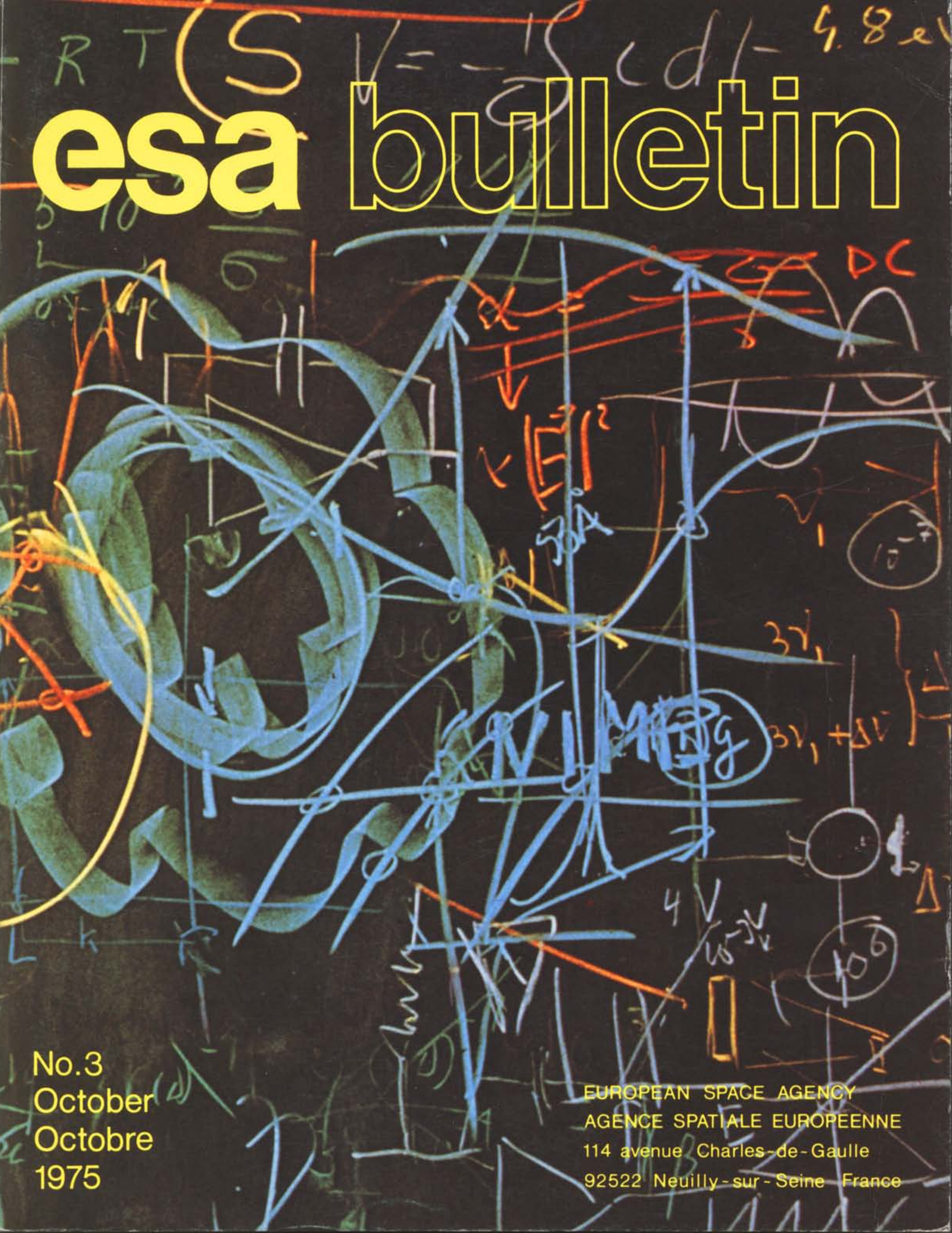

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EUROPEAN SPACE AGENCY
AGENCE SPATIALE EUROPEENNE
114 avenue Charles-de-Gaulle
92522 Neuilly-sur-Seine France

The European Space Agency was formed out of, and took over the rights and obligations of, the two earlier European Space Organisations: the European Space Research Organisation (ESRO) and the European Organisation for the Development and Construction of Space Vehicle Launchers (ELDO). The Member States are Belgium, Denmark, France, Germany, Italy, Netherlands, Spain, Sweden, Switzerland and the United Kingdom.

In the words of the Convention: The purpose of the Agency shall be to provide for and to promote, for exclusively peaceful purposes, co-operation among European States in space research and technology and their space applications, with a view to their being used for scientific purposes and for operational space applications systems,

(a) by elaborating and implementing a long-term European space policy, by recommending space objectives to the Member States, and by concerting the policies of the Member States with respect to other national and international organisations and institutions;

(b) by elaborating and implementing activities and programmes in the space field;

(c) by co-ordinating the European space programme and national programmes, and by integrating the latter progressively and as completely as possible into the European space programme, in particular as regards the development of applications satellites;

(d) by elaborating and implementing the industrial policy appropriate to its programme and by recommending a coherent industrial policy to the Member States.

The Agency is directed by a Council composed of representatives of Member States. The Director General is the chief executive of the Agency and its legal representative.

The Directorate of the Agency consists of the Director General; the Director of Planning and Future Programmes; the Director of Administration; the Director of Scientific and Meteorological Satellite Programmes; the Director of Communication Satellite Programmes; the Director of the Spacelab Programme; the Technical Inspector; the Director of ESTEC and the Director of ESOC.

The ESA HEADQUARTERS are in Paris (Neuilly-sur-Seine).

The major establishments of ESA are:

EUROPEAN SPACE RESEARCH AND TECHNOLOGY CENTRE (ESTEC), Noordwijk, Netherlands.

EUROPEAN SPACE OPERATIONS CENTRE (ESOC), Darmstadt, Germany.

EUROPEAN SPACE RESEARCH INSTITUTE (ESRIN), Frascati, Italy.

L'Agence Spatiale Européenne est issue des deux Organisations spatiales européennes qui l'ont précédée – l'Organisation européenne de recherches spatiales (CERS) et l'Organisation européenne pour la mise au point et la construction de lanceurs d'engins spatiaux (CECLES) – dont elle a repris les droits et obligations. Les Etats membres en sont: l'Allemagne, la Belgique, le Danemark, l'Espagne, la France, l'Italie, les Pays-Bas, le Royaume-Uni, la Suède et la Suisse.

Selon les termes de la Convention: L'Agence a pour mission d'assurer et de développer, à des fins exclusivement pacifiques, la coopération entre Etats européens dans les domaines de la recherche et de la technologie spatiales et de leurs applications spatiales, en vue de leur utilisation à des fins scientifiques et pour des systèmes spatiaux opérationnels d'applications:

(a) en élaborant et en mettant en oeuvre une politique spatiale européenne à long terme, en recommandant aux Etats membres des objectifs en matière spatiale et en concertant les politiques des Etats membres à l'égard d'autres organisations et institutions nationales et internationales;

(b) en élaborant et en mettant en oeuvre des activités et des programmes dans le domaine spatial;

(c) en coordonnant le programme spatial européen et les programmes nationaux, et en intégrant ces derniers progressivement et aussi complètement que possible dans le programme spatial européen, notamment en ce qui concerne le développement de satellites d'applications;

(d) en élaborant et en mettant en oeuvre la politique industrielle appropriée à son programme et en recommandant aux Etats membres une politique industrielle cohérente.

L'Agence est dirigée par un Conseil, composé de représentants des Etats membres. Le Directeur général est le fonctionnaire exécutif supérieur de l'Agence et la représente dans tous ses actes.

Le Directoire de l'Agence est composé du Directeur général, du Directeur des Programmes futurs et des Plans, du Directeur de l'Administration, du Directeur des Programmes de satellites scientifiques et météorologique, du Directeur des Programmes de satellites de communications, du Directeur du Programme Spacelab, de l'Inspecteur technique, du Directeur de l'ESTEC et du Directeur de l'ESOC.

Le SIEGE de l'ASE est à Paris (Neuilly-sur-Seine).

Les principaux Etablissements de l'ASE sont:

LE CENTRE EUROPEEN DE RECHERCHE ET DE TECHNOLOGIE SPATIALES (ESTEC), Noordwijk, Pays-Bas.

LE CENTRE EUROPEEN D'OPERATIONS SPATIALES (ESOC), Darmstadt, Allemagne.

L'INSTITUT EUROPEEN DE RECHERCHES SPATIALES (ESRIN), Frascati, Italie.

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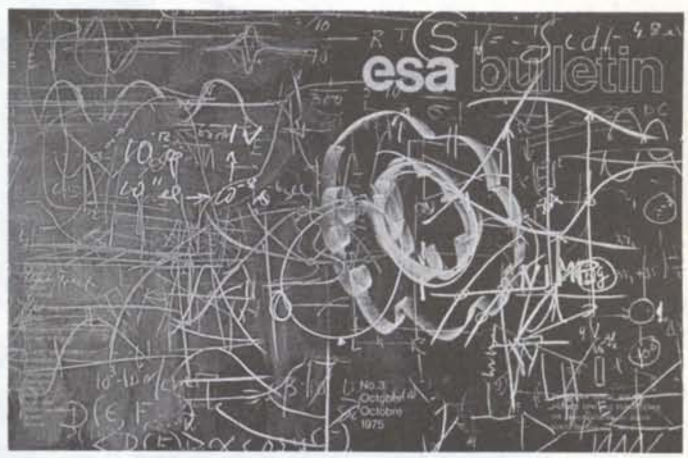

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Introduction

This issue of the ESA Bulletin is mainly devoted to space science. There are several difficulties involved in 'selling' science to the general public. It is not easy, for instance, to popularise science without simplifying its problems so much that the information given is no longer representative. Moreover, the usefulness of any experiment in pure science cannot be established *a priori*. Although in many cases pure science has subsequently demonstrated its usefulness for mankind, the layman has difficulty in accepting such *a posteriori* justification and tends to assume that the technological results would somehow have materialised anyway. This assumption is by no means correct, as we hope to demonstrate in the following pages.

To conduct scientific research is to investigate problems about which little or nothing is known. Successful research may lead to the expected results, it may give completely unexpected results, or it may even yield no results at all. Some results may lead to technical applications, others may not. In any case, the outcome cannot be predicted.

The basic motivation for any scientist in carrying out his research is curiosity – curiosity shared with men like Stanley and Livingstone, who wanted to know what was going on inside Africa; Kepler and Galileo, who found their observations inconsistent with the cosmological ideas of Aristotle; Hahn and Meitner who split the atom; and Carnot who discovered the heat cycle that governs the (lack of) efficiency in converting thermal to mechanical energy.

To help explain the scientific point of view, we have included in this issue an article by Prof. Reimar Lüst, who is now President of the Max-Planck Society and who was, in the early years of ESRO, its Scientific Director, on the role of science in the progress and survival of mankind.

As Prof. Lüst does not deal with space-related topics, I would like to mention here an example of interdisciplinary research which relates space science with energy studies. The greatest difficulty in achieving controlled nuclear fusion is the confinement of a hot plasma for a sufficiently long time, a feat which has not so far been achieved in the laboratory. Nature, however, does this job on a grand scale: the magnetosphere around our Earth is an almost perfect 'magnetic bottle', to which spacecraft give us access. It can safely be assumed that results already achieved and those expected from space missions to be flown within the next few years, such as the GEOS and ISEE projects, will enhance the cross-fertilisation between Earth-bound plasma research and space research. Active plasma experiments in space, as foreseen for early Spacelab missions, will certainly further this field.

Le présent numéro du Bulletin de l'ASE est principalement consacré à la science spatiale. Essayer de 'vendre' de la science au grand public n'est pas sans soulever quelques difficultés. Par exemple, on ne peut guère faire de la vulgarisation scientifique sans simplifier les choses mais ne risque-t-on pas, ce faisant, de déformer peu à peu l'information donnée? D'autre part, peut-on affirmer a priori l'utilité de telle ou telle expérience de science pure? Bien qu'il se soit souvent confirmé a posteriori que la science pure est utile à l'Humanité, le profane a du mal à admettre ce processus car il a tendance à croire que les résultats technologiques obtenus se seraient concrétisés d'une façon ou d'une autre, ce qui est absolument faux, comme nous espérons le démontrer dans les pages qui suivent.

Faire de la recherche scientifique c'est se consacrer à l'étude de problèmes sur lesquels on n'a que peu ou pas de lumières. Une recherche réussie peut aboutir aux résultats escomptés mais elle peut aussi donner des résultats complètement inattendus, voire ne rien donner du tout. Certains résultats peuvent déboucher sur des applications techniques, d'autres non. De toute façon, il est impossible d'en prévoir l'issue.

Ce qui pousse tout scientifique à effectuer ses recherches c'est d'abord la curiosité. Je veux dire la curiosité d'hommes comme Stanley et Livingstone qui voulaient savoir ce qui se passait au coeur de l'Afrique, celle de Kepler et de Galilée qui ont réalisé que leurs observations contredisaient les théories cosmologiques d'Aristote, celle qui a guidé les travaux d'Otto Hahn et de Lise Meitner sur la fission de l'atome, celle qui a poussé Sadi Carnot à découvrir le cycle thermique qui régit la transformation de l'énergie thermique en énergie mécanique.

Pour tenter d'expliquer le point de vue des scientifiques, nous publions dans ce numéro un article du Professeur Reimar Lüst qui est aujourd'hui Président de la Société Max-Planck et qui fut, dans les premières années du CERS, son Directeur scientifique. Cet article traite du rôle de la science dans le progrès et la survie de l'humanité.

Le sujet de l'article du Professeur Lüst n'est pas lié à l'espace; c'est pourquoi j'aimerais donner un exemple de recherche interdisciplinaire montrant comment la science spatiale peut s'allier à la recherche dans le domaine de l'énergie. Le problème le plus épineux que pose la fusion nucléaire contrôlée est celui du confinement d'un plasma à haute température pendant un temps suffisamment long. Jusqu'à présent, on n'a pu réaliser la chose en laboratoire, alors que la Nature, elle, y parvient à une grande échelle; la magnétosphère qui entoure notre Terre est une 'bouteille magnétique' presque parfaite. Or, les véhicules spatiaux nous y donnent accès. On peut à coup sûr supposer que les résultats déjà obtenus et ceux que

We have also included an article by Dr. Edgar Page, my successor as Head of Space Science Department, ESTEC, who highlights some of the results obtained to date with ESRO/ESA satellites. His summary clearly shows that, starting from scratch, ESRO has not only managed to put eight scientific spacecraft successfully into orbit, but has also obtained from them scientific results that compare favourably with those of any other space agency. These results would never have been achieved without the enthusiasm and competence of the approximately 30 institutes which have supplied, sometimes under very difficult circumstances, experiments of outstanding quality to our Agency. In this context, it should not be forgotten that national agencies have also flown many highly successful spacecraft and that, in addition, European scientists have also competed very successfully to have large number of experiments flown on the spacecraft of other agencies. Dr. Page also describes briefly the satellites presently under development.

The most important forum in which to exchange space science results is provided by the Committee on Space Research (COSPAR), which meets annually and also organises symposia each year on specific topics. We have therefore included a short article by Prof. C. de Jager, currently President of COSPAR.

A further article written by Dr. J. King, of the UK Science Research Council's Appleton Laboratory, demonstrates how sometimes the new interpretation of data that have been in the files for a long time may lead to interesting, directly applicable conclusions, however premature they may be at this stage. It may subsequently be shown that the complicated relationship between solar activity and climatic changes is of such a magnitude that it has had a dramatic influence on the economic development of mankind and will continue to have such an influence in the future.

The article written by B. Bizzarri of the Italian Meteorological Service, Rome, is a further illustration of the fact that it is not always possible to distinguish between science and so-called 'applications', in that Meteosat, apart from providing routine data, will also produce scientific results that may help the meteorological community to overcome successfully the transition from a purely synoptic to a more scientific approach to their problems.

E. Peytremann, Head of ESA's Future Scientific Programmes Department, rounds off this science review with a brief summary of the scientific missions presently being studied as potential candidates for future ESA programmes. He also deals

l'on peut attendre des missions spatiales prévues dans les prochaines années (par exemple, les projets GEOS et ISEE) rendront plus féconds les échanges entre la recherche sur les plasmas terrestres et la recherche spatiale; et les expériences actives portant sur les plasmas dans l'espace, telles que celles qui sont envisagées pour les premières missions du Spacelab, permettront certainement d'enrichir encore ce domaine.

Nous publions également un article du Dr Edgar Page, qui m'a succédé comme Chef du Département 'Science spatiale' de l'ESTEC; l'auteur y met en relief quelques-uns des résultats qu'ont permis d'obtenir les satellites CERS/ASE. Il ressort clairement de ce résumé que, partant de zéro, le CERS a non seulement réussi à mettre huit satellites scientifiques en orbite mais en a obtenu des résultats qui soutiennent favorablement la comparaison avec ceux de n'importe quel autre organisme spatial. Jamais ces résultats n'auraient pu être atteints sans l'enthousiasme et la compétence des quelque trente Instituts qui ont fourni à notre Agence des expériences d'une exceptionnelle qualité – et ce, dans des conditions parfois très difficiles. Dans ce contexte, il ne faut pas oublier que des organismes nationaux ont également lancé avec succès de nombreux satellites ni que des scientifiques européens ont embarqué un grand nombre d'expériences sur des véhicules spatiaux lancés par d'autres organismes qui ont choisi ces expériences à l'issue d'une compétition pourtant très ouverte. Le Dr Page décrit également brièvement les satellites en cours de développement.

Le Comité mondial de la Recherche spatiale (COSPAR) est le plus important centre d'échange des résultats obtenus dans le domaine de la science spatiale; il se réunit tous les ans et organise également chaque année des symposiums sur des sujets spécifiques. C'est pourquoi nous publions également un court article du Professeur C. de Jager, actuellement Président du COSPAR.

Dans un autre article, le Dr J. King (du 'Appleton Research Laboratory' du Conseil de la Recherche scientifique, Royaume-Uni) montre comment une nouvelle interprétation de données qui dormaient depuis longtemps dans des dossiers peut parfois conduire à des conclusions intéressantes et directement applicables, quelque prématurées qu'elles puissent paraître sur l'heure. On pourrait montrer par la suite que les relations complexes existant entre l'activité solaire et les modifications climatiques sont d'une ampleur telle qu'elles pourraient avoir eu une influence considérable sur le développement économique de l'humanité. On peut manifestement supposer qu'il en sera de même dans l'avenir.

with our plans for the scientific utilisation of Spacelab, on which scientists and technicians will themselves control and operate the complex experiments.

It is not without reason that the scientific programme is mandatory within the framework of the ESA Convention; without it ESRO/ESA would never have been able to propose an applications programme to the Member States, since it was only the experience gained with our scientific projects that enabled us to build our complex applications satellites. I am sure that this will also be true for the future. Apart, therefore, from making a valuable contribution in its own right, the science programme also provides the technological basis from which applications programmes can evolve. It is appropriate therefore that the 'blue pages' of this primarily scientific issue should contain progress reports on our applications as well as our scientific projects as a reminder of their interdependence.

I sincerely hope that this Bulletin will enable our readers to appreciate more fully what has been achieved by the scientific programme in the past, and what we hope to achieve in the future.

L'article signé par le Dr B. Bizzarri (du Service météorologique italien, Rome) montre clairement qu'il n'est pas toujours possible d'établir une distinction nette entre la science et ce que l'on appelle ses applications puisque Météosat fournira, en plus des données courantes, des résultats scientifiques susceptibles d'aider les météorologistes à passer avec succès d'une approche purement synoptique de leurs problèmes à une approche plus scientifique.

Enfin, le Dr E. Peytremann, Chef du Département des Programmes scientifiques futurs de l'ASE, décrit brièvement les missions scientifiques qui sont en cours d'étude et qui pourront éventuellement être proposées pour le programme futur de l'ASE. Il expose également nos plans d'utilisation scientifique du Spacelab, où des scientifiques et des techniciens contrôleront et exploiteront eux-mêmes des expériences spatiales complexes.

Ce n'est pas sans raison que la Convention de l'ASE prévoit un programme scientifique obligatoire. Sans programme scientifique, le CERS/ASE n'aurait jamais été capable de proposer à ses Etats membres un programme d'applications, puisque seule l'expérience que nous avons acquise avec nos projets scientifiques nous a permis de nous attaquer aux satellites d'applications complexes. Je suis sûr que ce sera également vrai dans l'avenir. Le programme scientifique, outre sa valeur intrinsèque, fournit donc aussi la base technologique à partir de laquelle les programmes d'applications peuvent se développer. C'est pourquoi il nous a paru approprié que les 'pages bleues' de ce Bulletin essentiellement scientifique contiennent des rapports d'avancement aussi bien sur nos projets d'applications que sur nos projets scientifiques, afin d'en souligner l'interdépendance.

J'espère sincèrement que ce numéro spécial permettra à nos lecteurs de mieux se représenter ce que le programme scientifique a permis de réaliser hier et ce que nous espérons accomplir demain.

Ernst A. Trendelenburg

E.A. Trendelenburg
Director of Scientific and Meteorological Programmes

Directeur des Programmes de satellites scientifiques et météorologique

Scientific Research in the Service of Mankind*

Prof. R. Lüst, President of the Max-Planck Society

Financial resources are always limited, but today the need to economise is greater than ever. Everywhere one faces the question of who can afford to invest, how much and where. This applies equally in the case of scientific research. Who in this field should receive the limited funds available – the cancer research worker at the expense of the astronomer, because cancer research is more useful to mankind than astronomy? Or should priority be given to energy research, by taking resources from the physicists who are engaged on elementary particle research, an area that offers no immediate prospect of useful applications? How, in short, can one plan research sensibly?

In all discussions devoted to the planning of research and the monitoring of its success, there appears to be an increasing tendency to ask the question: 'How economically relevant is research work, really?' In the various branches of research, each having its own justification, it is increasingly clear how difficult it is to orient research according to criteria such as 'the common wealth', 'social need', 'the quality of life', or even 'social realism'. It is not merely that the weight attached to the application and the requirement gradually diminishes as one considers, in turn, applied research, applications-oriented research and, finally, pure research. Even the selection of specific fields whose importance is evident for everybody – for example, cancer research – is too general and vague to provide any sort of useful framework for the necessary multidisciplinary, basic research.

The proposals made so far for developing methods of establishing priorities – for example, by means of opinion polls – have proved anything but convincing. In this connection it is perhaps useful to recall a study conducted in Germany in 1973. The fact that in this opinion poll most people opted for an 'improvement in the quality of our environment' as the most important aim of research policy is neither particularly convincing nor wholly surprising. Nor is it surprising that 'promotion of scientific progress in other research fields' came out at the bottom end of the scale in that poll. As for the ensuing recommendation that expenditure on nuclear-energy research should be reduced, it might well have taken a different form if the study had been carried out in the autumn of 1973, during the oil crisis, instead of during the spring of that year.

But these inconclusive efforts provide us with no answer to the question of how we are to meet the need to plan research in order to achieve maximum possible effectiveness. This problem poses special difficulties in the case of the basic research that is done in the universities and research institutes. Basic research is primarily directed at the acquisition of knowledge; it does not immediately aim at practical applications. It thus largely eludes a planned approach, the very concept of which postulates the existence of a specific objective.

If there is to be planning, it must be related to the function of basic research. This means that care must be taken to ensure that the 'humus' – the common sources of new knowledge, the theoretical basis for application-oriented research and the innovatory creativity – is preserved. Immediate, identifiable results cannot be the yardstick for assessing this kind of research, since the extension of basic theoretical knowledge – whether it be in physics, chemistry or biology – is the key to the solution of the practical problems that will face future generations, just as important practical developments of today have been achieved thanks to the basic research of past

* Translation of an article originally published in the 11 April 1975 issue of 'Die Zeit' under the title 'Dem Neuen eine Chance'.

generations. The ever-increasing speed with which knowledge can be expanded, at both theoretical and practical levels, calls for concentration on focal points, but plenty of room must still be left for flexibility of execution.

To decide on what areas research efforts should be concentrated, it is first necessary to have a precise knowledge of technical developments at both national and international level. It is important that these developments be carefully monitored and assessed through the medium of competent bodies. This assessment of priority research areas must take place at various levels; in the first instance within an individual field; e.g. that of molecular biology. Subsequently, selected items must be compared, at a higher level, with other fields.

In all research promotion one must strive to develop the decision-making procedures for this research planning process in such a way that the promotion of promising developments is given a higher priority at the expense of less promising projects. It must also be continuously borne in mind that there are no general rules for the attainment of this optimisation goal. This process, intended to permit as careful an assessment as possible of all identifiable considerations, is inevitably linked with the question of whether an outstanding scientist is available to work in a specific field. Likewise, in order to spend resources as efficiently as possible, exceptional talents must be used, and if they can be found they must be given maximum support. Fostering the coming generation is a necessary part of research promotion.

Whether these efforts to achieve better planning will lead in the end more rapidly also in the field of basic research to the desired result – namely, the procurement of exploitable knowledge – is a question that certainly cannot yet be answered. If one compares a few examples of developments in the field of natural sciences one will at least be very cautious in arriving at a conclusion on this point.

To show how difficult it is, in the field of basic research, to foresee developments, three examples may be quoted. In each case an important role was played by branches of science that one associates scarcely at all with the concept of practical applications.

The first example stems from the field of theoretical astrophysics. It was astrophysics that sparked off research into fusion, the plasma physicists seeking to solve the problems of fusion in order to find a practical way of producing energy from a virtually unlimited fuel supply. What motivated the astrophysicists was the desire to understand not only the

principle of fusion but also – and this is something which is perhaps even more surprising to technicians – the processes involved.

Already at the beginning of the 1920's, the great astrophysicist Eddington pointed out that the stars must derive their continuously radiated energy from the energy of the atomic nuclei, since no other known energy source could explain the stars' long lifetime. The next step in the understanding of energy production in stars was taken in January 1927, by the German physicist Houtermans and the English physicist Atkinson, who were working together in Göttingen at that time. Finally, in 1938, the two German physicists, H. Bethe and C.F. von Weizsäcker, succeeded, quite independently of each other, in demonstrating on the basis of the nuclear physics developed in the meantime the detailed processes by which nuclei of hydrogen can be fused into nuclei of helium and thereby release energy. This nuclear fusion occurs at temperatures of some 10 000 000°C in the Sun and in stars. In uncontrolled, explosive form this release of energy has already been successfully achieved on Earth with the hydrogen bomb.

It is also research work on astrophysics that has led to the demonstration of a method that may make it possible to heat a gas, in a controlled manner, to a temperature of more than 10 000 000°C and at the same time confine it so that the fusion reaction necessary to produce energy can take place. The vast majority of the gases in the cosmos have such high temperatures and pressures that the atoms have lost their outer electrons. In this process they become electrically conducting and react with magnetic fields. A gas that has undergone this process consists of positive ions and negative electrons and is known as a plasma; it can be held together by magnetic fields. This means that it should be possible to confine a hot gas without it coming into contact with material walls. Research into the physics of such plasmas, which were initially studied in the cosmos, led to the creation of a small Max Planck Institute devoted solely to theoretical astrophysics. In the last decade, this institute, at Garching, has grown to be the largest Max Planck establishment, with nearly one thousand staff-members.

In the USA this development has in part followed similar lines. Not only at Garching, but also at many other establishments throughout the World, man is today seeking, with the help of plasma physics, to harness the fire of the Sun to terrestrial needs. But not until towards the end of this century – if at all – is he likely to achieve this aim to a technically feasible degree. Almost a century, at least, will thus have been necessary for a development that stems from basic research that certainly not many in Germany considered immediately relevant from an economic point of view.

The second example, taken from the field of chemical research, will show how it can happen, on the other hand, that knowledge gained from basic research leads relatively quickly to practical applications and production on an industrial scale. The example in question relates to the work done by the Nobel Prize winner Karl Ziegler, former Director of the Max Planck Institute for Coal Research at Mülheim an der Ruhr, who died in 1973. His work in numerous areas of carbon chemistry reached a climax with the discovery and investigation of organo-metallic compounds, particularly organo-aluminium, a field that is today generally known as 'Ziegler chemistry'. This has led to the now universally adopted technique for producing synthetic materials from oil products by means of the so-called low-pressure polyethylene process. The multifarious products of this synthetic chemistry that characterise our environment had their starting point in this fundamental work on the 'synthetic production of natural rubber', as this revolutionary development was first called.

It is also worth mentioning that this research in the field of organo-metallic compounds was looked upon until about 1952 as a curiosity of organic chemistry. It was only because Ziegler promoted follow-up applications research at Mülheim that the fundamental research was transformed almost overnight into a fabulously rich field for the production of synthetic materials on a large scale.

Karl Ziegler's initial work leading to this development was done before and during the war. On his appointment as Director of the Max Planck Institute for Coal Research in 1934 he had made it a specific condition that he should be allowed to do work covering the whole field of the chemistry of carbon compounds; he would have considered any restriction to specific, applications-oriented goals as an unacceptable handicap to creative research and one that would, in his own words, 'have cut him off from the real roots of his ability'. Karl Ziegler certainly had a marked gift for converting the results of his research work into technical possibilities and for exploiting them commercially with energy and skill. Thus in 1968 – fifteen years after the decisive breakthrough in Ziegler chemistry which is today exploited in numerous production centres throughout the World – he was able to devote the fruits of his work to the foundation that bears his name, and by which the Institute in Mülheim is largely financed.

The final example is provided by the development of 'the pill'. Here again, two things are striking when analysing the 'research genealogy': first, the amount of time that elapsed between the beginning of the basic research work and the moment when the contraceptive was clinically tested and brought into general use; second, the multidisciplinary co-operation between the chemical, biochemical, physiological and medical research fields that first made possible an applications-oriented development of the contraceptive.

This extremely important breakthrough at a time of threatening overpopulation would never have occurred if the first applications-oriented research work had not had behind it the relevant fundamental knowledge acquired in the fields of chemistry, biochemistry and physiology. The beginning of the development can be traced back to shortly before the turn of the century. In 1896 the Viennese gynaecologist Knauer first suspected the existence of female sex hormones. Not very much later, in 1903, Adolf Windhaus started to study a special field of organic chemistry – that of steroids – which held the key to an understanding of the structure of sex hormones, their isolation and characterisation. In 1929, his pupil Adolf Butenandt succeeded in isolating the hormone progesterone in a pure form. But it was not until 1952 that the American scientist Gregory Pincus felt that the necessary knowledge had been assembled, and the necessary preconditions satisfied, to permit a start to be made on the methodical development of 'the pill'; and it was only in 1960 that its use was officially authorised. So something like another three decades elapsed after elucidation of the mystery of the sex hormone before the necessary knowledge was accumulated to permit the step to pharmaceutical production and actual use.

This example shows likewise not only that fundamental research is an essential prerequisite for every step forward, but also that the probability of success is relatively small and that it is impossible in advance to make firm forecasts on the issue of practical applications.

These examples do more than simply demonstrate the difficulties of planning in the field of basic research. They also show that the 'success control' that is increasingly insisted upon and which scientists should not resist, must be of a different kind, and be effected at a variety of levels, in order to take account of the particular characteristics of basic research:

(a) The new must be given a chance, in particular where there are doubts and even though the risk of failure is apparent. The trusty slogans of administrations – 'We have always done it this way', 'We have never done it that way', 'We'd open the door to everybody if we accepted that one! ' – certainly don't provide the right approach to research.

(b) Any research project must, of course, be clearly formulated. But unexpected results encountered on unplanned diversions merit special regard and should not be assessed in relation to the original intention. A well-known example is Columbus, who failed to reach the original goal of his (re)search. But what a 'by-product' he found!

(c) Research work, and research projects, are necessarily of a long-term nature, and the researcher should not invariably be blamed for failure to adhere to a planned schedule. In this connection, a particularly impressive case is provided by the Nobel Prize winner Perutz, who spent 25 years improving the X-ray structure method before he succeeded in elucidating the structure of haemoglobin.

'Success control', or 'research evaluation' as it might perhaps more aptly be described, is most certainly not an entirely new concept; subjecting the results of research projects to external judgement has always been the normal practice. It has relied, in the first instance, on publications which provide the medium for the researcher to submit his results to the critical judgement of his colleagues. The number of papers published, the frequency with which they are quoted, the number of invitations received to submit papers to international congresses, the award of major scientific prizes, the granting of

patents and licences – all these elements provide criteria by which to measure the success of what has been achieved. But it would be unreasonable to claim that these apparently quantifiable data are the sole or decisive criteria.

Effective Participation

Success evaluation in the area of basic research is particularly difficult. It would certainly not be sensible to apply to basic research the methods adopted in the case of industrial projects. A rigid research control mechanism could even result in work that had already been completed being recorded as part of the planning procedure and the 'success' consequently matching all, or most, of the expectations. It would seem better to concentrate on assessment of the scientific quality of the results and to be extremely cautious in posing the question of their relevance to nonscientific domains. A catalogue of the quality criteria, however carefully compiled, would be no substitute for the knowledgeable, critical judgement of appropriately qualified experts.

Laboratory work in the field of scientific research is largely done on a team basis. This is most clearly apparent in nuclear physics, plasma physics and radio astronomy, where group work and group research programmes alone can justify the use of the particularly costly apparatus such as accelerators and radio telescopes. But in the field of biomedical research, too, there has been a marked shift towards group work, and even other academic fields have not been unaffected by this trend.

This situation, in which work is done on a co-operative basis, must naturally be reflected in the participation of those concerned in the organisation of a research institute. Effective participation of the scientific and technical collaborators in the decision-making processes – on the basis of information exchange, joint consultation on the aims to be achieved, the methods to be adopted and the actual execution of research projects – is the logical and natural consequence of this development. The resulting enhanced sense of joint responsibility and of identification with the work and its successful outcome is an important aspect of this participation that is certainly not confined exclusively to the realms of research. This form of effective participation, which aims at a consensus of co-workers and leading scientists, is certainly the appropriate form of consultation in this particular field.

The view also seems to be gaining ground that adoption of the procedures of parliamentary democracy is not necessarily the soundest solution in all areas. At university level, at any rate, experience has shown that application of the parity principle, which leads to the creation of group interests and the establishment of factions, is not the one and only way of reconciling different viewpoints.

The real issue in this connection is not that of mutual consultation but rather that of the role of the individual within a group-structured research unit. It is the question of the dividing line between the individual and the collective effort in modern scientific research. In the interests of research development it is important to acknowledge the existing situation and to organise the structure accordingly, recognising that the team – often composed on an inter-disciplinary basis – is today the predominant form in science. The corresponding organisational and structural framework must be identified and tested.

But in the process it must not be forgotten that even under the group work system the original idea produced by the individual will always be a factor of great weight in ensuring the progress of research, and that the decisive breakthroughs will – notwithstanding all necessary 'embedding' of the individual in the scientific environment – be reserved to the few. □

Prof. Reimar Lüst is currently President of Max-Planck-Gesellschaft, the organisation with which he began his distinguished scientific career in 1950, as a Fellow and Assistant at Max-Planck-Institut für Physik, Göttingen. During the late fifties and early sixties, he worked almost exclusively in the United States, first at the universities of Princeton and New York, and later at MIT and CalTech.

In 1963 he was appointed Director of the Max-Planck-Institut für Extraterrestrische Physik, Garching, a post which he held until his appointment as President of Max-Planck-Gesellschaft in 1972. From 1969 to 1972, he was Chairman of the German Science Council.

Prof. Lüst's links with the ESA date back to the organisation's early days when he was its Scientific Director. He was subsequently elected Vice President of the ESRO Council from 1968 to 1970.

The Success of ESA's Eight Scientific Satellites

D. E. Page, Head of Space Science Department, ESTEC

Before the launch of COS-B in August 1975, ESA (then ESRO) had flown seven very successful scientific satellites – and COS-B looks like being yet another success (see p. 19). Of the 51 experiments so far flown, none has experienced catastrophic technical failure and the vast majority have achieved the expected scientific return. Some have far exceeded expectation and it is mainly these on which we concentrate here. More detailed descriptions of the scientific results appear each year in the ESA's report to COSPAR, the 1975 version of which lists 385 papers demonstrating the achievements of those scientists involved in the ESA satellite programme.

It must be emphasised that what we talk about here is a rather arbitrary selection, and each experimenter who has worked hard for near to ten years to get his experiment accepted, constructed, calibrated, flown and the data painstakingly analysed, will no doubt feel that we have done him an injustice.

A particularly gratifying aspect of the programme has been the excellent co-operation not only between experimenters on a particular satellite but also between those on different satellite missions. Co-operation with United States and USSR scientists has also been rather fruitful. The willingness of most experimenters to make their data available world-wide when requested has been greatly appreciated; the magnetometer experimenter on HEOS-1 and HEOS-2 merits special mention in this context.

The results achieved by the seven scientific satellites that have preceded COS-B will be described under the headings 'Sun-Earth Relationships' and 'Astrophysics'.

SUN-EARTH RELATIONSHIPS

While the study of distant exotic astrophysical objects is very exciting, the investigation of Sun-Earth relationships is in a way more compelling because of the immediately observable response of the Earth's environment to changes on the Sun. This is particularly true in northern Europe when, for example, the auroral lights in the sky every night oblige the observer to wonder what gives rise to such a dynamic multi-colour display. It is hardly surprising then that ESA's first seven satellites have carried a large number of experiments to study the Earth's magnetic surroundings and their response to changes on the Sun and in the interplanetary medium between Sun and Earth.

	Launch date	End of useful life	Mission
ESRO-II	May 1968	May 1971	Cosmic rays, solar X-rays.
ESRO-IA	October 1968	June 1970	Auroral and polar cap phenomena, ionosphere.
ESRO-IB	October 1969	November 1969	As ESRO-IA.
HEOS-1	December 1968	–	Solar wind, interplanetary magnetic field, bow shock.
HEOS-2	January 1972	August 1974	Polar magnetosphere, neutral point, interplanetary medium.
TD-1	March 1972	May 1974	Astronomy (UV, X- and γ-ray).
ESRO-IV	November 1972	April 1974	Neutral atmosphere, ionosphere, auroral particles.

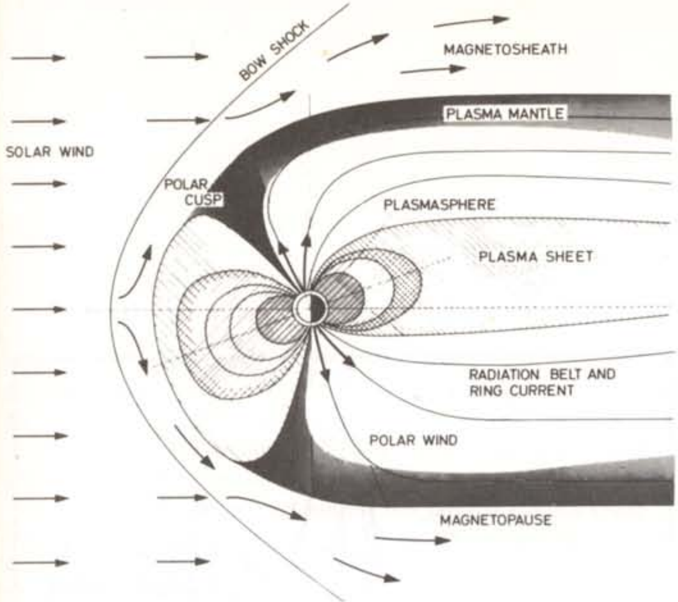


Figure 1 — Noon/midnight cross-section through the magnetospheric plasma distribution. Note the plasma mantle discovered by HEOS-2.

Less than 20 years ago, we believed that the Earth was surrounded by a dipole magnetic field which gradually weakened uniformly in all directions away from the Earth into the vacuum of space. Spacecraft measurements have shown, however, that the Sun continuously blows out a stream of plasma (the solar wind) at speeds around 400 km/s, and this plasma squeezes the Earth's field into a shape something like that shown in Figure 1. There is a continuous struggle for supremacy between the wind, which may briefly reach speeds as high as 1500 km/s, and the magnetic field. The region close to the Earth where the magnetic field remains in control is called the 'magnetosphere', and its boundary with the solar wind is the 'magnetopause'. When the Sun produces a strong gust in the wind the resulting change in the shape of the magnetosphere manifests itself on the Earth as auroral lights, as disturbances in radio communication, and as magnetic-field changes, which can on occasions be large enough to trigger safety devices in national electricity grids. There is too a growing suspicion that the Sun exerts a very direct control on the Earth's weather patterns, and through these on drought patterns and even economic conditions (see Dr. King's article on p. 24).

Although many satellites have been flown through the magnetosphere in recent years, and these have allowed us to construct the broad picture, new features are still appearing and the physical mechanisms producing the picture are very poorly understood. For example, we are still not even sure where the very high energy particle belts — discovered by Van Allen in the very first satellites — get their enormous energy in the first place. Much remains to be learned in the vast plasma laboratory accessible to us in the Earth's surroundings. This information can then be used in, for example, understanding the processes underway in inaccessible stars and in increasing our knowledge of the containment of plasmas by magnetic fields. It is our inability to contain plasmas in the laboratory that has prevented commercial exploitation of the enormous energy available in the nuclear fusion process.

Indeed our understanding of the magnetosphere and the Sun is probably very similar to Columbus's understanding of the Atlantic Ocean and America after his historic voyage. He could not possibly have managed to understand, for example, the Gulf Stream, which is now known to be responsible for the even and temperate climate of Western Europe. The velocity of his ship and local disturbances in the water would have made it impossible for him to measure the stream flow by putting his hand in the water! Only by patient observation over many voyages and from the drift of 'bottles with messages' did the true picture finally emerge. Plasma scientists and geophysicists look forward eagerly to experiments equivalent to the dropping of labelled bottles into the dynamic magnetosphere, by perhaps Spacelab, and careful monitoring by multispacecraft configurations in order to help resolve the flow patterns that exist there.

A few of the main 'Sun-Earth' results obtained by experiments flown on the ESRO-II, ESRO-I, HEOS-1 and 2 and ESRO-IV spacecraft are described below.

The Auroral Zone and The Polar Cap

The auroral zone occupies a band of latitudes between about 65° and 70° and extends all the way around the Earth in longitude. Poleward of the auroral zone is the region generally called the polar cap, and equatorward are the stably trapped Van Allen belts of high-energy particles. Reference to Figure 1 shows that the Van Allen belts are located in the dipole field of the Earth, while the polar cap is magnetically connected to the magnetotail, which has been dragged out by the solar wind. Thus, the auroral zone in fact marks the boundary of the region where the solar-wind influence almost ends and the dipole field takes control. It is scarcely surprising then that when the Sun gives an extra push, its effects show up most vividly in the auroral zone. Figure 2 shows the position of the poleward boundary of the Van Allen belts as observed by ESRO-I experiments on 3504 passes through the auroral zone, and this of course represents the zone's low-latitude boundary. The asymmetry between the morning and afternoon hours is attributed to an electric field across the magnetosphere from dawn to dusk. One of the interests of auroral physicists has been to establish which energetic particles entering the auroral zone are responsible for producing the light there. Figure 3 shows that one of the main auroral light features is in fact produced by electrons in a fairly narrow energy band around 10 keV.

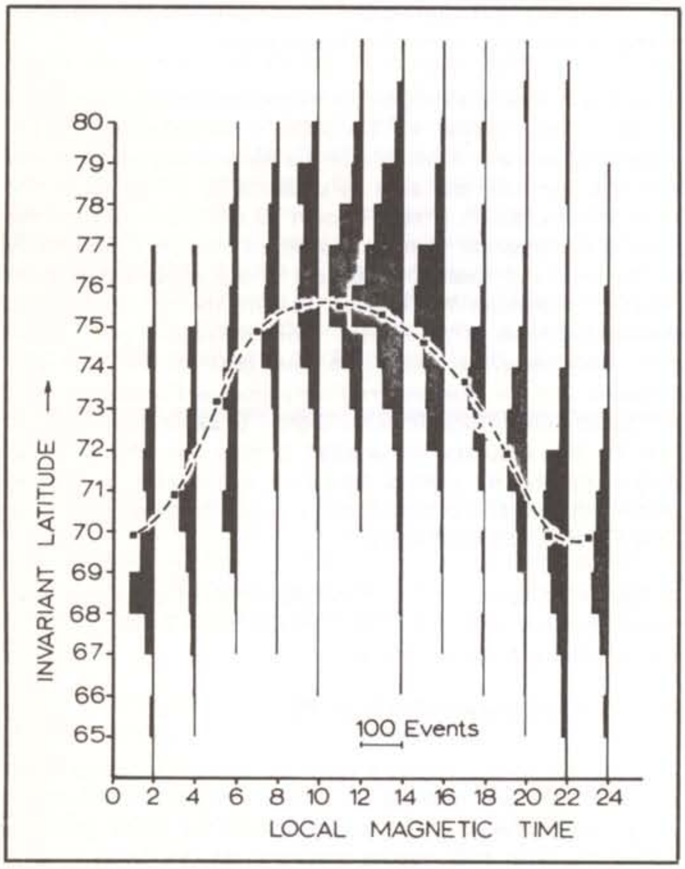


Figure 2 — Diurnal variation of the poleward boundary of the radiation belt for 40 keV electrons.

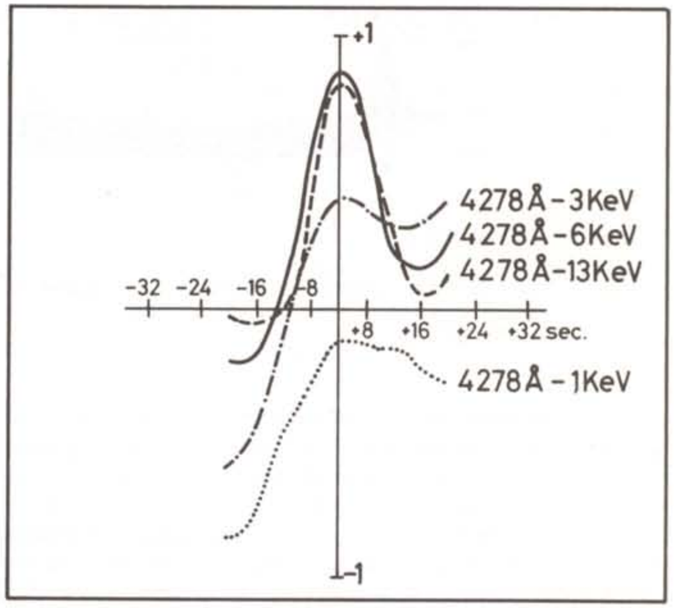


Figure 3 — A typical example of the cross correlation between the auroral emission at 4278 Å and different channels of precipitated electrons.

In the years just preceding spacecraft flights, it was suspected that solar particles of some sort arrived over the polar cap. Their arrival in discrete regions was mapped by the effects they produced on the local ionosphere. Some of the strange arrival patterns were understood better when the magnetic divide between the dipole field and the magnetotail was discovered. However, major advances were made by the combined efforts of experimenters on HEOS-1, ESRO-II and ESRO-I. HEOS-1 was able to measure the solar particles in interplanetary space directly and to see in what strength and from which directions they arrived. ESRO-II and ESRO-I passing over the polar cap close to the Earth were able to measure directly when and how these same particles arrived over the polar caps. Detailed computer calculations were made to plot the particle travel routes from their arrival just outside the magnetosphere until their appearance at the polar cap close to the Earth. Calculation and theory have fitted beautifully and, at least for the higher energies, the means by which solar particles reach the Earth now appear to be well understood.

Magnetospheric Structure

Theory predicts that, in the region where the dipole field ends and the polar magnetotail field begins, there exists a 'neutral point'. At this location the magnetic field becomes zero and charged particles therefore pass without hindrance. The HEOS-2 satellite, which operated flawlessly between January 1972 and August 1974, was the first deliberately flown to pass through the neutral-point region and the magnetospheric regions directly above the Earth's north pole. It has obtained several new and exciting results.

One of these is that the region of near-zero magnetic field indeed exists and is funnel-shaped. As such, it is probably more adequately described as a neutral 'point' than as a neutral cusp region extending round the Earth from noon through a broad range of local times.

An entirely new region not predicted by theoreticians has been discovered by the sophisticated plasma experiment on HEOS-2. This region (Fig. 1) has been called the 'plasma mantle' because of the way it drapes around the outer regions of the polar magnetosphere. It was previously believed that plasma did not penetrate the magnetopause – at least in any ordered sort of way – but within the plasma mantle there is always seen a distinct plasma flow at velocities around 100 km/s and in a direction down the magnetotail away from the Earth. The mantle can extend into the magnetotail for several Earth radii from the magnetopause, and this thickness varies with conditions in interplanetary space.

At the magnetopause, which is the outer boundary of the plasma mantle, another HEOS-2 experiment has found that a layer of high-energy electrons is always present and becomes very intense when geomagnetic activity is high. Again this did not appear in the theories previously developed. So far, we are unable to say whether the electrons are on their way out of the Van Allen belts, or whether they are being accelerated just where we find them.

The discovery of these two previously unsuspected regions and associated phenomena indicates that quite a few surprises may remain before the dynamics of the magnetosphere are properly observed, let alone explained.

The Interplanetary Medium

The experiments of HEOS-1 and HEOS-2 have made major contributions to the study of the interplanetary medium – that region filled by the solar wind and the Sun's magnetic field carried along with it. Typically, near the Earth the interplanetary magnetic field is seen to point toward the Earth for about seven days, and then to reverse and point toward the Sun for the next seven days. This 'sector structure' of the field, with about four sectors appearing in each solar rotation of 28 days, is somewhat of a mystery, which may be difficult to unravel before we can make measurements beyond the ecliptic plane, from which the Earth never departs by more than 7°. The magnetometer on HEOS-1 has operated perfectly for almost seven years and this stretch of continuous data, combined with similar excellent data from HEOS-2, has provided a wonderful opportunity to study how the interplanetary field evolves over the solar cycle. The data have been placed in the World Data Centers and are being used worldwide to support a great many studies in several scientific disciplines.

One of the most interesting results here is connection with the modulation of the cosmic radiation over the solar cycle. At sunspot maximum, the radiation able to penetrate to near the Earth is very significantly less than that which arrives at sunspot minimum. It was first thought that this could be explained by changes in the solar wind and interplanetary field, which at solar maximum provided a stronger obstruction to the arriving radiation. However, the HEOS data have shown that the changes in magnetic field and solar wind observed in the ecliptic plane near the Earth are far from sufficient to explain the observed variation in cosmic radiation. We are obliged to conclude that most of the important changes take place far out of the ecliptic.

We might have been tempted, particularly on the cosmic-ray evidence, to believe that the solar wind blew harder at solar maximum and that the magnetosphere would then be pushed closer to the Earth. This in fact is not so, as HEOS-1 discovered. Although the wind blows faster, the number of charged particles in it is lower, so that the squeeze it can exert on the Earth's field is actually reduced. We cannot be sure that the result can be generally applied to the solar wind as a whole. It may simply be that at solar maximum the main solar activity was at solar latitudes that were not well connected to the Earth. Again, to find out what is really going on, we need to study how the solar wind changes with solar latitude, and this can be done only when a spacecraft eventually travels out of the ecliptic plane.

The Sun sometimes emits very high energy particles, which can on occasions reach the Earth within a few minutes. However, the travel time to the Earth varies tremendously from event to event, and we find it difficult to sort out whether the differences are due to differing starting conditions at the Sun, or whether the particle travel routes through interplanetary space vary sufficiently to explain the observations. Study of the combined data from the high-energy solar particle experiment, the magnetometer and the solar plasma experiment on HEOS-2 has provided significant further understanding of the particle transport in the interplanetary medium. It has been found that when the solar wind blows three-dimensional snake-like 'tubes' in interplanetary space, the solar particles follow these obediently and show great reluctance to pass from one tube to its neighbours. The tubes may get entwined in such a way that the Earth sees the particles very late after the solar event, or not at all.

The Earth's Atmosphere

The ESRO-IV experiments rescued from the ill-fated TD-2 satellite proposal have combined in an excellent way to produce some outstanding results at this stage. Data analysis, which still has a long way to go, has been greatly facilitated by the faultless performance of the tape recorder during the 17-month satellite lifetime. This is the first occasion on which an instrument measuring the neutral atmosphere has enjoyed a completely successful flight and the intimate relationships between the neutral atmosphere and the ionosphere (charged atmosphere) have been remarkably demonstrated. A world map of neutral gas densities above 250 km – the first of its kind – is being prepared. Until now, we have had to rely on models of the atmosphere guessed at from, for example, the drag exerted on spacecraft.

Taking one result as an example, the ionosphere has been probed for many years by radio waves sent up from the Earth. Above some critical frequency, the waves penetrate right through the ionospheric layers and this critical frequency has been taken as a measure of the amount of ionisation present. Surprisingly, the correlation between ionospheric 'storms' and magnetic storms has not been very good. The ESRO-IV neutral mass spectrometer has found that the ratio of neutral oxygen to nitrogen (O/N_2) provides a very good measure of neutral atmospheric heating (atmospheric storm effects). A very close correlation has been found between the O/N_2 ratio and the critical radio frequency required to penetrate the F_2 layer in the ionosphere (Fig. 4). This is just one of the many results showing how the neutral and charged atmospheres are closely related.

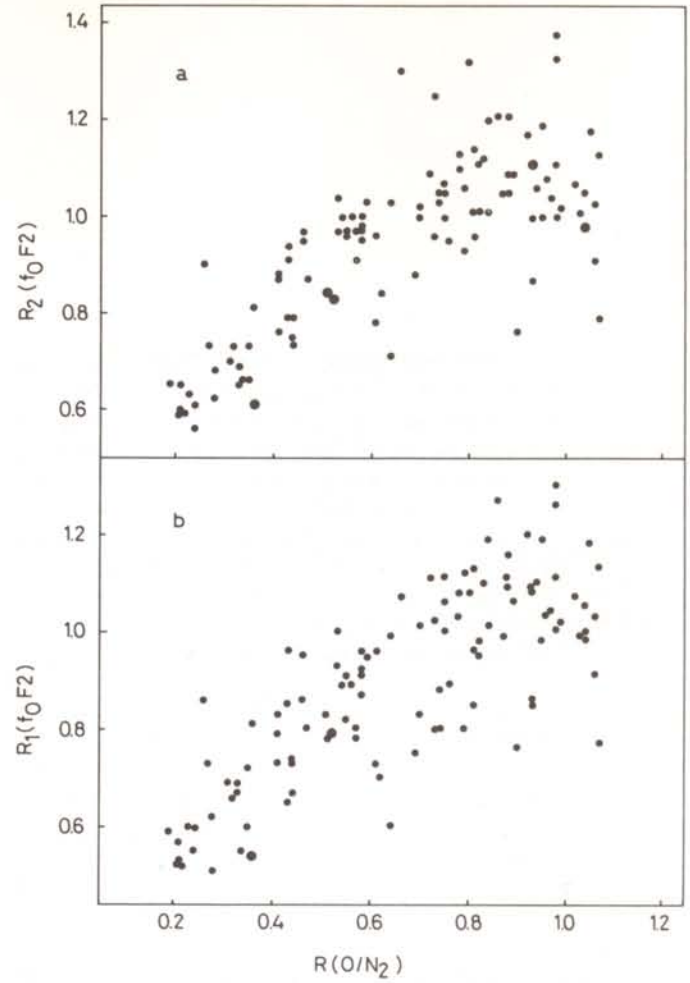


Figure 4 – Correlation between changes in the critical frequency of the F_2 layer (f_0 F_2) and in the O/N_2 ratio: (a) R_2 (f_0 F_2) versus R (O/N_2) and (b) R_1 (f_0 F_2) versus R (O/N_2).

ASTROPHYSICS

During the past ten years, dramatic advances have been made in the field of astrophysics. The first of these appeared through the techniques of ground-based radio astronomy. In this area we think primarily of quasars – radio stars with spectra shifted so far toward longer (red) wavelengths that they appear to be leaving us at very high velocities – and pulsars – stars whose radiation arrives with an almost eerily regular periodicity. Over the centuries, astronomy has been carried out essentially only in the visible part of the electromagnetic radiation spectrum. This is a relatively narrow band of wavelength to which the human eye is sensitive. In the early part of this century, it became clear that the study of the spectra produced by radiating or absorbing material was a powerful means of identifying the atoms or molecules present in that material, their degree of agitation and their velocity. But in order to study wavelengths outside the visible, where much interesting information was thought to be hidden, two problems had to be overcome. Detectors sensitive to the particular wavelength had to be developed, and in some cases the detectors needed to be carried above the Earth's atmosphere because this was a powerful absorber of the particular radiation.

Fortunately, measurements at radio wavelengths were little affected by the Earth's atmosphere and sophisticated ground-based apparatus could be constructed enabling sources in the sky to be pinpointed and studied with high accuracy. This led to the discovery of quasars and pulsars already mentioned. The next dramatic steps came with the study of X-ray sources from the NASA satellite Uhuru, orbiting clear of the Earth's atmosphere in 1971. This satellite found the X-ray binary stars which eclipse each other as they rotate and behave in such a way that astrophysicists think that one of the pair of stars may in some cases be a 'black hole'. A black hole is the ultimate end of a star that has squeezed itself under its own gravity to a size where its internal gravity pull is so strong that even light is incapable of escaping.

ESA has plans to continue these exciting X-ray studies by pinpointing the locations of sources with its Exosat satellite. However, its main contribution to astrophysics so far has been the highly successful TD-1 satellite launched in 1972. (It did,

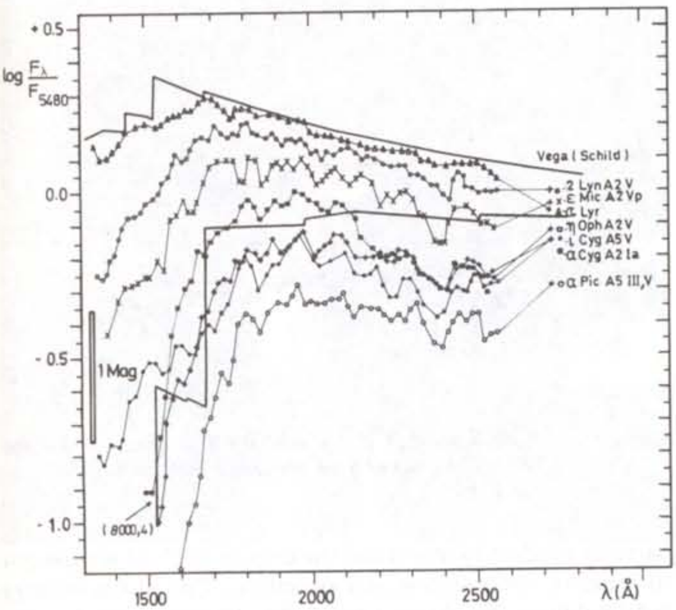


Figure 5 — Absolute energy distribution for some A2 and A5 stars compared with Vega and predicted flux from two theoretical model atmospheres.

however, with the very first satellite ESRO-II successfully fly an experiment to study the galactic magnetic field and the acceleration processes taking place there.) The main experiments of TD studied the sky in the ultraviolet (UV) region (just beyond the blue, short-wavelength, end of the visible spectrum) where it was thought some of the most interesting processes in stellar atmospheres would produce signatures. Hot atoms in the star might produce bright spectral lines in patterns which would permit those atoms to be identified. On the other hand, colder atoms higher up in the stellar atmosphere could absorb precisely those wavelengths and give rise to a recognisable pattern of dark bands in the spectrum. The study of these would enable astronomers to identify the composition of stars and their surroundings.

It is perhaps worth explaining further two very important pieces of information which can be extracted from the study of spectra. Each atom, when caused to radiate, produces a spectral pattern which is characteristic of that atom. If the atom is moving in an agitated way while it is emitting, the spectral lines in the pattern become broadened and fuzzy. The degree of broadening is a measure of the degree of agitation or 'temperature' of the atom. If the atom is moving, not back and forth, but with a constant velocity toward or away from the observer of the radiation emitted, then the spectral lines in the pattern remain sharp but they are all shifted by a fixed amount relative to the positions they would have taken up had the atom been at rest. If the atom is moving toward the observer as it emits, the radiation appears to be shifted to shorter (bluer) wavelengths and the amount of shift is a direct measure of the velocity of the atom. If, on the other hand, the atom is moving away, then the radiation appears to be shifted toward longer (red) wavelengths. It is this 'red shift' which has led astrophysicists to believe that the Universe is expanding away from us at high speed. (Indeed, the red shift is absolutely fundamental in the cosmological studies of the Universe, in which these shifts of wavelength are often referred to as Doppler shifts.)

Now, one of the TD experiments provided by British and Belgian scientists set out to survey the whole sky as seen through 'wide-open' ultraviolet eyes. Much of traditional optical astronomy has been based on the statistical classification of stars into groups or families according to their brightness and spectral type (e.g. the Hertzsprung-Russell classification) and one obvious aim was to find whether the ideas thus built up survived when extended to other regions of the spectrum. The experiment has been an outstanding success, exceeding the expectations of its builders, in spite of some initial worries. One of these was the failure of TD's tape recorders. This was overcome by the real-time ground station network set up world-wide to such good effect that 95% of the sky has been surveyed. The other big worry was that the experiment was to examine very faint stars against a fully sunlit background. The Sun baffle worked so well that stars down to a magnitude of 10.5 were measured – compared with a design aim of the 9th magnitude.

At this time, 15 000 stars have been examined and a large community of guest observers has been involved in the studies. A Bright Star (ultraviolet) Catalogue will be published by ESA in the near future, and a faint star catalogue is being planned. These will be of very significant value to the world astronomical community.

A hot, perfectly emitting body emits radiation over a wide wavelength region spread on both sides of a 'most popular' wavelength which is characteristic of the temperature of the body; the hotter the body, the shorter (bluer) the position of the most popular wavelength. Thus by plotting the flux radiated by a star at various wavelengths it is possible to allocate a spectral type and hence a temperature to that star. (These types were historically, for no very good reason, assigned the labels – from hot to cold – O, B, A, F, G, K, M.

Only astronomers can remember this, and ordinary physicists have to remember *'Oh Be A Fine Girl Kiss Me'.*) It was found by statistical analysis that the plotting of star brightness against O, B, A . . . etc. spectral type placed most stars on a particular curve. The curve is referred to as the Main Sequence, and the plot is called the Hertzsprung-Russel diagram. This relationship is used in a rather basic way in, for example, determining the distance to a star. It ought therefore to be valid at all wavelengths. The UV experimenters on TD-1 have made a special study of stars of spectral type A (as defined from visible observations) and have found that the UV fluxes differ enormously from star to star (Fig. 5). In other words, these stars do not lie tidily on any part of Main Sequence. This is an interesting result and tempts the nonprofessional astronomer to wonder whether our ideas might not be different had our eyes been tuned to accept a different wavelength range.

It is widely accepted, because of red-shift observations, that the Universe is expanding and that the most distant parts are expanding fastest. There are two main competing theories of what is happening. The 'big bang' theory postulates that it all started from an initial central explosion; the 'steady state' theory supporters suggest that matter is being created continuously to maintain the uniform Universe during expansion. A consequence of the steady-state theory is that the density of stars should not really depend on distance from us. Radio observations indicate that this is not so. The UV observations of TD indicate that the number of relatively very bright UV objects is significantly greater than expected on the basis of earlier visible measurements. This again seems a highly significant result.

A complication that arises in studying radiation arriving from distant stars is the understanding of what happens to that radiation en route. Astronomers refer to the degradation of the radiation on its travels to us as 'interstellar extinction'. One might reasonably have expected the amount of interstellar extinction suffered to depend on the position of the star on the celestial sphere. Another surprising TD result is that the amount of extinction seems to vary very little indeed with different viewing directions in the Galaxy.

A second highly sophisticated ultraviolet experiment on TD was provided by Dutch astronomers. This experiment locked on selected stars and steered itself so precisely that it was possible to measure lines in stellar spectra with resolution close to 1 Å (= 10^{-8} cm). While the British/Belgian experiment concentrated mainly on statistical studies of the whole sky, the Dutch experiment examined individual stars in great detail by the methods described earlier (identification of spectral

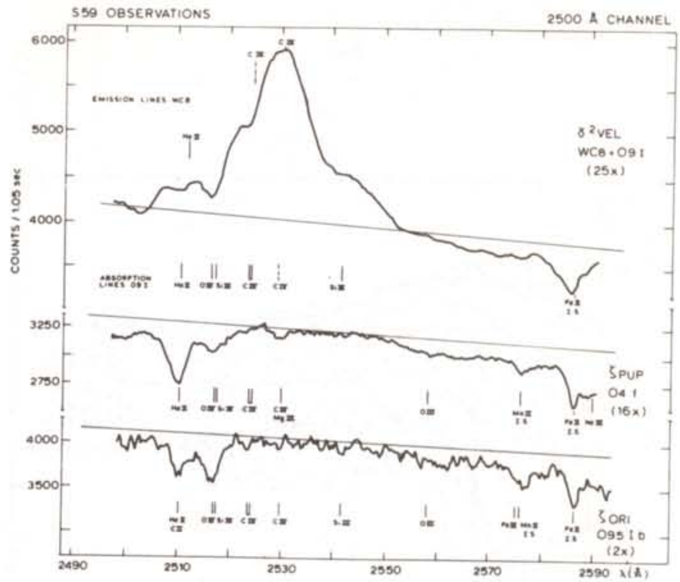


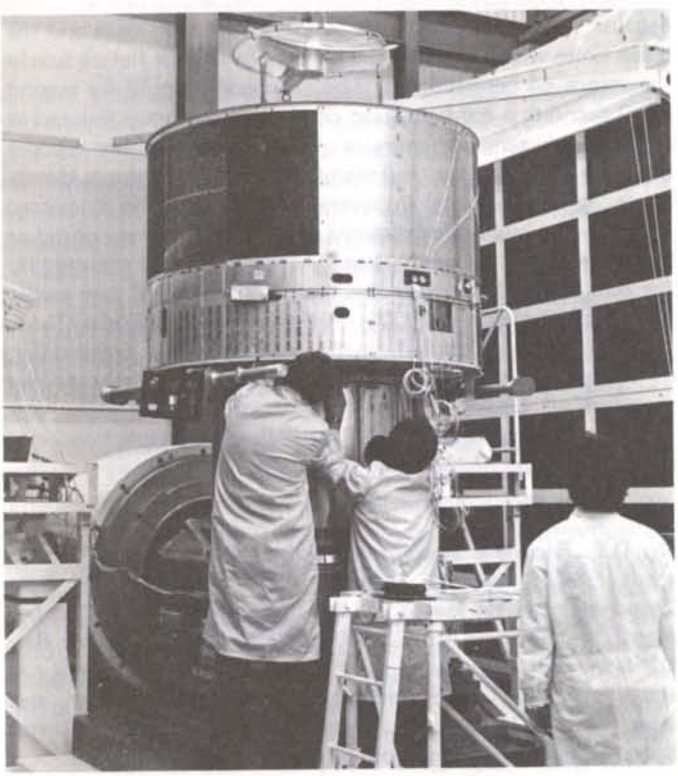
Figure 6 — The spectrum of γ^2 Vel (WC 8 + O9), as observed in the 2500 Å channel of S 59, compared with the spectra ζ Pup and ζ Ori.

patterns to identify atoms and the Doppler shift of wavelength to measure temperatures and velocities). One of the features outstanding in the observations is the strength of the spectral (absorption) lines of doubly ionised magnesium. Detailed study of the broadening and the shift of these lines has yielded a wealth of information on the stellar atmospheres. For example one star, called α Cygni, has been found to be losing mass at a very significant rate, i.e. its atmosphere was seen moving away from it. In γ^2 Velorum, a spectroscopic binary consisting of stars classified as O9 and WC8, the O-type star was found to be well described by existing models of stellar atmospheres (built up largely on visible spectral data), but the UV flux from the WC member of the pair was much higher than expected (Fig. 6). This has been explained as being due to a higher than expected amount of helium in its atmosphere.

Two further TD experiments produced results of significant astrophysical interest. One observed the abundance of cosmic-ray nucleii. The relative abundances of these particles tell the experimenters how long they have existed and the regions through which they have travelled on their way to the Earth. The second observed solar X-ray bursts with a time resolution of just greater than 1 s. This enabled the experimenters to discover that an X-ray event on the Sun was made up not of one large initial burst which then gradually decayed, but of a series of largely unrelated short-lived bursts. This result indicates that the particles producing X-rays in the solar atmosphere are not all injected then at the same time. The Sun is our nearest star and detailed results like this, which we cannot hope to obtain from distant stars, will help piece together the picture of how stars in general behave.

Launch of COS-B on 9 August 1975

GEOS vibration tests



THE EIGHTH SUCCESS AND MORE SPACECRAFT UNDER CONSTRUCTION

Scientists have just begun to study the early results from the COS-B satellite launched on 9 August 1975 and it would seem that both spacecraft and experiment are operating perfectly. Indeed gamma and X-rays have been measured arriving from known source positions in the sky and the spacecraft has just embarked on its exploration of the relatively unknown regions of space.

The position of gamma-ray sources is measured in order to investigate where the cosmic radiation originates and a study of the gamma energy spectrum helps decide which processes take place in the production region and en route to the Earth. Clearly the experimenters will want to look hard at those regions where pulsars have been seen at X-ray wavelengths. They will also be watching closely for those unexplained dramatic and apparently random gamma-ray bursts detected by American satellites in the past few years.

A problem in trying to measure gamma rays from a satellite is that there exists in space a high background of charged particles. Gamma-ray detectors insist on recording these unwanted particles as well as genuine gamma rays, but COS-B scientists and engineers seem to have found a way of reducing the background counts to a level where we can confidently expect to make the measurements hoped for.

GEOS

GEOS is a sophisticated and ambitious satellite which will carry seven experiments into a geostationary orbit during 1977. It will be the first purely scientific geostationary satellite and as such has been adopted as the 'reference' spacecraft for the International Magnetospheric Study (IMS). The IMS is a world-wide programme combining spacecraft, balloons, sounding rockets and ground-based observatories in an attack on the basic problems of magnetospheric physics. GEOS, with its experiments measuring electric and magnetic fields, plasmas and high-energy charged particles, will be shifted in longitude from time to time so that special studies can be made in co-operation with suitably located scientific ground stations in Iceland, Northern Europe and perhaps Antarctica.

ISEE

One particular difficulty encountered in studying magnetospheric and interplanetary phenomena has been the sorting out of space and time variations. When, for example, a single spacecraft encounters a bunch of particles it is frequently impossible to say whether the bunch is a relatively fixed feature in space or whether it is purely transient. Again when a single spacecraft encounters a wave, the measured wavelength may be severely distorted from the true one by the relative motion of spacecraft and wave. ESA and NASA have decided to attack this problem by flying a pair of satellites together in an eccentric orbit which cuts through the magnetosphere in different positions as the seasons vary. This Mother-Daughter tandem arrangement due for launch in late 1977 should help the scientists decide on the absolute magnitude of phenomena encountered and whether or not these are merely transient. In order to measure simultaneously the interplanetary conditions and features which give rise to those magnetospheric phenomena seen by the Mother-Daughter pair, a third spacecraft will be placed between the Sun and the Earth at 235 R_E (Earth radii) from the Earth, at that position where the gravitational pulls of the Sun and the Earth cancel each other. This Heliocentric spacecraft should at that distance see the interplanetary medium entirely free from disturbances injected by the Earth and its immediate surroundings. ESA is building the Daughter satellite, while NASA is responsible for the Mother and the Heliocentric. Both US and European experiments appear on all three spacecraft of the International Sun-Earth Explorer (ISEE) project.

IUE

The International Ultraviolet Explorer (IUE) is a joint NASA, United Kingdom and ESA venture. The scientific aims are to study high-resolution spectra of stars of all spectral types, to study the gas streams in and around some binary star systems, to examine with lower resolution spectra of faint stars, galaxies and quasars, to make repeated observations of objects known to show features which vary with time, and to define more precisely the way in which starlight is modified by interstellar dust and gas.

This IUE space observatory will have, by virtue of its geosynchronous position, a big advantage over previous astronomical satellites in lower orbits. Complicated operational procedures can be avoided. With the spacecraft sending back pictures continuously to a single ground station, it will be possible for astronomers to work with a flexibility close to that possible in traditional ground observatories. IUE should provide a logical continuation of the highly successful ultraviolet experiments flown on the TD-1 satellite and as such its flight is eagerly anticipated by a scientific community far wider than those astronomers actively engaged in producing the spacecraft hardware. Launch is now hoped for in late 1977.

EXOSAT

It is easy to describe this spacecraft mission in a dramatic way because it aims to probe the secrets of neutron stars and the black holes which exist on the borders of science fiction and in the minds of cosmologists. The spacecraft should fly around 1980 carrying a configuration of X-ray detectors – tailored to cover a wide range of energies – into an orbit with an apogee of some 200 000 km and visible from the Northern Hemisphere. It will operate in several modes, studying a selected X-ray source by looking directly at it through its own optics or by examining it in great structural detail as it is occulted by the disc of the Moon (for this reason, the satellite was earlier known by the name HELOS – Highly Eccentric Lunar Occultation Satellite). Detailed spectral and positional examination of X-ray sources will yield information particularly on the structure of binary stellar systems within which many cosmologists believe one of the stars to be a black hole. Not unnaturally, the flight is eagerly awaited. □

Dr. D.E. Page was appointed Head of Space Science Department, ESTEC, as from 1 August 1975, succeeding Dr. E.A. Trendelenburg. He joined ESLAB (later Space Science Department) in 1965 and from 1968 was Head of the Cosmic Ray Division. Before joining ESRO, he worked on cosmic-ray showers at the Dublin Institute for Advanced Studies, and later for the UK Science Research Council at the Radio and Space Research Station, Slough.

COSPAR

Prof. C. de Jager, President of COSPAR/Président du COSPAR

Professor de Jager has held the Chair in General Astrophysics at the University of Utrecht (Netherlands) since 1960, and since 1963 has also been Director of the Astronomical Institute at Utrecht. A former General Secretary of the International Astronomical Union, he is currently a Member of the Executive Board of the International Council of Scientific Unions and President of COSPAR. Until earlier this year, he had for some years been Chairman of the Astrophysics Working Group of ESA's Launching Programmes Advisory Committee.

Le Professeur de Jager est depuis 1960 titulaire de la chaire d'astrophysique générale à l'Université d'Utrecht (Pays-Bas) et est en outre depuis 1963 Directeur de l'Instituut d'astronomie d'Utrecht. Ancien secrétaire général de l'Union astronomique internationale, il est actuellement membre du Bureau exécutif du Conseil international des Unions scientifiques et président du COSPAR. Il présidait jusqu'à ces derniers mois, et depuis plusieurs années, le groupe de travail 'Astrophysique' du Comité consultatif des programmes de lancement de l'ASE.

At the International Geophysical Year (IGY) Rockets and Satellites Conference in Washington in October 1957, a resolution was passed which drew attention to the importance of continued research following the IGY, utilising instrumented rockets and Earth satellites, and it was recommended that the International Scientific Unions and the International Council of Scientific Unions (ICSU) develop suitable means for continuing this work. Following up the final recommendation of the Fifth Assembly of the IGY Committee, held in Moscow in August 1958, the ICSU, at its General Assembly of October 1958, set up the Committee on Space Research (COSPAR).

The purpose of COSPAR, under its Charter approved by the ICSU in 1959, is to further, on an international scale, the progress of all kinds of scientific investigations which are carried out with the use of rockets or rocket-propelled vehicles. COSPAR is concerned with fundamental research and it will not normally concern itself with technological problems such as propulsion, construction of rockets, guidance and control. COSPAR's objectives are achieved through the maximum development of space research programmes by the international community of scientists working through the ICSU and its adhering Unions and National Academies. For this reason, COSPAR also maintains a close relationship with a

La Conférence sur les fusées et satellites qui s'est tenue à Washington en octobre 1957 dans le cadre de l'Année géophysique internationale (IGY) a adopté une résolution soulignant l'importance de poursuivre, après l'Année géophysique internationale, les recherches à l'aide de fusées et de satellites terrestres équipés d'instruments et recommandant que les Unions scientifiques internationales et le Conseil international des Unions scientifiques (CIUS) créent les moyens nécessaires à cette fin. Donnant suite à la recommandation finale de la Cinquième Assemblée du Comité IGY, qui s'est tenue à Moscou au mois d'août 1958, le CIUS, à son assemblée générale d'octobre 1958, a créé le Comité mondial de la Recherche spatiale (COSPAR).

Aux termes de sa charte, approuvée par le CIUS en 1959, le COSPAR a pour objet de promouvoir, sur le plan international, le progrès des recherches scientifiques de toutes sortes qui mettent en oeuvre l'emploi des fusées et des engins propulsés par fusée. Le COSPAR s'occupe de recherches fondamentales. Il ne se préoccupe pas normalement de problèmes technologiques tels que la propulsion, la construction des fusées, leur guidage et leur contrôle. Les objectifs du COSPAR sont atteints en faisant développer au maximum les programmes de recherches spatiales par la communauté internationale des savants qui travaillent au sein du CIUS et dans les académies nationales et unions internationles qui en font partie. C'est pourquoi le COSPAR entretient également d'étroites relations avec un certain nombre d'organisations et d'agences intergouvernementales engagées dans les activités spatiales. Le COSPAR a le statut d'organe consultatif au Comité des utilisations pacifiques de l'espace extra-atmosphérique des Nations Unies. Aux termes de sa charte:

'Conscient du besoin d'examiner et de réglementer certains aspects des programmes relatifs aux satellites et aux sondes spatiales, le COSPAR se tiendra au courant des activités des Nations Unies ou d'autres activités internationales dans ce domaine, afin de s'assurer que la recherche internationale concernant les sciences de l'espace bénéficie au maximum de cette réglementation, et pour pouvoir faire toutes recommandations utiles sur les questions de planification et de réglementation qui contribueraient à réaliser le programme optimum de recherche scientifique'.

Reflétant le caractère mixte de la composition du CIUS lui-même, le COSPAR est constitué pour partie de représentants d'académies scientifiques nationales (ou instituts équivalents) et pour partie de représentants des unions scientifiques internationales. Douze unions scientifiques internationales et trente-quatre académies nationales (ou organismes équivalents) font actuellement partie du COSPAR.

number of intergovernmental organisations and agencies involved in space activities. COSPAR has consultative status in the United Nations Committee on the Peaceful Uses of Outer Space; in the words of the COSPAR Charter:
'Recognising the need for international regulation and discussion of certain aspects of satellite and space probe programmes, COSPAR shall keep itself informed of United Nations or other international activities in this field, to assure that maximum advantage is accorded international space science research through such regulations and to make recommendations relative to matters of planning and regulation that may effect the optimum programme of scientific research'.

Reflecting the dual nature of the membership of the ICSU itself, COSPAR is composed partly of representatives of National Academies of Sciences (or equivalent institutions) and partly of representatives of the International Scientific Unions. At the present time, 12 International Scientific Unions and 34 National Academies (or their equivalents) participate in COSPAR.

In accordance with the COSPAR Charter, the Executive Council of COSPAR is responsible for the formulation of the scientific policy and programmes. This Executive Council consists of the President, the two Vice-Presidents, and four other elected members (together forming the Bureau of the Executive Council), and of all the representatives of the Scientific Unions. The Plenary Meeting is the chief governing organ of COSPAR and is comprised of all International Scientific Union and National Scientific Institution representatives.

For the conduct of its scientific activities, COSPAR established a number of Working Groups. At present, these are as follows:

1. Tracking, Telemetry and Dynamics
2. Experiments in Interplanetary Space and in the Magnetosphere
3. Space Techniques as Applied to Astrophysical Problems
4. Experiments in the Upper Atmosphere
5. Space Biology
6. Application of Space Research to Meteorology and Earth Surveys
7. Space-Related Studies of the Moon and Planets.

In addition, *ad hoc* bodies are created from time to time to study specific problems.

Conformément à la charte du Comité, son Conseil exécutif est responsable de la formulation de la politique et des programmes scientifiques. Ce Conseil exécutif se compose du président, de deux vice-présidents et de quatre autres membres élus (qui constituent le Bureau du Conseil exécutif) et de tous les représentants des unions scientifiques membres du COSPAR. La Réunion plénière — principal organe directeur du COSPAR — rassemble tous les représentants des unions scientifiques internationales et des instituts scientifiques nationaux.

Pour mener à bien ses activités scientifiques, le COSPAR a créé un certain nombre de groupes de travail. Il s'agit actuellement des groupes suivants:

1. *Poursuite, télémesure et dynamique*
2. *Expériences dans l'espace interplanétaire et la magnétosphère*
3. *Techniques spatiales appliquées aux problèmes d'astrophysique*
4. *Expériences dans la haute atmosphère*
5. *Biologie spatiale*
6. *Applications de la recherche spatiale à la météorologie et à l'écographie*
7. *Etudes de la Lune et des planètes à l'aide de moyens spatiaux.*

En outre, des groupes ad hoc sont créés de temps à autre pour étudier des problèmes particuliers.

Responsable à l'échelon mondial de l'organisation de la recherche spatiale fondamentale, le COSPAR doit tenir informées les communautés scientifiques des résultats les plus récents de la recherche scientifique dans le domaine spatial. A cette fin il organise chaque année, lors de sa Réunion plénière, une présentation de ces résultats. Un certain nombre de symposiums sont également organisés à l'occasion de ces réunions. La dernière Réunion plénière et les derniers symposiums se sont tenus à Varna (Bulgarie) en mai et juin 1975. Ils sont rassemblé près de 600 scientifiques.

Les thèmes étaient les suivants:

A. *Phénomènes transitoires rapides dans les rayonnements X et gamma (COSPAR/UAI)*
B. *Résultats des programmes coordonnés de mesures dans la haute atmosphère (COSPAR)*
C. *Physiologie de la gravitation (COSPAR/IUPS/IAA).*

As a World organiser of fundamental space research, COSPAR must keep the scientific communities informed of the latest results in scientific research in space. To this end, an annual presentation of such results is organised during its Plenary Meeting. A number of symposia are also arranged in conjunction with this meeting. The last Plenary Meeting and associated symposia were held in Varna, Bulgaria, May/June 1975, and were attended by nearly 600 scientists:

A. Fast Transients in X- and Gamma-Rays (COSPAR/IAU)
B. Results from Co-ordinated Upper Atmosphere Measurement Programmes (COSPAR)
C. Gravitational Physiology (COSPAR/IUPS/IAA)

During the Plenary Meeting in Varna the election of COSPAR officials (Bureau) took place for the term of office 1975-1978. Its composition is now as follows:

President:	Prof. C. de Jager (Netherlands) (re-elected)
Vice-Presidents:	Dr. F.S. Johnson (USA)
	Acad. R.Z. Sagdeev (USSR)
Members:	Prof. W. Böhme (GDR) (re-elected)
	Prof. K. Maeda (Japan) (re-elected)
	Sir Harrie Massey (UK) (re-elected)
	Prof. K. Serafimov (Bulgaria)

This Plenary Meeting also approved the scientific plans for the 1976 COSPAR Meeting and Symposia, which are to be held in Philadelphia, USA, in late spring 1976. The COSPAR Secretariat (51, Boulevard de Montmorency, 75016 Paris) will circulate programme details in due course. □

Au cours de la Réunion plénière de Varna, a eu lieu l'élection des représentants du COSPAR (Bureau) pour la période d'exercice 1975-1978. La composition du Bureau est actuellement la suivante:

Président:	*Professeur C. de Jager (Pays-Bas) (réélu)*
Vice-Présidents:	*Dr F.S. Johnson (Etats-Unis)*
	Acad. R.Z. Sagdeev (URSS)
Membres:	*Professeur W. Böhme (RDA) (réélu)*
	Professeur K. Maeda (Japon) (réélu)
	Sir Harrie Massey (R-U) (réélu)
	Professeur K. Serafimov (Bulgarie).

La Réunion plénière a également approuvé les plans scientifiques pour la réunion et les symposiums 1976 du COSPAR qui doivent se tenir à Philadelphie (Etats-Unis) à la fin du printemps. Le Secrétariat du COSPAR (51, Boulevard de Montmorency, 75016 Paris) diffusera les détails de ce programme en temps opportun. □

Solar Phenomena, Weather and Climate

J. W. King, UK Science Research Council, Appleton Laboratory

It has been suggested in many papers published in past decades that the weather is influenced by the 11- and 22-year sunspot cycles. The accumulated evidence is now so compelling that it seems no longer possible to deny the existence of strong connections between the weather and radiation changes associated with a whole range of phenomena. Research on 'Sun-weather relationships' is expanding in the United Kingdom; this article reviews some of the relevant results that have been brought to light in the initial stages of this work and in work elsewhere. What are being sought now are (a) the mechanisms responsible for the complicated Sun-weather relationships that exist, and (b) greater insight into the practical consequences for agriculture, energy consumption and national economies which stem from these relationships.

RELATIONSHIPS BETWEEN WEATHER AND SOLAR CYCLE

Figures 1 and 2 show that the annual rainfall totals at Fortaleza in Brazil and at three locations in South Africa were positively correlated with the 'double' sunspot cycle for considerable periods of time. The modulation associated with the double cycle amounted to about 35% of the average annual total at Fortaleza, and to about 25% of the average annual rainfall at the South African stations. Data from Fortaleza are available from 1865 onwards, but after the first 60 years the relationship between the rainfall and the double cycle changed phase.

Particularly impressive evidence of an association between rainfall and the double sunspot cycle is given in Figure 3 which shows the date within each year from 1844 to 1944 by which one quarter of the year's rainfall at Adelaide (35°S, 139°E) had fallen. This quartile date oscillates between about April 15 and May 25 in phase with the double sunspot cycle. The dates of the other rainfall octiles exhibited similar oscillations; obviously, changes of up to six weeks in the date by which various fractions of the annual rainfall total have fallen are of considerable importance to agriculture.

Another striking illustration of the influence of the double sunspot cycle on the weather shows (Fig. 4) that during the period 1750-1880, the July temperature in central England exhibited an oscillation of nearly 1°C in phase with the double sunspot cycle. The temperature variation was somewhat anomalous during the years 1840-1855, when the temperature extremes occurred around sunspot minima instead of near sunspot maxima.

The double sunspot cycle appears to influence the climate of the United States in several ways. Droughts in various parts of the country seem to occur around every second sunspot minimum; winter temperatures in Boston, for example, have been reported to exhibit a 22-year periodicity, and the correlation between the July/August temperature in the corn belt of the United States and the double sunspot cycle is reported to be 'remarkable'.

Figure 5 shows how the incidence of lightning in Great Britain, plotted on an arbitrary scale designed to indicate variations in the number of power failures associated with lightning strikes, varied during four sunspot cycles. The number of events varies by a factor of nearly two in phase with the sunspot cycle.

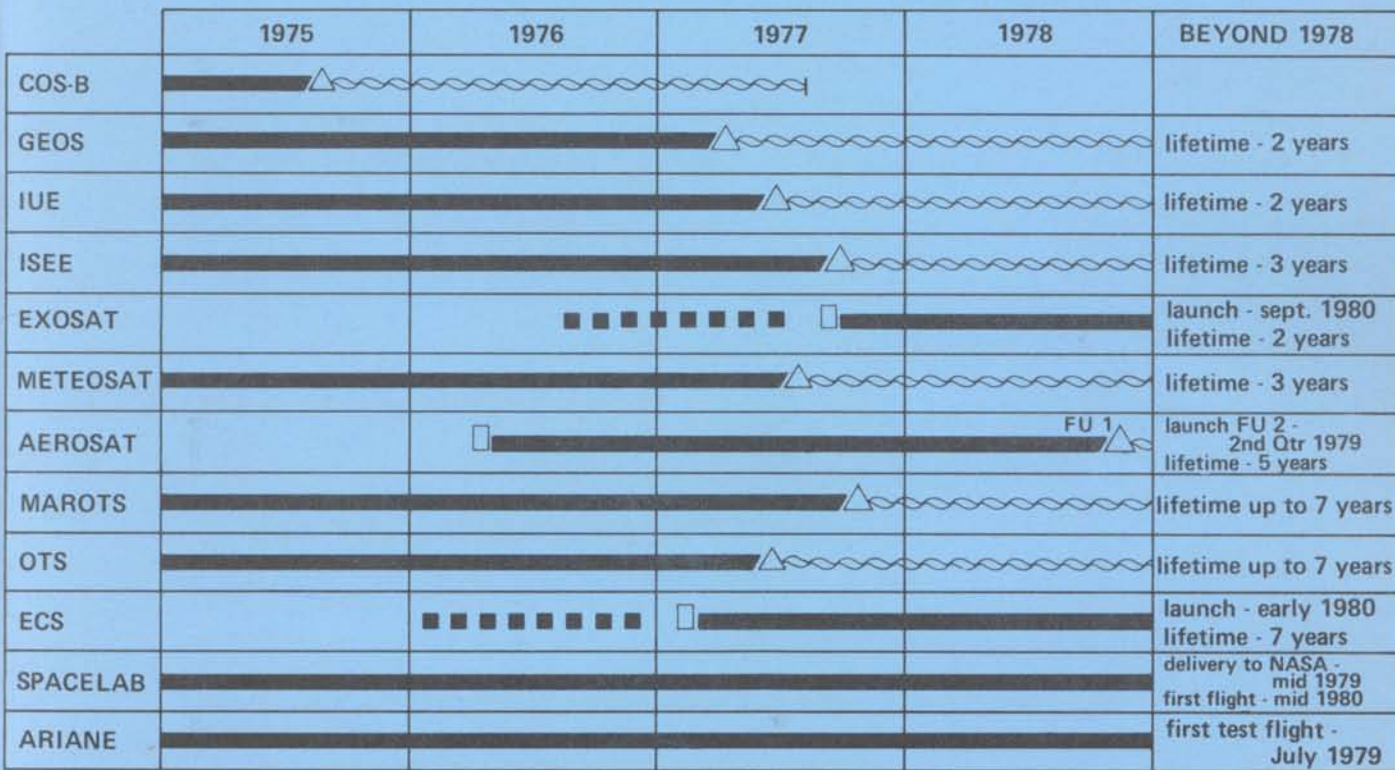
RESPONSE OF LOWER ATMOSPHERE TO SHORT-LIVED SOLAR PHENOMENA

In recent years, several analyses have indicated that short-lived solar phenomena may trigger a response in the lower atmosphere. Computations of the change in the height of the 500 mb level over the northern hemisphere during the first 24 hours after each of 53 solar flares have indicated that the pattern of height changes 'shows a remarkable regularity with

Continued on page 49.

Projects under Development
Projets en cours de réalisation

THE ESA DEVELOPMENT AND OPERATION PROGRAMME (as at September 1975)



■■■■■■ = phase B (design definition)
▯ = award of hardware contract
▬▬▬ = phase C/D (development)
△ = launch
∿∿∿∿ = operation

* In ESA Bulletin No. 1, two launch dates were quoted for the Canadian Technology Satellite (CTS). The correct date was December 1975 (this has since slipped to January 1976).

GEOS

The major technical event was the formal Electromagnetic Cleanliness (EMC) Review on 6 March when the results of the system level tests on the development model were scrutinised by an ESTEC Board. The data presented showed that the electromagnetic interference levels were extremely low, and close to target. Satellite performance was acceptable, although at that stage a solar array was not yet available, and noise radiation from the panels could lead to a deterioration in performance. In line with EMC Review recommendations, the development model programme has been extended and the following main activities have been performed during the reporting period:

- curing of outstanding faults and further investigation of power-supply subsystem instability
- extended tests on particle experiments
- preparation of simulation tapes for experimenters and ESOC

- RFI tests at both VHF and UHF
- antenna tests
- solar-array tests
- software tests on experiments.

The instability in battery operation modes was found to be caused by the battery discharge regulator. Design modifications have been successfully implemented at both unit and system level.

By contrast, difficulties still exist with the VHF antenna pattern, particularly at TCD frequency, in spite of the implementation of design improvements. Repetition of commands is, however, expected to solve the current problems.

As regards European technology, the hydrazine thruster programme has proceeded well. Qualification tests were completed in May and although the qualification thruster does not meet the specifications completely, its performance is considered acceptable.

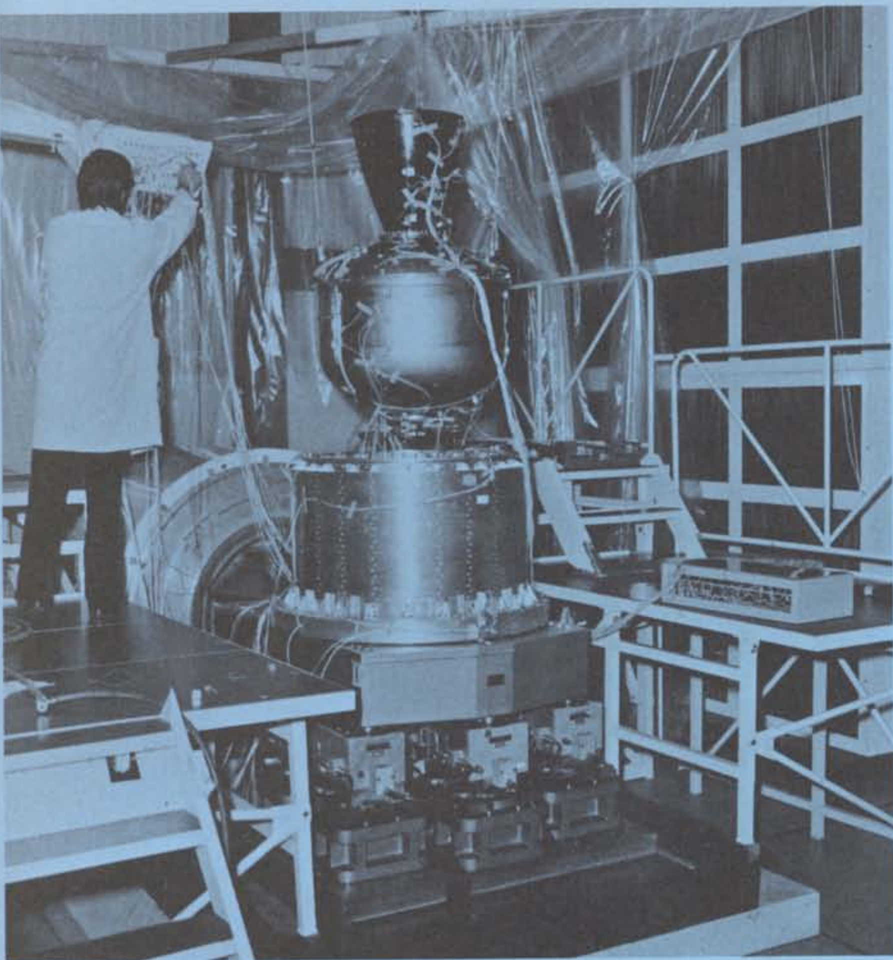
The apogee-motor-development test review was held at SNIA-Viscosa on 6-7 May to review the results of tests concluded with the firing of the four development motors. The Review Board was satisfied that the go-ahead could be given for formal motor qualification, and the first two qualification-model firings have since been completed successfully.

Units for the satellite qualification model are now beginning to arrive at BAC. The structure was delivered on 18 July and integration is due to start (with the harness) on 11 August.

Late arrival and poor quality of high-reliability components have had a major impact on deliveries of all electronic units, with consequent severe delay of the prototype and flight spacecraft. The prime contractor is unwilling to be committed to a launch date until all components have been delivered and their qualification status verified, hopefully during September 1975. On present forecasts, launch could not occur earlier than end February 1977.

Negotiations were undertaken with the prime contractor between March and May 1975 to discuss the cost to completion of the main development contract. A total fixed price of 42.5 MAU (1975 levels) was finally agreed at a meeting with BAC in Paris, on 14 May 1975. Negotiations have continued to finalise the definitive contract and agreement is expected in the near future.

Progress on the scientific payload continues to be satisfactory. Manufacture of the prototype units has been completed and qualification has now started. Acceptance of the units by ESTEC is scheduled for September 1975.



GEOS apogee motor

L'événement technique principal a été l'examen de propreté électromagnétique (EMC) qui a eu lieu le 6 mars, au cours duquel un groupe de l'ESTEC a passé au crible les résultats des essais effectués sur le modèle de développement au niveau système. Les données présentées ont montré que les niveaux d'interférences électromagnétiques étaient extrêmement faibles et voisins de l'objectif fixé. Les performances du satellite sont acceptables, bien qu'au stade actuel on ne dispose pas encore d'un réseau solaire, et que le bruit rayonné par les panneaux risque de provoquer une réduction des performances. Conformément aux recommandations de la réunion d'examen de l'EMC, le programme du modèle de développement a été étendu et les activités principales suivantes ont été exécutées pendant la période considérées:

- *correction des défauts non encore éliminés et poursuite des recherches sur l'instabilité du sous-système d'énergie électrique*
- *essais prolongés sur les équipements d'expériences concernant les particules*
- *préparation de bandes de simulation pour les expérimentateurs et l'ESOC*
- *essais d'interférences radioélectriques en VHF et en UHF*
- *essai des antennes*
- *essai du réseau solaire*
- *essai du logiciel des expériences.*

Il a été établi que l'instabilité dans les modes de fonctionnement sur batteries était causée par le régulateur de décharge des batteries. Des modifications de *conception ont été appliquées avec succès tant au niveau unité qu'au niveau système.*

Par contre, il existe encore des difficultés en ce qui concerne le diagramme de rayonnement de l'antenne VHF, en particulier à la fréquence de télécommande, en dépit d'améliorations apportées à la conception. On espère cependant résoudre les problèmes qui se posent encore par la répétition des ordres de télécommande.

En ce qui concerne la technologie européenne, le programme du propulseur à hydrazine progresse convenablement. Les essais de qualification ont été achevés en mai et, bien que le propulseur de qualification ne réponde pas complètement aux spécifications, ses performances sont jugées acceptables.

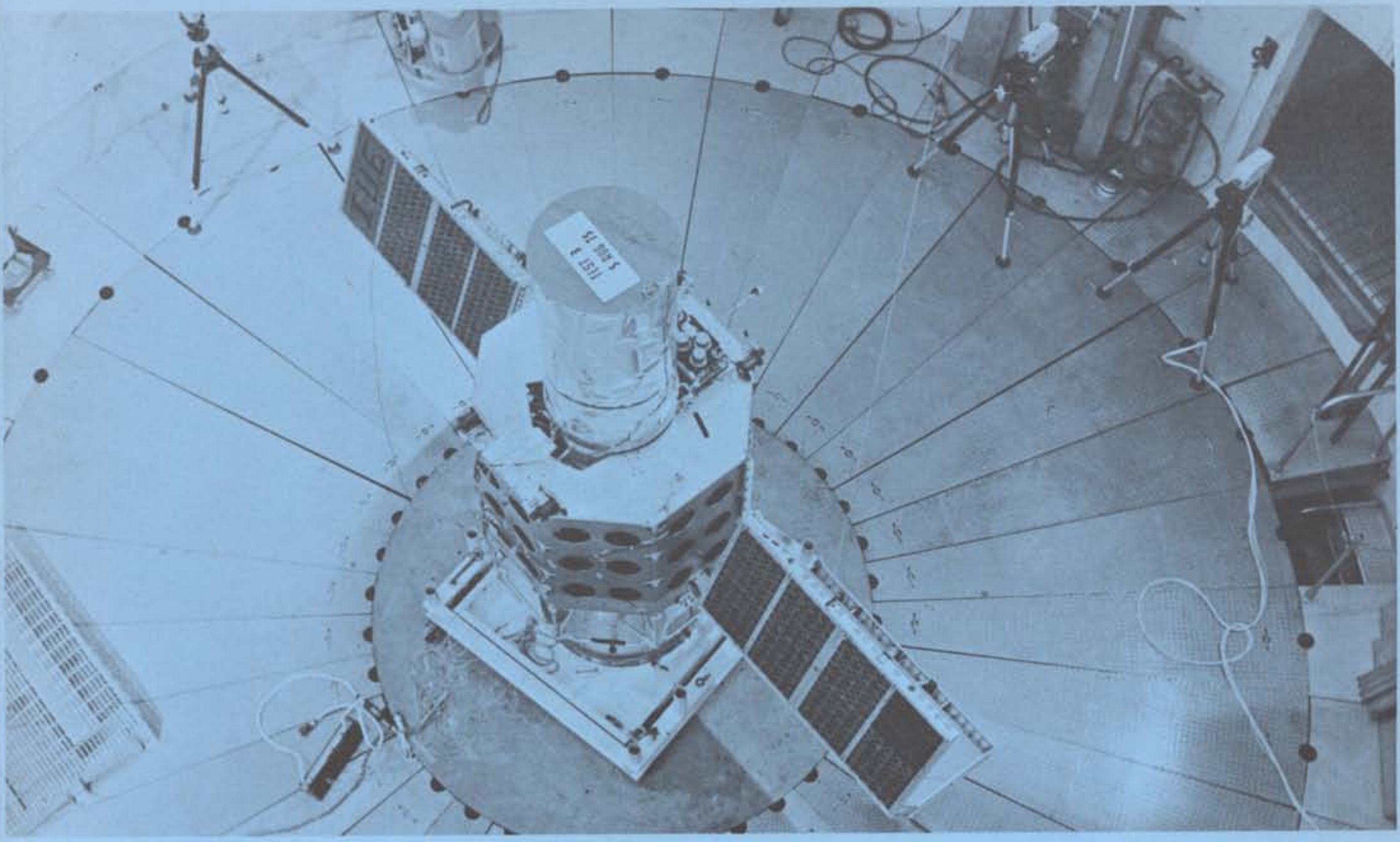
La réunion d'examen des essais de développement du moteur d'apogée s'est tenue à la SNIA-Viscosa les 6 et 7 mai en vue d'examiner les résultats des essais qui ont pris fin avec la mise à feu des quatre moteurs de développement. Le Groupe d'examen a décidé que l'on pouvait donner le feu vert pour la qualification officielle du moteur, et les deux premiers essais à feu du modèle de qualification ont été exécutés depuis avec succès.

Les unités destinées au modèle de qualification du satellite commencent maintenant à arriver à la BAC. La structure a été fournie le 18 juillet et l'intégration doit commencer (avec le faiceau de câbles) le 11 août.

La livraison tardive et la médiocre qualité des composants de haute fiabilité ont eu des incidences majeures sur la fourniture de toutes les unités électroniques, ce qui a entraîné de sérieux retards pour le prototype et le modèle de vol du véhicule spatial. Le maître d'oeuvre n'est pas décidé à s'engager sur une date de lancement tant que tous les composants n'auront pas été livrés et que l'état de leur qualification n'aura pas été vérifié, ce que l'on espère voir accompli au cours du mois de septembre 1975. Selon les prévisions actuelles, le lancement ne pourrait pas avoir lieu avant la fin de février 1977.

Des négociations ont eu lieu avec le maître d'oeuvre entre mars et mai 1975 au sujet du coût à l'achèvement du contrat principal de développement. On est finalement tombé d'accord sur un prix fixe total de 42,5 MUC (au niveau des prix de 1975), au cours d'une réunion qui a eu lieu avec la BAC à Paris le 14 mai 1975. Les négociations se sont poursuivies pour mettre au point le contrat définitif et l'on espère parvenir rapidement à un accord.

Les travaux relatifs à la charge utile scientifique progressent de façon satisfaisante. La fabrication des unités prototypes s'est achevée et la qualification a commencé. La recette de ces unités par l'ESTEC est prévue pour septembre 1975.



IUE

Solar array

The prototype solar array has been assembled at SNIAS and has undergone successfully its first series of qualification tests (development, vibration, acoustic noise). On 25 April 1975, it arrived at ESTEC for continuation of the qualification test series. Electrical tests and a rapid depressurisation check were successfully completed.

After successful thermal cycling tests under Sun-simulation conditions, the array was shipped to NASA/GSFC on 29 May for tests with the spacecraft's engineering unit. These included two full deployments of the array both before and after vibration tests, as well as the qualification test proper together with the spacecraft. The tests were carried out by a joint NASA/ESA/SNIAS team and were successfully completed by early August. One of the array paddles was then returned to ESTEC for thermal cycling in the solar simulation chamber.

In the meantime, manufacture of the parts for the flight-unit array has started and is progressing according to schedule.

Ground system

Construction work on the IUE building at Villafranca, and its planned extensions for Marots and Aerosat, has slowed temporarily, awaiting the finalisation of a revision of the plans. The new target date for completion of the building is 1 February 1976.

Progress has been achieved by the Spanish Authorities in improving the access road in that is has been re-routed and widened, allowing unhindered transportation of the S-band antenna parts at the beginning of May. Taking into account the accommodation of approved projects at Villafranca and the technical constraints associated with the IUE satellite, the IUE VHF command antenna has to be sited a little way outside the existing site boundaries. Technical discussions with the Spanish Authorities suggest that no serious delays are to be expected in acquiring the additional land.

Réseau solaire

Le prototype de réseau solaire a été monté à la SNIAS et a subi avec succès sa première série d'essais de qualification (déploiement, vibrations, bruit acoustique). Il est arrivé à l'ESTEC le 25 avril 1975 pour la poursuite de la série d'essais de qualification. Des essais électriques et une vérification de dépressurisation rapide ont été effectués avec succès.

Après les essais réussis de cycle thermique, dans des conditions simulant le rayonnement solaire, le réseau a été expédié au GSFC/NASA le 29 mai pour y subir des essais sur le modèle d'identification du véhicule spatial. Réalisés avec succès au début du mois d'août par une équipe conjointe NASA/ASE/SNIAS, ces essais ont compris deux déploiements complets du réseau solaire — l'un avant, l'autre après les essais aux vibrations — ainsi que son essai de qualification sur le véhicule spatial.

L'un des panneaux du réseau a été ensuite renvoyé à l'ESTEC aux fins de cyclage thermique dans la chambre de simulation solaire.

Entre-temps, la fabrication des pièces destinées au réseau de l'unité de vol a commencé; elle progresse conformément au calendrier.

Système au sol

La construction du bâtiment IUE à Villafranca, ainsi que de ses extensions pour Marots et Aérosat, s'est ralentie temporairement, en attendant la mise au point finale d'une révision des plans. La nouvelle date-objectif fixée pour l'achèvement du bâtiment est le 1er février 1976.

Des progrès ont été accomplis par les autorités espagnoles qui ont amélioré la route d'accès en modifiant son tracé et en l'élargissant, ce qui a permis de transporter sans encombre les éléments de l'antenne en bande S au début de mai. En raison d'une part de l'installation, à Villafranca, des équipements destinés à d'autres projets approuvés, et d'autre part des contraintes techniques imposées par le satellite, l'antenne de télécommande VHF d'IUE doit être installée un peu en dehors des limites du site actuel. Des discussions techniques avec les autorités espagnoles, il ressort qu'aucun retard sérieux n'est à prévoir dans l'acquisition du terrain supplémentaire.

ISEE

Progress has continued on the design of the ISEE-B satellite, the subsystem design reviews being held during May and June. The System Design Review, the object of which was to freeze the design, was held during the second week of July at the prime contractor's premises, with NASA participation, and the Review Board recommendations are currently being evaluated. However, no major problems were raised by the Board and no significant cost or schedule impact is expected from implementation of any of the recommendations.

The Critical Design Review of ISEE-A (one of the ISEE satellites being developed by NASA) took place at Goddard Space Flight Center during June. As provided for in the ESA/NASA Memorandum of Understanding, the Review Board membership included ESA representatives and ESA supplied a co-chairman.

Definition of the relevant responsibilities to be assumed by ESA and NASA concerning mission operations is proceeding.

Design meetings have been held for each individual experiment as well as a system level experimental payload/spacecraft interface design review. No major problems in either the technical or schedule areas were identified by this review.

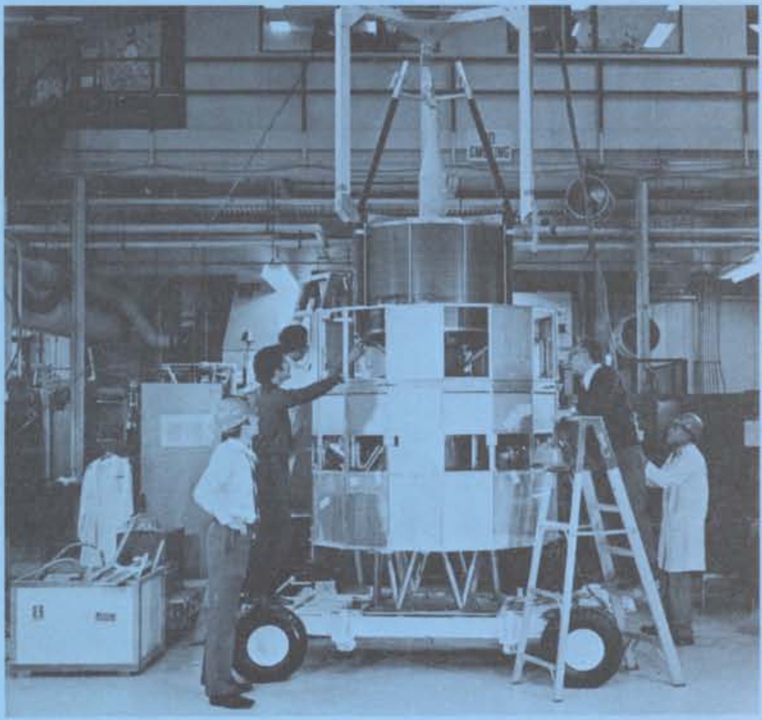
The ESA-built ISEE-B mass model and the NASA-built ISEE-A structural model, mated together in launch configuration, completed vibration and acceleration testing at Goddard Space Flight Center. Some combined frequency-response problems have been encountered and are presently being evaluated for their possible impact on the ISEE-A and B designs.

The next major milestone is the start of integration of the ISEE-B structural model in October this year.

La conception du satellite ISEE-B a continué de progresser, avec des examens de conception au niveau des sous-systèmes en mai et juin. L'examen de conception du système (SDR), qui avait pour objet d'arrêter définitivement la conception, s'est tenu dans la deuxième semaine de juillet chez le maître d'oeuvre, avec la participation de la NASA, et les recommandations formulées par la Commission d'examen sont actuellement en cours d'évaluation. Cette Commission n'ayant pas soulevé de problème majeur, l'on n'attend toutefois de la mise en oeuvre de ses recommandations aucune incidence importante ni sur les coûts ni sur le calendrier.

L'examen critique de la conception du satellite ISEE-A (l'un des satellites de la série ISEE développé par la NASA) s'est tenu dans le courant de juin au Goddard Space Flight Center. Comme prévu dans le Mémorandum d'Accord

Mating of the ISEE-A and -B spacecraft models at Goddard Space Flight Center.



ASE/NASA, la Commission d'examen comprenait des représentants de l'ASE et celle-ci a fourni un co-président.

La définition des responsabilités à assumer respectivement par l'ASE et la NASA pour les opérations est en cours.

Des réunions de conception se sont tenues pour chacune des expériences ainsi qu'au niveau du système (examen de conception de l'interface charge utile expérimentale/véhicule spatial). Cet exercice n'a fait apparaître aucun problème majeur ni du point de vue technique ni du point de vue du calendrier.

Le modèle de masse d'ISEE-B construit par l'ASE et le modèle de structure d'ISEE-A construit par la NASA, réunis en configuration de vol, ont été soumis au Goddard Space Flight Center à des essais en vibration et en accélération qui sont actuellement terminés. Quelques problèmes de fréquences/réponses se sont posés; ils sont actuellement en cours d'évaluation du point de vue de leur incidence possible sur les conceptions d'ISEE-A et B.

La prochaine grande étape sera le démarrage de l'intégration du modèle de structure d'ISEE-B, prévu en octobre de cette année.

EXOSAT

Scientific experiment

Progress has been made in defining the Exosat experiments in greater depth and steps have been initiated to produce some hardware for the scientific model.

Several ESA contracts have been placed to study the most critical elements of the experiments, e.g. the technology of the grazing-incidence X-ray mirrors, the position-sensitive X-ray gas proportional counter, the critical 'front-end' electronics, the large-area, sealed thin-window proportional counter. Some in-house work has been initiated, mainly in the fields of thermal control and mechanics. In addition, with the availability of two dedicated Exosat computers, work within the participating institutes has been significantly increased.

Spacecraft

The following documents for the invitation to tender for Phase A are in preparation:

- Specifications for the mission, the system and the subsystems and the interface specifications for the scientific experiment, the launcher and the ground segment.
- Work statement for Phase B.
- Description of the baseline satellite, based on:
  - internal ESTEC studies performed to date,
  - subsystem study contracts placed with industry (configuration, structure, mechanisms, thermal control, attitude control, data-handling system, including use of an on-board computer).
- Contractual and administrative documents.

Ground segment and operations

The decision has been taken to launch Exosat into a near-polar orbit with apogee in the northern hemisphere. Consequently, the main ESA ground station will be implemented near Madrid. The location gives a good coverage. The need for additional NASA ground support is under investigation by ESOC, as well as a study of adjustment of launch-window calculations to inclination 80° and a star-coverage study for different star-tracker fields of view and configurations.

Charge utile scientifique

Depuis le dernier compte rendu, la définition des expériences d'Exosat a progressé et la réalisation de certains matériels pour le modèle scientifique a commencé.

Plusieurs contrats ont été passés par l'ASE pour l'étude des éléments les plus critiques des expériences: ils portent notamment sur la technologie des miroirs à incidence rasante devant collecter les rayons X, le compteur proportionnel à gaz détecteur de position, l'électronique critique d'entrée et le compteur proportionnel à fenêtre mince scellée de grandes dimensions. Certains travaux internes ont été entrepris, principalement dans les domaines de la régulation thermique et de la mécanique. Enfin, la mise à disposition de deux calculateurs spécialisés pour Exosat a permis d'amplifier notablement les travaux dans les instituts participants.

Véhicule spatial

Les documents suivants sont en cours d'élaboration en vue de l'appel d'offres pour la phase A:

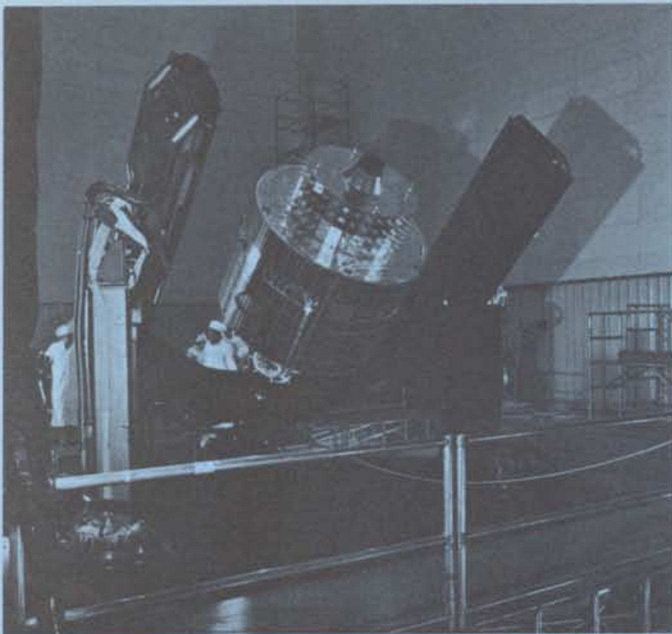
- *Spécifications relatives à la mission, au système et aux sous-systèmes et spécifications d'interface pour la charge utile scientifique, le lanceur et le segment sol;*
- *Descriptif des travaux pour la phase B;*
- *Description du satellite de référence sur la base:*
  - *des études internes effectuées par l'ESTEC à ce jour,*
  - *des contrats d'étude de sous-systèmes passés avec l'industrie (configuration, structure, mécanismes, régulation thermique, commande d'attitude, système de gestion des données avec utilisation d'un calculateur à bord);*
- *Documents contractuels et administratifs.*

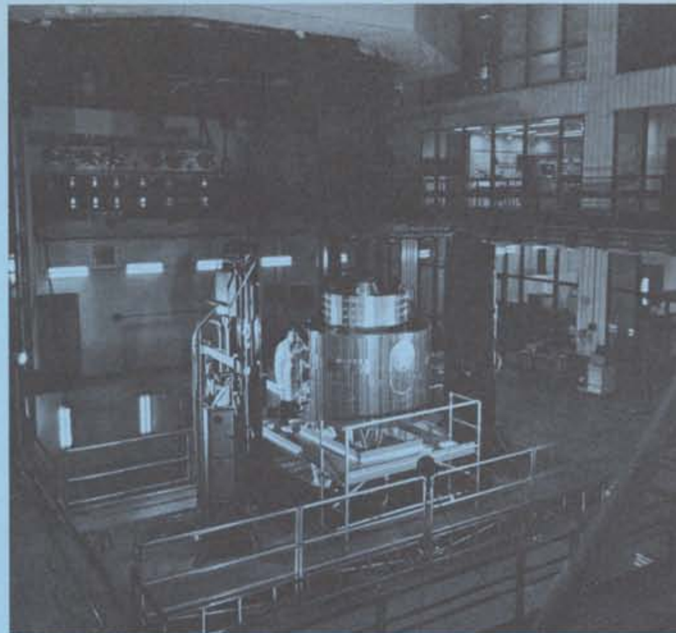
Segment sol et opérations

Il a été décidé de lancer Exosat sur une orbite quasi polaire dont l'apogée se situera dans l'hémisphère Nord. La principale station au sol de l'ASE sera en conséquence mise en oeuvre près de Madrid car cet emplacement assure une bonne couverture. L'ESOC examine actuellement si un soutien au sol additionnel par la NASA paraît nécessaire; il procède d'autre part à l'ajustement des calculs de la fenêtre de lancement pour une inclinaison à 80° ainsi qu'à une étude des couvertures d'étoiles obtenues avec diverses configurations et diverses ouvertures du suiveur stellaire.

METEOSAT

Earlier this year, integration of the Meteosat structural and thermal models was completed at MBB, Munich. The results of the subsequent structural model tests at IABG, Munich and thermal model tests at the Centre Spatial de Toulouse (CST) have proved very satisfactory and show that only small modifications to the satellite structure and the thermal control subsystem are required.





Meteosat thermal model being prepared for thermal test at Centre Spatial de Toulouse.

Integration of the satellite engineering model (PI) has been started, to schedule, in June, and manufacture of the units for the prototype (P2) was initiated some months ago.

The special weight saving effort initiated after the Critical Design Review in 1974 has been extremely successful, resulting in an adequate satellite weight margin. With radiometer development also, after the initial difficulties in the design of its cooler, very considerable progress has been made. This progress has been confirmed by the extremely good results of the recent cooler qualification tests and the functional tests on the radiometer engineering model. Early this year, development of a third channel package, which was not foreseen in the original programme, was initiated and the package is expected to be launched with the first satellite.

During the period of reporting almost all remaining Ground Segment development contracts have been awarded for:

- the Meteosat Ground Computer System (MGCS) – to ICL
- the software – to SESA
- the Data Collection Platform (DCP) – to LCT
- the Land-Based Transponder (LBT) – to MSDS
- the Operations and Control Centre (OCC) – to MBB.

At the end of May another Ground Segment Review was held at the Meteorological Programme Office (MPO), Toulouse, which revealed only minor interface problems within the Ground Segment and with the Space Segment.

The Meteosat systems activities have concentrated on the evaluation of last autumn's multipath experiments, the preparation of space/ground segment compatibility tests, and preparations for the Fifth Co-ordination Meeting on Geostationary Meteorological Satellites (ESA has been entrusted with the CGMS Secretariat). Co-ordination meetings between those contributing satellite systems to the First Global GARP (Global Atmospheric Research Programme) Experiments, namely Europe (ESA), Japan, the USA and the USSR, are taking place once or twice a year.

Recently, the nominal launch date has been postponed for financial reasons from April to July 1977, this still leaving almost one year in which to run-in the system and use it for regional purposes prior to the start of the GARP experiments proper, now scheduled for mid-1978.

Au début de l'année, s'est achevée chez MBB, à Munich, l'intégration des modèles structurel et thermique de Météosat. Les essais du modèle de structure et ceux du modèle thermique qui ont eu lieu depuis, respectivement chez IABG à Munich et au Centre spatial de Toulouse (CST), ont donné des résultats très satisfaisants puisque seules quelques légères modifications doivent être apportées à la structure du satellite et au sous-système de régulation thermique.

L'intégration du modèle d'identification (P1) du satellite a commencé, comme prévu, en juin et la fabrication des unités destinées au prototype (P2) a débuté depuis quelques mois.

Les efforts tout particuliers qui ont été faits, après l'examen critique de la conception de 1974, pour réduire la masse du satellite ont été pleinement couronnés de succès et celui-ci offre maintenant une marge de masse suffisante. Après les premières difficultés rencontrées dans la conception du dispositif de refroidissement du radiomètre, des progrès considérables ont également été enregistrés dans le développement de cet équipement, progrès confirmés par les résultats extrêmement satisfaisants des récents essais de qualification du dispositif de refroidissement et des essais fonctionnels du modèle d'identification du radiomètre. Au début de l'année, a été entamé le développement d'un bloc fournissant un troisième canal de télémesure, bloc qui n'était pas prévu à l'origine dans le programme et que l'on envisage de lancer avec le premier satellite.

Au cours de la période écoulée, presque tous les contrats restants relatifs au segment sol ont été attribués. Ils concernent le développement:

- *du système de calcul au sol Météosat (MGCS) — contrat confié à ICL*
- *du logiciel — contrat confié à SESA*
- *de la plate-forme de collecte des données (DCP) — contrat confié à LCT*
- *du répondeur terrestre de localisation (LBT) — contrat confié à MSDS*
- *du Centre de contrôle des opérations (OCC) — contrat confié à MBB.*

Une autre réunion consacrée à l'examen du segment sol s'est tenue fin mai au Bureau du Programme météorologique (MPO) à Toulouse; elle n'a fait apparaître que de petits problèmes d'interface à l'intérieur du segment sol et entre celui-ci et le segment spatial.

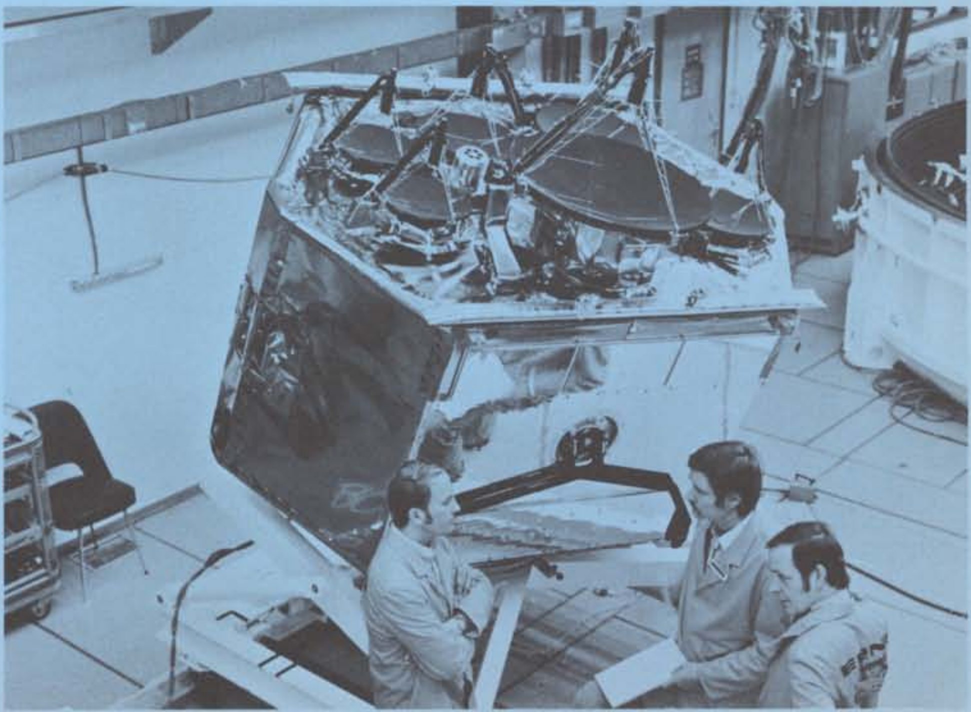
En ce qui concerne les systèmes de Météosat, les activités ont été essentiellement axées sur l'évaluation des expériences de trajets multiples effectuées à l'automne dernier, sur la préparation des essais de compatibilité des segments spatial et au sol et sur la préparation de la cinquième Réunion de coordination sur les satellites météorologiques géostationnaires (CGMS) dont l'ASE est chargée d'assurer le Secrétariat. Ces réunions de coordination, auxquelles participent les pays ou groupes de pays qui ont décidé de contribuer à la première expérience globale du GARP (Programme de recherche sur l'atmosphère globale) en mettant en oeuvre des systèmes de satellite, à savoir l'Europe (ASE), le Japon, les Etats-Unis et l'URSS, ont lieu une ou deux fois par an.

Récemment, la date nominale de lancement de Météosat a dû être reportée, pour des raisons financières, d'avril à juillet 1977, ce qui laisse toutefois encore près d'un an pour roder le système et l'utiliser à des fins régionales avant que ne démarre l'expérience GARP proprement dite qui est actuellement prévue pour la mi-1978.

OTS

Some 18 months of Phase C/D, the Main Development Phase, of the OTS project have been completed to date. The satellite design is now established, including the incorporation of the changes for the conversion from the 2914 to 3914 Delta launch vehicle. Much of the ground-support software has been produced by the contractor, HSD, and is being developed in conjunction with ESOC. In particular, considerable attention has been given to the Orbital Test Programme, devised in conjunction with the permanent nucleus of the CEPT.

OTS thermal model, prior to thermal vacuum testing in the HBF3 facility at ESTEC.



As far as satellite hardware is concerned, thermal-vacuum testing of the thermal model was completed in April, using facilities at Toulouse and at ESTEC. The results indicate that there are no serious problems with the thermal design, although some adjustment to the satellite thermal balance is necessary. The thermal model has subsequently been used for mechanical environmental testing at IABG, Munich, in order to provide early data on the dynamic behaviour of the satellite. The structural model proper is currently in manufacture and is expected to complete integration by the end of August. Static testing is to be completed in September and dynamic testing by the end of January 1976. The service module of the structural model is used jointly by OTS and Marots, the full structure test programmes of both projects being performed during the period September 1975 to February 1976.

The engineering model is now approaching the end of integration at Toulouse. The communications module, containing the antenna and repeater subsystems developed under the ECS Supporting Technology Programme, have been integrated successfully and the final integration of the service module subsystems is in progress. The first satellite Integrated System Test is scheduled for the end of August. Engineering-model subsystem design reviews have been conducted and the qualification and flight model design has been frozen. Progressive release of qualification-model equipment is taking place and there is a high degree of confidence that the satellite qualification tests will be completed in January 1977.

Currently, a launch at the end of May 1977 is being scheduled for monitoring purposes, in order to give some margin over the June 1977 requirement.

La phase C/D — phase principale de développement — du projet OTS en est actuellement à la fin de son dix-huitième mois. La conception du satellite est maintenant définitivement arrêtée, avec notamment l'incorporation des modifications nécessitées par l'adaptation du satellite au lanceur Delta 3914 en remplacement du 2914. Une bonne partie du logiciel de soutien au sol a été définie par le contractant, HSD, et est en cours de développement en coopération avec l'ESOC. On s'est particulièrement attaché au programme d'essais orbitaux, défini conjointement avec le noyau permanent de la CEPT.

En ce qui concerne le véhicule spatial, les essais sous vide thermique du modèle thermique, effectués dans les installations de Toulouse et de l'ESTEC, se sont achevés en avril. Les résultats prouvent qu'en dépit de certains ajustements à apporter au bilan thermique du satellite, la conception thermique ne pose pas de problème grave. Le modèle thermique a ensuite été soumis à des essais d'ambiance mécanique chez IABG, à Munich, pour *permettre de disposer rapidement de données sur le comportement dynamique du satellite. Le modèle de structure proprement dit est actuellement en cours de fabrication et l'on prévoit que son intégration sera terminée pour la fin d'août; les essais statiques doivent être achevés en septembre et les essais dynamiques pour la fin de janvier 1976. Le module de service du modèle de structure est utilisé à la fois pour OTS et pour Marots; les programmes d'essais de la structure complète pour les deux projets doivent se dérouler au cours de la période septembre 1975 – février 1976.*

L'intégration à Toulouse du modèle d'identification touche à sa fin. Le module de télécommunications, qui contient les systèmes d'antenne et de répéteur développés au titre du programme de technologie de soutien de l'ECS, a été intégré avec succès et l'intégration définitive des sous-systèmes du module de service est en bonne voie. Le premier essai du système de satellite intégré est prévu pour la fin d'août. Des examens de conception des sous-systèmes du modèle d'identification ont eu lieu et la conception du modèle de qualification et du modèle de vol a été définitivement arrêtée. Le feu vert est donné par étapes pour les différents équipements du modèle de qualification et il est très probable que les essais de qualification du satellite seront terminés en janvier 1977.

Aux fins de contrôle du programme, on prévoit actuellement un lancement fin mai 1977, de façon à disposer d'une marge de sécurité par rapport à juin 1977 – date impérative.

AEROSAT

During the period under review, the pace of the Aerosat programme has been accelerating. The Joint Space Segment Programme Office (SPO), currently housed at ESTEC, has built up to almost its full complement of staff, and has been joined by the Aerosat Co-ordination Office (ACO), the user-oriented group responsible for co-ordination of the European, American and Canadian plans for experimental use of the satellite.

The SPO's prime task in this period has been the preparation of the satellite specifications. It is now foreseen that the call for tenders for the spacecraft will be distributed to industry on 1 November 1975, with a time scale leading to a contract award in the middle of 1976.

Within Europe, the final steps are being taken for the approval of the legal framework within which the programme will be performed. At its meeting on 31 July/1 August, the ESA Council approved the text of the Protocol to the Arrangement between the Agency and the participating Member States which modifies the original arrangement signed in 1972. This Protocol takes account of the changes in the programme since it was originally defined (change from a two-ocean programme to an Atlantic-only mission, the necessity for the American partner for the space segment programme to be an industrial company rather than a government agency, etc.). Subject to a final discussion on the scale of contributions at the next meeting of the ESA Council, this Protocol will be open for signature by Member States from 1 October to 31 December 1975.

Within the Programme Board, much progress has been made in the definition of the European co-ordinated programme, the purely European programme of experimentation with the satellite. It is intended that this programme, which includes the provision of a communications ground station for the aeronautical service and an associated computer centre for air-traffic handling, together with the development of 20 sets of representative avionic equipment and their experimental use aboard aircraft belonging to the flag carriers of the Member States, will be performed in close liaison between ESA and a Conference of the Directors of air navigation services of the Member States. In order to assist ESA on a day-to-day basis, it is foreseen that a small secretariat of civil-aviation representatives will be formed by the Conference of Directors. This Secretariat will probably be located at ESA Headquarters in Neuilly.

Au cours de la période considérée, la cadence du programme Aérosat s'est accélérée. Le Bureau commun du programme de secteur spatial (SPO), actuellement installé à l'ESTEC, s'est progressivement constitué et est maintenant pratiquement à effectif complet. Le Bureau de coordination d'Aérosat (ACO), groupe axé sur les besoins des utilisateurs et responsable de la coordination des plans européens, américains et canadiens pour l'utilisation expérimentale du satellite, est lui aussi installé à l'ESTEC.

La tâche essentielle du SPO au cours de la période considérée a été la préparation des spécifications du satellite. Il est maintenant prévu que l'appel d'offres pour le véhicule spatial sera adressé à l'industrie le 1er novembre 1975, le calendrier d'appel d'offres devant en principe aboutir à l'attribution d'un contrat à la mi-1976.

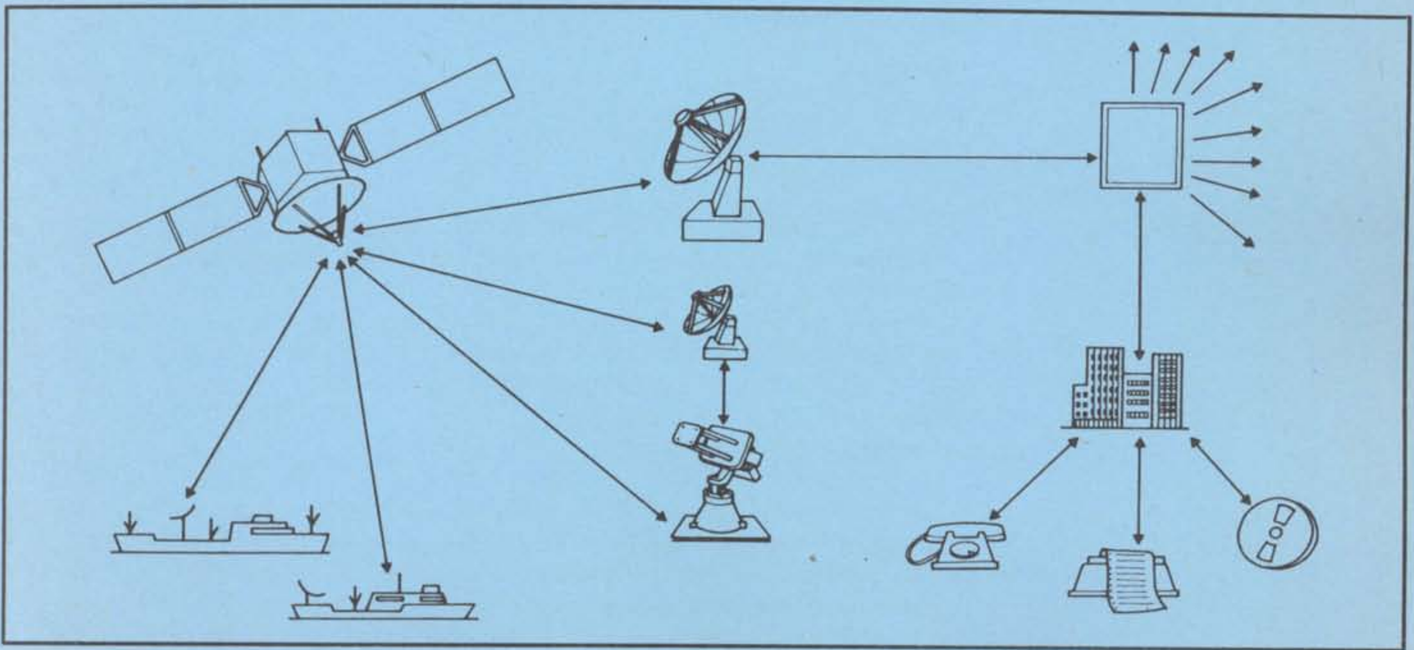
En Europe, les dernières mesures sont actuellement prises pour l'approbation du cadre juridique dans lequel le programme sera exécuté. A sa réunion du 31 juillet et du 1er août, le Conseil de l'ASE a approuvé le texte du Protocole relatif à l'Arrangement entre l'Agence et les Etats membres participant au programme, qui modifie l'Arrangement initial signé en 1972. Ce Protocole tient compte des modifications intervenues dans le programme depuis sa définition initiale (passage d'un programme de satellites au-dessus de l'Atlantique et du Pacifique à une mission ne couvrant que l'Atlantique, nécessité que le partenaire américain pour le programme de secteur spatial soit une société industrielle plutôt qu'une Agence gouvernementale, etc.).

Sous réserve d'une dernière discussion sur le barème de contributions, qui doit avoir lieu lors de la prochaine réunion du Conseil de l'ASE, ce Protocole sera ouvert à la signature des Etats membres du 1er octobre au 31 décembre 1975.

Au sein du Conseil directeur du programme, la définition du programme coordonné européen — il s'agit de la partie purement européenne du programme d'expérimentation avec le satellite — a beaucoup avancé. L'intention est que ce programme, — qui couvre la fourniture d'une station de télécommunications au sol pour les services aéronautiques et d'un centre de calcul associé pour la gestion de la circulation aérienne, ainsi que le développement de 20 ensembles d'équipements d'avionique représentatifs et leur utilisation expérimentale à bord d'avions appartenant à des compagnies battant pavillon des Etats membres —, soit effectué en liaison étroite entre l'ASE et une Conférence des directeurs des services de la navigation aérienne des Etats membres. Pour aider l'ASE dans son travail quotidien, il est prévu qu'un petit secrétariat composé de représentants de l'aviation civile sera constitué par la Conférence des directeurs et aura vraisemblablement son siège dans les locaux de l'ASE à Paris.

MAROTS

Breadboard models of most of the payload equipment have been delivered and comply with requirements. The ordering of high-reliability components for the qualification and flight models is progressing satisfactorily.



A number of interface problems between the platform and the payload have been solved without jeopardising the very high degree of commonality, or even interchangeability, between the OTS and Marots platforms.

Finally, requests for proposals have been issued in May for the Marots ground station to be located in Villafranca del Castillo, near Madrid, and by the end of July proposals had been received which are presently under evaluation.

A study contract on multiple access and access control methods for Marots has been placed with Elab (Norway).

Des modèles sur table de la plupart des équipements destinés à la charge utile ont été livrés et sont conformes aux spécifications. Les commandes de composants de haute fiabilité pour les modèles de qualification et de vol progressent de façon satisfaisante.

Un certain nombre de problèmes d'interface entre la plate-forme et la charge utile ont pu être résolus sans nuire au degré très poussé de banalisation — ou même d'interchangeabilité — entre les plates-formes OTS et Marots.

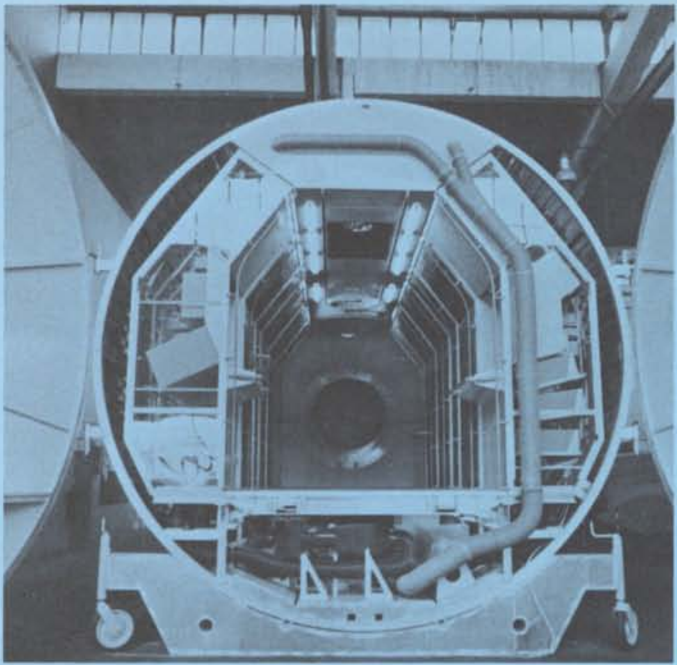
Enfin, des appels de propositions ont été lancés en mai pour la station sol de Marots qui doit être située à Villafranca del Castillo, près de Madrid, et à la fin de juillet le Secrétariat avait reçu des propositions qui sont actuellement en cours d'évaluation.

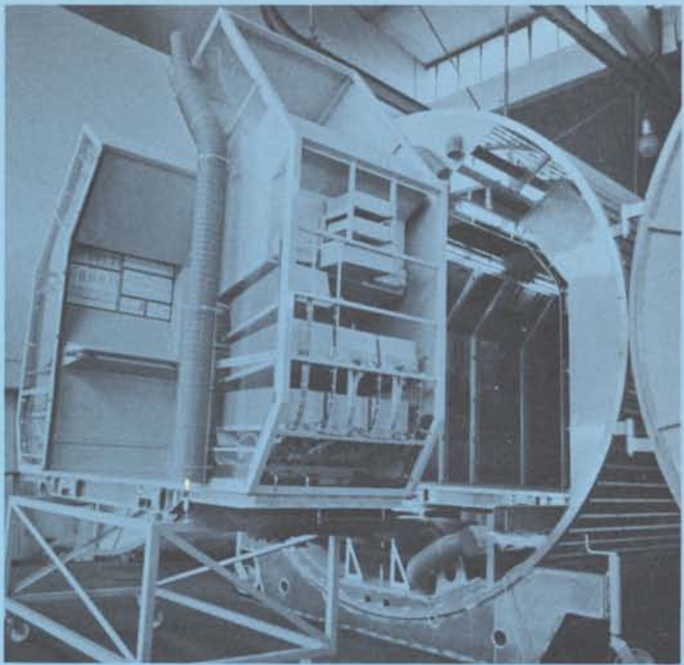
Un contrat d'étude sur les méthodes d'accès multiple et de contrôle d'accès pour Marots a été passé avec Elab (Norvège).

SPACELAB

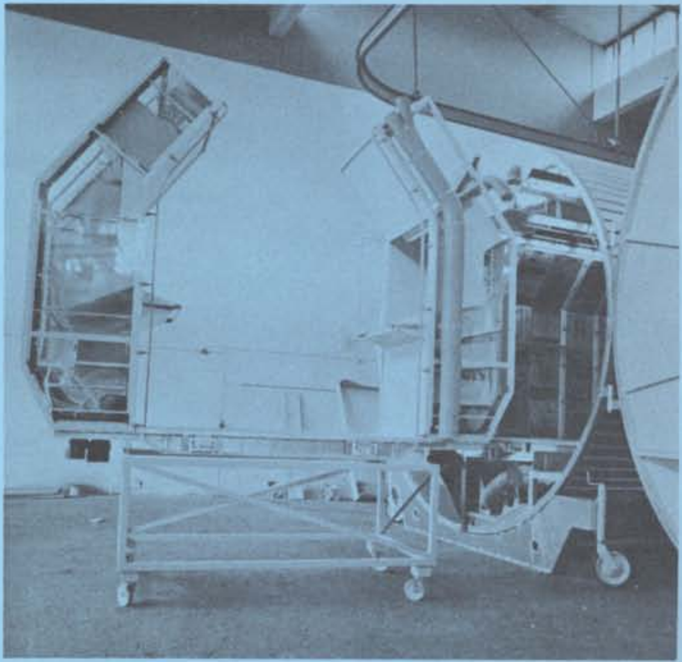
ESA's Director General Mr. R. Gibson and NASA's Administrator Dr. J. Fletcher held their second annual review of the Spacelab Programme on 4 June 1975 at ESA Headquarters in Neuilly. The Heads of the Agencies found the progress on the Spacelab development programme to be generally satisfactory, with substantial advancement in all aspects of the programme. As a highlight of the meeting, the experimental objectives of the first Spacelab flight — which will carry a combined ESA/NASA payload — were approved.

The Subsystem Requirements Review (SRR), directed by ESA with NASA participation, took place from 16 to 21 June 1975, at the prime contractor's site, with co-contractors present, in Bremen. The main objective was a concentrated effort at updating the system and subsystem requirements and to establish the acceptability of the contractor's subsystem specification





Spacelab mock-up prepared by the contractor for the June 1975 Subsystem Requirements Review.



baseline and of the corresponding implementation plans. The baseline established at the SRR will serve as the starting point for the final subsystem design phase, during which interfaces will be finalised, manufacturing drawings prepared and test procedures developed. The various documents issued by the contractor were reviewed by the relevant Review Boards, using the Review Item Disposition (RID) system.

A full-scale Spacelab mock-up had been prepared by the contractor to support the SRR and this provided an opportunity to evaluate the interior configuration, component arrangements, accessibility, maintainability, crew habitability and interfaces. This mock-up will remain at the contractor's site for further use as an engineering tool.

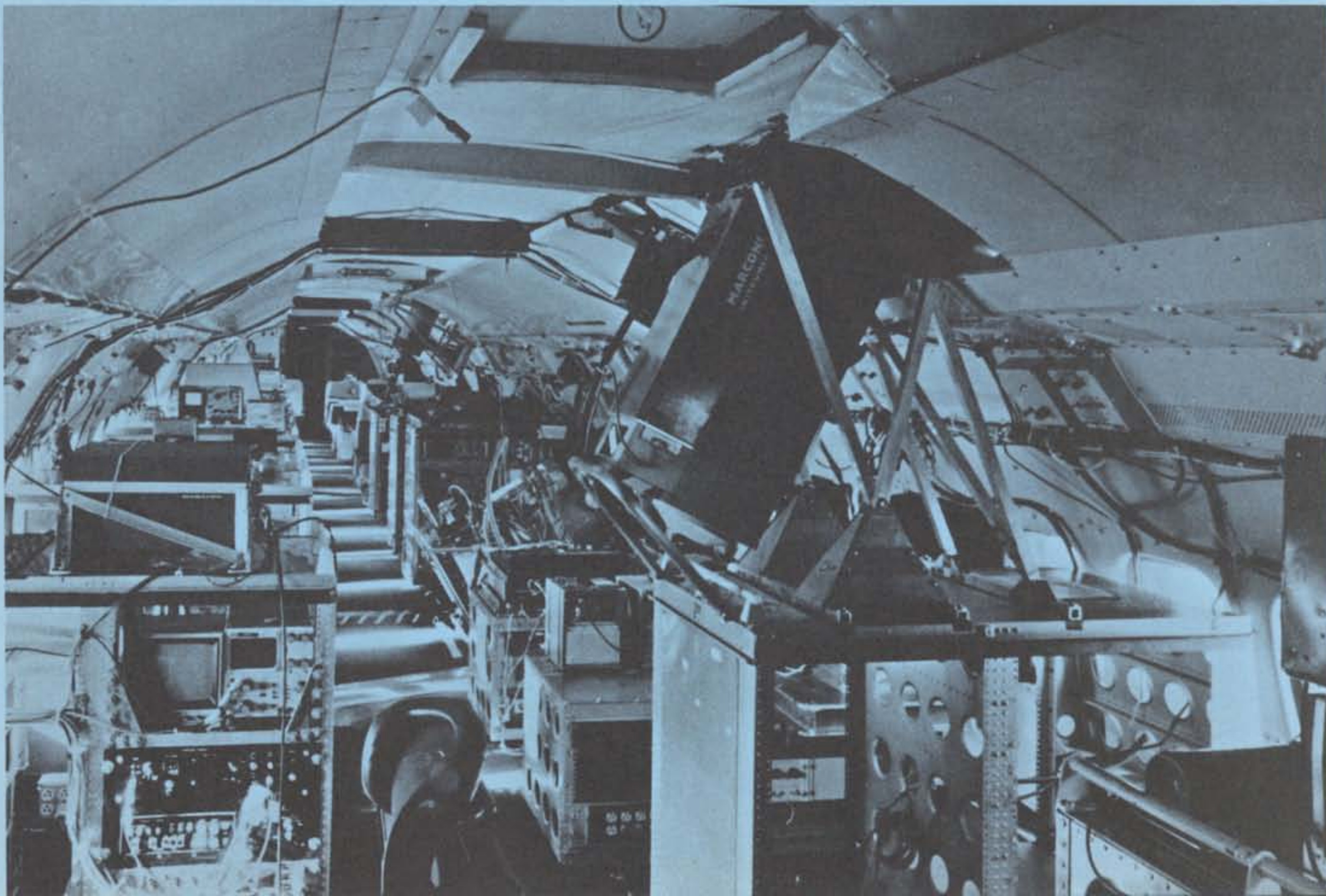
Studies, actions, changes and modifications arising out of the SRR meeting will be completed in the coming months, prior to the Preliminary Design Review, which is being planned for early next year.

The joint NASA/ESA ASSESS (Airborne Science Spacelab Experiments System Simulation) mission was flown in June 1975. The overall aim was to study techniques for operating payloads under constraints similar to those on Spacelab. Certain factors affecting Spacelab subsystem design, experiment operations and the 'manned' aspects of Spacelab experimentation could be evaluated.

Five six-hour flights were made in six days, and during this period the experiment operators were confined and isolated from their fellow scientists and support facilities, except for daily contact by voice and video links.

With a basic ground rule that authentic science should be performed, ESA funded three European experiments for the ASSESS mission while a further three compatible experiments were provided by US scientists. The experiments were devoted, in the main, to measurements of infrared radiation from the atmosphere and space.

Integrated ASSESS experiment payload installed in Convair-990 aircraft.



Le Directeur général de l'ASE M.R. Gibson et l'Administrateur de la NASA le Dr J. Fletcher ont tenu leur deuxième réunion annuelle d'examen du programme Spacelab le 4 juin 1975 au Siège de l'ASE à Neuilly. Les Chefs des deux Agences ont estimé que l'avancement du programme de développement était, d'une manière générale, satisfaisant, des progrès substantiels ayant été enregistrés sur tous les aspects du programme. L'un des points saillants de la réunion a été l'approbation des objectifs expérimentaux du premier vol de Spacelab qui emportera une charge utile conjointe ASE/NASA.

L'examen des impératifs du programme au niveau des sous-systèmes (SRR), dirigé par l'ASE avec la participation de la NASA, s'est déroulé du 16 au 21 juin 1975 chez le maître d'oeuvre à Brême, en présence des co-contractants. Le but principal de cet examen était de concentrer les efforts pour mettre à jour les impératifs aux niveaux système et sous-systèmes et de vérifier s'il était possible d'accepter les spécifications de référence des sous-systèmes établies par le contractant et les plans de mise en oeuvre correspondants. Les spécifications de référence définies lors du SRR serviront de point de départ à la phase finale de conception des sous-systèmes, au cours de laquelle les interfaces seront définitivement arrêtées, les plans de fabrication préparés et les procédures d'essai mises au point. Les différents documents établis par le contractant ont été examinés à différents niveaux par les groupes d'examen compétents, en utilisant la procédure dite de 'Review Item Disposition' (RID).

Le contractant avait préparé pour le SRR une maquette d'agencement en vraie grandeur du Spacelab; celle-ci a permis d'évaluer la configuration intérieure, l'agencement des éléments, les possibilités d'accès et de maintenance, l'habitabilité pour les équipages et les interfaces.

Cette maquette restera chez le contractant en vue d'une utilisation ultérieure pour le modèle d'identification.

La concrétisation des résultats du SRR sous la forme d'études, d'actions pratiques, de changements et de modifications se fera dans les mois qui viennent, en préparation de l'examen préliminaire de la conception du système (PDR), lequel est prévu pour le début de l'année prochaine.

La mission commune NASA/ASE dénommée 'ASSESS' (Airborne Science/Spacelab Experiments System Simulation) a eu lieu en juin 1975. L'objectif d'ensemble de cet exercice était d'effectuer une simulation des techniques d'exploitation des charges utiles sous des contraintes analogues à celles du Spacelab. On a pu ainsi évaluer certains facteurs susceptibles d'affecter la conception des sous-systèmes, l'exploitation des expériences et l'aspect 'habité' de l'expérimentation Spacelab.

La mission ASSESS a comporté cinq vols, de six heures chacun, en six jours. Pendant ce laps de temps, les expérimentateurs ont été tenus isolés de leurs collègues scientifiques et des installations de soutien à l'exception d'un contact quotidien par liaisons phonie et vidéo.

Partant du principe que les travaux devraient être authentiquement scientifiques, l'ASE a financé trois expériences européennes pour la mission ASSESS tandis que trois autres, compatibles avec les premières, étaient fournies par des scientifiques américains. Ces expériences étaient essentiellement consacrées à la mesure du rayonnement infrarouge en provenance de l'atmosphère et de l'espace.

ARIANE

First firing of the complete third-stage HM7 engine

A complete HM7 engine was fired by SEP on the horizontal test stand at Villaroche for the first time on 27 May 1975. The test lasted 10 s, including 5 s at full thrust, and took place without a hitch. It was the first of a series of tests intended to finalise the start-up sequence for the complete engine.

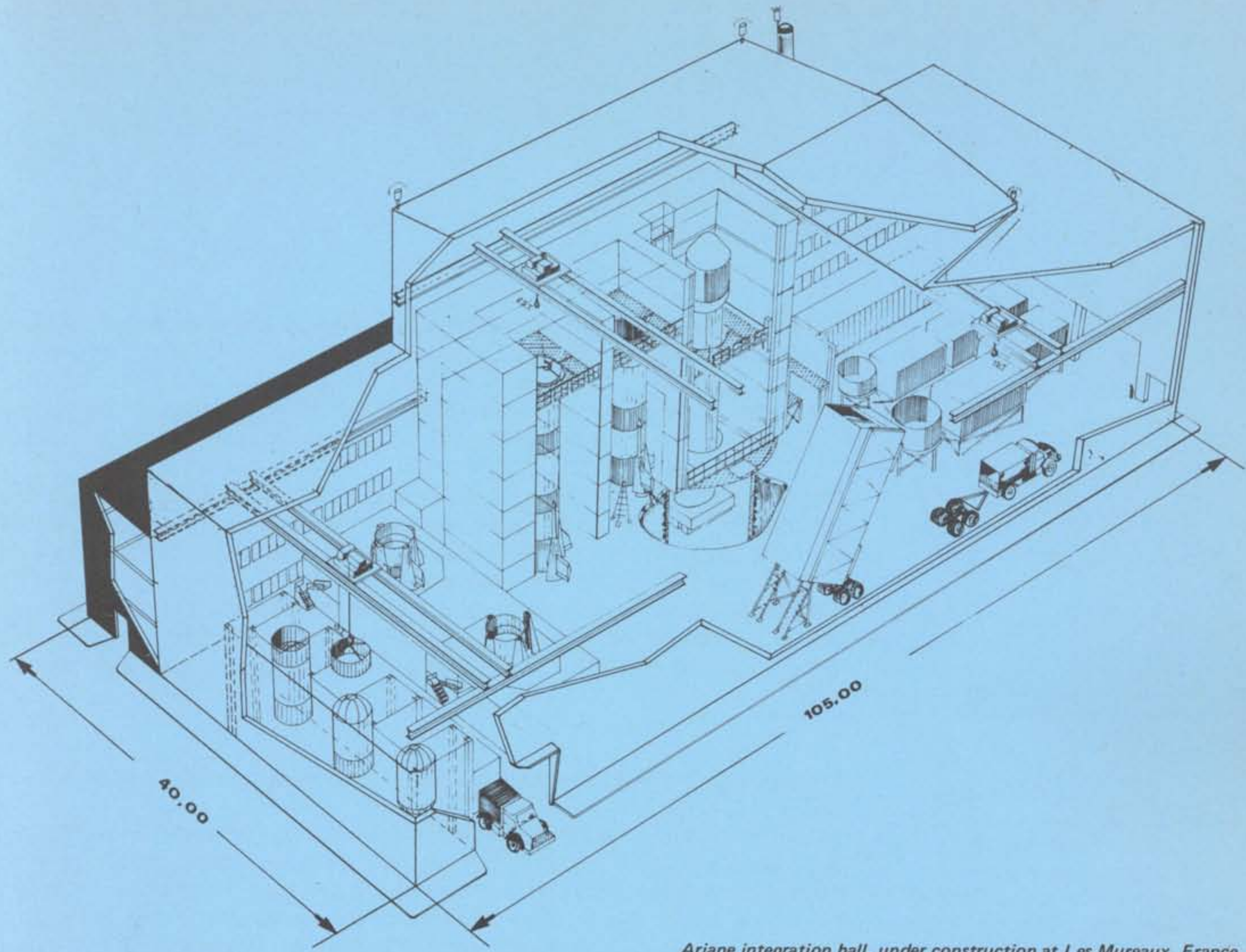
The soundness of the start-up principle as well as the correct operation of the complete engine and the test stand were demonstrated at this first test.

The HM7 engine powers the launcher's third stage (H8). It burns liquid hydrogen and liquid oxygen and produces a thrust of 60 kN for a chamber pressure of 30 bar. SEP has entrusted the development and manufacture of the combustion chamber's injection head and of the nozzle to MBB, Munich, while the development and manufacture of the turbopump and the integration and testing of the complete engine are being carried out by SEP itself at Vernon.

Passenger experiments aboard Ariane test flights

The proposal by ESA in March 1975 to fly passenger experiments on Ariane test flights aroused considerable interest. By 18 June, 77 experiment proposals had been received, and further propositions continue to arrive. All types of experiments are represented (scientific, technological and application), two of the proposals emanating from countries outside the Member States of ESA.

A briefing meeting organised by ESA at Frascati on 19 and 20 June brought together some 50 of the potential experimenters. The first day was devoted to a presentation of the launcher and the Ariane programme, and the second to a review of the experiment propositions in which interest had been



Ariane integration hall, under construction at Les Mureaux, France.

expressed. The review revealed several proposals relating to apogee motors and transfer modules. If these were to be flown, the range of experiments that could be achieved would be enlarged since, in addition to the 200/36 000 km elliptical orbit currently available, geosynchronous orbit could be envisaged for launches LO3 (mid 1980) and/or LO4 (end 1980).

It is expected that firm propositions will have been received by 30 September 1975. Thereafter, ESA will carry out the selection phase with a view to arriving at decisions by mid-1976. Following the Frascati meeting, consultation with the various potential experimenters is in progress to establish a first approach to possible configurations and their associated integration problems.

Première mise à feu du moteur complet HM7 du 3ème étage

Un moteur complet HM7 a été mis à feu par la SEP sur un banc d'essai horizontal à Villaroche pour la première fois le 27 mai 1975. L'essai a duré 10 s dont 5 s à plein régime. L'essai s'est déroulé sans incident. Il s'agissait du *premier d'une série d'essais destinés à la mise au point de la séquence de démarrage du moteur complet.*

La validité du principe de démarrage ainsi que le fonctionnement du moteur complet et du banc ont été démontrés dès le premier essai.

Le moteur HM7 est le moteur du 3ème étage (H8) du lanceur. Il fonctionne à hydrogène liquide et oxygène liquide et produit une poussée de 60 kN pour une pression de foyer de 30 bar. En vol, la durée de fonctionnement du moteur sera de 562 s. Le développement et la fabrication de la tête d'injection de la chambre de combustion, et de la tuyère ont été confiés par la SEP à MBB, Munich, tandis que la SEP, Vernon, développe et fabrique la turbopompe et effectue l'intégration et les essais de l'ensemble du moteur HM7.

Emport d'expériences passagers sur les vols de développement Ariane

La proposition d'emport d'expériences passagers sur les essais en vol Ariane, faite en mars 1975 par le CERS, a rencontré un grand intérêt chez de nombreux expérimentateurs potentiels: 77 propositions d'expériences ont été reçues le 18 juin et d'autres propositions continuent à être présentées. Tous les types d'expériences sont représentés (scientifique, technique, d'application) et deux d'entre elles proviennent d'Etats non-membres de l'ASE.

Une réunion d'information organisée par l'ASE à l'ESRIN (Frascati) a réuni une cinquantaine d'expérimentateurs les 19 et 20 juin 1975. La première journée a été consacrée à la présentation du lanceur et du programme Ariane, la deuxième à la revue des propositions présentées au titre des déclarations d'intérêt.

La revue des expériences proposées a révélé plusieurs projets de moteurs d'apogée et de modules de transfert dont l'emport, s'il était décidé, pourrait élargir la gamme des expériences réalisables; aux orbites elliptiques 200/36 000 km présentement offertes s'ajouterait l'orbite de satellite géo-synchrone qui serait envisageable pour les lancements L03 (mi-1980) et/ou L04 (fin 1980).

Il est prévu que des propositions fermes seront remises pour le 30 septembre 1975. Après cette date commencera la phase de sélection par l'ASE des expériences à embarquer sur les vols d'essai; les décisions correspondantes devraient être prises pour la mi-1976. Suite à la réunion de Frascati, la concertation se poursuivra avec les différents expérimentateurs potentiels pour une première approche des configurations possibles et des problèmes d'intégration associés.

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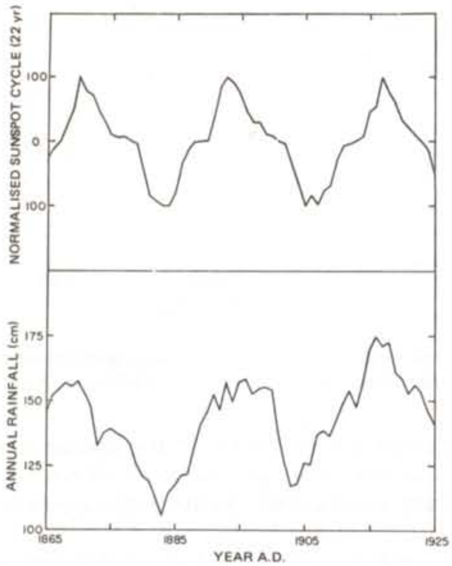

Figure 1 — Smoothed annual rainfall at Fortaleza, Brazil (after Markham, 1974).

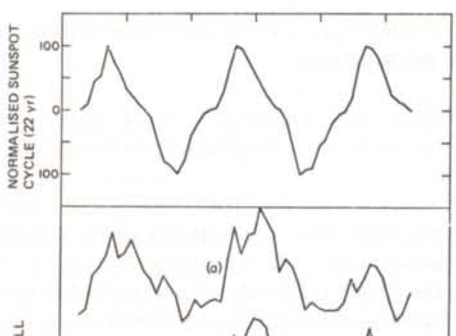

Figure 2 — Smoothed annual rainfall at (a) Rustenburg, (b) Bethal, and (c) Dundee, South Africa (after Tyson, 1974).

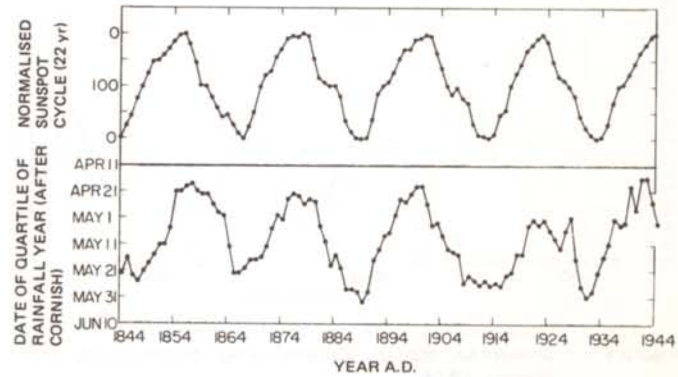

Figure 3 — Ten-year smoothed means of the date by which one quarter of the yearly rainfall fell at Adelaide, Australia (after Cornish, 1954).

a symmetry with respect to the geomagnetic rather than to the geographic pole. The main features suggested by the picture are an increase in height in the region of the geomagnetic pole and a wide region of fall in height coinciding quite well with the auroral zone'. Results such as these show that the circulation of the lower atmosphere is significantly modified after solar flares. The circulation, as measured by the vorticity at various heights in the troposphere, also appears to be modified at times when the interplanetary magnetic field sector boundaries cross the Earth. These boundaries originate at the Sun and sweep across the Earth as they rotate during the 27-day solar rotation.

Solar phenomena tend to recur with periods of the order of 27 days, the synodic period of revolution of the Sun. 27-day periodicities in wind speed and in soil temperature have been documented, and many authors have reported associations between magnetic activity and lower atmospheric phenomena.

ROLE OF THE EARTH'S MAGNETIC FIELD

Several studies have shown that Sun-weather relationships are most pronounced in the vicinity of the auroral zone. Figure 6 shows the latitudinal variation of the change in surface pressure (averaged around the Earth at particular latitudes) between sunspot minimum and sunspot maximum, calculated by the author from published data. The pressure variation associated with the 11-year sunspot cycle is particularly large in the auroral belt.

The evidence suggesting that the lower atmosphere is influenc-

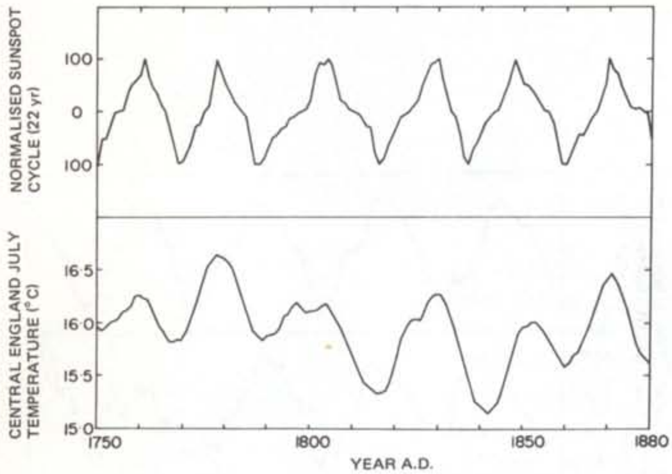

Figure 4 — Smoothed central England July temperatures (after Manley, 1974).

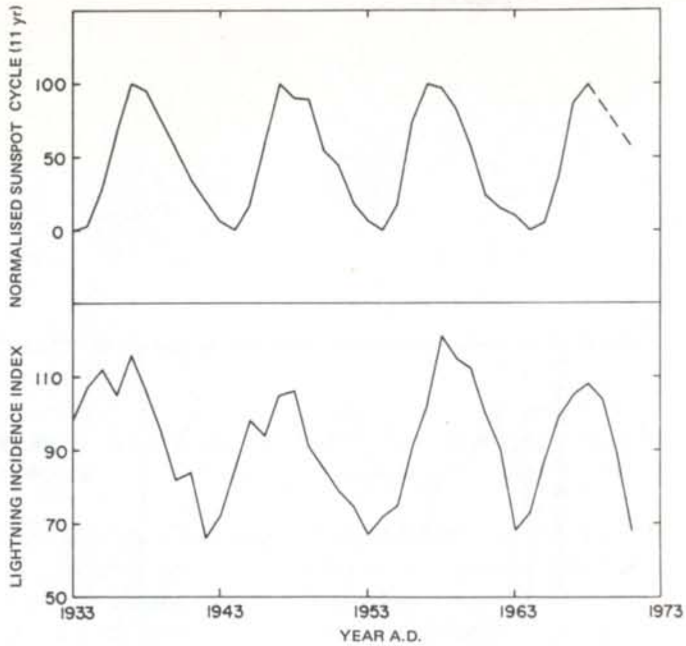

Figure 5 — Five-year means of the annual lightning incidence index for Great Britain (after Stringfellow, 1974).

ed by the auroral zone is perhaps not conclusive, but it is certainly sufficient for us to hypothesise that some of the observed Sun-weather relationships are caused by energetic particles that enter the atmosphere at auroral latitudes and, through some unknown mechanism, influence the circulation of the lower atmosphere. If this were the case, it would be expected that the geomagnetic field as a whole would influence the lower atmosphere. Several authors have in fact drawn attention to the high degree of similarity between meteorological and geomagnetic contour maps. Such similarity between different parameters is unusual in geophysics and, although it does not prove anything, its implications should not be lightly dismissed, particularly since existing models of the atmosphere do not satisfactorily explain the behaviour observed at high latitudes.

Figure 7 shows oxygen isotope data (which provide a measure of temperature) and magnetic intensity values obtained from a single deep-sea core formed during a 500 000 year period; cold epochs occurred when the magnetic intensity was relatively high, and vice versa.

POSSIBLE MECHANISMS INVOLVED IN SUN-WEATHER RELATIONSHIPS

It has been shown that various empirical Sun-weather relationships exist and that the Earth's magnetic field may play a role in bringing some of these about. It would therefore be useful to identify geophysical phenomena that vary during the solar cycle and that are also influenced by the Earth's magnetic field. One such phenomenon is cosmic rays; the effects of the sunspot-cycle-induced changes of lower-atmosphere conductivity on atmospheric electric fields, cloud formation, temperatures, thunderstorm activity and rainfall do not appear to be clearly known at the present time and the possibility that the solar-cycle variation of cosmic rays may lead to certain Sun-weather relationships cannot be rejected.

Another atmospheric parameter that varies during the sunspot cycle, and possibly also during short-lived solar events, is the total ozone content. Although it is not known whether such temporal variations of ozone cause or are caused by weather effects, it appears that ozone and weather disturbances are associated.

Apart from cosmic rays and ozone, other mechanisms that may possibly be involved include:

(a) The influence of energetically weak upper-atmosphere phenomena on lower-atmosphere systems that are close to resonance.
(b) The solar-cycle variation of the frequency of occurrence of short-lived phenomena; the response of the troposphere to the 11-year sunspot cycle may represent merely an integration of the effects caused by short-lived phenomena such as solar flares or geomagnetic storms which are much more frequent at sunspot maximum than at sunspot minimum.
(c) The effect of water vapour formed from solar-wind protons.
(d) The effects of possible, but as yet unknown, solar-cycle changes in the 'solar constant', i.e. in the total electromagnetic energy radiated by the Sun.
(e) Variations in the efficiency of the coupling between the solar wind and the magnetosphere as the direction of the interplanetary magnetic field varies during the sunspot cycle.
(f) The variable reflection by the upper atmosphere of upward-propagating gravity-wave energy.

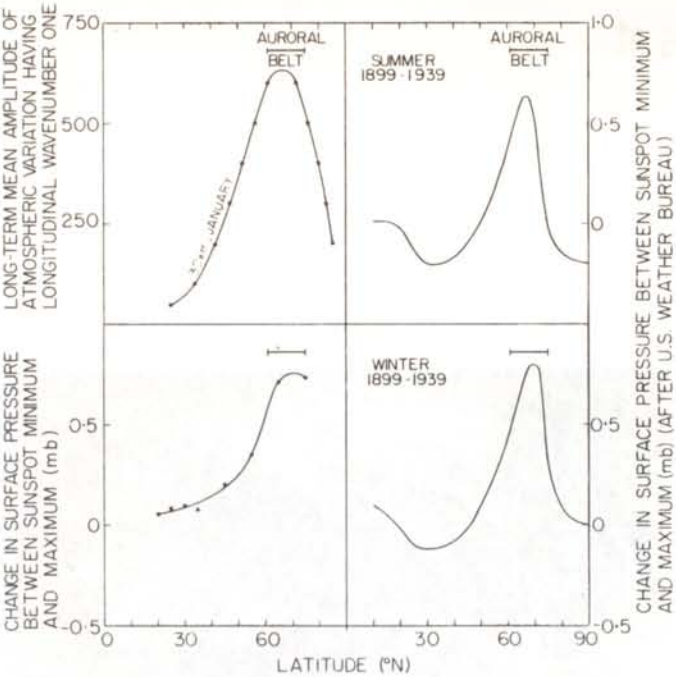

Figure 6 — Evidence suggesting that Sun-weather relationships are most pronounced in the auroral region. (Data from Wexler, 1953; Van Loon et al., 1973 and Miles, 1974).

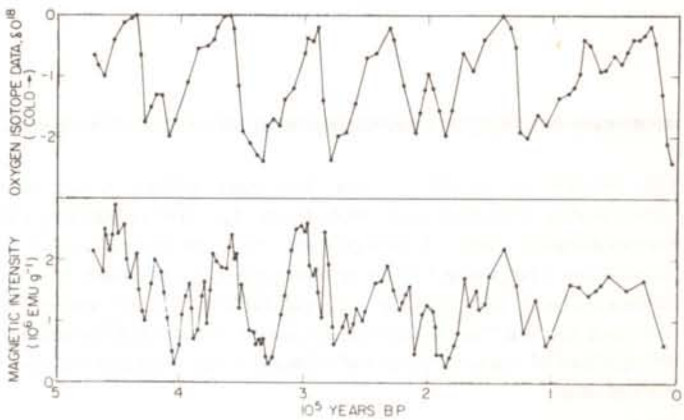

Figure 7 — Magnetic and climatic data obtained from a single deep-sea core (after Wollin et al., 1974).

IMPLICATIONS OF SUN-WEATHER RELATIONSHIPS

Energy budgeting and electricity distribution. Between 1900 and 1960 in Maryland, Delaware and Virginia (USA) oscillations of temperature averaging 2.5°C (4.5°F) occurred with 'a marked cyclic movement with about 22 years between successive peaks'; these oscillations are in phase with, and there seems little doubt that they are associated with, the 22-year sunspot cycle. A 2.5°C temperature oscillation extending over large areas will obviously affect the demand for energy.

Food production and famines. Several authors have drawn attention to the influence of the sunspot cycle on agricultural productivity; relationships between the solar cycle and agriculture are hardly surprising when one is reminded, for example, that the phase of the annual rainfall variation can vary by six weeks during the double solar cycle (Fig. 3).

The World wheat production figures for 1949-73 can be used to show how the sunspot cycle influences food production; it has been concluded that the present low level of food reserves may be associated with the decline in solar activity during the approach to the 1974-75 sunspot minimum.

Inadvertent man-made weather modification. The Canadian electrical power distribution system is reported to trigger VLF emissions in the magnetosphere. Such emissions are known to induce electron precipitation and, if particle events do indeed affect the circulation of the troposphere as suggested earlier, then there is a real possibility that electricity distribution systems may influence the lower atmosphere.

National economic systems. Several authors have gone so far as to suggest that solar-cycle-induced meteorological effects may be sufficiently important to influence the economies of industrialised nations. Current opinion seems still to be that held by the economist J.M. Keynes, who concluded in 1961 that the possibility of solar-cycle-induced meteorological phenomena playing a part in harvest fluctuations, which in turn affect the trade cycle, should not be lightly dismissed.

CONCLUSIONS

All the 'possible mechanisms involved in Sun-weather relationships' require further study to determine whether or not they play a role. It appears unlikely that significant progress will be made until the global morphology of, and particularly the role of the auroral zone in, Sun-weather relationships is known. The temporal coincidence of two major international meteorological and geophysical programmes, the Global Atmospheric Research Programme (GARP) and the International Magnetospheric Study (IMS), later in this decade may well stimulate, and provide a golden opportunity for, collaboration between two groups of scientists who must surely interact more than they do at present — meteorologists and space physicists.

REFERENCES

Full details of the published literature on which this review has been based can be obtained from the author, Dr. J.W. King, Appleton Laboratory, Ditton Park, Slough SL3 9JX, England.

The Scientific Aspects of Meteosat

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The advent of satellites over the past fifteen years has considerably affected our techniques for the collection of meteorological data. Satellites are now providing modern technology's response to the growing operational needs of the meteorological community, needs which reflect society's demands for ever more accurate forecasts, due to the increasing recognition of the economic and humanitarian values of weather forecasting.

The increasing availability of more powerful computers permits greater forecasting accuracy, provided that sufficient meteorological observations are available to determine the three dimensional distribution of atmospheric parameters at a predetermined time (initial state). Numerical integration methods can be applied to extrapolate from the observed state to the forecast state. Unfortunately the existing ground-based observation network is quite inadequate to supply input data of sufficient density and frequency. Furthermore, far from expanding to meet operational requirements, the network trend is one of continuous contraction because of economic and staffing difficulties.

For these reasons, since 1960 experimentation with techniques for collecting meteorological data by satellite has been undertaken. In fact, satellites provide important operational advantages, such as the ability to collect data from extremely wide areas of the Earth's surface, automatically, on a systematic, reliable, homogeneous basis and with an accuracy and resolution linked closely with the state-of-the-art of detector technology (one of the most rapidly advancing).

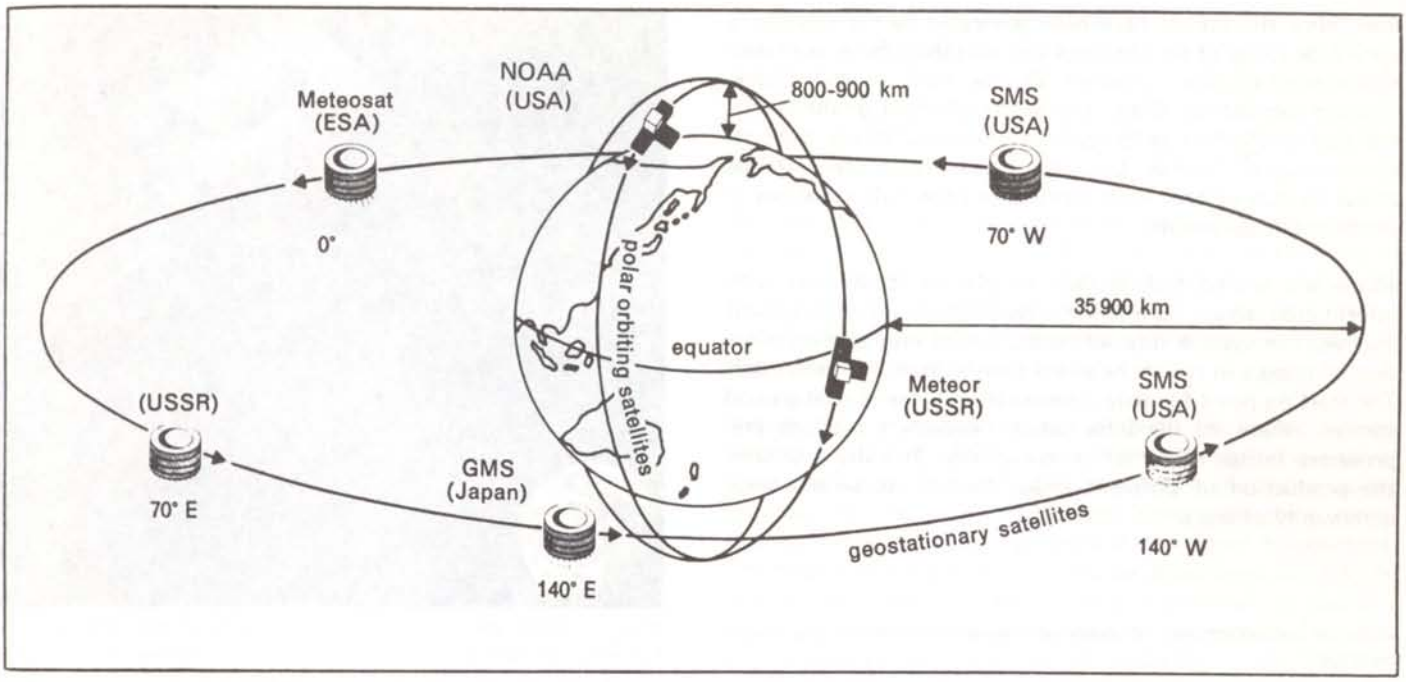
Augmentation (and, in part, replacement) of the conventional observation network to make it more cost effective is not, however, the only advantage of satellites. There are observations that could not be obtained at reasonable cost except by using satellites (large-scale cloud patterns, outgoing radiation, upper atmosphere water vapour). Thus, satellites not only provide data for forecasting models, but also influence the design of the models themselves, through their contribution to a better understanding of atmospheric behaviour.

The case for a European effort in satellite meteorology is therefore obvious. The cost-effectiveness of weather forecasting is very difficult to assess (estimates range from 20 to 200), but as it grows with increasing volume of transport and population density, it should certainly be very high for Europe. Thus the Meteosat programme should assign Europe its appropriate position in the framework of the world-wide meteorological community.

THE AIMS OF METEOSAT

The objectives of the European meteorological satellite programme were studied extensively around 1970. A decisive contribution to the fixing of priorities came with the development of the Global Atmospheric Research Programme (GARP), which first adopted numerical simulation techniques to determine objective requirements for a rational planning of observation systems. This GARP activity was intended as a preparatory for the First GARP Global Experiment (FGGE), a one-year campaign of measurements (presently scheduled for 1978-79), one of the objectives of which is to qualify an optimised global observation system to be used as a reference by the operational World Weather Watch (WWW) programme.

One of the earliest findings of the GARP Numerical Experimentation Programme was that long-range forecasting would



be unreliable even at mid latitudes if the Earth's tropical belt were not suitably monitored with wind observations. Furthermore, it was apparent that correct parameterisation of convection in the belt of tropical cyclones is essential for the description of the meridian transfer of energy on the Earth's surface.

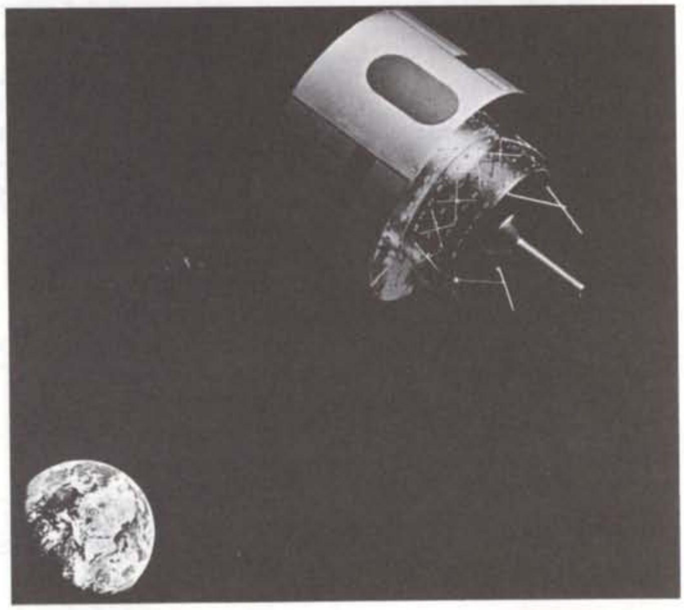
These findings created a demand for the development of geostationary satellites. It was estimated that a chain of four (possibly five) spaced equally around the equator, would satisfy the needs for wind estimates in the tropics and for surveying convection; two (possibly three) polar satellites would complete Earth coverage, providing vertical atmospheric temperature and humidity profiles (the most essential data at high and mid latitudes).

While the need for polar satellites was apparently satisfied by the American NOAA satellites and the Soviet Meteor, a large void was still to be filled in the field of geostationary spacecraft, the only advanced programme being the American SMS for two satellites (now flying) over the eastern Pacific and western Atlantic. Thus, highest priority was assigned in Europe to the development of a geostationary satellite, and this has provided Europeans with an excellent opportunity to play an essential role in the World Weather Watch's future Global Observing System.

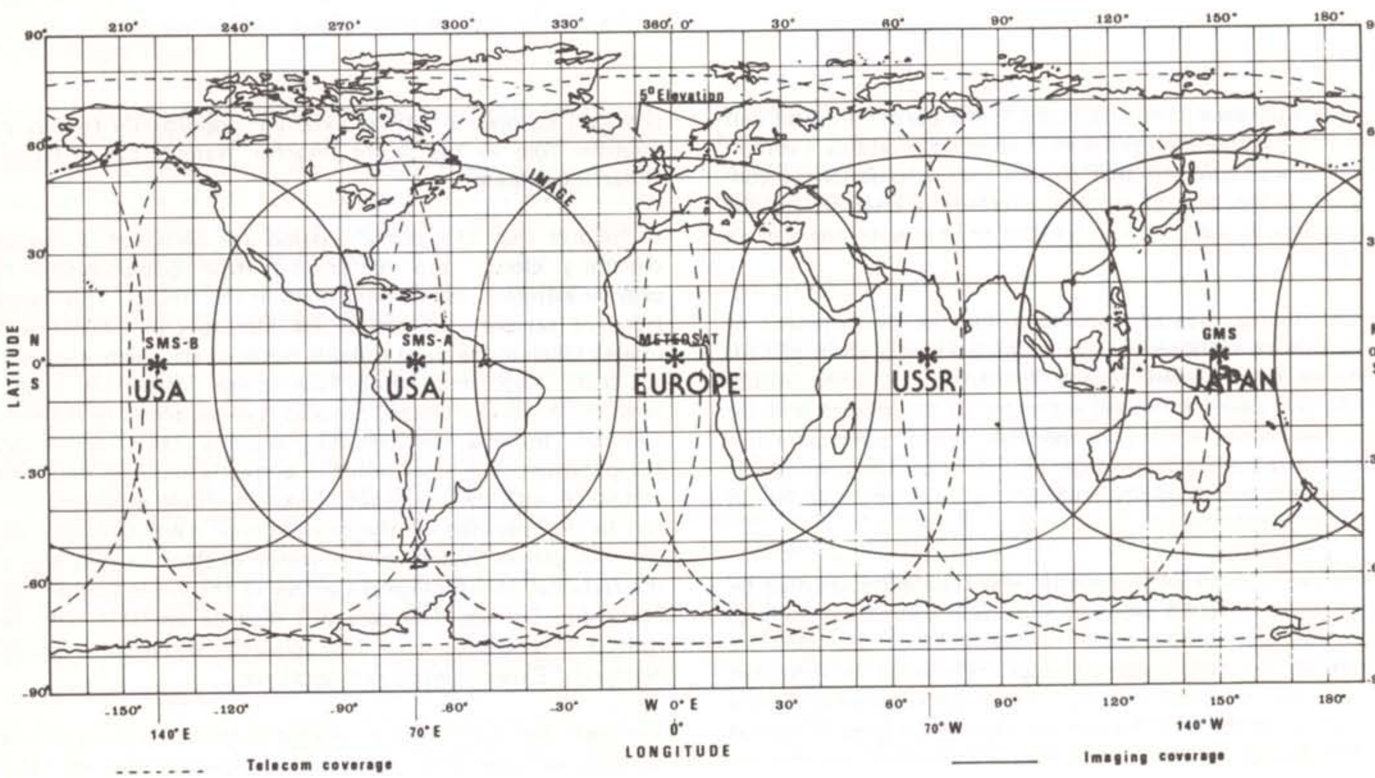
It follows that the prime mission for Meteosat is one of detecting clouds and recognising their displacements to provide estimates of the wind field in the tropics. This means frequent sampling of clouds (as atmospheric tracers) with images taken in the most suitable bands of the electromagnetic spectrum. Wind monitoring from image comparison is not, however, a straightforward process. It needs access to the most complete information (including satellite status) and heavy computation. The final result is a greatly reduced data flux compared with the initial set of images. These processed data can be disseminated via the conventional WWW Ground Telecommunication System to the World Weather Centres and to the National Meteorological Centres of the World Global Data Processing System. The data will then be available both for routine operations, and for research within the GARP Numerical Experimentation Programme.

The basic Meteosat mission concept is one of an observational satellite, and a ground station with processing facilities. However, once the images have been generated by the satellite, a very wide range of possible applications (apart from wind data extraction) become apparent in the field of short-range weather forecasting. Within the general concept of the WWW, the task of short-range forecasting is assigned to the National Meteorological Centres, because of their need for real-time access to data of only local interest, and the wide variations in processing requirements.

Meteosat's second task is then to provide local users with information about convection development, cyclone genesis and weather-system displacements, which implies dissemination of images in real or near-real time to each interested user. The starting point for data dissemination is the central ground station, where all the information needed to produce pre-processed images ready for use is available. This also facilitates the production of different image formats, to serve a wide community of users.



Meteosat spacecraft and its proposed telecommunication and image coverage.



The concept for this second task includes a central station as a source of pre-processed images, a network of peripheral receiving stations, and a satellite as a relay. In this respect, it is irrelevant that the images are originally generated on board the satellite itself: in fact, images from other satellites, or even documents other than images (such as weather charts, provided they are properly formatted) can be disseminated via this system. Telecommunication facilities always present the WWW with a considerable problem, not only when high data rates are involved, but also when the terminal is a small unit, such as an observing station.

Meteosat's third role is to promote the growth of the WWW surface observation network, by providing a reliable telecommunications link, always available to any station regardless of any problems arising from its position relative to the collection centre. This means a system in which a multitude of remote Data Collection Platforms (DCP's) can transmit their *in situ* measurements to the central station via a single relay, the satellite.

Clearly, the Meteosat mission, although originating initially from requirements of a scientific nature, is deeply oriented towards operational applications. The link between the scientific requirements (from FGGE) and these operational applications can be identified in the real-time mode of the system, depending essentially on the concept of complete image processing in the central station, and the nature of the information dissemination. This is perhaps the most characteristic feature of the European programme as opposed to the other geostationary satellite programmes. No other geostationary satellite system involves either a central station with as many processing tasks as Meteosat's, or such a powerful image dissemination system.

IMPACT OF TECHNOLOGY ON THE METEOSAT MISSION

The transformation of mission requirements into system performances has been conditioned by the available technology, and of course financial limitations, in Europe. The time schedule of the FGGE, and thus the need to use current technology and existing studies (mainly the definition studies conducted in France by the Centre National d'Etudes Spatiales), have played an important role. Although a detailed discussion of the technology of Meteosat is not appropriate here, the impact of the final design on the projected mission does merit comment.

First, the radiometer. The imaging mission is intended to: (a) sample clouds at appropriate intervals compared with their development rate; (b) estimate cloud displacement with the accuracy requested by GARP; (c) estimate the height of tracers used for wind determination. These three requirements give rise to three technological 'decisions': (i) choice of cycle time for images; (ii) choice of image resolution; and (iii) choice of spectral bands.

The first two choices are quite straightforward: one image per half hour, resolution about 4 km. The choice of the spectral bands, however, is conceptually more complex, and if the present plan for a water-vapour channel is maintained, Meteosat's radiometer might be regarded as the most advanced in this generation of geostationary satellites.

In fact, the primary aim in tracer sampling is to detect as many tracers as possible. Visible and infrared channels show essentially the same features (liquid water). A water-vapour channel, on the other hand, may show something more, namely the water-vapour patterns in the upper troposphere. The nature of the tracer must also be determined, in order to identify its radiative properties (e.g. emissivity), so that the necessary corrections to the measured radiances can be made. In this respect, the three-channel capability of the Meteosat radiometer gives it the potential to remove a very large number of ambiguities in determining the nature of the tracers. For instance, comparison of visible and infrared windows can discriminate stratus from cumulus clouds, while comparison of infrared and infrared-water-vapour channels can discriminate between cirrus and cumulus clouds; furthermore, the water-vapour channel is the most powerful discriminator between clouds and any Earth-surface feature. Finally the height of the tracer must be determined in order to assign the wind to the proper atmospheric layer. Here the radiometer's highly sophisticated infrared channel (best resolution and radiometric accuracy of any infrared ,radiometer yet to be flown at geostationary altitude) is likely to perform sterling work.

Turning to data dissemination, the novel problem for Meteosat is the wide range of users in the satellite's field of view, compared with other geostationary satellites (the American spacecraft, for instance, serve only a very limited number of meteorological services, each responsible for a very wide area). In Meteosat's case, cheapness and operational simplicity of the peripheral data acquisition stations are essential to promote use. This is why major emphasis has been given to time-stretched, APT-compatible dissemination, and this in turn has led to the satellite having two high-power dissemination channels (no other geostationary satellite of the same generation will have as many). At first sight, the emphasis given by the Europeans to this technologically unexciting and rather inefficient means of data dissemination, a real bottleneck in a system that provides data rates of some 170 kbit/s, may seem questionable. Nevertheless, a deep sense of realism and a strong commitment to the basic WWW concept have fostered this baseline choice, which will certainly allow a much wider meteorological community to experiment with Meteosat data for local application.

At the same time, however, nothing in the Meteosat system precludes complete information dissemination in real time. The high-data-rate, digital dissemination mode will be capable of a very wide range of possibilities, including the acquisition of all information in real time. This digital mode alone provides the inherent flexibility that allows the best use of the geostationary satellite's data.

Clearly, a good deal of emphasis has been given to the dissemination aspect of the Meteosat mission. One futher example is the plan to use the satellite to relay images taken by the American geostationary satellite sited over the Atlantic. These data are of primary importance for European services, but in practice they can only be acquired by a station at the extreme west of Europe – that of the Centre d'Etudes de Météorologie Spatiale, Lannion. The Meteosat dissemination system will be used to relay these data from Lannion to other European users.

Lastly, a few words about the Meteosat Data Collection Platforms. The system has been conceived to handle a wide variety of platforms (self-timed, interrogable, alarm platforms), in order to serve requirements arising both from meteorology, and from other environmental sciences such as oceanography and hydrology. The technological challenge here is to demonstrate high reliability and flexibility at low cost. If Meteosat succeeds in this, it will have a very large impact on the planning of future observational networks.

EXPECTED CONTRIBUTION OF METEOSAT TO METEOROLOGY

The previous discussion shows that careful definition of the Meteosat mission and the positive response of European technology have generated a first-class programme which will have a substantial impact on the future of meteorological operations and research both within and outside Europe.

First, the importance of the processed data to be extracted at the central station as the final step in the Meteosat primary mission has to be emphasised.

The absolute need for wind monitoring in the tropics has already been stressed as essential input to numerical models for long-range forecasting. What still remains to be mentioned is the importance of wind measurements for short-range forecasting at mid latitudes, when small-scale perturbations have to be accurately described. In general, the wind field cannot be extrapolated from the mass field (and thus has to be measured independently) either because of the low latitude, or because of the short wavelength of the perturbations.

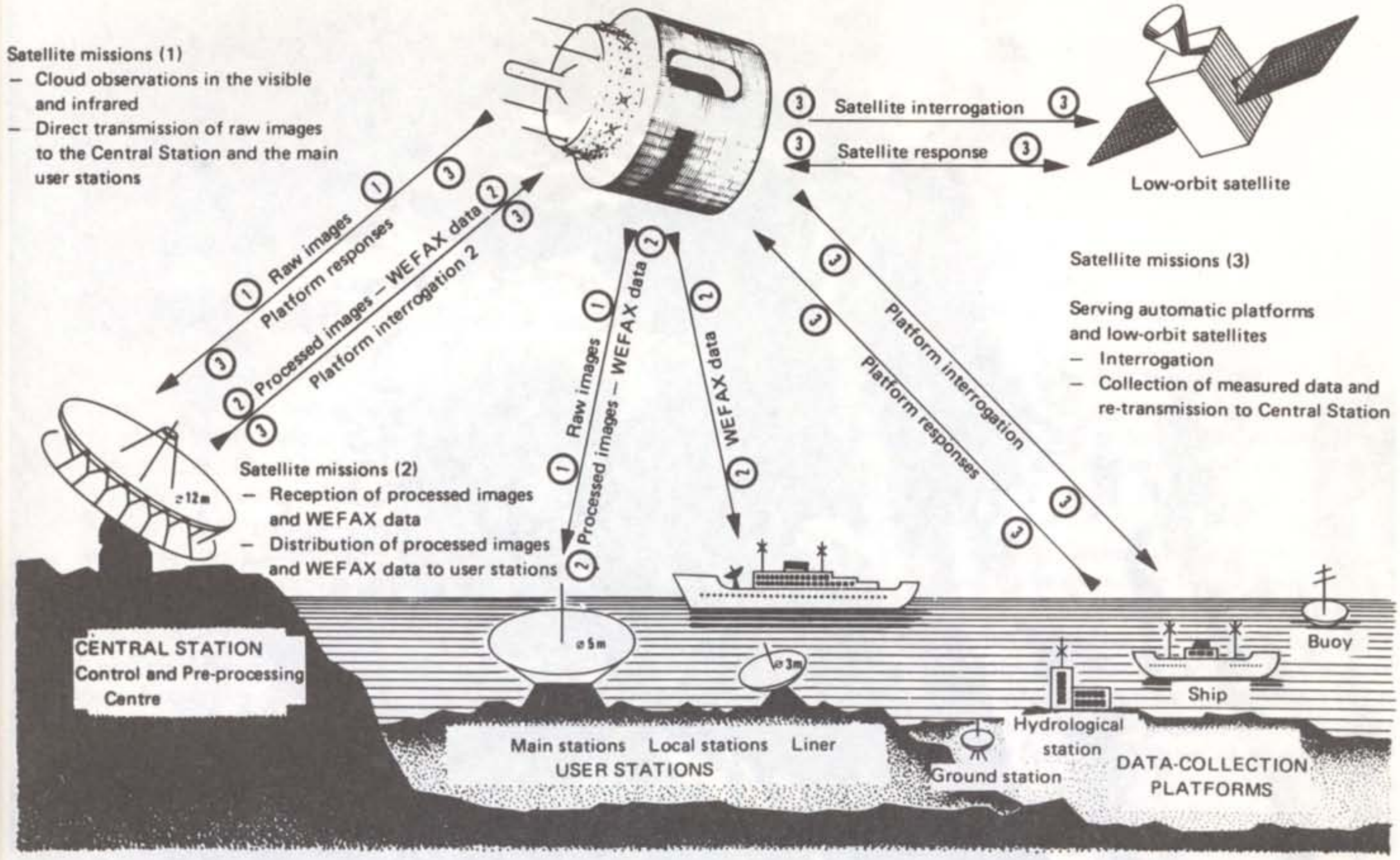
The combined effect of latitude and wavelength in determining the imbalance of wind field and mass fields is enhanced in southern Europe, where complex orography is a permanent source of short waves. These regions will fortunately fall in that part of the Meteosat image which is most useful for the extraction of processed data.

Another product of image processing at the central station is expected to be sea-surface temperature data. These data are needed for the parameterisation of heat and water-vapour fluxes through the Earth-atmosphere boundary layer, an essential process to be taken into account in numerical models for long-range forecasting. Parameterisation of the radiative heat flux is also important in long-range forecasting, and usually takes into account cloudiness, the main parameter affecting radiation transfer in the atmosphere. Cloudiness percentage and type data will constitute an interesting experimental product from the central station.

If the water-vapour channel is available, extraction of the water-vapour content of the 7-11 km atmospheric layer will be attempted. These data cannot be obtained from the ground, as hygrometric radiosonde measurements are rather inefficient at high altitude. Apart from their direct use in numerical models, they will also be important for correcting the infrared measurements for inferring the total long-wave radiation from the Earth-atmosphere system to outer space. If it proves feasible to deduce the reflected solar radiation from the visible channel, estimates of the radiative budget between the Earth-atmosphere system and outer space can be attempted.

All data mentioned so far are intended for use in numerical models. Other data could, however, be extracted for qualitative applications; the fine-mesh cloud analysis, for example, will provide the positions and maximum heights of clouds that interfere with aviation flight paths at cruise altitudes.

Turning to the utilisation of the images available to peripheral users through the dissemination mission, one of the most obvious applications of Meteosat images will be in equatorial



Overall Meteosat mission, showing the types of data transmitted to and from the satellite.

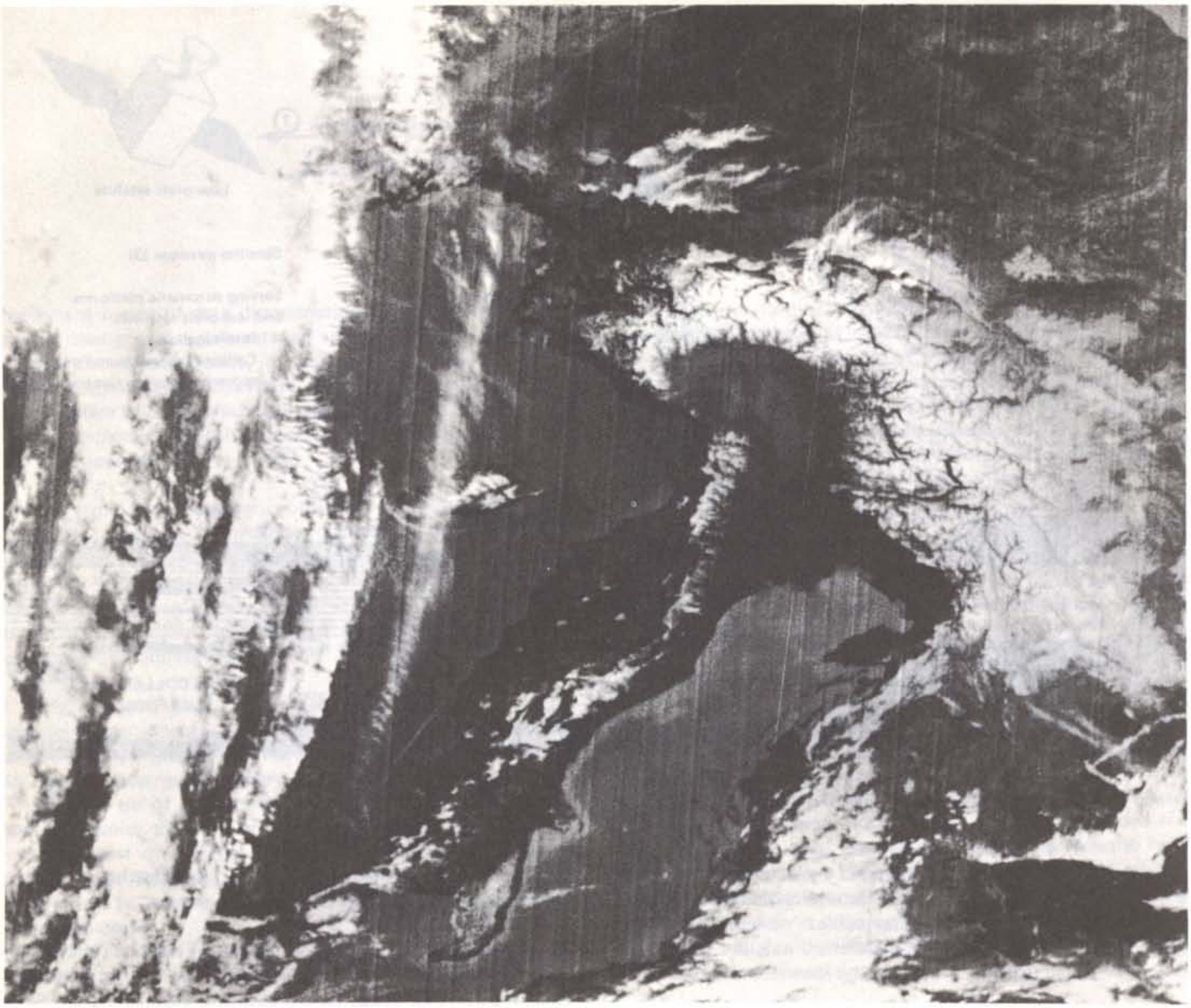
regions, where weather is dominated by convective systems that develop in a matter of hours. Deterministic forecasting of such phenomena is virtually impossible: 'now-casting' from sequences of images from a geostationary satellite seems the only practicable method, at least in the foreseeable future.

The provision of frequent Meteosat images at more European latitudes will also be very worthwhile for short-term forecasting. The meteorology of the Mediterranean area, for instance, is characterised by frequent short-wave disturbances imposed by the complex orography of southern Europe and northern Africa on the general long-wave circulation. Such orographic cyclone genesis, which occurs within air masses of very high potential energy into which abundant water vapour is injected by the relatively warm Mediterranean, usually occurs over the sea where, due to the very poor station density, it may well remain undetected. The continuous monitoring provided by Meteosat will solve this problem, which can also be found in other European areas, such as over the North Sea.

Apart from playing an essential role in detecting convection growth and cyclone genesis, Meteosat will provide the means for a continuous survey of the synoptic-scale perturbations that approach Europe from the Atlantic, where the sparse observation network is again insufficient at present for accurate determination of location, speed and stage of development of those atmospheric disturbances that determine the weather of at least all of Western Europe.

These applications of Meteosat images at national meteorological service level will be complemented by their utilisation at small operational units, if the cost and complexity of APT-type acquisition stations prove acceptable. Two of the more obvious examples of applications of this type could be continuous weather monitoring at airports and precipitation surveying by civil protection authorities.

The role of Meteosat in relaying messages from Data Collection Platforms involves a two-stage campaign. The first step is to automate the observation network, but, in spite of the increasing cost and difficulty in recruiting, automation programmes are very slow to be implemented, due partly to the high investment needed and partly to technical problems, including the development of automatic sensors. The second is to show the advantages of using the satellite for telecommunications. These are quite apparent in the case of remote stations, such as ocean buoys, and in the case of mobile platforms, such as shipborne DCP's or free-floating balloons or drifting buoys. For land stations or nearshore buoys, however, the case for collecting messages via a relay some 36 000 km away may seem doubtful. It has to be remembered however that once the Meteosat system has been implemented for its primary mission, the DCP role can be achieved at very marginal cost. If



NOAA-2 very-high-resolution radiometer imagery of the Alps and Italy, illustrating cloud formation over the Mediterranean.

it is assumed that the payload on the spacecraft, the data processing at the central station, and the dissemination of messages via the existing meteorological communication network are free of direct cost to the platform owner, the economy and simplicity of space relay becomes very attractive to the user, who has only to ensure that his platform is provided with the appropriate interface to the satellite. It may thus be that the Meteosat system, with its operational simplicity and the attraction of a new technology, will provide an important stimulus to the now somewhat dormant programmes for automating meteorological, hydrological and oceanographic observation networks.

ROLE OF METEOSAT IN RESEARCH

All that has been said so far about the value of the Meteosat programme for meteorology has been biased largely towards operational applications. However, it should always be borne in mind that 'operational' in meteorology has a very dynamic meaning. It does not imply the concept of a fully standardised input/process/output chain. Although the output is used operationally, the method of producing it is subject to continuous development. The data that Meteosat provides to the operational services will be both a contribution to operations and a contribution to research and development.

Nevertheless, it is worth mentioning here a few applications that are more directly intended to improve our basic knowledge of the dynamics of the atmosphere. These purely research applications are quite appropriate for a satellite that will operate during the FGGE.

First, the research value of Meteosat images for achieving a better understanding of the general circulation of the atmosphere has to be stressed. The main contribution will be the observation of the inter-hemispheric mass and energy flow, linked to the phenomenology of the Inter Tropical Convergence Zone (ITCZ). The GARP Atlantic Tropical Experiment (GATE, performed during Summer 1974) established the extreme value of geostationary satellites for observing and then modelling the ITCZ's perturbations throughout the convective-cells phase, the cloud-cluster phase, and the development of tropical cyclones.

Studies of atmospheric circulation at intermediate latitudes, like those of southern Europe, will also form an interesting application for Meteosat, especially in the transition seasons, when the interactions between tropical and mid-latitude circulations tend to be more intense.

Isolated convection development will be another important research item for Meteosat, with its capability for sampling cloud fields very frequently compared with their growth rates. There is still much to be learned about the relations between the onset of convection and environmental conditions, such as diurnal variations in solar heat flux, positions of larger scale perturbations, and boundary-layer features.

One general research item, which in a sense underlines what has already been said, to which Meteosat will make a major contribution is the study of energy transfer between different scales of motion. Correct parameterisation of these processes is essential if the limits of predictability of atmospheric motion on a given scale are to be extended as far as possible.

Lastly, it is very difficult at this moment to forecast all the research that Meteosat may foster in the field of radiation balance. The ability of the geostationary satellite to supply the total long-wave outgoing radiation is certain, provided the water-vapour channel is included. Hopefully, the ability to measure reflected solar radiation at different solar-elevation angles may be sufficient to determine the total reflected radiation. It must be remembered, however, that all the large-scale radiation studies that have been performed to date have been based on much less data than those that may be stimulated by the Meteosat mission.

This review of potential applications of Meteosat data in research confirms that the requirement for permanent archiving of all digital information generated by the satellite is well justified.

CONCLUSIONS

An attempt has been made to review the scientific aspects of Meteosat, considering only the potential of the mission as defined and the expected system performances, in comparison with the requirements of the meteorological and scientific communities.

The real use of the data will depend on the development of techniques for handling the dramatically large amount of data generated by the satellite. This problem has been resolved in the case of the central station, but has not yet been considered for the peripheral acquisition stations, where definition of operations for retrieving information from images is left to the user. It is hard to believe that a simple sequence of hard-copies will suffice; electronic or optical animation of image sequences, contrast enhancement, etc., are possibilities open to peripheral stations (the digital, at least), but as there are no provisions in the current programme for the co-ordinated development of suitable, standardised facilities, the users themselves will have to show considerable initiative (and support development costs) in this field.

Optimum use of Meteosat will depend on well-balanced application of its data in combination with data from other sources, such as (i) polar satellites, to have a periodic, very-high-resolution look at the weather systems and information on the vertical thermal structure of the atmosphere; (ii) the network of surface observation stations (possibly automated DCP's), to calibrate satellite-observed cloud systems in terms of actual weather on the ground; and (iii) the meteorological radars, to obtain information on the vertical structure of clouds.

Any effort directed towards making the best use of Meteosat is conditioned by suitable guarantees that this programme, if it succeeds, will be followed by a long-range operational phase. These guarantees do not exist in Europe at the present time. It seems agreed that the prototype will be kept in operation for all of its useful life. It also seems feasible (but is not yet agreed) to launch the spare unit to prolong the life of the Meteosat system to some five years. However, guarantee of an operational phase means something more; it means duplicating and launching the satellite indefinitely until obsolete, and at the same time preparing the next generation of satellites. Is Europe ready to take on this long-range engagement in space meteorology? This is the question to which the meteorologists themselves impatiently await an answer!

ESA's Future Scientific Projects
Projets scientifiques futurs de l'ASE

E. Peytremann, Head of ESA's Future Scientific Programmes Department/Chef du Département des Programmes scientifiques futurs

This year, ESA is conducting several feasibility (Phase A) studies of missions that have been recommended by the Agency's various scientific advisory committees but which have not yet been approved by the Science Programmes Committee. The following is a brief review of those Phase-A studies now in progress and of a number of other possible future projects, some oriented specifically towards Spacelab, that are as yet still in the mission - definition phase.

L'ASE mène cette année plusieurs études de faisabilité (dites de Phase A) concernant des missions recommandées par divers Comités consultatifs scientifiques de l'ASE mais non encore approuvées par le Comité du Programme scientifique. Dans cet article, on passe rapidement en revue ces études de Phase A actuellement en cours ainsi qu'un certain nombres d'autres projets plus spécifiquement orientés vers l'utilisation du Spacelab et qui sont encore dans la phase de définition de mission.

OUT-OF-ECLIPTIC AND SOLAR STEREOSCOPIC MISSION

This mission, which is a candidate for a joint ESA/NASA venture, involves two spacecraft which would travel out of the ecliptic plane (the plane in which the Earth travels around the Sun) with the help of Jupiter's gravitational field. Each spacecraft would then fly over the Sun almost at its north and south poles. Since all planets explored to date travel very close to the ecliptic plane, this mission would represent the first exploration of the solar system's third dimension, in an almost symmetrical manner with respect to the solar equator. Properties of particles, electric and magnetic fields would be studied, not only in the interplanetary medium, but also close to Jupiter while both spacecraft swing around this planet. In addition, the observations of a coronagraph placed on board one of the spacecraft, combined with terrestrial observations, would allow the study of various transient phenomena in the Sun's atmosphere in a stereoscopic fashion. ESA and NASA would each build one spacecraft, with NASA also providing the launcher (Shuttle + Interim Upper Stage) and the deep-space network. If the above mission were not fully accepted, a fall-back mission could consist of only one spacecraft provided by ESA, the launcher (an Atlas/Centaur) being supplied by NASA. In the latter case, the trajectory would not reach a heliographic latitude higher than about 70° for a meaningful payload mass.

MISSION HORS-ECLIPTIQUE AVEC STEREOSCOPIE SOLAIRE

Ce projet, dont la réalisation est envisagée dans le cadre d'une entreprise conjointe ASE/NASA, comporterait le lancement de deux véhicules spatiaux hors du plan de l'écliptique (qui est le plan dans lequel la Terre décrit son orbite autour du Soleil) en mettant à profit l'action du champ gravitationnel de Jupiter. Chacun de ces véhicules spatiaux passerait ensuite de part et d'autre du Soleil, presque à l'aplomb de ses pôles nord et sud. Le mouvement de toutes les planètes explorées à ce jour restant très proche du plan de l'écliptique, cette mission permettrait d'explorer pour la première fois la troisième dimension du système solaire, et ce, de façon quasi symétrique par rapport à l'équateur solaire. Les propriétés des particules, des champs électriques et des champs magnétiques seraient étudiées, non seulement dans le milieu interplanétaire mais également au voisinage de Jupiter lorsque les deux véhicules spatiaux contourneraient cette planète. De plus, les observations fournies par un coronographe embarqué sur l'un des véhicules spatiaux, combiné à des observations parallèles effectuées de la Terre, permettraient d'étudier sous forme stéréoscopique divers phénomènes transitoires de l'atmosphère solaire. L'ASE et la NASA construiraient chacune un véhicule spatial, la NASA fournissant également le lanceur (Navette plus étage supérieur intérimaire) et le réseau 'espace lointain'.

Si la mission ci-dessus ne devait pas être intégralement approuvée, on pourrait prévoir comme solution de repli une mission comportant un véhicule spatial unique fourni par l'ASE, le lanceur (un Atlas/Centaur) étant fourni par la NASA. Dans ce dernier cas, la trajectoire ne dépasserait pas 70° de latitude héliographique pour une masse utile digne d'intérêt.

GRAND TELESCOPE SPATIAL (LST)

Il s'agit ici d'un projet futur de grande envergure actuellement étudié par la NASA. Très brièvement, ce télescope serait équipé d'un miroir principal d'environ 2,4 m de diamètre accompagné de tout un jeu d'instruments (spectrographe à faible résolution pour objets de faible luminosité, spectrographe à haute résolution, appareil de prise de vues à haute résolution spatiale, instrument d'astrométrie). Dégagé des phénomènes d'absorption, de scintillation et de diffusion propres à l'atmosphère, le grand télescope spatial, ou LST, permettrait des observations impossibles à réaliser avec des télescopes situés au niveau du sol.

Le LST, qui serait mis sur orbite par la Navette, est prévu pour une durée de vie pouvant aller jusqu'à quinze ans, le remplace-

LARGE SPACE TELESCOPE (LST)

This is a major future project currently under study by NASA. In summary, this telescope would have a main mirror with a diameter of about 2.4 m and an array of instruments (low-resolution spectrograph, high-spatial-resolution camera, astrometry instrument). Due to the absence of atmospheric absorption, scintillation and scattering, the LST would allow observations that cannot be conducted with ground-based telescopes. Launched by the Shuttle, the LST is intended to have a lifetime of up to 15 yr, and some of its components could be replaced or refurbished on later Shuttle missions.

ESA has been invited by NASA to consider participation in the LST project. In addition to providing some items of hardware, such as the electrical power system, or sharing in the LST's scientific operations, ESA's contribution could consist of a faint-object camera and a two-dimensional photon counting detector: feasibility studies have been started in these two areas.

The above-mentioned instrument and detector could be used with few changes and with less stringent requirements, on a 1-Metre Ultraviolet Spacelab Telescope (MUST). Such a project would be studied by ESA should co-operation on the LST not materialise.

LARGE INFRARED TELESCOPE ON SPACELAB (LIRTS)

This is a three-metre diameter telescope intended to observe celestial objects in the infrared in the range 20 – 300 μm: this spectral region cannot be observed from the ground because of atmospheric absorption. The LIRTS, which would be carried on board Spacelab, would provide an excellent capability for carrying out high-sensitivity photometric observations with high spatial resolution, as well as for measuring atomic and molecular lines in the far infrared with very high resolution. Polarimetric observations would also be performed.

Although the duration of each Spacelab mission is rather short (from 7 days to possibly 30 days), the possibility to refly an instrument several times, and therefore to modify or improve it between flights, constitutes a unique experiment capability.

The major problems related to this project are the thermal control of the uncooled telescope, the cryogenic system for focal-plane instrumentation, the contamination induced by Spacelab and the safequarding of the Instrument Pointing System, due especially to the weight of the LIRTS, during launch and landing.

ment ou la remise en état de certains de ses éléments pouvant s'effectuer lors de missions ultérieures de la Navette.

L'ASE a été invitée par la NASA à envisager son éventuelle participation au projet LST. Outre certains éléments matériels tels que le système d'alimentation électrique ou une part des opérations scientifiques du LST, la contribution éventuelle de l'ASE pourrait consister en un appareil de prise de vues pour objets de faible luminosité et un détecteur à comptage de photons bidimensionnel; des études de faisabilité ont été entreprises dans ces deux domaines.

Il est à noter que les équipements ci-dessus pourraient tous deux être utilisés, avec peu de modifications et des impératifs moins sévères, sur un télescope d'un mètre fonctionnant dans l'ultraviolet pour le Spacelab (MUST). Si la coopération envisagée pour le LST ne devait pas aboutir, l'ASE étudierait un projet dans ce sens.

GRAND TELESCOPE A INFRAROUGE A EMBARQUER SUR LE SPACELAB (LIRTS)

Ce télescope de trois mètres de diamètre serait destiné à l'observation des objets célestes dans la région infrarouge du spectre située entre 20 et 300 μm, région qu'il est impossible d'observer à partir du sol en raison des phénomènes d'absorption atmosphérique. Un télescope de ce type embarqué à bord du Spacelab offrirait un excellent moyen de réaliser des observations photométriques de grande sensibilité à haute résolution spatiale et d'effectuer des mesures à très haute résolution des raies atomiques et moléculaires dans l'infrarouge lointain. Des observations polarimétriques seraient également réalisées.

Si la durée de chaque mission – de sept jusqu'à éventuellement trente jours – est plutôt brève, le Spacelab offre précisément, parmi ses avantages exceptionnels, la possibilité de lancer un instrument dans l'espace à plusieurs reprises et par conséquent celle de le modifier ou de le perfectionner.

Les problèmes majeurs qui se posent pour ce projet concernent la régulation thermique du télescope non refroidi, le système cryogénique destiné à l'instrumentation placée dans le plan focal du télescope, la contamination causée par le Spacelab et la protection du Système de pointage des instruments, en raison notamment du poids du LIRTS, au lancement et à l'atterrissage.

ATMOSPHERIC SOUNDING BY LASER BEAMS (LIDAR)

The region of the Earth's atmosphere between altitudes of approximately 35 and 120 km remains relatively unexplored, and several physical and chemical processes of this region are still not well understood. To the intrinsic scientific interest in studying these processes, one must add the fact that if one does not properly understand how the atmosphere functions, one will not be able to assess the possibly harmful effects of man-made perturbations of its upper regions.

By its capability in terms of payload weight, volume and available power, Spacelab will permit active sounding of the atmosphere with powerful laser beams, the backscattered signals from which could be analysed by a variety of spectrophotometric devices. Such a LIDAR facility is currently being studied by ESA. Again taking advantage of Spacelab's multi-mission capability, the design of the LIDAR would be such as to allow changes in the type of laser and appropriate detectors from one mission to the next.

The problems that could be studied with the LIDAR form part of the more general AMPS (Atmosphere, Magnetosphere and Plasmas-in-Space) programme. Except for the LIDAR and some subsatellites, the rest of the AMPS payload would be provided by NASA. Although the LIDAR, which is a candidate for the first Spacelab flight, will produce results of its own, as part of a complete AMPS payload it is expected to contribute to a better understanding of the relations that exist between the neutral and ionised regions of the atmosphere.

X-RAY SPECTROPOLARIMETRY ON SPACELAB (EXSPOS)

This mission comprises a set of instruments to be flown on Spacelab to study the spectra of cosmic X-ray sources and to detect polarised X-ray emission. So far, very little emphasis has been placed on high-resolution X-ray spectroscopy and polarimetry. The energy range to be studied extends from 2 to 10 keV and high-sensitivity (and therefore good time resolution for the brighter sources) spectrometry and polarimetry, and good spatial resolution, broad-band spectroscopy are among the features of the various instruments. Since the proposed payload makes only light demands on Spacelab's resources, it would be well suited for a large number of Spacelab missions. In the course of perhaps eight 7-day missions, this experiment could observe all relevant X-ray sources of the Uhuru catalogue.

SONDAGE DE L'ATMOSPHERE PAR FAISCEAUX LASER (LIDAR)

L'atmosphère terrestre n'a été que peu explorée entre 35 et 120 km environ et plusieurs processus physiques et chimiques de cette région sont encore mal connus. A l'intérêt scientifique intrinsèque que présente l'étude de ces processus s'ajoute le fait qu'une bonne compréhension de ce qui se passe dans l'atmosphère est indispensable pour pouvoir déterminer les incidences nocives éventuelles des perturbations que les activités humaines peuvent provoquer dans la haute atmosphère.

Grâce à son potentiel dans les domaines masse, volume et énergie disponible pour la charge utile, le Spacelab permettra de procéder à des sondages actifs de l'atmosphère au moyen de puissants faisceaux laser dont les signaux réfléchis pourraient être analysés par toute une gamme d'appareils spectrophotométriques. C'est un équipement LIDAR de ce type qu'étudie actuellement l'ASE. Ici encore, tirant parti des nombreuses possibilités offertes par le Spacelab, le LIDAR serait conçu de façon à permettre de varier d'une mission à l'autre le type de laser et les détecteurs utilisés.

Les problèmes dont le LIDAR permettrait l'étude s'insèrent dans le cadre plus général du programme intitulé 'Atmosphère, Magnétosphère et Plasmas Spatiaux' (AMPS). Mis à part le LIDAR et quelques sub-satellites, la charge utile AMPS serait fournie par la NASA. Le LIDAR, considéré comme candidat possible pour le premier vol Spacelab, fournira certes des résultats qui lui seront propres, mais en tant qu'élément d'une charge utile AMPS complète, il devrait produire des résultats susceptibles de contribuer à une meilleure compréhension des relations existant entre les parties neutres et ionisées de l'atmosphère.

SPECTROPOLARIMETRIE DU RAYONNEMENT X A BORD DU SPACELAB(EXSPOS)

Cette mission prévoit l'embarquement à bord du Spacelab d'un assortiment d'instruments pour l'étude des spectres de sources de rayonnement X cosmique et la détection de l'émission de rayonnement X polarisé. Jusqu'à maintenant, on a fort peu mis l'accent sur la polarimétrie et la spectrométrie à haute résolution du rayonnement X. La gamme d'énergies à étudier s'étend de 2 à 10 keV. Parmi les caractéristiques des divers instruments, on peut mentionner: polarimétrie et spectrométrie à grande sensibilité (donc bonne résolution temporelle pour les sources de plus forte brillance), bonne résolution spatiale, spectroscopie à bande large. Ne faisant que faiblement

OTHER STUDIES

In addition to the above feasibility (Phase A) studies, several mission-definition studies are presently being conducted by ESA. A Grazing Incidence Solar Telescope for the X-ray (and possibly far-UV) region has reached a fairly advanced stage of definition, while subsatellites to be jettisoned from Spacelab, or possibly to be tethered to it (tethers 100 m to perhaps 10 km long) are also being considered. The latter type of subsatellites would be recoverable and would be very simple in that they could receive power from Spacelab and communicate with it via the tether. They could be used for the AMPS mission (see above) and also for a study of the infrared cosmic background, which requires a telescope cooled to liquid-helium temperatures.

Astrometry, a fundamental discipline that has so far been neglected in space research, will also be the subject of one of our mission-definition studies.

Finally, in addition to the 'traditional' fields of space research considered above, I should like to mention briefly the various life-science disciplines, as well as the numerous experiments that ESA intends to develop in the field of material sciences. Both of these categories of science are being considered in the context of Spacelab.

Life Sciences

Following assessment by the Life Sciences Working Group in terms of scientific value and technical requirements, the following experiment objectives were recommended:
- various experiments on animals
- vestibular and physiological studies in a zero-gravity environment
- effect of hard environment, especially HZE particles, on biological systems
- studies of cell cultures in a zero-gravity environment
- effects of zero gravity on plant organisation.

The major piece of equipment considered to date has been a sled for vestibular studies. This sled and its passenger would be accelerated at well defined rates to try to achieve a better understanding of vestibular functions (there are some as yet unexplained phenomena related to space-sickness).

Continued on page 76.

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appel aux ressources du Spacelab, la charge utile envisagée conviendrait pour un grand nombre de missions Spacelab. En quelque huit missions de sept jours, il serait possible de réaliser les observations souhaitées de toutes les sources X intéressantes du catalogue Uhuru.

Autres études

Outre ces études de faisabilité (Phase A), l'ASE a en chantier plusieurs études de définition de missions. On peut citer le télescope solaire à incidence rasante pour le rayonnement X (et éventuellement l'ultraviolet lointain) dont la définition est déjà bien avancée. Sont également à l'étude des sub-satellites à lancer du Spacelab, autonomes ou rattachés à celui-ci par des câbles plus ou moins longs (de 100 m à peut-être 10 km). Ce dernier type de sub-satellite serait récupérable et pourrait être d'une grande simplicité puisque son alimentation en énergie serait assurée par le Spacelab auquel le câble le relierait. Ces sub-satellites pourraient être utilisés pour les missions AMPS (voir plus haut) ainsi que pour une étude du bruit de fond cosmique dans l'infrarouge qui nécessite un télescope refroidi aux températures de l'hélium liquide.

L'astrométrie, discipline fondamentale que la recherche spatiale a négligée jusqu'ici, fera également l'objet de l'une de nos études de définition de mission. Enfin, à côté des domaines 'traditionnels' de la recherche spatiale, je voudrais mentionner brièvement les diverses disciplines des Sciences de la vie, ainsi que les nombreuses expériences que l'ASE a l'intention de développer dans le domaine des Sciences des matériaux.

Sciences de la vie

Les objectifs expérimentaux suivants ont été recommandés par le Groupe de travail Sciences de la vie après évaluation de leur intérêt scientifique et des impératifs techniques s'y rattachant:
- *expériences diverses sur les animaux*
- *études vestibulaires et physiologiques en impesanteur*
- *effet d'un environnement à rayonnement dur, notamment des particules HZE, sur les systèmes biologiques*
- *études sur des cultures de cellules en impesanteur*
- *effets de l'impesanteur sur l'organisation des plantes.*

L'équipement le plus important envisagé jusqu'à présent est un traîneau coulissant destiné aux études vestibulaires. Il s'agirait d'imprimer des accélérations précises à cet appareil, supportant une personne assise, en vue d'acquérir une meilleure compréhension de la fonction vestibulaire (certains phénomènes liés au mal de l'espace sont encore inexpliqués).

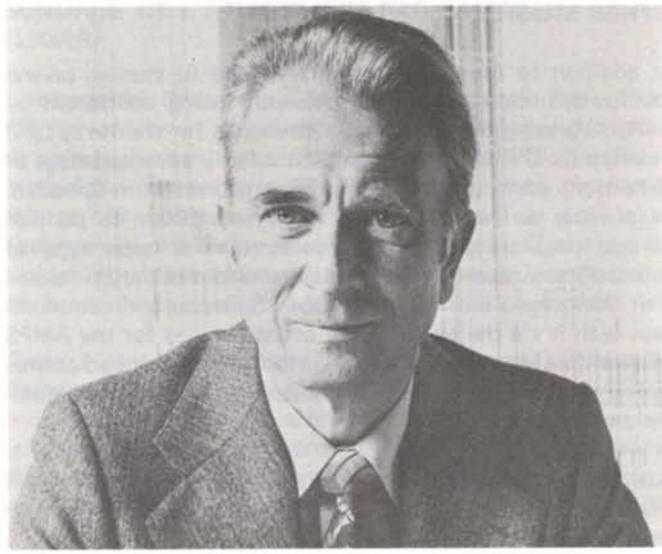
First Chairman of ESA Council
Premier Président du Conseil de l'ASE

At its first meeting, held in Paris on June 24 and 25, the Council of the European Space Agency elected German delegate Mr. Wolfgang Finke (Federal Ministry for Research and Technology, Bonn) as Chairman for one year. General Luis de Azcarraga (Spain) and Mr. Jan Stiernstedt (Sweden) were elected Vice-Chairmen.

The last Chairman of the ESRO Council was Professor Maurice Lévy (France).

Le Conseil de l'Agence spatiale européenne, réuni à Paris pour sa première session les 24 et 25 juin, a élu à sa présidence pour un an M. Wolfgang Finke (du Ministère fédéral de la Recherche et de la Technologie, Bonn, et délégué de l'Allemagne au Conseil). Le Général Luis de Azcarraga (Espagne) et M. Jan Stiernstedt (Suède) ont été élus Vice-Présidents.

Le Professeur Maurice Lévy (France) a été le dernier Président du Conseil du CERS.



Tenth ESLAB Symposium

At the invitation of the Austrian Space Agency, this year's ESLAB Symposium, with the theme 'The Scientific Satellite Programme during the International Magnetospheric Study', was held (10–13 June) at a conference centre just outside Vienna. It was attended by sixty scientists from the USA, Canada, Japan, Austria and the ESA Member States.

The International Magnetospheric Study (IMS) is proposed as an international co-operative venture of limited duration to advance our knowledge of the near-Earth space environment by combining observations made on the ground, by balloons and by sounding rockets with measurements made by scientific satellites during the same period. The IMS is of special importance for ESA, as two of its forthcoming satellites – GEOS and ISEE – are devoted to magnetospheric and near-Earth interplanetary research.

The opening session of the Symposium was held jointly with a meeting of the IMS Steering Committee. The welcoming address was given by Dr. E.A. Trendelenburg, ESA Director for Scientific and Meteorological Programmes, and the opening talk was presented by Prof. J.G. Roederer, Chairman of the IMS Steering Committee. Working Sessions were devoted to: (a) reviewing all satellite missions relevant to the IMS, the orbital configurations and measuring capabilities, (b) identifying special problems that can only be tackled by combining measurements conducted from at least two (and preferably more) spacecraft, (c) summarising outstanding questions which may be solved with the help of the GEOS and ISEE missions, and (d) discussing the best possible combination of satellite programmes with ground-based research.

In retrospect, it can be said that this symposium has resulted in a good definition of the science to be conducted during the IMS, an exchange of first-hand information on IMS satellite missions (including those carried out by the USA, the USSR and Japan), and a wider appreciation of the GEOS and ISEE missions in the context of the IMS. The 10th ESLAB Symposium can also be seen as a first step towards active co-ordination of IMS satellite programmes.

The Proceedings of the Symposium are in the process of publication and will serve as a reference for those who will be involved in preparations for and activities during the International Magnetospheric Study.

Forthcoming Symposia
Prochains symposiums

DYNAMICS AND CONTROL OF NONRIGID SPACE VEHICLES

Current and planned satellite configurations require both bulky and flexible appendages (antennas, booms, solar panels) which have a significant influence on spacecraft attitude control and stabilisation. This problem is aggravated by the increasing requirement for higher pointing accuracy of onboard instrumentation. How is the overall dynamic behaviour of systems comprising a rigid central body and flexible appendages to be correctly described? How are attitude and orbit control systems affected by spacecraft flexibility? These are two of the questions that it is hoped will be answered during a Symposium being organised under the auspices of ESA by the ESTEC Mathematical Analysis Division, at ESRIN, Frascati, Italy, from 24 to 26 May 1976.

The purpose of this multidisciplinary Symposium is to bring together specialists involved in the various techniques of analysis, simulation, estimation and flight verification of the dynamics of controlled nonrigid spacecraft. The Symposium will provide a general survey of the state of the art, covering the following topics in particular:

- Dynamics modelling techniques.
- Systems equations derivation and formulation; multibodies, large-angle motion.
- Tethered satellites, cable-connected systems; equilibrium states, local and global stability; stability methods for passive and active systems.
- State and parameter estimation; design of an in-orbit dynamic experiment.
- Design of a control system in presence of flexibility; related problems: controllability, active damping, etc.
- Selection of the simulation technique for the dynamics and the control system.
- Special problems: deployment, interaction flexibility/thermal, energy dissipation, fuel slosh.

All requests for information, applications for participation, papers and abstracts should be addressed to:

Mr. J.G. Ferrante
Mathematical Analysis Division
ESTEC
NOORDWIJK, Netherlands

not later than 20 January 1976

DYNAMIQUE ET CONTROLE DE VEHICULES SPATIAUX NON RIGIDES

Les configurations de satellites en cours de construction ou en projet font appel à des appendices (antennes, mâts, panneaux solaires) à la fois volumineux et flexibles, ce qui a une influence notable sur la commande d'attitude et la stabilisation. Ce problème est aggravé par l'exigence d'une précision de pointage de plus en plus fine des instruments embarqués. Comment rendre compte correctement du comportement dynamique global de systèmes constitués d'un corps central rigide et d'appendices flexibles? Quelles sont les interactions entre la flexibilité et les systèmes de pilotage et de correction d'orbite des véhicules spatiaux? . . .

Telles sont quelques-unes des questions auxquelles on essaiera de répondre au cours d'un Symposium organisé sous les auspices de l'ASE par la Division Analyse Mathématique de l'ESTEC du 24 au 26 mai 1976 dans les locaux de l'ESRIN, à Frascati (Italie).

Le but de ce Symposium à caractère interdisciplinaire est de réunir les chercheurs spécialisés dans les diverses techniques d'analyse, de simulation, d'évaluation et de vérification en vol du comportement dynamique des véhicules spatiaux non rigides. On passera en revue l'état actuel de la recherche en ce domaine et on traitera en particulier des sujets suivants:

- *Techniques de modélisation de la dynamique.*
- *Méthodes de dérivation des équations des systèmes et leurs formulations; multicorps, mouvements aux grands angles.*
- *Satellites amarrés, systèmes connectés par câbles; états d'équilibre, stabilité locale et globale; méthodes d'analyse de la stabilité des systèmes passifs et actifs.*
- *Estimation du vecteur d'état et des paramètres; conception d'une expérience dynamique embarquée.*
- *Conception d'un système de contrôle en tenant compte de la flexibilité; questions annexes: commandabilité, amortissement actif, etc.*
- *Sélection d'une technique de simulation pour la dynamique et le système de contrôle.*
- *Problèmes particuliers: déploiement, interaction entre flexibilité et effets thermiques, dissipation d'énergie, ballotement des liquides.*

Les demandes d'information et d'inscription ainsi que les communications et résumés doivent être adressés avant le 20 janvier 1976 *à*

M. J.G. Ferrante, Division Analyse Mathématique
ESTEC, NOORDWIJK, Pays-Bas

PRODUCT ASSURANCE FOR SPACE PROJECTS

ESA is entering a new era of space utilisation in which, besides the scientific satellite programmes previously planned, the manned space laboratory (Spacelab) and various application projects will play a major part. With these three aspects of space exploitation and the different approaches to product-assurance problems in different countries in view, a Symposium on Product Assurance for Space Projects is being organised under the auspices of ESA, by the ESTEC Product Assurance Division, at ESRIN, Frascati (Italy), from 4 to 6 May 1976 to facilitate an exchange of views between government and industrial specialists from Europe and the United States.

The main topics proposed for this Symposium – the first in Europe to be devoted entirely to this field – are the following:

- Product assurance requirements, programmes and plans; customer aspects, contractor aspects, cost-effectiveness.
- Reliability in design, reliability analysis methods; hazard and safety analysis.
- Component qualification, procurement and failure analysis.
- Materials aspects, outgassing, odour, inflammability.

Requests for information, applications for participation etc., should be addressed to:

Mr. D.A. Nutt
Head of Product Assurance Division
ESTEC
NOORDWIJK, Netherlands

not later than 20 February 1976.

L'ASSURANCE PRODUIT DANS LES PROJETS SPATIAUX

L'ASE est entrée dans une nouvelle ère d'utilisation de l'espace où, en plus des programmes de satellites scientifiques précédemment entrepris, les projets de laboratoire spatial habité (Spacelab) et d'autres satellites d'applications vont jouer un rôle de plus en plus important. Compte tenu de ces trois aspects de l'exploitation de l'espace ainsi que des différentes approches du problème de l'assurance produit dans différents pays, la Division Assurance Produit de l'ESTEC va organiser, sous les auspices de l'ESA, un Symposium à l'ESRIN, Frascati (Italie) du 4 au 6 mai 1976.

Ce Symposium, qui est le premier en Europe à être consacré entièrement au thème de 'l'Assurance Produit dans les Projets spatiaux', devra permettre aux spécialistes des organismes officiels et aux représentants de l'industrie venus d'Europe et des Etats-Unis de procéder à un large échange de vues sur ce problème. Les principaux sujets prévus sont les suivants:

- *Spécifications, programmes et plans d'assurance produit; assurance produit côté client et côté contractant; considérations de coût-efficacité.*
- *Fiabilité au niveau des études; méthodes d'analyse de la fiabilité; analyse des risques et de la sécurité des produits.*
- *Qualification, fourniture et analyse des défaillances des composants.*
- *Aspects relatifs aux matériaux; dégagement de gaz, odeur, inflammabilité.*

Les demandes d'information et d'inscription etc. doivent être adressées avant le 20 février 1976 *à*

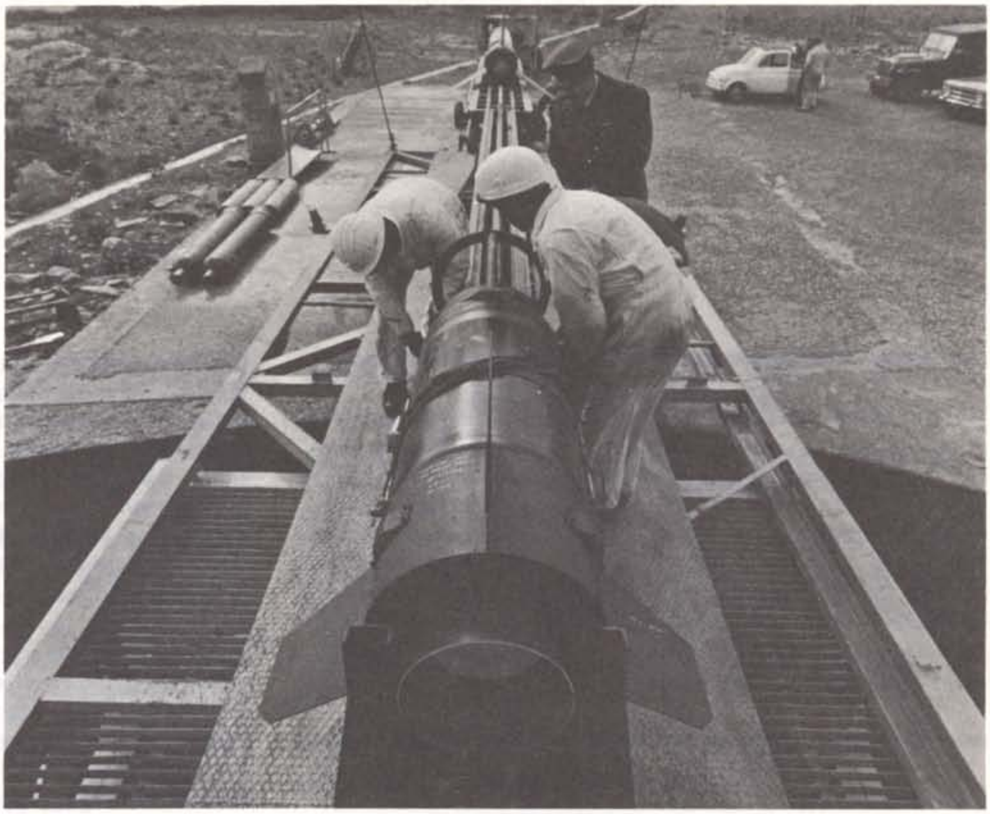
M. D.A. Nutt, Chef de la Division Assurance Produit
ESTEC, NOORDWIJK, Pays-Bas.

EUROPEAN SOUNDING-ROCKET AND SCIENTIFIC-BALLOON RESEARCH

In April 1973 and September 1974, two symposia devoted to sounding-rocket and related research were organised under the ESRANGE Special Project, the first at Spåtind, Norway, and the second at Örenäs, Sweden. In view of the favourable reaction of European scientists and technologists to these first two meetings, and considering the need for co-ordination of European activities in this area, the Programme Advisory Committee has decided that a third Symposium should be arranged under the ESRANGE Special Project with the follow-

PROGRAMMES EUROPEENS DE RECHERCHES PAR FUSEES-SONDES ET BALLONS

En avril 1973 et septembre 1974, deux symposiums consacrés aux recherches par fusées-sondes et autres moyens connexes ont été organisés dans le cadre du Projet spécial ESRANGE, le premier à Spåtind (Norvège) et le deuxième à Örenäs (Suède). Compte tenu de la réaction favorable suscitée par ces deux réunions parmi les scientifiques et technologues européens et de la nécessité d'une coordination des activités européennes dans ce domaine, le Comité consultatif des Programmes a décidé d'organiser un troisième symposium dans le cadre du



Skylark sounding rocket being prepared for launch.

ing theme: 'Present and Future European Sounding-Rocket and Scientific-Balloon Research in the Auroral Zone'.

The Symposium will take place at Schloss Elmau, near Garmisch-Partenkirchen (Upper Bavaria), from 3 to 7 May 1976. The Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (DFVLR/GSOC), Oberpfaffenhofen, has been entrusted with its organisation and will be responsible for all local arrangements.

Invited and contributed papers will deal with such topics as active experiments, co-ordination of launches, rocket and balloon experiments in relation to EISCAT (European Incoherent Scatter Facility), the sounding-rocket and balloon aspects of the IMS (International Magnetospheric Study), and relevant progress in sounding-rocket and scientific-balloon technology.

Applications to participate, contributed papers and abstracts should be submitted to:

Mr. T. Halvorsen
Secretariat of the ESRANGE Special Project
International Affairs Department
European Space Agency
114 Ave. Charles-de-Gaulle
92522 NEUILLY-SUR-SEINE, France.

before 20 February 1976.

A more detailed programme brochure for the Symposium will be issued by the Secretariat during the autumn.

Projet spécial ESRANGE sur le thème: 'Programmes européens actuels et futurs de recherches par fusées-sondes et par ballons en zone aurorale'.

Le Symposium se tiendra à Schloss Elmau, près de Garmisch-Partenkirchen (Haute Bavière), du 3 au 7 mai 1976. L'organisation du Symposium a été confiée à la 'Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt' (DFVLR/GSOC), Oberpfaffenhofen, qui sera également chargée de tous les arrangements sur le plan local.

Les communications porteront en particulier sur les points suivants: expériences actives, coordination des lancements, expériences par fusées-sondes et par ballons en relation avec le programme EISCAT (sondeur européen à diffusion incohérente en zone aurorale), expériences dans le cadre du programme IMS (étude internationale de la magnétosphère), progrès réalisés dans la technologie des fusées-sondes et des ballons scientifiques.

Les demandes d'inscription et les résumés des communications devront être soumis le 20 février au plus tard à

M. T. Halvorsen
Secrétariat du Projet spécial ESRANGE
Département des Affaires Internationales
Agence Spatiale Européenne
114 Avenue Charles-de-Gaulle
92522 NEUILLY-SUR-SEINE, France

Une circulaire plus détaillée sur le programme et l'organisation matérielle du symposium sera publiée par le Secrétariat au cours de l'automne.

Douglas Marsh Fellowship

Douglas Marsh was ESRO's Project Manager of the TD satellite system when he died in 1968 at the age of 35. To commemorate his outstanding professional capacity and the high regard in which he was held by his colleagues, Professor Bondi, Director General at that time, instituted the Douglas Marsh Fellowship for annual award, open to ESRO staff only. The purpose of the award is to enable the appointed Fellow to undertake, at an appropriate institute in Europe or the US, research or study related to the scientific, technical or management aspects of the ESA programme.

The 6th Douglas Marsh Fellowship has been awarded to Mr. Francesco Costanzo an engineer in the Structures Divsion of the Department of Development and Technology at ESTEC, for the purpose of research and studies in the human engineering aspect of manned spacecraft design. He will spend much of his time working with the Crew Station Design Branch at NASA's Johnson Space Center, Houston, to gain insight into the state of the art in such fields as environmental architecture for manned spacecraft, crew station development and integration, EVA/IVA accommodation, mock-ups and trainer development, displays and controls and man/machine engineering. Additionally, he will attend courses at the University of Houston in the basic aspects of environmental engineering and man/machine engineering.

Mr. Costanzo (33), an Italian national, graduated in mechanical engineering and naval architecture at the University of Genoa in 1967. After a period of research work on ship structures on behalf of the Consiglio Nazionale Delle Ricerche and the Registro Italiano Navale, he spent a short time at the Institut für Statik und Dynamik in Stuttgart, researching into new computer methods for structural analysis, before joining Structures Division at ESTEC in 1969. His recent work has been connected with the design, development and testing of the GEOS structure.

Publications

The documents listed here have been issued since the last publications announcement in the Bulletin. Requests for copies should be made in accordance with the following table:

Publication	Code	Availability
Scientific reports, etc.	SR; SN; SM	Notes 1 and 2
Technical reports, etc.	TR; TN; TM	Notes 1 and 2
Special Publications	SP	Notes 1 and 2
Contractor Reports	CR	Notes 1 and 2
	CR(P)	Note 2
	CR(P)*	Note 3
Technical Translations	TT	Note 2
Procedures, Standards, Specifications	PSS	Note 4

1. Available in hard copy as long as stocks last from ESA Scientific and Technical Information Branch, c/o ESTEC, Domeinweg, Noordwijk, Netherlands.
2. Available in microfiche or photocopy form, against a charge to meet reproduction costs, from ESA, Space Documentation Service, Reproduction Service, ESA, 114 avenue Charles-de-Gaulle, 92522 Neuilly-sur-Seine, France.
3. Not available from ESA. (Distribution restricted to National Delegations of those States participating in the programme from which the contract was funded).
4. These are working documents rather than information reports. Distribution is under the control of the ESA Department responsible for the particular document.

SPECIAL PUBLICATIONS

SP-89 Celestial objects and satellite astronomy, *by A. Bastos*

SP-103 Spacecraft power-conditioning electronics, *Proceedings of a Seminar held at Frascati, Italy, 20-22 May 1974*

SP-107 Sounding-rocket and scientific-balloon activity at high latitudes with emphasis on the International Magnetospheric Study (IMS), *Proceedings of a Symposium held at Örenäs Slott, Sweden, 9-12 September 1974*

SP-108 Space astrometry, *Proceedings of a Symposium held at Frascati, Italy, 22-23 October 1974*

SP-109 Research goals for cosmic-ray astrophysics in the 1980's, *Proceedings of an ESRO Workshop held at Frascati, Italy, 24-25 October 1974*

SP-110 X-ray astronomy and related topics, *(Preprint), Proceedings of a Colloquium held at ESTEC, Noordwijk, 25-26 February 1975*

TECHNICAL NOTES

TN-107 General description of the ESRO-IV satellite, *by G. Seibert et al.*

TN-116 ESRO-IV orbital programme, *by L.M. Palenzona and P.J. Berlin*

TN-120 Materials data retrieval at ESTEC, *by J. Dauphin and B. Ryden*

TN-123 Noise limitations in image pick-up tubes, *by H. Samuelsson*

TN-124 The outgassing of space materials and its measurement, *by J. Dauphin and A. Zwaal*

TECHNICAL MEMORANDA

TM-157 Hydrazine thruster contamination and heating effects for the scientific geostationary satellite, *by B.D. Dunn and J.A. Steinz*

CONTRACTOR REPORTS

CR-40 Tube de prise de vue à mémoire (EAID), *par INAG/CNRS, France*

CR-345 Oblique albedo sensor measurements, *by Dr. K. Endl, Germany*

CR-346 Evaluation of HEOS-2 attitude results, *by Christian Rovsing, Denmark*

CR-576 Tests on sealed Ni-Cd cells for satellite use – final report, *by Forsvarets Forskningsanstalt (FOA), Sweden*

CR-596 Study of the acoustic excitation of structures, *by Hawker Siddeley Dynamics Ltd., UK*

CR-633 Recherche sur l'amortissement en vibration des structures de satellite – Rapport final, *par SNIAS, France*

CR-634 *idem,* Rapport d'essais

CR(P)-635* Study on crossed field amplifiers for TVBS mission, *by GEC, UK*

CR(P)-636 Spacelab – ESRO utilization programme, supporting study for the definition of experimental objectives of the 1st Spacelab mission, Final presentation briefing brochure, *by Messerchmitt-Bölkow-Blohm GmbH, Germany*

CR(P)-637 *idem,* Vol. 1: Experimental objectives

CR(P)-638 *idem,* Vol. 3: Experiment data sheets

CR(P)-639 Study on critical aspects of a joint ESRO/NASA Jupiter orbiter, *by Messerschmitt-Bölkow-Blohm GmbH, Germany*

CR(P)-640 Investigation of the application of lasers for the measurement of deformations, *by Lasag SA, Switzerland*

CR(P)-641 Comparative study of methods for measuring magnetic moment, Vol. 1, *by Industrieanlagen-Betriebsgesellschaft mbH, Germany*

CR(P)-642 *idem,* Vol. 2

CR(P)-643 *idem,* Vol. 3

CR(P)-644 Study, manufacture and test of an electrical model of a shaped-beam antenna for maritime satellite, *by Marconi Ltd., UK*

CR(P)-645 Deployable antennas for satellites, *by Messerschmitt-Bölkow-Blohm GmbH, Germany and Centro Investigacionnes Fisicas, Spain*

CR(P)-646 Thermal vacuum qualification test of no. 1 Marconi Space and Defence Systems low-speed mechanisms (ESTL-11), *by European Space Tribology Laboratory, UK*

CR(P)-647 Satellite operations model extension, final report, *by British Aircraft Corporation, UK*

CR(P)-648 Adaptation study for 4/6 GHz satellite communications, *by Dornier System, Germany*

CR(P)-649 Study of PAP launch systems – Impact application satellites, *by Messerschmitt-Bölkow-Blohm GmbH, Germany*

CR(P)-650 Non-mechanical sweep of field of view, *by Cambridge Consultants Ltd., UK*

CR(P)-651 Etude des caractéristique du répondeur d'un satellite de radiodiffusion, Vol. 1 – Texte de Rapport Final, *par Thomson-CSF, France*

CR(P)-652 *idem,* Vol. 2 – Annexes du Rapport final

CR(P)-653 Wear of slip rings and brushes in ultra-high vacuum (ESTL-14), *by European Space Tribology Laboratory, UK*

CR(P)-654 Thermal vacuum acceptance test of no. 2 Hawker Siddeley Dynamics low-speed mechanism (ESTL-10), *by European Space Tribology Laboratory, UK*

CR(P)-655 AC power generation and distribution, Final report, *by Dornier System, Germany*

CR(P)-656 Evaluation of Ni-Cd cell covers. Results of testing of covers with protected brazing fillet, *by NLR, Netherlands*

CR(P)-657 Final report on colloid thrusters, *by Culham Laboratory, UK*

CR(P)-658 Guidelines for spacecraft power and signal cabling, *by Hawker Siddeley Dynamics Ltd., UK*

CR(P)-659* Investigations of thermal conductance interface to honeycomb panels of typical equipments, *by Hawker Siddeley Dynamics Ltd., UK*

CR(P)-660* Detailed design of a precision 2-axis IR horizon sensor, *by Officine Galileo, Italy*

CR(P)-661* Thermal cycling of NiCd for space use, *by Electronikcentralen, Denmark*

CR(P)-662* Influence of the geostationary cycle on capacity & study of lifetime of NiCd cells for space use, *by Forsvarets Forskningsanstalt (FOA), Sweden*

CR(P)-663 Temperature compensated dielectric microwave resonators, *by Forsvarets Forskningsanstalt (FOA), Sweden*

CR(P)-664 Non-mechanically tuned optical bandpass filters *by Cambridge Consultants Ltd., UK*

CR(P)-665 Développement et qualification d'une électrovanne double siège métal/métal destinée à la commande d'un micropropulseur à hydrazine, *par SEP, France*

CR(P)-666 Detailed investigation of the resonance effects on the vibration modes of a cable boom, *by Istituto per le Ricerche di Tecnologia Meccanica (RTM), Italy*

CR(P)-667 Etude de la mise en place d'un satellite géostationnaire – optimisation de l'orbite de transfert, de l'impulsion d'apogée et du rendez-vous final, *par ONERA, France*

CR(P)-668 Conservative filtering for orbit determination, Vol. 1., *by Analytical & Computational Mathematics, (ACM) Switzerland*

CR(P)-669 *idem,* Vol. 2., appendices

CR(P)-670* Follow-on study to the supporting study for the definition of experimental objectives of the 1st Spacelab mission – Executive summary, *by Messerschmitt-Bölkow-Blohm GmbH, Germany*

CR(P)-671* *idem,* Vol. 1, Part A, Experiment equipment definition

CR(P)-672* *idem*, Vol. 1, Part B, Cost and schedules

CR(P)-673* *idem*, Vol. 2, Cost comparison

CR(P)-674* *idem*, Vol. 3, Reliability study—programmatic aspects

CR(P)-675 Evaluation of the ESRO-IV attitude control and stabilisation telemetry data, *by Hawker Siddeley Dynamics Ltd., UK*

CR(P)-676 Exosat attitude control & velocity impulse systems, final technical report, *by SNIAS, France*

CR(P)-677 *idem*, Vol. 2

CR(P)-678 Exosat 'B' study – final report, *by Fokker-VFW NV, Netherlands*

CR(P)-679 Exosat 'C' study – optimisation of planning – final report, *by Messerschmitt-Bölkow-Blohm GmbH, Germany*

CR(P)-680 Exosat study 'D' – data handling system, summary, *by British Aircraft Corporation, UK*

CR(P)-681 *idem*, Vol. 1

CR(P)-682 *idem*, Vol. 2

CR(P)-683 Exosat study 'E' – AOCS & system study – final report, *by British Aircraft Corporation, UK*

CR(P)-684 Fan beam albedo sensor optical head, *by Officine Galileo, Italy*

CR(P)-685 Study of multiple access techniques for the transmission of data by satellite, Vol. 1, *by Marconi Ltd., UK*

CR(P)-686 *idem*, Vol. 2

CR(P)-687 Thermal vacuum acceptance and qualification tests of no. 2 & 3 Marconi Space & Defence Systems Low Speed Mechanism (ESTL-12), *by European Space Tribology Laboratory, UK*

CR(P)-688* Design, manufacture and test of a positive expulsion propellant tank (ESTEC Contract 1847/73) Final Report, *by British Aircraft Corporation, UK*

CR(P)-689 Design & development of a starmapper breadboard model, phases II & III, Final Report, *by Technisch Physische Dienst, Netherlands*

CR(P)-690 Image storage tube for space applications – phase III – Development of a prototype, *by Heimann GmbH, Germany*

CR(P)-691 Development of a prototype high resolution stepper motor – Final Report, *by Teldix GmbH, Germany*

CR(P)-692 Design and development of a gas controlled heat pipe radiator for communication spacecraft applications, *by Dornier System, Germany Germany*

CR(P)-693 Antenna arrays using high gain element radiators, *by L.M. Ericsson, Sweden*

CR(P)-694 A study of the prediction of antenna performance from near-field measurements, *by Marconi Ltd., UK*

CR(P)-695 Final report, experimental work on thin-film hybrid circuits, *by Svenska Radio, Sweden*

CR(P)-696 Design and development of a momentum wheel with a mainly passive magnetic bearing, *by SNIAS, France.*

CR(P)-697 On-off shutter for satellite thermal control, *by CASA, Spain*

CR(P)-698 Study of a dual-frequency ranging experiment to be included in the COS-B telecommunications package, *by Selenia, Italy*

CR(P)-699 Design modification and testing of a storage and deployment unit for a roll-up solar array (ROSA), Volume 1, *by British Aircraft Corporation, UK*

CR(P)-700 *idem*, Vol. 2

CR(P)-701* Theoretical and numerical study on near-field testing of the Meteosat electronically-despun antenna, *by Ticra A/S, Denmark*

CR(P)-702 Final report, improvement of solar cell covers, Volume 1, *by Pilkington, UK*

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TT-139 Current activities in the air-breathing engines sector in the FRG and in West Berlin. German Aerospace Information Documents 74-16, *by DFVLR*

TT-140 Prediction of unsteady airloads for the solution of the panel flutter problem of nose cones and conical shell structures, *by DFVLR*

TT-141 Theory of the propagation upstream of wave-like disturbances in a subsonic free jet, *by G. Neuwerth, Technische Hochschule Aachen*

TT-142 General differential equations in matrix form for thin elastic shells with a solution for twisted tubes, *by W. Wöbbecke, DFVLR*

TT-143 Methods of thrust vector control, *by H. Twardy, DFVLR*

TT-144 La Recherche Aérospatiale, No. 1974-1, *by ONERA*

TT-145 Dynamic & aeroelastic problems of stop-rotors and their analytical treatment. Part II: analytical equations and solutions, *by H. Försching, DFVLR*

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TT-164 Report on the joint meeting of the DGLR specialist committees for 'Flight Characteristics' and 'Flight Control' (Hamburg, 18 October 1973) on 'Control Configured Vehicles' (CCV), *by DGLR*

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TT-176 Proceedings of a colloquium held at the DFVLR research center at Porz-Wahn, 8 May 1973

TT-177 The M4 supersonic wind tunnel, *by W. Langefeld and M. Haake, DFVLR*

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TT-184 A new device for the vibratory excitation of mechanical structures, *by J.-F. Boisseau, ONERA*

TT-185 Flat solar collectors energy balance and efficiency, *by R. Köhne, DFVLR*

TT-186 Methods for approximate optimum thrust programming of solid propellant rockets for spacecraft applications, *by W.H. Diesinger, DFVLR*

TT-187 Influence of splitter wedges on the lift and drag of a rectangular wing with a blunt trailing edge, *by M. Tanner, DFVLR*

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The following papers were published in Vol. 1, Nos. 1 and 2. (Note: the last issue of the ELDO/ESRO Review was Vol. 7, No. 1).

Vol. 1, No. 1

Directional-Cosine and Related Pre-processing Techniques: Possibilities and Problems in Earth-Resources Surveys, *by F. Quiel*

ABSTRACT

The possibilities of using various pre-processing techniques (directional-cosine, ratios and ratio/sum) have been investigated in relation to an urban land-use problem in Marion County, Indiana (USA) and for geologic applications in the San Juan Mountains of Colorado. For Marion County, it proved possible to classify directional-cosine data from September 1972 into different land uses by applying statistics developed with data from a May 1973 ERTS frame, thereby demonstrating the possibilities of using this type of data for signature-extension purposes. In the Silverton (Colorado) area pre-processed data proved superior to original data when extracting useful information in mountainous areas without corresponding ground observations. This approach allowed meaningful classification and interpretation of the data. The main problems encountered as a result of atmospheric effects, mixing of different surface materials, and the performance characteristics of ERTS are elucidated.

RESUME

On a étudié les possibilités d'application de différentes techniques de pré-traitement (cosinus directionnel, rapport et rapport/somme), à propos d'un problème d'aménagement urbain à Marion County, Indiana et d'une étude géologique dans les Montagnes San Juan, Colorado (Etats-Unis). A Marion County, il s'est avéré possible d'exploiter des mesures de cosinus directionnel effectuées depuis septembre 1972 sur différentes catégories de terrain d'après des statistiques établies à partir d'une image ERTS datant de mai 1973. Dans la région de Silverton (Colorado), les données pré-traitées se sont révélées supérieures aux données initiales lorsqu'il s'agit d'extraire des informations utiles dans des zones montagneuses sans avoir recours à des observations sur le terrain. Cette méthode permet d'ordonner et d'interpréter les résultats de façon significative. Les principales difficultés rencontrées par suite des perturbations de l'atmosphère, de la texture complexe des terrains, et des performances caractéristiques du système de détection ERTS sont également précisées.

Origin and Propagation of Cosmic Rays, *by Catherine J. Cesarsky*

ABSTRACT

A short review of the origin and propagation of cosmic rays is presented, which emphasises the main unanswered questions in these fields and points to possible experimental tests to help resolve them.

RESUME

On présente une courte revue sur l'origine et la propagation du rayonnement cosmique, en mettant l'accent sur les principaux problèmes non résolus dans ces domaines et en indiquant des tests expérimentaux possibles et pertinents.

Quelques Questions Générales Concernant les Vibrations des Lanceurs (3ème Partie), *par J. Lacaze*

ABSTRACT

The response of a wall submitted to a random acoustic field is described as a function of the level, spectrum and space correlation of the impinging noise. The Statistical Energy Analysis (SEA) method allows the transmission of vibration between the various media to be calculated. From these analyses it is possible to arrive at some conclusions concerning the behaviour of launcher equipment and spacecraft.

RESUME

On examine d'abord la réponse d'une paroi à un bruit aléatoire, en fonction du niveau, du spectre et de la corrélation spatiale de ce bruit. On examine ensuite la transmission des vibrations haute fréquence entre plusieurs milieux, volumes acoustiques et parois par la méthode statistique énergétique (SEA). On en tire enfin des conséquences concernant le comportement des équipements des lanceurs et des satellites.

A Wide-Angle Large-Aperture Interferometer or Resonator, *by P.N. Kruythoff*

ABSTRACT

By modifying a Fabry-Perot type interferometer so that the mirrors coincide optically and their centres of curvature coincide optically or even physically, a wide-angle large-aperture interferometer or resonator can be produced. Such an interferometer could be used, for example, to filter the light from an extended incoherent source.

RESUME

En modifiant un interféromètre de Fabry-Perot de manière à faire coïncider, d'une part, les miroirs optiquement et, d'autre part, leurs centres de courbure par un montage optique voire de façon matérielle, on peut réaliser un interféromètre ou résonateur grand angulaire et à large ouverture. Un tel instrument pourrait être utilisé, par exemple, pour filtrer la lumière venant d'une source incohérente de grande dimension.

Vol. 1, No. 2

Possibilités d'Applications des Traitements de Surface au Frottement sous Ultravide pour Utilisations Spatiales, *par J.L. Polti*

ABSTRACT

The main results of a test programme carried out for CNES to investigate novel methods of dry lubrication in ultra-high vacuum are described. To date these results have shown that it is highly probable that the compatibility law can be verified for metals under ultra-high vacuum, and hence utilisation of different pairs of metals such as inox/Ag, Cu/Mo, inox/In, etc., can be envisaged. It has also been found that surface treatments represent a new and powerful tool, especially two treatments based, respectively, on the surface formation of diffusive metallic coatings, and on the formation *in situ* of molybdenum disulphide (MoS_2) by direct electrolytic synthesis.

RESUME

On décrit les principaux résultats du programme d'essais entrepris dans le cadre d'un accord avec le CNES en vue de rechercher des solutions nouvelles aux problèmes de frottement sans lubrification sous ultravide. Les résultats obtenus à ce jour montrent qu'il y a de fortes présomptions pour que la règle de compatibilité des métaux soit vérifiée sous ultravide, ce qui permet d'envisager l'utilisation de couples métalliques de frottement tels inox/Ag, Cu/Mo, inox/In, etc. Il a été trouvé aussi que les traitements de surface représentent une nouvelle arme puissante, en particulier deux d'entre eux qui sont basés l'un sur la formation à la surface des pièces de couches métalliques de diffusion, l'autre sur la formation in situ, *par électrolyse directe, de bisulfure de molybdène (MoS_2).*

Multispectral Scanning Systems and their Potential Application to Earth-Resources Surveys. 1. Basic Physics and Sensing Technology, *by A.D. Higham et al.*

ABSTRACT

This paper summarises the various processes affecting the interaction of radiation and matter that give rise to useful information about the surface of the Earth, the methods of sensing this information, the properties of specific materials of interest, the processing of the data acquired by a Multispectral Scanning System and the applications to which such a system may be applied.

RESUME

Cet article récapitule les divers processus susceptibles de fournir des informations utiles sur l'état des ressources terrestres à partir des phénomènes d'interaction rayonnement-matière, les méthodes permettant de capter ces informations, les propriétés des différentes sortes de terrains à prospecter, le traitement des informations recueillies par un système de balayage multispectral et les applications auxquelles un tel système pourrait servir.

Multispectral Scanning Systems and their Potential Application to Earth-Resources Surveys. 2. Earth-Science Applications, *by R.A.G. Savigear et al.*

ABSTRACT

The characteristics and potential uses of Multispectral Scanning Systems are reviewed and it is proposed that a multidisciplinary and integrated regional approach to evaluation and development should be followed. Their applications in agriculture and forestry, geology, hydrology and oceanography are considered as illustration of our current understanding of their advantages and limitations. Illustrations are also given of typical experimental programmes. The conclusions discuss developments appropriate for a European programme and insist on the importance of financing the establishment of properly instrumented test sites and areas representative of regional conditions and problems.

RESUME

Après avoir passé en revue les caractéristiques et utilisations potentielles de différentes techniques de balayage multispectral, on propose de suivre une méthode pluridisciplinaire et cohérente sur un plan régional pour évaluer et réaliser ces systèmes. Leurs applications à l'agriculture, la sylviculture, la géologie, l'hydrologie et l'océanographie sont envisagées à titre d'exemples pour illustrer la connaissance que nous avons actuellement de leurs avantages et de leurs limites. Des programmes d'expérimentation types sont également décrits. Les conclusions portent sur des réalisations à entreprendre dans le cadre d'un programme européen et insistent sur l'importance du financement des travaux d'aménagement à effectuer sur des aires expérimentales, convenablement équipées et représentatives des conditions et problèmes propres à une région.

Quelques Questions Générales Concernant les Vibrations des Lanceurs (4ème Partie), *par J. Lacaze*

ABSTRACT

The fourth and last part of this study on vibrations in launchers deals with the shocks generated during stage or payload separations. These shocks are perceived as damped sinusoidal oscillations. Methods for measuring such shocks and checking on the ability of equipment to withstand them are indicated.

RESUME

La quatrième et dernière partie de cette étude sur les vibrations des lanceurs porte sur les chocs générés lors des séparations. On y montre que ces chocs sont perçus comme des oscillations sinusoïdales amorties. On en déduit des méthodes d'essai pour connaître ces chocs et pour vérifier le comportement des équipements.

Continued from page 63.

Material Sciences

After some preliminary studies, ESA has concluded that studies of four materials processes are of particular interest: namely electrophoresis, crystal growth, fluid physics and metallurgy. These four fields encompass a wide variety of possible experiments and in view of results already obtained on the earlier Skylab missions we feel that Spacelab constitutes the ideal tool for conducting such a research programme. Research on material processes is in fact one of the experimental objectives of the first Spacelab flight.

As the reader will appreciate, there is no shortage of appealing scientific missions for future years, even discounting a number of other potential missions now being considered as part of a long-term planning exercise.

Obviously, financial limitations require a selection to be made, after completion of the various Phase-A studies, of those projects that are to be pursued within the framework of the Agency's mandatory scientific programme. This selection will be made in the Spring of 1976.

Suite de la page 63

Sciences des matériaux

Après quelques études préliminaires, l'ASE est parvenue à la conclusion qu'il serait particulièrement intéressant d'étudier les comportements des matériaux en impesanteur, dans les domaines suivants: électrophorèse, croissance des cristaux, physique des fluides et métallurgie. Ceci englobe une large gamme d'expériences possibles. Quelques résultats déjà obtenus au cours des missions Skylab nous font penser que le Spacelab est bien l'outil idéal pour mener un programme de recherches dans ces divers domaines. L'étude du traitement des matériaux fait partie des objectifs expérimentaux du premier vol du Spacelab.

Le lecteur peut voir que ce ne sont pas les projets séduisants qui manquent pour les missions scientifiques des années à venir et pourtant nous n'avons rien dit de plusieurs autres missions futures possibles envisagées actuellement dans le cadre des plans à long terme. Il est évident que la limitation des moyens financiers oblige à opérer une sélection, après l'achèvement des diverses études de Phase A, pour déterminer quels seront les projets à réaliser dans le cadre du programme scientifique obligatoire. Cette sélection aura lieu au printemps 1976.

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