ПРИЛОЖЕНИЕ

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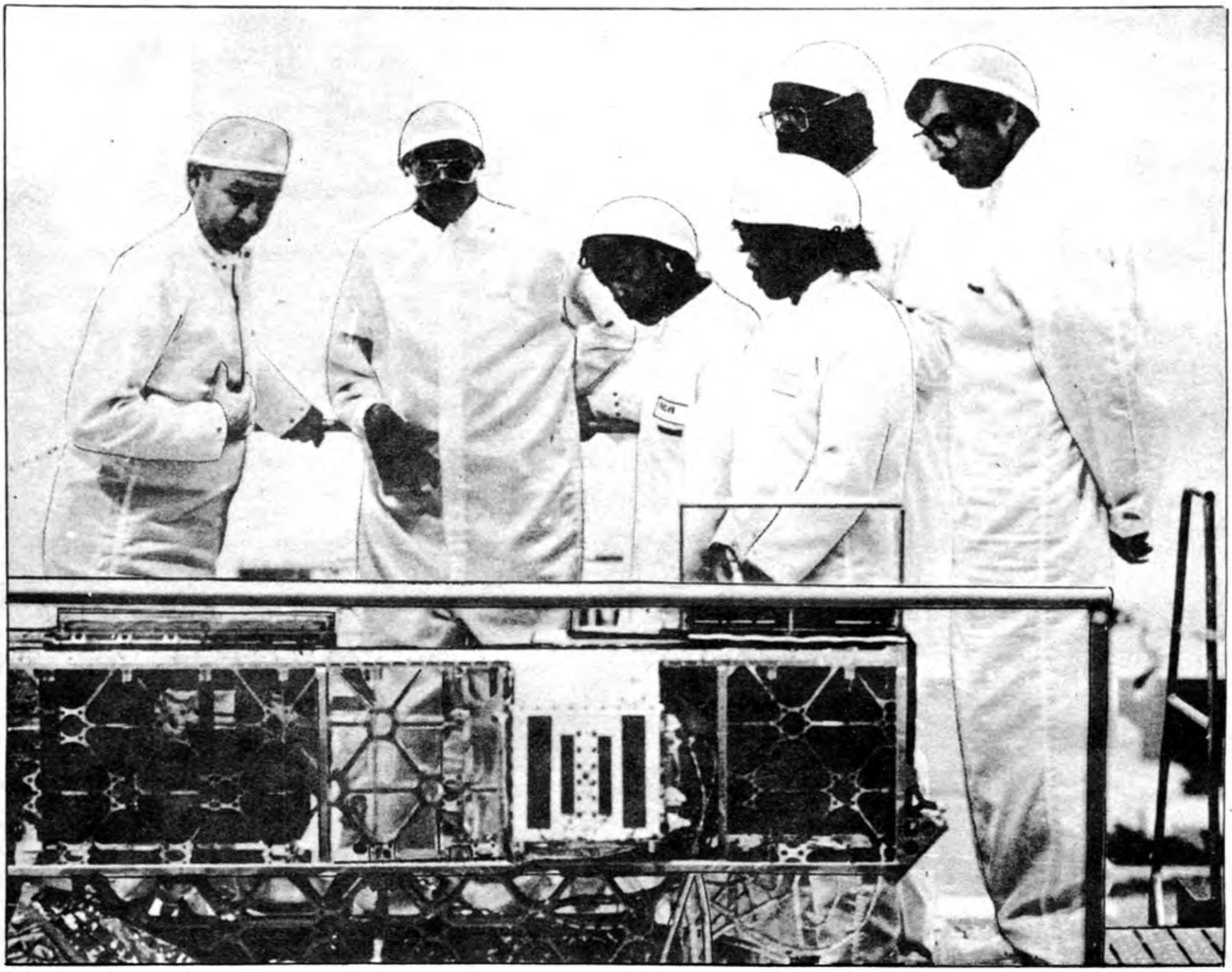
THE ORBIT '81 STUDENT PROJECT

By Nicholas E. Steggall



An RCA engineer, left, tells Camden High School Orbit '81 students about the workings of a weather satellite.

In late 1977, a meeting was held between NASA officials and community leaders from the Greater Delaware Valley (in the Philadelphia region of the USA). During this meeting Dr. Irving K. Kessler, Group Vice President of RCA suggested a project – an experiment for the Space Shuttle – that would motivate the minority and disadvantaged students in Camden, New Jersey to seek careers in science and engineering. From this meeting Orbit '81 was born.

The Concept

Orbit '81 is essentially a three year programme to build a Space Shuttle "Get Away Special". Final approval from the Camden School Board came on Jan 30 1978 after meetings between NASA, RCA and Camden School representatives. Two schools, Camden High School and Woodrow Wilson High School, were organised into two separate teams, one from each school. These were not meant to be rivals but to complement each other. Each school team was broken down into discipline groups, emulating the way industry would tackle such a project. The aim was to involve students at the schools from *all* disciplines – the sciences, engineering, manufacturing, management, social studies and the arts. Each school would build its own experiment and then they would participate in integrating them into the 'Camden High Schools district package".

Five primary objectives were laid down for the Orbit '81 programme:

1. To stimulate an interest in science, engineering and the potential of space amongst the students.
2. To make them aware of the potential in science and engineering careers.
3. To make the minority communities, especially, familiar with the US national space programme and its benefits.

4. To provide the minority and disadvantaged students with an enhanced science background for college.
5. To provide students with experience in supporting disciplines, e.g. management, library science, finance, social studies and the arts.

Support for Orbit '81

Basic instruction, advice and counsel is given by the High Schools' teachers. They have received some special training from various supporting groups. RCA have undertaken to pay the $10,000 fee for the Getaway Special slot, and provided assistance in a number of ways, such as learning kits, enrichment courses, literature, tours, and over $300,000 worth of surplus laboratory equipment. They also supplied the project's video camera (see below) and its microprocessor controller. The courses they helped with included computers and computer software, radio techniques and electronics.

NASA have also given assistance to the project by providing workshops, technical assistance, literature, special tours, demonstrations and presentations. The FAA (Federal Aviation Authority) have provided curricula material, scenarios, career guidance, workshops, teacher guides and texts. A number of Universities provided presentations, laboratory assistance and literature, as well as scholarships to outstanding students from the project. The computer manufacturers PRIME assisted with the interface between the schools, local colleges and universities. Other industries also provided small amounts of equipment and services.

A Colony of Ants

The students themselves chose the experiment. It had to be able to fit into one of NASA's "Get Away Special" payload canisters. These are five cubic feet (½ cubic metre) cylinders for small experimental payloads on a one-off basis, and must not draw upon the Orbiter's services beyond three on-off controls which a crew member will operate. The "Get Away Specials" were introduced by NASA to encourage the use of space by industry and schools, and over 300 have so far been reserved. NASA requires only a $10,000 fee and observance of basic safety requirements.

Before the Orbit '81 programme could be implemented, RCA and Camden schools officials agreed on a number of conditions.

* That the experiment had to be of significance. By being too elementary it would open itself to ridicule.
* A minimum of three years of enriched science courses would be required.
* The experiment to be conducted had to be a team effort and not primarily the work of one or two students. This condition was imposed so that the project would also act as a training for how industry tackles its problems by teamwork.
* Students from all disciplines had to be involved, from students of journalism through science and engineering to home economics. (There was an Orbit '81 newsletter, posters, an Orbit '81 song and even "space cooking").
* Student interest should be enhanced by many activities such as lectures, field trips, assemblies and other means.

Guion Bluford is scheduled to be the first American black astronaut, aboard the Space Shuttle *Challenger* in mid-1983. Lt.-Col. Bluford visited Camden High School to encourage the students in their Orbit '81 project.

In May of 1979, a group of students from the two schools selected their experiment. It would be "*Space Colonization - using ant colonies as a tool to explore the effects of the space environment on the colonists*".

NASA approved the experiment (being "of significance" in their terminology) in July of that year, and later the design was approved by RCA engineers and Prof. John Tarka of Temple University, Philadelphia.

As the students themselves said, the results from this experiment could well reflect the feasibility of manned space colonies. The ant colony was chosen for the experiment for a number of reasons:

1. Ants have a highly developed and observable social structure.
2. They have a hard external skeleton, able to withstand the high g-force of launch.
3. They have a short enough life cycle that all phases of their lives - from hatching of eggs to death - could be observed during the seven days in orbit.
4. A whole colony and the associated equipment would fit inside a Get Away Special canister.
5. The ants are accustomed to living in a close group.
6. They have team work instincts which would be useful to observe for comparison to a manned space colony.

7. The ants have clawed feet which would enable them to move around fairly normally under Zero-g. The behaviour of the colony could be monitored on video and movie cameras.

The Workings of the Experiment

The ant colony will be put into a specially designed "farm", which has a wooden frame and non-glare plexiglass windows. Much experimentation with different types of material showed that decaying wood was the best, especially as it was also their natural habitat. The other materials tried were sand, wood shaving and balsa wood.

The ant activities will be recorded by an RCA consumer grade video camera (donated by RCA) and a super 8 mm movie camera, each being powered by its own batteries. Both of these cameras, and fluorescent lights to provide illumination, are controlled by a microprocessor. The ants at liftoff and during their first weightless activities, will be filmed by the video camera and the movie camera would then photograph them periodically. Stills from the movie film will provide individual frames for study. A temperature of between 75°F and 85°F (23–30°C) will be maintained for the ants. If the canister becomes too warm or cold, a rod, connected to a temperature sensor and controlled by a solenoid, will be raised to touch the canister lid, for transferring heat. The microprocessor also operates a fan which circulates air throughout the canister.

Students at Work

At each High School, a core group of 15 students led the comprehensive pupil involvement. These groups received enhanced science courses, including space science aspects such as the space environment, the Space Shuttle and the Get-Away-Special programme, one course being taken each year. These courses were developed by the faculty and administrators of both schools.

Camden High School

The Camden High School Orbit '81 students were selected by the teachers and administrators from the freshman year (i.e. first year) and the students were expected to participate for four years. They were split into two teams – computer and ant teams – in the second year. The computer group learnt how to work with an RCA 1802 microprocessor and to develop flow charts to control the experiment, cameras, light and other equipment involved. The ant group studied the ants' behaviour and the conditions required to keep them alive throughout the experiment.

During the third year, the students were re-divided into four groups, the computer and ant groups as before plus an engineering group, and a filing group to update the accumulated data that the three other groups were gathering.

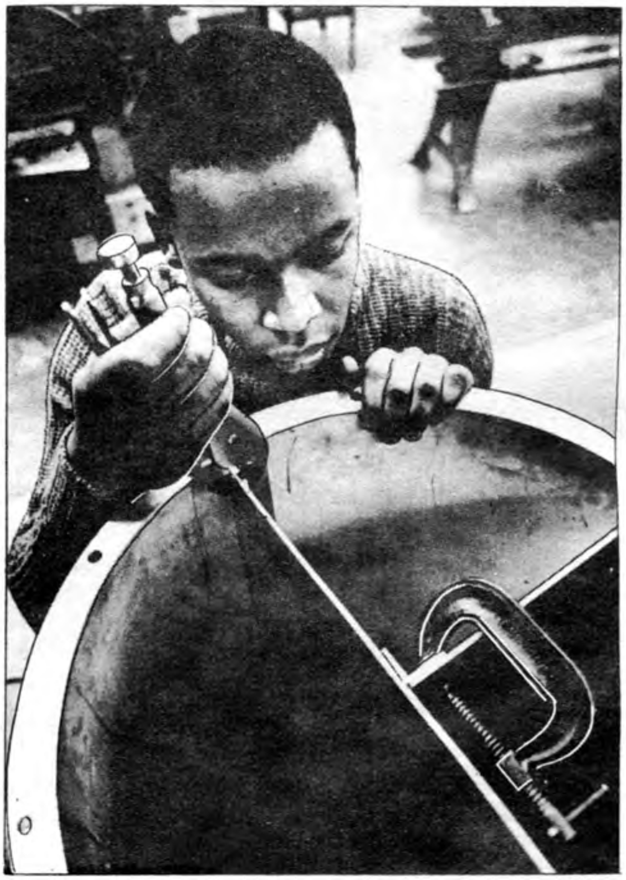
A full scale mock-up was built by the engineering group using wood and plastic for the structure and cardboard for the components. The computer group continued the experiment flowcharting and working on the programming procedures of the computer. An RCA electrical engineer was also assigned to this group.

Further experiments were undertaken by the ant group. In a number of experiments they tried to find out how to mark individual ants. A number of methods were tried. Two members of the ant group wrote of these experiments ... *"In one experiment, fluorescent chalk was applied to the entire body of the ants. In another experiment. the ants were allowed to move around in the chalk. Over a period of time (usually two or three days) the ants died. We believe the reasons was suffocation"*. These experiments were useful for demonstrating scientific method, and also that not all problems have an immediate, obvious solution.

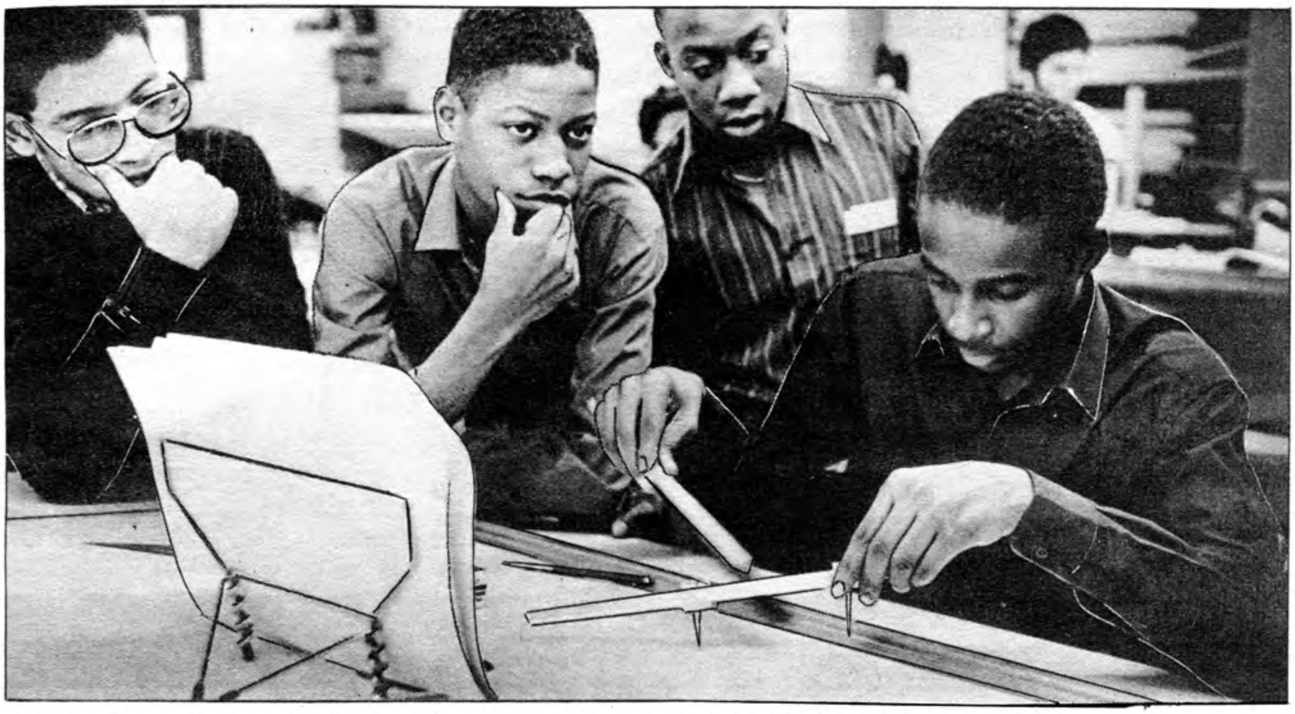
During the final year development turned to production. The wood, metal and mechanical drawing shops completed the Orbit '81 canister so that the arrangement inside of other equipment could be tried out. After this, the canister, ants and cameras were taken to RCA's labs where further tests took place. Later the instruments and ant colony were fitted inside the canister.

Woodrow Wilson High School

Participation at the Woodrow Wilson High School was left open to volunteers and the students could participate for any number of years.



Gilbert Futch, a metal shop student at Camden High School, clamps on a structural metal plate inside the Orbit '81 container.



Students in a mechanical drawing class at Camden High School prepare a blueprint for the Orbit '81 experiment.

Results

Though it is perhaps too early to fully evaluate how well Orbit '81 has met its goals some positive conclusions can already be drawn. It is already obvious that interest in science and engineering has increased dramatically in an area not normally noted for such interest. At Camden High School involvement in science courses has risen by 50% between 1980 and 1981, and there have been significant increases at Woodrow Wilson High School too. Interest runs high - Orbit '81 students averaged more than 5 hours overtime per week voluntarily - and even in the non-science disciplines there was an increased keen-ness. Drama and Art students did more than 50 hours overtime preparing for assemblies. In both schools new activities (e.g. rocket club and aircraft modelling) grew from this involvement. Camden planned and implemented a "Science Centre" within its school, and Woodrow Wilson collected funds for, and has built, a teaching planetarium. There were plans at Camden for a ground station to receive radio amateur satellites' signals (themselves an "educational" service - see last Space Education).

The students have, when interviewed, declared variously that the project changed their minds about their careers, matured them and made them more capable of team work, and that it increased their basic awareness of what science and technology meant. They learnt new skills - often ones they would not have thought of taking up, and their interest seems to have been maintained even beyond the end of the project.

Friendships were forged with industry, and student cooperation between the schools is said to have improved. There is little evidence that Orbit '81 created an increase in college enrolment, but it seems to have broken down the perceived barriers to some careers among the minority groups of New Jersey.

Coloured Astronaut visits the schools

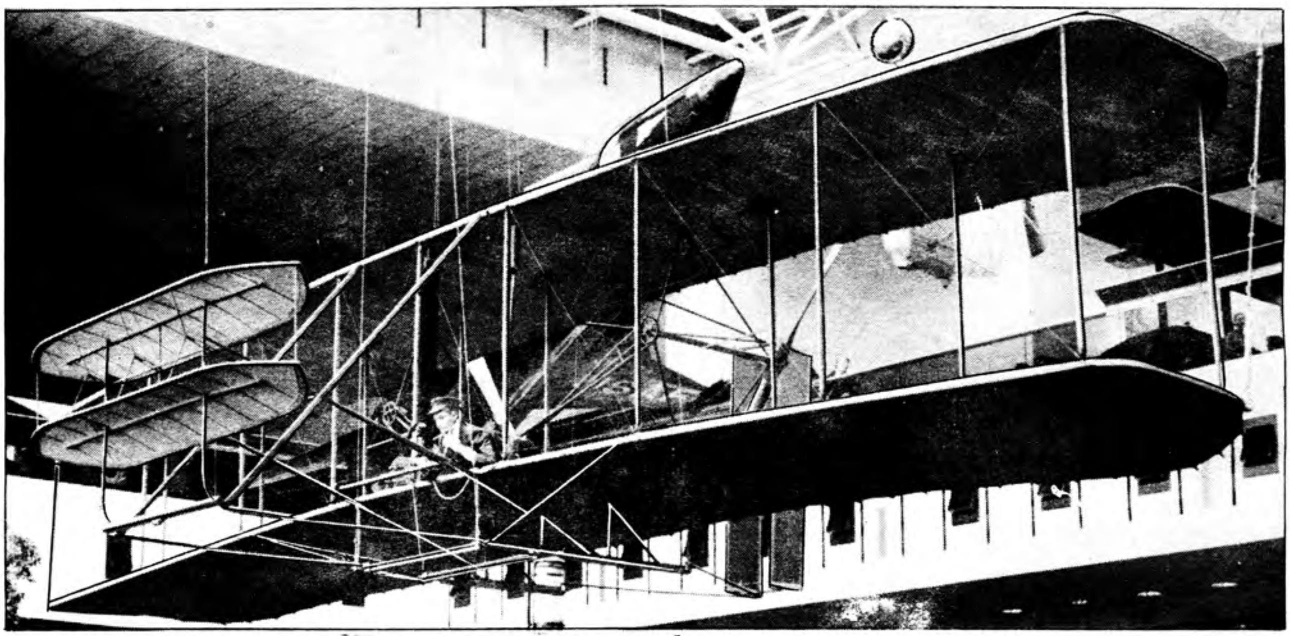
Lt. Col. Guion S. Bluford, Jr., the first black astronaut chosen for an orbital mission, in July 1983, visited the two schools in May 1982. He is a mission specialist and will be working with the launch of two communication satellites from the Shuttle *Challenger*. Bluford was selected for the astronaut corps in 1978, after being an Air Force Officer. It is thought the Orbit '81 experiment may make it into space before he does.

While at the schools Bluford, who has bachelor's, master's and doctoral degrees in aeronautical engineering, discussed career opportunities in science and engineering for the economically disadvantaged. He considered the work done by the New Jersey pupils, most of whom were from minority groups - black, Hispanic or women - as a demonstration that the barriers to advancement for pupils from such areas can be broken down if there is sufficient will.

What next?

With Orbit '81 coming to fruition and due for launch soon, probably in 1983, the students have begun planning a new experiment. Again RCA have agreed to pay the fee. The project being suggested this time is to put a fish into orbit and see how its ability to sense magnetic fields is affected by weightlessness. The adventure of space seems to have gripped the minds of one community of secondary pupils, at least!

THE NATIONAL AIR AND SPACE MUSEUM, WASHINGTON*



The Wright Flyer at NASM; an X-15 hangs above and behind it.

NASM

Introducing NASM

The National Air and Space Museum (NASM) of the Smithsonian Institution is one of the world's most visited museums. It houses an awesome family of air and space craft. The Museum displays the first, the fastest, the slowest, and the oldest of famous aerospace vehicles. In a single building, one can find such eminent air and space craft as the 1903 Wright Flyer, Lindberg's *Spirit of St. Louis*, Bell X-1, Apollo 11 Command Module, rockets, and missiles.

NASM exhibits these craft in a dynamic manner that underlines why they have achieved significance in their era. In the gallery where the Mercury spacecraft Freedom 7 is exhibited, the voice of John F. Kennedy echoes the words that directed the country to explore a new frontier. A colourful time line illustrates famous steps in space. Another gallery shows a Voyager spacecraft against an enormous stellar backdrop. Below the spacecraft is an audio-visual presentation of recent images from space, with descriptions by project scientists who point out similarities and differences of planetary features.

NASM does more than show the hardware; it shares knowledge, excitement, and the challenge met by each air and space craft. One can look, listen to, and sometimes touch those things that until a visit, are learned only from textbooks.

Visitors come from around the world and are of all ages. Many are in school groups, who visit the galleries in specialized-topic tours and are shown the basics of aviation and space science.

Tours and Demonstrations

A trained guide, a museum volunteer, will guide a group through the 23 galleries, threading it all together with a common theme such as the history of flight or exploring space. The guide will ask questions and play on the visitors' curiosity, trying to bring a special spirit to the museum experience. He or she will focus on selected exhibit units, people, and ideas. On a Discovery Tour, for example, youngsters can balance an oversized astronaut helmet on their heads, find their fingers lost inside an astronaut's glove, or exercise their imaginations in naming ways of travelling in space. Some tours can be combined with a special presentation in the Museum's planetarium. A tour of the Paul E. Garber Facility, the restoration

Young visitors view John Glenn's *Friendship 7* capsule.

NASM

* *Based on material supplied by the museum staff.*

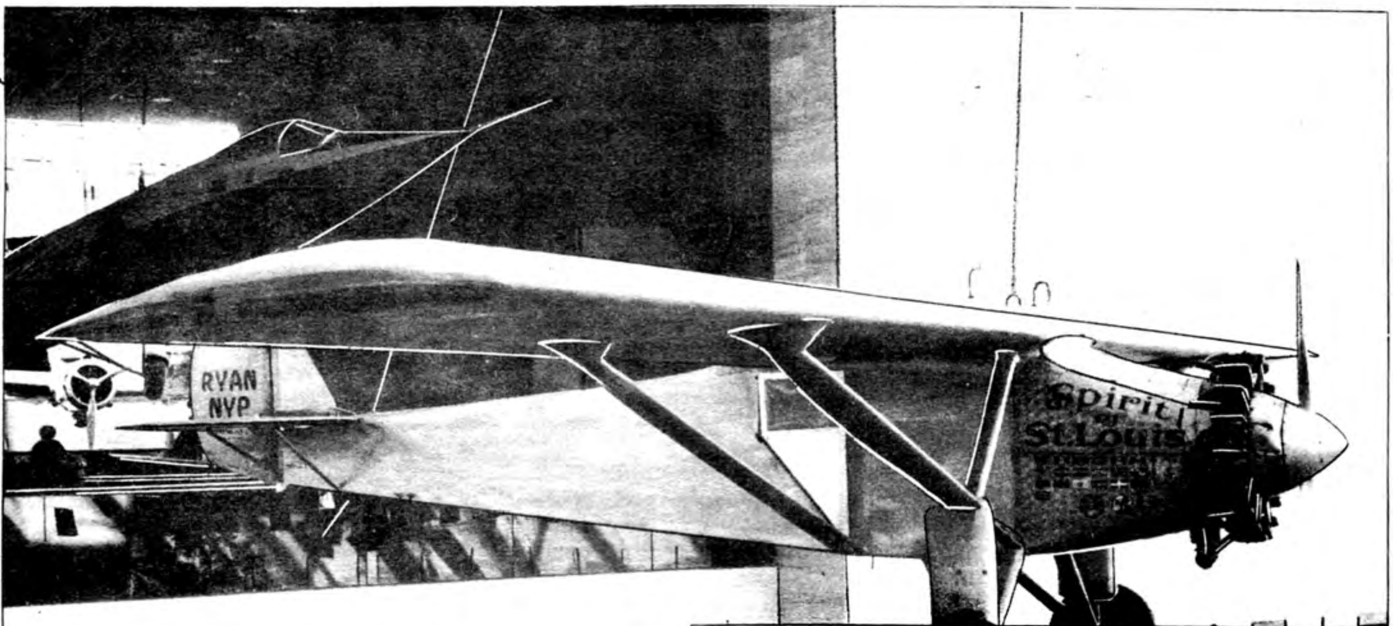
and storage facility of NASM, can also be arranged.

Visitors can also witness live demonstrations by NASM's staff. Several times during the year, curators offer firsthand appreciation of their favourite subjects, with anecdotes of heroes and heroines. These special curator sessions reveal the ingenuity of the Wright Brothers, the challenge of aircraft restoration, the strategies of military aviation, the quickening pace of the Space Shuttle Program, and the lore and lure of the starry night sky.

Education Services

The Museum promotes aviation and space sciences by exhibits, planetarium shows, publications, lecture and film series, curriculum material and audio-visual packages developed by the staff. The Education Services Division has produced material with a particular emphasis on the educational community. American teachers can obtain *Flight*, a sound filmstrip series on the science, history, and technology of aviation and space exploration. There are twenty-one titles in the series. Each includes filmstrips, cassettes, User's Guide, reproducible materials, and wall charts. The titles cover many curriculum areas and draw from the vast Smithsonian Institution archival material for their illustrations and photographs. Other materials distributed to educators include study prints, posters, pre-visit curriculum material, and monographs on the most popularly exhibited artefacts.

A Teacher Resource Center is available for educators who visit NASM. This facility allows them to develop their own learning units employing the resources found in vertical files, an extensive slide bank, and Audio-Visual (A-V) library. The Center provides the material and a quiet place for teachers to organize and design their unit plans.



Worlds apart: *above*, "The Spirit of St. Louis" as flown on the first solo non-stop crossing of the Atlantic; *left*, the world's only touchable lunar sample is displayed in the "Milestones of Flight" gallery. It was brought back in December 1972 by Apollo 17.

A National Facility

NASM is a place to see, hear, and learn about mankind's ventures into the skies and beyond. But the services of NASM also reach audiences not able to come to its doors. For example, the Regional Resource Program reaches a national audience. Educators selected to participate in this program currently serve in 45 communities in 32 states. Programme participants are trained and provided with support material to conduct seminars, teacher workshops, and general sessions on aerospace topics in their home towns. Produced also is *Air & Space*, a mini-magazine that combines information from varied sources to acquaint the reader with the history, science, technology, and social impact of aviation and space subjects. Unfortunately, because of budgetary restraints, *Air & Space* is distributed free only to teachers in the United States.

For further information about educational materials, one can write to Education Services Division, National Air and Space Museum, Room P-700; Washington, D.C. 20560. The same division will help educators to plan a visit. More information on the *Flight* series can be obtained from the National Audio Visual Center, National Archives and Records Service, General Services Administration, Reference EH, Washington, D.C. 20409.

SPACE TECHNIQUES TO MONITOR MOVEMENTS IN THE EARTH'S CRUST

By Dr. S. Hieber*

The time has come when space techniques can be expected to complement the classical geological, geochemical and geodetic tools employed in studying the Earth's crust as the birthplace of Earthquakes and volcanic activities. These space techniques, when applied to global and regional investigations, are expected to answer important questions concerning the relative motions of tectonic plates. The preparatory studies currently being performed by ESA in this field reflect the Agency's recognition of the role of such techniques as part of its Earth-Observation Programme.

Goals and Requirements

The precise determination of distances on the Earth's surface is no longer used exclusively for the classical geodetic tasks of tracing the boundaries of estates, establishing geometric bases for the construction of roads, bridges, dams, pipelines or tunnels, or producing data for cartography. Such determinations can also allow us to measure and monitor geodynamic phenomena, such as the very slow drift of tectonic plates or regional fault motions.

From improved knowledge of these crustal variations, geophysicists expect to acquire a better understanding of the processes in the Earth's mantle that initiate and maintain the motions of the crustal plates, and that are at the origin of seismic and volcanic activities (see Fig. 1). Given this better understanding, geologists may be able to establish correlations with mineral and fossil-fuel deposits.

Moreover, the results of crustal-movement measurements are extremely important for the assessment of the risks associated with the hazardous behaviour of the Earth's crust and, hopefully, for the prediction of earthquakes.

Today's major research objectives in geodynamics are:

1. Improved understanding of the dynamic processes in the Earth's crust:
   relative plate-tectonic motions (continuous or episodic),
   regional fault motions and strain accumulation,
   internal deformation of lithospheric plates.
2. Study of Earth kinematics and possible correlations with:
   plate motions,
   Earthquakes,
   other geophysical phenomena.

The investigation of relative plate motions is global in nature and involves measurements over intercontinental distances and over extended time periods. It remains to be established whether these motions are continuous or episodic. Study of the internal deformations of lithospheric plates may also contribute to providing an answer.

Our present estimates for the magnitudes of such motions as indicated in Table 1 are average values obtained through studies of the geological record of the past several thousand years, of prehistoric Earthquake and of examining the sea floor spreading rates as revealed in magnetic polarity patterns in many oceanic regions.

Equally, the dynamic behaviour of our planet as a whole is assumed to contribute to the various crustal phenomena. How do the irregularities in the kinematic behaviour of the Earth affect the velocities and directions of plate motions? How does the Earth's axis and the globe's rotation around it respond to Earthquakes? We may know the answer when we can measure the motions of the poles to centimetre, and the length of day to microsecond accuracies.

Our continual mapping of the geoid and its anomalies, such as those to be found in the subduction zones, has now reached a resolution such that it can provide further evidence regarding the existence of mineral and energy resources and the tectonic backgrounds to their formation.

With each of these research objectives are associated particular measuring requirements (Table 1).

Space Techniques

The goals and requirements that have been laid out above may not change for some time, but the means by which they are being pursued are certainly evolving. They have already increased in both number and precision with the progress in space techniques for Earth-oriented research. The fact that today we know the diameter of the Earth to an accuracy of about 1 m and the distances between continents with centimetre accuracies is attributable in large part to satellite geodesy using both static (triangulation with satellites as fixed points) and dynamic (analysis of orbital perturbations) methods. The four basic space techniques already employed, or being planned, for custal-movement measurements are listed in Table 2.

Table 1. Current measurement requirements for geodynamics and Earthquake research.

Phenomena to be observed	Magnitude of motion	Measurement accuracy required
Relative global plate motions	2–15 cm/yr	10^{-8}–10^{-9}
Regional fault motions	<10 cm/yr	1–2 cm/yr 0.7 cm/3 yr 0.4 cm/5 yr
internal plate distortions	<3 cm/yr	10^{-8} – 10^{-9}

* *Directorate of Applications Programmes, European Space Agency, Paris.*

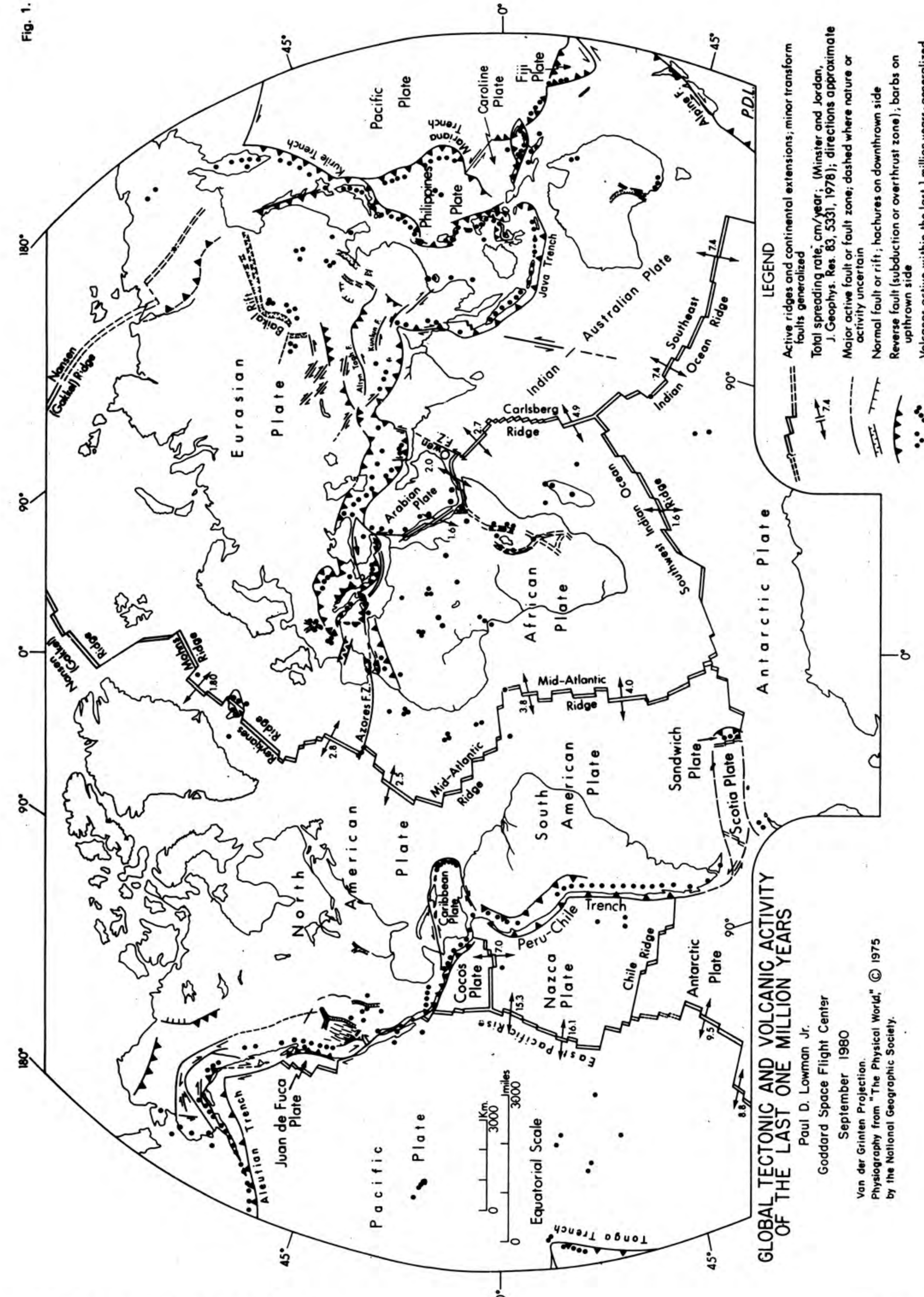


Fig. 1.
GLOBAL TECTONIC AND VOLCANIC ACTIVITY OF THE LAST ONE MILLION YEARS
Paul D. Lowman Jr.
Goddard Space Flight Center
September 1980
Van der Grinten Projection.
Physiography from "The Physical World," © 1975 by the National Geographic Society.
LEGEND
Active ridges and continental extensions; minor transform faults generalized
Total spreading rate, cm/year; (Minster and Jordan, J. Geophys. Res. 83, 5331, 1978); directions approximate
Major active fault or fault zone; dashed where nature or activity uncertain
Normal fault or rift; hachures on downthrown side
Reverse fault (subduction or overthrust zone); barbs on upthrown side
Volcanos active within the last 1 million years; generalized (some isolated basaltic centers omitted)
Equatorial Scale
Km. 3000
miles 3000
Eurasian Plate
Pacific Plate
North American Plate
South American Plate
African Plate
Indian Australian Plate
Antarctic Plate
Nazca Plate
Cocos Plate
Caribbean Plate
Juan de Fuca Plate
Philippines Plate
Caroline Plate
Fiji Plate
Arabian Plate
Sandwich Plate
Scotia Plate
Aleutian Trench
Kurile Trench
Mariana Trench
Java Trench
Tonga Trench
Peru-Chile Trench
East Pacific Rise
Chile Ridge
Mid-Atlantic Ridge
Reykjanes Ridge
Mohns Ridge
Nansen (Gakkel) Ridge
Carlsberg Ridge
Southeast Indian Ocean Ridge
Southwest Indian Ocean Ridge
Azores F.Z.
Owen F.Z.
Baikal Rift
Alpine F.
PDL
180°
90°
45°
0°

Table 2. Space techniques for geodynamics and Earthquake research

1. Satellite imagery: to reveal neotectonic structures, to find and map lineaments and geomorphological features.	Landsat, Spot, ERS
2. Ranging to and from satellites: using microwave and laser techniques, requiring high-accuracy and orbit determination.	Lageos/Starlette NNSS/GPS/ Popsat
3. Very-long baseline interferometry (VLBI): using natural and artificial radio signal sources.	GPS
4. Satellite gravimetry: to map the fine structure of the Earth's gravity field, using satellite-to-satellite tracking and gradiometry.	Slalom, Gravsat

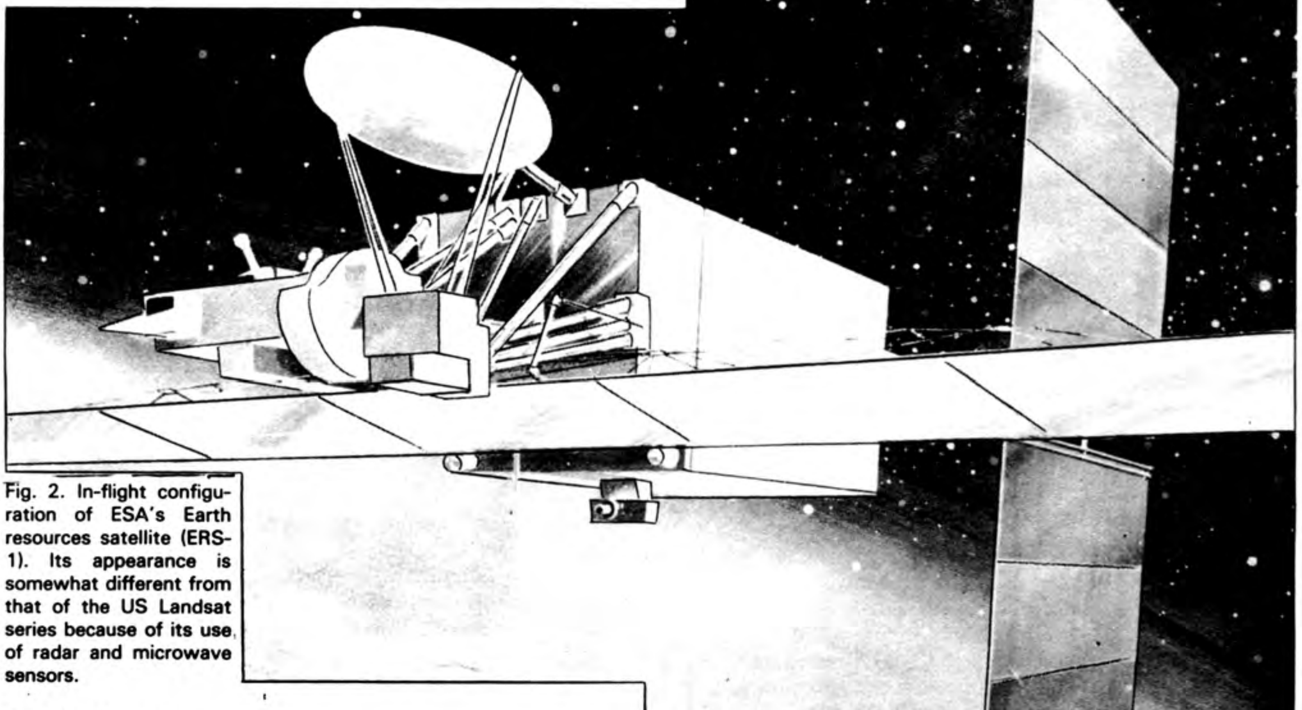


Fig. 2. In-flight configuration of ESA's Earth resources satellite (ERS-1). Its appearance is somewhat different from that of the US Landsat series because of its use of radar and microwave sensors.

Satellite Imagery

A number of *satellite remote-sensing* missions have been launched since the early 1970's, mainly by the USA (Landsat, HCMM), for a wide range of land and ocean applications. The present-day capabilities of satellite imagery lead to maps with scales of 1:250,000 and spatial resolutions of 30 × 30 m, sufficient for the discovery of significant neotectonic structures and for the identification and mapping of geological lineaments and geomorphological features. A European Earth-Observation Programme is under way which includes dedicated space missions for land observation. A French satellite, Spot, using optical instruments and to be launched in 1983, will be followed by the European Space Agency's ERS satellite which will carry microwave sensors and will thereby provide an all-weather observational capability.

Ranging to and from Satellites

In principle, geodesy can be considered as the most accurate form of ground-based navigation. A natural consequence of this has been the use since 1967 of the US Navy's Navigational Satellite System (NNSS or Transit) to measure range differences, employing Doppler techniques. These measurements allow absolute geocentric station coordinates and relative positions to be computed with accuracies of 20 cm for fixed-station positions, and better than 1 m for mobile stations.

A successor system, the Global Positioning System (GPS), to be completed in 1984, also applies microwave ranging principles. If made available for geodetic purposes this navigation system could improve position determination by an order of magnitude compared to NNSS. A substantial problem that limits the ranging accuracy to and from fast-moving targets like satellites is the difficulty or even impossibility of determining their orbits with an accuracy comparable to that of the range-measuring instruments.

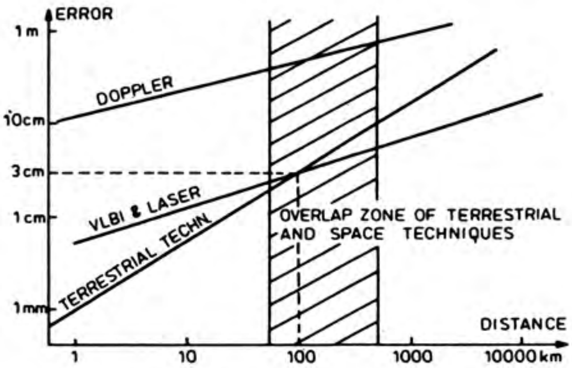
Future space missions with objectives in the fields of Earth observation and solid-Earth physics, and particularly geodetic satellites with applications in precise point-positioning and Earth kinematics, therefore require increasingly more precise determination of their orbits, compatible with the performances of the improved range and range-rate measurement systems.

It is for this reason that in the POPSAT (Precise in-Orbit Positioning Satellite) concept studies being conducted by ESA, use is made of a number of measures to reduce the effects that impair accurate orbit determination and to come to the determination of the satellite's position within decimetres. The principal payload would be an extremely precise microwave range and range-rate measuring system, in addition to optical reflectors for laser tracking.

	Mobile		Fixed	
	Number	Accuracy	Number	Accuracy
Microwave Doppler	10,000–12,000 including ships	<50 cm (Transit) 2–6 cm (GPS)	20 (Tranet)	20 cm
VLBI	7 (Aries, Series Mites)	5–10 cm (Aries) <3 cm (Series, GPS)	15 (Radio telescopes)	2–10 cm
Laser ranging	~10 (Moblas, TLRS)	5–10 cm relative	~10	5–10 cm point positive <5 cm relative

Table 3. Capabilities of space techniques for geodynamics and Earthquake research.

Below: Fig. 3. Typical accuracies for high-precision measurement techniques for geodynamics and Earthquake research (logarithmic scale). (After Campbell, 1978).



Laser tracking of satellites for crustal movement measurements calls for the installation of laser stations at the sites where significant features can be expected to be measured. In practice, this means constructing highly mobile laser terminals and moving them into sometimes difficult terrain or to remote sites without the appropriate infrastructure. There are presently about ten mobile laser stations in operation in the USA, and two more are under construction in Europe. Since 1972, some have been installed every other year on either side of the San Andreas Fault in California. They will also constitute the most modern instrumentation to be used in the large-scale Crustal Dynamics Research Project planned for the years 1981 to 1986.

As part of this project, a group of European geodetic and geophysical institutes will concentrate their joint measurement efforts, using mobile laser stations, on the Eastern Mediterranean area where the Earth's crust is known to be broken ito numerous smaller plates.

Very Long Baseline Interferometry

Currently competing with laser ranging is a radio-electric method based on very-long-baseline interferometry (VLBI). It is considered a space-based technique although for the time being the distant signal sources are not man-made spacecraft but natural radio stars (quasars). However, good candidates as artificial radio sources are the 18 satellites of the projected GPS system. These are to be at an altitude of 20,000 km and their radio signals will therefore present a quasi-plane wavefront to the observing stations. With the known angular positions of the radio sources, by employing time- or phase-difference techniques baselines can be measured with an accuracy of a few centimetres. The large radio telescopes in Europe and the USA have already demonstrated such a capability for intercontinental baselines, but again – as in the case of laser ranging – transportable units are needed for crustal-dynamics research applications. A few such stations have been built to observe Astronomical Emissions for Radio Interferometric Earth Surveying (Aries) and to receive Satellite Emissions for Radio Interferometric Earth Surveying (Series). Their antennas range from 1 to 4 m in diameter. A 5 cm accuracy is reported as being achieved with only 1.5 h of observations.

Satellite Gravimetry

The refined knowledge of the structure of the Earth's gravity field is the key to precise orbit determination for geodetic satellites and, therefore, a prime parameter for high-accuracy station positioning. The acquisition of this information, necessarily on a global scale, is an objective that cannot be separated from the goals of geodetic and geodynamical research.

Again, satellite techniques are an efficient means of solving the problem, the most interesting possibilities at this moment being satellite-to-satellite tracking and satellite gradiometry. Both methods rely on the fact that a satellite in its orbital trajectory reacts to variations in the gravity field: the lower the satellite's altitude, the greater its sensitivity to these forces. Nongravitational forces tend, of course, to introduce errors which have to be eliminated, either by measuring them separately (with a micro-accelerometer) or by using such measurements to compensate for their effects.

The principle of satellite-to-satellite tracking is to measure the relative velocity between two spacecraft and, from the accelerations derived, to compute the intensity of the gravity field, in particular its short-wavelength structure. The concepts studied include HI-LO (high-low) techniques, where the lower satellite is the sensitive element and the higher satellite in its almost unperturbed orbital represents a reference position); and LO-LO (low-low) techniques with two low-flying spacecraft in virtually the same orbit, but properly phased in that orbit. To recover gravity parameters with the requisite resolution, the relative velocity must be measured with an accuracy of a few millionths of a metre per second! Feasibility studies have shown that laser and millimetre-wave methods can provide this performance. Two systems under study in the USA and Europe for future projects have the names Gravsat and Slalom, respectively.

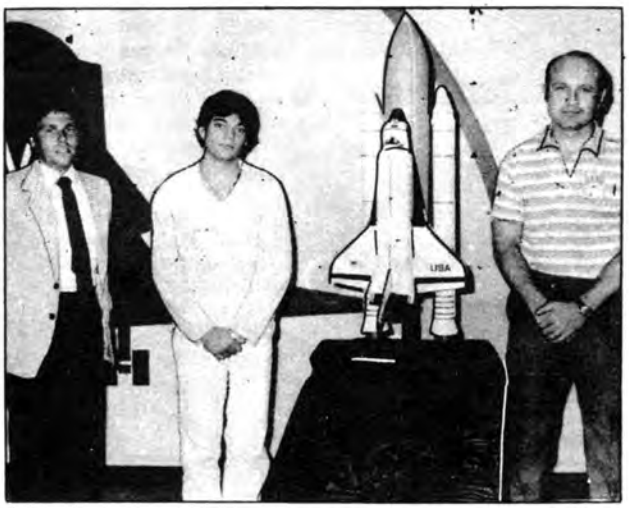
The second technique of interest is satellite gradiometry, whereby a single satellite carries an instrument that measures the gradient tensor of the gravity potential directly. Though simpler in its system configuration, this solution is still proving a technological challenge.

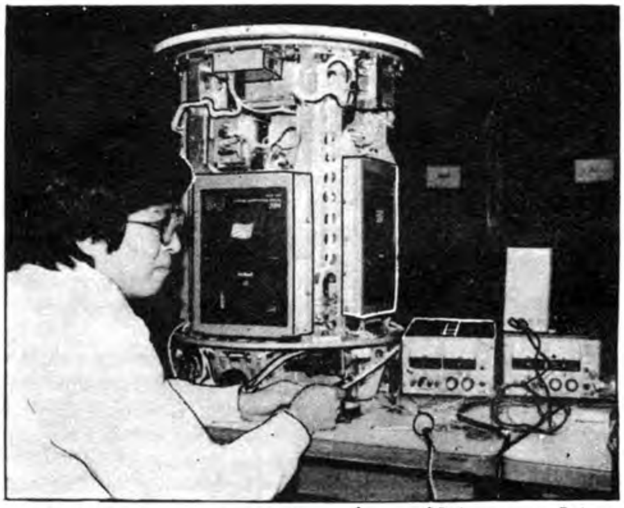
The present-day capabilities of the various space techniques are collected in Table 3. Figure 3 compares them in terms of measurement distances and hence their potential uses in local, regional, or global applications for crustal-movement research.

Conclusions

The time has come when space techniques can be considered complementary tools for geoid crustal-movement measurements, their usefulness being enhanced by their immediate availability for both regional and global applications. Satellite imagery can be used in many more ways to the benefit of interdisciplinary research in geophysics and geology, while the ultimate capabilities of microwave ranging techniques (Doppler) have yet to be fully exploited.

Very-long-baseline-interferometry and laser-tracking methods are direct competitors as regards performance, cost and operational flexibility. The new techniques that are coming along, such as active space sensors combined with passive ground targets, will further increase the cost-effectiveness of field operations, but they will not be available before the end of the decade.





Shuttle packages: *Left:* Shuttle Student Project winner Aaron Gillette with his school counsellor and NASA science adviser. Aaron's Shuttle experiment will test if a sponge's cells reaggregate, as they would on Earth, in zero-g after they are disassociated. *Right:* A Get-Away Special flown on the STS-6 Shuttle mission in April was this "Crystal Growth of Artificial Snow" experiment sponsored by Japan's *Asahi Shimbun* newspaper.

NASA

RETHINKING THE PREBIOTIC EARTH

New work by scientists in different NASA research institutes may be about to set our current theory of the Earth's prebiotic environment - and the origin of life - on its head. The studies included a theoretical computer calculation of the composition of the young Earth's atmosphere and ultraviolet (UV) radiation measurements from the Ultraviolet Explorer (IUE) satellite. The former casts doubt on the currently accepted composition for the young Earth's atmosphere and the latter suggests that far more harmful UV radiation was reaching the Earth's surface as life was forming than was previously suspected.

Current theories about the primordial Earth assume a heavily reducing atmosphere - mainly methane, ammonia and hydrogen. Energetic events such as thunderstorms, radiation impinging from the Sun, or volcanic activity, is thought to have caused chemical changes which led the reducing mixture to form complex molecules - proteins and amino acids amongst others - which were the "building blocks" for life. In this theory - the so-called "primeval soup" - these building blocks would have then had to be concentrated somehow, and in an environment without too much strong radiation which would cause the long molecules to break down. All experiments trying to simulate the conditions for creation of life so far have assumed the environment just described. But this new work has cast all those assumptions into doubt.

Workers at Langley Research Center in Hampton Virginia did some new computer calculations on the photochemistry of the new Earth's atmosphere. They state that, at the time complex organic molecules (the precursors of living systems), were first formed from atmospheric gases, the Earth's atmosphere was not composed primarily of methane, ammonia and hydrogen as was previously supposed. Instead, it was composed of carbon dioxide, nitrogen and water vapor, all resulting from volcanic activity. Langley calculations indicate that both methane and ammonia were extremely shortlived, and that such an atmosphere was photochemically unstable if it existed at all.

To add to this, the work with Ultraviolet Explorer has led to the conclusion that levels of oxygen in the primordial atmosphere (previously assumed so small as to be ignorable) may have been much higher than thought, and that the amount of UV radiation striking the Earth may also have been thousands of times greater than today. Prompted originally by theoretical work from Dr. Vittorio M Canusto, a study of IUE data was carried out. It was found that young stars - like the Sun would then have been - emit orders of magnitude more UV radiation than was previously believed.

This extra radiation would have broken down the atmospheric gases of the young Earth - hence the extra oxygen from CO_2 and water. The oxygen level would still have been small (about 1 part in 10^9), but this raises it to the level where such trace components can become important. Certainly its importance to the formation of life is profound. Too much free oxygen might oxidize the large molecules of the primeval soup, or it is possible that with free oxygen available some other non-reducing mechanism can be found for formation of life's building blocks. The use of oxygen for "respiration" has previously been considered a later addition to life's repertoire - indeed the existence of oxygen in such large quantities in the atmosphere is largely the *result* of life, it being the by-product of photosynthetic breakdown of carbon dioxide.

There is a certain self-regulating feature of the increase in UV radiation. Creating more oxygen would have meant more was available for further ionisation to form ozone (O_3), so a layer would have formed, as we have above our heads today, to protect the Earth's surface from the very radiation that formed it. Unfortunately, calculations suggest there would not have been sufficient concentration to protect the Earth more than a little from the extra radiation - most would still get through.

These are still theories, of course. The assumptions made in the new work can be questioned as much as those made in previous studies. There are some pieces of evidence that support it, though - such as the fact that analysis of the oldest known rocks show levels of oxygen higher than would have been expected from the older theories (though not necessarily at the new level now suggested).

So the great detective job goes on - theory meets counter-theory and new hypotheses are tried in the search for the solution to life's origins. Could life have evolved even with the vast amounts of UV striking the surface that is now proposed? Would the radiation have helped in some way, at least initially, in instituting chemical bond-breaking that gave a more reactive mixture? Are there further assumptions that can be challenged?

It seems certain that many more interesting results - and controversies - will be seen before we can start to feel certain about the way things truly were.

ANOTHER SSIP-S EXPERIMENT FLIES

The fourth mission of the shuttle Columbia made 16-year old Amy Kusske from Long Beach, California, the youngest person to have an experiment flown aboard the shuttle. She was selected by NASA as one of 10 student finalists in the first Space Shuttle Student Involvement Program one day before her 15th birthday - and notified that her experiment would be assigned to the STS-4 mission the day before her 16th birthday.

Amy has worked closely with Dr. William K. Douglas, an advisor assigned to her by her industrial sponsor, McDonnell Douglas Astronautics Company. Dr. Douglas, director of life sciences program engineering in the company's design and technology subdivision, served as a personal physician and flight surgeon for the Project Mercury astronauts during a 30-year Air Force medical career. He joined McDonnell Douglas in 1977.

That background fits perfectly with Amy's experiment: a careful study of the astronauts' diet and exercise programs before, during and after the mission in an effort to determine the effect of prolonged weightlessness on lipoprotein levels in the body. The high density lipoproteins could be viewed as cholesterol "scavengers," collecting and disposing of excess cholesterol in the blood.

Amy spent the week prior to launch with NASA crew support medical personnel at the Johnson and Kennedy Space Centers monitoring the early phase of her experiment. She helped record the astronauts' diet and exercise program and reviewed the results of pre-flight blood tests, taken thirty, ten and two days before the flight.

During the mission, the crew kept accurate daily diaries of their meals and snacks as well as the type and duration of exercises performed. Immediately following their return to Earth, blood samples were taken followed by more after seven days. The results of the pre- and post-flight blood tests for lipoproteins are being compared to determine whether any changes have occurred.

"I hope to draw some conclusions regarding the type of diet and exercise program best suited to prolonged space missions," Amy says of her experiment. "This is necessary if we are to have permanent space facilities in which people will be living for one or two years or perhaps longer in the future."

LUNAR SAMPLES FOR U.S. COLLEGES

Colleges and universities in the USA may now borrow lunar samples, in an "educational package" for several months, allowing undergraduates or graduates in the geosciences the chance to work with thin (.03mm) sections of lunar material. Mounted on microscopic slides, the eleven sections are thin enough to transmit light, allowing microscopic studies of texture and mineral content.

Each "package" contains samples from three general types of rock found on the Moon: plutonic rocks (igneous rocks from depth) like anorthosite, volcanic rocks (basalt), and breccias (sedimentary or crushed types). There are also samples of the lunar soil, which consists of ground-up rock and various glasses formed by fusion and rapid meteoritic heating. A brief description of the samples will be included, together with explanatory notes on categories of lunar rocks, their occurence on the Moon and their significance to the understanding of lunar history and processes.

Educational institutions receiving the material must agree to certain security conditions for the safekeeping of the lunar material, which is considered irreplaceable. There is no cost to the institutions for the use of the lunar samples and the only equipment needed to study them is a standard petrographic microscope.

MOONROCKS IN LONDON

For the third successive year the Geology department of the City of London Polytechnic borrowed NASA's "Lunar Thin Section Education Package" (see above) for display during 18–29 October 1982. This year, for the first time, the package also included a clear plastic disc in which were embedded specimens of lunar rock and soil. During the two weeks that the package was held by the department, over two hundred people were able to study the lunar material at first hand.

Five half-day courses for schools (pupils and teachers) were held. The numbers attending were limited to between sixteen

and twenty, partly to ensure adequate contact between staff and students doing practical work, and partly to facilitate security arrangements. The courses covered "Lunar and Terrestrial Geology", and utilised maps and photographs as well as the lunar samples. Closed circuit television facilities, incorporating a colour television camera attached to a petrological microscope, were used for demonstrating the thin sections. Topics included the origins of major lunar surface features (e.g. ringed basins, maria, craters, rilles), the ages of lunar rocks, the origin and evolution of the moon, and the history of the Apollo moon-landing programme. Lunar rocks were compared with terrestrial rocks; the courses included both lectures and practical sessions, during which the thin sections could be studied with the aid of petrological microscopes. On one day, two films (hired from the BIS) were shown: "Apollo 17: On the shoulders of giants", and "Mercury: Exploration of a planet".

Second and third year undergraduates in the Geology Department examined the thin sections as part of their Degree course studies in igneous petrology. The lunar samples were also used to supplement a lecture on meteorites, and a practical session involving lunar samples, meteorites and tektites were

held. Two members of the Geology Department staff used the lunar thin sections for private study, and a number of other Polytechnic staff and interested outside persons were also able to see the display.

The department hopes to have the Educational Package again in 1983, in late October or early November. Anyone interested in seeing it can obtain details by writing to the Curator (Miss Joyce Church) at the Geology Dept., City of London Polytechnic, Walburgh House, Bigland St, London E1 2NG.

MSc COURSE IN REMOTE SENSING

In recognition of the increasing national and international requirements for Earth resources data during the next decade and beyond, the Natural Environment Research Council, and the Science and Engineering Research Council have agreed to jointly support a one-year MSc postgraduate course in Remote Sensing. The course will be organised jointly by University College London and Imperial College of Science and Technology. Both institutes have considerable expertise in this field. The course is expected to begin in October 1983.

Students will be taught the basic principles, not only of image processing and data handling techniques but also of the physics of sensors and space platform design, and the fundamental principles of electromagnetic radiations and their behaviour in the atmosphere. The course will also cover the many applications of remote sensing data such as the location of mineral resources, environmental monitoring, hydrology, crop prediction, oceanography and meteorology.

The course will be open to suitably qualified applicants for NERC and SERC studentships. Further details may be obtained from the course convenor, Professor E. H. Brown, Department of Geography, University College London (tel: 01 387 7050 ext. 542).

METHANE AT THE EDGE

American scientists believe they have evidence for the presence of frozen methane (CH_4) on Pluto, and Neptune's Moon Triton. On Triton where the temperature is always less than methane's 50°K sublimation point it remains solid. Pluto's highly elliptic orbit, however, brings it nearer the Sun than Neptune when it is near its perihelion and the surface can then heat to 65°K. Pluto should then acquire a gaseous methane atmosphere.

NASA hopes to confirm the Triton finding when Voyager 2 approaches Neptune in 1989. Pluto is not the target, however, for any current space probe, so astronomical techniques alone will be used in the near future to find out its structure and composition. The Space Telescope may offer an advance in Plutonian observational science when it flies in the mid 1980s, but in the meantime ground-based observatories do their best. Pluto is due to reach its closest point to the Sun in 1989.

The methane on Pluto and Triton would mark them down as different from most satellites of the outer solar system which have surfaces primarily of water ice. The only other exception is Saturn's Titan, which has a dense atmosphere of nitrogen and methane.

REMOTE CONTROL SEEING

British scientists have been busy trying out remote control techniques that should enable scientists to control and monitor the new British telescopes now under construction in the Canary Islands from their home institutions.

In the tests the UK infrared telescope in Hawaii has been controlled from Edinburgh and direct TV pictures from the Kitt Peak Observatory in Arizona, have been received in Sussex. The Kitt Peak test included transmission of direct pictures and of spectra, and the control of the telescope pointing. The same communication line can be used between observations for voice communication.

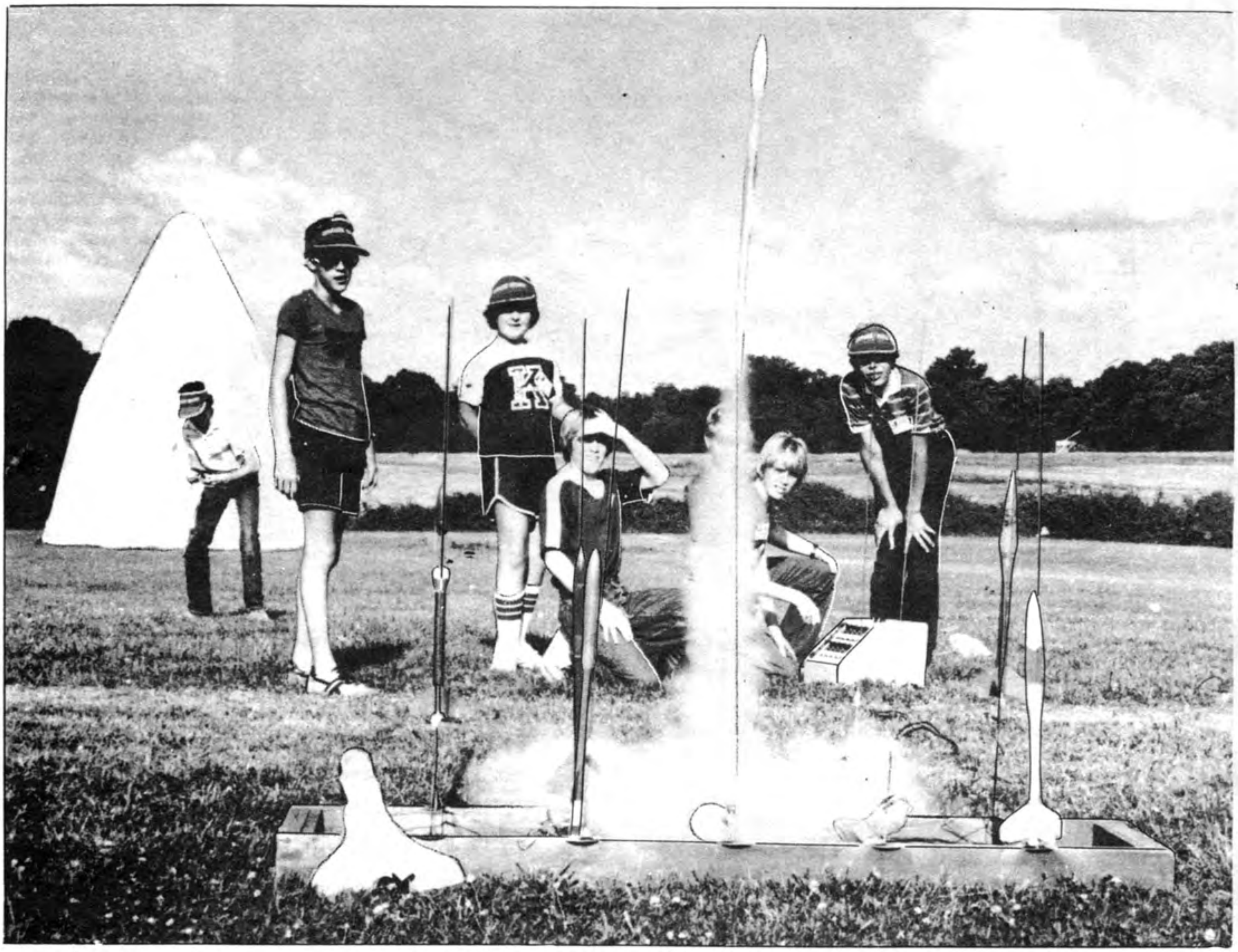
The tests are aimed at developing techniques to allow UK scientists to carry out experiments, without leaving their home institutions, on the new 1m, 2.5m and 4.2m telescope in the Canaries. The two smaller telescopes will start operating in 1983 and the larger in 1985. The 4.2m William Herschel telescope will be the world's fourth largest optical telescope and the first to be designed from scratch for remote control from another continent.

OUT OF THIS WORLD

In Huntsville, Alabama is the largest space museum on Earth. The Space and Rocket Museum has a Space Park in the open air where a Saturn 5 reclines and a Saturn 1 towers amongst a collection of rocket hardware covering the whole history of the US space programme. The Space Park flanks the huge, squat Space Museum Building and its attendant Spacedome. The idea for the museum is attributed to Wernher von Braun himself, and an important part of the exhibits are his awards and personal effects. In addition there are models, examples of space hardware and displays of all sorts.

The Museum is trying to promote space awareness in many new and interesting ways. The staff believe in involving the visitor. One can climb into a command module, or undergo one of a series of delightful simulations like the Lunar Odyssey, a centrifugal force theatre moving much as a spaceship would during lift-off, flight and Moon landing. There is also a mock passenger-carrying Shuttle, a zero-gravity simulator and many "hands-on" exhibits. Special effects play an important part, of course.

The Museum staff have taken this concentration on "experiencing" Space one step further in the establishment of a summer camp for boys and girls. Huntsville is a "space town", with the Manned Space Flight Center (MSFC) and other NASA institutions, so it is not surprising there is a concern for promoting interest in space exploration. The idea of the camp is to provide that promotion for 12–14 year old youngsters



interested in aerospace careers, reinforcing their interest by allowing them an eight-week long exposure to all aspects of space exploration. They are given a chance to try the museum's simulators, along with other equipment most tourists are *not* allowed near - including many of the MSFC facilities. They are given a chance, for example, to try out space suits, and practise in a neutral-buoyancy tank. They sample freeze-dried food, are taught how to control a flight console or "fly" a Shuttle simulator. They are set tasks, problems and projects. They are given the chance to fire model rockets with miniature payloads (e.g. insects and plants). The evidence is that they all find it highly enjoyable, and stimulating.

At the moment the campers are accommodated at the nearby University of Alabama but there are plans for a permanent "village" with dormitories, lecture halls, laboratories and other facilities. Attendance costs $175 per week; eight hundred youngsters took part in 1982.

IMAGING RADAR FINDS PARADISE

The imaging radar on the second Shuttle mission in November 1981 produced some remarkable pictures of the subterranean structure of the border region between Egypt and Sudan. The pictures support the suggestion by some scientists that the area was once covered by lush forests or at least intermittent savanna-like growth. There are anthropologists and historians who believe that man evolved in what is now the Sahara region, migrating into Asia and Europe as the climate changed. In more recent times, there are known to have been human habitation there 200,000 to 400,000 years ago, with some re-occupation as recent as 10,000 years ago (Quaternary wet periods). The sand in the Sahara desert region, which has been created by the wearing action of its once-great rivers, eventually dried out completely and filled the valleys of the rivers that had formed it - or so the theory goes.

Now NASA has had a chance to test that theory. Sand is relatively transparent to radar, so radar can map the features below it. That is what the Shuttle did, to a resolution of 60m, with its 9m×2m imaging radar system. Average depth of penetration varies locally from 1-5m. What it discovered, so scientists from JPL and the US Geological Survey believe, was indeed ancient canyons and river beds, together with terraces which once bordered large lakes. Some of the subsurface features are nearly as broad as the Nile River Valley and could be up to 50 million years old. The radar survey will help to interpret old patterns of drainage. At least four river systems predate the Nile, parts of some of them flowing opposite to current systems.

In September 1982 a team of Americans associated with the project organized a short expedition to the region to start an archaeological search to confirm their findings. Using the radar maps they hoped to identify possible sites where early man's

This 40 m resolution image of the Sardinia coast-Mediterranean Sea area was the first returned by the radar experiment aboard the second Shuttle flight. The star-like point at bottom centre is a ship's reflection and the mottled effect is caused by the choppy sea.
NASA/JPL

1903 up

remains might be found, and start a process of uncovering them which will be carried on, hopefully, by others in years to come. Some of the radar images have shown rectangular features similar to pre-Hispanic agricultural features in the coastal desert regions of Peru, and it is thought they may be previous unrecognised pastoral or agricultural sites.

The area now looks very little like its earlier self – it rains there typically once every 30–50 years (and has not rained since World War II). One practical result of this research, though, might be to locate what water resources there are there today in the way of underground reservoirs and streams, perhaps the sources for oases. If this is possible it is a technique which could be used in other similar desert regions of the world. There is a possibility of using it on at least one other world too. Mars, also, is covered by sand, and imaging radar might tell us for sure if it once had rivers and lakes, and what their distribution was. There may even be clues as to whether it ever supported life.

On the Earth the same techniques could also be used to search for features in the Arctic and Antarctic wastes. It might seem strange that one needs to go into space to discover what lies under our feet.

Radar penetration is possible only where the ground is extremely smooth, avoiding backscatter, and where its electrical characteristics make it virtually transparent to the signal (dessicated sand being a good example, wet clay bad). The angle at which the radar signal strikes, wavelength and power are all also important parameters, though the physics are not yet thoroughly defined. Work is continuing on the theory, but it seems certain that geologists and archaeologists have found themselves a powerful new tool.

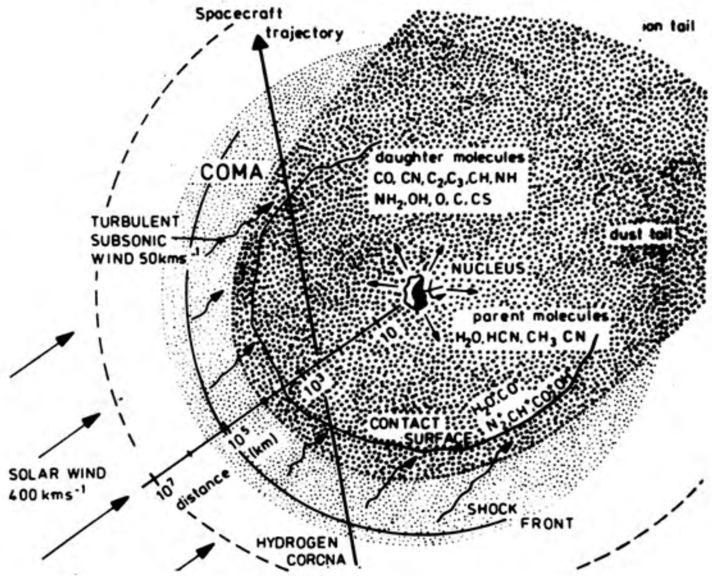
HALLEY COMET WATCH

An international network of scientists and amateur astronomers is being organised to observe Comet Halley as part of a coordinated programme when the Comet passes Earth in 1986. The organisation will be called the International Halley Watch (IHW), and be led by Ray Newburn, cometary science team leader at the Jet Propulsion Laboratory in California.

All observers, professional or amateur, are invited to share their data in a "Halley Archive", which will probably be the largest ever produced on a single comet. Ground-based, balloon, airborne and Earth-orbiting instruments will complement data from the Japanese, Soviet and ESA probes planned for launch to encounter the comet in 1986.

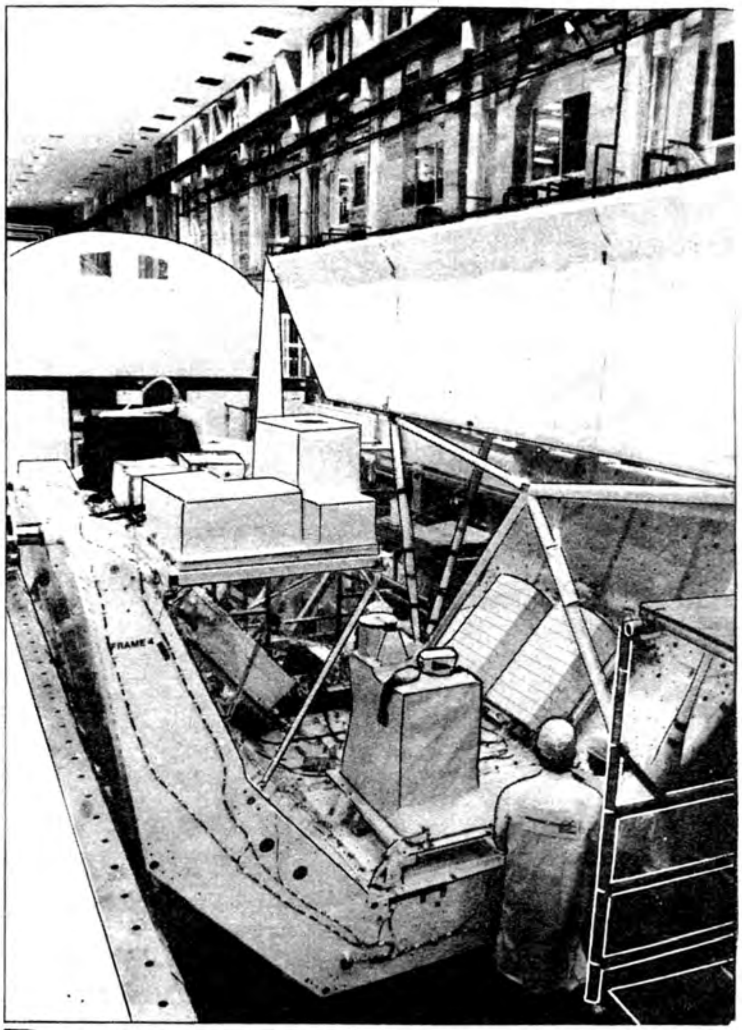
Experiment teams supported by the IHW will study the comet using seven general techniques:

- Wide angle photography to study the comet's tails.
- High-resolution photographic and electronic imaging of the coma to yield data on the nucleus' rotation rate and surface structure, and the comet's general activity.



- Spectroscopy and spectrophotometry to provide data on the physical composition of the nucleus, coma and tail.
- Photometry and polarimetry to determine the abundances and distribution of volatile and non-volatile components of the coma and tail.

- Radio science experiments to study the chemical composition and motions of the coma, nucleus and tail, searching for chemical species not discernable at optical wavelengths. Radio experiments will also detect thermal emissions from solids and perform studies of plasmas.
- Infrared spectroscopy and radiometry to determine the temperature, size and composition of dust particles released by the comet. Gaseous components may also be identified.
- Astrometric observations (studies of Halley's position in relation to stars) to provide information on the comet's orbit and ephemeris. The observations will also help determine what effect outgassing of ice from the nucleus has on the comet's velocity.
- The efforts of amateur astronomers will be coordinated by the IHW to complement those of professionals. Amateur visual and photographic observations will be compared with those of the 1910 apparition of Halley, and spectroscopy and photoelectric photometry could provide supplementary coverage in cases of weather interference at major observatories. Amateur studies of meteors during the Halley apparition will be especially helpful, since few professional astronomers devote time to such observations. The Eta Aquarid meteor shower in May 1986 and the Orionid Meteor shower in October in the same year are believed to originate from Halley.



The payload for the second Shuttle mission carried both radar (see "Imaging Radar Finds Paradise" news. item) and infrared (see "Prospecting from Space" at left) Earth observations experiments. The long rectangular radar antenna is at upper right.

NASA

PROSPECTING FROM SPACE

A previously unprospected area, potentially rich in ore deposits, has been located in a remote Mexican desert by a JPL infrared instrument carried on NASA's Space Shuttle. This is the first time that a group of minerals typical of metal-rich areas has been pinpointed from space. The identification was verified by on-site analysis.

The infrared radiometer measurements of the Baja California site were found to have identified iron oxide minerals as well as kaolinite (a clay), and possibly alunite (a potassium aluminum sulphate). These minerals are indicators of past hydrothermal activity and were probably formed at this site when volcanic rocks were subjected to hot circulating acidic waters and changed to clays, alunite and secondary quartz. Areas containing these minerals are high-priority exploration sites for gold, silver, copper, lead and zinc deposits. The surface minerals identified are similar to those found in large hydrothermal areas in the western United States.

From the Shuttle's payload bay, the infrared instrument sampled 80,000 km in swaths 100 m wide circling the Earth. It identified minerals by their reflectances in the infrared portion of the spectrum. In sampling four continents, it identified limestone (a carbonate-bearing rock), the clays kaolinite and possibly also montmorillonite. This is the first time that minerals other than limonite (a common group of iron-bearing minerals) have been identified by a spacecraft sensor.

SPACE PROCESSING

For the past six years, the McDonnell Douglas company has been funding research on the Electrophoresis Operations in Space (EOS) project. This project may lead to dramatic breakthroughs in the treatment of a number of diseases like Diabetes, Emphysema, Dwarfism, Thrombosis and viral infection. At the heart of it is a device that will be used in space to obtain certain proteins and cells by separating them from other biological materials.

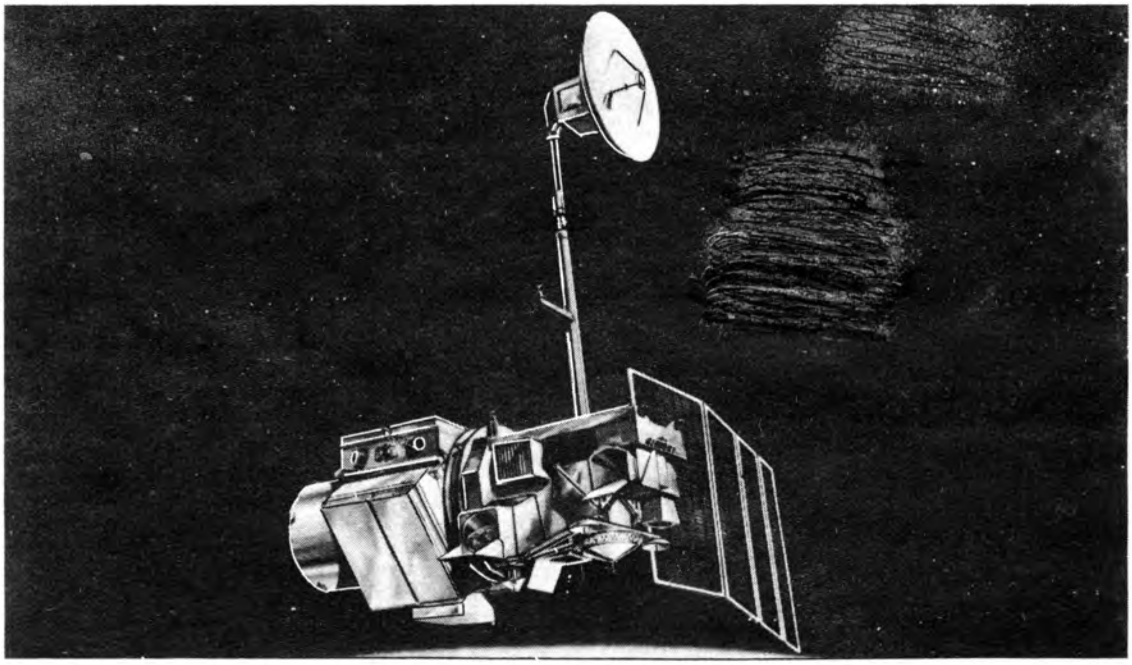
McDonnell Douglas uses a process called Continuous Flow Electrophoresis which separates materials in solution by subjecting them to an electrical field. Although material separated by this process are obtainable on Earth, the processes are so limited by gravity that only small amounts are available. In space, however, away from gravity, it may be possible to obtain these materials in the quantities and purities needed to effectively treat diseases.

In tests conducted on the STS-4 Space Shuttle mission in July 1982, the device separated 500 times more material than it could have done in similar operations on Earth. In 1978, Ortho Pharmaceutical Corporation joined McDonnell Douglas as a partner to investigate the feasibility of space-based processing. McDonnell Douglas will develop the process and hardware and will conduct the space verification and commercial feasibility flight tests. Ortho Pharmaceutical will be responsible for market research and product testing to gain regulatory approval. Ortho will also package, market and distribute any products arising from this arrangement.

Flight tests are conducted aboard the Shuttle. A production prototype unit is scheduled for two development flights in the Shuttle starting in mid-1985. If these tests continue to prove successful, the companies hope to have a production unit in orbit 1987

TESTING THE THEMATIC MAPPER

Thirteen West Virginian high school students interested in science were paid one day's US minimum wage on 7th October 1982 for helping five JPL (Jet Propulsion Laboratory) scientists lay more than four acres of plastic across a local cornfield. The field, one of the few flat ones in the area, had been harvested and the stalks plowed under before a portion was covered with 90 20'×100' (6m×30m) sheets of black and white plastic. It was then used as a target for a Landsat 4 pass the next day. It served as a test area to determine the quality of data acquired by the satellite's instruments, especially a new one called the Thematic Mapper. This differentiates between soil and vegetation, coniferous and deciduous trees, and between healthy and unhealthy vegetation. Geologist Dr. Anne Kahle is the experiment's principal investigator.



Landsat 4.

During the overpass simultaneous readings were taken from a C-130 airplane, from on the ground, and from a cherry-picker loaned by a local telephone company. (Use of helicopter was dropped because it might scare the local turkeys). A comparison of the results will aid the JPL scientists in subtracting atmospheric interference from the satellite data, thus providing better refined satellite images. The Thematic Mapper's readings of the plastic target will be used to construct a scale ranging from black to white, with 254 shades of grey in between.

The Mapper acquires information on the colour and state of health of vegetation in seven spectral regions. From those measurements, scientists can construct a map showing the distribution and kinds of forest or other types of vegetation that predominate in an area, and then associate it with local geology. The October test was conducted at the time of peak autumn foliage display when colour differences between leaves of different tree species are exaggerated.

The October experiment was a continuation of a study started in 1978, with the cooperation of local residents and businesses, on the geology, botany and topography of the region to determine what relationships, if any, exist between surface rocks and soil, foliage, and hidden natural gas reserves that occur near Lost River. Some results to date indicate that concentrations of maple trees may be a vital clue. Maps made from data collected by an airborne Thematic Mapper, like that on Landsat 4, show anomalous distributions of maple trees. Varieties of oak, hickory and evergreen trees dominate the area, but isolated circular or linear stands of maples appear in some areas where oak would be expected to dominate.

Maples are more tolerant of harsh soil conditions than other trees and may be growing over leaking reservoirs of natural gas. Red maples, for example, will grow in areas with a high water table and thus anaerobic (non-oxygenated) soil, similar to the conditions which might characterize soils containing methane. There could be other explanations for the maple concentrations but the JPL scientists are excited at the possibilities uncovered so far.

In another study the Thematic Mapper is also being tested for its use in assessing hazards from waste disposal sites. More than a score, both in-use and abandoned, have been identified in the Carquinez Straits of San Pablo Bay (the northern extension of San Francisco Bay) from information provided by the California Department of Health and the U.S. Environmental Protection Agency. The area has historically had a high concentration of waste-generating major industrial complexes because of its proximity to railroad lines and deep water ports. Much of the area is private property, making regulation difficult.

Thematic Mapper data will be used to study the area for water quality, stress on vegetation, land use, soils, surface geology and topography. Using the data, researchers will analyze potential waste hazards to nearby urban areas. They will study effects of waste on bay water by looking for signs of turbidity, chlorophyll concentration (an indication of abnormal algal growth), and distribution of heated waters entering the bay.

Geologic faults will be assessed for their potential to cause leaks of toxic materials from hazardous-waste disposal sites. Criteria will be developed to determine buffer zones – where further development should be limited – around such sites.

Techniques from the Carquinez Straits study will be tested later at a site in south-eastern Utah by assessing compatibility of Thematic Mapper data with a geographic information system for the area.

Until the satellite data become ready available, researchers are working with a Thematic Mapper simulator – a U2 aircraft-mounted instrument with resolution and other characteristics similar to the one aboard the satellite.

SATELLITE REMOTE SENSING NEEDS AND APPLICATIONS IN LESS DEVELOPED COUNTRIES

By Dr. Eric Barrett*

Many satellite and spacecraft systems have been designed and developed for looking outwards into the Universe. However, some scientists are more concerned with the benefits of looking back toward planet Earth from satellite altitudes. In the last decade there has been an explosive growth of Earth-orientated satellite remote sensing techniques and applications. This article reviews some of the recent work in this field undertaken by the Geography Department of a leading British university. It is based on a lecture given by Dr. Barrett to the BIS Study Course in Remote Sensing on 6 January 1982.

Dr. Barrett, the author.

Problems

It is not easy to present a brief review of a field as varied and contentious as satellite applications in the Developing World. In attempting to achieve something suitable, two strategies must be adopted. First, it is necessary to be as plain, straightforward and objective as possible concerning the needs of Less Developed Countries (LDCs). Characteristically, commentators of LDCs tip-toe around the core problems without daring to enunciate them effectively and honestly. Second, because illustrations abound, it is necessary to be highly selective in the choice of examples of ways in which satellite remote sensing can be used with benefit in such regions. The examples chosen here all stem from work carried out recently as part of the remote sensing activity of a modern department of Geography. But they represent only the personal opinions of the author, after his 10 years of activity in this field.

The key problems necessitating and circumscribing the use of satellite remote sensing applications in LDCs include the following:

1. The supply of conventional data (from *in situ* sensors and sensor systems) is generally less than that required even for present environmental monitoring programmes and associated decision-making. This must be true of most of the world today.
2. The supply of conventional data has generally *declined*, not improved, through recent decades.
3. The economies of LDCs are characteristically fragile, and their populations (for a variety of reasons) are very susceptible to adverse environmental impacts.
4. Environmental conditions encountered in LDCs are thick with hazards easily underestimated by workers who have not experienced them first hand, e.g. droughts, flash floods, insect plagues and severe convective storms.
5. Practical difficulties in establishing remote sensing systems to upgrade environmental monitoring and management abound. They include capital costs, suitable staffing, security, social attitudes and politics.

Satellite Remote Sensing Applications and Results

The applicability of satellite remote sensing in LDCs can be illustrated through reference to three projects, all involving use of the "Bristol Method" of satellite-improved rainfall monitoring, but embracing progressively more complex sets of environmental phenomena, and relating to three very different types of environmental problems. In each case, however, a fundamental aspect of the remote sensing philosophy of the Bristol Department is borne out: satellite data are best viewed as *complements* to, not *substitutes* for, conventional observations. Conventional ("ground truth") data are still used wherever possible, both as accurate fixes for spatial analyses of selected variables, and as calibrators for the satellite data, which provide evidence of patterns between the *in situ* data points.

Rainfall monitoring for *assessment of agricultural potential* in part of eastern Oman can be used to illustrate satellite remote sensing of a relatively simple kind. At present most of Oman's foreign currency earnings are derived from sales of petroleum. However, its oil reserves are much more restricted than those of its Arab neighbours. The Sultan wishes to expand other industries with the oil revenue and so provide a more diverse economy for the future. Most rain (an average of about 100 mm p.a.) falls in very rugged and inhospitable mountains, the Jebel Akhdar range. In conjunction with a United Nations Development Programme (UNDP) project, comparisons were made between rainfall measured daily by rain gauges, and that assessed jointly by rain gauge and satellite data.

When the results were aggregated over a whole year it emerged that the satellite-improved estimates were some 30 per cent less than those obtained using conventional data only with established isohyetal interpolation techniques (see Fig. 1a & 1b). This suggested that groundwater recharge is more closely in line with earlier "conservative" rather than "liberal" estimates. Since removal of groundwater already follows the liberal recharge curve (Fig. 1c), the satellite evidence seems to show that there is little, if any, scope for further agricultural development in Oman. Indeed, over-exploitation of groundwater reservoirs may already be in progress, with serious implications for this small, emerging country.

Improved rainfall monitoring using satellite visible and infrared image analysis to supplement rain gauge data is the basis for a solution to a much more complex problem in north-west Africa: *how the destructive Desert Locust might best be controlled.* This migratory insect pest is endemic across the expansive sparsely-populated Old World desert belt from

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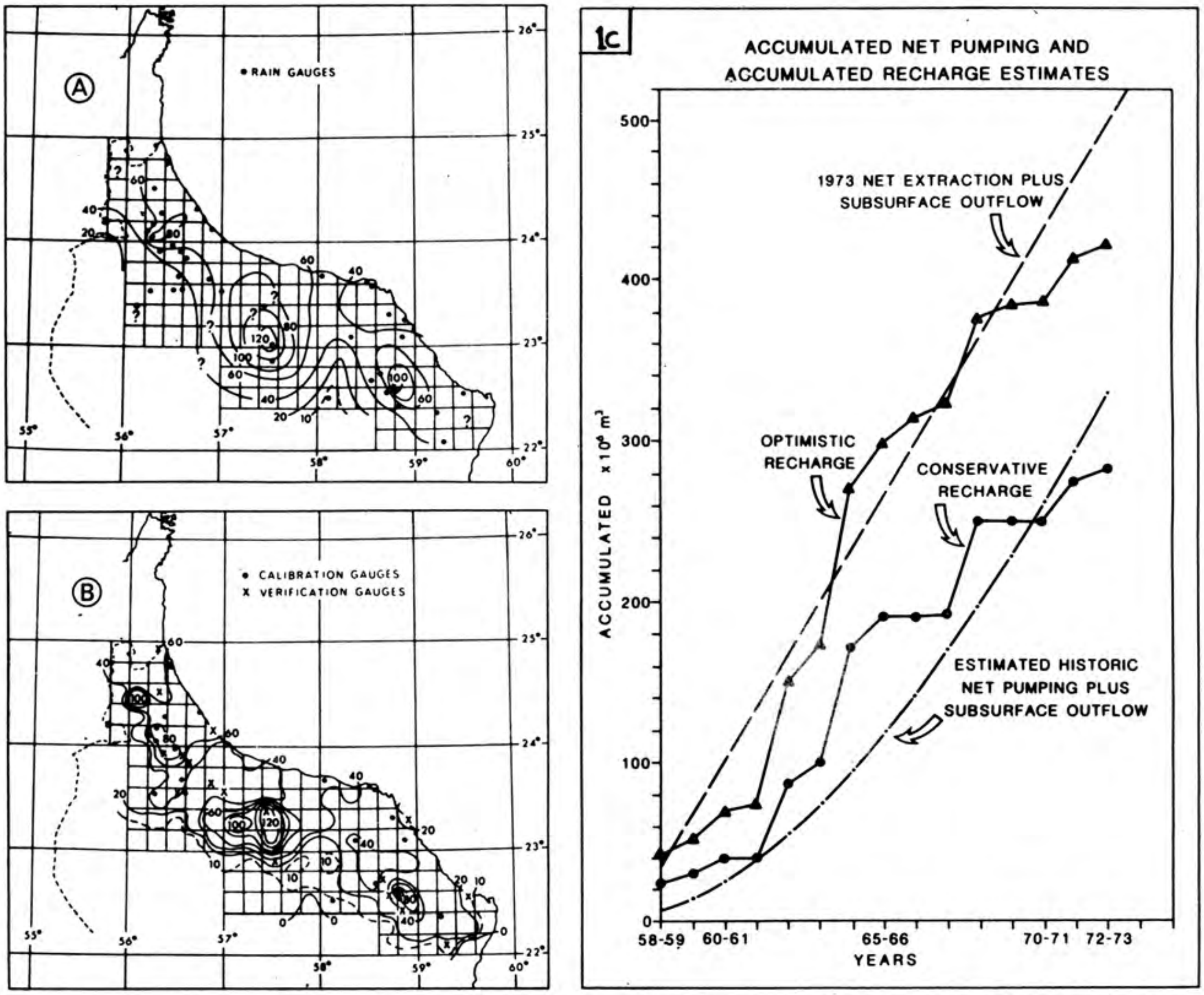

Fig. 1. Rainfall in north-eastern Oman mapped from rain gauge data alone (top left), and from rain gauge data plus satellite imagery (bottom) for 1975. Test wells suggest that recent annual net extraction of water from the ground-water reserve corresponds much more nearly with "optimistic" natural recharge curves, unlike the historic extraction, which follows the "conservative" curve (right).

south-central Asia to the west African coast. Most of the time the Desert Locust is "in recession" – very thinly spread over many countries, in its "solitary" form. When rain falls, the soil moisture is suitably replenished and vegetation flushes, so that the solitary locusts can quickly congregate in these temporarily more favourable locations. Often they are swept inwards by the converging winds that feed the convectional rainclouds. Rapidly the insects then change their shape, colour and behaviour. Now in their "gregarious" form they breed rapidly, prompting geometric rises in populations until plagues are formed. These may then migrate in search of further food. The problem is to survey vast desert areas for regions conducive to the growth of this threat.

A satellite-based answer has been developed for the Food and Agriculture Organisation of the United Nations and the international Desert Locust Commission. First, rainfall is monitored in the chosen areas (e.g. N.W. Africa), by both rain gauge and satellite (see Fig. 2). Second, periodic "hazard maps" are prepared from the resulting rainfall maps. Third, interpreting these maps through knowledge of desert surface characteristics mapped from high-resolution (80m) multispectral data from Landsat satellites, leads to areas of high *effective* hazard being identified. In these, rain water may be expected to collect in wadis, or be retained long enough in the soil for vegetation to develop. For these key areas post-rainfall event Landsat frames are ordered (see Fig. 3). These are analysed for confirmatory evidence of plant growth. Any such growth in the desert becomes quickly evident when the images are subjected to false-colour enhancement processing. In the meantime, ground inspection teams have been directed towards the general high hazard areas. The Landsat evidence helps to narrow, even pinpoint, the field search for populations of young desert locusts. Once located, these may then be sprayed with insecticide before they are old enough to swarm or migrate.

Elsewhere, satellites are proving useful in the control of other major insect pests; for example, the Armyworm in East Africa, and the Screwworm in Mexico and the southern USA.

Finally, reference may be made to a very broad and widely-ramifying project of NASA, NOAA, and the US Department of the Interior to assist the US Dept. of Agriculture in *crop prediction* for political and commercial purposes, and associated decision-making (see Fig. 4). The basic relationship to be quantified is crop production (i.e. harvest volume), calculated from yield (i.e. productivity per unit area) multiplied by the area. Complex Landsat image-processing techniques are being used to establish the areas of different crops, especially in regions from which agricultural statistics are poor, or generally unavailable. Meteorological satellite data analytical techniques are being developed simultaneously to evaluate key weather parameters affecting *yield*. These include outgoing

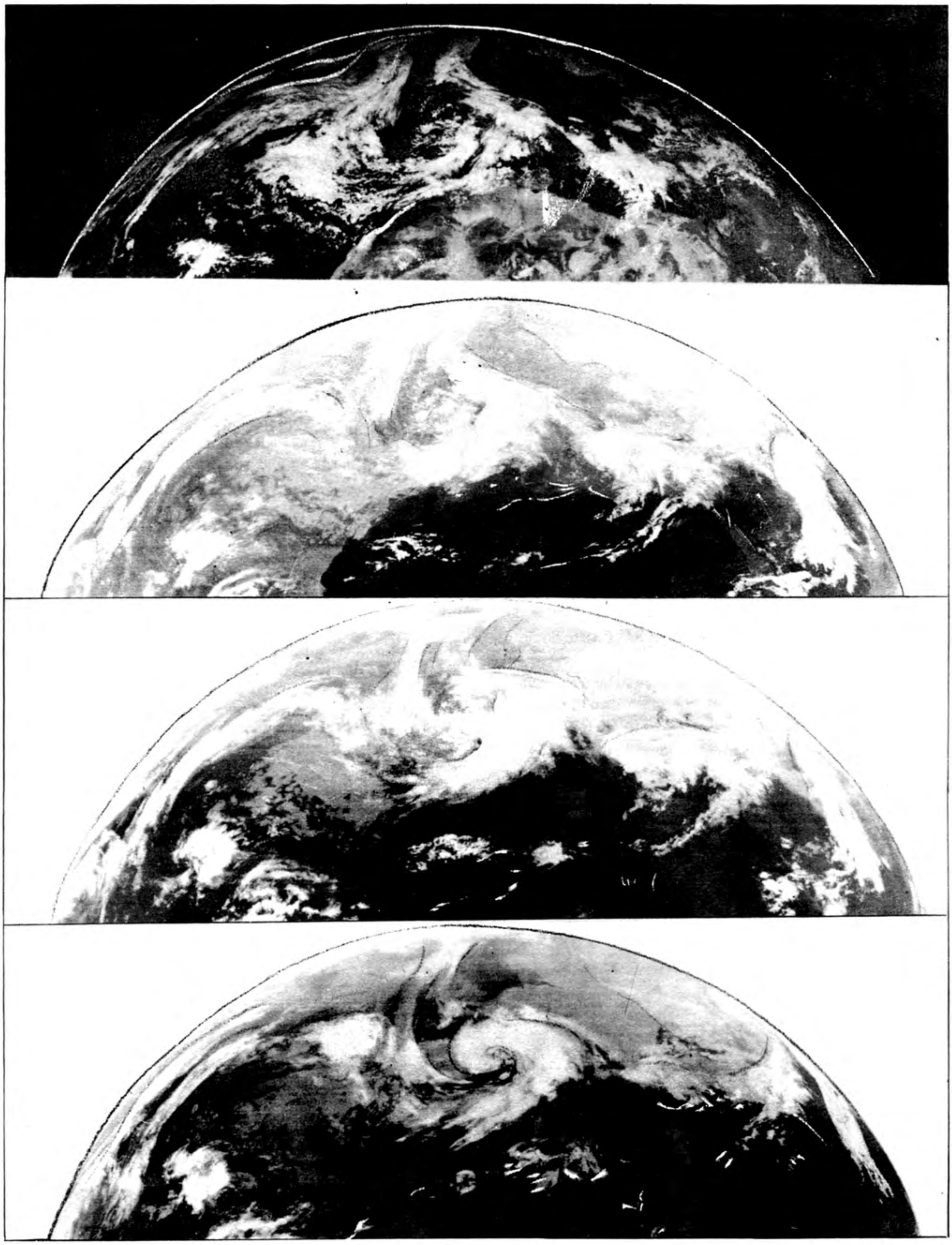

Fig. 2. Visible and infrared imagery from the ESA satellite Meteosat-1 for (from top to bottom) 1225Z vis, and IR for 1225Z and 1755Z on 26 October 1979, and 0555Z on 27 October 1979, showing a Mediterranean depression trailing rain-bearing fronts over parts of north-west Africa. Such imagery may be analysed in detail in conjunction with rain gauge data to provide the best possible maps of rainfall. (Z is Universal Time, the equivalent of GMT.)

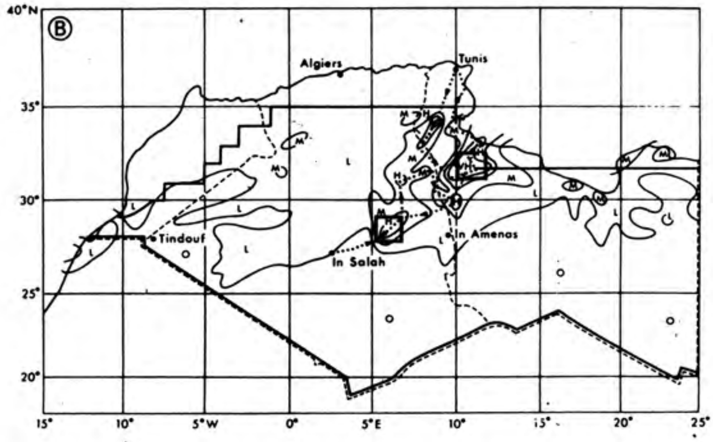

Fig. 3. A "rainfall hazard" map prepared for the Desert Locust Control Commission in North-West Africa, for a 10-day period in March/April 1977. (VH: very high; H: high; M: medium; and L: low risks of vegetation flush/locust population upsurge. Boxed areas show sizes of individual Landsat frames ordered to pinpoint post-rainfall vegetation growths. Dotted tracks show the associated most efficient route patterns to be followed by ground inspection teams. Broken lines are national boundaries. The continuous line generally running from east to west in the south marks the southern boundary of the test area.

longwave (heat) radiation, maximum and minimum temperatures near the ground, and, most importantly because of the degree of its influence on plant productivity, precipitation. The aim is that a range of different crops should be "grown in the computer" through the use of sophisticated crop growth models evaluated on a day-to-day basis by inputs of conventional and satellite weather observations. This far-reaching scheme, the likes of which are already being implemented (at a less advanced level) by certain private remote sensing companies, is of interest in the context of LDCs because:

1. LDCs are included amongst the AgRISTARS satellite target areas.
2. Software developed for AgRISTARS will be freely available for use elsewhere and by others because this is a US Government-funded civilian research project.
3. Information issued from an operational AgRISTARS programme would be of direct interest to national and international agencies involved in the prediction and relief of foodcrop shortages and associated famine.

Needs and strategies

A variety of needs emerge from almost any consideration of fuller use of satellite remote sensing in LDCs. The commonest include:

1. Education and training. The potential of satellite remote sensing systems must be demonstrated practically to politicians, decision-makers, and the better-educated members of the general public. Would-be remote sensing practitioners must have appropriate scientific backgrounds, and be given proper training: usually the "crash courses" which are commonplace are not adequate as a basis for routine operations.

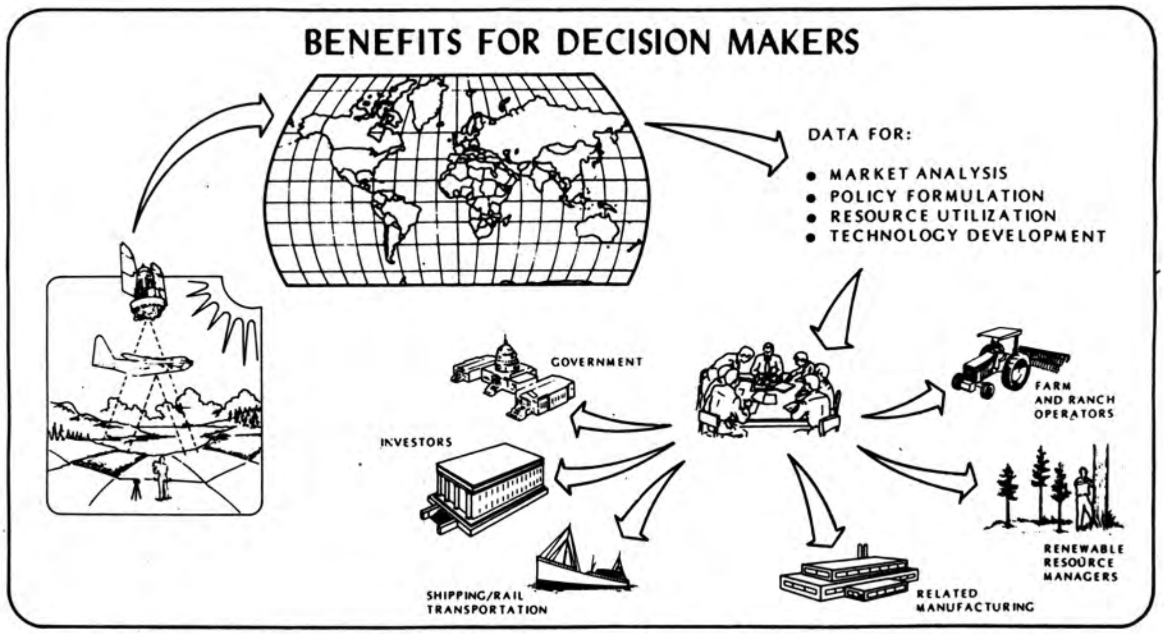

Fig. 4. An artist's impression of the AgRISTARS Program Concept. (Courtesy, US Dept. of Commerce).

2. Equipment and technical assistance. All too frequently these are provided through aid programmes which fail to meet real needs. Multi-national aid programmes may further a temporary growth of expertise which lacks local roots, and later withers. The current tendency for countries to give aid unilaterally may be no more productive; often the money "given" returns to the donor nation, leaving the "beneficiary" with goods and/or services inappropriate to its situation.
3. Integrated analytical programmes. Traditionally many environmental agencies (e.g. concerned with weather, water, soils, agriculture, etc.) have enjoyed partial or complete independence of action. This often prompts resistance to co-operation, to data-sharing and, above all, to the centralisation of satellite data analysis facilities and procedures which (nationally or even sub-continentally) is essential if such programmes are to be fully cost-effective.
4. International co-operation. Satellite data reception is an expensive business. Unfortunately national rivalry and/or outright hostility bedevils many efforts to rationalise the basic and costly flow of high quality data from satellites to would-be users.
5. Appropriate operational satellite systems. Even after 21 years of environmental satellite activity (begun with the launch of the American weather satellite Tiros-1 in April 1960) satellite strategies are being determined more by technologists and research scientists than by would-be operational end-users of satellite data. No authority, agency or undertaking will commit itself wholeheartedly to the regular use of satellite data until it has promises of specified data in a prescribed form continuously through an acceptable period of time. Weather services have become the most accustomed to such promises. Generally, other environmental services which cannot use weather satellite data have not.

Many important questions could be posed in respect of the growth of effective satellite remote sensing applications in LDCs. However, one may be more critical than all the rest. Many believe that we stand only at the beginning of the era of environmental monitoring, management, and even control, by satellites; few dispute than, eventually, it may become more convenient for each country or agency of even quite modest size to have its own satellite data reception, processing, analysis and interpretation facilities. Whether this is reasonable or not there would seem to be an urgent question to be answered in relation to the arrangements necessary to meet present and short-term needs: *would the LDCs be served better by satellite remote sensing facilities of their own – or by the provision of satellite data processing results from elsewhere?*

Where satellite reception and data processing facilities already exist, further analytical and/or interpretation results can often be financed relatively cheaply. At existing centres in developed countries procedures are subject to stringent quality control. So, at least as an interim solution to the problem, LDCs might gain more from the purchase or receipt of customised data-analysis products from other countries than from the acquisition of the very expensive hardware and software needed if they are to generate equivalent products for themselves.

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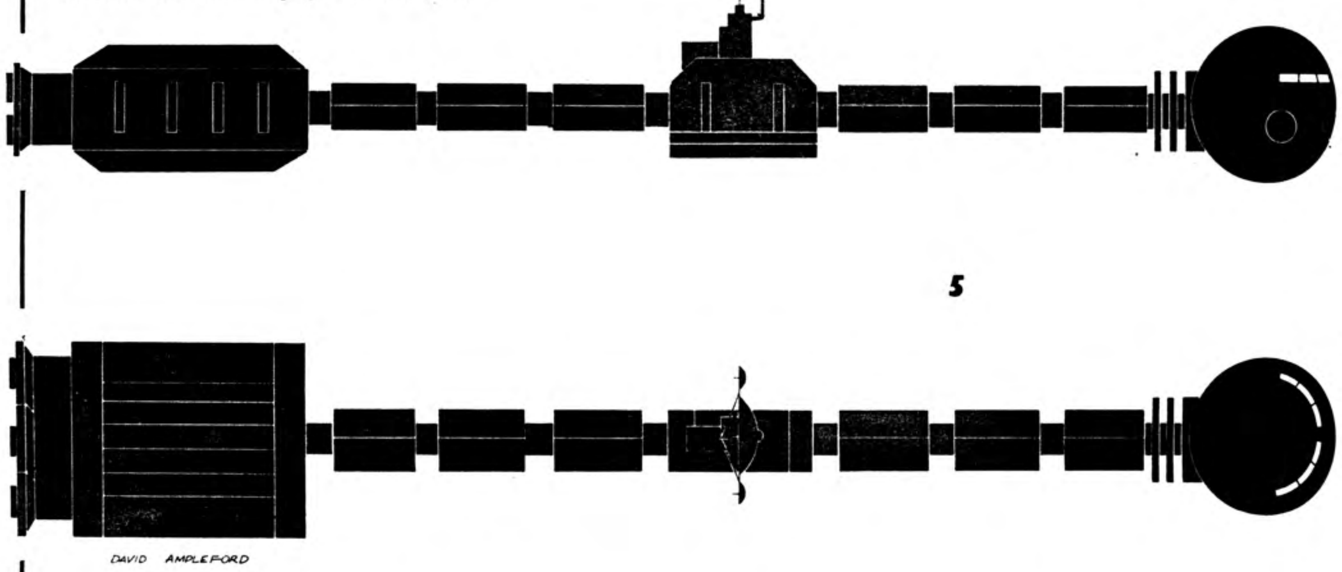
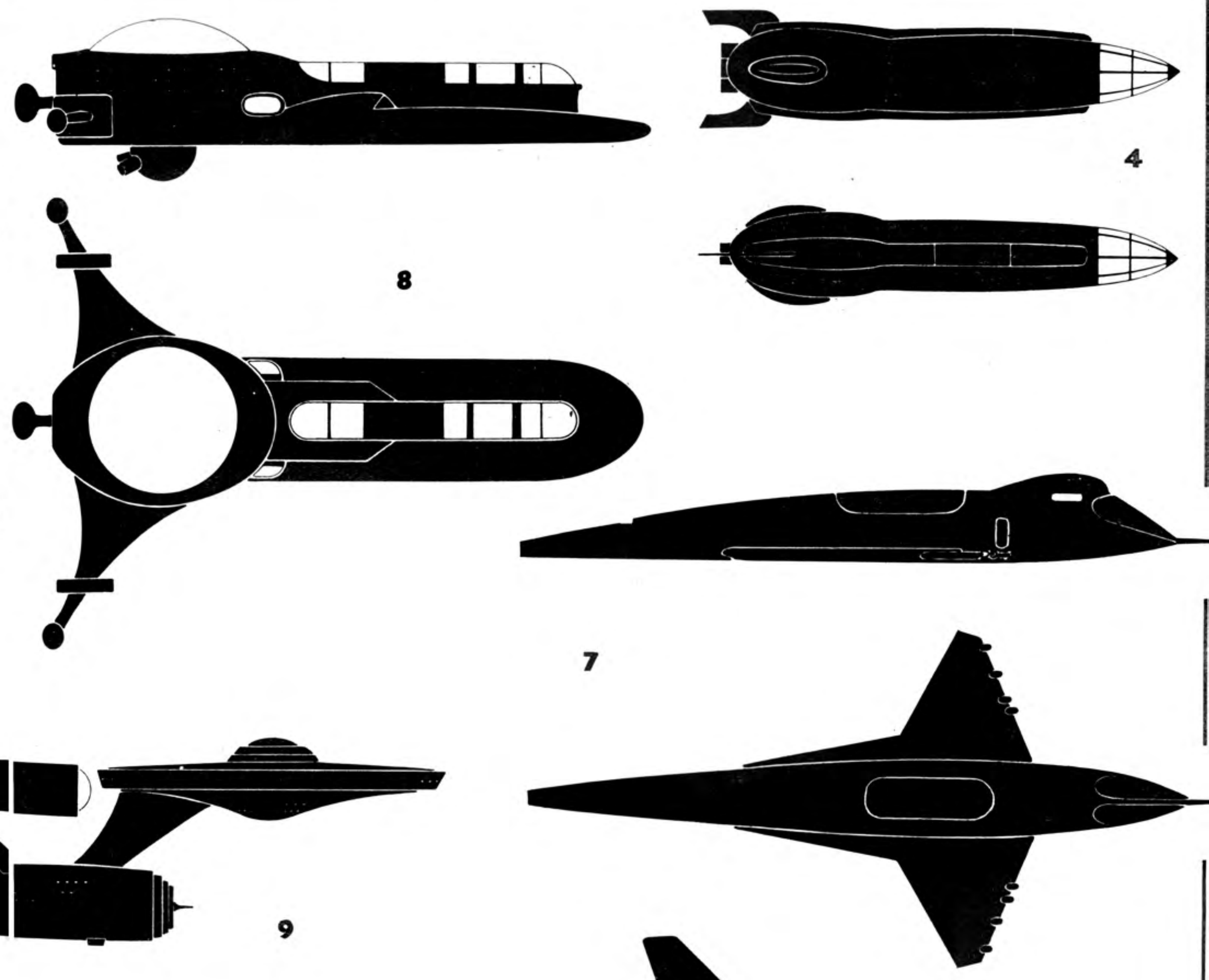
Landsat 4 is the latest remote sensing satellite of the series that began in 1972. This multispectral scanner image, the original with a resolution of 80 m, shows the New York City area.

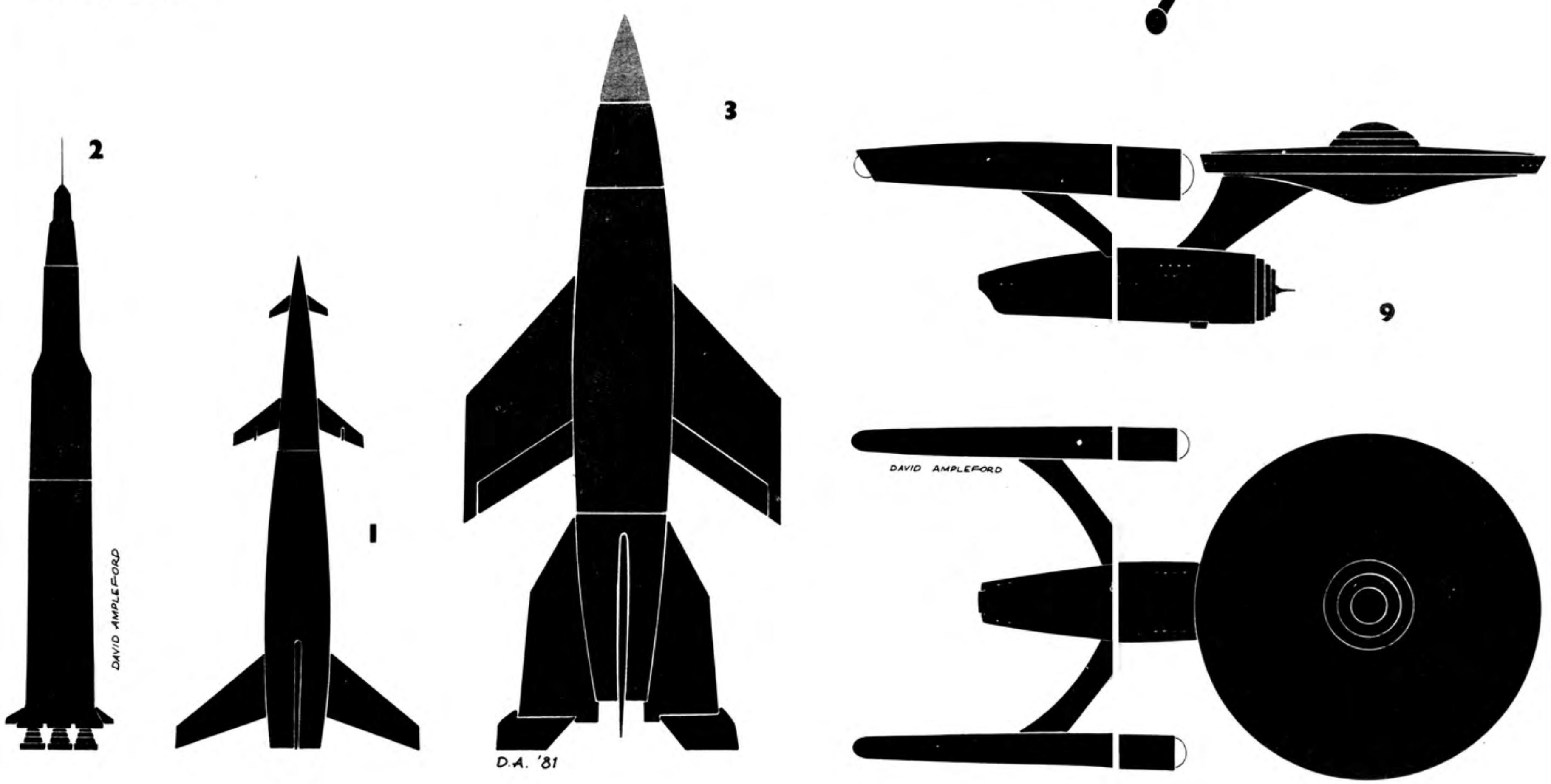
NASA

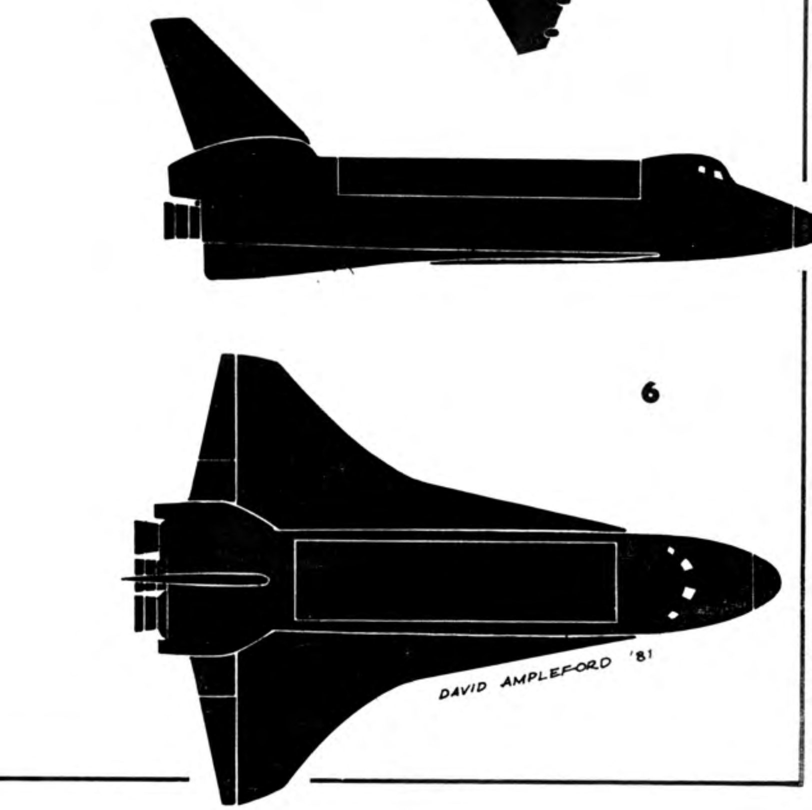
Space Vehicles from Fact and Fiction

Whose spacecraft were these? How many of the silhouettes can you recognize and who flew them in fact or fiction? See foot of page for answers.









(1) "Luna", piloted by Jet Morgan and crew, "*Journey into Space*" 1953. (2) Saturn V (approximately) piloted by various NASA astronauts to the Moon 1969–1972. (3) A4b, unpiloted – Winged version of A4 (V2) missile flown in 1944. (4) Dan Dare's "Valiant", probe to the outer planets. 1953 drawing. (5) "Discovery", from "*2001*", an outer planets' manned probe ("Flown" by HAL 9000 Computer and 3 Crew Members). (6) The Shuttle (STS) flown by various US astronauts 1981+ (7) "Orion", the Shuttle from "*2001*". Crew unknown. Includes pretty air (space?) hostess. (8) Dan Dare's starship, the "Galactic Galleon". Drawn early 1950s, use around year 2000. (9) Starship "Enterprise" from "*Star Trek*". No prizes for names of Captain and first mate.

SPACE ART: VISUALIZING MAN'S JOURNEYS FROM EARTH

by Adrian Perkins*

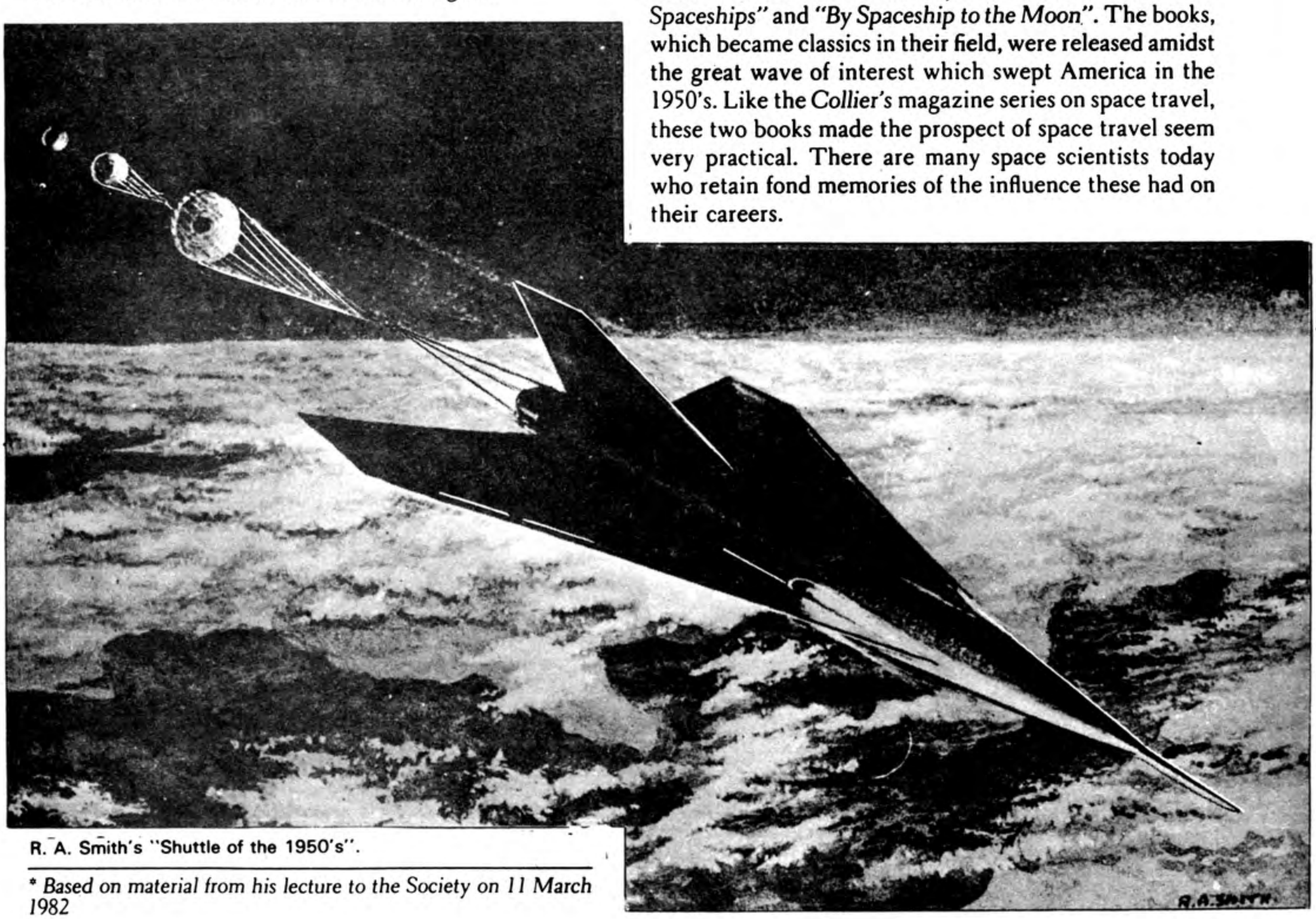
When Neil Armstrong first set foot on the Moon in July 1969 millions of men, women and children were watching that historic television broadcast to see if NASA's discoveries would live up to the visions they had already seen. Those earlier visions had been supplied, not by scientists, but by artists – by people such as Chesley Bonestell, Robert McCall, David Hardy and R. A. Smith. They had been extrapolating and synthesizing human knowledge from Science, Nature and Art, for many years to infer what man would see when he took his first steps outward.

When the scientific artist creates an accurate vision he provides inspiration to those working in the field, and forms a method of communication to the rest of the world, the non-scientific public The space artists of the last few decades have had as much to do with the success of the space effort as any technician. Just as the early American artists showed the public views of the unconquered West and helped promote interest in exploration and expansion, so, too, have modern artists shown the public what the unseen planets, moons, comets, and distant reaches of the galaxy might look like were we able to be there in person. So the fields of space science and technology have produced several great artists along with the eminent scientists and technologists.

Aerospace artists, primarily because their work is so close to illustration, are unfairly ignored by the art community as a whole. However, they *do* have a role to play! They can make us aware of what we are doing out there, while space artists of the fantastic school stretch our imaginations with visions of where we may go. In a previous article I have shown how Chesley Bonestell in the 1950s through books and illustrations for *Colliers* magazine was important in firing imaginations. His style was copied by many. In Britain, too, Dan Dare's creator Frank Hampsom stoked the fires in young minds.

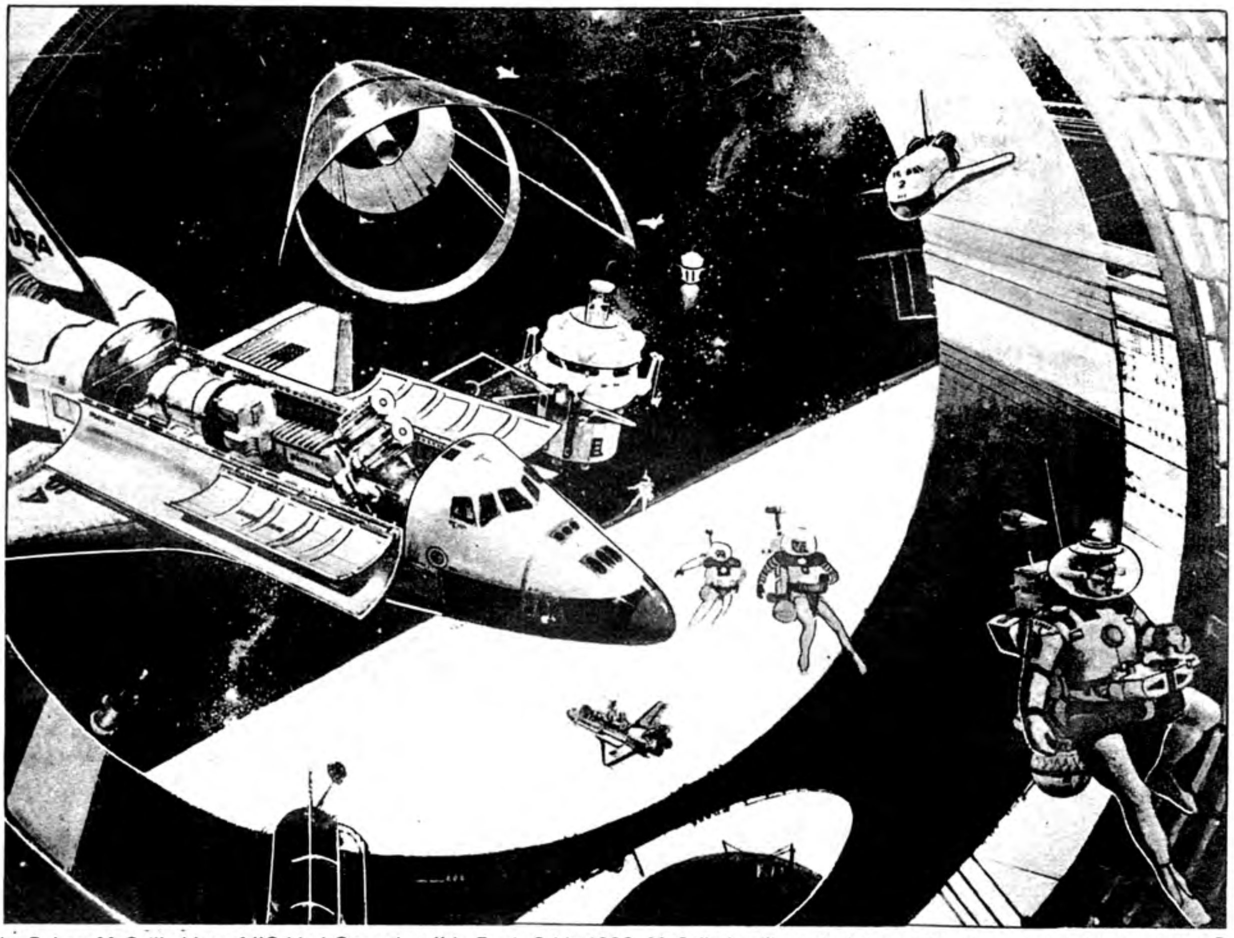
1903 wp

There were others. In 1951 and 1952, artist Jack Coggins collaborated with author Fletcher Pratt to produce two books, *"Rockets, Jets, Guided Missiles and Spaceships"* and *"By Spaceship to the Moon"*. The books, which became classics in their field, were released amidst the great wave of interest which swept America in the 1950's. Like the *Collier's* magazine series on space travel, these two books made the prospect of space travel seem very practical. There are many space scientists today who retain fond memories of the influence these had on their careers.



R. A. Smith's "Shuttle of the 1950's".

* *Based on material from his lecture to the Society on 11 March 1982*



Artist Robert McCall's idea of "Orbital Operations" in Earth Orbit 1998. McCall also illustrated the well-known posters for the film *2001*.

Space art blossomed in and after the 1950's. In the years around the time of Sputnik I, in 1957, the Space Art that appeared in magazines and books helped convince the public that space exploration was far from a fantasy, and that it was well within the reach of contemporary science and engineering. Realistic and accurate paintings of other worlds showed that the moons and planets were not as insubstantial as fuzzy astronomical photographs made them seem, but were genuine worlds in their own right.

As the Space Age progressed, however, the photograph seemed set to displace the artist as the medium for recording the new technology. But in March 1962, NASA decided that, despite filmed documentation of all the Agency's projects, there was a lack of emotional impact to the recorded history. They concluded that artists should be invited to contribute their imaginations and perceptions in recording what was going on.

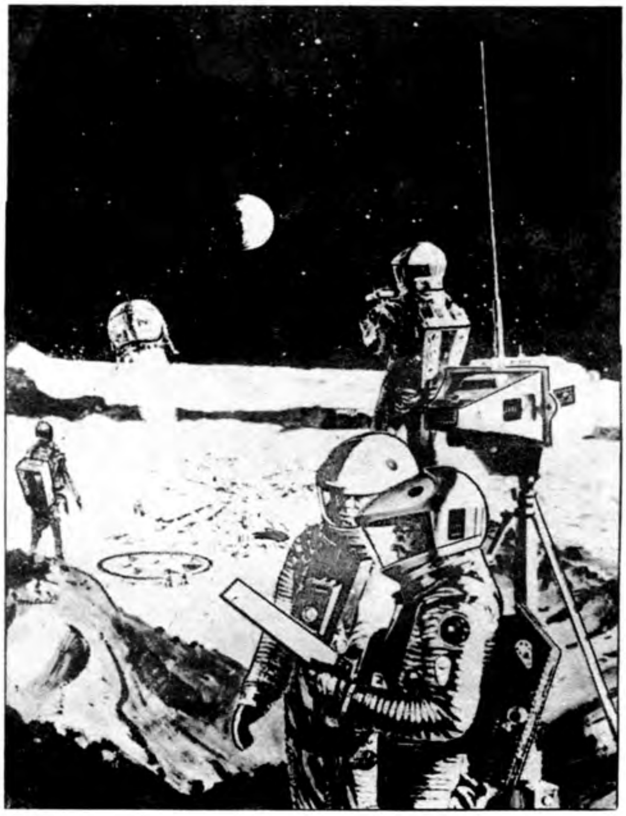
In announcing the inception of the Fine Arts programme in 1963, NASA adminstrator James E. Webb said, "Important events can be interpreted by artists to give a unique insight into significant aspects of our history-making advance into space. An artistic record of this Nation's programme of space exploration will have great value for future generations and may make a significant contribution to the history of American art".

The scheme began just as the NASA project of one-man Mercury launches was nearly completed. It has continued to record key events in the space programme into the 1980s, albeit at a fraction of the initial funding. Many of the 53 artists who participated in the original programme are still actively taking part in the space programme – however, they are mostly now future-project visualizers for the commercial giants of the American aerospace industry. They produce material a camera could not.

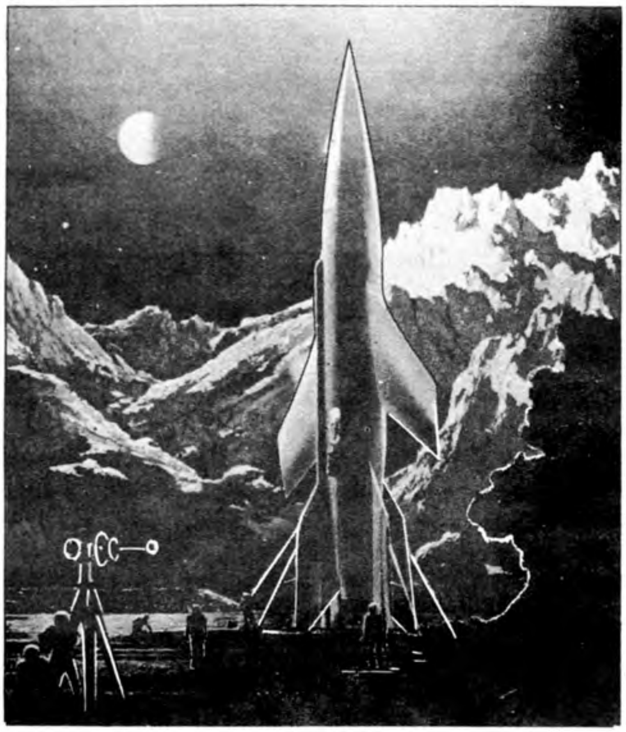
Films

During later years cinema films have drawn more and more on artists' conceptions, epecially with cinema block-busters like *"Star Wars"* and *"Close Encounters"*. Mixed with the pure SF have been attempts at capturing audiences for more serious space tasks by use of imaginative stories. These can be said to have begun in the late-twenties with Fritz Lang's *"Die Frau im Mond"* (1928), continuing in 1936 with *"The Shape of Things to Come"* from Alexander Korda, and George Pal's *"Destination Moon"* in 1950. The classic of recent years (premiered April 1968) was, of course, *"2001: A Space Odyssey"* directed by Stanley Kubrick.

Each film had professionals, usually scientists, as advisors: Herman Oberth and Willy Ley (of the VfR) on the 1928 German film, H. G. Wells on Korda's film, Chesley Bonestell on *"Destination Moon"* and Arthur C. Clarke (of the BIS) - together with several ex-NASA space vehicle experts - on *"2001"*. These films reached far more people than the *Collier's* magazine articles on Space Travel had ever done. All have in their own ways, become "cult" movies, *2001* because it was capable of so many interpretations -especially as the psychodelic-type images it contained appeared in the late 60s, an era of rapid cultural change, drugs and flower power. - *Die Frau im Mond* and *Destination Moon* because they broke new technological and artistic ground, and *"Shape of Things"* for its historic placing and vision.



Exploring the Moon: visions of different ages. *Below*, Chesley Bonestell's 1950's view of how it could be, and *right*, Bob McCall's 1970's illustration of a Moonbase for a *2001* poster (*courtesy of MGM*). Bonestell's picture is also linked to a film - *Destination Moon*.



Much like Chesley Bonestell, Bob McCall's artwork is now displayed at every major centre of astronautics, for example his Apollo exploration murals ("Spaceflight Environment") in the Smithsonian Institution's National Air & Space Museum in Washington D.C.

Modern space artists have it easier in some ways, more difficult in others, than the space artists of a generation ago. More discoveries have been made about the nature of our neighbouring planets in the last decade than in all the previous history of astronomy. Contemporary artists certainly have more factual material to draw upon, yet this abundance also limits them. We know what the surface of Mars looks like now - there is far less leeway for the artist's own imagination. But this does not stop them giving us new vantage points to familiar objects, or sending their imagination out beyond or inside where man's instruments and probes can reach.

Modern Space Artists

When we talk of "modern" space artists we distinguish a generation that has grown up with the space age rather than predating it. Many of the "older" artists are still alive and working. We can see from the previous section that many involved with stills artwork were also those involved with movies. The modern artist often has a foot in both camps, too. On *"2001"* Kubrick and MGM employed one of the foremost American space artists to do the publicity artwork: Robert T. McCall.

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VIDEO TELECONFERENCE BY SATELLITE

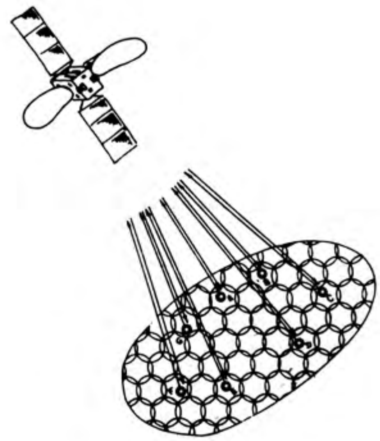
By S. E. Dinwiddy†

Video teleconference is an extremely promising application of communication satellites and experiments in this are planned using L-SAT. This article looks at types of meeting, the impact of their size on the way in which they are conducted, and how and where satellites can be used for "conferences-at-a-distance" in the future.

Introduction

Video teleconference is recognised as an extremely promising application of satellites [1, 2, 3]. ESA have undertaken studies of this [4 & 5] and are discussing the use of two of the four L-SAT payloads for this application with Phillips Telecommunicatie Industrie, Politechnico di Milano and others.

Optimal use of these facilities demands an understanding of the basic principles concerning the structure of meetings. Information, ideas and advice have been collected on this subject from published literature and discussions with experts. An outline theory has emerged which hopefully will prompt further discussion and a deeper appreciation of the problems. The objective at this early stage is not to determine all the answers but to define the questions so that experiments can be planned to look for the answers.



Face-to-Face Meetings

We need to consider all forms of contact to have a full insight into how face-to-face meetings are conducted. We should examine direct physical contact - generally limited to the handshake - and aural and visual contact, not only public (to the meeting) but also private asides and corridor talk. We should consider pictures and text shown to the meeting and given out as hard copy. We should also distinguish general written communication to all participants from private notes between two, or a small group of them. All these aspects should be examined for every sort of meeting, from the small, informal, round-table discussion up to the large, formal conference.

For the purpose of this discussion, let us look at two types of meeting: 1) the round-table meeting in which, in principle, each member has an equal voice and 2) the forum meeting in which, in principle, one person has the floor at any specific time. For each meeting type, three sizes are considered - small, medium and large, labelled for convenience as shown in Table 1.

Table 1. Classification of Meetings.

Meeting Size	Meeting Type:	
	Round Table	Forum
Small Medium Large	Conversation Discussion Council	Lecture Symposium Conference

Round-Table Meetings: Conversation

In a small "conversation" meeting, verbal information exchange takes place freely. Although there may be a chairman, formally appointed or informally implied (say, the one who called the meeting, or the senior participant), he often makes no obvious intervention, after the introductions are completed, unless the meeting strays from the point or a particular participant requires control. All participants can see each other, fully and clearly, but private exchanges are difficult.

A meeting on this scale can be set up quickly and easily, so it can take place in or near the office of one of the participants. This can be an advantage for access to files and secretarial help but can also be a disadvantage if callers and visitors keep interrupting.

Because of the small number of participants, writing or drawings on paper or blackboard can be seen by all, and copies to take away can usually be made as required.

Round-Table Meeting: Discussion

In a larger "discussion" of ten to twenty people, it is generally necessary to have a chairman to keep it to the point. The "round-table" principle is maintained, because everyone can see everybody else and can ask to speak at any time, but, particularly if the meeting is intended to transact some form of business efficiently, it must be properly controlled with an agenda.

Normally not all participants will have equal status, or contribute equally to the discussion. Often there are observers who have little to contribute. Sometimes, the meeting is essentially between two teams, each with its

† *Communication Satellite Department, ESTEC (European Space Research and Technology Centre), Noordwijk, Holland*

own leader and various specialists who in turn argue out the points. If the meeting is between a larger number of delegations, each may be invited to put their point of view in turn.

Graphical aids have to be prepared in advance, as slides, viewgraphs or hard copy. The quantity required usually prevents on-the-spot preparation of more than the simplest hand-drawn viewgraph or flip chart. Private conversations in the meeting room or the corridor are possible with meetings of this size. It is also possible to arrange side-meetings on a formal basis to discuss particular matters.

It is a curious fact that a meeting of this size is often allocated a complete day, independent of the amount of business, and requires that lunch be provided. This sometimes is where the real work is done since it may be easier to express one's true opinions there than in the meeting proper.

Round-Table Meetings: Council

As the meeting gets larger, the machinery of the meeting becomes more elaborate. Microphones may be used and simultaneous translation provided. The agenda and papers to be presented may be circulated in advance. Resolutions and other agreements made by the meeting may have to be drafted, printed and signed during the meeting. Procedure may be elaborate so that smooth running of the meeting requires exercise of considerable skill and experience by the Chairman and the Secretary.

Often, though, presentation material will be less used in larger meetings, as the formal written record is considered more reliable. Because of the formal nature of the large round-table council, private exchanges in the meeting, in the corridors and during lunch become of paramount importance. (As, for example, in modifying extreme resolutions to ensure majority support.)

Forum Meetings: Lecture

We will define a lecture as a single talk by a single lecturer to a number of listeners. There are often questions - sometimes at random if the audience is small, otherwise usually at the end. It should also be possible for members of the audience to make private contact with the lecturer at the end of the lecture.

Graphics are generally essential. Permanent graphics may be a specified textbook or printed course notes. Transitory graphics will be writing on the blackboard or something similar. Lecturers generally discourage private exchanges among members of their audience.

Forum Meetings: Symposium

A symposium will be taken to be a forum meeting in which a number of lectures are presented in succession. A chairman may be appointed to introduce them and to regulate the discussion. There may be pre-prints, as a copy of the lectures or as additional material, use of the blackboard, slides or film.

In the post-graduate world a symposium is often more than just the lectures; it may combine travel to somewhere new and interesting, meeting professional colleagues, visits to relevant facilities and a chance to get to know one's own colleagues a little less superficially.

Forum Meetings: Conference

A conference is here distinguished from a symposium by the use of parallel sessions in which different lectures are presented simultaneously. Each conferee may move from lecture to lecture and try to catch as much information as possible ... or he may move from bar to bar and try to meet as many old friends as possible.

STRUCTURE OF TELECONFERENCE MEETINGS

Audio Teleconference

Audio teleconferencing (i.e. where one does not see the speaker) in its simplest form comprises interconnection of two loud-speaking telephones over the public switched telephone network (PSTN). Unfortunately, this sort of system is generally very unsatisfactory, as switching has to be introduced in the telephone set to prevent build-up of echoes, both from the transmission circuit of the telephone and from reflections in the acoustically untreated room. The result is distortion and clipping of speech, inability to interrupt and uncertainty over whether the far end has heard all that has been said.

Various professional audio teleconferencing systems have been built [6, Part III], including multiple-point systems and stereophonic/multiple-loudspeaker systems which allow the speaker to be identified by voice location. For an acceptable audio conference, high-quality transmission is generally necessary - see "sound quality" below - and echo-free four-wire circuits are required. These will not be widely available from the telecommunications authorities for a long time.

Although there is a body of opinion which claims that audio conference would satisfy most of the demand, there is an equally strong argument in favour of video, on the grounds that both require a specialised services network which will be an expensive facility regardless of the bandwidth used. The cost of transmission is generally small compared with the cost of switching, control and administration of a network, and the bandwidth required for video is being steadily reduced by advances in video signal processing, so that the cost difference between video and audio is expected to become an unimportant factor [10].

Computer Conference

In passing, it is appropriate to mention a technique with which the speaker is neither seen nor heard and which has the misleading name of "computer conference". This is really a computerised message system by means of which computer users can make use of their terminals to send each other written messages. By means of the computer, messages can be stored, retrieved, re-directed, replied to, tagged for later reference or erased. The systems are interesting [11] but will not be considered further here.

Voice-Switched Video

With face-to-face forum meetings, an experienced lecturer will rely on getting some response from his audience. This can be satisfied by having part of the audience in the same auditorium as the lecturer (as a television "studio audience") with the rest not necessarily visible. With round-table meetings, however, a proper view of the listeners is important to the

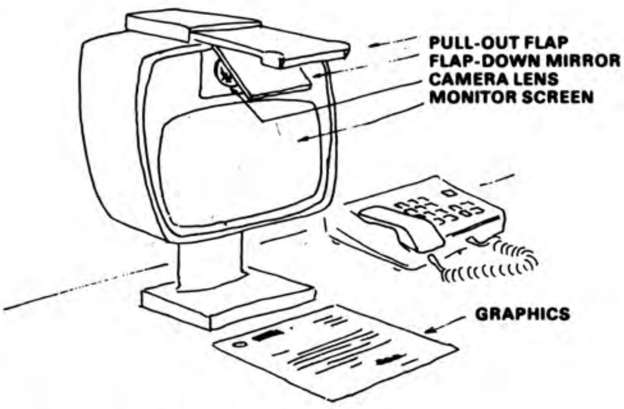


Fig. 1. Videophone in Graphics Mode.

Broadcast Standard		Picturephone Standard
4:3	Aspect Ratio	4:3
625	Lines/frame	313
50	Frames/second	50
2:1	Interlace	2:1
4-5 MHz	Bandwidth	1 MHz

Table 2. Video Picture Standard.

speaker. The video channel can allow silent replies (nodding or shaking heads) or interventions (raising a hand) to be made without interrupting the speaker's audio channel. Recent research by Bell Laboratories [12] has shown that there is an advantage of such a "continuous presence" over a "voice switched" system which provides a view only of the speaker. In a series of tests using the two schemes, the "continuous presence" scheme proved to be the better not only in comparative terms – which system was preferred, more enjoyable, was easier to use – but also in absolute terms – the extent to which the video conference had the feel of a face-to-face meeting: how effective, friendly and productive it was.

This conclusion seems to reinforce the importance of comprehensiveness of the video service. Nevertheless, the widespread use of voice-switched video teleconference systems (many of which are based on the video-phone) makes further consideration of these systems necessary (see below).

Graphics Display

Nearly all video teleconference systems and proposed systems include graphics display as a matter of course. The commonest technique is by use of an overhead camera focused on a specific "graphics area" on the conference table. This is the cheapest and simplest technique because it uses the same type of video link (or even the same camera; see Fig. 1). However, the quality is not as good as printed hard copy, slides or viewgraphs, and a hard copy record may be essential. Before the meeting mail distribution is possible but during the meeting facsimile transmission is the only solution. Indeed NASA [6, pp. 38–39] considered high-speed facsimile, for top-quality graphics, to be more important than the video link itself, and SBS recommend a high-resolution scanner with electronic storage and display [7].

Video Quality

Some video teleconferences, particularly those run by broadcasters using television studios, use full broadcast-quality cameras complete with all the movements and effects (elevation, traverse, run-in, pan, tilt, zoom, fade, wipe) seen on television. Unfortunately most users will not normally be able to afford the skilled camera operators and other studio technicians that would be required and fixed camera positions must be accepted, with no focusing and limited-aperture lenses. Zoom (or field of view) controls, though, are sometimes incorporated.

The choice of video picture standard is important for studio and system configuration. The basic choice lies between "broadcast standard" and the "picturephone standard" (see table 2). It will be noted that the two standards are very similar, so that conversion from one to the other is relatively easy, though the detail of 625 lines cannot be recovered from a 313 line signal.

The reduced definition of the picture phone standard (designed expressly for displaying a head-and-shoulders view of one person) is not generally reckoned sufficient to handle a full meeting of more than two people. As mentioned already the technique of voice switching has been used to extend the capabilities of the picturephone, but generally with less successful results than have been obtained with broadcast-standard video systems.

With fixed-view cameras the changes in picture content from frame to frame are relatively small. This opens the way to successful bandwidth reduction by digital encoding and processing for redundancy reduction. The COST 211 Project has developed a picturephone codec capable of transmitting a 313-line picture over a 2.048 Mbit/s link [8]. The choice of 8.448 Mbit/s as the nominal transmission rate for the L-SAT 20/30 GHz narrow-band communications channel was based on extrapolation of these techniques to handle a 625-line colour video signal with approximately four times the bandwidth.

Colour

A number of problems are raised concerning the use of colour, though all seem soluble. Colour requires high lighting levels which gives extra heat, and air-conditioning may be needed to keep the room cool. However, when more sensitive camera tubes are developed this will cease to be a problem. Colour requires more careful attention to transmission quality and monitor adjustment to avoid sick green or flushed red faces. Again technology should be able to solve this problem in time.

Colour requires more transmission band-width, but coding techniques are continally improving and the overhead is not very great, except with low-definition systems which probably

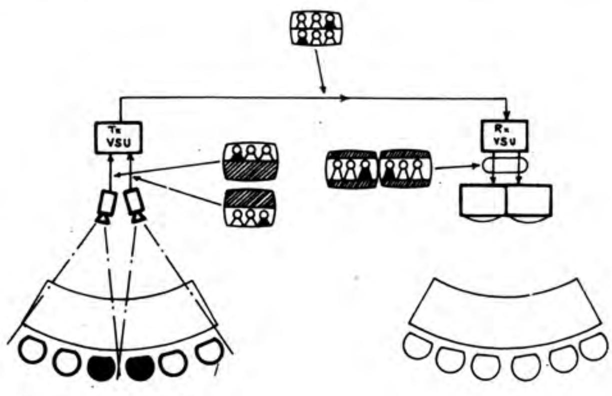


Fig. 2. Split-Field Video.

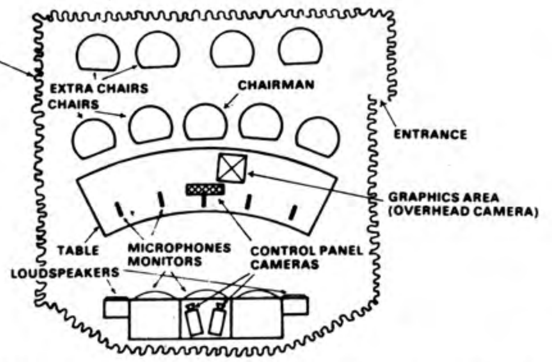


Fig. 3. Video Teleconference Studio Plan (i). (Sectoral Table: Overhead Graphics).

offer inadequate picture quality in any case. The coder and decoder for colour will be more complicated, but, with large-scale integration, complexity has less effect on cost than production quantity, and colour is more "marketable" than black and white.

Split-Field Video

This technique was pioneered by the Australian Post Office and is also used in the British Confravision system. Two cameras (see Fig. 2) are aligned one on each half of the studio. The cameras are angled so that the participants in one half of the studio are in the top half of one camera's view and those in the other studio are in the bottom half of the other camera's view. Both cameras use the same time base and a Transmit Video Switching Unit (VSU) switches the camera outputs onto the transmission line so that a composite picture is sent over a single video channel. At the distant studio, a Receive VSU splits the incoming signal between two display monitors. The aspect ratio of each camera is thus 8:3, half the standard 4:3. That of the whole system is 16:3. This is thus a more effective viewing format for a row of seated meeting participants.

Sound Quality

Ref. 9 highlights the problems encountered by many video teleconference system operators in providing a fully satisfactory sound system.

- The audio channels must be continuously open both ways. Manual or voice switching is unacceptable.
- The microphone must not impede the participants', or camera's, view.
- The participants must be able to speak at a voice level appropriate to a conference of twelve people.
- They should not be required to wear, hold, or sit up close to the microphones.
- The received sound must be natural in quality and loudness.
- The acoustics must not be so dead that people unused to such an environment would feel uncomfortable, or have difficulty in pitching their voices comfortably.
- To ensure privacy the system must be stable and not require monitoring by an operator.
- The microphone placement must not restrict the use of the desk top.

Private Communication

The possbility of private asides both around the table and outside the conference room has been mentioned as an essential feature of some meetings. At the conference table, telephones independent of the teleconference audio and video but sharing the teleconference transmission system would probably be most convenient. Care must be taken to isolate the telephone voice from the conference sound, which is difficult with the modern, unshielded telephone handset designs. A possible answer is the hooded microphone and separate earpiece of the old-fashioned "candle-stick" telephone, to provide privacy and exclude background noise.

Outside the conference room, the telephone should again provide a suitable link. The principal difficulty is likely to be attracting the attention of one particular person without the whole conference being disrupted. One possibility is to have a receptionist-cum-secretary for passing messages but this is an expensive solution.

Refreshment

When teleconference splits a meeting into two or more parts, it is going to cause problems if coffee arrives in one meeting room and not the others or if there is a certain disparity in services (as with conferences across time zones). There may also be problems, as video teleconferencing expands, if different organisations "meet" and find their catering during breaks are of differing standards.

GEOMETRY OF THE TELECONFERENCE STUDIO

Round and Other-Shaped Tables

The strong similarities between the various "continuous presence" round-table video teleconference systems make it possible to classify most of them in comparison to two "standard" studios. Fig. 3 shows the plan of a studio with a sector-shaped table facing a row of monitors. With a two-studio meeting, this configuration can give the impression of an across-the-table discussion. With three or more studios, each remote studio being seen at every other, an effective round table can be simulated.

Above the monitors are the cameras. One camera can give an overall view of the meeting participants or two or more cameras each cover a part. With the latter, split-field or video multiplexing can be used to accommodate the signals from several cameras within one video channel. Loudspeakers are shown on either side of the monitors and microphones in front of each chair. Curtains or some other acoustically optimised wall cladding is used to ensure "open sound".

Real-time graphics are provided by an overhead camera i.e. camera (perhaps with zoom) focused on an outlined "graphics area" of the conference table-top. Other graphics systems, both real-time (e.g. video tape, film or slide projection) and off-line (i.e. facsimile) may be added.

Fig. 4 shows another popular studio configuration, with chairs grouped around three sides of a table and the monitors and cameras placed so that the distant studio in a two-way teleconference appears to be at the other end of the table. In a multi-point teleconference, the table faces several others, giving a spoked or star-shaped effect. In this example, a vertical screen is shown for graphics, which could be wall-chart or "flip-chart" or could (with careful lighting) be a screen for slides or viewgraphs. The graphics camera is mounted near the ceiling opposite the graphics area. An extra monitor may be provided to allow the graphics presenter, standing next to the screen, to see either himself or his audience.

Some studio plans suggest extra chairs, to one side of the studio, out of view of the cameras, for "observers". However, this could be taken as a breach of confidentiality and it would seem preferable to leave the whole studio visible to the camera. Similarly, the entrance should be at the far end of the room from the camera.

Table 3 lists some of the features of a number of video teleconference studios for which plans have been published (many in [6]). The distinctions between primitive and extravagant furnishings and between essential features and gimmickry are obviously very difficult to make, yet equally obviously essential to the successful acceptance of a system.

Table 3. Video Teleconference Studio Features.

	TABLE SHAPE	NUMBER OF SEATS		ACOUSTICS	CAMERAS		
		FRONT	BACK		GENERAL VIEW	SECTORAL	GRAPHICS
BELL TELEPHONE LABORATORIES (Murray Hill)	sectoral	9	6	overhead loudspeakers	1	3	overhead
BRITISH TELECOM CONFRAVISION	transverse	5 nom.	(as needed)	curtains	1 (zoom) or 2		overhead
AUSTRALIAN POST OFFICE	sectoral	6	-	open loop	-	2 split field	separate table
FIRST NATIONAL CITY BANK	longitudinal	11 to 13	-	long-reach microphones	1	-	overhead
BANKERS TRUST COMPANY	circular	6 max.	-	long-reach microphones	1	-	overhead or screen
NIPPON TELEGRAPH AND TELEPHONE	sectoral	6	6	glass-wool walls	1	-	screen
SATELLITE BUSINESS SYSTEMS	radial	6	-	quality audio	1	-	screen

Fragmented Tables

As mentioned before, the "continuous presence" which is the common feature of the systems described in the last section, and which seems an important feature, is nevertheless not provided by many systems.

Because the whole studio is not normally seen, there is additional flexibility in arranging the furniture, as shown in Fig. 5.

These different arrangements can have significant impact on the "feel" of a meeting. The sectoral table (plan "a") gives the impression of a confrontation across the table whereas the circular table (plan "c"), with the monitors inset into the table top, could allow the remote half of the meeting to be overlooked (both physically and mentally) while a local round-table discussion takes place. Conversely, the more fragmented plans (such as "b" and "d") tend to destroy the unity of the local as well as that of the remote, team.

The Forum Studio

In contrast to the round-table, the forum adapts to video teleconference in a relatively straightforward manner. A single camera, out of the way behind the audience, can pick out the lecturer and the blackboard or screen. In the remote viewing fora, an ordinary monitor will suffice for a small audience of up to twenty or so; a large-screen projection TV is preferable to multiple monitors in a larger auditorium.

The participation of the remote audience need not affect the studio geometry but is more a problem of the overall transmission system topology, considered in the next section.

TOPOLOGY OF THE TELECONFERENCE SYSTEM

Point-to-Point and Multi-Point

A point-to point teleconference requires a single pair of

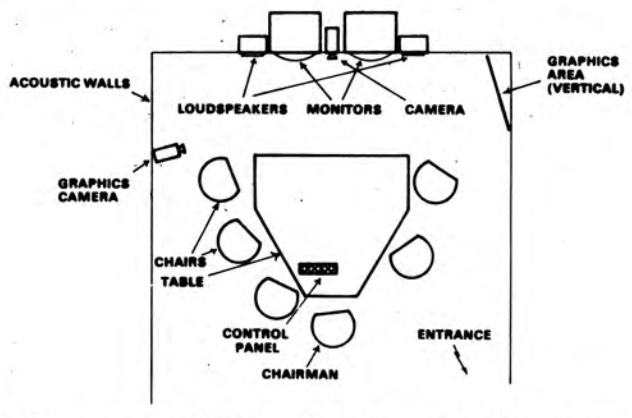


Fig. 4. Video Teleconference Studio Plan (ii). (Radial Table, Screen Graphics).

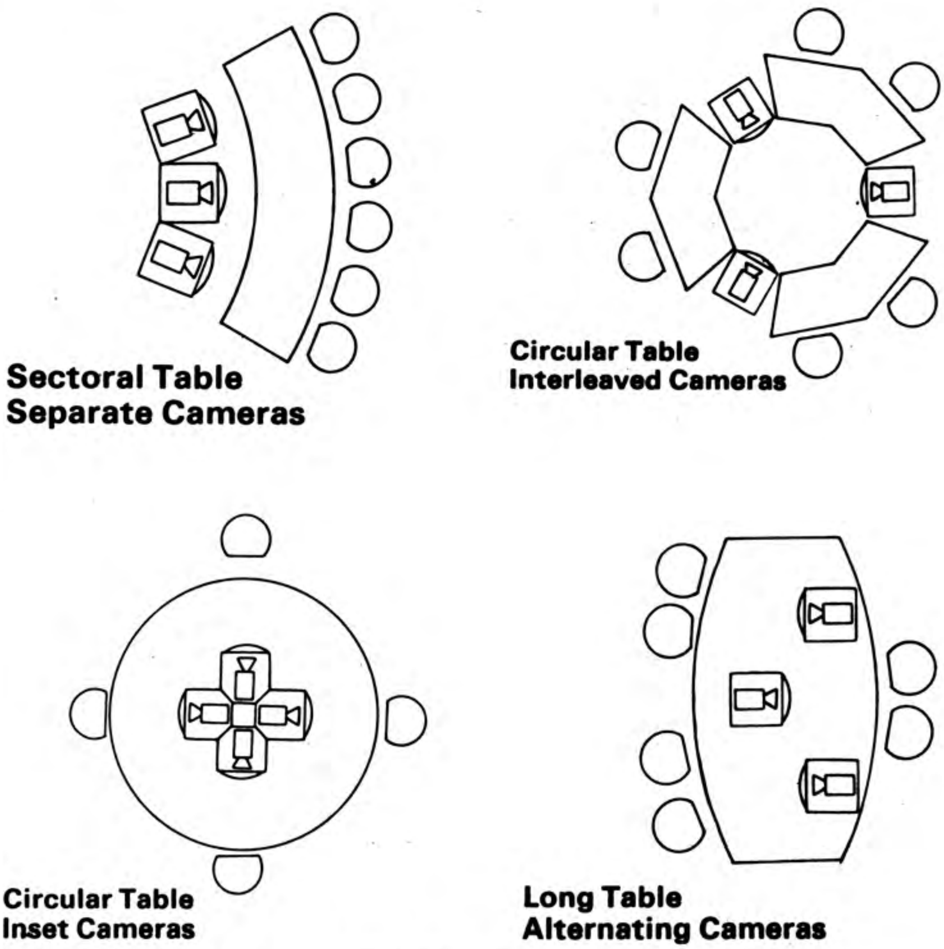


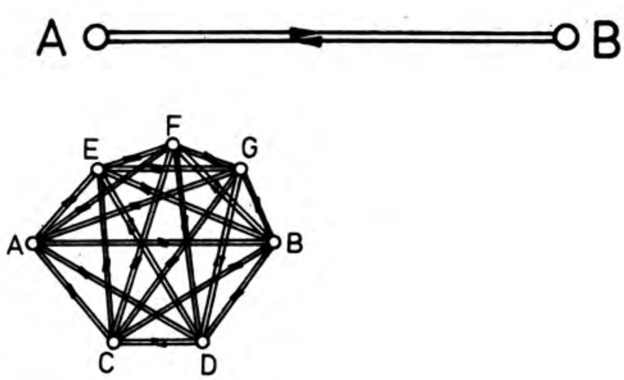
Fig. 5. "Fragmented Tables" setting for video conference.

channels (Fig. 6(a)). A multi-point teleconference requires, for full continuous presence of all parties, up to n(n-1) one way links to interconnect n studios (Fig. 6(b)). A star connection scheme can reduce this drastically, and a satellite can provide the ideal star-connection node (Fig. 6(c)), which enables all studio transmissions (up links) to be broadcast to all other studios (down-links).

There are two problems with this approach. The first is that the receiving studios are probably not able to handle such a large amount of visual information, either from the conferees' point of view or from the amount of equipment (receivers, demodulators and monitors) required. The second is that the satellite configuration will probably not be as simple as that suggested by Fig. 6(c). Coverage is likely to be divided into spot beams, each served by separate satellite transmitters to save energy and to allow re-use of the frequency spectrum (as shown in Figure 7). This would mean than an n-point teleconference again requires up to n(n-1) satellite channels for full interconnection.

Small Round Table Topology

The descriptions of small face-to-face round-table conversation showed that full visibility is essential for the success of the meeting. We may therefore assume that full continuous presence is an important requirement for small video teleconference meetings. The big question is, "How big is small?", as an apparently small number of locations may require a startlingly large number of transmission channels (Table 4).



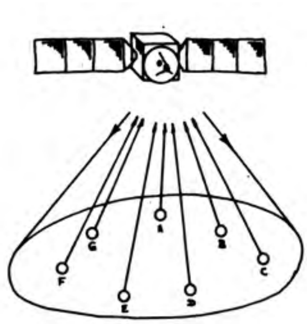


Fig. 6. Teleconference Topology. (a) Point-to-point; (b) Multi-point mesh; (c) Multi-point Star connection by satellite.

Table 4 Transmission Demand for Full Continuous Presence.

Number of Studios	Maximum Number of Channels
2	2
3	6
4	12
5	20
6	30
7	42

Large Round Table Topology

For the larger face-to-face round-table meetings, the "discussion" and the "council" the full continuous presence requirement is less important; the discussion is likely to polarise very often into a dialogue between two particular parties, with the chairman maintaining the role of "referee" and the other members of the meeting becoming "spectators". In the extreme, one can consider cutting such "spectators" out of the picture offering them only say a push button to signal their desire to speak. It may seem rather extreme however to cut out all other access and not allow the camera to show the other participants at least intermittently.

Further study and experiments are required to determine the extent to which a limited system may be expected to perform satisfactorily. It is important that an experiment be able to go further than the optimum, otherwise the optimum cannot be identified - if the minimum commercial studio will have six monitors and four cameras one should experiment with at *least* seven monitors and five cameras!

Forum Topology

Finally, the lecture, symposium and conference will require, for the most part, only one picture for each lecturer. At question time, some means of finding questioners is needed (possibly by a push-button signalling channel) and then of contacting the questioner (possibly by audio link alone). In a real lecture, it is often not possible for the audience to see the questioner (or sometimes even hear him), so there is no inherent reason to require that he be seen in a video-teleconference lecture. Sometimes, however, the discussion following a lecture takes the form of a dialogue or panel with the rest of the audience requiring a view of all the panel members in all their locations. (A "round table in the forum".)

Evaluation of Meeting Media

Evaluating video teleconference against face-to-face means a trade-off between objectives achieved and relative cost. It is difficult enough to calculate the balance in cost between different video teleconference arrangements and the corresponding travel (plus subsistence, cost of travelling time, stress of extra time away from home, cost of lost working efficiency etc.). On top of this, the comparison must take into account the meeting objectives, as these have different sensitivities to the substitution of face-to-face by teleconference systems. Thus bargaining and negotiation are relatively sensitive and problem solving and information solving relatively insensitive to the medium of communication. Consequently, it is clear that some meetings adapt better than others and can even profit from the teleconference environment [6, 13]. Various forecasts have been made of the share of the total number of meetings which could use video teleconference systems. These vary from 1% to 30%. Even at the lower traffic level, the total communications network requirements are very substantial [1].

DEPLOYMENT OF TELECONFERENCE STUDIOS

The Permanent Studio

Various concepts for the video teleconference studio unit have been proposed both for experimental and operational phases. At one end of the scale is the permanent installation of the studio and transmission equipment in the user's own building. This is justified only by sufficient usage, which is almost certainly incompatible with an experimental (L-SAT) system and unlikely to be compatible with an operational system, until it well established, except in the biggest centres of the biggest companies.

Permanent studios in "central" locations are used by some small-scale operational systems (such as the British Confravision and the American Picturephone Meeting Service). Experience shows that the travel from office to studio gives the conferee all the disadvantage of displacement from his office (need to travel, even if not so far; separation from facilities and services of the home office; inability to entertain) without any of the advantages (visit to interesting new location; chance to see opposite number's facility, factory or product; occasion to be entertained) and, as a result, the "central" studio is not a successful scheme.

The Temporary Studio

The temporary studio, which can be set up in a vacant room in a building, is probably a cheap solution for an experiment but may be unsuitable in any number of ways. Installation may be awkward and may also be subject to a sudden need for the room to be returned to its original state. This technique may be relatively easy to apply to forum meetings, which use lecture

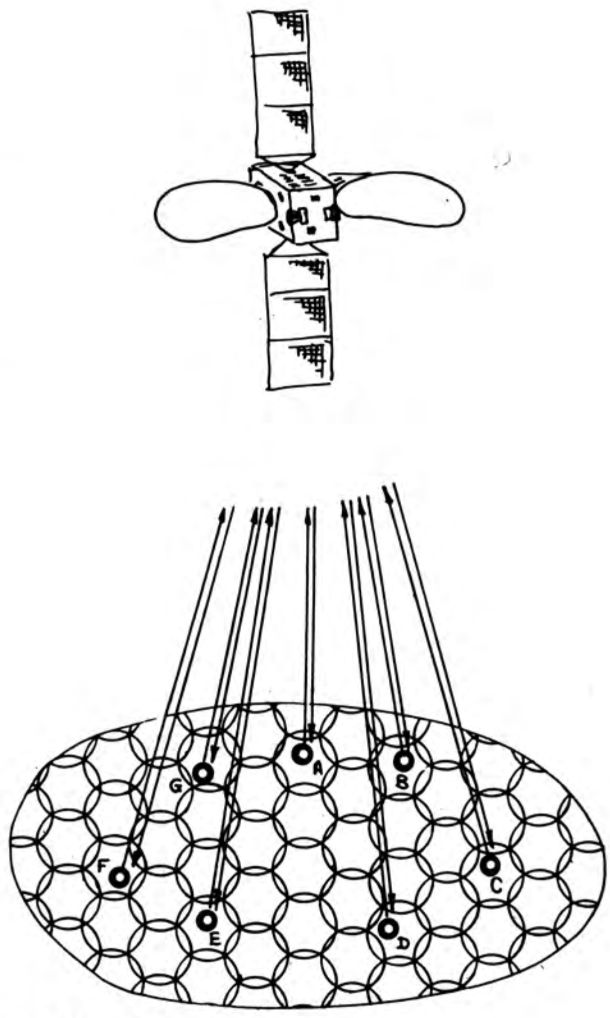


Fig. 7. Multi-spot beam satellite.

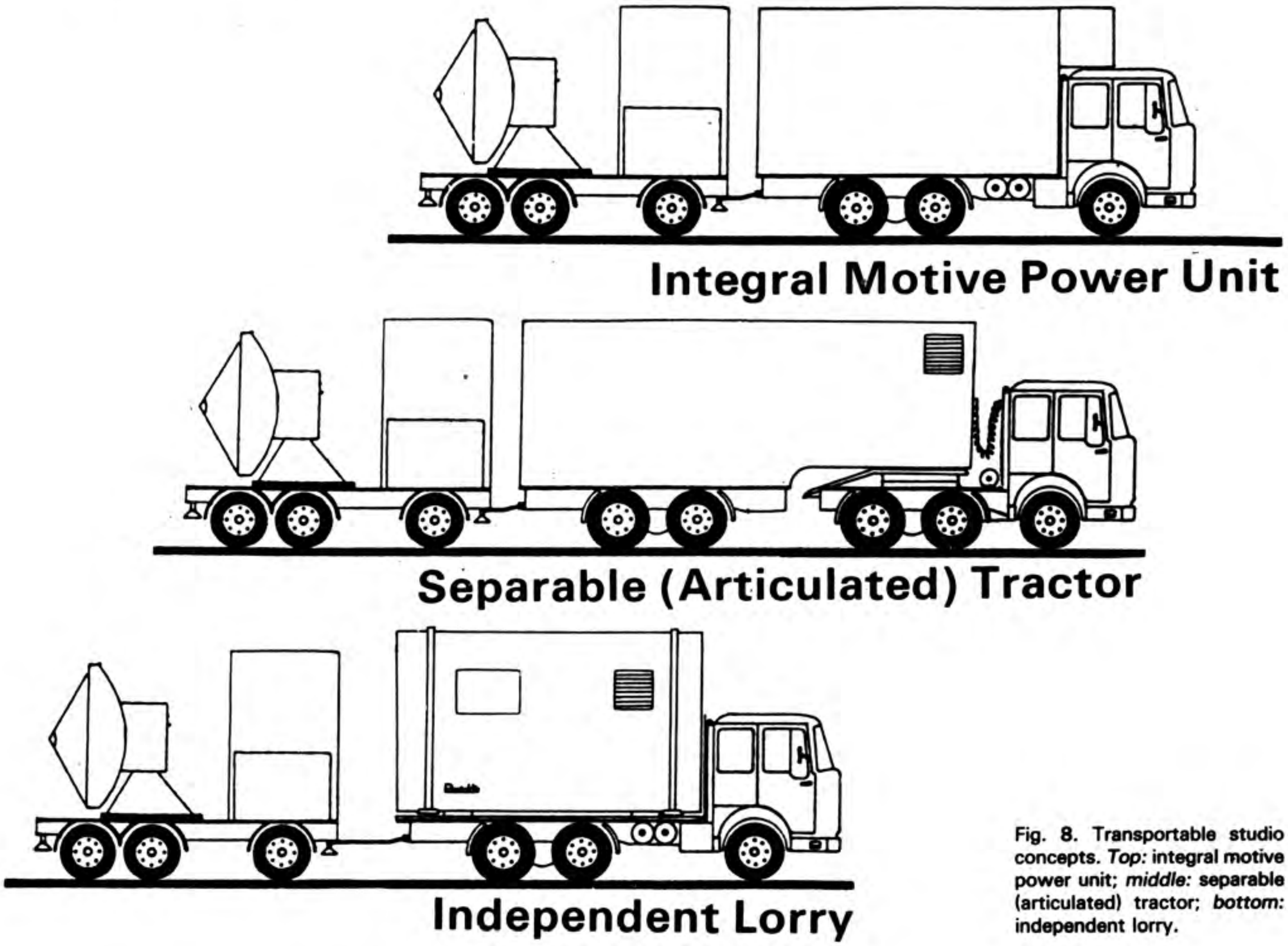


Fig. 8. Transportable studio concepts. *Top:* integral motive power unit; *middle:* separable (articulated) tractor; *bottom:* independent lorry.

theatres or auditoria which already have most of the necessary facilities laid out in a suitable configuration. (Note that this is the field to which the American company Videonet has successfully applied itself, offering "Satellite Seminars" and "Teleseminars" as a commercial service.)

The Transportable Studio

Transportable studios avoid the problems of installation. The whole studio, completely installed, and the complete earth station is driven to the customer's site. There are various ways to design the transportable unit. The motive power unit may be integral, separable (articulated) or independent (Fig. 8). For an operational system, rented out by the hour or the day, the motive power unit will probably stay with the studio. It can be integral or, more expensive but more flexible, articulated. For the experimental system, however, the independent ("Portakabin") concept is possibly sufficient and, as the lorry can be hired or acquired when required, is probably cheaper.

It makes sense to separate the earth station and the studio not only so that these can be sited independently (the former with a good view of the satellite and the latter with good access for the conferees) but also to isolate the noise of generators and cooling fans from the studio.

Conclusions

There are obviously enough questions to justify the proposed programme of experiments and demonstrations over L-SAT. Nevertheless, they will require careful planning to achieve their two objectives: first the technical experiment, to ensure that the system and equipment design problems are properly investigated; second the commercial demonstration, to show operators and potential users that video teleconferencing can be a useful and profitable service.

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Earthwatch
C. Sheffield, Sidgwick & Jackson, 160 pp, 1981, £10.

The beauty, variety and richness of the Earth's structure and appearance is revealed in this large-format book which contains over 70 full-colour satellite images taken from an altitude of 570 miles by Landsat spacecraft.

The information content of a single Landsat picture is immense. More than a million separate items of information were returned from the spacecraft to Earth every second spent on the daylight side of the globe.

The total area of the Earth, land and sea combined is about 200 million square miles. Each single Landsat scene shows a ground area of about 13,000 square miles and requires the processing of more than 30 million numbers before the returned data emerges in the form of an image. In addition, special computer enhancement is often required before a comprehensive display can be made in picture form. This book describes the process and includes some of the best results obtained.

Each photograph reproduced is accompanied both by descriptive text and by an outline map which indicates the features portrayed, for easy identification. Examples of all the main features of the Earth appear to be covered: mountains, plains, valleys, forests, deserts, seas, oceans and rivers.

The text is particularly interesting. Although generally short, each section contains a mine of information which draws attention to important features, even where these may not immediately be appreciated, and explains exactly what is revealed.

This work will be of value alike to geographers, geologists, cartographers, oceanographers and many others.

The Telescope
L. Bell, Constable, 287pp, 1981, £4.10.

This book, which first appeared in 1922, is still surprisingly timely even though it predates the Schmidt field-camera and the Ritchey-Chrétien design. It was originally written for those observers who use relatively small telescopes for study or pleasure and require more information about their construction and properties. Not being a handbook, it provides neither exhaustive technicalities nor popular descriptions of great observatories but deals, instead, with those principles of telescope construction likely to fall within the ken of the keen amateur.

The contents more than bear this out. After an enjoyable first chapter on the evolution of the Telescope, the book then gets on to a description of some of the classical optical instruments, optical glassworking, properties of objectives and mirrors, mountings, eyepieces, etc. This is followed by chapters on accessories and the use of small telescopes and binoculars, but then reverts to practical applications once more with the problems involved in setting-up, caring and housing a telescope, as well as how to make the best use of it.

This is very much a practical volume illustrated with 190 photographs and diagrams. Notwithstanding the passage of time, it is still well worth reading. Its re-publication testifies to its status as a "classic" of pre-war fame.

Observational Astronomy for Amateurs
J. B. Sidgwick, Pelham Books, 348pp, 1982, £14.95.

The enthusiast who acquires a telescope may think he needs do nothing else to become a competent amateur astronomer. Unfortunately, all too soon, enthusiasm begins to wane when it ought to be blossoming. The nightly vigil with the stars first envisaged becomes more and more spasmodic until, finally, the telescope finds its way into some dusty corner.

The reason for this is that, at first, the keen amateur really does not know where to look. In trying to see everything, he sees little or nothing. This is why an authoritative guide to the Heavens can be indispensable.

This, the fourth edition of a well-known book, has been extensively revised and updated. Each chapter is devoted to the observation of a particular class of object, with promising areas carefully indicated. The observational techniques are described in considerable detail, much more than normally required, or found, in books for the amateur. Among the subjects covered will be found descriptions of astronomical telescopes, optical aberrations, eyepieces, mountings, drives, testing and adjustment of mirrors, accessories and equipment for astronomical photography, besides an extensive but not-too-difficult-to-follow mathematical context where appropriate.

How to Buy and Understand Refracting Telescopes
J. Levenson, Levenson Press, 96pp, 1981, $18.95.

Buying a refracting telescope (either astronomical or terrestrial) is full of pitfalls. Incorrect selection, through lack of knowledge or misunderstanding of what one can expect from a telescope, can lead to a major disappointment.

This volume deals with the design of materials used in and manufacturing differences between, telescopic optics. They fix the quality obtainable, capability and price. It covers eyepieces, magnification limits, resolution, tubes and mounts, and, although slightly above the level of popular science, is written for the layman.

Although the book concentrates on refracting telescopes, most of the material is applicable to reflecting telescopes also, as well as to other optical instruments. Mathematical explanations have been kept to secondary school level.

The volume has been reproduced directly from double-spaced typescript.

The Origins of Life and Evolution
Eds. H. O. Halvorson & K. E. Van Holde, Alan R. Liss, Inc. (Wiley, UK Distributors), 140pp, 1980, £10.90.

The study of the origin of life suffers from the lack of hard scientific data. However, recent advances in geology, paleobiology, molecular and cellular biology and space exploration all dictate that our opinions on the origins of life should be re-evaluated and show the need for radical new theories.

For example, Oparin's classic proposal that life began in the oceans has been accepted without question for generations. However, some of the contributors to this book suggest that this theory contradicts current thinking about thermodynamics and biochemistry. One contributor even suggests that the crucial transformation of the inorganic precursor chemicals into self-replicating organisms is more likely to have occurred in water droplets suspended in the hot primeval atmosphere than in the sea itself.

Other contributors to this interesting volume offer more new perspectives on such topics as organic studies of ancient rock deposits, testing hypotheses about the synthesis of organic molecules from inorganic ones and the possible presence of organic and pre-organic compounds in space.

The volume reprints the proceedings of a symposium held in 1979. It is slim but well-printed and well illustrated

Genetic Takeover and the Mineral Origins of Life
A. G. Cairns-Smith, Cambridge University Press, 477pp, 1982.

This book is about the origin of life on Earth but framed in the context of a scientific detective story with clues, deductions and a somewhat surprising outcome. The clues are the nature of living things i.e. the chemistry of crystals and molecules and the geochemical and biochemical processes now seen in operation.

One of the author's first deductions is that the very first organisms on Earth, simple enough to have arisen spontaneously, must have possessed an altogether different design from any organisms which exist now. From this stems the idea that the component parts of these "starter" organisms were minute mineral crystals, rather than the larger organic molecules which form the base of life now. The startling conclusion, in other words, is that our first ancestors were literally made of clay!

The problem then is how they could have evolved from clay to DNA. The author proposes a simple mechanism for the change, based on evolutionary processes. He argues that these was no gradual transformation of clay into DNA but, quite literally, a gradual replacement of an old technology by a new. This he calls the genetic takeover.

Before life existed there had to be a buildup of the proper component molecules viz. amino acids, sugars and such-like. The first organisms were a sub class of colloidal mineral crystallites forming continuously in open systems. By adopting modes of survival and propagation they evolved into the first forms of life.

The author has no truck with life brought here by spacemen or specially contrived by God nor, apparently, by cometary fall-out either.

This is a well-written, well-illustrated and well-argued book written at an eminently readable level and guaranteed to interest not only chemists and biologists but all interested in the origin of life.

Genesis
J. Gribbin, Oxford University Press, 360pp, 1982, £3.95.

This is a paperback version of a book which appeared in 1981 with the subtitle of "The Origins of Man and the Universe".

The main areas dealt with are the origin of the Universe and the origin of our own Galaxy. This is followed by chapters on the origin of our Solar System, of the Earth in particular and of life.

The theme of "life" is carried further in four subsequent chapters, one dealing with the origin of species and the evolutionary process in general terms, the others examining our own origin and eventual destiny.

The above is a concise summary which really does less than justice to a book which is both easily readable and entertaining.

The Lighter Side of Gravity
J. V. Narlikar, W. H. Freeman, 194pp, 1982, 13.95 (paper £6.95).

Gravity is the basic force in the Universe, summed up simply by Newton in his inverse-square law. Einstein saw something of deeper significance which linked it to space and time, with modern theoretical physicists attempting to accommodate it within a unified theory to comprise all basic forces. Even so, gravity still remains an enigma.

The author describes the diversity and importance of gravity, focusing especially on astronomical phenomena because this was the area that first provided, and continues to provide, the testing ground for gravitational studies. Phenomena in the heavens include the motions of planets, comets and satellites, the structure and evolution of stars, binary star systems, neutron stars, black (and white) holes and, no doubt, the origin and evolution of the Universe itself.

The presentation throughout this book is at a non-technical level, making good use of humerous anecdotes, masses of illustrations and examples from astronomy which make gravitational properties more intelligible to the reader.

All in all, this is a very readable and entertaining book, clear to follow, and yet concerned with presenting some of the most fundamental concepts. Those readers interested in learning about a strange and exciting subject need no longer be put off by ponderous tomes. This is one for the fireside or when the tellie is on the blink, or at any time.

The Rebirth of Cosmology.
Jacques Merleau-Ponty & Bruno Morando (Trans. from French by Helen Weaver), Ohio University Press, 1982, £6.75 paperback.

This is an interesting new approach to Cosmology. Two French "savants", one (Merleau-Ponty) a professor of epistomology at University of Paris-Nanterre, and the other an astronomer (at Central Astronomical Office, Paris) each take their own look at the history of cosmological/astronomical thought. The book is divided into three sections covering the Ancient, Classical and Modern views of the universe, and in each section first the philosophic and then the astronomical/mathematical cosmology of the time is given. Although to the same "framework", the authors wrote their contributions independently. The result is interesting if not always entirely successful. The two sections on ancient cosmology (pre-Galilean), for example, seem completely at odds, with little to connect the significant points they make; the astronomical part is often only astrometry. The philosophy sections are usually the more interesting and thought-provoking, although they suffer at times from stating the obvious or making banal points in an overblown fashion. The later parts of the book offer an interesting scientific précis of the state of our present knowledge and here it is the philosophocial side which dims a little by comparison (though it is at all times thought-provoking).

The title is derived from the thesis that cosmology "died" during Classical times when it was thought that celestial bodies were randomly distributed about an infinite Universe and had no connection with the space they occupied. They were thus of little bearing on, or interest to, Man. But, the book contends, Cosmology has been "reborn" with the Einsteinian theory that space and the objects that inhabit it are inextricably linked, the objects creating and bending the geometry of space-time about them. It could be argued that this "death" is a questionable thesis, but be that as it may, an interesting book has evolved from the contention.

The philosophical sections are written entirely without mathematics, and even the astronomer's parts are of a simple enough standard for any 6th-former or first year undergraduate to understand (except perhaps for a few paragraphs towards the end). The philosophical section throws out a wealth of ideas, but should perhaps be approached critically at times. For example, Merleau-Ponty ascribes the Ancient Earth-centred view of the Universe partly to Man's seeing all things being drawn to a central point - all things on our world being attracted towards a central point and hence creating a spherical Earth. Yet surely one of the cornerstones of Ancient cosmology was that Earth was not circular but flat - else why did Columbus have such a problem organizing his expedition?

Oceanography from Space
Ed. J. F. R. Gower, Plenum Press, 978pp, 1981, $95.

This volume attests to the surge of new information, technologies and ideas which have followed in the wake of successful demonstrations of ocean remote sensing undertaken by such satellites as Seasat, Nimbus and, to a lesser extent, earlier weather, land and experimental satellites. The small but increasing contribution to satellite ocean data gathered by countries other than the US is also evident from the content of this work.

The volume provides a comprehensive review of the techniques now available for studying the oceans from space. It includes a wide variety of examples of applications, ranging from the chlorophyll content to the motion of the seas. Among the topics considered are satellite altimetry, the remote sensing of ice, passive microwave observations, radar studies of the sea surface, water colour measurements and infrared temperature measurements.

A problem which has always occurred in this field lies in comparing the accuracy of satellite sensor measurements with ground-based measurements. It is interesting to see that, in some cases, satellite accuracy is now superior to many of the surface observations. Besides this, in almost all cases, satellite sensors range over a much larger area than surface measurements, thus providing a wide and rapid coverage.

WALLPOSTERS

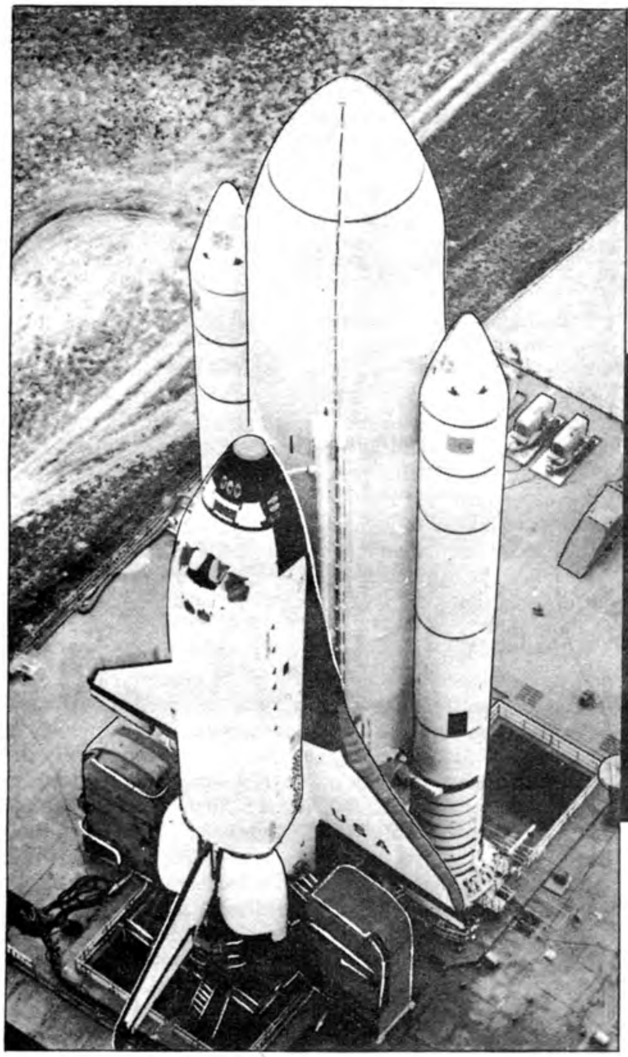
SPACECHARTS
Four wallcharts/posters approx. 1m×60cm on the subjects "Mars", "Jupiter", "Saturn" and "Space Shuttle", by Robin Kerrod, Spacecharts 1982, £1.95 each.

Putting together the material for a wallchart or poster is not as easy as it seems. The differences in tone, emphasis and layout between success and failure are not always so obvious or simple to explain. The Space Shuttle chart that one can buy at the Science Museum, for example, (I assume nothing to do with Robin Kerrod), is irritatingly disappointing. It has a cutaway drawing of the Shuttle which is just too detailed for a wall chart, and is too confused and detailed.

It is interesting, therefore, to compare how Robin Kerrod has tackled the same subject, and gratifying to find that his layout, presentation and design work seem to have succeeded much better. He has a Shuttle cutaway too, but this one successfully treads the line between over-complexity and information content. He has a number of pictures - Shuttle launch, landing and flight sequence, for example - which give a good overview without overcrowding. And the write-up accompanying it all is crisp and informative without being overladen with detail.

This fine presentation style is continued in the three planetary charts. They each present an interesting amount of material, without trying to cram in too much. The writing is crisp and in an exciting style that still allows the imagination room amidst the colour vistas and technical drawings.

A lot of the reason for this series' success must be due to the standard



of presentation - full colour photos, glossy thick paper and a readable fair-sized script. The "Mars" script is especially good, and the "Saturn" poster subtly gets around the blandness of the Saturn disc, the lack of contrast in most pictures of it, by using false colour images which enhance the detail.

There are, of course, minor points one could quibble about. The grammar of the second paragraph on the "Mars" poster is strange. Why a diagram of the old-fashioned Pioneer probe on the "Jupiter" poster? And why no picture of the Jovian ring? On the whole, though, these posters are successful and far more pleasing than most.

They would be useful in a classroom, perhaps as a focal point for a lesson or topic group. They have impact, and an interesting overall format which lead one to the details peppered throughout the text. There are enough ideas squeezed into the space available too, to suggest further study, or as the basis for project work. Good food for the imagination.

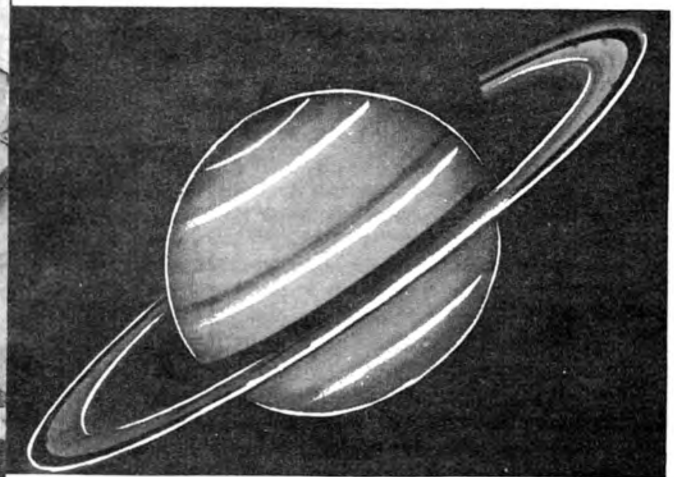
Alan Farmer

SLIDE SETS

Voyager in Space: Jupiter
Nick Argent & David Carter (£10.00)
Voyager in Space: Saturn
Nick Argent (£7.50). Slide sets in a ring binder with explanatory booklets. Focal Point Audio Visual Ltd., Portsmouth, Hants, PO3 5EE (75p less for each without ring binder).

These slide sets are selections of the best of Voyager 1 and 2 images of the gas giants Saturn and Jupiter. The Jupiter set is by far the more impressive. It is not just that the disc of Jupiter itself is more striking - Saturn's by comparison is rather bland and lacking in colour contrast - but also the Jovian satellites seem to have been given a far more thorough treatment. Of the 30 pictures of the Jovian system (curiously called the "Torian" system in the accompanying write-up), 11 are actually of Jupiter itself. Apart from one diagram of the Voyager trajectories the rest are views of the system's satellites. In the Saturnian set, similarly, of the 20 slides only eight show the gas giant itself - though this may be more explicable given the featurelessness of the disc.

The Jupiter set is superb, with virtually no evidence of the photomosaic construction of some of the views. The colours, with only a couple of exceptions, are bright and exciting. The pictures would be ideal for a number of educational uses. Apart from pure astronomical studies, one has a meteorological interest in the great swirling cloud



patterns of Jupiter and the geographic/geologic interest in its satellites' surfaces. The volcanic activity on Io, for example, is well illustrated and with helpful notes.

A small book comes with each slide set and is sufficient to form the commentary for the slide show. More detailed reading, however, would be needed for background for project work or to put the discoveries here into context. (And to field any of the "nastier" questions that might arise during a showing). A useful reference list is given. There are some curious pieces of English in the handbook - what, for example, is a "bypass" of Jupiter? Surely "flyby" is intended? But there are also lots of fascinating facts: Jupiter's bigger satellites are big enough to have been visible to the naked eye if they were not occluded by the central body, the mixture of gases in Jupiter's upper atmosphere would smell of garlic . . . and so on.

The Saturn slide set is slightly disappointing. It may be that it could be nothing else compared to the other set, though one wonders if the lack of detail even in the photos of the satellites is because of their intrinsic nature, or the photographic selection made. The slide showing the Voyagers' flight paths is a bit confusing since at first sight one could easily misinterpret it to believe Voyager 1, too, will be going on to Uranus. Strangely, too, the "spokes" in the Saturnian ring system, one of the more scientifically interesting features of it, are not at all clearly seen in these slides though mentioned in the text.

On the whole, then, one may say that these slide sets offer an interesting and useful way of presenting material to science classes, the Jupiter set in particular illustrating many topics in a colourful, striking fashion.

SPACE BENEFITS

By Alan Farmer

While space exploration is a wonderful spectacle, and an exciting foray to the frontiers of human knowledge, it is also beneficial to mankind in many less direct ways. "Spin-off" is a term used to describe the techniques, technologies and fields developed for the space industry which have come to be useful in other areas. The most quoted – so much so it is almost now a cliché – has been the Teflon coatings used in frying pans (developed first as an ablative coating for reentry vehicles). But today "spin-off" means much more. Space exploration has paid for itself many times over in terms of the benefits it has already produced.

Keeping Watch on the Earth

The most obvious day-to-day examples of benefits from space technology are communications, Earth resources and meteorological satellites. No weather forecast would be complete now without the "satellite picture" which has given meaning to the "fronts" and anticyclones on weather charts. Weather forecasts are more accurate, and the savings in life, property and crops is immeasurable. The world's long-range communications now depend in large measure on communications satellites, and they are playing a larger and larger role in the transfer of information and news across the planet. They bring people nearer together, they aid in the dissemination of information, and they give us almost unlimited power to reach everyone with educative, informative and entertaining material. Earth resources satellites meanwhile help us manage our planet, show us where deposits of valuable minerals lie, help us monitor our crops, our oceans, our environment. If we are to "manage" our world in the most efficient and least damaging way, we need such comprehensive information.

Though there is an unfortunate tendency towards an increasing militarisation of space, let us not forget that satellites help us keep the peace, too. Early warning satellites from East and West help to monitor the delicate nuclear balance, while sensors on others ensure that non-proliferation and test ban treaties are honoured.

These, then, are the "mainstream benefits". Together with advances in the sciences made possible with astronomical and geophysical satellites, they are the more directly observable and obvious ones. There is, however, a whole mass of minor benefits, spin-offs and developments of everything from small components to whole new ways of manufacturing that space has given us, is giving us and will continue to give us.

Satellite Technology aids Medicine

Satellite technology has helped in many fields of medicine. Satellite engineering demands compact, efficient, light-weight materials and has led to the development of microminiaturisation. This has given us small, reliable electronic components. Medical uses of these are manifold; one example is body implant systems. These are computer-directed implants which release regular amounts of a required medication. Safe levels of insulin, chemotherapeutic and anti-alcohol drugs, pain medications and anti-coagulants may all be maintained in the body in this manner.

There are other medical microminiaturisation spinoffs. Heart fibrillation can now be detected and treated by an implanted pulse generator. Another implant – for tissue stimulation – offers relief for victims of severe pain or multiple sclerosis.

Other ways in which space technology has benefitted medicine include a photometer designed to provide accurate measurements of body-fluid bacteria, originally developed for the Viking mission to detect life on Mars, and cordless surgical instruments derived from self-contained lunar drills. The technology developed for the remote manipulator arm on the Space Shuttle has been used for a wheelchair manipulator device – and many other things, including remote manipulators for hazardous materials, underwater vehicles and nuclear plants.

Such is the degree of beneficial spin-off to medicine that special points of contact and agreements often exist between medical and space centres. An example is a 5-year agreement signed in 1982 to make official a long-term collaborative programme between the University of South California, the Dept. of Medicine and the Jet Propulsion Laboratory. USC is using JPL technology for the development of a computerised image enhancement system for cardiovascular research and the study of arterosclerotic diseases.

Langley Research Center, amongst other things, develops new materials for NASA. It has set up a Technology Utilization Office to promote the use of those materials outside the space programme, and medical uses are high on the list of takers. They will often themselves develop a device for a medical institute or firm, but having done so they encourage outside interests to take over and market it. Use of lightweight materials – graphite filament composites, for example – is their "speciality". It can be moulded, shaped and worked by filing, cutting or drilling, yet is as strong as metal and half the weight of aluminium.

Another technique of importance to medicine which it seems may be developed most efficiently in the zero gravity of orbit, is that of electrophoresis. This is a method of separating different components of a colloidal suspension by applying an electric field. A test device has already flown on the Shuttle, processing concentrations up to 125 times that possible on Earth, at flow rates up to four times achievable on the ground, and with comparable purity. The process known as Continuous Flow Electrophoresis, is seen as a way of greatly increasing the quantity of key enzymes, hormones and proteins needed for medical research – and perhaps later for medical treatments.

The successful flight of this device on STS-4 (separating albumens and a mixture of proteins) has given confidence that a more strenuous test on STS-6, and four subsequent flights ending in May 1984, will successfully separate even greater quantities, and up to purity levels four times that achievable at present. Long term plans include developing a production unit for an Earth-orbiting facility.

Home Design

Even in such apparently non-advanced areas as home design, space technology has had an influence. NASA is one of the leaders in research on alternative energy sources, and its complementary field of energy saving. As a demonstration of the latter they have built an energy-efficient home (based on Apollo spacecraft systems) which incorporates an aluminised "heat shield" to keep in or hold out heat, water vapour and air flow.

The quality of other household devices and goods has improved due to improvements in quality assurance techniqes for space vehicles. Safety clothing, driver-training simulators – and even such banal things as more efficient golf clubs – are among the literally thousands of common goods and services benefitting from space technology.

Even the art world can learn a thing or two from space technology. Space scientists at NASA's Jet Propulsion Laboratory working with picture restorers at the Los Angeles County Museum of Art, have developed a new technique for separating paintings hidden beneath master works. Image enhancement techniques are used to separate X-ray images of paintings where two or more works exist on the same surface. The technique is derived from computer-processing of photographs from NASA's unmanned spacecraft.

The technique at JPL was first perfected for a 17th Century oil painting "The Crucifixion" by an unidentified Flemish artist, painted on paper over a painting made directly on the wooden mounting underneath. In order to separate the two images, the team first designed computer programs to minimise the appearance of the grain pattern of the wood on which the original work was painted. Next, a photograph of the top painting was matched with the X-ray image. Any brush stokes from the X-ray version that matched the top painting were subtracted. Consequent subtractions removed most traces of the top painting, while the remaining was computer-enchanced to bring out detail.

Future applications of computer processing to art conservation might include techniques to date paintings by determining the age of wood on which compositions were painted. Dendrochronology, the science of dating wood based on the number and character of tree rings, usually requires shaving wood away from the edge of the original wood panel. Computer enhancement of the wood grain of a panel would elimate the need to remove original support material in order to date it.

Yet another technique of conservation developed using space equipment is one for preserving books. Most books produced since the mid-19th Century are printed on acidic wood pulp paper that turns brittle after 25–100 years. The Library of Congress has found a way of impregnating books with diethyl zinc by pumping the gas into a vacuum chamber containing the books. This neutralises the acid in the paper. The vacuum chamber was necessary since diethyl zinc bursts into flames on contact with air or water (as the chamber is being pumped down with the books inside, about 50 grams of water is drawn out of each book).

Space Technology in the Furnace

A piece of Shuttle technology has recently been introduced to the UK for use in furnaces and fire-proof installations. It is in the form of an alumino-borosilicate ceramic fibre which was used as a thermal barrier on the NASA Shuttle Orbiter. The material can withstand temperature up to 1260°C for long periods, and up to 1450°C short term. Since the material is produced as fibres and then woven into blankets, it is also a good insulator. (It is distinguished from traditional ceramic fibres in that it is woven from a continuous filament, flexible and easy to weave.)

As a furnace curtain the material reflects back up to 60 per cent of escaping radiant heat, helping to save energy. That is besides the energy loss the curtain prevents by reducing airflow and convection.

The material could also be used as a fire protection material – it can be wrapped around objects like cloth. It is also available in cable and thermocouple sleeving material – and as such can seal off the hole in a fire wall where cables pass through.

Databanks

Another way in which space communications technology is helping industry and educational/research establishments, is in the widespread access to large databases *via* satellite.

ESA, the European Space Agency, announced in May 1982 the first databank on raw materials and prices. Developed by the Italian firm SLAMARK International, in collaboration with ESA-IRS (the Information Retrieval Service of the European Space Agency), PRICEDATA – as this new databank is called – contains price quotations for the major world commodities and exchange rates of the currencies used in international dealings, as well as international indices of prices with associated synoptic tables.

Data for the product and money series, spot or future prices, are obtained from the major world commodity and exchange markets, with a total of 220 series on values received at close on the day of the dealing. The file is updated daily, weekly and monthly.

Price data has been "on-line" since January 1982 and is accessible from ESA-IRS *via* user terminal or telex.

This is an example of an area expected to grow rapidly in the near future. In the UK one can subscribe to services like PRESTEL where a central computer databank is kept of various sorts of information which one can access with a visual display screen or television, and telephone or other medium. Many of the databases on offer are only commercially viable if large numbers of accesses are made, or large numbers of people have the ability to use it. By making databases available over a large geographic area – for instance, the whole of Europe – costs are reduced and resources more efficiently utilised. The possible uses for education and research are obvious!

Friction-less Refrigeration System

Another spin-off item for possible domestic or industrial use, though it has not yet itself flown in space, is a friction-less refrigeration system. Refrigeration systems work usually by absorbing heat into an adiabatically expanding gas which is then pumped to a radiator area where it is re-compressed to give off the heat it has absorbed. This involves at least two pumps usually linear piston-in-tube designs.

Refrigeration systems are of use in space for a number of things, but in particular Goddard Space Flight Center, in conjunction with North American Philips Labs in Briarcliff Manor NY, have been considering the extended mission possibilities for infrared and gamma-ray instruments if their cooled detectors did not have to rely, as now, on a constantly diminishing supply of cryogenic coolant. By flying a refrigerator unit the same coolant could be re-used in a closed cycle and mission lifetimes increased from the present maximum of about one year (for example, the British/Dutch/American – IRAS project) to several times that. The only problem is that pumps have moving parts – and that means friction, which in turn means wear and subsequent unreliability.

So Goddard and Philips have been trying to perfect the friction-less pump. Their unit, already under test as an engineering model, uses linear-magnet pumps where the piston is held in place by magnetic levitation – i.e. it is held in a magnetic field away from contact with the tube it slides in. It is not quite as simple as that, of course – electronic control on a feed-back cycle is needed to correct for sideways movement – but experiments so far has been promising.

A further advance is in the use of a linear drive motor to drive the piston. This a motor which works by electromagnetic induction – a coil with an electric current passed through it will try to move in a magnetic field. Using the linear drive motor eliminates mechanical linkages – drive shafts and the like – all of which are potential failure points. Combining these techniques with other improvements in Stirling cycle, closed-loop refrigeration design, has created a long life system that has achieved 5 watts, 65 K, cooling and should be capable of operating for five years or more in space.

At the same time as this unit is being developed for space, ground-based usage is not being ignored. The same idea could be applied in most of the places where refrigeration systems are used here on Earth, with great savings in repair and maintenance costs, and longer lifetimes. It would be particularly useful in under-developed countries where it might save on usage of scarce maintenance personnel.

EMBLEMS OF THE ASTRONAUTS

D. J. Shayler and Curtis Peebles

Mission emblems, official and semi-official, for American and Soviet space flights, have become collectors' items. The choosing of an emblem often involves complex, and perhaps unexpected, decisions. Designing one for an actual, or fictional mission, could be an interesting and educational task for, say, an art class. We present here an introduction to the badges selected up to the time of ASTP, and how they were arrived at.

Introduction

Earlier work by the authors [1] described US and Soviet call-signs for manned space missions. Many American crews and some Soviet ones of late, have adopted mission emblems to further personalize their flights. Such emblems often show a distinctive character more to do with the crew members than the project objectives.

Fig. 1. NASA emblem until 1974, worn also on astronauts' suits. White letters on blue, red ellipse and white capsule.

Mercury

None of the Project Mercury missions (1961–3) had an official emblem worn by the astronaut in flight. They carried only the early (pre-1975) NASA emblem shown in Fig. 1, above their identifying name tag on the right hand side of their pressure suits. *Commemorative* emblems, however, were instituted by NASA, and these are shown in Fig 2.

The only emblem carried *on* the missions were on the outsides of some of the capsules. Grissom had a Liberty Bell, with its famous crack, painted on. After his vehicle was lost following spashdown, jibes from his fellow astronauts attributed the sinking to the crack letting in water!

Fig. 2. Mercury emblems (commemorative only):

(i) Mercury 3: Silver and black capsule with flight tracks back to Cape. "Mercury 3" in blue, "Shepherd" in green, yellow background. "Freedom 7" silver on green-blue Earth. Red border.

(ii) Mercury 4: Blue and black capsule on grey background. "Grissom", flight trails and "Liberty Bell 7" in gold, black vapour trail for spent Redstone booster, "Mercury 4" in red, silver border.

(iii) Mercury 6: First orbital flight. Blue background. "Friendship 7" and trailing lines in white and silver. Green-blue Earth showing Florida. Three silver orbital tracks. "Mercury 6" in green, black border.

(iv) Mercury 7: red background, purple border. "AURORA" and "Mercury 7" in white. "Carpenter" and "7" in silver, circles yellow and white. Yellow rising sun behind blue Earth.

(v) Mercury 8: Black background, green-blue Earth, "Mercury 8" in gold, "Schirra" in silver, red border. The Greek letter sigma and "7" in silver/blue.

(vi) Mercury 9: Blue and silver capsule, silver 5-point star. "Faith 7" and "Cooper" in blue, "Mercury" and "7" in yellow. Globe: two shades blue. Purple background, crimson border.

(The "seven" on all the badges refer to the original seven astronauts.)

Some capsules had only a name painted on, others a motif. Aurora 7 added coloured auroral rings (for the "shimmering dawn" of the Space Age), and Schirra's Sigma 7 had a Greek letter sigma in place of the name. All the capsules carried the US flag, as have subsequent projects, and the words UNITED STATES in white (changed to black for Gemini on). Capsule artwork was the responsibility of Cece Bibby.

Gemini

The Gemini series had a programme emblem, shown in Fig. 3. Again all the astronauts wore the NASA emblem (this time on the left side of their suits due to a suit design change). From Gemini 5 on the astronauts have been allowed to wear emblems on their suits (Fig. 3) below their name tags until Gemini 7, when another design change (to allow for longer missions) meant they had to be moved to the upper right arm. For Gemini 3 and 4 the emblems shown in Fig. 3 are only commemorative ones, authorized by NASA. The astronauts on Gemini 4 were the first to wear the US flag on their suits.

The idea for Gemini 5's pioneer's wagon ('Conestoga') came from a model belonging to the father-in-law of Conrad, one of the crew. The '8 days or bust' referred to the pioneering length of time the mission was due to last. The motto was unathorized since NASA thought it might prove an embarassment if the mission failed to complete. A parachute rigger was asked by the crew to sew a small piece of silk over the slogan. It was ripped off on the successful completion of the mission. (Some of the difficulties the crew had had, however, prompted Conrad to draw, between the two spacecraft seats, a covered wagon halfway over a cliff [2].)

The stars on the Gemini 6 badge were meant to represent, from the upper tip of the '6', following its curve: Capella, Castor and Pollux (the Gemini capsule), Procyon, Sirius and then the Orion constellation. On the line from Orion back to Sirius is a representation of the Agena capsule Gemini 6 was supposed to dock with (GTA on the badge means Gemini Titan Agena). In fact the Agena was lost in a launch failure and they rendezvoused with Gemini 7 instead. (Interestingly, the Gemini 6 crew first saw the other craft in roughly the celestial position depicted on the badge for the Agena capsule!)

The olympic torch emblem for Gemini 7 was chosen because it was meant to spend a 'marathon' fourteen days in orbit. The names of the crewmen were omitted on the flight version of the badge to highlight the

Fig. 3. Gemini Emblems:

(i) Gemini programme emblem. Blue letters, black background, "II" in gold. The stars were meant to be Caster & Pollux, the heavenly twins (hence "Gemini"). II signified 2-man crews *and* the Titan II launcher.
(ii) Gemini 3, commemorative only: Capsule orange, white and red. Green background. Crew names in red. "Molly Brown" (unofficial name) in white. "GT-3" and border in orange.
(iii) Gemini 4, commemorative only: Red background, blue border, rest in white except "First Space Walk" and umbilical in yellow.
(iv) Gemini 5: white background. Wagon black and white, detail in silver. Lettering red, black border.
(v) Gemini 6: white/yellow stars, black background, white border and lettering.
(vi) Gemini 7: Black background, red border; white arm, torch, spacecraft and "VII". Gold torch flame.
(vii) Gemini 8: Gemini twin 8-pt stars in yellow and blue. White background with black border. Blue/yellow prism with spectral colours into Roman numberals. Names in black.
(viii) Gemini 9: Background dark blue. Grey border, astronaut and tether. Spacecraft and names light blue. "IX" in white.
(ix) Gemini 10: Background and border, 2 shades of blue. "X" in red. Crosses represent double crew/twin stars. Gemini chases Agena around the "X"
(x) Gemini 11: Black background and yellow border. Tracks and stars yellow/gold. Major features white with yellow details.
(xi) Gemini 12: Gold and orange Gemini, Gold and black moon and names. "XII" in orange.

importance of the mission rather than the people involved.

The prism on Gemini 8's badge signified the spectrum of tasks it undertook, while Gemini 9's badge showed the Gemini spacecraft about to dock with an Agena (which it again failed to do), and an astronaut doing a spacewalk. Gemini 10's badge was designed by the wife of the command pilot, John Young. She was a former commercial artist. It was simpler than most of the others. The Gemini 11 emblem showed the docked Gemini-Agena combination and a spacewalk again, this time in an elliptic orbit depicting the orbital altitude attempt the craft made. The last of the series, Gemini 12, had a much simpler design. The crescent behind the capsule was said to represent the Moon, next target for America's space programme.

Fig. 4. Apollo project badge. "A" and constellation white. Green and blue Earth, Gold, yellow and white moon, black background, white satellite trail.

Apollo

The Apollo project badge is shown in Fig. 4, though it never actually flew on a mission. The Greek sun god, from which the project got its name, appears above a green and blue Earth. The badge was selected from proposals submitted by NASA and contract personnel [4].

The suit patches worn on the individual Apollo missions are shown in Fig. 5. The Apollo 1 mission perished, of course, in the capsule fire which killed Grissom, White and Chaffee, its crew. A replica of their suit patch, however, was taken to the Moon by Apollo 11.

Before settling on the conventional design shown for their mission, the Apollo 7 crew had considered several others, including two of some note. Tom Stafford's daughter Karin, then 10, had suggested the three wise monkeys in a bathtub, and another suggestion was a Phoenix rising from the fire of Apollo 1, though they were worried this might have been considered in bad taste [5].

Apollo 8 went around the Moon, and Apollo 9 was the first flight of the complete Apollo vehicle - hence their designs. Apollo 10 carried out the undocking and redocking tests of the lunar module in Moon orbit, and it and the CSM (Command & Service Module) are shown separated on their badge. The 'X' for the mission number is shown sitting on landing site 2, prime target for the first landing attempt.

As might be expected, the Apollo 11 badge took a great deal of consideration, since the first lunar landing would obviously be an historic event which would come under a great deal of scrutiny the world over. Whether the Eagle chosen (on the suggestion of Jim Lovell) could be said to represent a 'peaceful landing by all mankind' may be a matter of opinion, but the symbolism of the olive branch is obvious. Fig. 6 shows the original idea for the badge to compare with how it eventually turned out. It was Collins, the Command Module pilot, who traced the bird's picture from a copy of the *National Geographic Book of Birds*. The crew names were left off, as with Gemini 7, to demonstrate the importance of the mission rather than the crew involved.

It may be illustrative to give some of the reasons for the changes made between initial concept and final patch. Armstrong disapproved of the word 'ELEVEN' spelt out since it would mean nothing to non-English speakers. 'XI' and '11' were discussed, and the latter finally used. The olive branch was an addition, and its positioning took some consideration - it was eventually moved from beak to claws to 'soften' the impact of the open talons, which Washington thought looked too war-like and aggrandizing ('grabbing' the Moon).

The Apollo 12 badge was influenced by the fact its crew was 'all Navy'. The CSM's name 'Intrepid' came from Conrad's liking of 'wonderful British warship names'. The Ocean of Storms landing site was shown behind an American Clipper ship, with the three higher stars representing the crew men, in ascending order of seniority. The fourth star below the others was for C. C. Williams who had died in October 1967 whilst in training as the crew's lunar module pilot [6].

Apollo 13's badge showed the god Apollo being pulled by three horses in a chariot from Earth to Moon. Its Latin text EX LUNA SCIENTIA means "*From the Moon, Knowledge*", and the chariot was meant to show the increasing scientific workload en route to the Moon. Apollo 13, of course, was the one that didn't make it!

The Apollo 14 emblem featured the astronaut's Gold pin en route to the Moon. The Gold pin is awarded only after a spaceflight, rookie astronauts getting a Silver pin. The landing site Fra Mauro, is also shown. There is an 'alternative' badge for this mission, unofficial, and designed by the back-up crew. It parodies the main crew's badge, with the Warner Bros cartoon characters Road Runner and Coyote taking leading roles. Copies did, however, fly to the Moon with Apollo 14 [7].

The all Air Force crew on Apollo 15 went back to simple flight symbology with three birds, in patriotic red, white and blue. Apollo 16 revived Apollo 11's eagle, adding also a picture of the Descartes landing site, and sixteen stars in the border representing the Apollo missions to date.

Apollo 17 had perhaps the best emblem of the series, designed by the space artist Robert T. McCall [8]. The face of Apollo is copied from the Apollo Belvedere, the

Fig. 5. Apollo Mission Emblems:

- (i) Apollo 1: CSM b/w, blue-brown Earth (showing Florida), Moon in Silver, black background. Inner border in yellow with lettering in black. Outer border colour of US flag with black edging.
- (ii) Apollo 7: Green-blue Earth, "VII" in gold, CSM in white with black details. White letters on dark blue background. Black border.
- (iii) Apollo 8: Mainly blue, with white border. Yellow and gold moon, green/blue Earth. "8" in red, names in white.
- (iv) Apollo 9: B/w Saturn V, CSM & LM. Yellow orbit. Lettering white except USA (red) on Saturn V. Blue background, red border. D in McDivitt filled red denoting "red rover", LM pilot Schweikert's call sign during EVA.
- (v) Apollo 10: Blue background/yellow border. "Apollo" in black, crew names in grey, "X" in white. CSM in b/w with light blue trail. Lunar surface blue/green and grey. LM b/w with red/yellow plume. Earth green/blue and white. Blue background.
- (vi) Apollo 11: Black sky. Eagle "natural" colours. Olive branch green. Grey brown moon, Earth "natural". Blue and gold border with yellow belt.
- (vii) Apollo 12: Black space, white stars. Yellow clipper with gold wake. Gold, white and blue border.
- (viii) Apollo 13: Black background, grey moon, blue brown Earth, gold horses with yellow wings. Orange Sun God, blue trail. White border and lettering.
- (ix) Apollo 14: Blue background. "Natural" colours of Moon and Earth. Gold Pin with border in tan. Brown lettering and border.
- (x) Apollo 15: Red, white and blue birds and border. Flight name and crew names in black. Grey moon with black and white details.
- (xi) Apollo 16: "Natural" eagle. Red, white and blue shield and border. Yellow flight symbol and border.
- (xii) Apollo 17: Apollo gold. Gold-brown moon. Grey border. Red, white and blue mostly elsewhere.

Fig. 6. Original Apollo 11 design

sculpture in the Vatican City. There is an eagle with four bars in red on its wings, representing the bars of the American flag, and there are three stars to represent the crewmen. The gaze of Apollo, and the thrust of the eagle's neck towards representations of the Moon, Saturn and the Stars, is meant to show Man's future reaching still further out into Space.

Skylab

The Skylab programme had the emblem shown in Fig. 7, designed by Bob McCall. It showed the Skylab cluster in orbit. The first manned mission badge (Skylab 2, Skylab 1 being the station's launch) was designed by Frank Kelly Freas [9], a science fiction artist. After much consideration of alternative representations for the peaceful uses of outer space, another simple drawing of the lab itself was chosen. A solar eclipse was included to illustrate the importance of solar studies to the mission. After considering several alternatives the idea of a motto was dropped.

Skylab 3 motif included a half Earth globe (showing America), a blazing Sun, and a Da Vinci drawing of a man. The latter was supposed to represent Man's reach, with all three together being the main areas for the mission's research – Man, the Sun and Earth. The Skylab 4 badge had a large 3, as it was the third manned mission, a tree to represent the Earth Resources studies undertaken, and a human form for the medical research. The spectrum, as on Gemini 8, represents the spectrum of tasks. An alternative emblem for the flight included comet Kohoutek over the '3'.

There was also an unofficial badge for a 56-day ground-based simulation of Skylab, from 1972, which used the Snoopy cartoon character, but it was not produced for sale.

ASTP

The ASTP programme emblem is shown in Fig. 8, and includes a drawing of the linked spacecraft. Both crews wore flight emblems in addition. Until this flight

Fig. 7. Skylab Emblems:
(i) Project emblem: "natural" coloured Earth and Skylab. Gold letters, light-green border.
(ii) Skylab 2: Skylab cluster and lettering black with white outline; Earth shades of blue, Sun in blazing yellow, gold, white and brown. Black border, crew names in white.
(iii) Skylab 3: Black crew names, blue/white Earth. Red/Yellow Sun, white figure and background. Red, white and blue border.
(iv) Skylab 4: Spectrum in "natural" spectral colours. "3" and letters in black. Background and border in blue. Names white. Tree green, planetary system black and red. Man black on white with silver background.

Fig. 8. ASTP Emblems:
(i) Project Emblem: Gold vehicles on a white globe. Red and blue border. Apollo and (Russian for) Soyuz in gold.
(ii) Individual Emblems: "Natural" colours with space dark blue. Border of white, gold and red with three white stars on blue for American astronauts and 2 gold ones on red for Soviet. Names in black.

Fig. 9. New NASA Emblem. Bright red on white.

the Soviets had not used flight emblems. They have been introduced again since this for the InterKosmos Cosmonauts to Salyut-6.

NASA's new emblem

The Skylab 4 astronauts were also the last to wear NASA's old emblem shown in Fig. 1. A new, more modern and simple logo was introduced, as shown in Fig. 9. (This was part of a general programme of improvements in communications within and without the Space Agency, under the Federal Graphics Improvement Program of the National Endowment of Arts, instituted by President Nixon in 1972).

The two As in NASA have become nose cones, the whole name smoothed to represent technological precision and the smooth continuous development of space.

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CORRESPONDENCE

Satellite Tracking

Sir,

I am a mathematics teacher and propose to offer a course in SATELLITE TRACKING as a part of the school curriculum, to prospective pupils of "O" level and C.S.E. (mode 1).

The course can also be offered as one of the optional subjects in the 4th and 5th years. Only the most able pupils of 4th, 5th and 6th years who have a strong inclination in mathematics and physics will be eligible for the course. (I believe that would mean not more than six to ten pupils in each year).

Among the topics that will be dealt with will be:

(1) Elements of CELESTIAL MECHANICS (Astrodynamics). The study of this subject will enable a pupil to determine the orbital parameters of a satellite in orbit - viz. orbital inclination, measurement of perigee and apogee, nodal period, eccentricity etc. Also the weight and life of the satellite and the time and place of launch.

(2) Elements of SPHERICAL ASTRONOMY.

(3) MATHEMATICS: Relevant differential and integral calculus, algebra, trigonometry, vectors and matrices etc.

There will be an examination for the C.S.E. Mode. 1. pupils at the end of their fifth year and for the "O" level pupils in their sixth year. The exam results will be subjected to moderation.

Can you help in locating equipment or material that could be used in such a course?

B.S. SETHNA, MSc (Hons) AFBIS
Cleveland

Reply: We would like to hear from any teacher or educationalist who could help Mr. Sethna with his course. In general if any teachers know of sources of equipment or other material for any type of space-based courses we would be glad to disseminate further the information through the pages of Space Education. *Does anyone know of anything second-hand or as a gift that might be useful? Mr. Sethna's school has three Tandy TRS-80 microcomputers, so computer-based material is also of interest.*

Astronomy Syllabus

Sir, Referring to Mr. Lintern-Ball's Astronomy Syllabus (*Space Education* 1 (3), May 1982 p. 141) I feel the amount of work involved would be too much for the average Sixth-former. This would be especially true of an Arts student taking A-levels simultaneously. (And this would only be an advanced O-level).

With the present system, this could only be an extra paper taken with Physics, or possibly Chemistry - e.g. Physics-with-Astronomy A-level.

If Astronomy is to find a place in Sixth-form work, an A-level system of Normals and Furthers would have to be adopted - i.e. say five subjects studied in the first year (N-level) then two continued in more detail in the second (F-level). N-level astronomy could have a similar, though reduced, syllabus to that proposed. It would be popular since it would not be thought as "impossible" a subject to do as physics is.

MICHAEL BLACK
Wimbledon

Thanks

Sir, I would like to express my deepest thanks for the enormous batch of display material for my school's library. It shows the degree of commitment which the Society has in the area of education. The BIS publications contained in the display material are of immense educational value as well as being a real credit to the Society.

S. R. MATTHEWS
Merseyside

School Materials

Sir, I am writing to thank the Society for the pictures and magazines on space. I did not expect such a large amount of material and I am very grateful for the time and effort which went into sending it. I am sure the children will enjoy looking at the pictures and it will help create interest in the topic "Space".

MISS K. M. HONEYFORD
Manchester

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