not all play, however, and Charlie Walker continued to be a very busy man. His manual CFES processing activities were continuing and seemed to be producing good results. He took a small sample of the material he was making, ran some tests on it and confirmed that the quality was as good as the CFES investigators had hoped it would be. McDonnell Douglas would later assert that had Walker not been aboard it is probable that no material would have been obtained.

Meanwhile, Resnik put in a second day of work with the OAST-1 solar array. She first extended it once more to the 70% position for additional dynamics tests before finally raising it up to its full 31 m length. Spectacular TV views were transmitted to Earth showing the shadow of *Discovery's* tail and OMS pods backlit through the thin plastic of the brilliant gold-coloured wing (*Discovery* was flying with her tail toward the Sun).

With the array up at its full extension, more dynamic tests were conducted to see how much the wing would sway. With each thruster burst, the top of the panel would swing back and forth about 50 cm. This was far less than predicted.

Late in the day, after the wing had been stowed, a totally unexpected problem cropped up that was to dominate most of the rest of the mission. It was found that a large chunk of ice was clogging a waste water dump outlet on the port side of the Orbiter. The crew

moved the end effector of the RMS arm over to the blockage so that it could be inspected with a TV camera. They found a 9 kg icicle roughly 50 cm long.

While the ice posed no threat to the crew, it did present a potential hazard to the Orbiter. On Mission 41B in February 1984 one of the OMS pods sustained substantial damage from an unknown source. Engineers theorised that just such an ice chunk had formed on that flight, only to break off during entry and fly back to hit the pod.

Hartsfield tried firing the RCS engines to shake the ice loose but it stayed stubbornly in place. Since it was getting close to bedtime, MCC-H controllers decided to have the crew orient *Discovery* with the ice block facing the Sun overnight in the hope that it would be gone by morning. They also gave the crew instructions not to use the toilet. Controllers feared that the waste management tanks would fill up with urine before they could be dumped overboard. Thus, the astronauts resorted to the plastic bags used during the old Apollo flights.

'We tried out the Apollo bags,' one of the crew announced shortly before bed, 'and we decided that those Apollo astronauts must have been real men.'

'You don't want to hear what Judy has to say,' added another.

Mission Day 5: 3 September 1984

After the astronauts awoke, one of the first things they did was to check on the ice. To their dismay, it had hardly melted at all. Hartsfield tried harder, sharper RCS firings in an effort to jar the block loose but his attempts were still unsuccessful.

MCC-H began working on alternate procedures. Astronauts Joe Engle, Ron McNair, Sally Ride and Bob Springer boarded the Shuttle Engineering Simulator at the Johnson Space Center to see what they could suggest. The most promising solution involved using the RMS arm very carefully to tap the icicle free. The problem was that in order to get to the ice chunk, the end effector had to be positioned in such a way that the astronauts would be unable to see it. Pictures from the arm's TV cameras were available, of course, but normal RMS operations are designed to use a combination of both TV and direct visual cues. Making matters worse, the ice was very near some critical thermal tiles on the leading edge of the left wing. Accidentally bumping them with the arm could cause significant damage. Arm clearance around the open payload bay doors and radiators would also have to be carefully monitored. In summary, Engle, McNair, Ride and Springer found that the method would work, but only with much difficulty. Ride said that she hoped another way could be found.

Up in *Discovery,* plans were being made for just that eventuality. Ride's husband, Steve Hawley, along with Mike Mullane, began pre-breathing pure oxygen just in case they might have to go outside to chisel the ice free. Hartsfield also lowered *Discovery's* cabin pressure to make an EVA easier but the main course of action decided on was to try the RMS method first. Only if that did not work would Hawley and Mullane make a spacewalk.

Mission Day 6: 4 September 1984

The crew was awakened early to allow them extra time in case of unforeseen problems in the ice chipping operation. Since it was to be such delicate work and the risk factor was fairly high, mission commander Hank Hartsfield operated the arm himself. He did not want any of his crew to have to take the blame if the Orbiter were damaged in any way. Resnik sat in the left front cockpit seat, craning her neck to look back down the side of the Shuttle in an effort to try to guide him visually but, for the most part, Hartsfield had to rely completely on the end effector TV camera.

As it turned out there was no need for worry. Hartsfield made the operation look easy as he carefully gave the icicle a tap with the arm. The block swiftly floated away and only a harmless 5 to 10 cm piece remained. This was not expected to cause any problems.

With MCC-H now calling them the 'Icebusters' (after the popular American film *Ghostbusters*), the crew began packing up to come home.

Walker shut down the CFES and flushed out its lines. Things had not gone completely according to plan for him, but still he estimated that he had obtained about 80% of the material he had hoped for before the flight. These were excellent results in the light of the earlier problems. He was also comforted in the knowledge that he would soon be getting another chance - Walker and the CFES are scheduled to fly on Mission 51D in March 1985.

The other astronauts also tidied up, unstowed seats and made preparations for entry. Hartsfield and Coats performed a check of *Discovery's* flight control system, pronouncing it to be in excellent shape. The weather was also cooperating, with excellent conditions predicted for Edwards Air Force Base.

Mission Day 7: 5 September 1984

While the astronauts were sleeping, just before 03:00, MCC-H detected an oxygen leak aboard *Discovery*. It seemed that one set of tanks in the cryogenic oxygen system was emptying three to four times faster than normal. Reluctantly, MCC-H awoke the crew 90 minutes early to have them correct the problem by isolating the leaking system. Oxygen was then drawn from a second redundant set of tanks.

For a time, flight controllers considered bringing *Discovery* down two orbits early because of the leak, but when things seemed to stabilise a decision was made to hold to the original plan.

Since this was the first flight of a new Orbiter, the wide expanse of Rogers Dry Lake at Edwards Air Force Base was chosen as the primary landing site. Touchdown was planned for just ten minutes after sunrise at the base with *Discovery* part way through its 97th orbit.

The six crew members donned their helmets and assumed their assigned seats. Pilots Hartsfield and Coats, who would be doing all of the flying, took the left and right hand cockpit seats respectively. Between and slightly behind them sat Steve Hawley, who was acting as flight engineer. To Hawley's right was Judy Resnik, and down below on the middeck sat Mike Mullane and Charlie Walker. For entry, Resnik and Mullane swapped places.

Discovery's first descent from space began with a perfect deorbit burn at 12:36 as it made the last pass over the Indian Ocean. Some minutes after the 168 second OMS manoeuvre was completed, the Orbiter plunged into the atmosphere.

Soon *Discovery* appeared in the clear dawn skies over Edwards, looking little the worse for wear. Hartsfield had kept the spacecraft under automatic control for most of the entry but; as soon as the Orbiter went subsonic and began its 251° turn onto final approach, the veteran pilot took the controls himself. He aimed *Discovery* squarely at the centreline of Lakebed Runway 17 and landed the spaceplane in the rays of the rising Sun. The Orbiter's main landing gear wheels first touched the ground at 13:37:54, giving a flight time of 6 days 0 hours 56 minutes and 4 seconds. The nose gear came down smoothly and *Discovery* rolled for just over 3 km before coming to a stop after about 60 seconds.

SATELLITE DIGEST-179

Robert D. Christy

Continued from the December 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.

PROGRESS 23 1984-86A, 15193

Launched: 0628*, 14 Aug 1984 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz T-12 except for the absence of solar panels.
Mission: To carry scientific and technical equipment, research materials, food, fuel and mail to the long stay crew of Salyut 7. Docked with Salyut's rear port at 0811, 16 Aug; undocked at 1613, 26 Aug and executed a destructive re-entry manoeuvre at 0128, 28 Aug 1984.
Orbit: Initially 186 x 250 km, 88.80 min, 51.60°, then by way of a 210 x 266 km transfer orbit to rendezvous with Salyut at 341 x 369 km, 91.59 min, 51.60°.

COSMOS 1590 1984-87A, 15197

Launched: 0950, 16 Aug 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1582.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 210 x 266 km, 89.33 min, 82.35°.

AMPTE 1 (CCE) 1984-88A, 15199

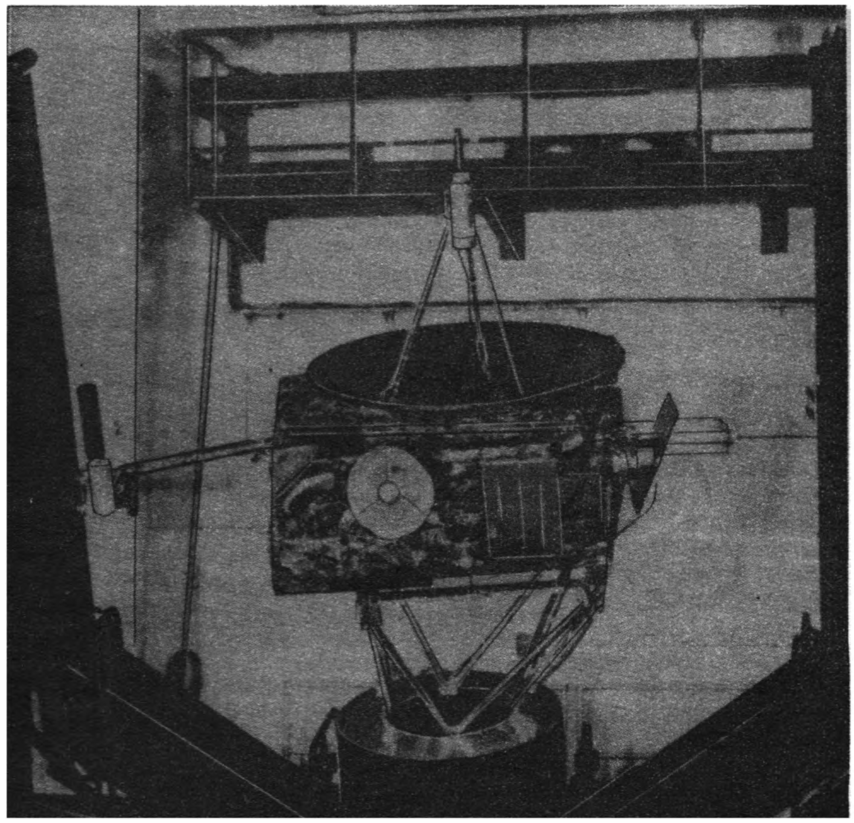
Launched: 1448*, 16 Aug 1984 from Cape Canaveral by Delta 3924.
Spacecraft data: Octagonal prism, approx 2 m diameter and 1 m high and mass 242 kg. Power is provided by a solar array of one panel on alternate sides.
Mission: Part of a three spacecraft mission, this US satellite is also known as the Charge Composition Explorer. Its role is to detect tracers ions released into the magnetosphere by the German IRM satellite. AMPTE stands for Active Magnetospheric Particle Explorers.
Orbit: 1124 x 49925 km, 944.23 min, 4.83°.

AMPTE 2 (IRM) 1984-88B, 15200

Launched: With AMPTE 1.
Spacecraft data: Irregular cylinder, approx 2 m long and 2 m diameter. The mass is 605 kg.
Mission: To release, at intervals, clouds of lithium and barium ions which will interact with the magnetosphere and will be detected by the US and British built satellites. One major event was the formation of an artificial comet in the solar wind, the first performance of such an experiment.
Orbit: 383 x 114570 km, 2657 min, 29°.

AMPTE 3 (UKS) 1984-88C, 15201

Launched: With AMPTE 1.
Spacecraft data: Multi-faced prism, approx 1.5 m diameter, 0.5 m long and mass 77 kg.
Mission: Third AMPTE satellite, flying in formation with IRM and measuring disturbances in the immediate vicinity during the ion cloud release.
Orbit: As IRM.



The European Ulysses (formerly ISPM) solar probe undergoes tests in a solar simulator at Toulouse in France. Launch is set for May 1986.

MOLNIYA-1(62) 1984-89A, 15214

Launched: 0827, 24 Aug 1984 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body with conical motor section at one end, deriving power from a 'windmill' of six solar panels. Length 3.4 m, diameter 1.6 m and mass 1800 kg approx.
Mission: Communications satellite providing telephone, telegraph and TV links through the 'Orbita' system.
Orbit: Initially 474 x 40901 km, 738.57 min, 62.74°, then lowered to 718 min to ensure daily ground track repeats.

EKRAN 13 1984-90A, 15219

Launched: 1951, 25 Aug 1984 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of boom-mounted solar panels and a flat aerial array at one end. Length 5 m, diameter 2 m and mass in orbit around 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving aerials in remote areas of the USSR.
Orbit: Geosynchronous above 99° east longitude.

1984-91A 15226

Launched: 28 Aug 1984, possibly from Vandenberg AFB.
Spacecraft data: Not available.
Mission: Not available.
Orbit: Not available.

COSMOS 1591 1984-92A, 15232

Launched: 1010, 30 Aug 1984 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length 6 m, max diameter 2.4 m and mass around 6000 kg.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 209 x 263 km, 89.28 min, 82.34°.

BOOK NOTICES

Halley's Comet
D. Tattersfield, Basil Blackwell, 108 Cowley Road, Oxford OX4 1JF, 164pp, 1984, £6.50.

This book is bound to be popular. It is written for the layman with no background of scientific knowledge but who will be stimulated by the once-in-a-lifetime reappearance of Halley's comet. It is clear, informative and contains just the sort of information that the ordinary reader will want to know e.g. the comet's history, motion, myths and superstitions and, furthermore, how to photograph it and how to enjoy micro-computer programs such as those also devised by the author to show the comet's path in the sky.

This is a very timely work. It deals with its subject by responding to a series of hypothetical questions, but exactly the sort of questions most people ask, such as as "how bright will it be?, how fast is it moving?" etc.

There are several references to Society publications in its pages though the text appears to have been finalised before publication of the Jan 1984 issue of *JBIS* devoted wholly to Halley's Comet and which contains much additional information.

The New Race for Space
J.E. Oberg, Stackpole Books, P.O. Box 1831, Cameron and Kelker Streets, Harrisburg, Pennsylvania 17105, USA., 1985, 224pp, $14.95.

This book continues the story of the Russian space programme begun by the author in a previous volume and now expanded to include a comparison of the US and USSR programmes, detailing both accomplishments and probable goals.

The author, of course, knows his subject well and many worldy-wise comments come from his lips, for example "the old conflicts about the respective values of manned v unmanned space exploration continue... the same arguments simply recycle themselves every few years..."

On balance, the author predominates in his examination of Soviet space activities, no doubt reflecting genuine American interest in this, but there is much else. For example, a chapter is devoted to advanced-type spaceships in which he mentions not only Daedalus but the anti-matter propulsion issue of *JBIS* which, again, broke new ground.

The book presents a mixture of purely factual accounts of various flights, with an extrapolation into the future to indicate various programmes likely to develop, interspersed with comments on some of the political aspects involved. The result is a most readable volume, fascinating both in what it describes and for the implications for the future. It provides a guide, not for the specialist but for the general reader to show how some aspects of the space drama are unfolding.

Planetary Rings
Ed. R. Greenberg and A. Brahic, University of Arizona Press, 1615 E. Speedway, Tucson, Arizona 85719, U.S.A., 784pp, 1984, $35.00.

Our conception of planetary rings has undergone a revolution in recent years. Saturn's rings have changed from fuzzy ovals to finely detailed structures; the rings of Jupiter and Uranus have progressed from mere hypotheses to well-measured entities, while interpretation of the properties of rings is beginning to produce explanations about the processes that shape or process them - matters that may have ramifications to systems such as galaxies or the nebulae from which planets form.

Strangely, despite the flood of new information, there is very little direct evidence about what rings are, how they are formed or how they behave. Such questions can only be answered by building theoretical models and by comparing these with past and future observations. The subject-matter of this book is thus concerned with presenting a first-generation of such models. To this extent, although particular emphasis is given to observations of the rings of Jupiter, Saturn and Uranus, an extremely large part of the book is concerned with dynamical processes such as dust-magnetospheric reactions, the effects of radiation forces, collisions and the formation of waves.

For many years, Saturn's rings, for example, were regarded either as the uncoagulated remnant of a disc from which later satellites formed, or were fragments of a satellite which approached too close i.e. inside Roche's limit. More than a century later this central issue is still unresolved, though the presence of "shepherd satellites" (i.e. large collision fragments) coexisting in the same orbital range as ring particles appears to favour the latter idea.

Atoms of Silence: An Exploration of Cosmic Evolution
H. Reeves, The MIT Press, 126 Buckingham Palace Rd, London SW1W 9SD, 244pp, 1984, £14.20.

The Universe is a vast and forbidding place, with a plethora of complex phenomena that we do not yet understand. The author, an astrophysicist, takes the reader through the basics of cosmology and how Man might fit into it. He uses the metaphor of music for all the orderliness in the Universe that might have been cosmic "noise" instead.

The book takes a philosophical view of the Universe with a chatty narrative peppered with all the basic facts. It is not a volume to be consulted when in search of hard information but rather one to be enjoyed at leisure to answer the more general questions of why? and what happens next?' It cannot fail to excite the interest of the newcomer.

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.

DO YOU REMEMBER?

25 Years Ago...
7 January 1960. NASA's first administrator T. Keith Glennan at a meeting with NASA staff agrees that the follow-on programme to Project Mercury should have the objective of manned flight to the Moon. The NASA plan called for manned circumlunar flights for the late 1960's and a lunar landing for some time after 1970.

20 Years Ago...
21 December 1964. The 46 kg Explorer 26 scientific satellite is launched by Delta 27 from Cape Canaveral to study natural and artificial radiation belts around the Earth.

15 Years Ago...
18 December 1969. NASA announces that Launch Complex 34 at KSC is to be used for manned Apollo Applications Programme (Skylab) Saturn 1B launches. However, the following May it was decided that significant cost savings could be made if the launches were made from Launch Complex 39 and the plan to use LC-34 was abandoned.

10 Years Ago...
14 January 1975. Earth Resources Technology Satellite 1 (ERTS-1) is renamed Landsat 1 by NASA. Eight days later Landsat 2 reaches orbit from Vandenberg AFB in California.

5 Years Ago...
24 December 1979. First launch of the ESA Ariane rocket from Kourou, French Guiana. During this successful test flight a 1.6 tonne technological payload was placed into a geostationary transfer orbit.

K.T. WILSON

JBIS

The January 1985 issue of *JBIS* is devoted to 'Soviet Astronautics,' with the following papers:

1. 'The Evolution of the Vostok and Voskhod Programmes,' by R.F. Gibson and P.S. Clark;
2. 'The Soviet G-1-e Manned Lunar Landing Programme Booster,' by C.P. Vick;
3. 'Soviet Spacecraft Masses for Earth Orbital Programmes,' by P.S. Clark;
4. 'Soviet Spacecraft Masses for Deep Space Missions,' by P.S. Clark;
5. 'The Soviet Space Year of 1983,' by P.S. Clark.

Copies of this issue are avaiable at a cost of £2 ($4) post free, from The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ. Copies of the October 1983 'Soviet Astronautics' issue are still available at £2 ($4) each.

The December 1984 issue of *JBIS* is devoted to "Space Technology." The following papers are included:

1. "Advanced Space Transportation Requirements and Options" by M.W.J. Bell.
2. "Future Prospects in Space Envisaged by a Forum of European Space Companies" by M. Toussaint.
3. "Commercial Utilisation of Space: New Business Opportunities" by L. Bellagamba and K.H. Robinett.
4. "A Future European Launcher: Ariane 5/Hermes" by J.C. Cretenet and P. Marx.
5. "An Unmanned Platform as an Initial Capability in Space" by T.J. Sheskin.
6. "Satellite Constellations" by J.G. Walker.

This December's issue is available at a cost of £2 ($4) post free from the Society. Earlier "Space Technology" issues still available at a cost of £2 ($4) each are: February 1984, September 1983, July 1982, December 1981 and April 1981.

SURPLUS LIBRARY BOOKS

We have a number of surplus Library Books and Reports on astronomy and space that are being offered at very low prices. To secure a list of those available, simply send a reply-paid envelope with your request to The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ. If you spend £20 or more you may deduct a 10% discount.

Please enclose a 20p stamp and specify if you require the Book List, Technical Report List, or both.

DELUXE CERTIFICATES

Both Fellows and Members may now purchase high-quality certificates suitable for framing. These are 29.5 41.5 cm in size, printed in three colours and with the member's name hand-inscribed. They are available for only £5 ($8) post free.

When ordering, please indicate membership grade and allow six weeks for delivery. Provision for ordering these certificates also appears on the 1985 subscription renewal form.

1985 SUBSCRIPTION FEES

There is good news for all members: fees for 1985 will remain unchanged from 1984 in spite of rising costs.

Direct Debit Scheme

Our old Bankers Order System has now been phased out. Direct Debit slips are available from the Executive Secretary but, as these will not now come into operation until 1986, a separate remittance for 1985 must be made.

Amounts payable for the calendar year January-December 1985 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £4.00 ($6.00) is allowed to members of every grade over the age of 65 years on 1 January 1985.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($6.00).

Methods of Payment

Europe

(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling payable at a bank in Europe must include £2.00 to defray charges and collection costs. Eurocheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions.*

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling.* Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they cannot be cashed in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

spaceflight

Correspondence, manuscripts intended for publication and requests for information on membership may be addressed to the Executive Secretary at the Society's Offices at 27/29 South Lambeth Rd., London SW8 1SZ. Tel: 01–735 3160.

NOTICES OF MEETINGS

Film Show
Theme: **MOMENTS IN HISTORY (PART 2)**

The second of two meetings devoted to historical space films will be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **6 February 1985,** 7.00-8.30 p.m.

The programme will include the following:

(a) A Man's Reach Should Exceed his Grasp
(b) Small Steps, Giant Strides
(c) A Moment in History
(d) Blue Planet
(e) Meteosat

Admission is by ticket only. Members wishing to attend should apply in good time, enclosing a stamped address envelope.

Lecture
Theme: **COMMERCIAL LAUNCH VEHICLES**
By G.M. Webb

The context in which Europe will be competing commercially using its post-Ariane 4 series of launcher will probably be very different from the present situation; the viability of the various options open in the mid-1990's will be discussed.

To be held in the Socity's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **20 February 1985,** 7.00-9.00 p.m.

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

Symposium
Theme: **EUROPE-US SPACE ACTIVITIES**

The **1985 Goddard Memorial Symposium,** in conjunction with the **19th European Space Symposium,** will be held at the NASA Goddard Space Flight Center, Maryland, USA on **28-29 March 1985** organised by the American Astronautical Society and co-sponsored by The British Interplanetary Society in association with other Societies.

Offers of papers are invited. Futher information is available from the Executive Secretary and registration forms will be available in due course.

One-day Symposium
Theme: **SPACE STATIONS**

A one-day symposium on the obove theme, considering the technology and applications of Space Stations, will be held in the Society's Conference Room on **17 April 1985.**

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary, at 27/29 South Lambeth Road, London SW8 1SZ.

Lecture
Theme: **COHERENT LIGHT FROM SUPERNOVAE**
By A.T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **15 May 1985**, 7.00-9.00 p.m.

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

Lecture
Title: **SATELLITE INSURANCE**
By R Buckland

Launching satellites into space is a risky business. No commercial project can go ahead without insurance to cover launch and other risks. This talk will describe the role that satellite insurance plays in the development of commercial activity in space.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **12 June 1985,** 7.00-9.00 p.m.

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

36th IAF Congress

The 36th Congress of the International Astronautical Federation will be held in Stockholm, Sweden on **7-11 October 1985.**

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

LIBRARY

The Library will be open to members from 5.30 to 7 p.m. on the following dates:

6 Feb 1985
20 Feb 1985
1 May 1985
15 May 1985
12 Jun 1985

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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