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Editor:
G. V. Groves

Assistant Editor:
C. A. Simpson

Managing Editor:
L. J. Carter

Editorial Office:
27/29 South Lambeth Road,
London, SW8 1SZ, England.
Tel: 01-735 3160.

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Front Cover: An artist's impression of Hotol flying into orbit. The British Aerospace/Rolls Royce horizontal takeoff spaceplane relies on a revolutionary new propulsion system. If development proceeds as planned the spaceplane could be in operation before the end of the century. A full report on Hotol plans begins on page 147 and is followed by a special review of British space activities. *BAe*

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HOTOL – TOWARDS THE 21st CENTURY

The announcement that the Hotol "Proof of Concept" Study is underway at last on joint government/industry funding must be welcome to those who look for a new UK attitude to Space. The amounts involved are small, and it has taken a perhaps characteristically long time for the announcement to be made, but the decision shows a positive readiness to look to new ventures in Space for the future. If this is to set the "style" for the new British National Space Centre, it should be applauded.

Let us be clear just what has been agreed. The Hotol Proof of Concept Study is to establish whether the breakthrough in launch vehicle concepts claimed for Hotol by British Aerospace and Rolls Royce is real, and more importantly how immediately that breakthrough can be translated into a usable launch vehicle. Establishing the timescale is a key. It is not a commitment by the UK to develop such a vehicle, still less to develop it as an independent project separate from its partners in Europe. The UK now has perhaps 18 months to achieve the objectives of Proving the Concept before it must go to its partners as a proposer of a joint project.

In the mean time the French will continue to press Europe down the route of Ariane 5 and Hermes as the launch vehicle for the late 1990's.

It is probably the French who will have to make the most difficult decision regarding Hotol. The UK has made it clear that, at the end of the Proof of Concept Study, it will share the results with its European partners. If those results are positive then the French will have to decide whether to abandon Ariane 5 and Hermes, or more realistically just Hermes, and embrace Hotol. This is why the potential timescale is important. It establishes whether Hotol is a replacement, or a successor to Ariane 5/Hermes. But the decision is not simply whether Europe should take a conservative or high risk route on its future launch vehicle.

Across the Atlantic, while the UK finds a few million pounds for studies, the USAF is putting hundreds of millions into a new vehicle concept called the Trans-Atmospheric Vehicle or TAV for short. The immediate need is military, but if it can be made to work the TAV will have a direct impact on civil launch costs. It will bring launch costs per kilogramme down by an order of magnitude.

If Hotol can work, then TAV can work. And if TAV flies, NASA will have, by the end of the Century, the low cost launch the Shuttle should have been but was not. The UK is pursuing a number of lines which look remarkably similar to Hotol – and against that competition, Ariane 5 and Hermes will make no in-roads whatsoever. Without a competitive launch vehicle, Europe could find itself not only out of the launch vehicle business, but out of commercial Space altogether.

That is the real challenge of Hotol – not whether Europe can afford to do it, but can it afford not to?

But if Europe does manage to take a deep breath and plunge in, the rewards could be much greater than simply remaining in the Space Business. Almost every aspect of the commercialisation of Space, with the exception of communications satellites, is today held back by the high cost of launches. To lower the costs by a factor of five or more would be an immense stimulus to growth in these other areas.

Finally, there is a converse to this subject. It may be that Hotol proves not to be the route to the 21st Century for Europe. In that case the UK must be prepared to support Ariane 5 and Hermes as actively as it would have expected France to support Hotol. In not joining directly with the US TAV studies, but showing a readiness in the first instance to share the Hotol findings with Europe, the UK has indicated its readiness to be a "good European". The next generation of launch vehicles and the European capability for man-in-space operations are too important for the UK to ignore or simply to fill a minor sub-contractor role supplying bolts and fittings. Hotol has shown that the UK is prepared to think innovatively in Space and to participate with Europe, and it must continue to participate at that level.

Viewpoint

Flying into the Future

by Clive Simpson

Development of a revolutionary new engine by Rolls Royce is the key to British plans for Hotol, the horizontal takeoff and landing vehicle, a project which could put Europe at the forefront of commercial operations in space by the turn of the century.

The dual-functioning engine being designed for Hotol represents a quantum leap forward in propulsion technology – it will be able to breath air from the atmosphere during initial stages of operation before switching to internal fuel supplies when external air becomes too rare.

In tandem with development of the Rolls Royce propulsion system, British Aerospace is studying the feasibility and design of the Hotol spaceplane. Initial studies should be complete by the second half of 1987 and will cost £3 million, half of which will come from the government-funded British National Space Centre (BNSC). The Hotol development programme includes 12 test flights and seven orbital test flights, which would begin in early 1996 and conclude with the start of commercial operations between 1998 and 2000.

British Aerospace first announed its ideas for Hotol in August 1984 and since then the concept has become a subject of increasing interest both within Europe and in the United States.

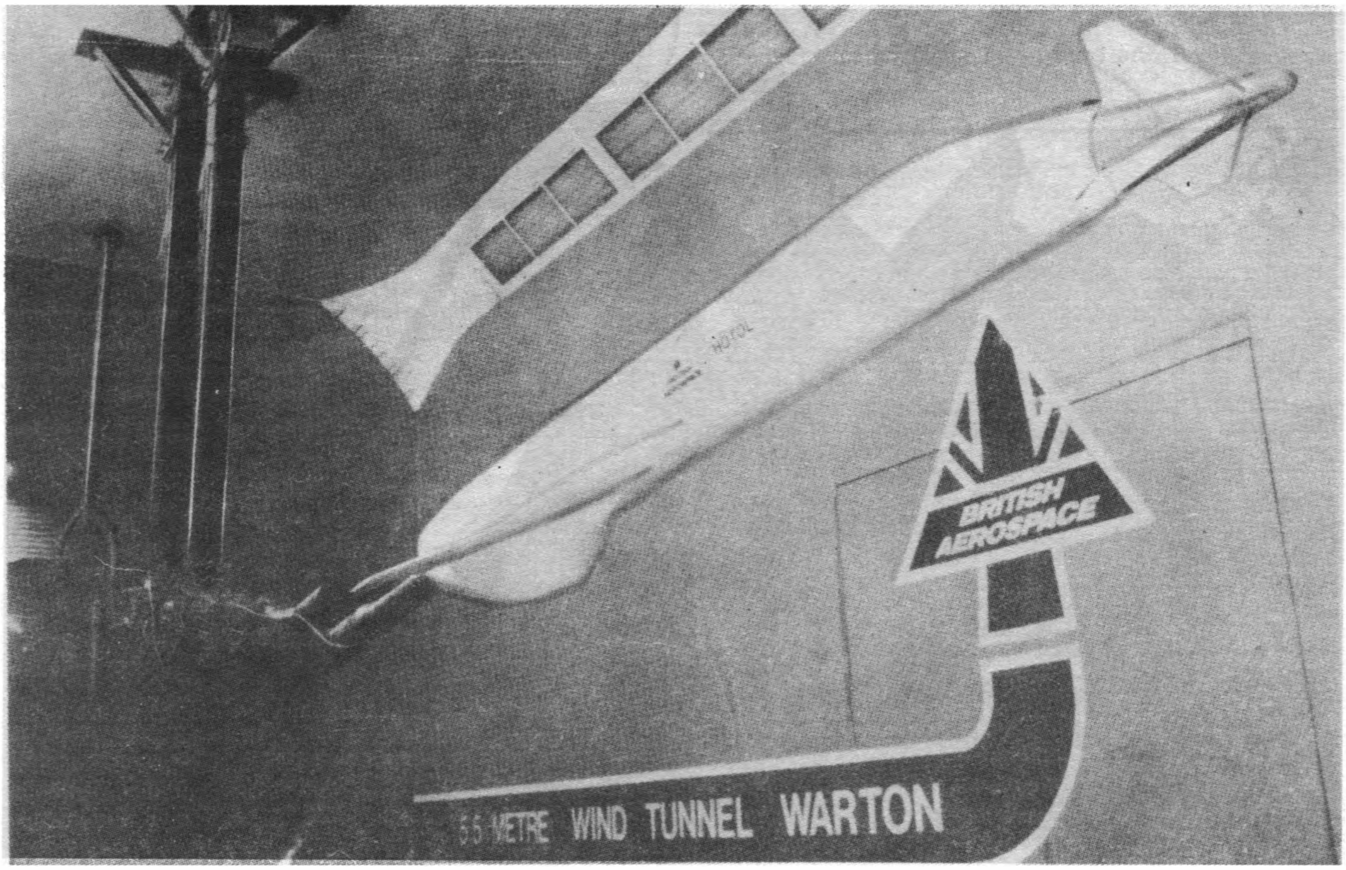
The goal of Hotol is to achieve launch costs to low Earth orbit of about one-fifth those of current launch systems such as the Shuttle for a typical seven tonne payload. The ability of Hotol to recover satellites and dock with Europe's Columbus and the American Space Station will also be investigated during the proof-of-concept studies.

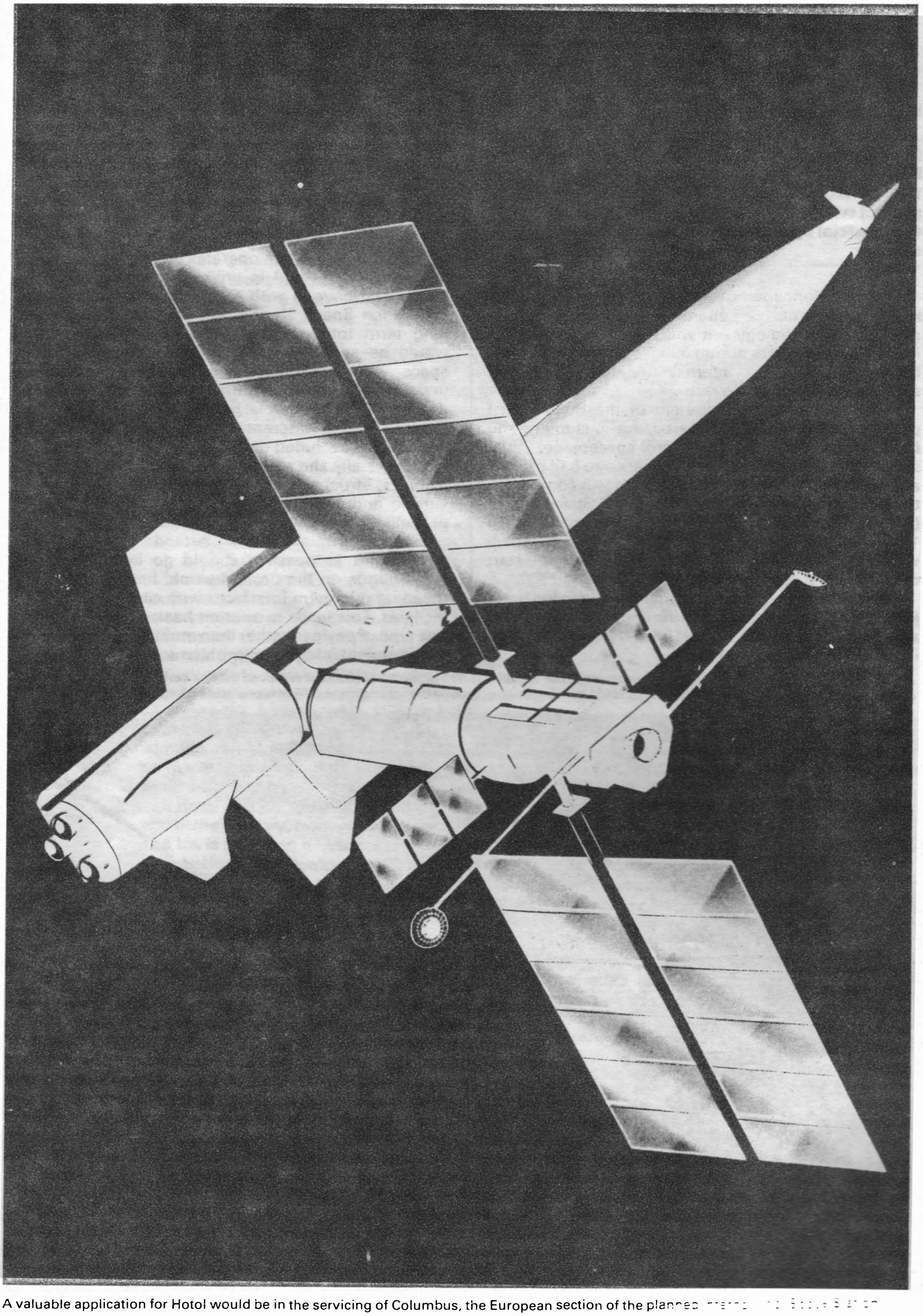
The spaceplane concept stems from the belief that a launcher system which operates by throwing away its components in flight is unlikely to compete in the 1990's and beyond with a greatly improved, second generation Space Shuttle. So, convinced that in the long term total reliance on expendable launchers would be seriously detrimental to Europe's future space interests, British Aerospace engineers undertook far-reaching studies to identify and design the optimum commercial launch vehicle.

More than 30 different configurations were studied and it was concluded that for a recoverable, reusable launcher all the expensive hardware (engines, avionics, structure) should be collected into a single vehicle and anything that left the ground – except propellants and payload – should return again.

In addition engineers agreed that as little deadweight as possible should go into space and turnarounds on the ground would have to be rapid, meaning minimum interfaces with cargo and ground facilities. This leads to another basic design criteria – one type of payload rather than multiple payloads with the attendant integration problems.

A scale model of Hotol in the 5.5 metre wind tunnel at BAe Warton. Recent design changes have removed the two vertical fins at the rear and altered the small foreplanes which are now spaced 120 degrees apart around the vehicle's nose. Wind tunnel testing began in early February.





A valuable application for Hotol would be in the servicing of Columbus, the European section of the planned [illegible]

As a result the concept of the "ideal" launcher emerged – a single-stage-to-orbit vehicle able to operate from a simple launch area with an airliner-type frequency.

Hotol is based on a remarkable new propulsion technique which allows the use of atmospheric oxygen to reduce the onboard propellant mass and permits the use of wings to optimise the initial flight trajectory after takeoff from a standard runway.

This combination makes the long sought after, single-stage-to-orbit launcher a practical proposition. The propulsive and aerodynamic characteristics result in a vehicle that is fully recoverable and totally and quickly reusable with minimum refurbishment, preparation and expense.

Hotol's hybrid engine would use atmospheric oxygen and onboard liquid hydrogen to accelerate the vehicle to high speed in the lower, denser layers of the atmosphere and then transfer at a suitable altitude and speed to pure rocket propulsion using the liquid hydrogen and onboard liquid oxygen.

The vehicle emerging from the design boards is basically part aircraft and part spacecraft with a brand new propulsion system. It is roughly the same size as Concorde and the two also have in common the same take-off mass and payload.

Most of the forward fuselage of Hotol is occupied by a large pressurised liquid hydrogen fuel tank while at the rear is a liquid oxygen tank for flight outside the atmosphere where air breathing is not possible.

The payload bay – of Shuttle diameter – is between the two tanks and the overall layout ensures minimum movement of the centre of gravity during flight.

Engines would be conventionally mounted at the rear and protection for re-entry heating would be concentrated largely underneath the fuselage and wing. Thermal protection would be by carbon carbon material on areas of high temperature and a titanium/Rene 41 nickel sandwich on low temperature areas. The skin panels (measuring one foot by three feet) would not require periodic replacement as do the Space Shuttle tiles.

Take off mass would be some five times the landing value, as opposed to about twice on a conventional aircraft, giving rise to a great disparity between takeoff and landing undercarriage requirements. Therefore, Hotol would be launched from a laser-guided trolley with a lightweight undercarriage provided for landing. This arrangement would meet one of the criteria of ensuring as little deadweight as possible being carried into orbit.

A take-off speed of 290 knots would be achieved with an acceleration of 0.56g and a run of 2300 m. Vertical acceleration at lift-off would be 1.15g with a climb altitude of about 24 degreees.

Hotol would go supersonic after two minutes, clearing commercial air lanes (12,000 m) after 4.5 minutes and reaching a speed of Mach 5 after just nine minutes. The fuel burned up at this point would be about 18 per cent of take off mass, compared to a typical value of 50 per cent for a vertical takeoff vehicle.

At the nine minute point external air-breathing would no longer be possible and a ballistic trajectory on main engine would begin. Orbital velocity would be achieved at 90 km, the main engine would then cut off and Hotol coast to an operating altitude of around 300 km.

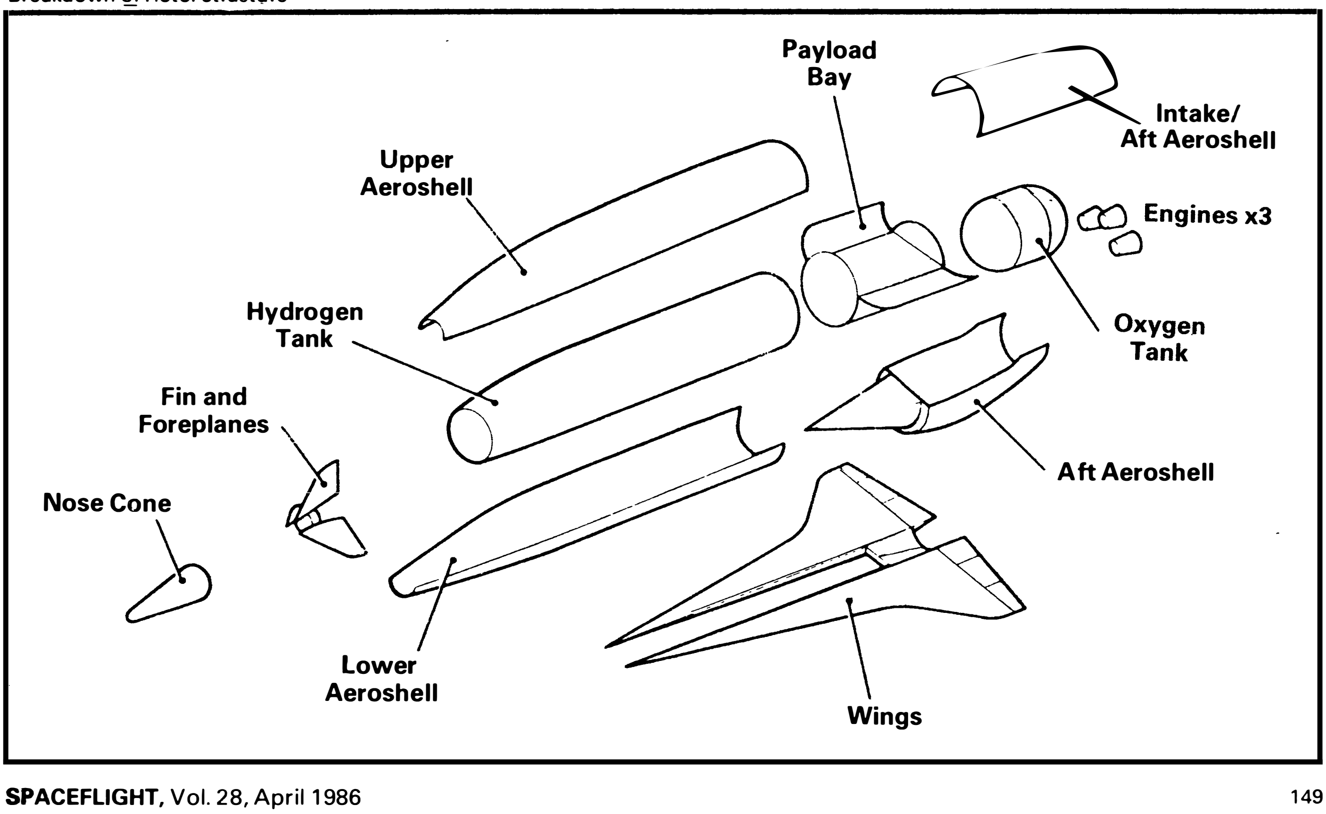
Maximum mission duration would be 50 hours with position and altitude changes achieved by an orbital manoeuvring system.

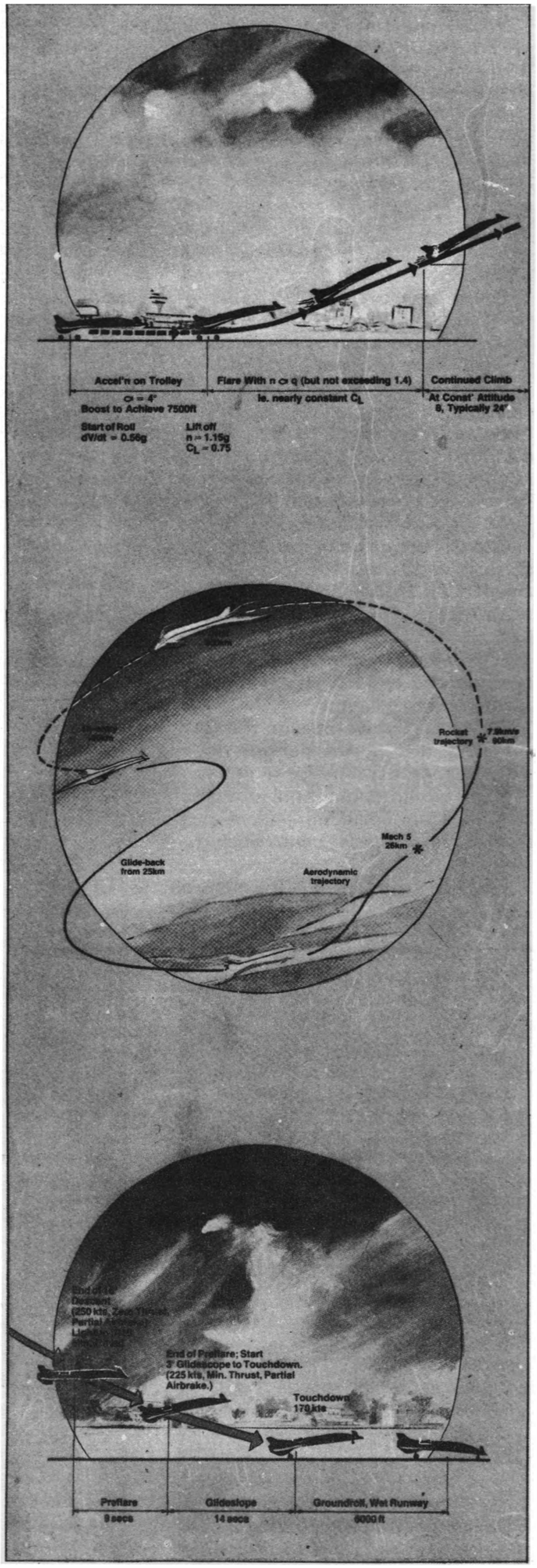
At the end of its mission the OMS would slow the vehicle and bring the perigee down to about 70 km altitude in preparation for re-entry.

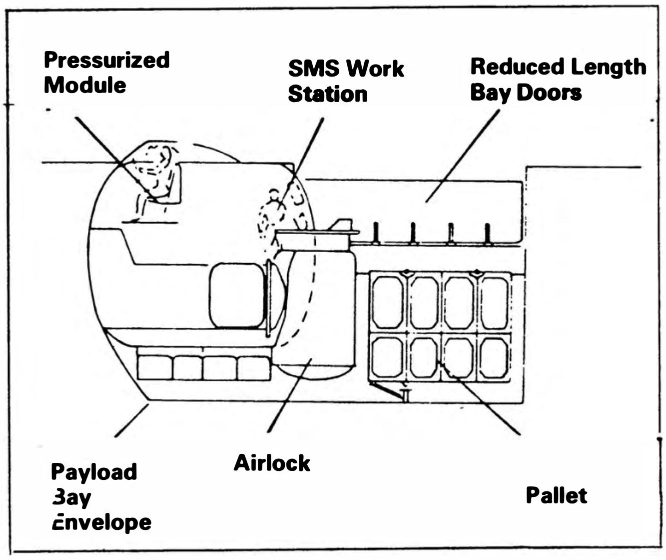
Hotol would re-enter the atmosphere at a very high incidence (about 80 degrees), reducing as speed falls – a hypersonic glide commencing at about 25 km altitude.

Because of its large wing area and low mass the

Breakdown of Hotol structure







vehicle would behave much less like a projectile than the Shuttle. Re-entry temperatures would therefore be lower and a high-temperature metal alloy skin would suffice for protection of the under surface, all meaning simpler construction and maintenance.

The high hypersonic lift-to-drag ratio of Hotol during re-entry (more than twice that of the Shuttle) gives a high cross range capability, sufficient for a landing in Europe from an equitorial orbit.

Final approach and landing techniques would be similar to the Shuttle but gentler: approach angle 16 degrees, touchdown speed 170 knots and the roll on a wet runway 1800 m.

For simplicity and economy the first operational Hotol will be remotely piloted by means of artificial intelligence and robotics systems. However, from the very outset provision will be made for manned operation.

The strategy on manned operations is only to include men when they are needed for orbital or Space Station operations. A manned module would be situated in the cargo bay and those onboard would play no role in launch and landing activities.

Manned missions would only take place after the unmanned version of Hotrol was fully proved and it is likely that one vehicle from a fleet of about six would be dedicated solely for manned missions.

Designers confidently predict that Hotol will reduce costs to low Earth orbit by a factor of five and, even with current perigee stages, will halve the cost of putting a satellite into geosynchronous orbit.

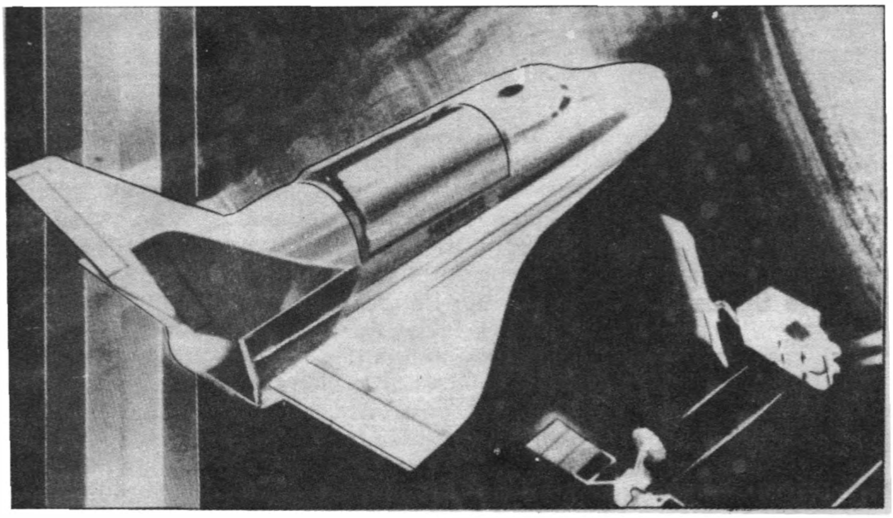
Such economy of operation, coupled with quick reaction and a rapid turnaround time (less than seven days) would enable Hotol to compete realistically for about 75 per cent of the commercial launch market from the year 2000 onwards.

In addition Hotol technology is forward looking with ample potential for development beyond the cheap and effective spacecraft launcher which it is presently planned to be.

Indeed, a one hour passenger flight from Europe to Australia is a distinct possibility around the year 2010 and it takes little imagination to identify other important uses for such a remarkable flying machine. A second generation Hotol could also have the potential for world-wide sales. Development costs for Hotol are currently estimated at £4,000 million.

HOTOL VERSUS HERMES

Britain and France could be shaping up for a head on clash within the European Space Agency (ESA) in trying to win formal approval of their respective Hotol and Hermes programmes.



Towards the end of 1985 the French Space Agency, CNES appointed Aerospatiale and Dassault-Breguet as prime contractors for development of its manned mini-shuttle project, Hermes.

The craft, to be launched atop the as yet to be developed Ariane 5 heavy lift launch vehicle, would essentially be used as a service vehicle for space stations, transporting crew and cargo.

Typical missions might include the assembly of space structures and scientific and applications experiments, as well as in-orbit repairs, maintenance and refurbishment of satellites.

Development of Ariane 5, an expendable booster, was approved during ESA's Ministerial Council meeting in January 1985 and the current design is based around a configuration known as Ariane 5P which has a central body with an HM60 large crygenic engine with two side-mounted strap-on solid boosters.

France is keen for Hermes to be adopted as an ESA programme and a project briefing was given by CNES to member states before the January 1985 ministerial meeting.

Reaction was lukewarm and the project was merely "noted with interest" (together with Britain's Hotol plans) in resolutions passed by the ESA members as a last minute compromise. CNES has stated that it will look for bi-lateral agreements with other European nations as an alternative route. Belgium, Sweden and Italy have already shown interest.

The proposed mini-shuttle is 15.5 m long with a delta wing and small vertical stabilisers at the wing tips. The wingspan is 11 m. A large vertical stabiliser would be located behind the payload bay, which has a volume of 35 cubic metres, above the orbital manoeuvring engines.

Propulsion into orbit after Hermes separates from its launcher will be provided by two 20 kN engines mounted in the rear fuselage. Dissipation of excess heat from the systems onboard, crew and variable solar heating once in orbit would be provided by radiators on the inner side of the payload bay doors, similar to the system used by the American Space Shuttle.

In contrast to the development of Hermes, the United Kingdom is actively pursuing an alternative and altogether more innovative path to the future.

The joint British Aerospace/Rolls Royce Hotol project is for an advanced horizontal takeoff and landing spaceplane which would be completely reusable and capable of operating in manned or unmanned modes.

Hotol relies on revolutionary new propulsion technology being developed secretly in Britain and so far unmatched by the rest of the world.

The choice facing ESA between Hermes and Hotol is not easy: Hermes is based on existing technology, Hotol is at the cutting edge; and if Europe chooses Hermes will it loose out when the United States develops its own transatmospheric spaceplane as a replacement for the Space Shuttle? It is doubtful whether both Hermes and Hotol would be financed simultaneously by ESA member countries.

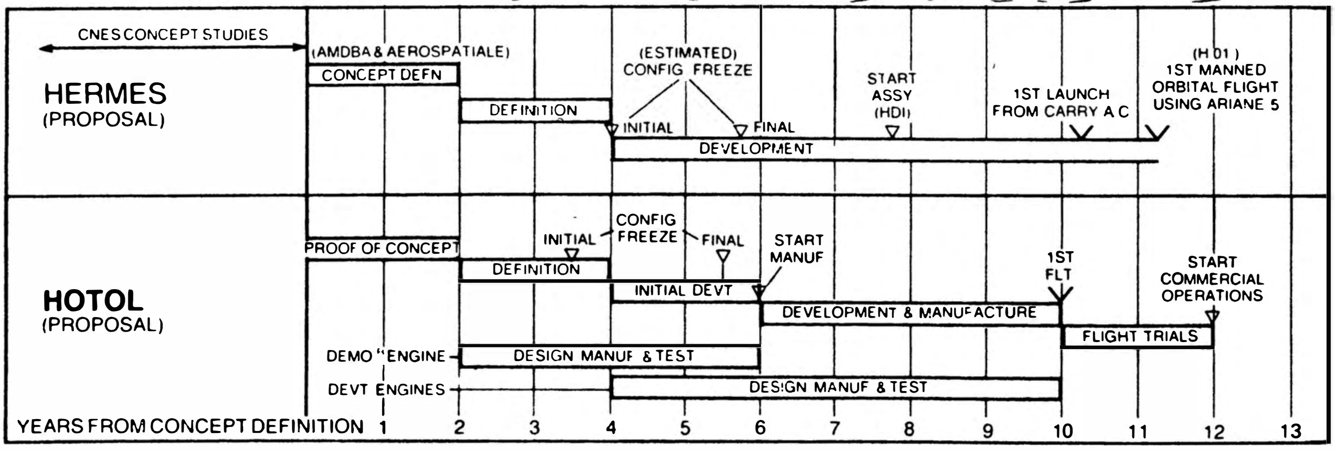
Peter Conchie, business development manager for British Aerospace Space and Communications Division, describes it as "a very difficult situation".

"We don't have any solution to the problem of how we get the Hotol programme endorsed by ESA. It is only a matter of time before the US catches up – all we can do is give Europe a little grace.

"Traditionally France spends most money within Europe on launch vehicles. It is not easy to see how they can embrace Hotol," he says.

The estimated cost of development for Hermes through to the initial two test flights is £1,050 million, More than £9 million has been provided for Hermes studies in the period 1985/6 with a further £15 million allocated for 1987. This compares with the £3 million recently announced for proof-of-concept studies lasting into the second half of 1987 for the Hotol spaceplane.

Comparison of development programmes for Hotol and Hermes.



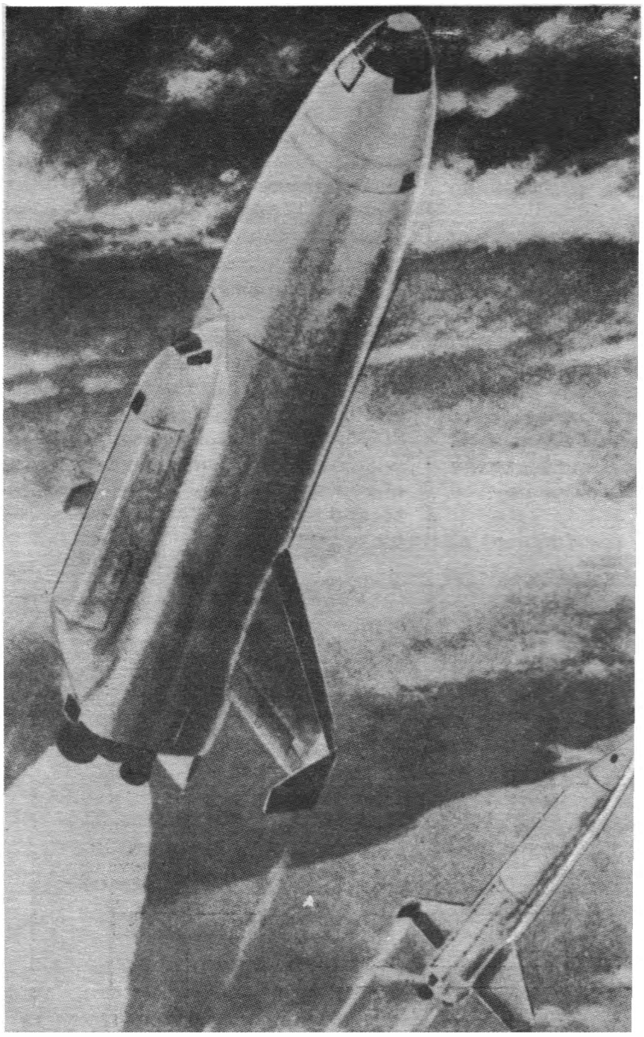
US Pumps Cash Into Spaceplane Development

by Stephen Byford

As British engineers begin work on the next phase of the design of Hotol (see previous pages), their American colleagues will also be engaged in the initial planning of a one-stage horizontal-take-off spaceplane capable of accelerating directly into orbit. It is hoped that this project will evolve into a possible successor to the Space Shuttle.

In the aftermath of the tragic Space Shuttle accident, President Reagan has stressed his continuing support for the American manned space programme, including the Shuttle and the proposed permanently occupied Space Station. In addition to these existing commitments, he has announced the development of a transatmospheric vehicle which, after taking off from Washington like an ordinary aircraft, could "accelerate up to 25 times the speed of sound, attain low Earth orbit or fly to Tokyo within two hours". Reagan calls this new craft the "Orient Express" of the next century.

A vertical takeoff two-stage concept for a spaceplane developed at NASA Langley in 1984. The orbiter would use both hydrocarbon and hydrogen engines, and the crew and payload would be located above the propellant tank.



The President has thus emphasised the civilian applications of the proposed spaceplane. The Orient Express could be described, however, as a spin-off from a project born of military motives. A joint programme for the design of an experimental aero-spaceplane is already planned, Defence Advanced Projects Research Agency (DAPRA), Strategic Defense Initiative Organisation (SDIO) and NASA. Only a fifth of the funding for the project will come from NASA – the rest will be supplied by the Defence Department. Separate hypersonic research efforts within these two organisations have already been brought together.

A major pressure for the development of a single-stage launcher comes from President Reagan's Strategic Defense Initiative (SDI). Such a system for defence against ballistic missiles would probably require a decrease by a factor of almost ten in the cost of putting a given payload into orbit before it could become economically viable. This can only be achieved by the development of a second-generation Space Shuttle.

The US administration also feels the need to match what it sees as the more responsive launch capability now posessed by the Soviet Union. They point out that the Soviet space effort is much more closely tied to military operations than is the case in the USA, and that the Soviets have a greater capability to produce boosters and rocket engines than all of the western allies put together. They are also currently developing a number of new launch vehicles.

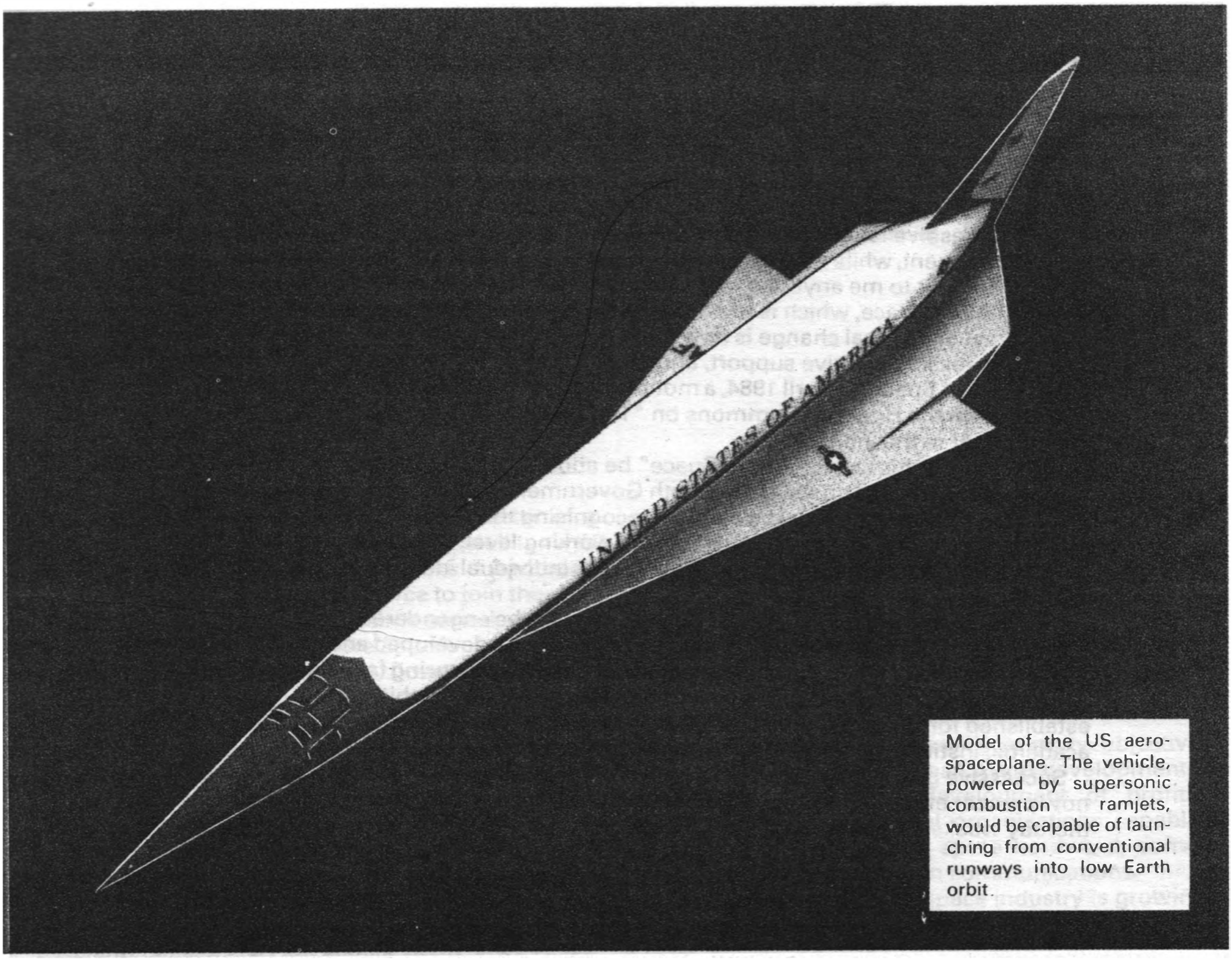
It is therefore feared that, during an international crisis, a combination of expendable launchers and the existing Space Shuttle would be unable to replenish military space systems quickly enough. This task could become vital, with intelligence gathering, early warning and global communication now becoming increasingly dependent on satellites.

The overall technological direction of the programme is the responsibilty of a joint office at the USAF Aero Propulsion Laboratory, Wright-Patterson Air Force Base, Ohio.

Despite the mainly military purpose of this project, however, commercial and scientific users will, no doubt, also benefit in the long term from the greater launch flexibility and lower costs involved in using the new craft.

Although the programme involves substantial risks, it is widely believed within the aerospace community that it may now be technically feasible. Several developments have contributed to this belief, including breakthroughs in propulsion research, advanced materials, cooling techniques, solid oxide fuel cells, giving greatly improved thrust-to-weight ratios, and the design and simulation facilities provided by the latest large computers.

The propulsion question will prove to be central if the new vehicle is indeed to be capable of taking off horizontally, from a runway, without the need for the



Model of the US aerospaceplane. The vehicle, powered by supersonic combustion ramjets, would be capable of launching from conventional runways into low Earth orbit.

large support crews currently required for Shuttle launches. The current concept is a hydrogen-powered aircraft that would, for much of its ascent, consume atmospheric oxygen instead of carrying large tankfuls of liquid oxygen. It would fly at speeds of Mach 12-25. Work at the USAF Aero Propulsion Laboratory suggests that such a vehicle could be operational by the end of the century.

During its air-breathing phase, the craft would most probably be propelled by supersonic combustion ramjets (scramjets). These are essentially modified remjets, which rely on the aircraft's motion to compress the gases, since they lack turbines. However, scramjets will only operate efficiently at hypersonic speeds (above Mach 5). Consequently the Americans are alleged to be interested in the secret of Hotol's engines which, according to Rolls Royce, also work well at lower speeds.

The latest ideas for a US spaceplane have evolved from the initial exploratory efforts of NASA and DARPA in the period from 1982 to 1985. This year sees the beginning of the next phase of the programme, which will consist of the additional technological development required for an experimental flight vehicle, and the construction and testing of engine modules up to the current maximum wind tunnel speed of Mach 8. This phase will be directed by DARPA.

The aerospaceplane programme was allocated $30 million in last year's budget; this will now rise to $500 million over the next three fiscal years. The implications of the idea will be studied in the context of global flight, civil transport and as a long-range air defence interceptor. This constitutes the most extensive American air/space research programme since the North American Rockwell X-15 project of the late 1950s.

THE WIND OF CHANGE

For many years, the BIS voiced the message that 'Money spent on Space is spent here on Earth . . . on new know-how, new training and new high-tech industries', but it almost always fell upon deaf ears.

Political resolve for a broad-based and long-term commitment to Space has long been noticeably absent, while other countries forged ahead. From MP's on both sides of the House one heard 'Don't put to me anything that I cannot offer to the electorate', or 'My postbag is full of everything but Space, which is of no interest whatsoever to the public'.

The wind of political change is now blowing, even in Britain. MP's *do* receive letters about Space, expressing positive support, and there are MP's who realise and advocate the national importance of Space. In April 1984, a motion, proposed by six MP's and sponsored by 51 others, was tabled in the House of Commons on "The Space Industry", calling for greater Government commitment to the industry.

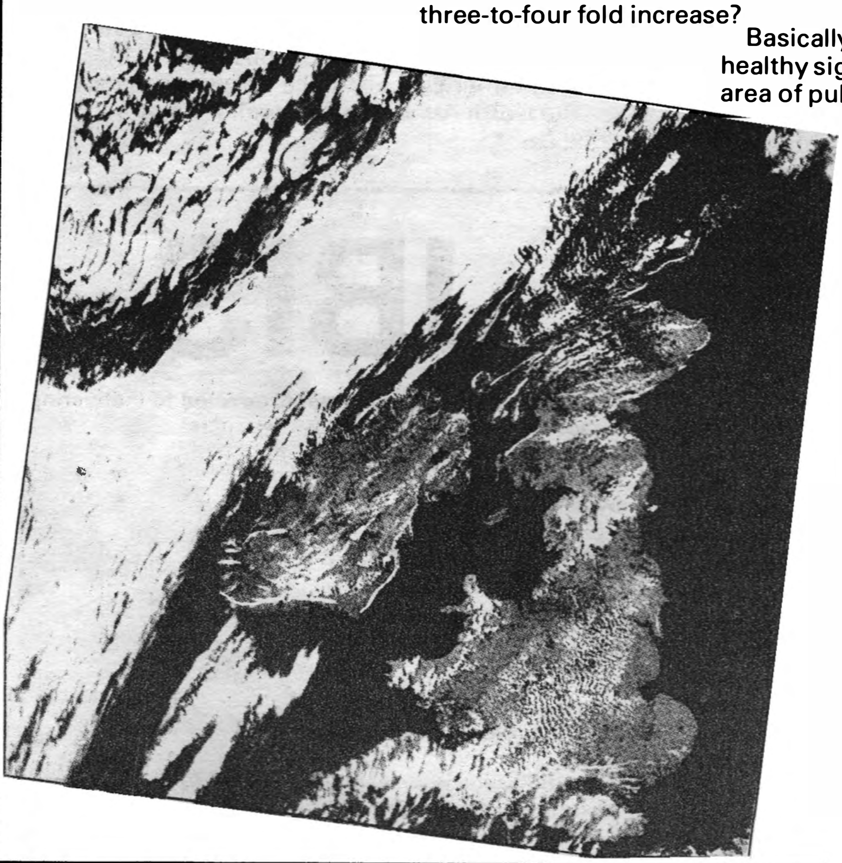
What should this call for "more Space" be about? First, more resources and a better use of resources are needed on the part of both Government and Industry. Also a routine and progressive attitude to Space is needed, recognising that Space provides many spin-offs by raising levels of interest and competence at working level, by opening up new areas of employment and by bringing financial returns to individual industrial companies and the nation as a whole.

The vision needed is a broad one. Interest needs to be engendered at school level and carried on into universities where innovative capabilities can be developed and new know-how created. Training programmes together with technical and manufacturing facilities need to be supported in a co-ordinated and sensible way to meet Space-orientated objectives. UK Centres need to be established for the commercial development of space which are closely associated with academic institutions actively researching in the same specialist fields.

Successive governments have failed to realise the country's true Space potential and even now present effort and expenditure are well below the nation's potential level of achievement thereby weakening its position internationally.

The Space Station programme is here to stay and needs to be exploited to the full in all its aspects, including an astronaut programme of selection and training to be initiated at an early date. The UK has been dragging its heels instead of moving boldly forward in many important areas.

Can the situation be remedied? Can we expect the UK Space Budget to equate to that of Germany or France within, say, the next five years with a three-to-four fold increase?



Basically, a change is already taking place. A healthy sign is that the change is underway in the area of public opinion.

Space is now commanding public interest and approval. The news media sense this and are treating the topic more respectfully, thus providing the informed and balanced presentation which the public need. Space in the UK is finding acceptance with the electorate. The Government has sensed the new situation and has established the British National Space Centre to co-ordinate the country's hitherto fragmented Space effort. The follow-on period is now all-important. Expenditure will need to be restructured and in certain directions substantially increased.

This special UK section highlights the present position of the UK in space. We gratefully acknowledge the assistance of Mr Geoffrey Pattie, Minister of State for Industry and Information Technology, Mr Roy Gibson, Director-General of the BNSC, and Mr Tom Mayer, Chairman of the UKISC, as contributors.

Space – Today's Challenge and Opportunity

by Geoffrey Pattie, MP

MP Geoffrey Pattie, UK Minister of State for Industry and Information Technology, Department of Trade and Industry, London, puts forward a British view on past, present and future developments in space.*

Geoffrey Pattie, UK Minister of State for Industry and Information Technology.

The space age is only a little over a quarter of a century old. When the first Sputnik satellite was launched, few then realised that mankind had been given the key to a whole new resource to join those of the land, sea and air. In this short time period, we have landed men on the Moon, explored portions of the two nearest planets (Mars and Venus), flown near Jupiter, Saturn and now Uranus, provided revolutionary new means of communication, built great new industries, brought remote sensing from space to the threshold of operational use and begun to plan how to achieve a permanent manned base in space. Most importantly, we have come to rely on space in a significant way because of its unique vantage point and special properties.

Britain's Space Heritage

British scientists and engineers were among the first to realise the potential of space and Britain's space industry was established in the early 1960's with the Ariel series of scientific satellites. Our first home-built satellite was Ariel III which, following its launch on an American Scout rocket, established our scientists among the leaders in the field of x-ray astronomy, a position they still hold today.

Our Defence Ministry was also quick to appreciate the potential of satellites for communication, setting up its first such links in 1966 – it was after all an Englishman, Arthur C. Clarke, who first pointed out the potential of the geosynchronous orbit to provide worldwide high quality communications – and we put the world's first military geosynchronous satellite, Skynet I, into service in 1969 and subsequently its British-built successor, Skynet II, which is today still providing useful capacity.

Thus we now find ourselves in Britain very creditable users of space systems – indeed perhaps the biggest user of space systems outside of North America in the OECD countries and therefore probably third in the world with a strong and active involvement in military, scientific, operational and commercial sectors.

In the civil field, we played a leading part in setting up the necessary international organisational structures and we are founder members of Intelsat and its European regional equivalent Eutelsat, of Inmarsat and Eumetsat and above all the European Space Agency.

**Adapted from an address at the Western European Union, Colloquay, Munich, September 1985.*

In Britain the Government's primary objective in supporting civil space research and development has been to promote the development of profitable industrial and commercial organisations capable of producing and exploiting space hardware, software and services, particularly in communications.

Employment in British space industry is growing at more than 10 per cent a year and the current order book is twice the size of annual turnover. This is quite a success story and Government has been undoubtedly achieving its main goal. Continuity of policy has been an important factor in this providing a stable climate for growth but the responsibility, and congratulations for its growth lie, quite rightly, with the industry itself.

The space business is a risky business and just as it has been impossible for the space industry to bear the burden of investment by itself, so it has been important for Britain to co-operate with the governments and industries of other countries in major space projects. The United States and Soviet Union have had the economic strength, political will and defence requirements to develop a fully comprehensive space capability. There is now a recognised third force in space – Europe. By collaborating through the European Space Agency, the 13 member states and one associate have between them developed a comprehensive capability. It is through ESA that the main British effort has been directed over the last ten years and now we can see that it has been remarkably successful with its scientific, meteorological, launcher and applications programmes.

It is ESA which has established Europe as a powerful force in space and made its industry second only to the US in the market place. A major virtue of ESA is that it is structured so that new space programmes can be started with a minimum of formality and with different mixes of contributions from the member states. The elements of each programme can be selected from the countries best able to produce them successfully and economically, whilst still having formal mechanisms

to ensure that each member state gets a fair share of interesting work in return for its financial contribution.

Our experience in space so far in Europe has shown that:

- Europe acting together in high technology can be a major force on a par with the super powers;
- Organisations need to be flexible, able to adapt to changing circumstances and manifestly fair for each of the partners;
- Genuine co-operation draws on the strengths of the participants. Thus so far in ESA, Britain has concentrated on telecommunications satellites, France on launchers and Germany on manned space facilities, all with notable success. These aspects will be brought together even more closely in the Columbus Space Station Programme.
- It can pay to be bold in creating new institutions –with ESA, Arianespace, Inmarsat and Eutelsat all excellent examples.

British Organisation for Space

A recurrent concern for Governments, because of the high costs of space research and development, is when, where and for how long should it be involved in funding space efforts? And what is the proper balance between public and private funding for space research and development? Even more directly – what incentives are needed to encourage the private sector to assume a larger role in developing and exploiting space technology?

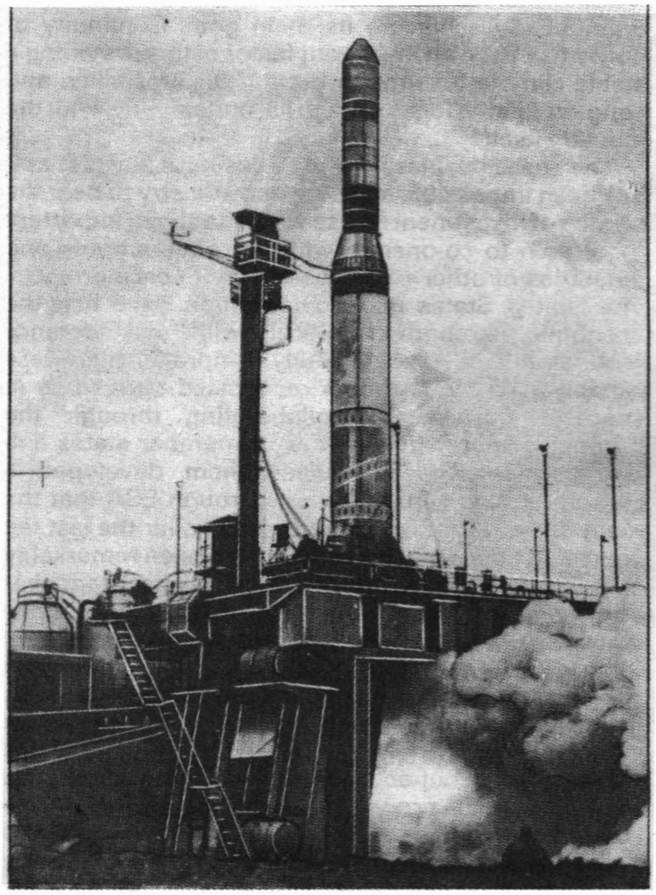
In Britain the Government took the decision early in 1985 that there was a need to build on present arrangements for co-ordinating what Government did in space by establishing a British National Space Centre to improve the development of space technology in the United Kingdom and to co-ordinate policy more effectively.

In Britain, as elsewhere, a growing range of users of space services is spread across Government, academic institutions and all types of industry. As they have become more aware of the benefits offered to them by space, it has become more important to establish a single focus to which they can turn for advice and technical support. We hope they will seek to influence the programmes of the Centre by making their own financial and in-kind contributions. Our aim is to improve the use of public resources and I believe that one of the most effective ways in which we can be sure of achieving this is to invite industry to play a major role within the new Centre.

The establishment of a National Space Centre does not signal a new direction in our space policy in Britain. Rather it emphasises the Government's commitment to the development of space technology for industrial, scientific and defence purposes. Our aim is to ensure the best use of available technology and that national resources are not wasted through unnecessary duplication of effort. Uniquely, we will be seeking to run some civil and defence space efforts together. One gain that we look for from this is the easier transfer of the results of publicly funded research into the civilian economy. Our new agency will therefore be orientated towards serving a variety of national needs including some of those in defence and we see it providing a single focus for space research and development in support of Government and the private sector.

Gains we look for include better budgetary and programmatic co-ordination of national space research and development effort, and a better balance between technology "push" and user "pull". More positively we hope that the new Centre will permit the total space budget to be adjusted more readily to changing policy priorities and that it will facilitate the development of joint programmes in areas such as space infrastructure of interest to the entire space community in Britain. ESA will remain the cornerstone of our civil space activities.

The successful Blue Streak booster used here as the first stage of Europa after the British-built ballistic missile was cancelled as a military project.



The Pace of Progress

Turning from means of implementation to applications, we find today that Intelsat, now 20 years old, has over 100,000 satellite voice circuits installed, working into 650 Earth stations in 165 countries. At the time of Los Angeles Olympics, live TV was brought to over one billion viewers in 68 countries – something that only satellites could do but which we now take for granted.

Against this background it is hard to believe that there has been, and remains, a perennial problem of bringing about the new services that satellites can offer. A classic case of this pre-dates space, and goes back to the early day of aviation when the Australian Post Office is said to have dismissed as uncompetitive the communication possibilities of aircraft in favour of

camels!

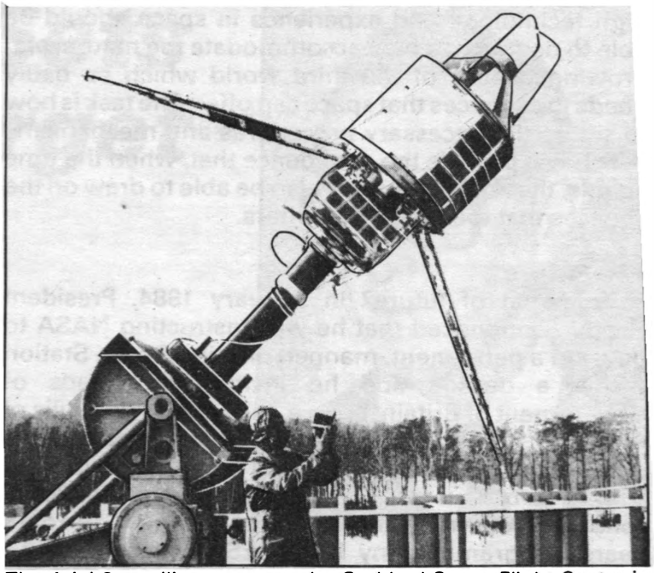
All too often we find prospective customers saying that they have grown and prospered without the new capabilities and the services that space has to offer. Examples abound of telecommunication authorities who, in the 1960's and indeed into the 70's, insisted that their existing technology of microwave links, undersea cables and so forth could adequately meet their needs, and who were all too ready to reject as insupportable the prospective costs of satellite services. And yet, this was in a field which had an organised user community and technology was being offered which was merely going to be a substitute for other technology. It is not surprising that we find yet more difficulty with other fields of space, such as remote sensing, where no one single user has a dominant role or need.

The problem of course is the classic error of failing to foresee how advances of technology can outmode habitual ground rules and ways of thinking and so alter the way in which routine everyday tasks are accomplished. We have to be alive to continuing advances in technological capability out-dating principles that had previously been thought to be fundamental. Whereas in the early days it seemed self-evident that the role of satellites was that of inter-continental communications, linking national telephone systems and using large dishes – like additional cable services in outer space rather than in the deep space of the oceans – we now see increasing use of the widespread coverage afforded by satellites to bring international television programmes via small individually-owned dishes straight to hotels and blocks of flats.

Satellites can also now provide a vital contribution to industrial infrastructure, with computer talking directly to computer via satellites in a deluge of digital bits as it organises the day-to-day working of an industrial conglomerate.

Up to now the world's satellite communications have been provided by legislated or de facto monopoly organisations, and complete liberalisation would be both highly contentious and, in my opinion, ill-advised. However, it seems likely that we will have to look carefully through the 1980's and 90's at the institutional arrangements of Intelsat and other bodies that we have established to organise services and share the cost of space facilities. These bodies have been extraordinarily valuable in developing effective and reliable satellite services, and the oldest of them, Intelsat, has shown the importance of a dynamic approach to its mandate and to the changing environment of telecommunications. But with satellite communications moving more and more from the macro to the micro level, we must make sure that reasonable opportunities are provided for the entrepreneurs in our society, without at the same time jeopardising the good facilities that we currently have.

Satellites are also, of course, causing some deep thought on the question of broadcasting policy. Previously, terrestrial technology has ensured that live television transmissions were effectively confined to national borders. But from a vantage point 36,000 km above the Earth's surface, satellites recognise no frontiers and, working into small dishes situated in the back gradens or on the roofs of dwelling houses, are now bringing other cultures into the homes of millions in the shape of foreign TV programmes. The implications of this technological trend are far-reaching and need to be considered with great care.



The Ariel 3 satellite on test at the Goddard Space Flight Center in America.

Today, we find that Britain is the largest user of satellite capacity in Europe, with half a dozen UK-originated television channels being beamed into cable heads and hotels throughout Europe. In social terms, this represents a revolution of considerable political significance which, I am glad to say, has so far proceeded relatively painlessly. But the potential for objections to "cultural invasion" and possible pressure for encryption in order to control reception is self-evident. The conflict is one of freedom of speech and political unification as opposed to a natural desire on the part of all countries to preserve their cultural identity, and with its multiplicity of nations, each with its own distinct language and traditions, this is particularly relevant to Europe.

A further issue which we can be sure will not go away is the question of how to ensure that all countries gain free and equitable access to the natural but limited resources of the geostationary orbit and the radio frequency spectrum. This is a problem which relates not so much to satellite broadcasting as to satellite telecommunications. It is a matter of entirely understandable concern to many countries for whom a national telecommunications satellite is an ambition for the future that, by the time they are ready, the advanced countries may have occupied too much of the orbit and of the most desirable spectrum. To that end, many developing countries have set their sights on a rather rigid form of planning which would set aside a "slot" for each country. The difficulty is the waste involved in reserving parts of a valuable resource, unused, against a need which may be several-lifetimes distant in many cases.

The other side of the coin is represented by present users who have already built a growing business from operating satellites and who, looking for a reasonable degree of security of tenure, view with reluctance the idea that they may at some future date be asked to move aside to make room for a newcomer.

This is an area where the developed world with its

high technology and experience in space should be able to do much to help accommodate the natural and growing conern of the third world which so badly needs the services that space can offer. The task is how to set up the necessary procedures and mechanisms which will provide the confidence that, when the time comes, these countries will also be able to draw on the services that the Space Age offers.

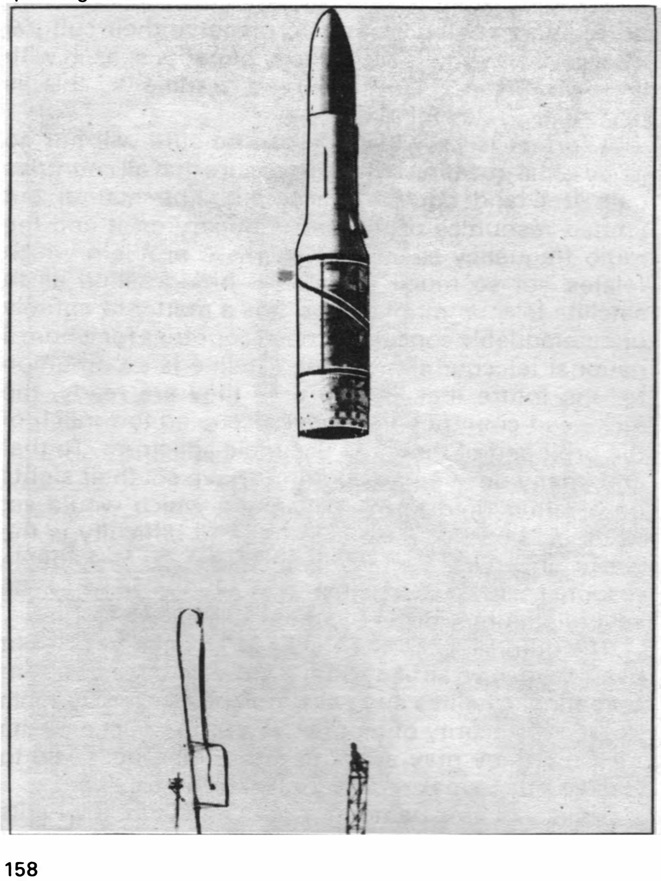
The Future

But what of future? In January 1984, President Reagan announced that he was instructing NASA to develop a permanent, manned orbiting Space Station within a decade and he invited the Heads of Government of Britain, France, the Federal Republic of Germany, Italy, Japan and Canada to participate in this project. Costs were expected to be in the region of $10bn. Subsequently at a special meeting in Rome called to determine the shape of our next 10 to 15 years' programme, my fellow ESA Ministers and I decided in principle to participate in this great co-operative endeavour, subject of course to satisfactory arrangements on costs, involvement and access being agreed.

The Space Station is a logical extension of the lessons and experiences of the last 25 years. The move towards more wide-spread and personalised services, the need for even greater reliability and the finite capacity of the orbital resource, all point to the need for larger, more closely-integrated space systems such as can only be achieved by man's intervention in orbit, and the Space Station is to be the first step on the road towards this objective.

But it is not only what the Space Station will technically enable that will be important. Equally important will be the effect that the Space Station will have in capturing the imagination of the young and encouraging them into the pursuit of high technology careers upon which the continued growth of the world as a whole depends. Success in this area too will be an important manifestation of the bonds between the Western democracies. But co-operation implies genuine partnership, and my fellow Ministers and I in Europe will be looking for an opportunity to play a meaningful and worthwhile role which is clear-cut and free-standing. For we are acutely aware that, although technically successful, Spacelab, our contribution to the Space Shuttle programme, has fallen somewhat short of real operational success, with operating costs and access arrangements making it relatively unattractive to the customers for whom it was intended. We do not want to make this kind of mistake again.

A British Black Arrow rocket being launched from Woomera in South Australia in October 1971 with the X-3 (Prospero) technology-proving satellite.



We now have a period of intensive work before us with the Space Station project in the definition stage which will detemine mission, design and cost details. In parallel with this, we shall be holding detailed Governmental discussions to clarify the important questions of technology transfer and terms of access which will be crucial to our joining the building and operational phases. All being well, I hope that we will be able to cement Western solidarity with a mutually-beneficial co-operative programme having an impact extending well into the 21st century and that we will be able to move forward together in 1987 with full development.

Conclusion

I urged at the Rome Ministerial meeting at the beginning of 1985 the importance of balance in what we did in setting goals for Europe's future space programme. By "balance" I mean particularly balance between activities such as the development of launchers, manned space vehicles and Space Station activities which are the means of conducting space research and the achieving of more effective and attractive space services – the ends. We will not achieve the real fruits of space development unless we can continue to mount lively, relevant and well-timed utilisation programmes – in space science, in tele-communications in its different aspects, in Earth observation, in the potential new application areas of materials processing and so forth.

This should not be taken as a negative comment on Columbus/Space Station planning nor on Ariane 5 or Hermes or Hotol – but we do have to get our strategy for achievement and our timing correctly pitched if future ESA activities are to have the right span, if we are to make our goal of progressive European autonomy in space meaningful, and if the costs are to remain within affordable bounds in amount and in timing. And a central concern here is obviously the high cost and vulnerability to over-runs of manned space flight activities.

What started a quarter of a century ago as a muscle-flexing technological contest between the super powers has now blossomed into a major force for the advancement of mankind. Let us hope that we will be equal to the challenge it presents so as to maximise the opportunities for mankind that are undoubtedly there.

Space Centre Sets June Policy Target

by Roy Gibson

Roy Gibson

Newly appointed Director-General of Britain's National Space Centre, Roy Gibson, is now involved in drawing together the country's space interests and defining a long term plan for development and participation in national and international space projects. Below, Mr. Gibson writes for *Spaceflight* on the task ahead.

Why Organise Space?

At a press conference in London on November 20, the Minister of Information and Technology, Geoffrey Pattie, announced the formation of the BNSC and my appointment as its first Director-General. Readers of this journal will scarcely need reminding that this marked the end of a long campaign amongst space enthusiasts to have a focal point for the country's space activities. It had been traditionally held in the UK that space did not merit a separate organisation – government departments being free to use space as a tool, an instrument or a vehicle for its own activities, with coordination assured by a committee of representatives of the various departments.

So it has been for the past 20 years, and it has not worked so badly. The UK has many important space achievements to its credit and these should not be forgotten or belittled in the excitement that many of us feel in now having a national space organisation.

Why, then, is a space organisation needed at all? Many arguments have been brought forward over the years and I am not sure that all of them merit consideration. Avoiding duplication, for example, is often cited as one of the advantages. The new organisation will certainly enable a certain amount of rationalisation of resources and will help to facilitate communication between the various groups engaged in space activities in different parts of the country, but if any savings are to be found from this process, they are certainly offset by the cost of creating the central organisation – however slim we decide to keep it.

No, for me the overwhelming arguments in favour of having a national space organisation are to be found in the infinitely greater need there now is for a central national point in order to develop and to carry out a coordinated national space programme.

That is not to say that the space organisation need necessarily be responsible for every single space activity in the whole country, but it should certainly be aware of it and should have a word to say about any government funding it may require – and that in the light of an overall national plan.

In the same line of thinking, the space centre is needed to allow industry's needs and industry's contributions to be fed into the national plan in a timely way. Perhaps, for these reasons, it would have paid off to have had such an organisation some years ago, but the need is very much greater now because of the inter-dependence of space programmes.

We are no longer in the era where it was possible to decide on satellite programmes one by one, and with little thought of their relationship one to another except for the total bill. Nowadays, particularly with the advent of the Space Station, we need to have an agreed overall framework for our space activities. We cannot possibly do half the things that many people would like to see included, but those which we think we can afford must together make sense.

Moreover, there must be enough money left in the national till for us to be able to use properly the facilities which we have created or helped to create through international cooperation.

And so this will be the first priority of the British National Space Centre: the production of a national space programme. Our target for this is the end of June – perhaps I should, for the cynics, add 1986.

Building Up the Organisation

Of course, the first task is to get organised. The BNSC has inherited contributions from a number of major participants, and these have to be put together in a sensible way. The principal initial contributors are the following:

Department of Trade and Industry, of which the Space Division headed by Mr. Clifford Nicholas is transferred to BNSC forthwith, as well as Mr. Jack Leeming, the Under Secretary who has done so much to bring about the formation of the BNSC. He is now the Director of Planning and Programmes. Joining him in his Directorate are not only his colleagues from DTI but also senior staff seconded from the other major contributors: SERC, NERC, and the Ministry of Defence.

SERC is also seconding a significant number of staff from the Rutherford and Appleton Laboratory.

NERC is seconding staff, principally in the remote sensing area, to serve with BNSC at RAE, Farnborough, and in London.

Ministry of Defence is seconding a major part of the Space Department at Farnborough.

This will mean that the BNSC has somewhat over 300 staff seconded from its founders, and these will be managed by the DG, the Director of Planning and

Programmes previously mentioned, plus a Director of Projects and Technology still to be appointed.

The London office is in Millbank Tower on the Thames at Westminster, and the other personnel will be located at RAE or at RAL – with the minimum movement of personnel consistent with an acceptable organisation.

Due to the nature of the parent organisations, not all of the personnel seconded from the laboratories can, at least in the first instance, be full-time, nominated persons. It is envisaged that some of the manpower will be provided in the form of man-years: it would be impracticable, indeed undesirable, for the BNSC to attempt to be wholly independent in all the specialities it will need. Far more important than the supposed prestige which might be attached to having a larger number of BNSC badge-bearing personnel, is the need to have a logical organisation with sensible long term arrangements with the host laboratories.

Looking Ahead

Another priority task of the BNSC management in the first few months of its life is to recommend what sort of a beast it should become. It exists at the moment thanks to the cooperation of a number of government departments and government funded organisations, but it will need to have its status more clearly defined over the coming months.

This is probably an appropriate moment at which to emphasise the excellent spirit of cooperation which I have found in the weeks since I took up this new post. At all levels I have found nothing but cooperation – much more than I could ever have expected. I realise that this is a sort of honeymoon period and that the BNSC must soon show what advantages it has brought, or will shortly bring, to its contributors, but the constructive atmosphere in which all this is taking place deserves to be known to a wider circle.

Some readers may have noticed that I have not so far made much mention of industry's role in the BNSC. This is not at all because of the BNSC does not need industry's help – quite the contrary, but it is only reasonable for industry to be able to see exactly what is planned and how programmes will be executed, before asking for their substantial financial and material support. In the short term, there is a real need for help from industry in the form of short secondments of specialist personnel to serve on the BNSC's planning group and to help put together a plan which industry will later feel able to support. I am confident that this help will be available from industry.

Many journalists, particularly those from the Continent, have asked whether the formation of the BNSC heralds a move away from the European Space Agency, and of course this is certainly not the case. Space programmes will continue to be extremely costly, and it makes good sense for us to be doing most of this work with our European partners.

Perhaps we are hoping to be a little more discerning in our choice of the morsels which come our way in these cooperative programmes; perhaps we need to have a higher profile in the European decision making, but these are ambitions for the future. In the mean time there is much to be done to identify what it is we want out of our space effort and expenditure, and this will be our number one priority as these lines are being read.

Thanks for Your Support

May I take this opportunity of thanking the British Interplanetary Society for its active support over the years for the concept of a British National Space Centre. Many members in all parts of the country have already written expressing their satisfaction. My colleagues and I can make no promises other than to assure you all that we are full of enthusiasm, and that the expressions of support we are receiving both from inside the country and from abroad make us sure that no-one will regret the November decision.

Space Bill Goes Before Parliament

Lord Lucas of Chilworth, Parliamentary Under-Secretary of State for Trade and Industry, has introduced a Bill to enable the United Kingdom to fulfill certain international obligations concerning private sector activities in outer space.

The obligations arise under three United Nations conventions to which the UK is a party: the 1967 Outer Space Treaty, the 1972 Convention on International Liability for Damage Caused by Space Objects and the 1976 Convention on Registration of Objects Launched into Outer Space.

These conventions oblige the Government to exercise a measure of supervision over private sector activities in outer space; to pay compensation if such activities cause damage to foreign states or persons; and to enter details of private sector satellites into a register of "space objects".

Describing the Bill, Lord Lucas said: "In the past, the launch of satellites and their operation was seen as the job of the public sector or of international organisations. This view is changing and today the prospect of a UK private sector satellite project no longer seems remote. We have therefore decided to introduce legislation to enable us to fulfill our international obligations in respect of private sector activities in outer space, when they occur.

"This legislation will allow the private sector to plan outer space projects with knowledge of how the legal framework will operate. It will apply to all commercial, scientific and experimental satellite projects unless they are carried on by an arm of Government.

"The Bill introduces the minimum of regulation necessary for us to meet our international obligations."

A non-statutory register of space objects has been kept since 1976 and the only non-Governmental space objects registered are satellites owned by the Science and Engineering Research Council (SERC) and by the University of Surrey. The continued operation of these satellites will eventually need to be licensed (although the Bill does contain transitional provisions). SERC is likely to be given one "open licence" covering all its science projects in outer space.

There are a growing number of private sector satellites in the United States but there is no imminent private sector satellite project in the UK.

Administration of licensing will be carried out by existing staff working in the British National Space Centre and costs incurred will be recovered from fees.

Mr. Tom Mayer, CBE, Chairman of the United Kingdom Space Committee (UKISC) since 1984. Mr. Mayer, who from April 1 becomes Chief Executive of THORNE EMI Technology, is a founder member of UKISC and has been closely involved in its work since 1975.

UKISC

The United Kingdom Industrial Space Committee (UKISC) represents the British Companies which have activities in the Space Sector. The committee is jointly formed from members of the Society of British Aerospace Companies and the Electronic Engineering Association to represent companies involved in a whole range of Space activities, from launcher guidance and satellite construction to ground stations for telemetry and communications. The companies are engaged in design and manufacture of both hardware and software for many different programmes. Within UKISC there are 14 participating members and three corresponding members.

Industry Invests in Space

by Tom Mayer, CBE

The major role of British companies in space-related programmes was highlighted in a presentation to UK diplomatic staff in London during February. The audience comprised Foreign and Commonwealth Office staff about to take up new duties at UK diplomatic posts overseas. A two week long series of specialist briefings updated them on the capabilities of all apsects of the British Aerospace Industry. We are pleased to present here a short summary of Tom Mayer's overview of the wide-ranging activities of British companies in space.

The British Space Industry

Following the cancellation of the British launcher programme 20 years ago, Industry has concentrated on the electronics and high technology aspects of the business and has particularly excelled in the construction of satellites and the ground station elements of a number of key programmes. Support of major ESA activities has been a critical element of the work carried out, and key contributions have also been made to NASA programmes and to a number of projects for countries in the Middle East. Industry is looking forward to increasing its export business to countries who have activities concerned with any aspect of Space, in communications, navigation, meteorology or Earth resources mapping.

The contribution that British Industry makes to ESA programmes is indeed the foundation of our Space business. Following the recent review of the British national contribution to the ESA budget, the Government is committed to an expanding programme of support for European programmes including the joint ESA/NASA activity on the Space Station. During the last 20 years British industry has contributed to the European programme in more than 30 projects. These include:

HEOS	Studies of interplanetary magnetic fields
ISEE	Research in the Earth's magnetosphere
GEOS	First ESA satellite for which UK industry took prime responsibility in 1977
METEOSAT	Weather satellite
OTS	Experimental satellite TV transmission
EXOSAT	Location of X-ray sources
SPACE TELESCOPE	For detecting very faint stars

And shortly to be launched are:

ISPM	For exploration of Solar Poles
HIPPARCOS	To measure star motion
ERS 1	Remote sensing of oceans and coastal areas

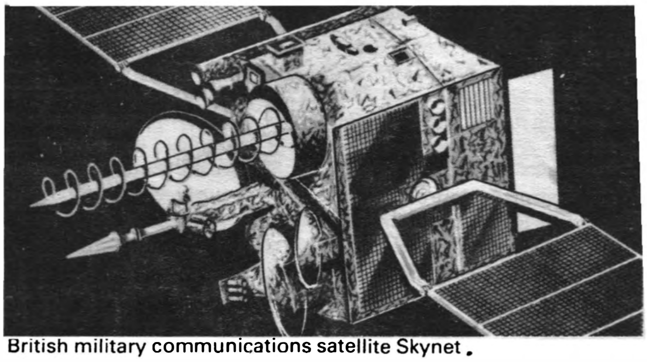
The wide scope of design and manufacture to support the ESA programme requires a large investment in the creation of very comprehensive manufacturing and test facilities. All such facilities are located within British Industry and give a comprehensive capability to the UK for Space projects.

Military Satellites

In the military field industry has concentrated on the supply of communications satellites and ground stations. In this review it is not possible to go into the detail of the facilities provided to the Armed Services which include voice transmissions, data communications and visual images. The very advanced series of Skynet satellites together with the ground equipment which include large antenna stations and vehicle and man-portable equipment enable communications to be made between land, air and sea. Work on military satellites also includes meeting the needs of NATO.

Applications Satellites

Many satellite programmes have been concerned with Earth observation either to obtain meteorological data or to carry out terrestrial surveying for minerals or mapping. These missions are accomplished using satellites which either orbit the Earth continuously covering the whole of the surface, or are fixed in



British military communications satellite Skynet.

geostationary orbit over a particular sector of the globe. Typical orbiting satellites are Meteosat used for weather forcasting, Landsat used for terrain mapping and ERS1 used for Earth resources measurements. An important business aspect of this work is the supply of the large number of ground stations all around the world to enable the agricultural, fishing and mineral extraction agencies to determine the best conditions for their operations.

Another key use of satellite systems is to provide a method of global navigation. The NAVSTAR system provides mobile units on land, sea and in the air with an ability to fix their position to an accuracy of a few metres using small, low cost ground stations.

Communications Satellites

Today, telephone calls can be routed via Space over thousands of miles at a lower cost than a terrestrial link of only a few hundred miles.

The existing ECS satellite supports communications within the whole of Europe. Its use highlights the astounding growth in communications over the last 50 years. In many parts of daily life, technology has had a profound impact. For instance, the speed of transport has increased perhaps 10 times and agricultural efficiency by a similar factor. In communications terms however the improvement in signal capacity and distance travelled has increased by a factor of a million or more. This prodigious capability, by which for instance a whole continent such as North America can receive simultaneously 50 television programmes from Space, shows quite astounding growth. The ECS satellite scored a first in Europe by providing the commercial relay of television programmes.

Scientific Satellites

Some of the most spectacular successes of the Space programme have been the scientific missions in which the galaxy has been explored by telescopes, infrared and X-ray cameras. The recent mission to Uranus and the rendezvous of the Giotto probe with Halley's comet captured the public imagination but do not perhaps lead to the same prospects for export sales as other Earth-related programmes.

Ground Equipment

The greatest potential for expansion in Space equipment for commercial use is the growth of the use of satellites, especially geostationary satellites, for voice, data and television communications. Not only do British companies make the satellites used for many of these transmissions but they also provide the complex ground equipment used to uplink the calls, data and programmes and the simpler receiver-only equipment for cable head end for business and domestic use. The whole area of ground stations is one of great potential for British industry.

A single satellite system can generate a market for thousands of ground stations covering wide areas of the globe. Some of the installations already in place are Goonhilly 1, Goonhilly 2, Madeley (where the red brick building is full of electronics – one notices the dish but the expensive equipment is indoors!) and the installation at Masirah.

Links are provided to serve many Government communication needs and our Embassies abroad are all equipped with up-to-date equipment of British design and manufacture.

Looking to the Future

Although much of the work of British Industry in recent years has been in association with ESA it is important to establish a continuous involvement with the enormous USA Space programme. The UK Government is a leading supporter of the ESA initiative in contributing to the US Space Station. In addition to many other projects, UK industry is planning involvement in polar orbiters and in data communications associated with the commercial exploitation of the Space environment, for the production of new materials in gravity free envionments.

Three of the many projects in which UK companies are actively engaged with NASA are: The Space Station: The Space Telescope project: and Gamma Ray observatory in Space.

One of the most topical programmes associated with Space activities is the US Strategic Defence Initiative. Very recently a Memorandum of Understanding was signed by the UK and US Governments in support of a British contribution to the programme. Within the next few weeks British Industry will be outlining to US Departments of Defense and Industry how our capability, built up in recent years in all aspects of Space-related technology, can be developed to carry out a number of the research tasks to be funded by the US Department of Defense.

It may come as a surprise to many people to realise how much the activities of British Industry have contributed to the Space business. We have perhaps as an Industry been lacking in public visibility but Industry views the Space market as very important in generating a large export business.

Following discussions with the British Government over the past few years, Industry was delighted by the decision to set up the British National Space Centre (BNSC) under the direction of Roy Gibson. Detailed plans for the work of the centre are now being prepared and Industry has pledged to give its full support to the preparation and implementation of the National Plan. The BNSC is critically reviewing future British activities in Space and one of the important projects is the proposed polar orbiting Space platform associated with the NASA Space Station.

In this short overview I have discussed the achievements and capabilities of industry in Space and outlined the solid foundations on which we intend to base our future business. There is a wealth of talent in industry seeking to exploit new technologies and HOTOL is just one of the exciting new concepts we are looking at for the future.

UNITED KINGDOM

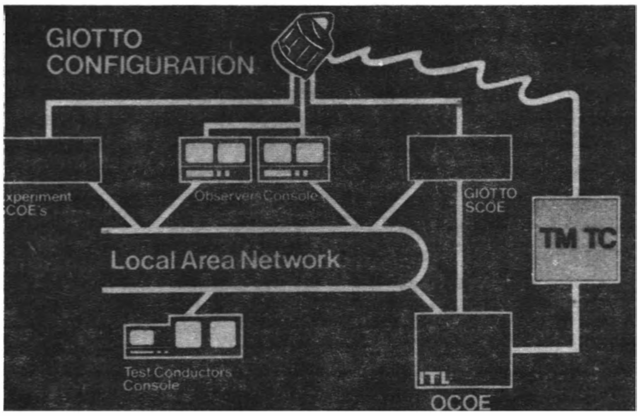
British Super-Minicomputer Boasts Reliability

Information Technology Limited is a leading British computer company which researches, designs, manufactures, sells and services a wide range of advanced computer and communications products for business, industry, science and government through its own nationwide network of 16 sites.

The Information Technology Limited Momentum 9000 super-minicomputer at the European Space Operations Centre is capable of processing and distributing vast quantities of telemetry data at high speeds despite having only 0.75 megabytes of main memory. Momentum was used as the development base for ETOL, the European Space programming language, which allows scientists and engineers to program their applications without needing to be computer specialists. It is currently monitoring the health and housekeeping of the Giotto satellite mission to Halley's Comet.

When the European Space Agency first started using Momentum or its predecessors for satellite testing and monitoring, its standard procedure was to buy two computers in case one failed. Soon after working with the Momentum, however, this requirement was abandoned. Even on so critical a satellite as Giotto, where years of work and tens of millions of pounds have been dedicated to achieving a mere 30 minute conjunction of satellite and comet after a nine-month flight, ESA only found it necessary to buy one Momentum computer. No satellite program using ITL computer systems has ever been delayed by ITL computer failure.

Momentum will feed continuous data on 2,000 parameters relating to the status of Giotto and its 10 experiments through an ITL Cablestream Local Area Network selectively into 10 other computers – from Apples to DEC PDP-11s. Momentum's selectable multi-colour synoptic displays of each satellite sub-system also make satellite and experiment status visible and adjustable without mountains of printouts. Cablestream is a range of ITL equipment which makes



up Europe's most popular broadband cable local area network and is used by a considerable number of industrial and commercial giants.

When the European Space Agency commissions a new satellite from a European prime contractor and sub-contractors spread throughout Europe, it is built on a Cablestream Local Area Network (LAN) which connects the satellite test equipment to a resilient Momentum and to the satellite and its battery of experiments. This network then tests out the satellite's system and experiments under the control of the Momentum. During this process, not only the ESA satellites but their entire Cablestream LANs and Momentum computer systems are often required to be transported, heated up, cooled down, subjected to vacuums, and severely shaken. In fact, Momentum is the only equipment ever to have passed the ESTEC-defined EMC tests (electro-magnetic compatibility), in which it has proved it can keep operating while subjected to varying strengths and combinations of magnetic emanations, electrical current fluctuations, wide temperature variations and air cleanliness degradation. More than 20 British, Italian and ESA satellites, including Giotto, have been built using the Momentum/Cablestream system

SATELLITES IN EDUCATION

The University of Surrey has catalysed an initiative in the UK to promote the specific use of satellites in education – involving not only the two UoSAT spacecraft but also meteorological, TV and other satellites that are readily available to the individual experimenter.

As reported in *Spaceflight* (March 1986, p116), a UK Coordinating Committee for Satellites in Education was created in early 1985 comprising representatives from all strata of education. It is currently under the chairmanship of Dr. John Gilbert.

A national resource centre is planned to be established at UoS to support this programme which is intended to provide a central coordinating team, to assist in the preparation of materials, experiments and software, and to advise on hardware focussing directly on educational applications.

It is anticipated that there will be opportunites quite soon for a small number of science teachers to join or be seconded to UoS to develop the centre and educational resources. Any qualified teachers who may wish to be considered should contact Dr. John Gilbert at UoS.

BOOK REVIEW

History of British Space Science •

H. S. W. Massey and M. O. Robins, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge, CB2 2RU, 514 pp, 1986, £45.00.

This book documents how a new and complex branch of science emerged within the UK and was encouraged to grow both nationally and internationally, as seen through the eyes of two who played a major role in many of the events described.

It traces the beginnings of the British Space Science programme from its origins in the 1950's up to the 1980's, providing both information about its background and highlighting some of its successes. Cooperation with NASA is described in some detail, as well as the part played by Britain in establishing European collaboration and a more modest collaborative programme with Commonwealth countries.

It is interesting to note that, during this 30 year period, British science experiments were carried aboard more than 600 rockets and 37 spacecraft.

INTERNATIONAL SPACE REPORT

A monthly review of space news and events

EURO BUSINESS FOR CHINESE

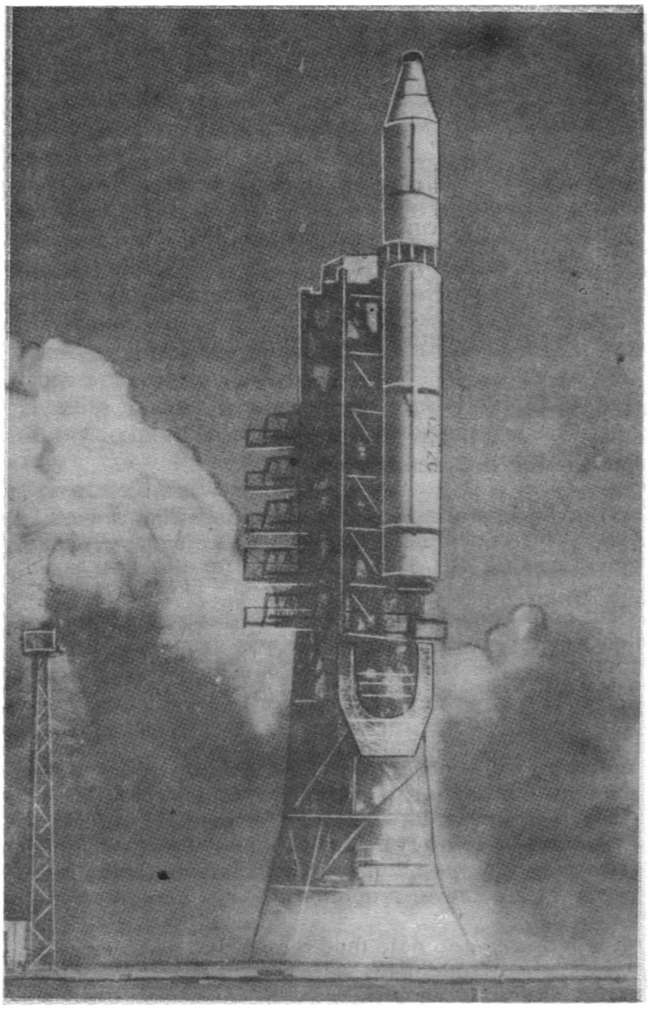
Sweden is considering use of the Chinese launcher Long March 2 for its proposed Mailstar satellites.

A one year launch reservation agreement has been signed between the Swedish Space Corporation and China. If it goes ahead the contract would be one of the first commercial launch agreements secured by China.

Mailstar, a small satellite being evaluated for electronic mail service to parts of the world where the telecommunications infrastructure is under-developed, would be launched piggyback with a Chinese Earth observation spacecraft.

These are placed in low Earth orbit by Long March 2 and an extra propulsion system would be needed by Mailstar to boost it to operational altitude. Joint work is currently taking place to design an appropriate propulsion system.

Launch of China 17 last October by the Long March 2 rocket which could be used for Sweden's Mailstar satellite.



1986 NASA LAUNCHES

NASA has five launches of unmanned rockets scheduled for the remainder of 1986 from Cape Canaveral. They are:

- May 1 – GOES-G weather satellite aboard a Delta rocket.
- May 22 – Navy communications and navigation satellite aboard an Atlas-Centaur.
- Aug 14 – DoD payload aboard a Delta rocket.
- Oct 9 – GOES-H weather satellite aboard a Delta rocket.
- Nov 16 – Navy communications and navigation satellite aboard an Atlas Centaur.

JAPANESE DBS

RCA is to design and manufacture major subsytems for the BS-3 Spacecraft bus as a part of Japan's third generation direct broadcast satellite. RCA is under contract from NEC Corporation of Japan, who have worked together on the Broadcasting Satellite programme since 1981, ***writes Nicholas Steggall.***

BS-3 will provide three broadcast channels to all of Japan and its nearby islands. Two channels will carry NHK (Japanese Broardcasting Corporation) programmes and one channel will carry programmes from the Japan Satellite Broadcasting Inc., a conglomerate of private companies which will share the capital.

NASDA has contracted for two satellites to be launched in the summer of 1990 and 1991 by the H-1 launch vehicle now under development.

HISTORIC TRANSMISSION

Live television was brought to the high seas for the first time at the end of January by the American-based Communications Satellite Corporation, Comsat.

The American Super Bowl Game was transmitted live to Cunard Line's Queen Elizabeth 2 which was at sea in the Pacific Ocean.

It was organised to demonstrate the technical feasibility of relaying television programming via the Inmarsat satellite system to ships at sea and offshore drilling rigs.

However, since the live transmission of the popular sporting event took place during the ship's dining hours Cunard chose to video the game for a showing later the same evening!

SATELLITE DIGEST – 191

Robert D. Christy

Continued from the March 1986 issue

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

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

COSMOS 1713, 1985-120A, 16434.

Launched: 1705, 27 Dec 1985 from Plesetsk by A-2.
Spacecraft data: as Cosmos 1702.
Mission: Possibly a space engineering applications mission.
Orbit: 216 x 398 km, 90.67 min, 62.82 deg.

COSMOS 1714, 1985-121A, 16437.

Launched: 0920, 28 Dec 1985 from Tyuratam, possibly by a version of the D vehicle.
Spacecraft data: not available.
Mission: Possibly a failed launch of a large electronic intelligence gathering satellite.
Orbit: 443 x 853 km, 97.72 min, 70.99 deg, although another object (catalogue number 16434) may be the payload in an orbit of 163 x 850 km, 94.75 min, 71.00 deg.

COSMOS 1715, 1986-1A, 16447.

Launched: 8 Jan 1986 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft, with spherical re-entry module, instrument unit and a supplementary package of instruments at the forward end. Length about 6 m, diameter (mas) 2.4 m, and mass around 6000 kg.
Mission: Military photo-reconnaisance, recovered after 14 days.
Orbit: 227 x 283 km, 89.65 min, 72.82 deg.

COSMOS 1716-1723, 1986-2A-H, 16449-56.

Launched: 0249, 9 Jan 1986 from Plesetsk by C-1.
Spacecraft data: Each satellite is possibly spheroidal in space, about 1 m long and 0.6 m diameter, and with mass approx 40 kg.
Mission: Single launch of eight satellites to provide tactical communications for troops or units in the field.
Orbits: 1480 x 1698 km, 118.00, min, 74.00 deg (lowest), 1475 x 1515 km, 115.91 min, 73.99 deg (highest).

STS-61C, 1985-3A, 16481.

Launched: 1155*, 12 Jan 1986 from the Kennedy Space Centre.
Spacecraft data: Shuttle Orbiter 'Columbia'.
Mission: Carried crew of Gibson, Bolden, Nelson, Hawley, Chang-Diaz, Cenker and Nelson (US Congressman). Mission objectives included materials science experiments, tests of SDI related surveillance equipment and launching a communications satellite. 'Columbia' landed on the runway at Edwards AFB at 1359, 18 Jan 1986.
Orbit: 324 x 346 km, 91.05 min, 28.47 deg.

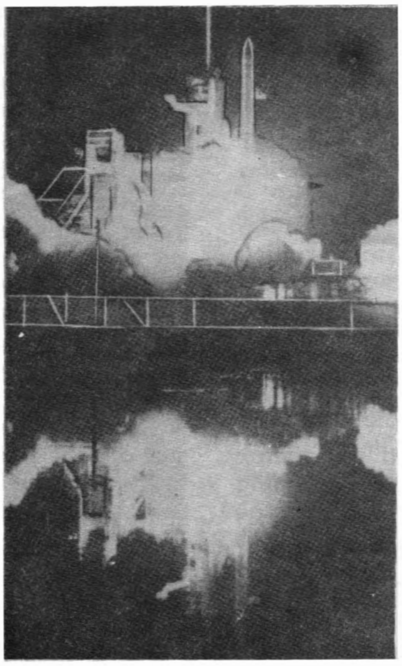
RCA SATCOM K1, 1985-3B, 16482.

Launched: 2125, 12 Jan 1986 from the payload bay of 'Columbia' by PAM-D2.
Spacecraft data: Three-axis stabilised, box shaped body, 1.7 x 2.1 x 1.5 m, with a 15 m span solar array and mass around 1100 kg.
Mission: Commercial communications satellite.
Orbit: geosynchronous above 85 deg west longitude.

COSMOS 1724, 1986-4A, 16490.

Launched: 1420, 15 Jan 1986 from Plesetsk by A-2.
Spacecraft data: as Cosmos 1715.
Mission: Military photo-reconnaissance.
Orbit: 169 x 332 km, 89.54 min, 67.15 deg, manoeuvrable.

The spectacular night launch of Shuttle Columbia on January 12, 1986.



COSMOS 1725, 1986-5A, 16495.

Launched: 1139, 16 Jan 1986 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum shaped solar array with length and diameter both about 2 m. The mass is around 700 kg.
Mission: Navigation satellite.
Orbit: 972 x 1003 km, 104.91 min, 82.94 deg.

COSMOS 1726, 1986-6A, 16495.

Launched: 0723, 17 Jan 1986 from Plesetsk by F-vehicle.
Spacecraft data: not available.
Mission: Electronic intelligence gathering.
Orbit: 632 x 663 km, 97.74 min, 82.53 deg.

RADUGA 18, 1986-7A, 16497.

Launched: 1020, 17 Jan 1986 from Tyuratam by D-1-E.
Spacecraft data: Cylindrical with a pair of solar panels at right angles to the body, and an aerial array at one end. Length 5 m, diameter 2 m, and mass around 2000 kg.
Mission: To provide round the clock radio, television and telegraphic communications within the Soviet Union through the 'Orbita' system.
Orbit: geosynchronous above 25 deg west longitude (Statsionar 9).

COSMOS 1727, 1986-8A, 16510.

Launched: 1853, 23 Jan 1986 from Plesetsk by C-1.
Spacecraft data: as Cosmos 1725.
Mission: Navigation satellite.
Orbit: 962 x 1016 km, 104.95 min, 82.95 deg.

COSMOS 1728, 1986-9A, 16512.

Launched: 0835, 28 Jan 1986 from Tyuratam by A-2.
Spacecraft data: as Cosmos 1715.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 225 x 273 km, 89.52 min, 69.97 deg.

UPDATES:

1985-109D, name should read **'RCA SATCOM K2'**
1985-112A, Cosmos 1706 re-entered or was recovered 9 Feb 1986 after 60 days.
1985-120A,. Cosmos 1713 was recovered 22 Jan 1986 after 26 days.

Space Station – Build-up Begins

The new Soviet initiative in manned spaceflight comes at a time when the United States manned programme is still reeling from the crisis following the Challenger disaster.

On March 12, the Soviet space programme broke with tradition and gave its first advanced notice of a space launching scheduled for the following day. The mission was the first of a series of launchings to the new Soviet space station, Mir, which was placed in orbit on February 20.

The start of manned operations at the space station is to be led by veteran cosmonaut Leonid Kizim and space endurance record holder Vladimir Solovyov. Long-term occupation of the space station is indicated by the 252 and 237 days of space experience already credited to the cosmonauts. The Soviet spacecraft involved in the 13 March launching was Soyuz T-15.

The new space station has six docking ports for manned or unmanned capsules ferrying to and from the Earth. Its launch, by a Proton booster, is seen as the first stage in Soviet plans to form a new modular space station complex. Shortly after launch a manoeuvre to correct the orbit was completed. Four days later Tass reported that everything was going to plan and a series of control tests on the structure and on-board systems were being carried out.

The Space station is currently in a 352 km by 324 km orbit, with a period of 91.6 minutes and an inclination of 51.6 degrees.

Vladimir Solovyov

Leonid Kizim

Control of Mir and the previously in orbit Salyut 7 is being conducted by the mission control centre in Moscow with help from tracking stations in the Soviet Union and research vessels.

The new station represents a third generation Soviet space laboratory and it will mark the beginning of a transition from experimental research to large scale production activities in outer space. Experts believe that one of its uses will be for the production of semi-conductors.

Each of the space station modules has purpose-orientated functions for uses ranging from technological production to biological research.

For the first time in a space station occupants will be able to retreat to the privacy of their own cabins which each contain a desk, arm-chair and sleeping bag.

The new station has two solar array wings mounted on the middle of the vehicle, unlike the previous Salyut design which used arrays on three sides.

VEGA PROBES ENCOUNTER HALLEY

Instruments onboard the Vega 1 spacecraft were activated and its tracking platform located Comet Halley, directing TV cameras towards it for the first time on March 4.

Vega 1 was at a distance of 14 million kilometres from Halley and 171 million kilometres from Earth.

For 90 minutes the TV cameras on the tracking platform transmitted pictures of the comet taken through various filters.

Two days later Vega 1 passed through the gas and dust envelope of Comet Halley at a distance of some 9,000 km from the nucleus.

For the first time ever instruments recorded large-scale images of the nucleus together with measurements and analysis of the chemical compostion of the gas and dust.

During the three hour session of scientific measurements and photography Vega 1 flew past the nucleus with a relative velocity of 80 km per second. More than 500 TV pictures were transmitted to Earth during the encounter.

The spacecraft was not seriously damaged and according to post-encounter telemetry signals was functioning normally after flying through the gas and dust.

Vega 2, the second Soviet probe, encountered Halley on March 9.

Scientific instruments on the two spacecraft were developed jointly by the Soviet Union, Austria, Bulgaria, Hungary, Germany, Poland, France and Czechoslovakia.

ATLAS OF VENUS

Soviet Scientists have compiled an atlas of Venus which includes 20 maps, each measuring three square metres. They have been drawn up from the data of radar probing carried out by the Venus 15 and Venus 16 interplanetary stations which took photographs of the surface of the planet every day during almost a year, from October 1983 to July 1984.

Geologists believe that, judging by photographs, the surface of Venus resembles that of Earth. Mountain ranges and valleys, volcanic peaks and craters are visible. Scientists have also detected signs of tectonic activity like that on Earth.

The highest mountain on Venus is 11.5 kilometres and the planet also has a large mountain range stretching from north to south over several hundred kilometres. Two huge craters with a diameter of 15-20 km each are marked on the maps. Scientists believe that they were caused by the impact of celestial objects onto the surface.

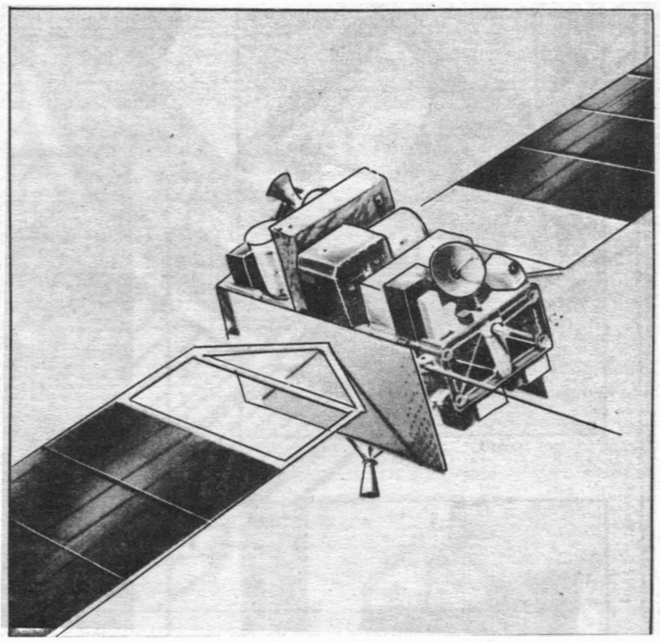
EUROPEAN RENDEZVOUS

MARCONI COMMUNICATIONS

The French Space Agency (CNES) has awarded Marconi Space Systems of the UK a contract to develop and supply communications equipment for launch on the ESA platform Eureca – the European retrievable carrier. This contract covers a major contribution to the inter orbital communications experiment.

The Eureca platform is due to be launched from the NASA Shuttle in 1988. It is planned to carry out a six month mission during which automatic experiments will take place in microgravity. Eureca will then rendezvous with Shuttle for recovery and return to Earth.

The Marconi communication equipment operates at EHF and by using a steerable antenna and tracking system will enable data to be passed from Eureca to a geostationery communications satellite some 24,000 miles distant. For the first mission Eureca 1 will communicate through the ESA satellite Olympus, also due to be launched in 1988. This will constitute the European Space Agency's first demonstration of communications between two satellites.



The European retrievable payload carrier, Eureca, will encourage commercial space activities. *ESA*

The Mediterranean coastline in the region of the Nice Riviera as seen by the French Spot satellite after being placed into orbit by an Ariane 1 launcher on February 22. The image has a ground resolution of 10 metres and streets of Nice can be seen.

SOHO AND CLUSTER

ESA's Science Programme Committee has given unanimous approval to the Soho and Cluster missions which together form the Solar Terrestrial Physics cornerstone of ESA's long-term scientific plan.

In coming months the Agency will request the scientific community to put forward proposals for experiments to be carried on-board these missions. These proposals will be evaluated early next year and the complete mission will be presented to the Science Programme Committee before the start of detailed systems studies and pre-development work (Phase B) in 1988.

With the choice of the Soho and Cluster missions, work on the first of the four cornerstones, the Solar Terrestrial Physics Programme, will now get underway.

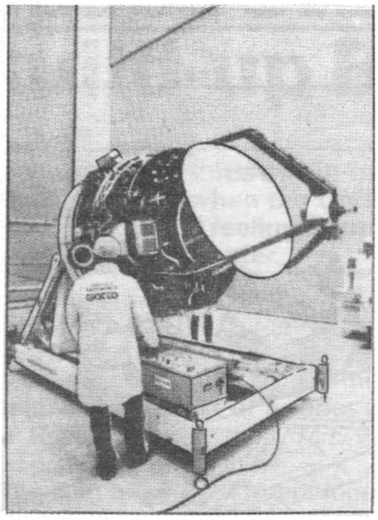
Soho (Solar and Heliospheric Observatory) is a multi-disciplinary mission designed to investigate, using remote sensing techniques, the outer layers of the Sun, to measure, in situ, the solar wind streams and associated wave phenomena and to probe the interior structure of the Sun by monitoring the velocity and luminosity oscillations of the solar surface.

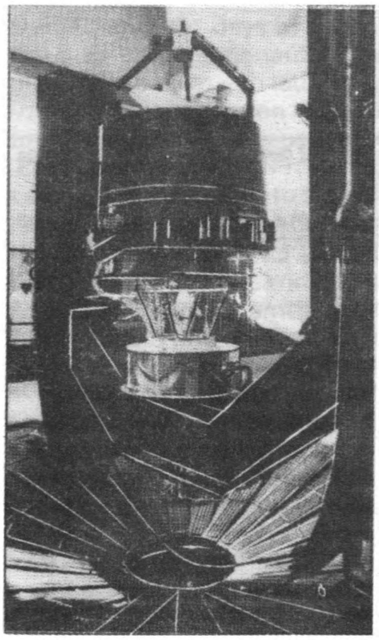
The Cluster mission has been designed primarily to study small-scale structures in the Earth's plasma environment and the associated turbulence. Cluster takes its name from the fact that the mission will consist of four spacecraft orbiting in different planes in the Earth's magnetopause, geomagnetic tail and plasma sheet.

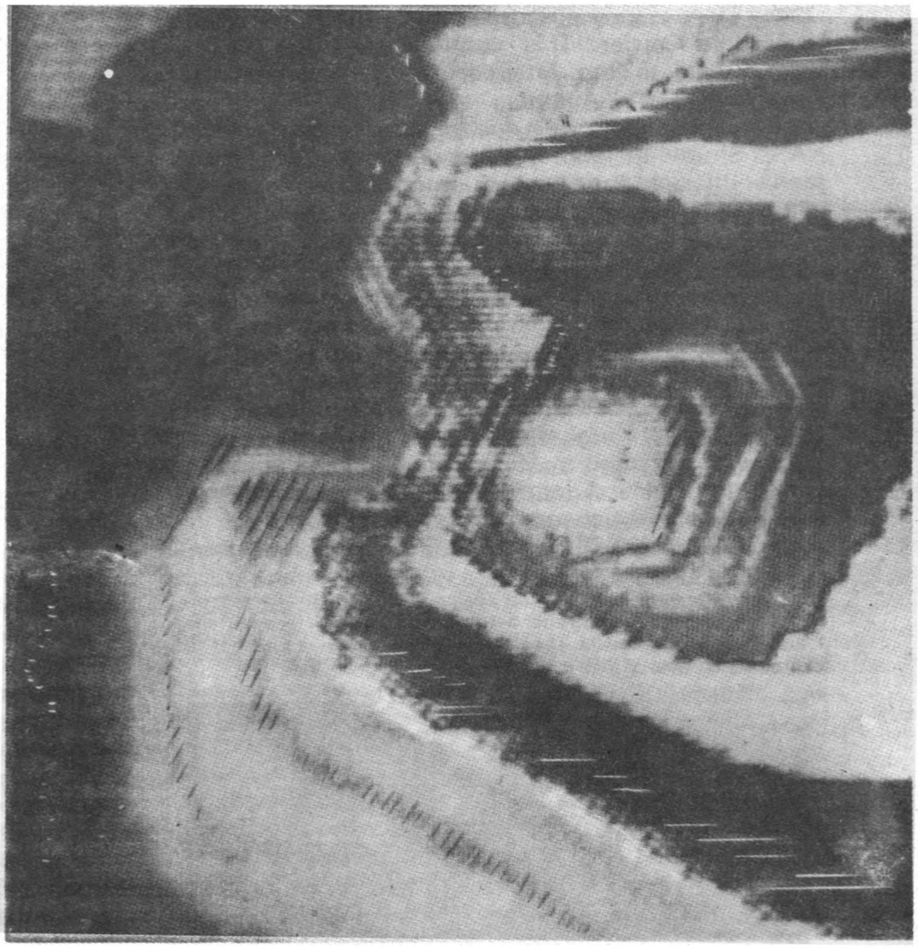
Present planning foresees the launch of the five spacecraft in the 1993-1995 time frame.

SUCCESS FOR EUROPE'S

Close Enc

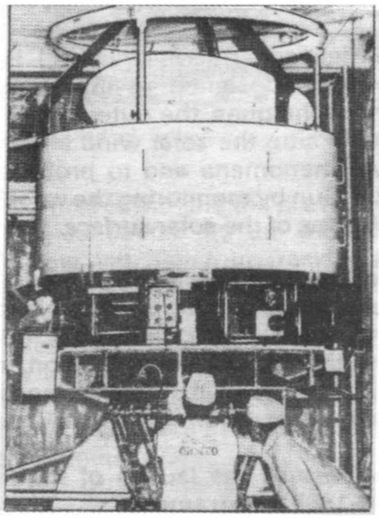


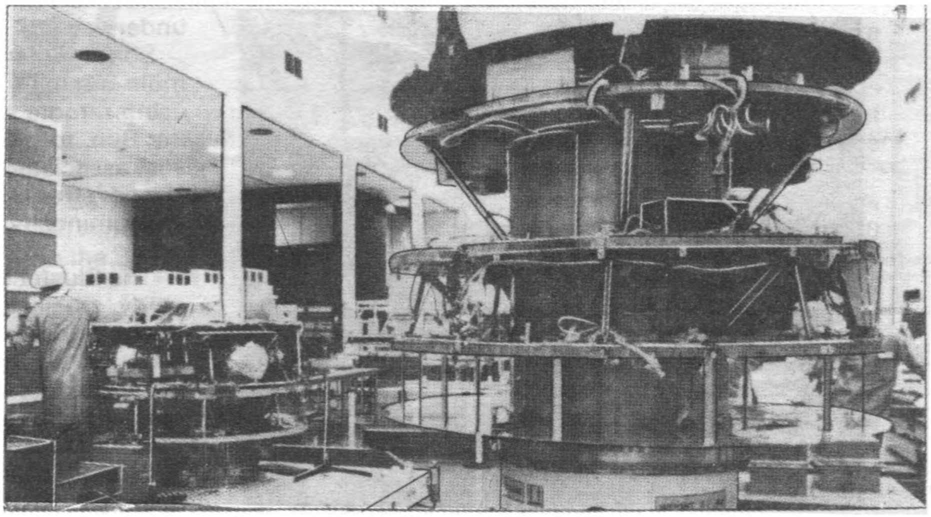




One of the first pictures returned by Giotto shortly before midnight on March 13 as it homes in on the Comet Halley nucleus.

The contouring effect is caused by false colour processing to highlight





HALLEY PROBE

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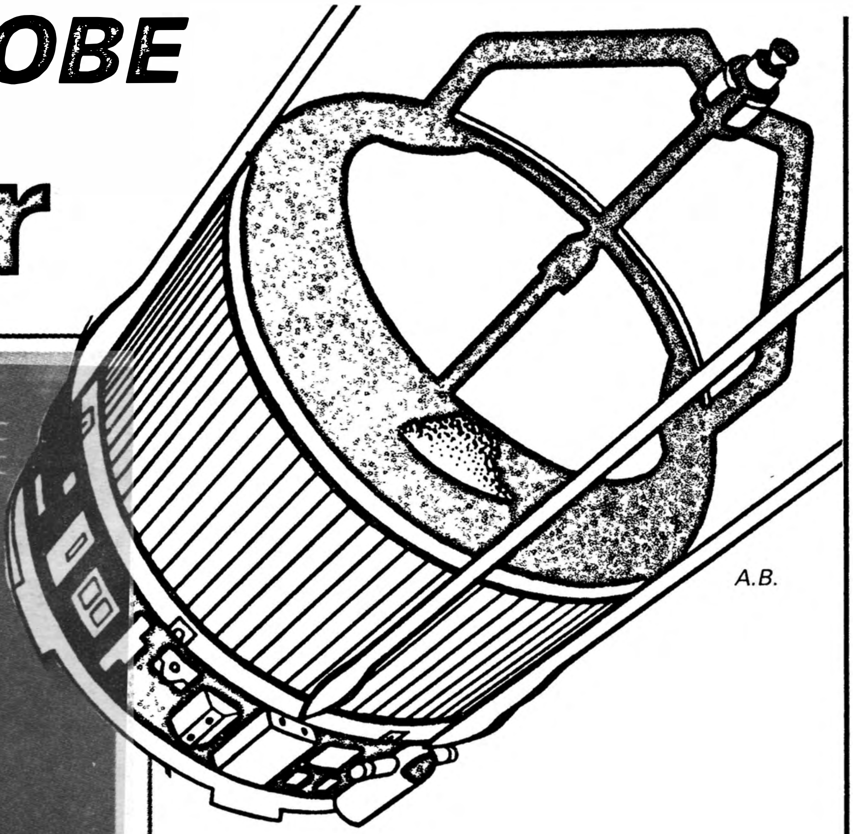
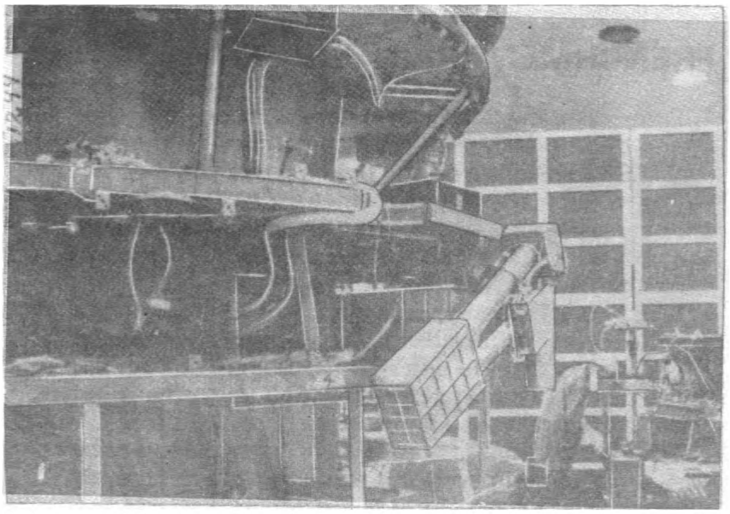


areas of varying light intensity. The pictures left and below show the Giotto spacecraft at various stages of testing and development by British Aerospace.



The Giotto spacecraft, built by British Aerospace on behalf of the European Space Agency, performed perfectly during the interception of Halley's Comet on March 13, 1986.

The mission was regarded as a complete success by the scientific investigators for whom it was designed. All experiments performed as intended and returned high quality data.

Giotto passed within 540 kilometres of the comet's nucleus but seconds before the closest approach and the end of the mission, Giotto was hit by cometary debris which caused it to oscillate and prevent further pictures being taken.

After about 40 minutes, Giotto's active damping system stabilised and enabled operations to continue. From this time of full recovery – which was well after the mission's planned conclusion – further data from Giotto was regarded as a bonus by Mission Control at the European Space Operations Centre in Darmstadt.

Giotto was damaged by its collision with particles from the comet and there were many penetrations of its protective bumper shield but it is believed to remain sound.

The full implications of this spectacular encounter are being investigated, but it is understood that there is no damage to the de-spin system or degradation of the solar cells. The star mapper, which provides data on the spacecraft's position in space, was damaged but is still functioning.

The surface of the comet nucleus was much bigger and darker than predicted by scientists. It measured 9.3 miles by 2.5 miles compared to estimates made by the Soviet Vega probes of 6.8 by 4.3 miles.

● A full report of the Halley comet encounters with more pictures will appear in the next issue.

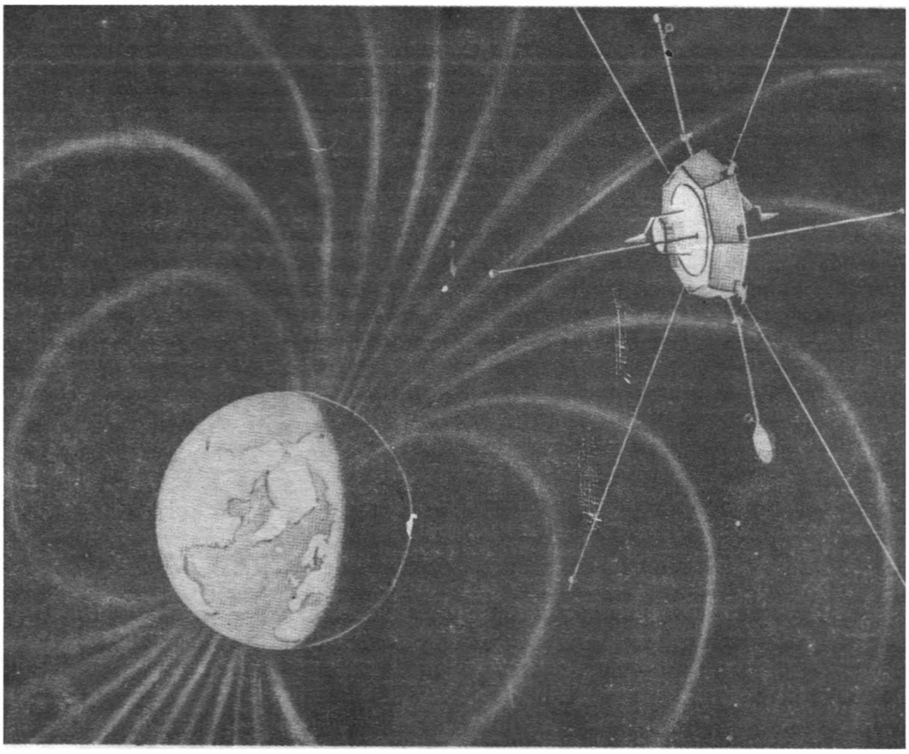
EUROPEAN RENDEZVOUS

VIKING IN ORBIT

Sweden's first scientific satellite, designed to study the Earth's magnetosphere, was launched in tandem with the French Earth-resources satellite aboard Europe's Ariane launch vehicle from Kourou, French Guiana, on February 22.

During its eight-month mission, Viking (pictured right) will study space plasma phenomena, believed to be responsible for the aurora borealis, in the Earth's magnetoshere. This is of special interest to higher-latitude countries because the aurora borealis phenomenon, also known as the Northern Lights, disturbs radio communications and other electronics.

Apart from the scientific mission Viking was from the beginning also meant to be a learning project for Swedish industry in the field of satellite services. Thus the Swedish company Saab Space was awarded prime contractorship for the satellite with Boeing Aerospace Company as main subcontractor.



EXOSAT ON WAY BACK

The European X-ray Observatory Satellite, Exosat, could re-enter the Earth's atmosphere during May unless engineers extend its planned period of operation by using on-board hydrazine thrusters to modify the orbit.

When launched in May 1983, Exosat had a planned operational life of two years and its chosen orbit meant it would re-enter the atmosphere approximately three years after launch.

On February 19, 1986 it completed 1000 days of in-orbit operation and during this time has made over 2000 observations of cosmic X-ray sources covering the complete range of celestial objects from the very familiar planets and stars we see in the night sky to such mysterious objects as quasars, neutron stars, black holes, supernova remnants, active galactic nuclei and clusters of galaxies.

The observations have been carried out from the European Space Operations Centre (ESOC) in Germany and have formed a rich data base that will provide a source of research for many years to come.

ULYSSES MUST WAIT

Prior to the tragic accident which occurred on January 28, Ulysses was scheduled for launch by the Space Shuttle on May 15, 1986. After consultation with the ESA Director General, Professor Reimar Lüst, NASA has now formally announced that it has postponed this mission. A new launch date will be decided upon by NASA after a schedule for resumption of Shuttle launches has been established.

Ulysses is a unique mission in that it will be the first spacecraft to study the poles of the Sun out of the ecliptic plane in which the planets orbit around our star. It was scheduled for launch on Challenger, and a NASA mission, Galileo, a planetary mission to Jupiter, was due to be launched by Atlantis five days later, on May 20.

Because of their trajectory requirements, both Ulysses and Galileo are dependent on the relative position of Jupiter and the Earth at the time of launch; Jupiter must be almost directly on the opposite side of the Sun from the Earth. This geometric arrangement occurs once every thirteen months. Therefore, for a direct launch to Jupiter, both missions would be delayed at least thirteen months until another launch window occurs. The Ulysses spacecraft and its scientific payload recently underwent successful final testing at Kennedy Space Centre, Florida. It will be placed in storage in anticipation of a launch which could be between June 22 and July 14, 1987.

FRENCHMEN TRAIN FOR MIR

France and the Soviet Union are finalising plans for a long duration flight of a French national on the new Soviet Space Station during the next two years.

The mission, at present planned for 1988, would last between six and seven weeks and is a follow-on to the Soyuz T-6 flight in 1982 when Jean Loup Chretien visited Salyut 7.

CNES, the French space agency, would conduct a number of scientific and biological experiments and is expected to offer the use of a new echo-cardiograph for gathering data on blood flow and performance of the heart during space flight.

The Soviet flight is also seen as an opportunity by France to experiment with equipment it ultimately plans to use on the Hermes mini-shuttle.

UP-DATE USA

Divers Find Challenger Cabin

Engineers at NASA have been piecing together more clues to the Challenger explosion following the discovery of the Shuttle's crew compartment on the ocean floor.

First indications that the cabin had been located in 100 feet of water about 20 miles from Cape Canaveral came on March 7.

Relatives of the crew were informed immediately but it was several days before a public announcement of the find was made.

The search for wreckage has been going on since the explosion which destroyed Challenger shortly after launch on January 28. It has involved 11 ships and two small unmanned submarines operating across 350 spare miles of the ocean.

Meanwhile, as the Presidential Commission continues its inquiry, NASA has set up a "Headquarters Re-planning Task Force" to study alternatives for the future and evaluate the role that expendable boosters could play in replacing the Shuttle as primary satellite carriers.

As well as reviewing the requirements for a replacement Orbiter, currently estimated at costing £200,000 million, the task force is also considering:

- Producing a new launch schedule for the remaining Shuttle fleet supplemented by expendable launch vehicles.

- Bringing the Vandenberg launch site "on line" and assigning a Shuttle there for several weeks to aid the process.

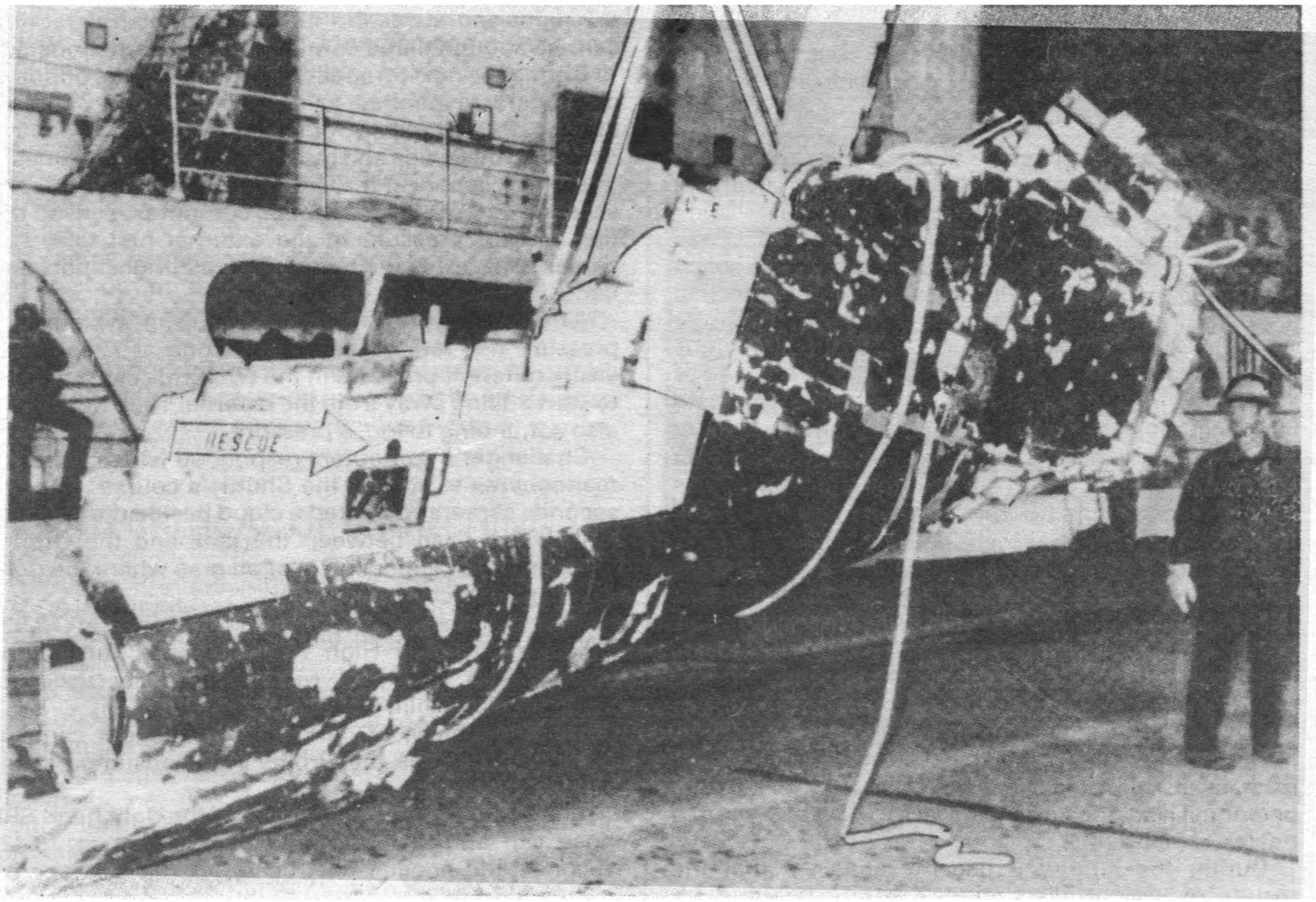
- Retaining ground communications stations which were to have been phased out with expansion of the Tracking Data and Relay Satellite System. A TDRS satellite was lost in the Challenger explosion.

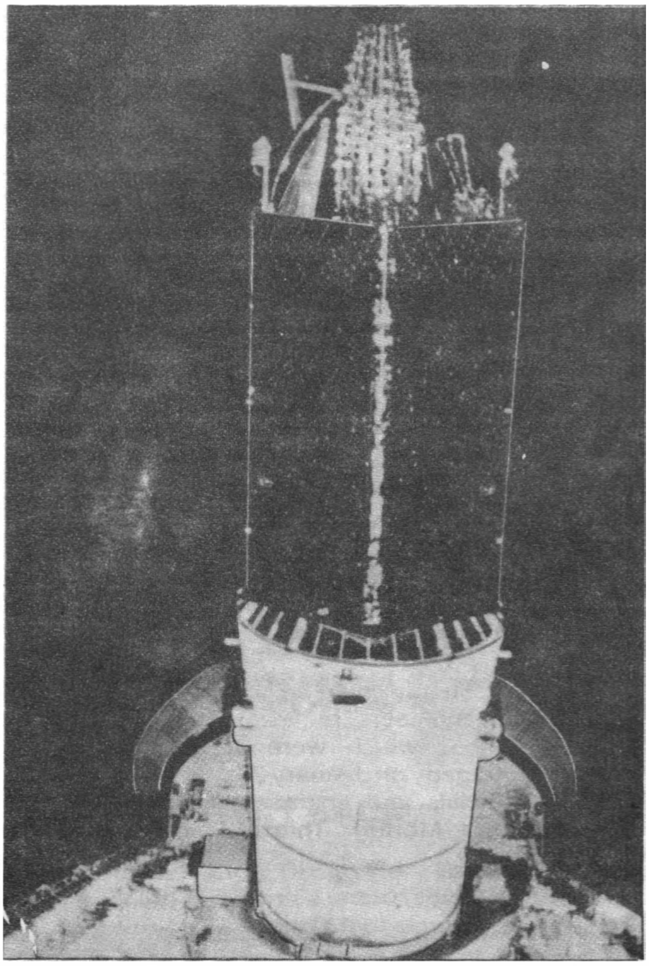
President Regan is also expected to ask Congress for emergency funds to replace Challenger with a new Orbiter within the near future.

The Space Shuttle could be grounded for up to two years while engineers re-design the Solid Rocket Booster O-rings which were at the root of the Challenger tragedy on January 28.

NASA officials and engineers from the booster manufacturer, Morton Thiokol, agree that the

Wreckage of the Shuttle Challenger being returned to dry land by a US salvage ship.





The TDRS satellite and its Inertial Upper Stage ready for release on flight STS-6. A similar satellite was lost in the Challenger explosion.

explosion was triggered by a rupture in the booster casing joint when the seals, which are adversely affected by cold weather, failed.

The launch site temperature for mission 51L was only 38 degrees Farenheit, by far the coolest conditions ever for a Shuttle launch. The next lowest temperature recorded at the time of a launch was some 13 degrees warmer and occurred on the previous flight, mission 61C on January 12.

The Presidential Commission set up to investigate the accident has been told that 15 engineers from Morton Thiokol raised serious concern over the effect of such low temperatures on the Solid Rocket Boosters (SRBs), prior to launch. They petitioned the company's senior representative at Kennedy Space Center, Allan McDonald, to disapprove of the launch.

As a result McDonald refused to sign the mission 51L flight readiness statement. Inquiry board members were told that this was the only occasion during the Shuttle programme such a recommendation not to fly had been made.

However, these launch objections were over-ruled by Joe Kilminster, Morton Thiokol vice-president, from his base at Thiokol facilities near Salt Lake City. NASA personnel also questioned the lack of data to support a postponement.

During the inquiry it became apparent that the results of various discussions were not passed on through the NASA chain of command for review at the highest levels. Key NASA managers involved in launch decisions were not informed of the serious flight safety considerations that were raised in the 24 hours prior to launch.

The inquiry board has also released a detailed account of what happened after Challenger lifted off from Pad 39B. The timeline was part of a presentation to the Presidential Commission on its visit to Kennedy Space Center during an early part of the inquiry.

The account starts with the ignition of Challenger's main engines 6.6 seconds before lift-off. At launch the SRBs ignited normally and the Shuttle's first movement off the pad occurred at 0.0587 seconds.

A puff of black smoke was detected between the right hand SRB and the External Tank as early as 0.445 seconds. This was the first indication that something was wrong.

By 2.147 seconds the black smoke extended halfway across the booster. Cameras continued to detect the smoke through tower clear, the roll manoeuvre, and as late at 12 or 13 seconds into the flight.

The mission then appeared to be functioning normally until 58.774 seconds into the flight when there was evidence of smoke from the side of the right SRB forward at the lower External Tank attach ring.

At this stage the Shuttle main engines had throttled up to 104 per cent thrust and the Orbiter was in its period of maximumn dynamic pressure. A second later the tracking cameras detected a well-defined plume of smoke.

Onboard computers sensed a difference in pressure between the right and left SRBs at 60.164 seconds into the flight and a fraction of a second later a tracking camera spotted flame coming from the right booster.

During the next three seconds Challenger's onboard computers responded to a change in the Shuttle's flight path by making minor adjustments to control panels on the wings and by moving the main engines.

A bright spot near the Orbiter was detected at 66.174 seconds and at 66.484 seconds computers sensed the first loss of pressure in the external fuel tank and cameras recorded the merging of the bright spots and flame.

AT 67.684 seconds the main propulsion system inlet pressure rise rate decreased. Starting at 72 seconds vastly different pressure in the two SRBs caused them to start pulling away from the External Tank which was also continuing to loose pressure.

Challenger's computers responded with a series of manoeuvres to correct the Shuttle's course. After 73 seconds cameras detected a cloud beside the external tank and a flash between the tank and the Orbiter followed by an explosion near an area where the right booster is attached to the tank.

Main engine number one shut down at 73.534 seconds after the High Pressure Fuel Turbopump became too hot, and rockets normally used for manoeuvring while in orbit began firing.

The final piece of data from Challenger came at 73.605 seconds as the Orbiter was consumed in the explosion

Cameras recorded separation of the right hand SRB nose cap and drogue chute deployment at 76.425 seconds and booster destruction at 109.604 seconds (right) and 110.266 seconds (left) by ground control.

NEW ORBITER NEEDED

NASA faces a launch crisis over the coming years even if Congress agrees to press ahead with construction of a replacement Orbiter for Challenger.

By 1990 it is predicted that Challenger's destruction will have resulted in the loss of 24 flights and without a replacement that figure is likely to increase at the rate of six per year thereafter.

If the Shuttle is only grounded for six months the near-term effect on launch schedules would be minimal, although in the longer term backlogged launches would be building up. Should the Shuttle be out of action for up to two years, a distinct possibility if major re-design work is undertaken on the boosters, the situation will worsen considerably.

The backlog would soon rise to 30 flights and with military flights taking priority NASA missions would be further delayed. The result of a full two year slippage would mean the postponement of 35 missions and the Department of Defense would find itself lumbered with 21 high priority payloads.

The alternative to Shuttle of expendable launch vehicles (ELVs) is also being examined as a means of relieving the launch crisis but it would still take two years for the production of eight Delta launch vehicles from the point of initial go ahead.

Amongthe other ELV options being considered are to increase the number of Titan 34D-7's available beyond the present plan for 10. These are capable of launching payloads of a similar size and shape to those put into orbit by the Shuttle.

Other options include continued modification of the retired Titan 2 ICBM beyond the planned 13 and the continued launching of existing ELV's like the Atlas and Titan 34D.

William Graham, NASA's acting administrator, believes that a three Orbiter fleet reactivated within a year would achieve launch rates of nine during the first 12 months, 14 in the second and up to 18 in third 12 months.

It seems increasingly likely that any delay in the construction of a fifth Orbiter (which could take approximately three and a half years) would seriously impinge on NASA's Space Station plans.

The Station's assembly would require 12 to 18 dedicated Shuttle flights and once built, by 1994 under current plans, would need up to nine flights a year for servicing.

YOUNG CRITICAL OF LAUNCHING

Veteran astronaut John Young, commander of the first Space Shuttle mission, has claimed NASA "risked lives" to avoid falling behind on a crowded launch schedule.

In a strongly worded memo dated March 4 Young, chief of NASA's astronaut office, delivered a harsh attack on the agency.

The 12 page memo warned: "If the management system is not big enough to stop the Shuttle programme whenever necessary to make flight safety corrections it will not survive and neither will our three Space Shuttles or their flight crews."

He spoke of the increasing pressure to launch NASA had been under for mission 51L even after experts had given various warnings and called for a postponement.

"We have already launched with less than certain full reliability and full redundancy of the systems," he stated.

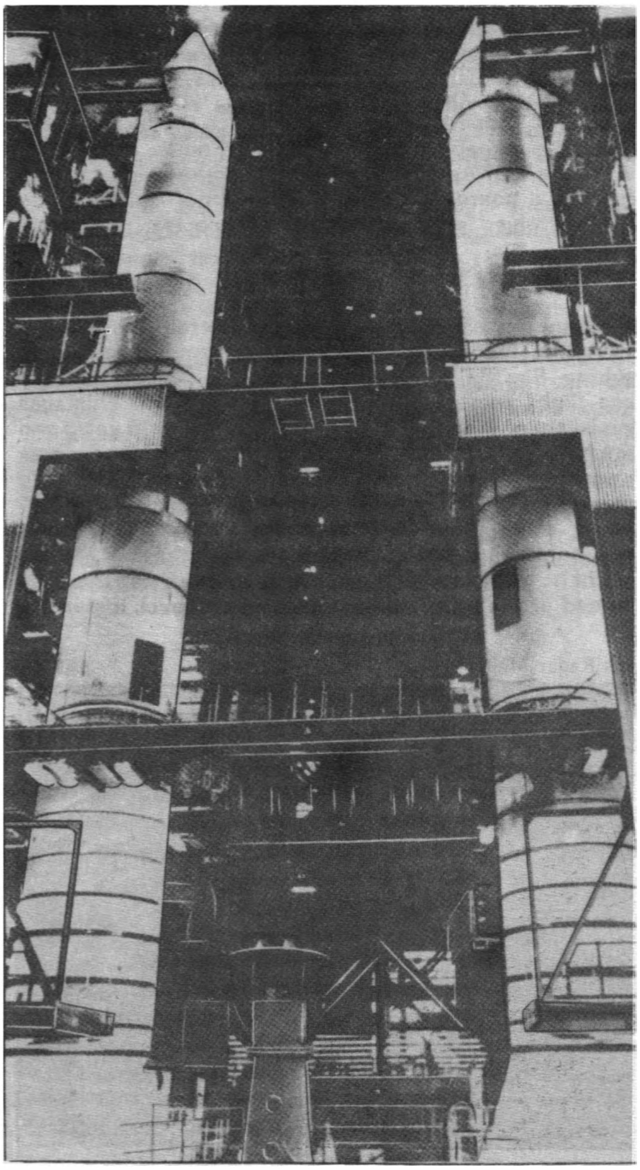
"We should not allow any increase in the inherent risk of operating the Space Shuttle just to increase the launch rate, reduce operating costs, or fly unsafe payloads."

Detailing what he termed an "awesome list" of safety problems that threatened astronauts' lives, Young claimed that NASA had relegated safety to a back seat on several occasions.

Astronaut Dr Sally Ride, a member of the Presidential Commission, has publically stated that she is not yet ready to fly again in the Shuttle.

In response to the criticism from astronauts NASA has reiterated its intention not to launch the Shuttle again until all safety related issues have been properly addressed.

Investigation work is continuing on the SRBs seen here stacked in the Vehicle Assembly Building before mating with the Shuttle for an earlier mission



UP-DATE USA

Notebook From The Cape

by Gordon L. Harris

President Reagan's FY 1987 budget includes $7,641,347,000 for NASA, a slight increase over the FY '86 total of $7,587,203,000. This does not include the cut of 4.3 per cent directed by a new Balanced Budget and Emergency Control Act, another $28 million slice this year caused by termination of the Advanced Communications Technology Satellite, or the impact of the January 28 tragedy which reduced the Shuttle fleet to three vehicles.

There is a new item of $45 million for "transatmos-pheric research and technology" to develop a winged craft powered by ramjet, capable of taking off horizontally, reaching low orbit, and returning to Earth at will – two hours New York to Tokyo, Reagan said. This is considered a likely successor to the Shuttle.

★ ★ ★

The current television commentators unfamiliar with the U.S. Space programme's history and unwilling to learn something about it, reacted hysterically on February 15 when William Rogers, chariman of the presidential commission, asked the acting NASA administrator to remove certain personnel from the investigating activity.

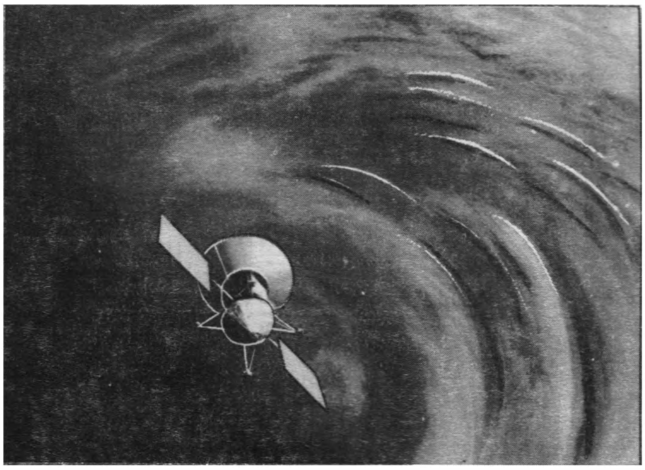
Rogers said that since the January 28 decision to launch "may have been flawed," those involved in the decision-making process should not investigate themselves. While Rogers did not name individuals, this was taken to mean the directors of Kennedy and Marshall Space Centers plus the programme manager at Johnson Space Center.

After the 1967 Apollo fire the administrator, James Webb, appointed a board of inquiry which did not include those actively involved in the test when the spacecraft burned.

★ ★ ★

Washington news bureaux also reported February 15 that Acting NASA Administrator Graham issued orders requiring Shuttle programme managers at the manned space flight center to report directly to him. This was reminiscent of Webb's action following the fire 19 years ago when he gave Boeing a special contract to look into the way the agency managed Apollo. It became infamous in the field centers as the Boeing TIE (technical integration effort) because other major contractors would not open their books to Boeing. When the effort was finished, Webb thought he had a modified system that would keep him fully informed at the programme management level, instead of through his field center directors. Men like Wernher von Braun, Kurt Debus and Robert Gilruth did not appreciate the implications of such an arrangement.

Venus Radar Mapper.



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Five unmanned launches are currently scheduled this year. A NOAA GOES-G weather satellite will be flown on Delta, May 1. A Navy navigation satellite will be launched by Atlas Centaur during the summer. Another defence payload will be launched by Delta August 18. NOAA will sponsor a second launch October 9 of GOES-H aboard Delta. Navy will sanction a second navigation satellite mission aboard Atlas Centaur November 6.

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The Aerospace Safety Advisory Panel warned in January 1985 that extra precautions were necessary because of the stepped-up pace of Shuttle launches. "The standard set during the first 15 safe and successful missions is admirable and commendable," the group wrote. "To maintain or improve on those standards will require exceptionally perceptive management and disciplined execution of the programme."

The panel was created in 1967 following the Apollo 1 fire which killed Astronauts Virgil Grissom, Roger Chaffee and Edward White. The Hartford, Conn, Courant reported February 8 that Shuttle inspections formerly conducted by full time inspectors are now performed by the workers themselves. As many as 18,000 fewer inspections are routinely performed on Shuttles because of changed NASA policy.

★ ★ ★

The Presidential Commission investigating Challenger's unexpected end arrived at the launch base February 13, for closed hearings of witnesses involved in NASA's probe. The group held a public session in Washington February 11, because of press reports that a NASA budget analyst had warned, in July 1985, that O-ring seals on SRBs might lead to a catastrophic failure. Chairman William Rogers, lawyer and once Secretary of State, handled the witnesses like a prosecutor as if to defend the space agency against its employee. Richard Cook held his ground and said he was leaving NASA for a more desirable job with the Treasury. His superior recalled the warning memo, said he talked to his superiors about it, and all hands were inclined to dismiss it because Cook was not an engineer.

Appointed Feburary 3, the commission also includes Neil Armstrong, deputy chairman, now chairman of Computing Technologies for Aviation, Inc. of Charloettesville, Virgina. He is also a member of the National Commission on Space and the Apollo veteran who walked on the moon.

Brig. Gen. Charles Yeager, retired, broke the sound barrier and was the first pilot to exceed 1,600 miles per hour in December 1953. He is also a member of the National Space Commission. Dr. Sally Ride, first U.S. woman in space, flew on STS-7 June 18, 1983. She is a physicist and mission specialist. Dr. Albert Wheelon, another physicist, is a vice president of Hughes Aircraft. Robert Rummel, formerly a TWA vice president, heads the firm of Rummel Associates of Mesa, Arizona.

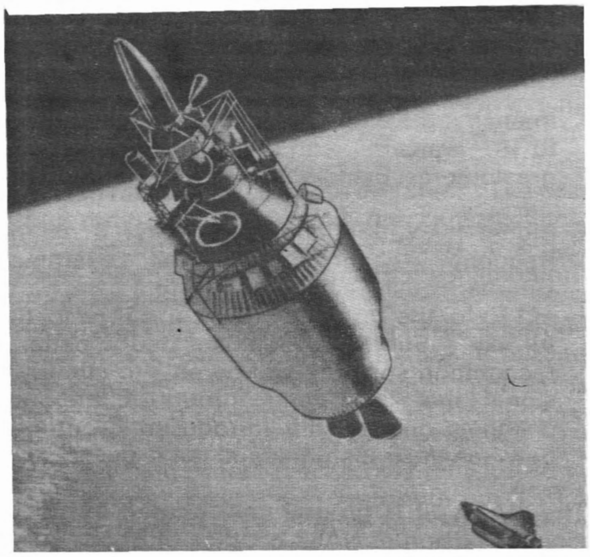
Dr. Arthur Walker, Jr. is a Stanford University professor of applied physics. Richard Feynman is professor of theoretical physics at California Institute of Technology and won a

Nobel prize in 1965. Eugene Covert is aeronautics professor at Massachusetts Institute of Technology and consultant to NASA on rocket engines. Robert B. Hotz is the retired editor of Aviation Week and Space Technology. David C. Acheson is a Washington attorney who was formerly vice president of Communications Satellite Corp. Maj. Gen. Donald Kutyna directs space systems, command control and communications for the U.S. Air Force.

★ ★ ★

The engineer in charge of SRBs at Marshall Space Flight Center, Lawrence Mulloy, said that if O-rings used to seal booster segments are found to have caused the mishap it could take from four months to three years to develop another solution or replacement.

★ ★ ★



An artist's impresison of the Galileo probe to Jupiter. It has now been delayed for at least 12 months.

The retired Army commander who managed the von Braun team when America's space programme was in its infancy believes the nation invited disasters by turning over too much responsibility to aerospace and armaments industries. Major General J. Bruce Medaris, now a priest of the Anglican Catholic church, said the government had lost competence to inspect, control quality and ensure safety and reliability among thousands of suppliers like those working with NASA.

The major change in policy occurred in the early 1960s under the Kennedy administration when the Defence Department abolished Army's arsenal system, becoming wholly dependent upon private industry. That change did not immediately affect the Medaris-von Braun team which joined forces in 1955. Medaris retired in 1960 after President Dwight Eisenhower decided to turn von Braun and Co. over to the NASA set up in 1958.

★ ★ ★

Air Force Lt. Col. Robert Nicholson said the range safety officer, an Air Force member, had no discretion when he blew off nose covers of Challenger's solid rocket boosters. Both strayed beyond the pre-determined flight path which made their destruction mandatory although at the instant neither threatened any populated area.

★ ★ ★

The Presidential Commission investigating Challenger's fiery end began hearings February 6, in the National Academy of Sciences. NASA witnesses briefed members on the agency's manned flight organisation, Shuttle design, construction and operations. The interim inquiry begun by Associate Administrator Jesse Moore will continue as an arm of the commission. Dr. William Graham, acting administrator, did not appoint the formal Board of Inquiry suggested by Moore immediately after the disaster. Congress may or may not follow the Commisison with another probe. Reagan gave Chairman William Rogers, deputy Chairman Neil Armstrong and the other commissioners 120 days to complete the job.

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NASA's consistent, even monotonous claim that it would never risk astronaut lives – repeated by its political supporters including two members of Congress who flew as Shuttle passengers, came into sharp prominence during the Presidential Commission's investigation of Challenger's last, short flight.

The New York Times of February 9 quoted internal NASA memoranda warning that problems with O-ring seals employed at SRB mating could result in catastrophe, loss of mission, vehicle and crew. One such memo was dated in July 1985. Seventeen charred O-rings had been recovered with SRB cases after flight, suggesting that the plastic material was badly damaged by fire and pressure when the solid fuel ignited. The commission immediately called upon the agency to produce all such records.

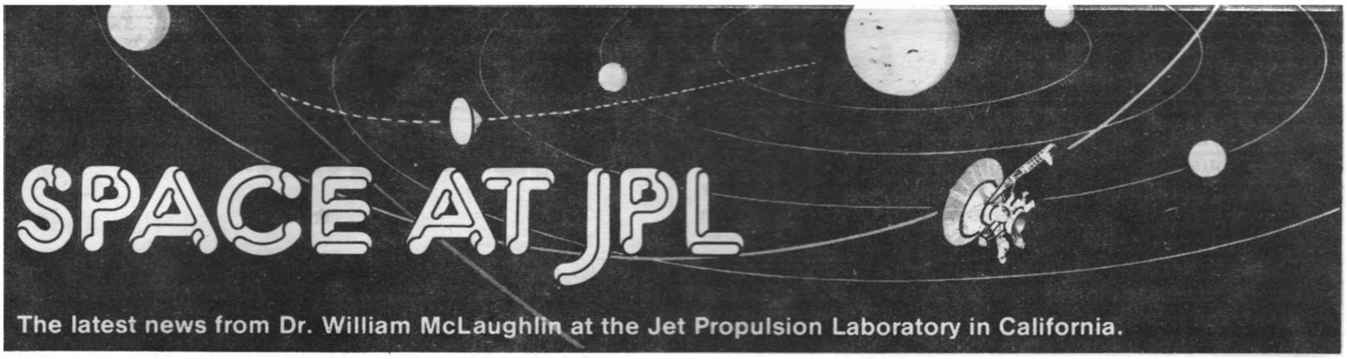
Whatever the outcome, the agency's record of 55 manned flights in 25 years came to a sudden halt January 28 with the worst space disaster of all time.

★ ★ ★

NASA has renamed two planetary missions which were supposed to fly in 1988 and 1990. A mission to map Venus, previously called Venus Radio Mapper, is now known as Magellan. The Mars Geoscience/Climatology Orbiter is now Mars Observer. Magellan will map Venus with a synthetic aperture radar instrument with subkilometre resolution. The spacecraft would orbit the planet every three hours as near as 250 kilometres from the surface. Mars Observer will map the planet to determine global elemental and minerological features and will record the Martian climate.

★ ★ ★

Dr. William Graham, acting administrator, relieved Philip Culbertson of his duties as NASA general manager February 16. Culbertson had held the post about two months, responsible for day-to-day operations. He will continue to work on long range planning. Charles Redmond, agency spokesman, said Dr. Graham indicated that given the conditions that followed the Challenger accident, what he called two-tiered management was cumbersom and he felt by taking direct control it would be more responsive to conditions. That change was followed up February 20, by announcement that Jesse Moore, associate administrator in charge of the Shuttle programme, would become chief of Johnson Space Center immediately. And former astronaut Richard Truly, a Navy rear admiral, returned as Moore's replacement. William Rogers, head of the President's investigating commission, called Moore's job change satisfactory because it removed him from control of the internal investigation of Challenger's loss.



Ploughmen to the Search

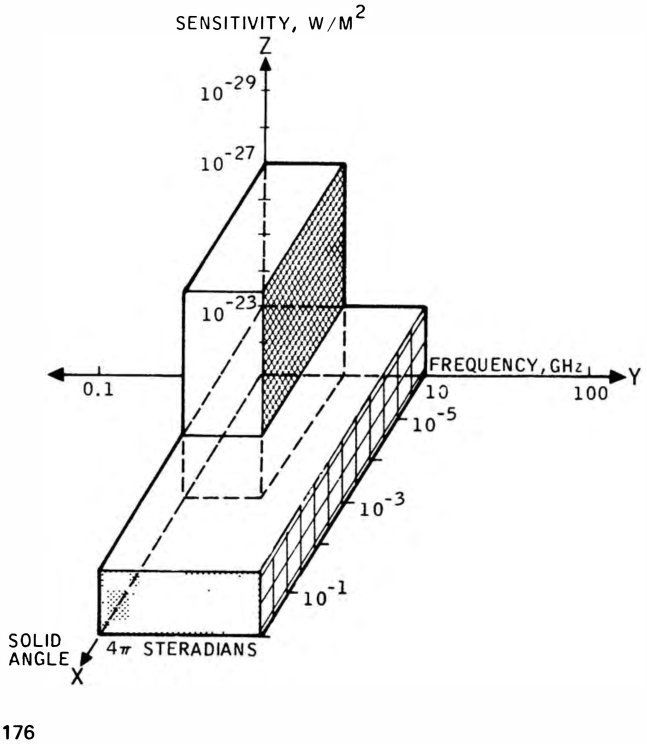
Since Frank Drake's pioneering Project Ozma, numerous attempts have been undertaken in the Search for Extraterestrial Intelligence (SETI), from spur-of-the-moment glances to systematic searches, and now a NASA SETI programme has been initiated with the intent of providing a wide-ranging search, yet one that is bounded in time, ending with the completion of a planned series of observations.

The systematic search started with Drake's Project Ozma. During May, June and July 1960, Drake employed a 26 m radio telescope at the National Radio Astronomy Observatory to examine the nearby, Sun-like stars Tau Ceti and Epsilon Eridani for signals of intelligent origin. The search concentrated near the 21 cm hydrogen line, which is favoured in SETI lore as a search frequency. For a tabular recapitulation of SETI efforts see [1].

The new search that is now being designed has strength in five key areas:

1 Area coverage: the whole sky will be searched.

The "SETI Cosmic Haystack" illustrates some of the properties of the two planned searches in the NASA SETI Programme: the All-Sky Survey and the Targeted Survey. The former covers the entire sky in a broad range of microwave frequencies. The latter looks at reduced ranges for spatial and frequency coverage but investigates stellar systems of interest using high sensitivity. NASA



2. Selectivity: although the whole sky will be observed, Sun-like stars within about 75 light years will independently be examined as part of a targeted search.

3. Frequency range: the search will cover a very large frequency range, 1 to 10 GHz (3 to 30 cm) for the All-Sky Survey, 1 to 3 GHz for the Targeted Survey.

4. Intensity: the entire sky will be observed down to 10^{-23} watts/m^2, with the selected portions of great interest being observed to 10^{-27} watts/m^2.

5. Signal resolution and complexity: 8 million frequency channels will be examined simultaneously, each one having a bandwidth of 1 Hz for the Targeted Survey and 32 Hz for the All-Sky Survey. Sophisticated pattern-recognition software will be able to identify a signal that is drifting through contiguous channels due to shift introduced by motion between the transmitter and the receiver.

The NASA SETI programme, funded by the Life Sciences Division of NASA's Office of Space Science and Applications, began in 1983 with a five-year initial preparatory phase. The goal of the programme is to carry out the dual-mode strategy (targeted and All-Sky) in the 10 years from 1988 and 1998. The necessary instrumentation will be built between 1988 and 1992; and the last six years will be occupied with heavy observing.

The plan is to use *existing* radio telescopes. The giant Arecibo dish and a 64m southern hemisphere radio telescope would support the Targeted Survey of individual stellar systems, primarily stars of spectral classes F, G, and K (the Sun is spectral class G), and 34m antennae of JPL's Deep Space Network would be used for the All-Sky Survey.

The Targeted Survey would spend between 100 and 1000 seconds observing each star, taking an independent spectrum once per second. The All-Sky Survey requires about 10 hours per day of observing time in order to complete the programme in 10 years. Of this time eight hours would be spent on the search and two hours for set-up time and re-examination of possible detections obtained during the day's search.

For the All-Sky Survey the antenna beam will be swept back and forth across the sky in a boustrophedonic pattern as in ploughing! Consecutive scans are to be separated slightly less than the half-power beam width of the radio telescope, to aid in the

detection of enduring signals. An interesting question arises as to what power to set as the level (threshold) at which a possible signal is re-examined. If that level is set too high, the sensitivity of the survey would be adversely affected. If that level is set too low, the system would be flooded with "detections" (false alarms) caused by noise and there would not be enough time to re-examine all of them. Hence, the threshold will be set so that statistically one can expect to have only about five false alarms per observing session to look at again; this number is manageable.

The SETI Program Office is located at NASA's Ames Research Center. The programme manager is Dr. Bernard Oliver, who has long been a driving force behind the theory and practice of SETI. The deputy is Dr. Michael Klein of JPL, whose recent book on SETI was reviewed in the May 1985 edition of this column. The Targeted Survey is the responsibility of the Ames Research centre, while JPL will conduct the All-Sky Survey. Dr. Samuel Gulkis is the project scientist for the All-Sky Survey.

There are numerous facts and streams of thought that have led to the present NASA SETI programme, but a few major influences can be distinguished. After the Project Cyclops study in the early 1970's, which envisaged an array of 100 antennae or more, each of 100m diameter, SETI thinking turned towards "doing it with silicon rather than concrete and steel". The use of existing radio telescopes and the construction of efficient spectrum analysers was felt to be a better approach for an early search than the construction of large, new radio-telescope facilities.

This type of thinking was brought to the forefront in a series of workshops held at the Ames Research Center in the mid 1970s.The resulting report [2] is a fundamental SETI document. Informal discussions at JPL among Bruce Murray, Sam Gulkis, Dick Goldstein, Bob Edelson and others reached the conclusion that the Laboratory could best contribute to SETI by applying its expertise to build large digital spectrum analysers and through utilisation of the Deep Space Network. Neither type of facility would be easily available to private individuals.

A major boost for SETI came when the prestigious National Research Council Astronomy Survey Committee report (the commitee was chaired by Dr. George B. Field of the Harvard-Smithsonian Center for Astrophysics) recommended a modest level, long-term SETI programme that would be open to the general scientific community.

A second major impetus for SETI took place in 1983 when the International Astronomical Union (IAU) created Commission 51, to address the search for extraterrestrial life. With the formation of this body, a scientific forum for SETI now existed. In October 1983, the *SETI Science Working Group Report* [3] evoked a response from NASA, and the current programme became a reality.

Our gratitude is extended to Dr. Samuel Gulkis for discussions on the NASA programmes.

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[1] **The Planetary Report**, March/April 1983, p.19

[2] P. Morrison, J. Billingham and J. Wolfe (Eds.),**The Search for Extraterrestrial Intelligence**, NASA SP-419, 1977

[3] Frank Drake, John H. Wolfe and Charles L. Seeger, **SETI Science Working Group Report**, NASA Technical Paper 2244, 1983

Joint Plan for Saturn Orbiter

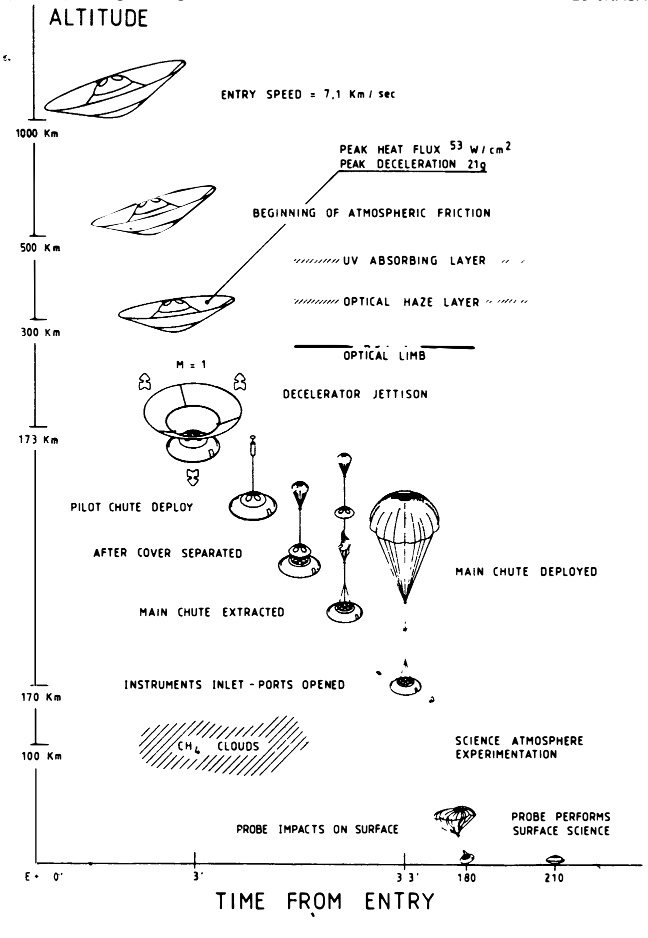
Comet Rendezvous Asteroid Flyby (CRAF) has been proposed as the first in a series of Mariner Mark II missions [1] and it is hoped that CRAF will be funded as a new project start for Fiscal Year 1988. Attention has already turned to the form of the second Mariner Mark II mission. Following the Galileo mission to Jupiter the next logical step would be a similar mission to Saturn.

A Saturn Orbiter/Titan Probe has been the subject of a recent ESA/NASA assessment study and may be the second Mariner Mark II mission. The proposal has been dubbed "Cassini" after the Italian-French astronomer Giovanni Cassini (1625-1712) who discovered four satellites of Saturn and the major division in its rings.

The basic mission scenario would begin with a Space Shuttle/Centaur G-prime launch in May 1994. The mass of the spacecraft relative to the launch-system capabilities precludes a direct flight to Saturn, so an Earth-gravity assist is planned (a so-called "delta-VEGA" manoeuvre, with "delta-V" representing the change in velocity and "EGA" an acronym for "Earth Gravity Assist", the source of the detla-V). The delta-VEGA is implemented by a three-year orbit around the Sun ending with a re-encounter with Earth, followed by a 4.5 year trip to Saturn.

Arriving at Saturn in January 2002, the spacecraft

The proposed ESA/NASA Cassini mission would release a probe into the atmosphere of Saturn's largest satellite Titan. An orbiting spacecraft would explore the Saturnian system for four years, perhaps beginning in 2002. ESA/NASA



would go into orbit about the planet with some help from a Titan gravity assist. After completion of the first orbit about Saturn, the Probe would be deployed into the atmosphere of Titan at 7 km/s. Probe data collected during its descent to the surface of the satellite would be relayed to Earth by the Orbiter. The Orbiter would continue to explore the Saturnian system for four years. The Probe would be built by ESA, the Orbiter by NASA.

Although Saturn has been explored to some extent by Pioneer 11 (1979), Voyager 1 (1980), and Voyager 2 (1981), these flyby missions have left many questions unanswered. The ESA/NASA assessment study lists scientific objectives in five categories: Titan, Saturn, rings, icy satellites, and magnetosphere of Saturn.

For example, a scientific objective with respect to Titan is to determine the nature and composition of the surface of this satellite, whose features are obscured by thick layers of aerosol. One model for the surface postulates hydrocarbon oceans, mostly of ethane, punctuated by a solid crust emerging in places from the ocean. A thick layer of organics, deposited from the atmosphere over geological periods, might cover the crustal upthrusts.

The actual structure of the surface could be investigated by both Orbiter and Probe with radar and infrared measurements from the former, visual and infrared observations from the latter. Several additional experiments can be considered if the Probe survives its landing on the surface and continues to transmit data to the Orbiter.

Another objective of Cassini ring studies is to investigate the interrelation of rings and satellites, including embedded satellites. The Voyager observations of the rings revealed an incredibly complex dynamical system. The narrow, "braided", F-ring is affected by two shepherding satellites, and several other nearby satellites have been proposed, but not observed, to account for F-ring dynamics. The presence of small satellites, or moonlets, has also been hypothesised, but not confirmed, within the main system of rings.

The solid-state imaging system of Cassini, with narrow-angle and wide-angle cameras, would allow a search for embedded moonlets as well as other aspects of ring structure such as correlations of ring morphology with the electromagnetic field.

Titan is the only satellite in the Saturnian system with enough mass to provide effective gravity assists for the Orbiter during its four year tour. Hence, Titan would be encountered more than 30 times in the tour: as an object of interest in itself and as a switching point, not only to the other satellites but also to desired points in the magnetosphere of Saturn.

Prior to encountering Saturn, Cassini would have two sojourns in the asteroid belt which would present excellent opportunities for encounters with asteroids. The first opportunity arises during the three year delta-VEGA loop. The large (114 km radius) asteroid Themis is a candidate for flyby in April 1996. The relative velocity at encounter would be a low 6 km/s. The second crossing of the asteroid belt, in the 4.5 year direct flight to Saturn after the Earth gravity assist, could feature a 16 km/s flyby of asteroid Viljev (10 km radius) in January 1998.

The structure of the Orbiter would be based upon the Voyager-type 10 bay, toroidal bus which provides a home for the electronics and a support for the high-gain antenna, RTG power source, Titan Probe, scan platform containing the remote sensing instruments, the fields and particles instrument turntable, etc.

Orbiter telecommunications would use X-band for uplink and downlink, and S-band and (possibly) K_a-Band for downlink. The X-band downlink data rate at Saturn would be somewhat over 19 kilobits per second.

Power would be supplied by radioisotope thermoelectric generators (RTGs) with 433 watts at launch, declining to 348 watts at the end of the mission.

The three-axis stablised spacecraft would employ a main engine with hydrazine bipropellants while hydrazine monopropollant is planned for attitude control to minimise contamination.

The dry mass of the Orbiter would be under 1500 kg.

The ESA Probe design features two major components: the high-speed deceleration system and the descent module. The deceleration system is used for braking during the entry phase of the mission in order to achieve subsonic speed high in the atmosphere of Titan so that atmospheric measurements can begin. The descent-module design employs a parachute. The total mass would be less than 200 kg for the probe.

The Galileo mission to Jupiter, scheduled for May 1986 launch, will follow-up the findings of Voyager and Pioneer with an intensive investigation of the giant planet. A logical next step in the exploration of the outer solar system would be to send Cassini to Saturn to perform a similar service. The mission would also continue the effective and enjoyable tradition of co-operation in space which has been growing between Europe and the United States in the last few years.

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[1] D. H. Collins and S. L. Miller, ***JBIS,*** 1986 (to be published)

Space Station Boosts Robotics

Artificial intelligence, robotics, teleoperation, expert systems, automation: these disciplines, and others, are emerging as the digital computer is being upgraded from the role of numerical device to that of assistant-to-humans. The Automation and Robotics Office at JPL is managed by Donna Pivirotto, who describes some of the activities in which her organisation is currently involved.

Two basic programmes are underway. The first seeks to develop the necessary core technology and the second will apply that technology to Space Station needs in the area of robotics.

The core-technology effort is being conducted not only at JPL but also at other NASA centres and in universities. Sub-disciplines include: sensing and perception (vision, touch, force); task planning and reasoning (artificial intelligence); operator interface (man-machine interface); control execution (mechanical); system architecture and integration. The concerted effort by NASA results from a congressional mandate to develop a plan for incorporating automation and robotics into Space Station and how to spin the technology off to industry. For Fiscal Year 1986 the sum of $5 million has been appropriated out of a total allocation of $205 million for Space Station.

An example of task planning and reasoning is the computer programme PLAN-IT, under development at the Laboratory. It builds upon previous experience with the construction of artificial intelligence tools (see "Space at JPL", *Spaceflight*, April 1985). As the name indicates, the programme will provide planning capability, a capability which will feed into subsequent applications in robotics. PLAN-IT also supports systems autonomy work now in progress at the Ames Research center, an action which is reciprocated by technological support from Ames for the JPL robotics work.

The Greek root "tele" means "far off" or "at a distance" and is used in compounds such as "television" and "telemetry". Thus, the discipline of "telerobotics" can correctly be supposed to combine the autonomy associated with a robot with human control from afar. The goal is to introduce telerobotics into Space Station at the appropriate time, ie. when the technological maturity of the programme, as shown by the demonstrations, fits the needs of the Earth-orbit facility. The first phase of Space Station in-orbit assembly is scheduled for 1992 and the Laboratory's support of Space Station with telerobotics will be acomplished through demonstrations in 1987, 1990, 1993 and subsequent years.

What is a teleoperated robot in this context, and what functions could it be expected to perform?. It will have two arms, vision and not be equipped with superhuman reach or strength. The reason for the latter limitations is that a Space Station requirement states all work in orbit must be able to be done by humans, in case of problems with the automated system.

Naturally there will be much assembly work in conjunction with the establishment of Space Station, and a prime candidate for telerobotic tasks is thereby indicated. Robots would hold lights for labouring astronauts, hold tools, or, in more advanced modes, snap together pieces of the structure. Robots can also be taught to focus their vision systems upon a designated part or particular human, tracking it as it moves about and supplying a picture to a desired work station. One scenario for assembly features five people outside the facility, working along with the robots, and three people inside operating the telerobotics systems.

Initially, the telerobots will be designed with emphasis on "tele", the autonomy of the "robot" will grow as more and more capabilities are removed from the human and transferred to the machine.

Work by the Ames Researach center in systems autonomy will also be displayed in a series of demonstrations. The first two demonstrations are scheduled for 1988 and 1992 and will address the automation of portions of mission operations for the Shuttle: communications, station scheduling, fault diagnosis, etc.

Eventually, the system-autonomy effort could translate into Space Station support through supplying autonomous subsystems such as power and life support and protecting the station and crew through automatic fault protection algorithms.

The entire effort within NASA seems to promise a happy blend of the things that humans do best with the capabilities of smart machines, working together towards a common goal.

FUTURE MISSIONS

James R. French, a member of the technical staff in the Spacecraft Design and Engineering Section at JPL provides a summary of planned and possible future missions.

Missions firmly in the schedule beyond Galileo and ESA's Ulysses are an interesting mixture orientated towards astronomy, planetary exploration, and Earth observation. Before the Challenger disaster additional flights were planned of the Shuttle Imaging Radar (SIR), a synthetic aperture radar capable of high resolution imaging from the Space Shuttle. In addition TOPEX, a free-flying spacecraft, will use radar to study variations in the surface of the Earth's oceans to understand current flows, bottom profiles and other significant characteristics.

Turning away from Earth, 1988 will see the launch of Venus radar mapping mission Magellan, planned to obtain 1 km resolution mapping of 90 per cent of the surface of Venus using imaging radar techniques. In 1990 the Mars Observer will be launched towards a low polar orbit of Mars to conduct a detailed study of surface and atmospheric constituents and the interactions between them. This mission is of additional interest because it represents the first use of a spacecraft designed for Earth orbit to investigate another Solar System body. A possible later mission in this series would be a rendezvous with a near-Earth asteroid.

In the field of astronomy, JPL has a major role in the Hubble Space Telescope, contributing two major instruments in one package which will use the telescope optics. The Wider Field/Planetary Camera comprises the Wide Field Camera for survey and mapping and the Planetary Camera for very high resolution work studying planetary surfaces as well as other demanding tasks such as looking for the tiny wobble in the motion of distant stars which might indicate the presence of planets.

Missions as yet not approved include the Mariner Mk II series of highly flexible, adaptable spacecraft for a variety of outer Solar System missions. The first for this series would include rendezvous with a short period comet with flyby of one or more asteroids enroute. The second mission would be a Saturn orbiter carrying a probe to be dropped into the dense atmosphere of the satellite Titan.

More ambitious missions yet to be firmly scheduled include a large autonomous unmanned rover vehicle for Mars. Scientists would also like to have sample Martian materials returned to Earth for analysis and various approaches to this goal have been studied. The Mars Airplane operated as a remotely piloted vehicle was discussed as useful adjunct to a manned mission. Manufacturing of propellants for return to Earth from Martian resources would greatly reduce transport cost for support of a large Mars exploration. Finally, high energy, low thrust electric propulsion using a nuclear power source offers the possibility of missions not achievable by any other means. An example is a spacecraft which could hover above the rings of Saturn for close observation.

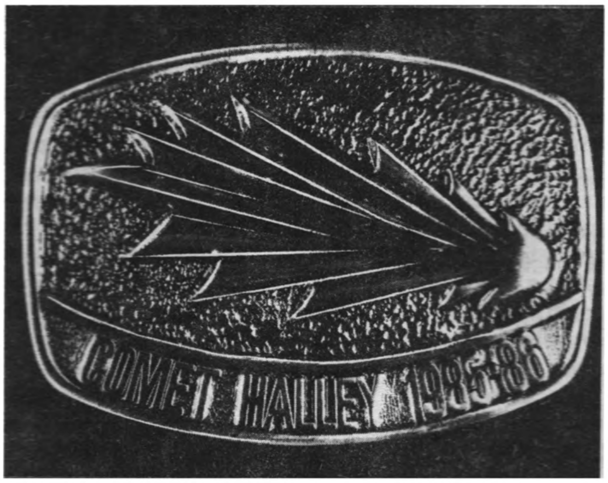
VINTAGE COMET

Among the more whimsical or romantic matters brought to light by current research related to comets (notably, of course, that of Edmund Halley) one of particular interest in the wine-producing areas of Europe, especially France, is the firmly established belief that a visiting comet will guarantee a good vintage for the year of the visit. This belief owes much to the fact that the passage of the great comet of 1811 (not Halley's) marked a year of quite exceptional vintage in both quality and quantity. So much so that there was a popular song in Paris cabarets around the end of last century which ran:

Each morning, after midnight
The Comet, rising high
Turned all the grapes to silver
With soft light from the sky;
Jealous of the Comet's work
The Sun gave warm, sweet days
Painting every laden vine
With pure gold from his rays.

Special bottles, bearing a moulded representation of a comet, were produced in substantial numbers (see page 370, September/October 1985 issue of *Spaceflight*). Ever since, the best champagne vintages have been bottled with a similar representation on their corks and/or their labels.

Unfortunately, reality does not confirm this relationship between heavenly visitors and heavenly vintages. For example, the last three returns of Halley's comet (1759, 1835 and 1910) were far from brilliant either for champagne or other wines, whereas there have been several "non-comet" years (the most recent 1983) when weather conditions similar to those of 1811 produced some very fine vintages indeed.

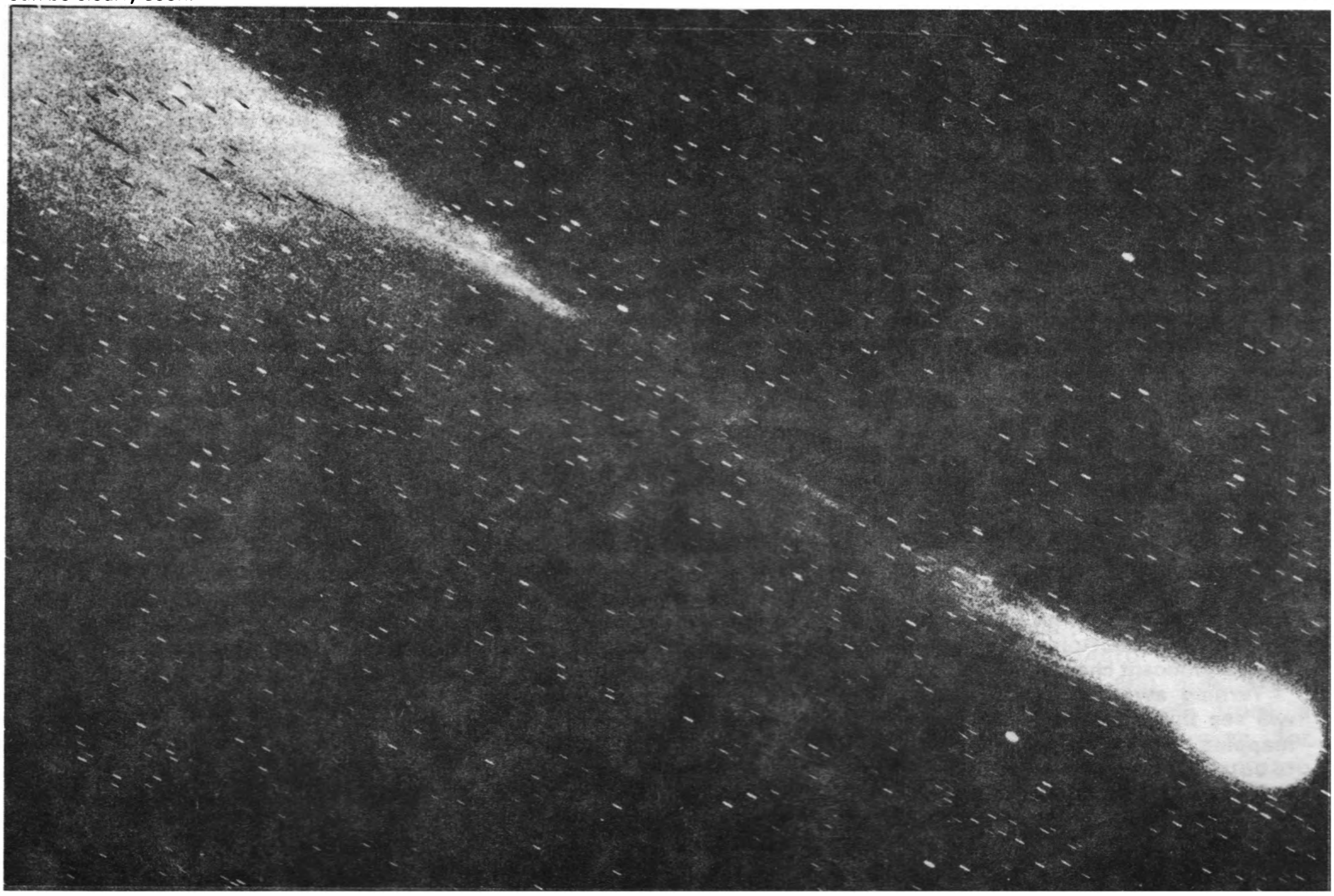


COMET BUCKLE

This Halley's comet item is a belt buckle on sale in the US and bought recently by Society Fellow Douglas Arnold. It is composed of "solid alloys finished in antique brass" and was created by Californian artist Michael West who based the design on the 684AD apparition of the comet, published in the Nuremberg Chronicle.

Nonetheless comet emblems have become established as indicating superb champagne, cognac and other vintages, and any reader of this note who is lucky enough to possess such a bottle might care to dedicate it to the BIS, for use according to ancient custom at next year's Halley celebrations. The empty bottle could then be preserved in the Society's museum.

Halley's comet photographed on January 10, 1986 at the Max Planck Institute for Astronomy, Heidelberg, Germany. Discontinuities in the tail can be clearly seen. *MPI*



GIOTTO SEES SOLAR FLARE

The Giotto probe has measured some dramatic effects caused by a burst of solar flares. One huge flare, very unusually coming up after solar minimum, was seen on February 6. By February 7, the shock wave in the solar wind caused by the flare reached the Earth causing disturbances to the magnetic field which were so great that the aurora was seen over southern England on the evening of February 8.

Meanwhile plasma experiments on Giotto were measuring the solar wind at a different part of the Solar System. At 0236 on February 8, a sudden increase was noted in the solar wind density, temperature and speed. An event like this is known as an interplanetary shock. Further events associated with the flare were seen on the two following evenings, including an increase in the helium content of the solar wind, a sudden drop in solar wind temperature, and other boundaries between different plasma regions. At one point the solar wind was travelling at the unusually high speed of 900 km/s (over 2 million miles per hour). The average speed is only 400 km/s.

Comparisons to be made over the next few months with other spacecraft nearer Earth should give information on the shape of this sudden and temporary protrusion of the Sun's atmosphere.

The aim of the MSSL-led Johnstone Plasma Analyser (JPA) experiment is to investigate the formation of the comet's ion tail. This is done by measuring both the ions from the solar wind which slow down and deflect around the comet and also the ions from the comet itself.

UPDATE ON BACKDATE

Although the earliest known recorded observation of Halley's comet was made by the Chinese in 240 BC, attempts have been made to determine its long-term motion back to 1404 BC by taking account of gravitational effects of other planets. [1].

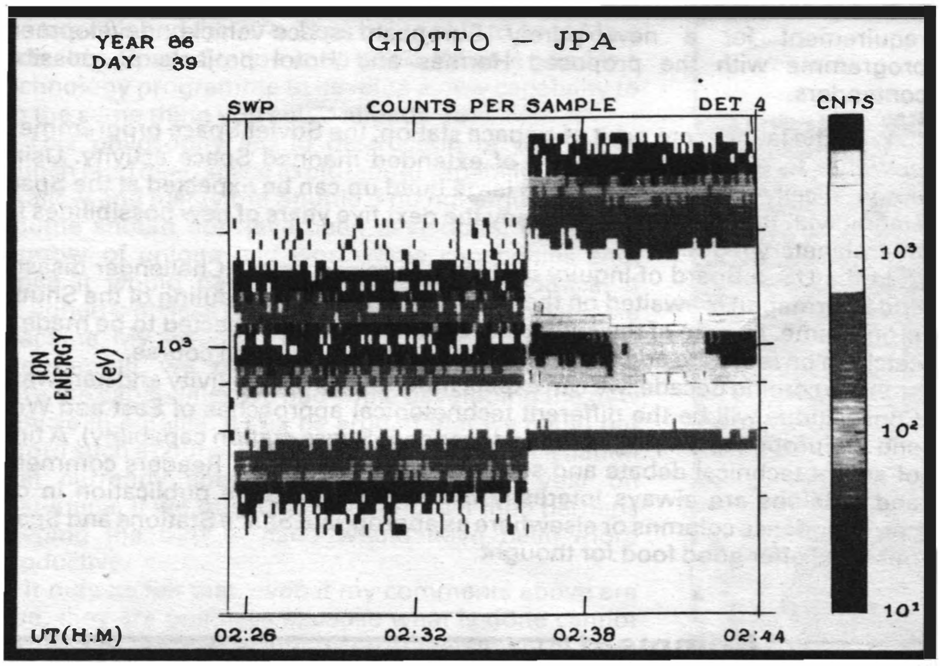
Generally, returns of the comet between 315 BC and 140 BC would have been hard to spot. Only two were really favourable (in 126 BC and 140 BC) with the latter seeing the comet pass the Earth within a distance of just 0.04 Astronomical Units (1AU = Earth, Sun distance).

The recent discovery of the Babylonian tablets recording the 164 BC return [2] and personal recollections of a Babylonian stele [3] of even earlier date invite speculation as to whether pre 240 BC observations of the comet really exist.

Apart from difficulties both in interpreting anything recorded and prolonged periods of cloudy weather, the 1985/6 return has shown how inconspicuous the comet can sometimes be, while the 1910 return amply illustrated the chances of more confusion with the appearance of the Great Daylight comet a few months before Halley. On the other hand, Halley's comet (now "middle-aged") would not have lost so much of its gases three thousand years ago.

References

[1] "The long-term motion of Halley's comet" by D. K. Yeomans and T. Kiang. Month, Not, R.A.S. Vol. 197 (1981) pp633-646.
[2] "Halley's comet and Babylon" by R. Stephenson, G. K. Yau. Spaceflight, Vol.27 (9-10) p.360.
[3] "From the Secretary's Desk" Spaceflight Vol.27 (9-10) p.370.



The Johnston Plasma Analyser (JPA) measures an interplanetary shock. The picture shows the detection of an interplanetary shock by the JPA instrument on ESA's Giotto spacecraft early in the morning on February 8, 1986.

In the plot 19 minutes of data from the Fast Ion sensor are shown. The solar wind distribution is measured once every 8 seconds. The vertical axis is energy/charge and the horizontal axis is time. The colours (here shown in black-and-white) represent numbers of counts detected at a particular energy, summed over all directions.

Before the shock two distinct peaks are visible. These are due to the solar wind protons (hydrogen ions, lower peak) and alpha particles (doubly charged helium ions, upper peak) which travel at almost the same speed. At the shock the energy of the distribution increases dramatically, corresponding to a speed increase from 370 to 430 km/s.

MSSL

SPACE STATIONS AND SPACE MISSIONS

Let us first recognise that putting a payload into orbit requires a massive propulsion system. Space launch vehicles look deceptively smaller on the TV screen than in real life! The case for optimising design could not be more overwhelming. So why do we not see the two Space superpowers doing the same Space spectaculars in the same way, both ideally optimised? The Space 'race', if that is what it is, has similarities with the athletics track. Competitors develop their own tactical approach according to their inherent strengths, immediate or long-term objectives and natural inclinations.

Soviet Space developments have been spectacular. The launching of the first Sputnik astounded the world as did the launch-vehicle capability that its size and weight implied. The event has since been repeated with larger payloads and larger implied launching capabilities. Automation and remote control first featured in Soviet lunar exploration and then in automatic docking in Earth orbit. The Soviet approach has centred round continuous evolutionary development of carefully selected basic technologies such as the two just mentioned to which may be added their system of land recovery by parachute and jet-braking. The evolutionary approach is commended by the many 'firsts' that it can claim particularly in the area of manned spaceflight, including the Space endurance record.

The US Space programme can be credited with Space spectaculars in the superlative. The Apollo lunar programme, which is now all but relegated to the history books, involved a whole range of new technologies for the manned exploration of an airless Moon. The US unmanned planetary programme has broken new technological ground in a different direction, whereas manned space flight has continued with Shuttle and Orbiter development and a whole range of new technologies, including those needed for the return of a winged vehicle from orbit to a runway on Earth. The US Space programme can be seen as a broad one in which radical conceptual changes have been accepted leading to a great variety of new in-space capabilities, spectacularly demonstrated.

With the approach of the 21st century, the major Space requirement will be for the transportation to orbit (generally to a space station) of large payloads, cheaply. Two types of Space transportation are foreseen. One is for an unmanned, unsophisticated cargo-carrying launch vehicle, which may be reusable (if the payload market is sufficiently large to justify the additional cost of reusability). The Shuttle clearly does not meet this requirement being manned, sophisticated and carrying to orbit only one quarter of the payload of a Saturn V.

The other type of vehicle will be for shuttling men and supplies between Earth and orbit. The Shuttle fulfills this role, but not cheaply. The Shuttle was designed for flexibility in its applications and not for cost optimisation. To illustrate the point, we have in the case of conventional aircraft, both experimental aircraft and operational aircraft. The Shuttle is the Space counterpart of the experimental aircraft, whereas what is needed is the Space counterpart of the operational aircraft. Europe is looking at this type of requirement for a new purely European space-vehicle development programme with the proposed Hermes and Hotol projects as possible contenders.

With the launch into orbit of a space station, the Soviet Space programme is now due to embark on a period of extended manned Space activity. Using automatically-docking satellites, a large build up can be expected at the Space station with the opening up, over say the next five years of new possibilities for interplanetary flight.

In the US, a Board of Inquiry is shortly to report on the Challenger disaster and information is awaited on the resumption and re-scheduling of the Shuttle programme. In spite of the setback every effort can be expected to be made to catch up on lost time and keep the Space Station project on course.

In the coming decade, we can expect mounting orbital activity and hardware. Conspicuous will be the different technological approaches of East and West and of Europe (now vying for an independent Space station capability). A time of ardent technical debate and soul-searching lies ahead. Readers comments and opinions are always interestly received for possible publication in our correpondence columns or elsewhere as appropriate.Space Stations and Space missions offer good food for thought.

Comment

New Missions Ousted By Technology Love

Sir, In reading "Space: the Long-Range Future" by Jesco von Puttkamer, (*Spaceflight* 1985, pages 348-354 and 395-400), I was struck by his quotation of a NASA study that what we really require for major space exploration efforts are: a heavy lift launch vehicle and a low cost means of transport to orbit. The reason that I find this striking is that we had these capabilities 15 years ago and discarded them.

The Saturn V had a demonstrated capability to place over 100,000 kg into low orbit and was potentially capable of a substantial upgrade. True, it was not reusable. However, it probably could have evolved toward partial reusability had we elected to apply the same heroic efforts to it that have gone into making the Shuttle SRB's "reusable". The magnificent Saturn now exists only in museums and the memory of those of us who helped develop it.

As for transport of personnel and smaller cargo, the Apollo/Saturn 1B combination with a cargo cannister riding below the Service Module could have delivered several persons and some cargo to a Space Station. An unmanned all-cargo version would also have been attractive for satellite launches and other cargo in the 25,000 to 30,000 kg range.

A Space Station comprising two second generation, refurbishable Skylabs docked end-to-end would have provided more volume than NASA's present concept will ever have. Further we would by now have eight to ten years of experience with long term operations in space rather than still waiting for the chance to begin such activities in perhaps another eight years.

To what malign influence can this waste of a tremendous capability be attributed? Simply to the characteristic of so many engineers and managers: the love of new technology. Space planning is dominated (in the US at least) by the spinoff mindset which implicitly states that space endeavours are not useful in themselves but only for the technology they generate. Such thinking seems to derive from the desperate efforts to justify space exploration in terms of frying pans and portable radios which characterised the late 60's and the 70's. Thus being able to go to Mars or build a Space Station is no good. What is good is a technology programme to develop a new capability to do the same thing you could already do.

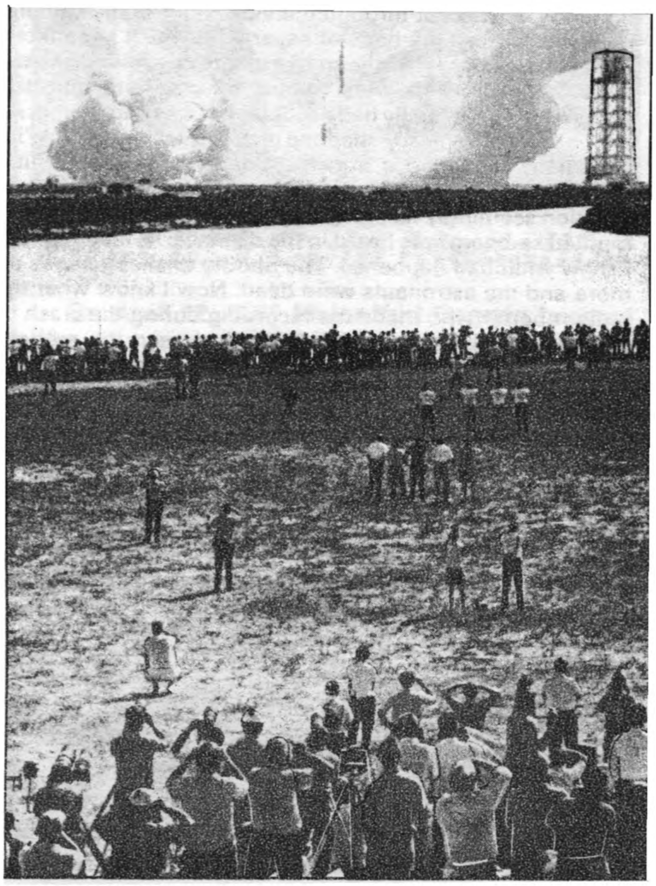
This philosophy led to destruction of our heavy launch (and deep space exploration) capability in order to allow and justify the Shuttle. I do not argue that the Shuttle should not have been developed. It offers a number of unique and worthwhile capabilities and, while it would have been far more economical if designed with less political help, it is still a remarkable machine. My argument is that, in a properly run space programme, we should have continued operations with the capabilities we had while developing the new vehicle in parallel. It will be argued that we could not afford such a course but that seems farcical for a nation that currently spends $1600 million per year on marijuana. If we truly could not afford it then perhaps keeping the bird in hand would have been more productive.

It may be felt that, even if my comments above are true, they are pointless because what is done cannot be undone. No one can argue the irreversibility of time, however, the study of history is worthwhile if we can learn from it. The point to be made here is that, since Apollo, there has been no focus upon doing missions. Instead effort is totally directed towards new development. This is a part of the reason why it would require 15 years to return to the Moon when it took only eight to go there the first time. Similarly, any mission to Mars will be far in the future because of the development that will be done whether it is really needed or not.

Like Arthur Clarke, I can think of no more appropriate celebration of the 500th anniversary of the voyage of Columbus than for a small fleet of spaceships to depart Earth en route to Mars. This is not impossible even starting now. But, I fear, it will remain only a dream stifled by unending planning efforts and studies which lead nowhere. We seem to be lacking an Isabella who will sell her jewels to back the expansion of human horizons; and we seem to be short of those with the spirit of Columbus to take the ships he found available and set forth rather than propose a new ship-building technology programme that might make it more comfortable to go exploring in the next century. We need Columbus' kind of vision far more than we need new technical breakthroughs.

J. R. FRENCH
California, USA

The Saturn V rocket, seen here in July 1969 at the launch of Apollo 11, demonstrated the capability of placing over 100,000 kg into low Earth orbit and was potentially capable of substantial upgrade.



CORRESPONDENCE

Recollections

Sir, I do not know how many of your readers witnessed the tragic Challenger accident from the Kennedy Space Center on January 28 but I thought I would send along some of my recollections of that day's events.

Having earlier toured the gargantuan flame trench and pad fixtures of the newly renovated Shuttle Launch Complex 39B at the Kennedy Space Center, I was anxious to see the first launch from the second Shuttle launch pad. The situation was better than I had hoped for – the Orbiter Challenger was fully visible from the press site and would provide the best ever view of a Shuttle launch. With launches from Pad 39A the presence of the Rotating Service Structure prevented viewers from seeing the vehicle until the tower was clear.

The chill Florida air had warmed slightly during the long two hour unplanned hold called to ensure that ice formation at the pad would not damage the fragile TPS tiles during liftoff. The familiar red glow (from TV) appeared under each Shuttle main engine at the T-6 second ignition time, and at T-0 Challenger rose off the pad on the distinctive twin pillars of flame from the SRBs. A sudden roar and the buffeting and rattling of the nearby press grandstand shattered the eerie silence of the launch (the pad is nearly five km distant after all, although it seemed to be closer than Pad 39A). This was the voice of the main engines, followed rapidly by an even louder noise and further grandstand buffeting as the SRBs made their contributions known. Unlike other launches the sound seemed to peak very rapidly and then diminished in intensity sooner than expected. Challenger's roll manoeuver and astonishing acceleration were especially thrilling on this day.

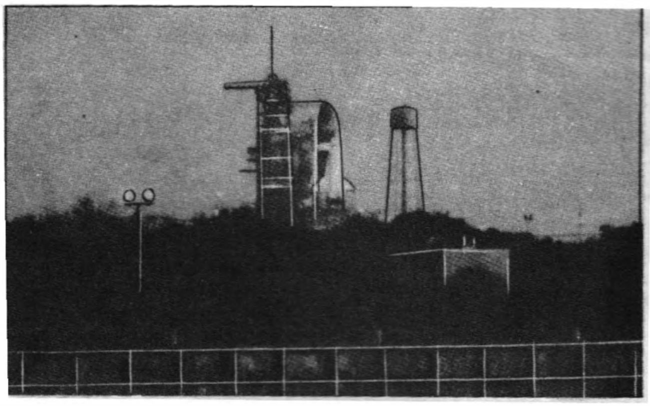
The Shuttle seemed to be heading almost straight up into the sky, a faint glow visible at the tip of the pure white smoke plume. Then, suddenly it seemed to me to stop. I was following the ascent through the viewfinder of my camera, hoping to record the booster separation which is perfectly visible in clear skies. As the smoke plume was rolling and the solid rocket boosters were veering off crazily to form the pattern of a 'Y', I literally had no idea what was happening. As my finger mechanically snapped pictures, I thought that "it" had finally happened, a launch accident and an abort. But it was too early for an abort! As I watched the enormous eruption seemingly fill the dark blue sky at 1139 local time, a muffled ka-boom was heard in the distance. At that moment I knew what had happened. The Shuttle Challenger was no more and the astronauts were dead. Now I know what the radio reporter who made the recording during the crash of the dirigible Hindenburg felt: I had just seen the modern equivalent with my own unbelieving eyes. The awful empty feeling and the anguished faces of the reporters and the lingering smoke cloud are something I will never forget. We were utterly helpless.

I think Steve Nessbit can be forgiven for his seemingly callous 'major malfunction' remark from Houston. Most of the reporters were out of sight of the TV monitors at the grandstand, and the launch and explosion scenes were not replayed (I had to wait until I arrived home late that evening before I saw those heart-rending replays). A few minutes later the SRB drogue parachute drifted out of the sky but that was all that was visible of the debris shower or the SRB destruction.

I don't know about you but the grief and the pain has turned to shock and anger as the incredible series of events leading to the disaster unfolds. It is going to be a very long year: shades of the Apollo 204 fire nineteen years-and-a-day ago...

JOEL POWELL
Calgary, Canada

The scene at launch complex 39B prior to the 51L launch on January 28. *Joel Powell*



March Issue

Sir, My congratulations to the editor of ***Spaceflight*** and everyone else involved with the March issue for the in-depth and thoughtful coverage of the Shuttle disaster. It must have involved considerable re-working of the issue at very short notice.

MIRIAM E. MASON
Redhill, Surrey

Sir, Just a few lines to say how much I enjoyed reading the March ***Spaceflight***. Several of the articles I anticipated in advance but your presentation was even better than I had expected. Congratulations on a magnificent magazine.

W. P. DILLON
Luton, Beds.

Ed. *Thank you kindly on behalf of everyone involved including the many BIS members who voluntarily provide the written contributions on which* ***Spaceflight*** *depends.*

Comet Port Wine

Sir, I quote from George F. Chambers' "The Story of The Comets", 2nd ed.(see 'Comet Wine' in *Spaceflight* 1986, Vol. 28, p.88) 1910 – "...The comet 1811 obtained in Western Europe and especially in Great Britain, fame of a very un-astronomical character. Its year of appearance was also the year of an unusually celebrated port wine vintage in Portugal, and the "Comet Wine" figured for a long period of years, first of all in the price lists of wine merchants, and afterwards in the cellar books of many private houses, and finally in the advertisements of auction sales. The last such advertisement which I remember to have seen appeared in the Times somewhere in the "Eighties", so the wine and the label thereof lasted long."

Sir Arthur Conan Doyle also appreciated this vintage, as he reveals in his story "The Stockbroker's Clerk". He causes Watson to observe – "...Then Sherlock Holmes cocked his eye at me, leaning back on the cushions with a pleased yet critical face, like a connoiseur who has just taken his first sip of a comet vintage".

It is possible that little of this vintage may still exist. I remember seeing, some years ago, port vintages in a strongroom in the Real Companhia Vinicola vinyards, which spanned years back to 1800. I cannot remember whether a comet vintage was included.

MAX WHOLEY
Midhurst, Sussex

40th ANNIVERSARY

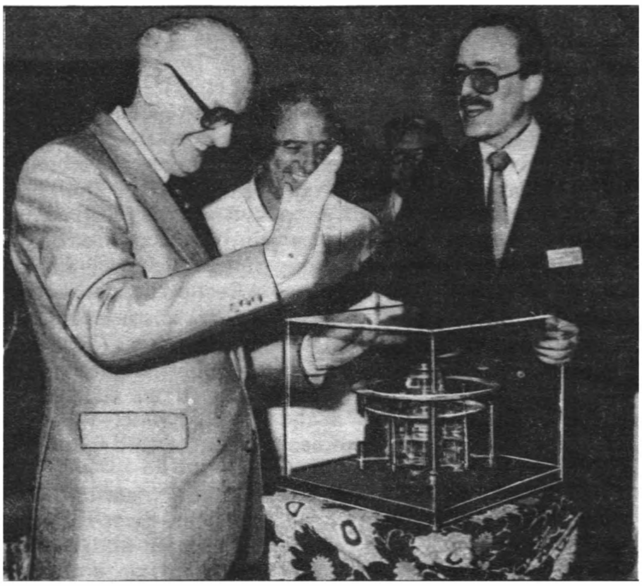
BIS Honorary Fellow Arthur C. Clarke, widely recognised as the "father" of satellite communications, has been presented by British Telecom with an Orrery clock. The presentation in Sri Lanka, where Mr. Clarke has lived for 30 years, was made by Mr. John Baker, Regional Director for British Telconsult, part of BTs newly-formed Overseas Division.

The clock is based on a model produced by George Graham in the early 1700s and copied by George Rowley, whose patron was the fourth Earl of Orrery. It shows the position of the Earth in relation to other planets.

The ceremony marked the 40th anniversary of the publication by Mr. Clarke of the principles of geostationary satellite communications and took place at an exhibition in Sri Lanka, where the Arthur C. Clarke Centre for Modern Technologies is based.

Presenting the clock Mr. Baker said: "Telecommunications are the infrastructure upon which the economic viability of nations depends. They turn the wheels of commerce and support our most vital social services. There are few people in the world today whose lives are not influenced in some way by satellite communications. By presenting this clock, British Telecom – as one of the world's major providers of international satellite communications – can in a small way pay tribute to the man who started it all."

Arthur C. Clarke (left) receives an Orrery clock from Mr. John Baker of British Telconsult. *Telecom Today*



GIOTTO ENCOUNTER

Our Executive Secretary, Len Carter, represented the Society at the European Space Operations Centre (ESOC) at Darmstadt, in Germany, on March 13 and 14 to witness the encounter of Giotto with the near-nucleus of Halley's comet.

Those attending heard a welcoming address by Professor Lust, the Director-General of ESA, followed by a number of papers on the scientific objectives of the mission, the spacecraft itself and its operational aspects. Also included was a report on the first Vega results from Academician Sagdeev, of the Space Research Institute at Moscow.

The Encounter programme appeared on Eurovision TV which included continuous status reports from the main control room with inputs from the Science Centre, the Flight Dynamics rooms, etc.

The closest approach to the nucleus took place at two minutes past one a.m. on the morning of March 14, a fact particularly attractive to our Executive Secretary since it coincided with his birthday.

Return to the hotel was in the early hours with another stint following later in the day with overviews of the encounter, given by Dr. R. Reinhard, the Giotto Project Scientist, and presentations by the 11 Principal Investigators.

First BIS Gold Medallist

On April 12, 1961 Major Yuri Gagarin became the first man to orbit the Earth. His Vostok spacecraft landed safety in a prearranged area in the Soviet Union ofter completing one orbit of the Earth in a flight lasting 1 hour 48 minutes. It is now 25 years later and man has walked (and driven!) on the Moon and pushed the Space endurance record to 237 days. Soviet cosmonauts have spent in total more than 10 man-years in Space.

Yet, it was Gagarin's flight that signalled the arrival of a new era of spaceflight and a new era in the history of mankind. Appropriately, the Society awarded its first Gold Medal to Yuri Gagarin, "in recognition of his achievement of the first manned orbital flight round the Earth". During a memorable visit to this country in July 1961, the medal was presented to him by the Society's President, Dr. W. R. Maxwell at the Soviet Trade and Industry Exhibition at Earls Court, London on July 11, 1961.

38th International Astronautical Congress

BRIGHTON, 1987

The 38th International Astronautical Congress is scheduled to be held in Brighton from October 11 to 16, 1987. The principal venues will be the Brighton Conference Centre and the Metropole Hotel. The International Astronautical Congress (IAC) is the annual conference of the International Astronautical Federation (IAF) and its associated organisations, the International Academy of Astronautics (IAA) and the International Institute of Space Law (IISL). This will be the third meeting in the UK of this major world space organisation

The International Astronautical Congress has been held every year since its inception, in late summer or early autumn. The meetings last for a week, during which the principal activity is the presentation of an extensive programme of lectures covering a wide range of subjects that relate to the exploration and exploitation of space. During the Congress, the General Assembly of the IAF (its governing body) meets in plenary session to conduct its yearly business, with the guidance of a Bureau made up of its elected officers. The membership of the IAA and IISL and their management boards also meet during the Congress, as do the many committees of the three organisations.

The International Academy of Astronautics and the International Institute of Space Law were founded by the IAF in resolutions adopted by its General Assembly at the 10th IAC which was held in London in September 1959. Since then these two organisations have held their own meetings and lecture sessions at the annual Congresses.

The IAC does not have a fixed venue, but is held in various countries which have member societies of the IAF. It is the accepted practice that a voting member-society invites the Federation to hold a forthcoming Congress in its respective country. If the invitation is accepted, that member-society is charged with the responsibilities of hosting the Congress in accordance with the requirements of the IAF Secretariat, Bureau and International Programme Committee.

Dr. L. R. Shepherd

The British Interplanetary Society, which is one of the 12 original founders of the IAF and is its UK voting-member, has been charged by the General Assembly with the task of organising the 38th IAC following the acceptance of its invitation to the IAF to hold the 1987 Congress in Britain. Dr. L. R. Shepherd, BIS Vice-President and Chairman of the Society's International Liaison Committee is responsible for international negotiations and is actively engaged with the hosting arrangements.

The IAC has been held, so far, in 21 different countries in North and South America, Europe and Asia and has grown enormously in scale over the years. Twenty papers were presented in the first lecture programme at the 1951 Congress in London. The number of papers now presented has risen to around 500, with authors drawn from all the major space programmes in the world. Over this period, the number of member societies and institutions of the IAF has increased almost six-fold from the original twelve and now come from 35 countries. Other UK members of the IAF are the Astronautics and Guided Flight Section of the Royal Aeronautical Society and two recently admitted institutional members, the British Aerospace Space and Communications Division and Logica Ltd.

BIS Officers for 1986

Rex Turner, Society President.

At its meeting in February, the BIS Council re-elected Mr. C. R. Turner as President for a second one-year term. Dr. L. R. Shepherd was re-elected Vice-President for a further year. At the same meeting Mr. G. W. Childs took office as a new Vice-President, succeeding Mr. M. R. Fry whose three-year term of office had expired. Following the recent elections to Council (reported in the March issue of *Spaceflight*) Mr. C. R. Hume, MBE, joins the Council for the first time.

Mr. G. W. Childs was educated at Eltham College, Mottingham, Kent and George Watsons Boys' College, Edinburgh before entering Bristol University to study aeronautical engineering. On graduating in 1956 he joined the De Havilland Aircraft Company, Structures Department as a stress engineer in a team carrying out design, structural analysis and development testing of the Blue Streak Ballistic Missile airframe. In 1960 he became Section Leader working on airframe structural analysis of the DH125 business jet. The following year he returned to space projects as Senior Engineer, Design Department of the Space Division, BAC carrying out design and development of the Blue Streak airframe as the first stage of the ELDO A launch vehicle as well as on future project studies for ELDO B and C and high energy upper stages.

In 1967-68, Bill Childs advanced from Engineer-in-Charge Vehicle Design to Deputy Chief designer, Space Division assuming wider responsibilities as Assistant and, then, as Deputy Departmental Head for satellite design and future

Mr. G. W. Childs

project studies. Between 1968 and 1973 he was responsible as Chief Designer for the design and development of a range of spacecraft including ESRO IV, X4, GTS and OTS; for developments of the ELDO Launch Vehicle first stage; for advanced technology developments on propulsion and for future project studies for spacecraft, launch vehicles and space transportation systems. In 1980, he resumed his association with space projects as Chief Engineer, Space and Communications Division, BAe, being responsible for the design, development and manufacture of spacecraft, vehicle systems and equipment, technology development and future project studies. His present position at BAe, Stevenage, is that of Chief Engineer (Mechanical Equipment).

Mr. C. R. (Bob) Hume received his early engineering training in the Royal Electrical and Mechanical Engineers. He served in the ranks and was commissioned at the age of 23 from Warrant Officer. He attended higher education courses and served in a variety of posts mainly associated with the maintenance of anti-aircraft equipment. While commanding anti-aircraft workshops he produced schemes for improving the accuracy of fire and for this was appointed a Member of the Military Division of the Order of the British Empire in the New Years' Honours List of 1951. He went on to serve in MI10 and retired from regular service in 1957, when he joined the De Havilland Aircraft Company as a Senior Trials Engineer.

Bob devised a system of interlocking instructions subsequently called Contractors Standard Procedures which were used for the first launch of the Black Knight research rocket at Woomera in June 1958. These were used for setting up of the site and rocket and during the Countdown. He then transferred to the Blue Streak Project and became Chief Trials Engineer responsible for the development static firings of the Blue Streak rocket at Spadeadam during the period 1960-1963. He was appointed Deputy Officer in Scientific Charge (DOISC) on behalf of the Ministry of Aviation, of the F1 Blue Streak launch at Woomera and spent the period from August 1, 1963 to December 16, 1963 preparing the launch site and conducting the first static firing with a development model rocket. This series of tests was considered by the senior Ministry of Aviation Officer in Scientific Charge to have strongly contributed to the smooth operation of the Trials Team in the F1 trial. Bob continued as DOISC throughout the F1 trial leading to the launch on June 5, 1964.

On returning to the UK, Bob led a team of engineers at Hawker Siddeley to propose for the first ESRO contract for a scientific satellite known as ESRO II. On winning the contract he was appointed Project Manager and Chief Engineer. The programme schedule, starting on December 1, 1964 led to a launch on a Scout rocket in May 1967. Unfortunately, a malfunction occurred during 3rd stage burn and the 4th stage did not ignite. As a result the ESRO II satellite failed to orbit as planned. The back-up satellite was successfully launched a year later and performed its mission completely. The project was a trial blazer in ESRO, later to become ESA, and many notable European space personalities including Roy Gibson, Professor Lüst, Dr. Edgar Page, George Van Reeth and Ants Kutzer were part of the overall management team.

In 1967 Bob Hume moved to the RCA Space Center at Princeton, New Jersey and became a member of the Vice-Presidents Staff as Manager of Programme Management. During the 13 years at RCA he was associated with all the RCA Space Programmes including TIROS and DMSP. Bob was particularly involved with space communications, managing the RCA Satcom programme in 1973 and 1974 which was the first three-axis communications satellite using frequency re-use and which flew on the first Thor Delta 3914 launcher. He also managed the Anik B communication satellite programme with duel frequency usage which had not been previously accomplished.

Management of the Viking Lander communications system and the colour camera on the Moon were also part of his responsibilities. Viking Lander gave the first pictures of the Mars surface while the colour camera gave TV pictures world-wide of the Apollo 15 mission from the Moon.

Mr. C. R. (Bob) Hume

In 1979 Bob returned to Europe and became a consultant. During the next three years he consulted for various companies, although mainly for Matra. Whilst with Matra he acted as Proposal Manager for the Satcom International's Aussat bid. Arising from this experience he suggested the need for a new satellite bus which eventually became Eurostar.

In April 1983 he joined Marconi Space Division at Portsmouth to manage the Skynet 4 Military Communications Payload and Ground Equipment Project. This design was completed by Marconi who manufactured 85 per cent of the payload equipments at Portsmouth. Since December 1984 an engineering Model and two Flight Payloads have been completed ready for assembly to the satellite bus. Latterly, Bob has been appointed Business Operations Manager at the new Marconi Space Systems Ltd. (MSSL) including Skynet, Olympus, Meteosat and ERS-1.

He has published 12 papers and lectured in Europe, USA and Australia. In his long experience in Space he has met many well known space personalities and astronauts together with appearing on TV and radio in all three continents.

SPACEFLIGHT BY AIR MAIL

With this issue of ***Spaceflight,*** the Society offers an Air Mail delivery to overseas readers in non-European countries. This service is now possible following the introduction of new label addressing equipment at the Society's Offices. The advantage is considerable for readers in the US, Canada, the Far East and Australia who exprience delivery times of four to six weeks by surface mail.

Requests for Air Mail delivery need to reach the Society by the 14th of the month to be effective for the next month's issue and should enclose a remittance of US$2.50 (£1.50 sterling) per issue for each remaining 1986 issue.

LIBRARY REPORT

Main Library

Our Society is continuing to make a strong and positive effort to establish itself as a Centre of Learning, with its Library and proposed archives as essential aspects of this work.

Interest in the Library's collection of books and reports continues to grow, as borne out by the increasing number of members seeking to research some aspect of space activity. The early decision to specialise our collection has proved of great benefit. Although a representative collection of popular works is still held, most volumes are specialist works printed in relatively small numbers and not thus easily available elsewhere. This, at the same time, explains the slow growth in our collection. We no longer merely add books but include only those specifically required.

Our current Library stock is as follows:

Books	2,600
Reports	4,700
Total	7,300

Among recent works presented to us was a book of Tycho Brahe from Donald Larson, one on Space Law from Paul Sowerby, a History of Rockets and Space Travel from Francis Fears, an Encyclopaedia of Space and many incidental publications by Michael Stone and a Biography of John Glenn from Kimperley Baker. There was also a book on comets from Mike Hendrie while two books, duly inscribed by their author, arrived from Henry S. F. Cooper Jr with a note offering help in obtaining other similar material of interest. Captain John London produced a number of interesting papers and an Apollo recording, while even back issues of "Spaceflight" which proved very useful, arrived with a number of photographs from Phil Heard.

Our thanks go to all these donors both for their generosity and goodwill.

Society Records

One of our main activities, surprising thought it might seem at first sight, is to endeavour to collect early Society records and to create an archive of Society activities.

Little has survived the years but John Maynard produced some early magazines, correspondence and similar items which threw light on the immediate post-war years. We still lack much to do with our early meetings, including the two London Congresses of the International Astronautical Federation held in 1951 and 1959, but are still hopeful that such material will turn up.

First Day Covers

The Society's collection of First Day Covers has now reached a respectable size, as also has its collection of space medallions. Most of the latter are of relatively recent vintage, for example a specimen of the AIAA 50th Anniversary medallion kindly given by Jim Harford. It seems unlikely that we shall have the good fortune to accumulate early comet medallions, though we have found one contemporary with Cheseaux's Comet of 1744 and the gold coin issued within a year or two of the appearance of the Crab Nebula in 1054.

Special thanks are due to Keith Wright and Rex Hall, who have continued to supply European and Soviet covers respectively, and to Gisela Grunewald, Chief of the UN Postal Administration, for a complete set of all UN covers relating to space, as well as to Geoff Perry – among many others – who provided occasional gifts.

We have, somewhat incidentally, managed to accumulate a collection of space stamps. One very nice albumn contains a complete set of Apollo-Soyuz stamps from all over the world, together with the signature of Aleksey Leonov and Valeriy Kobosov, who took part in the ASTP joint flight from 15-21 July 1975.

Our thanks are due to Eric Stevens, representative of a number of members who have forwarded space stamps to us.

Archive

We have identified an initial target of duplicate copies of some thousands books and reports, grouped under a number of headings, worth holding in a permanent collection for a basic Society archives.

An account of a few of these appear below:

(a) Notwithstanding that Halley's comet proved a disappointing object to the casual observer, our collection of memorabilia and general books on comets is now representative and approaching 80, all of recent vintage.

(b) A new venture lies in building up a collection of early Prints relating to space. Such items usually sell at a premium. It is somewhat late in the day to start such a collection but it is essential to do so if our Society is to become a full repository of space learning.

(c) We have started a special collection of biographies and of books and literature written by or relating to astronauts, space scientists, space engineers and pioneers of astronautiacs. There is still a long way to go in this area.

(d) The same applies to books on eclipses of the Sun and transits of Mercury and Venus most of which are now regarded as antiques, but there is better news on the star maps front. Here, although most early items are denied to us by virtue of cost, we already have a good holding of current material.

(e) The proposed sound archives received a boost with a collection of Shuttle launchings from Esa Anttolainen and a tape recording of the first Blue Streak launching from Professor Ian Smith. One

Society Fellow Douglas Arnold was among those at the memorial service in the USA for the seven Challenger astronauts and he took these pictures. On the left Neil Armstrong can be seen talking to Karl Henize, Spacelab 2, and Owen Gasriott, the Spacelab and Shuttle veteran. On the right some of the bereaved families join other mourners before the President's arrival.

problem with sound recordings are that they come in differing shapes, sizes and sound tracks, so we will one day have the considerable problem of placing all these on a standard basis.

(f) We have also been fortunate in adding a few more space models to our Library display, with one from Bob Hume and another from President Layton at RCA. All who use the Library find them attractive and hope to see the collection enhanced. As it stands, we still have another 20 to find.

Future Plans

The Library Committee has identified a need to make our HQ as interesting as possible to members and visitors. Knowing that this cannot be done immediately, they have set up a 25 year plan, with actual progress depending on enterprise, support from members and the availability of finance.

CHESEAUX'S COMET OF 1744

Cheseaux's comet must have been a most beautiful object. Its remarkable form was at its clearest on March 8, 1774 when all six divergent branches of its tail extended from the nucleus in luminous curves.

The Library Committee had cause to re-examine this striking event from the past on the acquisition of a German Medallion, issued in the same year. This Medallion shows the comet poised above a tree-lined landscape but, surprisingly, with only two well-defined tails, though there is suspicion of a third (a jet) between them.

The reverse contains the inscription "Wer hat des Herrn Sinn erkannt? – a Biblical reference to Romans Ch.11, V.34. Translated into English this reads: "Who knows the mind of the Lord?".

SPACE STATION EXPLOITATION

Such has been the demand to participate in the Society's forthcoming symposium on Space Station exploitation, scheduled for May 21 and 22 next, that practically all places were taken before the programme had even been formulated.

The meeting, the third in a series devoted to studies of the Space Station, is designed to break new ground. The aim is to provide a series of updated overviews on progress – political, administrative and technical – followed by updated accounts on advances in the technology but with the main thrust devoted to utilisation.

In general terms, the aim is to consider a "user-friendly" Space Station and develop techniques of how this might operate in the most effective manner. At the same time, ideas are needed for new users for the Space Station, some of which are mere gleams in the eye at present. The range of uses involves both science and industry, frequently on an international basis.

In the current meeting microgravity aspects are developed further, together with, particularly, papers exploring biomedical and bioprocessing aspects. Breaking yet further ground is another paper on how the Space Station might be used for pharmaceutical research and manufacturing.

What a crew! Bill McLaughlin, Voyager Flight Engineering Manager (left), Len Carter, BIS Executive Secretary, and Donna Wolff, deputy Voyager Flight Engineering Manager, discussing the finer aspects of the Voyager spacecraft, while standing in the Voyager Mission Support Area at the Jet Propulsion Laboratory. The picture was taken during Mr Carter's visit to JPL for the January Voyager encounter with Uranus (see *Spaceflight*, March 1986, for report).

PROMOTION

We have frequently urged members to make known the Society's aims, activities and publications to friends and colleagues, whenever they have an opportunity of doing so. For most members, this is a matter of individual conversation but many other opportunities can arise, as our postbag testifies.

For example, Mel Smith referred to the Society in his book "An Illustrated History of the Space Shuttle" while Tim Furniss did the same in his "Guinness Book of Space Flight Records". A paper in the *Reader's Digest* for September 1985 on SETI quoted a comment from Dr. Tony Martin, a former Vice-President of the Society, while Tim Furniss surfaced yet again in *Flight International* of October 19 last, this time recalling the pressures exerted by the Society over the past 25 years for the establishment of the British National Space Agency. David Hardy, too, gave several mentions to the Society in his articles in *Space Voyager*, during which he referred readers to both ***Spaceflight*** and ***JBIS***.

THE PERSEID PROJECT

Members may be interested in exercising their astronomical talents in support of a good cause by associating themselves with this Project. The basic idea is to raise funds for the National Society for the Prevention of Cruelty to Children through sponsored meteor watches – and members do not have to be experienced observers to take part!

The project runs from July 23 to August 20 when the Perseids regularly give high rates and outside temperatures are reasonably good. Observers are sponsored by friends and relatives for each meteor observed, and just a couple of hours of observation spread over a few evenings should suffice. Sponsorship forms and Report sheets can be obtained on receipt of an SAE from British Meteor Society, (Perseid Project), 26 Adrian Street, Dover, Kent, CT17 9AT.

MEETINGS DIARY

All meetings unless otherwise stated are held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ.

9 April 1986,7-9 pm **Lecture**

AN ENCOUNTER WITH COMET HALLEY – dust impacts on-board Giotto

by Professor Tony McDonnell

Exploring a cometary nucleus at the closest distance ever, dust impact sensors of the DIDSY experiment on Giotto recorded the bombardment by the comet's dust grains of the meteroid shield.

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

14 May 1986, 7-9 pm **Lecture**

ARTISTS IN SPACE

by David A. Hardy

Chesley Bonestell is without doubt the 'Old Master' of astronomical art. But there were artists painting the landscapes of other worlds many years earlier – some very accurately. David Hardy shows examples of these, and of the many space artists at work today, and explains how our view of the universe has changed since the turn of the century.

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

21-22 May 1986 **Symposium**

SPACE STATION EXPLOITATION

A two-day Symposium on the above theme considering the scientific and industrial opportunities offered by the Space Station and free-flying platforms and the problems of management and buisiness planning to ensure both technical and economic success.

Registration details available on request.

7 June 1986, 10 am – 5 pm **Forum**

THE SOVIET SPACE PROGRAMME

Offers of papers are invited. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £5.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

11 June 1986, 7-9 pm **Lecture**

PROSPECTS OF A MANNED MARS MISSION BY THE YEAR 2010

by J. Daniels, *University of Leicester*

After completion of the Space Station in the mid 1990's one possible goal of the US and its partners is a manned mission to Mars. This lecture will examine the why's, how's and prospects of an actual mission by 2010.

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

26-28 September 1986 **Conference**

SPACE '86 – PROFILES OF THE FUTURE

A weekend conference at the Brighton Centre including Civic Reception and banquet. Programme includes:
Advancing Frontiers
Space probes
Deep Space Astronomy
The Space Station
Living in Space
Details from: The Executive Secretry, British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

19 November 1986 **Symposium**

SPACE TRANSPORTATION

A one-day symposium on the above theme. Offers of papers invited. Potential authors should contact the executive Secretary. Registation details available on request.

LIBRARY

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

9 April 1986
14 May 1986
11 June 1986

Whilst 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.

BIS Staff Vacancies

The Society has vacancies on its staff for the following positions:

1. **An audio-typist with opportunities arising for conference administration.**
2. **An experienced word processor operator to work on Decmate II for publishing work. We will cross-train if necessary.**

Members who require further details or who may know of someone interested in either of these positions should contact the Society's office, 27/29 South Lambeth Road, London, SW8 1SZ. Tel: 01-735 3160.

Space Manufacturing 5: Engineering with Lunar and Asteroidal Materials

Eds. B. Faughnan and G. Maryniak, AIAA, 1633 Broadway, New York, NY 10019, USA, 268 pp, 1985, $49.50.

The 30 papers in this volume are grouped under space manufacturing and solar power satellites, space transportation and mass drivers, space stations and habitats, materials processing, biomedical and social matters, international and economic considerations, ending with a poster session.

The concept of processing lunar and asteroidal materials has been around for quite some time but has invariably been relegated to the far future. It is only recently, with the advent of comet probes and proposed asteroid sampling probes, that the concept has entered the realm of reality. In the case of the Moon, for example, the reasons are not far to see, for the energy costs of lifting materials from the Moon to orbit is less than one twentieth that of lifting the same materials from Earth to orbit, not counting the fortunate fact that the Moon has vacuum environment.

In the case of asteroids it may also prove feasible to alter their orbits to more convenient paths. Studies of the asteroids, however, are still in a primitive stage. Although some have been classified according to their probable compositions, much is entirely speculative. The actual choice of minerals to be sought, too, has varied enormously, ranging from outsized diamonds on the one hand to the manufacture of propellants (and/or water) at the other with, in between, a search for rarer elements. All this underlines that this is an area still containing an unduly high proportion of speculation, so the need for detailed investigation is acute.

Although this book goes into the far future, including space law, nuclear waste-disposal and problems for a new civilisation, it does not consciously set out to make the case for a return to the Moon in a political sense.

Monitoring Earth's Ocean, Land and Atmosphere from Space – Sensors, Systems and Applications

A. Schnapf, AIAA Marketing Dept, 1633 Broadway, New York, NY 10019, USA, 1985, 830pp, $79.

This is a comprehensive survey of the past, present and probable future remote sensing projects of many countries.

Following an overview of the problems and opportunities provided by remote sensing both of the Earth and space, several chapters examine the history of meteorological and environmental satellites over the past 25 years. Upper atmosphere satellites are also studied leading, in due course, to the Landsat series.

Sensing of the oceans occupies a substantial part of the book for this is obviously an area in which much has both been done and yet remains to be done. This is followed by a description of many International Remote Sensing Programmes, including Meteosat, ERS1 and the proposed Japanese Marine Observation Satellite (MOS-1) scheduled for launch this year.

A short section is included on remote sensing opportunities available from the Space Shuttle, the volume ending with an analysis of future NOAA requirements, spaceborne active laser sensors and multidisciplinary Earth observations from space platforms.

Space Shuttle Log

T. Furniss, Jane's Publishing Company Limited, 238 City Road, London, EC1V 2PU, 1986, 128 pp, £6.95.

Contrary to the view of the general public, Shuttle flights are far from almost-routine missions. Those interested in the details of individual flights yet frustrated by the lack of media coverage, which leave many unsure of the objectives of certain flights or ignorant even of the names of the crews, will find this book fills the gap.

It is divided into four parts viz the Shuttle-based Space Transportation System, its development and how it works: a log of missions so far – including a complete cargo manifest: a look at future missions: and a biographical guide to all who have flown or is currently scheduled to participate in Shuttle flights.

Towards Columbus and the Space Station

DGLR, Godesberger Allee 70, 5300 Bonn 2, Germany, 1985, 380 pp, Special Price to BIS Members $24.50.

This volume contains the proceedings of an International Symposium held last year organised by the DGLR and co-sponsored by a number of space organisations, including the BIS.

It is not often that the proceedings of such a Symposium appears promptly afterwards but, in this case, the secret lies in the fact that reproduction has taken place from the original manuscripts – so the price paid is one of unevenness in style and presentation.

Even so, this is a most topical volume which presents a good account of Europe's planned and potential involvements in the US Space Station programme. Of these, Columbus represents a major first stop and thus underlines the opening appeal by Claude Nicollier to give greater attention to the need to start now to provide more opportunities for a manned European space presence.

1985 World Satellite Almanac

M. Long, Comm Tek Publishing Company, PO Box 53, Boise, Idaho 83707, USA, 1985, pp.544, $39.95.

This volume is divided into two parts. In part one, chapters one to four introduce basic satellite transmission and reception techniques. The remaining four chapters provide comprehensive descriptions of various telecommunications systems currently around the world, as well as those planned for the future.

In part two, chapters nine to eleven give individual descriptions of more than 70 domestic, regional and international satellites positioned in geosynchronous orbit, described in order of their orbital assignment.

Each satellite description includes a technical account of the spacecraft and background information on the organisation responsible for orbiting the system. In most cases, operational or planned satellite services are also described. A reference chart which follows in most cases summarises the basic technical and other data for each satellite.

Chapter twelve consists of no less than 15 appendices on a variety of related topics, including the Shuttle and Ariane deployment schedules for 1985-1987 and directories of satellite operators, manufacturers and service organisations.

Milestones

February

4 Contract for launch by Arianespace of the fifth European telecommunications satellite, ECS-5, was signed.

5 British National Space Centre announces £3m in cash support for proof-of-concept studies of the British Aerospace/Rolls Royce Hotol spaceplane. Half of the cash to be provided by industry.

6 Presidential Commission began hearings at the National Academy of Sciences into the Challenger accident. Given 120 days to complete the job.

7 ESA science programme committee gives its approval to the Soho and Cluster missions which form the Solar Terrestrial Physics cornerstone to ESA's long term scientific plan.

10 NASA announces formal postponement of the Ulysses, Galileo and Astro-1 launches as a result of the grounding of the Shuttle following the mission 51L launch disaster.

16 Dr. William Graham, NASA acting administrator, relieved Philip Culbertson of his duties as NASA general manager.

19 EXOSAT completes 1000 days in orbit, having made over 2000 observations of cosmic X-ray sources for the European Space Agency.

20 NASA announced that Jesse Moore, associate administrator in charge of the Shuttle programme, would become chief of the Johnson Space Center. Former astronaut Richard Truly, appointed as Moore's replacement.

20 Soviet Union launches a new Space Station into Earth orbit. Called Mira, it boasts six docking ports and individual cabins for crew members.

22 Ariane gets back into business with the launch of the Swedish Viking satellite and the French Spot satellite.

25 James Beggs submitted his resignation as NASA administrator, a position he held since July 10, 1981. Beggs was named in an indictment charging General Dynamics and four current and former executives with improper accounting on a defence contract.

March

4 Soviet Vega 1 probe transmits TV pictures of Comet Halley for 90 minutes from a closing distance of 14 million kilometres.

6 Vega 1 approached within 9,000 km of the Halley nucleus.

7 Divers begin the grim task of recovering Shuttle Challenger's crew compartment found by sonar equipment on the ocean floor.

Comet Fever

D. Gropman, Simon & Schuster Inc. P.O.Box 102448, 68 Annex, Atlanta, Georgia 30368, USA. 1985, 189pp, $7.95.

Nostalgia is by no means a thing of the past, as is amply borne out by this book which concentrates on the return of Halley's comet in 1910 and which affords the most useful comparison with the euphoria surrounding the current apparition.

It appears that obsession with Halley's comet reached a peak in the 1910 return, leaving in its wake madness, suicide and terror, gallows humour, comet cocktails and dances!

Startled by "scientific" announcements of the day, a semi-panic reached a crescendo when the Earth, reputedly, passed through the comet's tail. In Constantinople (now Instanbul) tens of thousands of terrified people packed services at churches while "hoards of Londoners roamed the streets all night" (sic). In Paris, the elite gathered for soirees on hotel rooftops.

Comets have long enjoyed fame of being mysterious and powerful objects but, if the current return is anything to go by, one's impression is that much of the furore has been artificially drummed-up by the media, the comet itself being very much of a non-event as far as an ordinary man in the street is concerned.

However, in spite of all that, Halley's comet is a most absorbing object, as are practically all accounts about it. This volume is one which is greatly to be commended. It recaptures the flavour of the 1910 return with its many quotations from the media and illustrations of the memorabilia of that time.

DO YOU REMEMBER?

25 Years Ago...
12 April 1961. Yuri Gagarin becomes the first human to enter space. Gagarin, aboard Vostok 1, completes one revolution in a flight lasting 108 minutes.

20 Years Ago...
16 March 1966. Gemini 8 achieves the first docking in space when it links up with an Agena. A faulty thruster aboard Gemini causes the mission to be terminated early, giving a total flight time of just over 10 hours.

15 Years Ago...
1 April 1971. The Canadian-built International Satellite for Ionosphere Studies (Isis 2) is launched into polar orbit by Thor-Delta. The satellite measures electron densities in the ionosphere.

10 Years Ago...
22 March 1976. Scientists are invited by NASA to submit proposals for experiments to be flown on the first flight of Spacelab, then planned for 1980.

5 Years Ago...
12 April 1981. A million spectators view the launch of STS-1, the first Space Shuttle mission, from Launch Complex 39A at the Kennedy Space Center. The crew, John Young and Bob Crippen, put *Columbia* through a series of flight tests during the succesful 54 hour mission.

K.T. WILSON