ESA's Spacelab

Research is the watchword

Spacelab offers scientists unique conditions for future research. **Stuart Sharrock** describes how

THE pioneer phase of manned spaceflight is now over and plans are well advanced for the exploitation era due to begin in 1980. NASA's Space Shuttle will reduce transportation costs and expand the potential applications of space technology by removing many of the constraints imposed by conventional launch vehicles. Spacelab is intended to capitalise on these principles.

A re-usable manned space laboratory with comparatively low operating costs for applications-oriented and scientific experiments, Spacelab is being developed by the European Space Agency (ESA) as a joint European endeavour and will be launched into near-earth orbit in the cargo bay of the Orbiter section of the Shuttle. Thus Europe is for the first time embarking on a new phase of space technology simultaneously with the United States.

The emphasis of the ESA's programme is on satellites for telecommunications, meteorology, Earth resources surveying and air and maritime traffic control. Scientific research is an important but by no means dominant component; the scientific satellite programme concentrates on upper atmosphere and magnetosphere research and astronomy, particularly in the X-ray and γ-ray regions. Spacelab complements these programmes to provide a balanced package of scientific research, but though maintaining the balance, not all future projects under consideration by ESA are likely to be funded. Areas of research will inevitably suffer as the emphasis shifts towards usage of major facilities, but the dwindling national programmes in Europe might be steered to help cover the gaps.

Where Spacelab fits

The Orbiter section of the Shuttle can be launched into near-Earth orbits of various inclinations with an altitude range of 200 to 900 km and a flight time of from 7 to 30 days. Equipment may be placed in orbit or returned for servicing and evaluation after the Orbiter has returned by landing like a conventional aeroplane. The Shuttle concept can be used for launching and servicing satellites, but the accessible range of orbits is limited and conventional 'throw away' launch vehicles will remain necessary unless the inter-orbit 'Space Tug' under consideration by NASA becomes a reality.

Spacelab is a particular unit that slots into the cargo bay of the Orbiter. It is of modular design with two basic building blocks: a pressurised module providing a 'shirt-sleeved' environment for a manned laboratory connected to the living quarters of the Shuttle by a crawl-tube; and an unpressurised pallet on which instruments can be mounted and exposed directly to space. Various combinations of module and pallet are possible, providing a versatile manned space laboratory with a typical experiment payload of 5 tonnes. Up to four instrument operators can be carried (two are planned for the first flight); they will need a scientific background but do not have to submit to astronaut training—the standards required will be similar to those of commercial airline flight engineers.

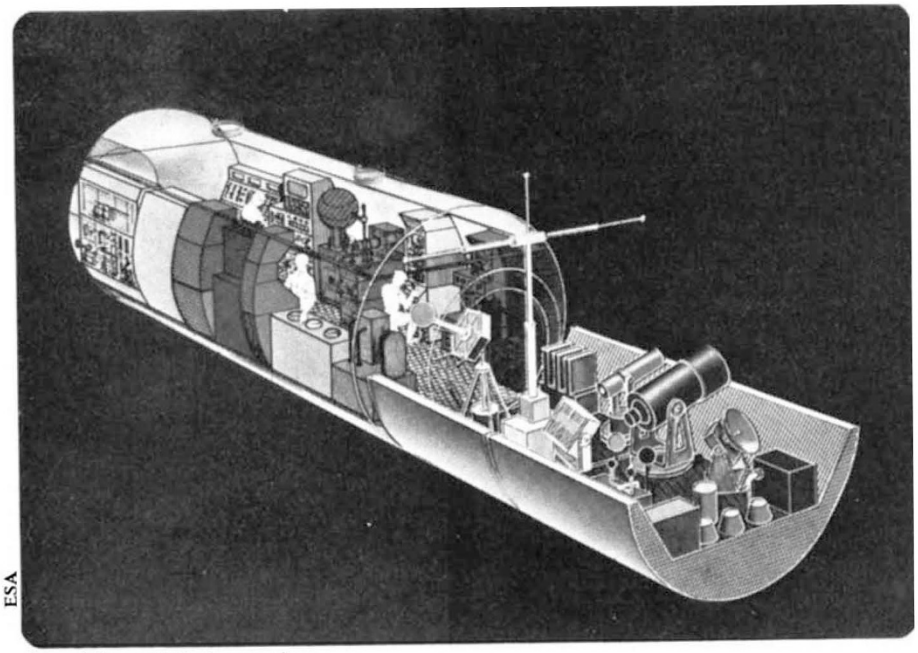
The immediate advantages of this arrangement are that the stringent requirements on weight and volume that bedevil satellite experiments are relaxed, although the problems are to some extent transferred to the strict safety regulations necessary to protect the instrument operators. Existing requirements based on astronaut protection are unnecessarily severe for Spacelab, though some amelioration remains possible. Previous manned spaceflights which have shown the advantages of having operators for some classes of experiments have mainly involved man either as an experimental subject or in his capacity as a dexterous machine; the decision-making capabilities of man in connection with an experiment have yet to be fully exploited. Re-usability is an important new facility: equipment can then be flown many times rather than abandoned at the end of each mission. Perhaps of greater significance is the ability to return materials processed or separated in a space environment and the means of collecting large volumes of data, stored for example on film, beyond the capability of feasible data transmission systems.

Cost immense

Clearly the cost of such an enterprise is immense; the design, development and delivery of one engineering model and one Spacelab flight unit is estimated at around $500 million at mid-1975 prices. Currently the cost of the Spacelab project is under review and, according to ESA, "severe cuts in the deliverable hardware will be necessary in order to accomplish the development project within the established funding ceiling"—not an unusual problem in these times of high inflation.

Value for money is possible if frequent use is made of the facilities. Spacelab is intended to be carried on around 40% of the Shuttle flights and is designed for a minimum of 50 seven-day flights, or about 10 years of operation. This schedule allows the lead time for experiments to be much reduced from the present position with satellite projects. The advantages are clear; the realisation depends largely on funding and management.

Such a large international venture can easily become constipated by its own administration. The Spacelab concept can only be a success if flexibility is maintained for much longer than in



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Spacelab: artist's impression

earlier space projects, but the organisational and management structure have at the same time to cope with an unprecedented mixture of political, financial, technical and scheduling constraints. Major efforts are being made to provide a structure capable of reacting sensibly to these problems.

Experience from previous manned space missions has been invaluable. It is generally agreed, for example, that insufficient thought and preparation went into many experiments conducted aboard Skylab, and a far greater degree of control is being exerted over Spacelab proposals. A simulated Spacelab mission was conducted in 1975 to test out the role of the instrument operators on board Spacelab and the suitability of the proposed management procedures. Short lead times for experiments were demonstrated to be practical, results being obtained from experiments executed only 16 months after proposals were requested, but the mission highlighted the need for greater integration of the instrument operators with the evolution of experiments, and a second more realistic simulation mission is planned for May 1977.

Spacelab research

Areas of research in which Spacelab will provide a valuable addition to satellite facilities include astronomy, atmospheric and solar physics and earth observation. Long continuous periods of observation are often required in these fields and Spacelab is seen as an intermediate step towards mannable orbital systems containing heavy and complicated astronomical equipment that would require regular maintenance; these 'Free-Flyers' would be serviced via the Shuttle.

The use of Spacelab simultaneously for astronomical and Earth observations clearly presents problems, and future Spacelab flights will be dedicated to specific areas of research. The flight profile is not really suited to investigation into the magnetosphere and certain atmospheric phenomena, and in these fields of research Spacelab will be used primarily as a satellite launcher, particularly as the Shuttle is liable to pollute the environment. Measurement of this pollution in terms of emitted gases and magnetic fields is one of the primary aims of the initial Spacelab flight.

For the life sciences and materials science Spacelab will provide a new opportunity for the study of fundamental problems in an environment unattainable on Earth. Additional benefits for the life sciences are the availability of a wide spectrum of high energy particle radiations, whereas materials science and plasma physics welcome the ready attainment of a vacuum over large volumes and the possibility of studying processes under containerless conditions.

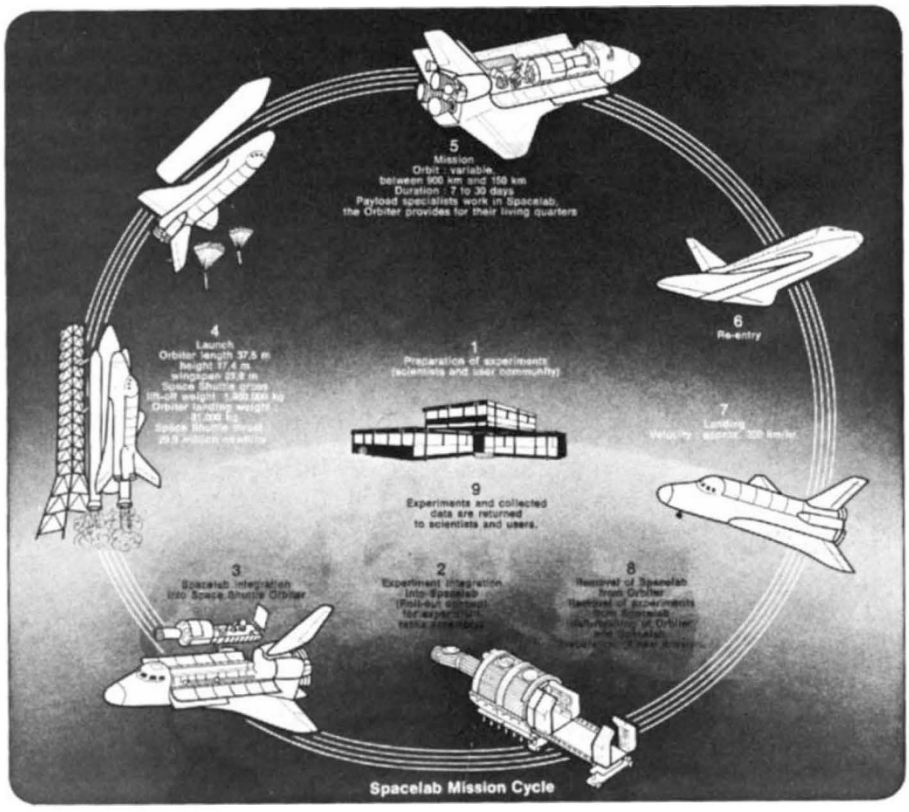
The effects of weightlessness and radiation on biological systems are the major areas of interest in biomedicine on Spacelab, and the first payload will include a Space Sled facility for studying the effects of acceleration on astronauts under weightless conditions. Materials science experiments require steady conditions which preclude the use of the Sled and spacecraft manoeuvres—luckily the majority of these experiments are of short duration.

Commercially the field of materials science offers immense potential and this is reflected in the set of experiments recently chosen as the payload for the first Spacelab flight where materials science experiments outnumber those in all other disciplines. The effective absence of gravity ($<10^{-4}$ g) removes convection and buoyancy effects, so enabling fundamental physical and chemical processes to be studied in the absence of otherwise maskings phenomena and allowing the production of novel and improved materials.

In ESA jargon Spacelab is a 'Special Project'—a programme in which participation by all member states is not mandatory. Countries participating in the finance of the project get a proportionate share of the contracts and use of experimental facilities. The major contributors to Spacelab are Germany (53%), Italy (18%) and France (10%). The initial Spacelab flight in mid-1980 is a joint ESA/NASA mission in which the available facilities are shared equally between Europe and America. The primary objective of the first flight is to demonstrate the capability of Spacelab for space research and to check out all the support systems. Experiments therefore receive second priority, although 100 man-hours have been allocated to them and the necessary test programme restricts the power available to experiments to around 30% of that ultimately to be provided.

In spite of the limited experimental facilities available on the first test flight, the response to the call for experimental proposals has been high. Of over 2,000 applicants, a total of 222 have been accepted, providing 77 experiments from 16 countries. Some proposals were no doubt motivated by the feeling that previous Spacelab experience will carry weight in proposals for future flights; others sprang from uncertainties concerning the funding of these future flights, although these fears will be groundless if Spacelab can be used with its planned frequency.

NASA will charge around $10 million to launch each subsequent Spacelab mission. Details of how this cost will be distributed between participating states within ESA and the experimenters have yet to be worked out. This cost is small compared with the investment, and it will be a pity if details over funding jeopardise the exploitation of Spacelab. It will be a disaster if ESA's future proposals for a balanced scientific programme are affected. □



Spacelab Mission Cycle

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