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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

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NORTH ATLANTIC TREATY ORGANIZATION

The lectures will consist of:

- Introduction on requirements (quantities to be measured, boundary conditions, needed techniques);
- Laser-doppler and laser-two-focus velocimetry (fundamentals, analysis of errors, limits, practical use, design details, equipment and data processing);
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Lecture Series 91: **Advanced Manufacturing Techniques in Joining of Aerospace Materials** (with Structures and Materials Panel)
17–18 October 1977, London, UK
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Advanced aerospace structures depend to a large extent on new joining techniques. The highest possible material strength-to-weight ratio is an important requirement. Advanced light materials such as titanium alloys or plastic matrix composites are answers, as well as improved welding and adhesive bonding processes. Often the selection of the optimum joining technology is the prior condition for success in introducing advanced structural components in the aircraft industry. This Lecture Series will present improved or new cost-effective welding methods for joints of high integrity and with properties close to those of the parent metal. Progress in joining composites will be discussed, based on modern design principles.

Lecture Series Director: Professor Dr.-Ing. H.D.Steffens, University of Dortmund, Germany.

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13th Meeting of **Aerospace Applications Studies Committee**
2–11 May 1977, The Hague, Netherlands

The Committee will receive the final report on Study No.11 on "Suppression of Detection and Guidance Systems, Other than Radar, Associated with SAMs, ASMs and Guided Bombs", refine terms of reference for Study No.12, organize a new Working Group for Study No.12, and define terms of reference for Study No.13.

14th Meeting of **Aerospace Applications Studies Committee**
7–17 November 1977, Paris, France

The Committee will conduct a mid-term review of Study No.12, refine terms of reference for Study No.13, and organize a new Working Group for Study No.13.

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This issue highlights the AGARD annual meeting in Istanbul, Sep 76. Articles on the following topics are included:

(11) Mar 77

(12) 55p.

THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Program and the Aerospace Applications Studies Program. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

Published March 1977

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Foreword

The present issue 'highlights' our Annual Meeting of last September in Istanbul, Turkey.

The conference facilities at the Tarabya Hotel were cast in a setting overlooking the scenic, historical waterway of the Bosphorus. The magnificent receptions given by Defense Minister Melen and General Ayan, a boat trip on the Bosphorus, and the excursions arranged for the ladies to the heart of Istanbul with its fabulous mosques, museums and markets were memorable events which reflect the gracious hospitality and rich history of the country.

The address by Professor Doğrusöz on Science Policy, published in this issue, and a visit to the Scientific and Industrial Research Institute of Marmara, gave AGARD a good view of research and development in Turkey. It is through our Annual Meetings held in the Fall in the various NATO nations that our National Delegates Board can acquire first-hand knowledge of the individual countries' activities in aerospace science and technology, and thus guide AGARD toward greater responsiveness to their needs. Many fruitful AGARD activities have evolved as a direct consequence of our Annual Meetings. This is part of our job within NATO.

We have had a busy year in AGARD Headquarters, and I am happy to say that, in spite of the additional workload occasioned by Project 2000 (mentioned in the previous issue of the Highlights), we foresee continually growing activities in our technical panels. It is, of course, through their programs that AGARD stays in the forefront of aerospace science and technology.

On the personal side, we are saddened by the passing away of Professor Baudouin Fraeijs de Veubeke, of Belgium, for many years an active member of two of our Panels. Our sincere sympathy goes to his family and his colleagues.

The Highlights are designed to give news of the AGARD community. I hope you will enjoy reading this issue and that it will encourage you to submit contributions of articles for future issues.

Robert H. Korkegi

Robert H.Korkegi
Director, AGARD

All members of AGARD, whether National Delegates, Panel Members or AGARD Staff, are cordially invited to submit articles likely to be of interest to other AGARD members for the next issue of AGARD HIGHLIGHTS which will appear in the Autumn of 1977. Articles should be addressed to:

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or, from US and Canada only:

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The cover shows the Blue Mosque in Istanbul. Photo by courtesy of the Turkish Tourist Bureau, Paris.

Twelfth AGARD Annual Meeting

The 1976 AGARD Annual Meeting was held in Istanbul, Turkey, from 15th to 17th September. AGARD was welcomed by the Turkish Minister of Defence and the Chief of Staff of the Turkish Air Force, and addresses were delivered on ISSUES OF SCIENCE POLICY IN TURKEY by Professor Halim Doğrusöz of Middle East Technical University, and on the SPACE TRANSPORTATION SYSTEM by Dr William C.Schneider of the United States National Aeronautical and Space Adminstration.

WELCOME by

THE HONOURABLE FERIT MELEN, Turkish Minister of National Defence.

Mr Chairman, Honorable representatives and Distinguished Guests,

On behalf of the Government of the Turkish Republic and the Ministry of National Defence, I would like to express my great satisfaction in welcoming the National Delegates of AGARD after a period of sixteen years.

I have been asked by the President, the Prime Minister and by the Chief of Staff to convey to all participants their regret for not being able to attend the inaugural session due to their rather heavy schedules. Nevertheless, they have all given me the pleasant task of conveying to you their sincere wishes for the success and fruitfulness of the meeting.

I feel very proud when I remember the 11th General Assembly of AGARD which was convened in Istanbul back in 1960, and I wish similar success to all these meetings of the National Delegates Board, the Panel Chairmen and so on.

From the first days of joining NATO, Turkey has always retained her belief in the need to promote co-operation in order to strengthen further the ties between the member countries.

From 1952 on, fulfilling very important services in scientific co-operation and solving problems for the common interests of NATO, AGARD has always been held in great respect in our country.

The general impression I have from our members of the AGARD panels is that your success is continuing most effectively.

I would particularly like to point out that our country will benefit from "Project 2000" which was assigned to AGARD by the Military Committee.

Our geopolitical location forces us to keep powerful armed forces, thus stretching our limited economical resources. Your research in the aerospace field, in technological forecasting, and the work you have done in scientific fields will help us to solve the problems with which we are faced. Turkey wishes to reach the level of her allies in aerospace technology as in every other field, and thus take a more positive share in the alliance. We are aware that at present research and development need large amounts of money and that it takes a long time to acquire the necessary manpower, money and technological atmosphere. For this, the publications and meetings and the valuable advice of AGARD are beyond praise.

In this beautiful city of Istanbul, joining the two continents of Asia and Europe and full of historical interest, I wish you success in all your meetings.

WELCOME by

GENERAL ETHEN AYAN, Chief of Staff of the Turkish Air Force.

General Ethen Ayan

General Ayan *was born in 1918 in Denizli. After graduating from primary school, he entered Military School and graduated from the War College as a Third Lieutenant in 1940. He completed his flight training in 1942 and became a fighter pilot. In 1953 he entered the Air Staff Academy and graduated in 1955. After serving in various units and headquarters of the Turkish Air Force, he was promoted to the rank of Brigadier General in 1963. He was then appointed to the post of the Deputy J-1 in the Turkish General Staff. He was appointed to the Commandery of the Third Air Force Command in 1964.*

In 1965 he was promoted to the rank of Major General. During the period 1966–1969 he served at Turkish Air Force Headquarters. He was appointed Deputy Undersecretary of the Ministry of National Defence in 1969 and to the rank of Lieutenant General in 1970. He was appointed as the Chief of Inspection Board of TAF in 1970 and as the Chief of Air Training Corps Command in 1971. He became the Commander of the First Tactical Air Force in 1972.

He was appointed Second Chief of Staff of the Turkish Air Force in 1973. Following his promotion to the rank of General in 1974, he served in the High Military Council. On 23 July 1976, his appointment to the post of Chief of Staff of TAF was ratified.

Brigadier-General Emin Sifa, Turkish AGARD National Delegate

Lt-Colonel Dogan Kaya, Turkish AGARD National Coordinator

Mr Chairman, Honorable Delegates and Guests:

It is a great pleasure for me to have the opportunity to address you and welcome you to Turkey. I am glad that AGARD has chosen to hold its 1976 Fall meeting in my country, especially in Istanbul. I should like to take this opportunity to present a summary of information on the Turkish Air Force, and mention some problems we encounter.

Turkey recognised the importance of the first flight of an airplane in 1903. At the same time as the major industrial nations, in fact before some of them, she established aviation organizations and started to operate them. Since that date, the two world wars have caused amazing and unbelievable developments, both in military and civil aviation. The basis of these developments, besides the financial resources, are the technological advancements which result from the achievements of research and development organizations. Between the wars Turkey was unable to establish a strong aviation industry because she did not have the necessary scientists, and was faced with economic difficulties. Before the Second World War, there were some individual attempts to build some small training aircraft, and an aircraft factory and a Mach 0.3 windtunnel were built, but it was not possible to improve them.

After we joined NATO in 1952, our aircraft were provided through military assistance and our existing facilities were converted to supply and maintenance centres which provided maintenance, repair and depot level maintenance for aircraft in our inventory. Currently, these facilities are able to do depot level maintenance on some of the present aircraft and engines.

Today, we have different types of aircraft and helicopters in our inventory. As you will appreciate, different types sometimes create supply and maintenance problems and cause large financial expenditures.

Our attempt to establish an aircraft industry to decrease the number of types and to overcome the waste of resources, is supported by our government, and the work to establish this industry continues.

When the time comes to support and develop this enterprise, I shall wish to ask the advice and recommendations of AGARD – an organization that has been a leader for different NATO countries in space research and development and has been the best example in the field of scientific co-operation. I know that an establishment cannot advance without research and development, and I whole-heartedly desire to establish an aerospace research center.

Distinguished members of AGARD, as the commander of the Turkish Air Force, I am very pleased with your project 2000, and glad that the NATO defense research group and other research groups attached to NATO are working hand-in-hand in technological forecasting activities. The project will assist NATO future planning in years ahead.

I want to extend our good wishes to the distinguished and able scientists who will be working in different panels of AGARD and our best hopes for your future efforts.

Issues of Science Policy in Turkey

by

Professor Doctor Halim Doğrusöz
Professor of Operational Research
Middle East Technical University

***Dr Doğrusöz** was born in 1922 in Malkara and received his MS Degree in Mechanical Engineering at Technical University of Istanbul in 1948. He attended a one year training in Power Engineering in the USA, 1952–1953 and received his Ph.D. Degree in Operations Research at Case Institute of Technology in 1962.*

During the period 1961–1965 he worked as Operations Research Associate for Mobil Oil Corporation. During the years 1965–1968, he was the Director of the Operational Research Unit of the Scientific and Technical Research Council of Turkey. In 1971 he again became the Director of the Unit he had founded and served for another two years. He was a Visiting Associate Professor of Statistics and Operations Research and Senior Research Fellow at the Management and Behavioral Science Center, University of Pennsylvania, 1969–1970.

Since 1966, he has been a faculty member of the Operations Research Department of Middle East Technical University, Director of the System Sciences Research Institute since 1974, and Chairman of the Department of Operational Research and Statistics since 1975.

Dr Dogrusöz is a member of the following institutions: Science Board of Scientific and Technical Research Council of Turkey; Special Program Panel on Systems Science of NATO; Advisory Board on Research and Development of Ministry of National Defence; Operations Research Society of America; The Institute of Management Sciences; Sigma-Zi; Association of Turkish Engineers, and Chamber of Mechanical Engineers of Turkey. He has published many papers and reports on Decision Theory, Queuing Theory, Development Programming and various military topics.

INTRODUCTION

This paper endeavours to shed some light on the issues related to the science policy of Turkey, and proposes an organizational mechanism for designing such policies. It argues that the science system of Turkey has followed certain guidelines for developing scientific research in the past, but has not attained a desired state as yet, and then evaluates the present state of the system critically in order to raise issues which may constitute the foundation of formal policy-making process. In the sequel, special attention is paid to the defence system, as one of the most pronounced science-based sectors of the society which may also become a dynamic force for promoting Turkish science.

"The term policy is rather vague . . . . ." writes N.Jéquier[5]. This short statement very eloquently characterizes the situation with regard to the meaning of the concept. Professionals belonging to the newly emerging discipline called policy science, are desperately attempting to remove the persistent ambiguities as much as they can[4,5,6,7]. The concept of policy is in general related to other less ambiguously characterized concepts, such as decision making, planning, strategy, tactics, operations, etc. Even these latter are perceived differently by different authors.

Most generally, policy-making is viewed as top level decision making. In this sense, the characteristic properties are the level of organizational authority where the decision is taken, and perhaps its scope, both in time and space. Thus, according to this view, policy is a decision taken by the highest level decision-maker (by the cabinet or even by the parliament, for example) comprehending the distant future of the entire organization. For some authors, however, policy-making appears on all levels (tactical, strategic and goal level)[5]. According to some other authors, on the other hand, in a whole complex process leading to "rational creative action", "policies are the first expressions and guiding images of normative thinking and action"[4]. Decision making comes next before implementation, i.e. *rational* *creative action*. Here the concept of decision making is taken in a more restrictive sense.

If decision making is viewed as making a conscious and deliberate choice from among alternatives to provide guidance for action, policy making also can be regarded as decision making. If one regards consciousness and deliberation, however, as removing all ambiguities about the state that the system attains by pursuing such a guidance, a policy can hardly be viewed as a decision. In this sense a choice is a decision only if the decision maker knows exactly what state that the system, under his control, attains, when he pursues the guidance provided by the choice[3,12].

Another restriction to the concept of decision making is that the choice is made from among a set of known alternatives. But policy-making implies the creation of new alternatives, i.e. it is an innovative activity, in that it aims to bring about a change in the structure of the system ("science" in our case) rather than changing the values of the system's variables. Creation of new "institutions and instrumentalities"[6] are in focus.

Summing up, *policy formulation* can be regarded as a process which, starting from a critical examination of values, establishes new norms, and concludes with the design of a coherent set of goals and objectives for which the system is to strive for. Thus, a policy forms a foundation on which all subsequent planning and decision making for the system is based. Therefore, it is all encompassing, but very general with no details. It guides subsequent decision making, but does not contain any decisions, if decision making is taken in its restrictive meaning. Therefore, science policy may be articulated in the form of a set of ambiguous statements, in the sense that it indicates the targets to be strived for without explicitly specifying how, and gives no assurance of success (meaning that it involves risk taking), and therefore should be subjected to correction and revision as a result of feed-back from the system.

POLICY MAKING AS A DYNAMIC PROCESS

Science policy is not something made once and for all to remain intact forever. Policy-making is and should be a continuing process for two reasons:

- it takes into account the past performance and the present state of the system which is changing,
- it should be subjected to correction and revision by evaluating its consequences.

This implies that science policy making can be viewed, in a very broad sense, as a feed-back control process. It differs, however significantly from the notion of feed-back control in an engineering system. Engineering system feed-back control is ordinarily reactive and seldom goal seeking; policy making, on the other hand, is a purposeful behaviour, as defined by R.L.Ackoff and F.Emery[1]. That is, engineering feed-back control systems react to changes in the environment to keep the system in a predetermined state, or seek to arrive at a predetermined goal. Policy making, however, includes determination and even creation of new goals.

From the foregoing brief discussion, one can conclude that a continuously functioning device is needed for science policy-making. Such a mechanism must continuously and critically examine the science system and its environment (economy, educational system, political system etc. for example), to establish new norms and create new goals and objectives. This means that science policy issues are time-dependent. In the Turkish science system, for example, issues that were significant a decade ago have now been replaced by others. Accordingly, in the following sections, the issues that appear to be most significant at present will be brought to light.

PAST AND PRESENT STATE OF THE TURKISH SCIENCE SYSTEM

Any attempt to create science policy obviously requires a critical examination and evaluation of the past performance and the present state of the science system. This should include the policies adopted and their respective consequences, from which we can learn how the system responds to various policies and decisions and consequently their effectiveness. Thus, a brief examination of the Turkish science system is offered in this section.

Prior to the Second World War, scientific research in Turkey was regarded predominantly as a university function, with the exception that a few institutions were created, during the 1930's for surveying and studying natural resources and improving agricultural productivity. Those are the "Mineral Survey and Exploration Institute" (MTA), the "Electrical Study and Survey Department" (EİE) and several small agricultural experimental centers. Although their titles and constitutions imply *research*, these organizations were primarily engaged in surveys, classical engineering studies and routine experiments, useful in their own right, but not instrumental in any innovation or breakthrough.

Research done in universities during that period rested on the individual interests of faculty members, were very small scale and academic and had no association with the country's needs; nevertheless, they perhaps made modest contributions to international science.

This situation continued to persist during the post war period until the end of the 1950's. There were, however, a few sporadic attempts to institutionalize research activity mainly in applied areas, which were promoted by visionary government executives and outside stimulants. These were the establishment of the Atomic Energy Commission (AEK); the Hydraulic Works Research Institute; the Sugar Institute, and the Highways Department Research Institute.

The period starting in the early 1960's saw a significant change in the institutional arrangements related to scientific research. "With the adoption of a new constitution in 1961, the state has assumed a larger responsibility for economic and social development, and the process of planning for development has become institutionalized" says M.Celasun[2]. Among the various institutions founded during that era, one of the most important was the State Planning Organization (SPO) which has been charged with the task of formulating and monitoring the implementation of Five Year Plans and Annual Programs. The organization, obviously, had the responsibility of providing guidelines to promote industrial development and technological advancement as one of its primary instruments.

The most notable institutional creation, directly related to promoting scientific development, was the foundation of the "Scientific and Technical Research Council of Turkey" (TÜBİTAK) in 1963; this reports directly to the Prime Minister. For the first time the scientific development of the country was charged to a central authority. TÜBİTAK enjoys a considerable autonomy in managing its funds and its internal affairs, and is charged with the authority and the responsibility to promoting scientific and technical research in pure and applied branches of "positive science" (a term used in this part of the world, and almost equivalent to "Hard Science" or "Exact Science"). TÜBİTAK is also charged with the responsibility for giving advice to the government for the formulation of science policy.

In this sweeping reorientation and institutional rearrangement, Defence Research was covered by the establishment of a "Scientific Research Advisory Board" (İLAR) and the creation of a "Research and Development Center" (ARGE). İLAR is charged with giving advice to the Ministry of Defence on military science policy and on the scientific management of ARGE. The Board is composed of prominent scientists of the country, covering as many disciplines as deemed necessary, and the director of ARGE serves as its Secretary General.

We saw no significant institutional development for research in industrial enterprises (public or private) during this period. There were, however, a few exceptions. We have already mentioned the "Sugar Institute", a well organized research institute which undertakes research for the Sugar Industry. There were also attempts to seed research activities in government-owned firms in textile, fertilizer, petrochemicals, cement, machine manufaeturing etc., which have not, however, reached a satisfactory level.

In this organizational set up, TÜBİTAK deserves special attention, as it has considerable potential power and authority for affecting the scientific development of the country. When it was first established, TÜBİTAK was regarded by Turkish Scientific Community as a primary hope to remedy the ills of the science system and to bring it to a viable and healthy state. There existed a potential scientific manpower handicapped by the lack of funds, research equipment and organizational inefficiencies. This potential was to be mobilized. There was a need to train more research scientists and to establish a media for efficient scientific communication. TÜBİTAK's attention was first directed to these needs. It has launched various programs, and its achievments, so far, can be summarized by a statement made by M.Celasun as follows:

"As a sweeping generalization, it can be stated that TÜBİTAK has been successful in creating a public awareness over the need to actively promote scientific affairs and technological progress in Turkey. Through the implementation of a series of modest but spirited programs in the way of (i) providing fellowships and grants to students and professionals of science and technology at various levels, (ii) supporting the financing of a large number of minor research projects (predominant portion of which being carried out in universities), (iii) sponsoring various courses and seminars, (iv) collection of data on national R and D activities and setting up a center of documentation, TÜBİTAK has begun to fill in a vacuum of central authority in national scientific affairs that has been existing for a very long time in the country's scientific history."[2]

TÜBİTAK, through its fellowship programs, has had a considerable effect in training the new generation of scientific manpower. Many young research scientists and academicians now in the Turkish science system are the products of these fellowship programs. Its financial support of research projects, proposed by individual scientists or groups of scientists (mainly academicians), made it possible to fully utilize the existing potential, which was also instrumental in developing and strengthening a tradition to run research on a project basis, a first step toward the institutionalization of research activities in universities. Traditionally, university researches have been conducted as individual efforts, pursued informally and motivated by academic reasons. A basic motive was to write a dissertation or publish a paper in an internationally recognized journal. TÜBİTAK's efforts, however, required the organization of research teams and conducting research according to a previously devised program.

Through this research sponsorship, TÜBİTAK hoped to stimulate the existing scientific manpower to direct its attention to the pressing problems of the country, but with very little success. The customary way of doing research, and the values and norms in academic circle were alien to the idea. Few of the research reports were implemented, and they contributed very little to the solution of the country's pressing problems. To remedy this situation, TÜBİTAK's management decided to take the initiative and devised a program of sponsorship, so-called Guided Research Projects, meaning projects initiated and formulated by TÜBİTAK and contracted to outside research groups (mainly to university groups, since the largest potential still existed in universities). For this purpose, in order to identify research problems, TÜBİTAK contacted industry. The response was that industry had no problems which required research for their solution. The management of the newly developing industries, having practically no research activity of their own, had no idea what research could do for them. Similarly, potential industrial researchers in the university, secluded to their inner circles, had no idea what they could do for industry. The program of guided research is still pursued, but is very modest in scale.

Industry had a potential research demand that had to be brought out into reality. For this, industrial managers and researchers had to be brought into contact. Thus the TÜBİTAK management took a decision in 1966 to set up its first research organization, the Marmara Scientific and Industrial Research Institute", (MBEAE), whose main function was to serve industry, so that a large group of researchers was put into constant contact with industry. MBEAE was put into operation in 1972 in its planned location in Gebze near Istanbul, although some of its research units had been established earlier to function temporarily in various university campuses.

To give an idea of the total magnitude of scientific activity of Turkey, it is pertinent to cite some statistics on R and D expenditure. The first survey run by TÜBİTAK shows that Turkey spent 274 million TL. in 1964, which is about 0.41% of GNP. Results of subsequent surveys are given in the following table[11].

Year	R&D Expenditure Million TL		R & DE/GNP %
	Current Prices	Fixed Prices (1965)	
1964	274	286	0.41
1969	435	351	0.36
1970	492	363	0.35
Annual Growth Rate	+0.102	+0.041	−0.027

No figures are available for later years.

An examination of the above table shows that R and D expenditures in Turkey during the 1960's remained below 0.5% of GNP; it grew at a rate of 4% annually between 1964 and 1970, slower than the growth of GNP, and its share in GNP declined from 0.41% to 0.35%. R and D expenditure to GNP ratio figures are very low compared to those of industrially developed countries (in the vicinity of 3% for USA, 2% for most European countries).

In particular, the decline in the share of R and D expenditures in GNP, in spite of recent efforts to promote scientific research, is symptomatic. It can be attributed to various reasons, which will be analyzed more in detail later. Here we simply state that R and D expenditure is low not because the country cannot afford it, but because there does not exist the machinery to spend more.

CRUCIAL PROBLEMS

As is apparent from the foregoing analysis, the crucial problems of the Turkish science system appear to be mainly institutional, in spite of recent attention directed to this aspect. Although we cannot attempt, in this short essay, to formulate these problems elaborately and propose satisfactory solutions, we must try to shed some light on them.

In a country with a well organized science system, the most crucial element of science policy is, perhaps, the amount of financial resources supplied to R and D and its allocation to various research areas. But if there do not exist sufficient research manpower and efficiently operating research organizations to use these financial resources effectively, either money goes down the drain or simply cannot be spent at all. In Turkey, allocation of more funds to R and D activities, for example, is no problem. Total R and D expenditures still remain within the order of ½ billion TL. The country can afford to double this within a year, without any hardship, especially if larger sums can be spent effectively. This is the crux of the matter. Can the Turkish science system spend one billion TL per year effectively? In the present state the answer is no, but the system can be brought to an adequate state by institutional improvement. There are two main problems: shortages of qualified scientific manpower; and lack of efficiently functioning research organizations.

One way of solving the first problem is to provide scholarships, and this has been done extensively. Scholarships motivate students to get a degree in this or that scientific discipline, but do not guarantee that they become researchers, if there do not exist attractive research employment possibilities. Attractive research employment possibilities are a stronger motivation to become a researcher for a bright young student than are scholarships. On the other hand, getting an advanced degree, even a Ph.D., does not alone necessarily qualify a person as a professional researcher. A person becomes a researcher by working in a research organization. Thus the solution of the manpower problem, also rests on institutional improvement of the science system. Conversely the strength of research organizations depends upon the existence of qualified manpower.

Such an institutional improvement should focus on three basic components: devising a policy-making mechanism; reorganizing and strengthening existing research organizations; and establishing new research organizations.

The subject of science policy-making mechanism will be treated in more detail in a separate section later. But it can be said that the present organization is insufficient for this purpose. TÜBİTAK had been charged with looking after this function by its constitution, but it has not been effective, although it made sincere efforts to be so. It even formed an organizational unit which struggled with the problem with no apparent impact. The State Planning Organization (SPO) also carries some responsibility. Attempts at collaboration between SPO and TÜBİTAK have been made, again with no fruitful result. There must be a good reason for this state of affairs, and that must be examined.

As far as reorganizing the existing research organization is concerned, one must be aware of the defects that these organizations suffer. These can be stated as follows.

It is not rare in Turkey to see a very small number of professionals put together and called a research institute or a research center. The size of research manpower of such a research organization is far from reaching the so called 'critical mass'. This situation is most pronounced in agricultural research, and is summed up in the following statement:

"Although the relative share of the agricultural R and D is prominent in the total . . . . . . R and D effort . . . . . the available resources are thinly distributed over a large number of research units. Within the general purview of the ministry of agriculture, there are approximately 100 research units for agriculture and nearly 90 such units for veterinary and livestock activities. The number of research units employing more than 10 professionals is only 30 according to the TÜBİTAK sources."[2]

Those units are very poorly managed due to lack of managerial skill, and many misconceptions and prejudices. There is a prevailing misconception that nature and society are organized like universities, and the domain of research activities is parcelled out into jurisdictional areas according to the titles of university diplomas. Thus the whole of agricultural research, for example, is within the jurisdiction of agricultural engineers, electronics research is a subject for electronics engineers, and so on. Therefore these small research units are uni-disciplinary; university graduates bearing the same title in their diplomas are rarely put together to make up independent research units.

This leads to jurisdictional fights and professional rivalry among various disciplines. Scientists trained in the branches of pure science are virtually banned from entering into applied research, and these scientists accept the position that applied research is none of their business. Thus the Turkish science system generally does not benefit from interdisciplinary interaction.

One of the areas which need radical reorganization is university research. University research is virtually unorganized; it is carried out as the pursuit of individuals, and TÜBİTAK's policy up to recently encouraged this by financing individuals or groups of individuals rather than institutions. The biggest research potential, however, still resides in the university. Its full utilization can only be realized by institutionalizing university research, and TÜBİTAK can play a significant role in this by appropriately devised promotional programs.

Another drawback of existing research organizations is the lack of qualified support personnel. A researcher's time is often wasted by the lack of efficient supporting services and personnel.

There does not exist a fertile ground for promoting the development of scientific manpower, especially in the basic sciences, because of the organizational reasons mentioned above, and the salary scales which are not particularly motivating. Employment opportunities exist only in government research units and possibly in universities. According to the personnel regulations of government employees, research personnel are treated as ordinary employees with no incentive to become researchers. They are sometimes even at a disadvantage. The situation is worse in basic science disciplines, like physics, chemistry, biology and mathematics, for reasons cited before. Thus there is a need to remove those inhibiting factors by making the research profession attractive and respectable.

Concluding the above discussion, there is a need to reorganize the existing science system in such a way, that

- The present small organizational units are converted into larger ones,
- They constitute a media of interdisciplinary interaction,
- They house basic research and scientists, even if their main purpose is applied research,
- Their management is improved,
- The status of research personnel in government is improved,
- University research is institutionalized and made more sensitive to the country's needs,
- The system is expanded by establishing new research organizations especially in the industrial sector and in government organizations,
- Demand for research is created in the various sectors of the society and directed to research organizations, and especially to those in the universities.

These points outline some guidelines which are worthy of pursuing. How they can be made effective so that the effectiveness of science system in development is increased, is another question. The answer can perhaps be found in a conscious policy-making mechanism, and this will briefly be discussed in the next section.

SOME SUGGESTIONS TOWARD DEVISING A SCIENCE POLICY-MAKING MECHANISM

Science system is one of the sectors of the society most difficult to develop and to ensure increased effectiveness. It functions on the support provided by society, mostly through the government. Its inner mechanism is hard to understand, especially by outsiders. Thus to improve its management, requires an elaborate system. The present system is inadequate. It does not include all the forces and powers that it should involve. Science policy-making should be a participative, continuous and dynamic process, i.e. a process in which all parties involved should participate. The following parties are vital:

- Political insitutions, as the representatives of society;
- representatives of the science system itself; and
- representatives of the sector which it directly serves.

Up to the present, the science system was remote from the attention of the legislative and the executive branches of the government, especially on policy matters. Scientific affairs were brought to the attention of these institutions only as secondary budget items submerged in the crowd of bigger numbers, and therefore they did not attract any attention. In a 10 billion TL budget of a government organization a 5 million TL research budget is too small to gain attention. The science system is discussed as a whole, in the cabinet or in the Great National Assembly. To remedy this, the establishment of a Science Commission in the Great National Assembly composed of members with scientific orientation, and Science Advisory Board, reporting directly to the Prime Minister and composed of scientists and industrialists, would be useful. If included in the latter, the representatives of SPO and TÜBİTAK could serve a useful purpose, as they are most keenly concerned with the science system.

The national science policy, as visualized here, is made up as one hierarchicly integrated whole of which organizational policies down the ladder constitute its integral parts. Such organizational policies should be integrated and made consistent with the guidelines adopted at the cabinet level.

In this scheme, TÜBİTAK as its central authority, would serve to implement the largest part of government policy, and would formulate its own policy in conjunction with guidelines authorized from above.

Informational support is provided to the Science Commission of the Great National Assembly and the Prime Minister's Science Advisory Board from below, and TÜBİTAK serves as an information processing and reporting agent. For this purpose TÜBİTAK maintains an organizational unit (Science Policy Unit) which also carries out surveys and studies to this effect.

As it is visualized in this sketchy scheme, the National Science Policy is not construed as a document or a report, but as a gradual build up of an integrated system of decisions.

ISSUES OF DEFENCE RESEARCH POLICY

Defence research has a special and important place in the science system of any country and plays a significant role in scientific development in general, in addition to the vital service it provides to the defence system. Most breakthroughs in civil life are realized as a result of scientific research carried out for defence purposes. Development of nuclear energy, radar, sonar and jet propulsion are only few examples. Apparently, concern for national survival stimulates the scientific mind to be most creative and productive. Besides sentimentalities, however, the effect of defence research can be attributed to the huge amount of resources it receives.

Similarly, defence research in Turkey can play a role both in strengthening the defence system as well as promoting the scientific development of the country. Up to the present, however, such a role does not seem visible. There are various reasons for this. Most fundamental ones, again, are institutional, and will be discussed briefly in the following paragraphs.

Defence research has been done till now only by the internal units of the military system. This imposes a severe restriction on tapping the potential of human resources of the country for scientific development. We observe, however, in industrially developed countries, that the biggest portion of defence research is performed by the civilian sector, although financed by the military organization. A similar process is just beginning in Turkey. There are defendable reasons for this delay. The most fundamental one is that the civilian sector had not been organized for it. In particular, industry is not organized even to do its own research. Mainly due to this, the defence authorities have not had sufficient confidence in the civilian sector to initiate any inquiry. Without an effective demand and promotion, on the other hand, the civilian sector is not motivated to initiate such a development. This vicious circle must be broken, and it seems that the initiative has to come from defence authorities. The most promising starting place would be the universities, where the most capable research capacity exists.

Establishment of special status defence research units in universities would have another advantage. Employing graduate students would aid in the supply of a large part of the research personnel requirement and would orient potential scientific manpower to defence research at the source. This may be an effective means of scientific manpower development. The most workable arrangement for such an initiative, of course, would have to be determined by a detailed analysis. Later similar initiative could be attempted in the industrial sector.

Developing defence research organizations outside the defence system would not mean, of course, that internal research is not needed. There are various reasons for this. First of all, there is a large part of defence research that cannot be done outside, and should be undertaken internally. Secondly, unless the Ministry of Defence and the Armed Forces are organized to guide, orient and coordinate outside research activities, such activities would be anything but useful. Such outside work, on the other hand would also be a stimulant to strengthen the currently weak internal research activity.

REFERENCES

1. Ackoff, R.L. and Emery, F.E., *On Purposeful Systems*, Aldine-Atherton, Chicago, 1972.
2. Celasun, M., *Technological Advances as a Factor in the Turkish Development Planning: Some Observations and Suggestions*, in 10.
3. Doğrusöz, H., *Decision Theory as a Basis for Model Construction in Operational Research*, Proceedings of the Conference on the Role and Effectiveness of Theories of Decision in Practice, Hodder and Stoughton, London, 1975.
4. Jantsch, E., *From Forecasting and Planning to Policy Sciences*, in 10.
5. Jéquier, N., *National R and D Strategies: Toward a New Science Policy*, in 10.
6. Moravcsik, M.J., *Basic Scientific Research in Developing Nations*, in 10.
7. Özbekhan, H., *Toward a General Theory of Planning*, in E.Jantsch (ed.), *Perspectives of Planning*, OECD Paris, 1969.
8. Price, D.J., *The Implication of Theoretical Studies for Decision-Making in R and D Management*, in 10.
9. Sagasti, F., *Towards a Methodology for Planning Science and Technology in Developing Countries*, Unpublished PhD. Thesis, University of Pennsylvania, 1972.
10. Türkeli, A. (ed), *Issues in Research and Development Planning and Management*, Scientific and Technical Research Council of Turkey, 1971.
11. Türkeli, A., *Millî Hedefler ve Araştırma Geliştirme Harcamaları* (National Objectives and R and D Expenditures), Scientific and Technical Research Council of Turkey, 1971.
12. White, D.J., *Decision Theory*, Aldine Publishing Co., Chicago, 1969.

Space Transportation System

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A whole new era of space transportation will come into being in the 1980's with the operational phase of the Space Shuttle and its ability to inexpensively transport a variety of payloads into orbit. In the 1960's, the US began its development phase of the manned space flight program. The Mercury Program demonstrated orbital flight and flight extension. The Gemini Program concentrated on extra vehicular activity, rendezvous and docking, controlled entry, and work in space. The Apollo Program with its manned systems landed men on the moon who explored the lunar surface. Lunar exploration flights continued in the early 1970's. The first of three Skylab flights working with habitability and life support, vehicle systems, and experiments was launched in 1973. The international program, the Apollo-Soyuz Test Project (ASTP), was launched in 1975 with rendezvous and docking of the United States and the Soviet Union vehicles and the accomplishment of the transfer of crews.

The technological and operational experience underlying these accomplishments is being applied to the development of the Space Shuttle to serve the future beneficial uses of Space. The program objective is to establish a national space transportation system capability that will substantially reduce the cost of space operations and provide a capability designed to support a wide range of scientific applications, defense, commercial, and international uses. (Figure 1)

The Space Transportation System (STS) consists of the Space Shuttle, the Spacelab, and a family of Upper Stages. (Figure 2) The prime element for this low cost approach to routine space flight is the reusable Space Shuttle. Its development is essential to the beneficial use of space in coming decades. The system must accommodate all classes of users – science, applications, civilian, government, commercial and military, US and foreign. The Space Shuttle development continues to progress on plan and within the cost estimates.

The Space Shuttle, unlike previous manned space projects, will be a reusable spacecraft with reusable systems, will be capable of frequently launching and returning large complex payloads in addition to passengers and crew, can act as a space station for short duration orbital missions, will fly and land like an airplane, will approach an airline type operation and will enhance the present era of international cooperation through mutual benefits derived from national and international payloads.

The Space Shuttle vehicle (Figure 3) consists of an orbiter, an external tank, and a booster made up of two solid-rocket motors. The first orbiter, 101 (Figure 4), will be rolled out in Palmdale, California, tomorrow, September 16, 1976 (Figure 5). The orbiter and solid rocket booster are reusable elements, while the external tank is expended on each launch. The orbiter main rocket engines used during ascent obtain their propellants from the external tank. Smaller orbiter rocket engines provide maneuvering and control capability during space flight. Aerodynamic surfaces on the wings and vertical stabilizer control the orbiter during atmospheric flight on landing. Elements of the Space Shuttle and the propulsion system are covered in more detail later.

The orbiter will normally carry into orbit a crew

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From December 1968 he served as Director of the now completed Skylab Program. Upon the successful completion of the program, Dr Schneider was awarded NASA's highest honor – the Distinguished Service Medal – for his contribution to the success of the program. He was also honored for Skylab by presentation of the Robert J.Collier Trophy for 1973. He was awarded the Astronautics Engineer Award by the National Space Club and the American Astronautical Society's Space Flight Award for 1973.

From July 1967 to December 1968, Dr Schneider served as NASA Apollo Mission Director and Apollo Program Deputy Director for missions, and directed Apollo missions 4 through 8. For his contribution to the success of the Apollo 8 mission, Dr.Schneider was awarded the NASA Distinguished Service Medal. Dr Schneider was Gemini Mission Director for 7 of the 10 manned Gemini missions and Deputy Director of the Gemini Program prior to that. He received NASA's Exceptional Service Medal for his role as the Deputy Director, a position to which he was appointed November 1963. Dr Schneider joined NASA and the Gemini Program in June 1963, after two years as Director of Space Systems at International Telephone and Telegraph Company's Federal Laboratories. Prior to that, he worked for the US Navy and NACA.

Dr Schneider was born 24 December 1923 in New York City. He earned his BS Degree in Aeronautics in 1949 from the Massachusetts Institute of Technology, his MS Degree in Aeronautics in 1952 from the University of Virginia, and his Doctor of Engineering Degree in 1976 from Catholic University. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics and a Fellow of the American Astronautical Society.

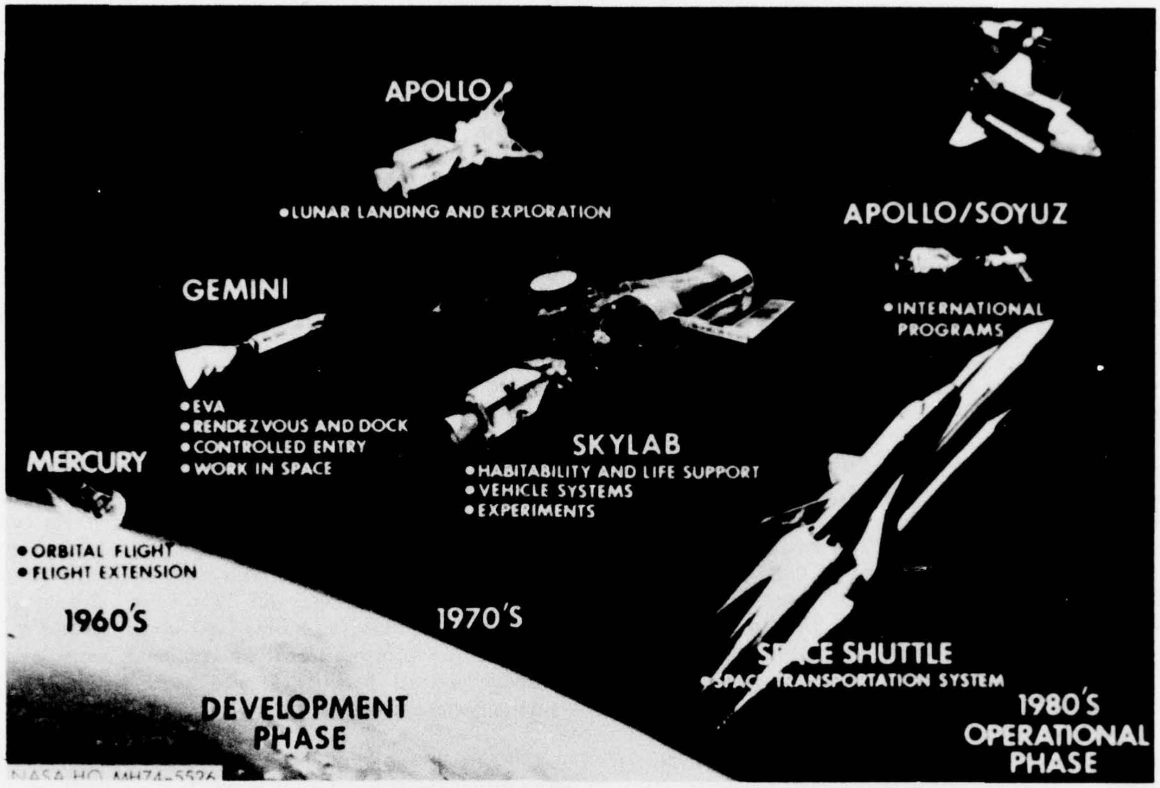

Fig.1 US manned space-flight overview

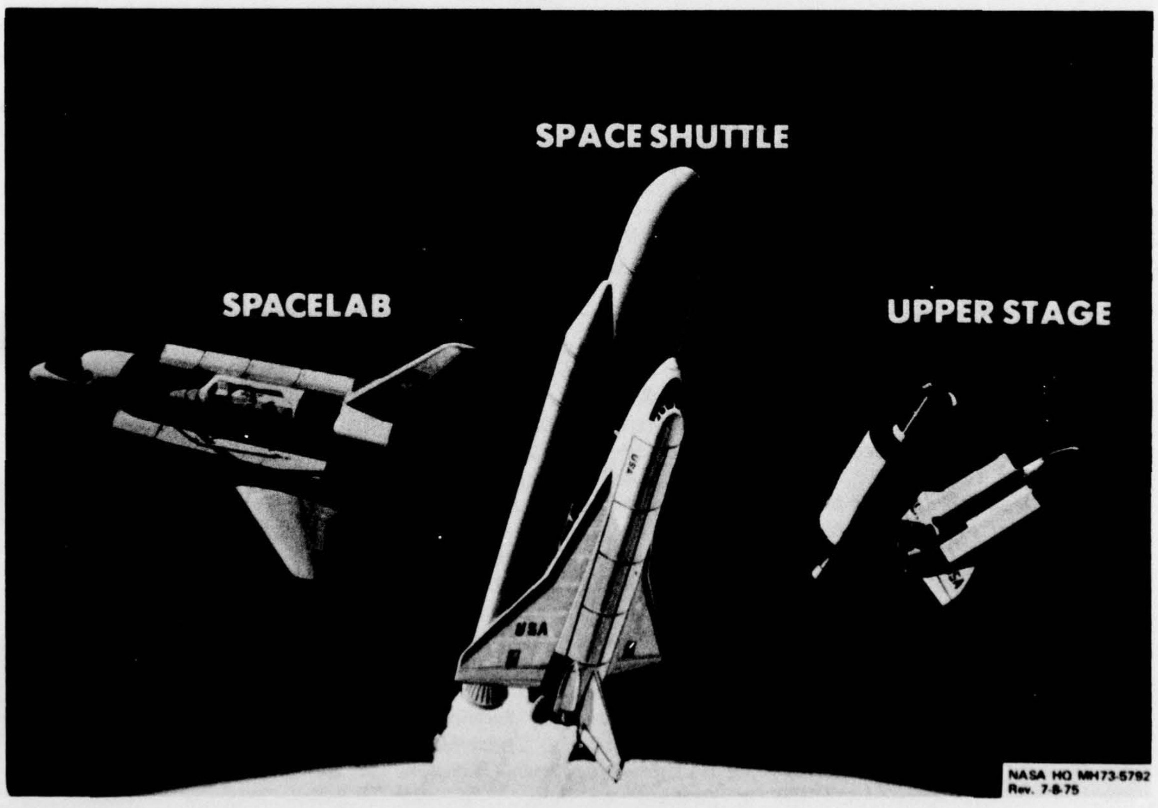

Fig.2 Space transportation system

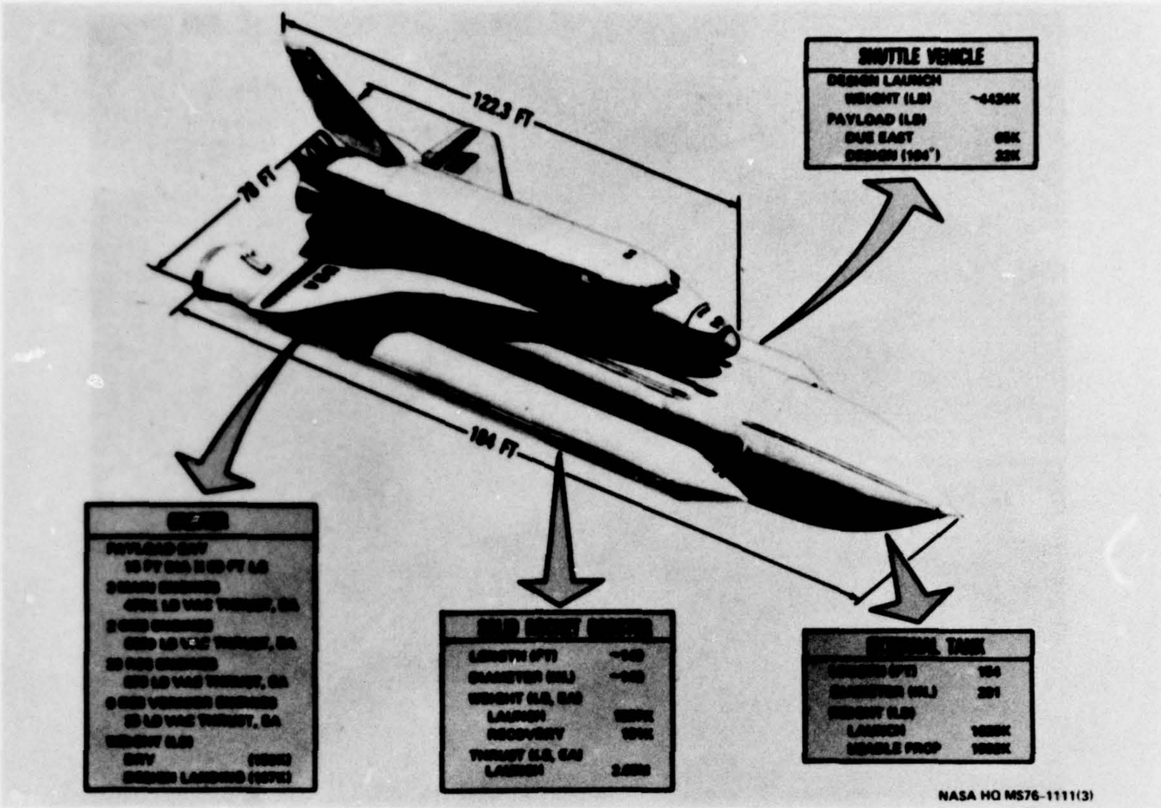

Fig.3 Space shuttle vehicle

of four, with provisions for a crew of as many as seven. It can remain in orbit nominally for seven (7) days (up to 30 days with special payloads), return to earth with personnel and payload, land like an airplane, be refurbished for a subsequent flight in 14 days, and provide for a rescue mission launch on short notice.

The crew includes a commander, pilot, mission specialist, and up to four payload specialists. (Figure 6) The crew occupies a two-level cabin at the forward end of the vehicle. They control the launch, orbital maneuvering, atmospheric entry, and landing phases of the mission from the upper level flight deck (Figure 7). The crew also performs payload handling. Seating for up to three additional crew members and habitability provisions are provided on the mid deck. The load factors experienced by the crew on any of these missions is 3g's or less.

Crew/passenger provisions include normal earth atmosphere of 14.7 psi vs 5 psi used on previous programs with a controlled environment of humidity and temperature, hot and cold food, and male and female hygiene facilities. Space suit operations are included for payload support, rescue, and extra vehicular activities (EVA).

The integrated Shuttle vehicle ascends from the launch pad (Figure 8) to an altitude of about 23 nautical miles, at which point the solid rocket boosters (SRB) are jettisoned. The SRB's fall in an arc back to earth, are decelerated by parachutes, and are recovered from the ocean for reuse. Shortly before orbital injection, the orbiter main propulsion engines are shut down, and the external tank is separated from the orbiter. The orbital maneuvering system provides thrust to inject the orbiter while the external tank follows a ballistic trajectory into a remote ocean area for disposal.

A typical mission profile is shown in Figure 9. The Shuttle is launched with the three orbiter Space Shuttle main engines (SSME's) and the two solid rocket boosters (SRB's) burning in parallel. The main engine cutoff (MECO) takes place 479 seconds after liftoff and the external tank (ET) separation occurs at MECO. The orbital maneuvering system (OMS) engine is used to attain the desired orbit, and OMS engine cutoff occurs 600 seconds after launch.

Following the completion of orbital operations, the orbiter is oriented to a tail-first attitude. After the OMS provides the deceleration thrust necessary for de-orbiting, the orbiter is reoriented nose-forward to the proper attitude for entry. The orientation of the orbiter is established and maintained by the reaction control system (RCS) down to the attitude where the atmospheric density is sufficient for the pitch and roll aerodynamic control surfaces to be effective (about 250,000 feet altitude and 26,000 feet per second velocity).

The orbiter entry trajectory provides lateral flight range to the landing site and energy management for an unpowered landing. The angle of attack is established at 38 degrees for theoretical entry interface of 400,000 ft. altitude. The 38 degree attitude is held until the speed is reduced to 21,200 feet per second (about 220,000 feet

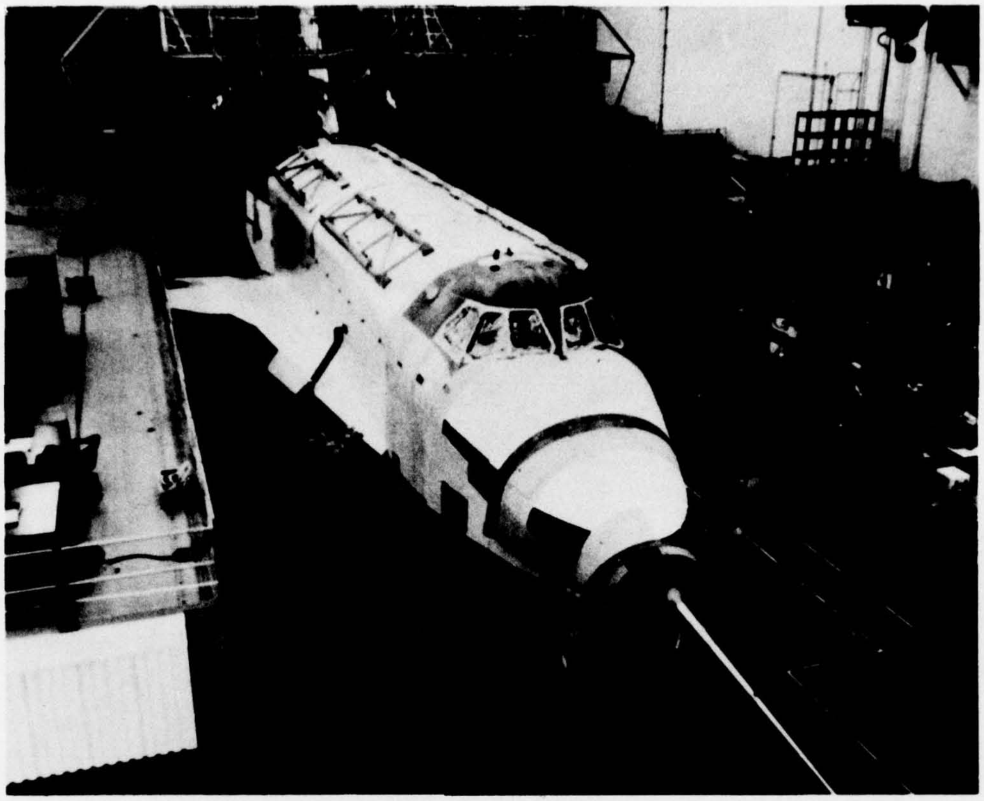

Fig.4 Orbiter 101

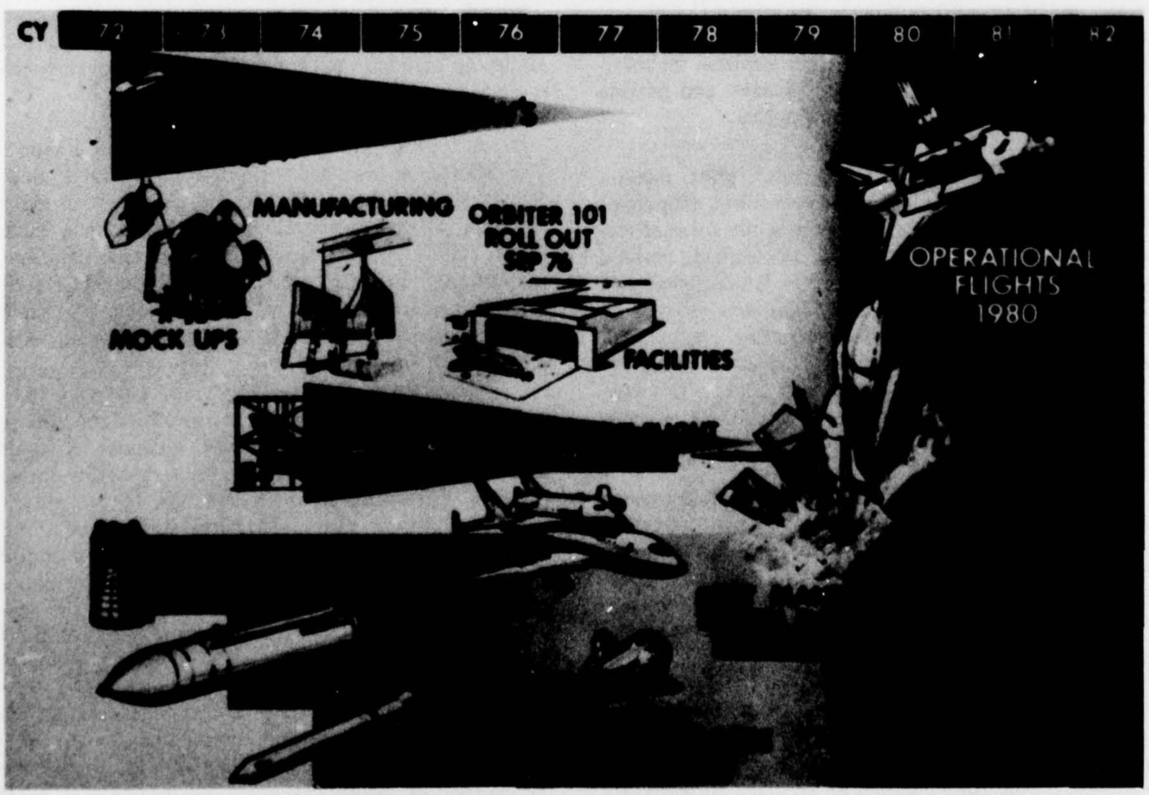

Fig.5 Space shuttle activities

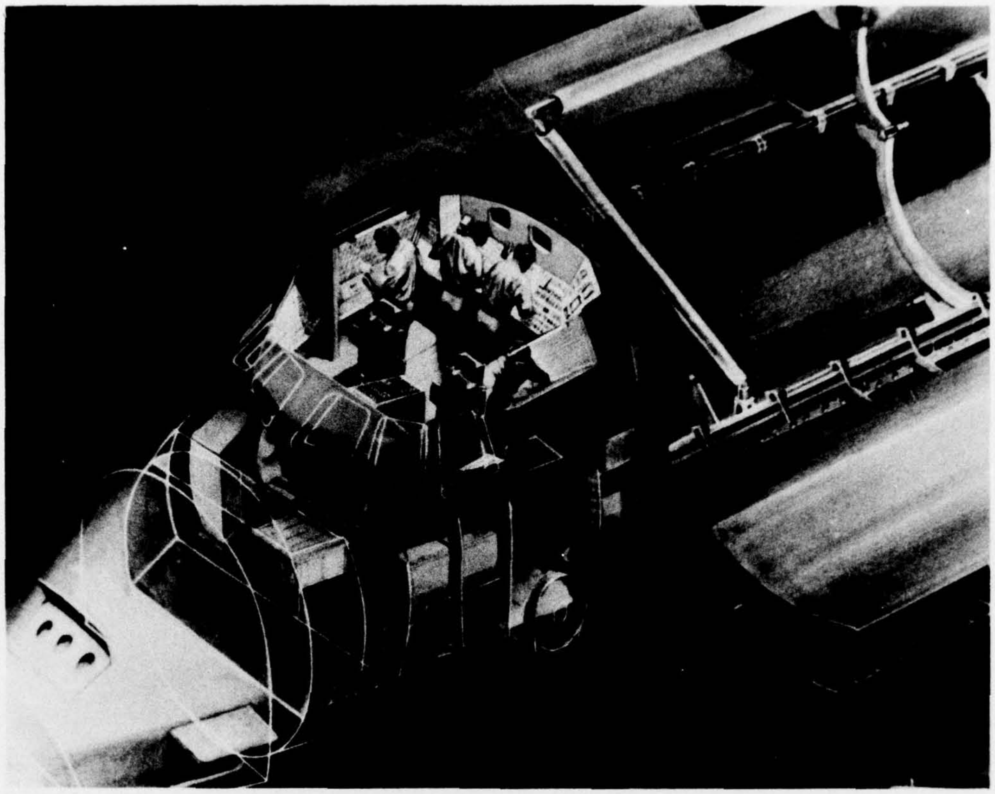

Fig.6 Crew stations

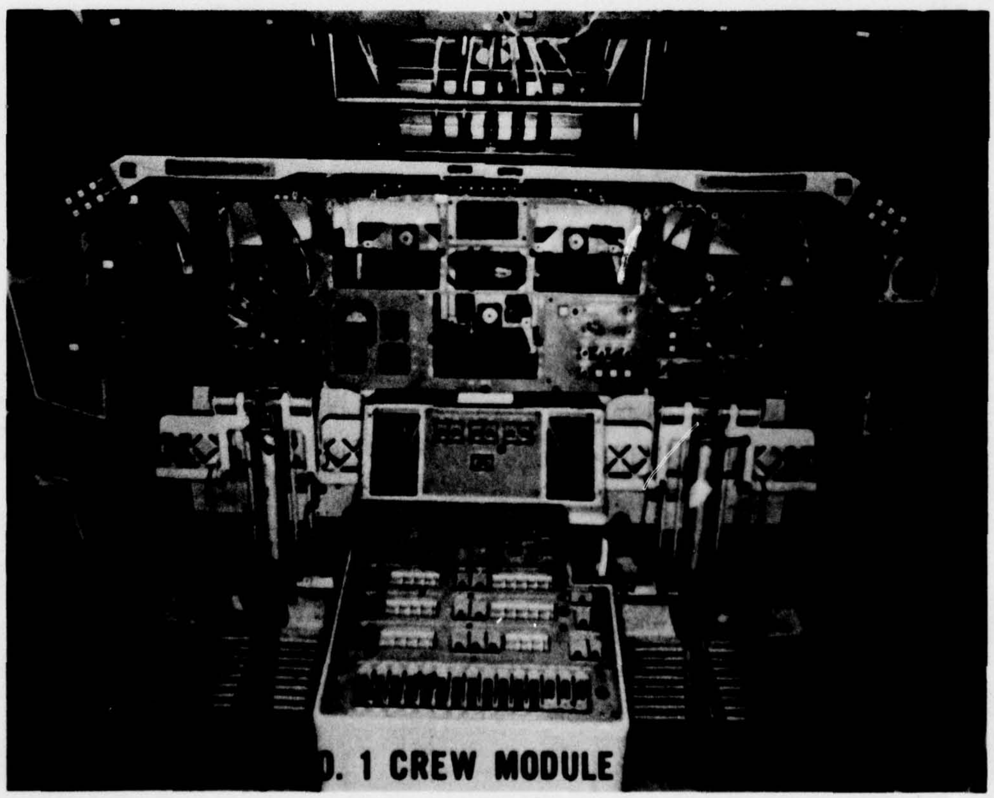

Fig.7 Upper level flight deck

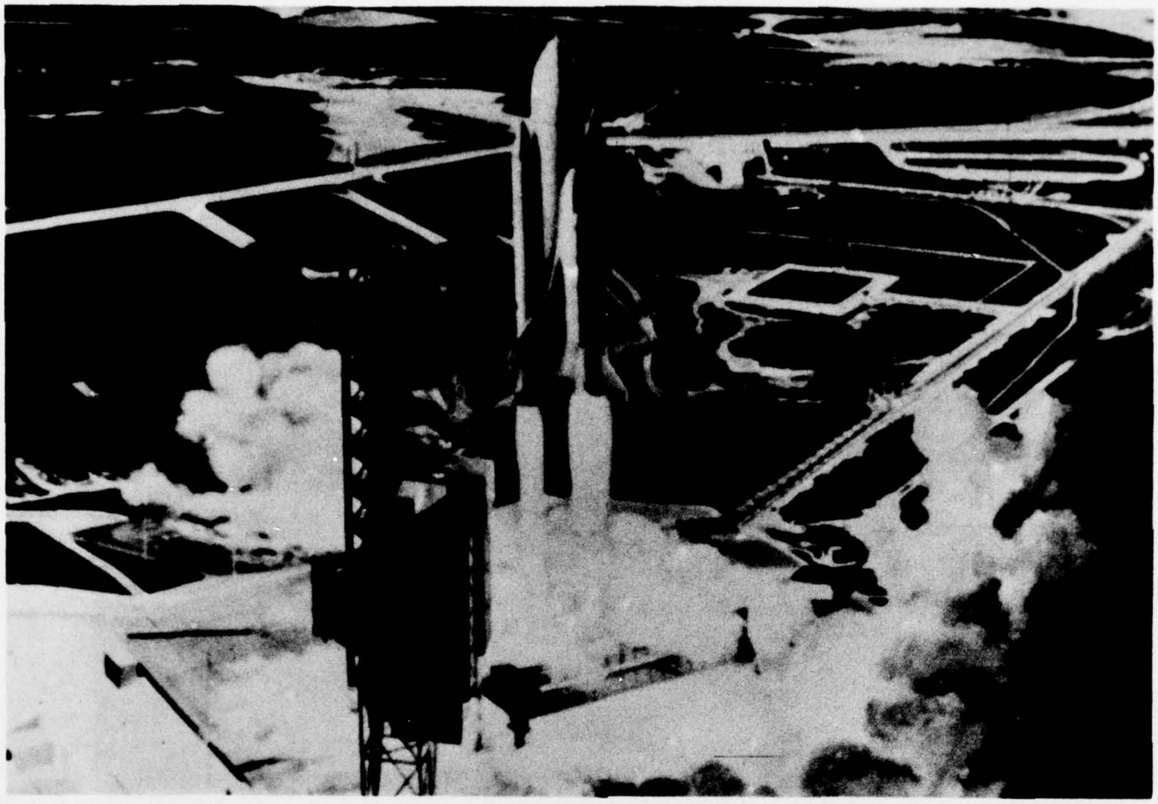

Fig.8 Space shuttle lift off

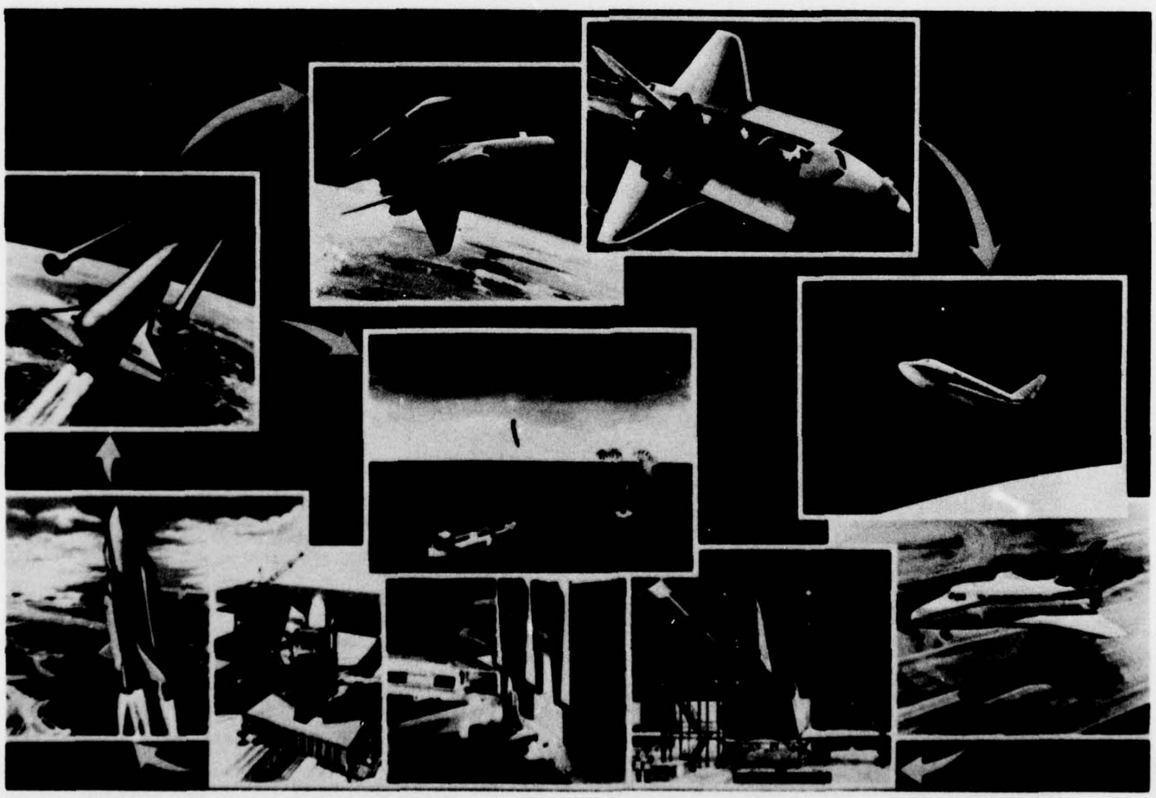

Fig.9 Space shuttle mission profile

altitude), and is then reduced gradually to 28 degrees at 17,200 feet per second (about 190,000 feet altitude), it is held at 28 degrees until speed is reduced to 8,500 feet per second (about 150,000 feet altitude), and then reduced gradually to 6 degrees where the speed is about 1,500 feet per second (about 70,000 feet altitude) at the beginning of terminal area energy management (TAEM).

During the final phase of descent, flight path control is maintained by using the aerodynamic surfaces. TAEM is initiated to provide the proper vehicle approach to the runway with respect to position, energy, and heading. Final touchdown occurs at an angle of attack of 16 degrees for an aircraft-type landing.

Another Shuttle operations capability which is unique to the Space program is on-orbit satellite servicing or refurbishment. (Figure 10) This capability provides the payload designers with new freedom in developing and operating satellites that can reduce payload costs as well as improve performance. Alternative techniques for on-orbit servicing of satellites are under study in the two primary concepts – servicing and replacement.

Low-cost refurbishable payloads are carried by a retention system for land distribution. A docking ring is pivoted by the retention system to allow rotation of the satellite in and out of the cargo bay. Deployment away from the Shuttle and capture/docking are accomplished by a Shuttle attached manipulator system. (Figure 11) A rotary magazine carries the replacement modules and presents them at the proper time to an exchange mechanism. The exchange mechanism first removes the old module from the satellite, stows the old module temporarily, removes the new module from the magazine, installs it in the satellite, and finally stows the old module back in the magazine. Additional propellant for the Shuttle orbit maneuvering system (OMS) can provide capability for an increase in operational altitude. The remote manipulator system is being developed by the Canadian government.

Mixing payloads into efficient cargoes for Shuttle flights is a probable operating mode since a single payload will not always utilize the full capability of the Space Shuttle vehicle. Mixing of the payloads can provide economic advantages where mission and schedule constraints are compatible. (Figure 12)

A 160 working hour ground turnaround is the goal for the Space Shuttle orbiter and the support system to relaunch the orbiter after it returns from an orbital mission. (Figure 13) This short ground turnaround time is in the interest of decreasing the maintenance cost, decreasing the inventory of orbiters and support system elements, and increasing the utilization rate of the orbiter. Various ground turnaround processes take place after the orbiter lands with respect to safing, maintenance, and checkout, pre-mate preparations, Shuttle assembly, and pre-launch. The Shuttle runway (Figure 14) at the Kennedy Space Center in Florida is one of the key elements that make possible the recovery

Fig.10 On-orbit satellite servicing

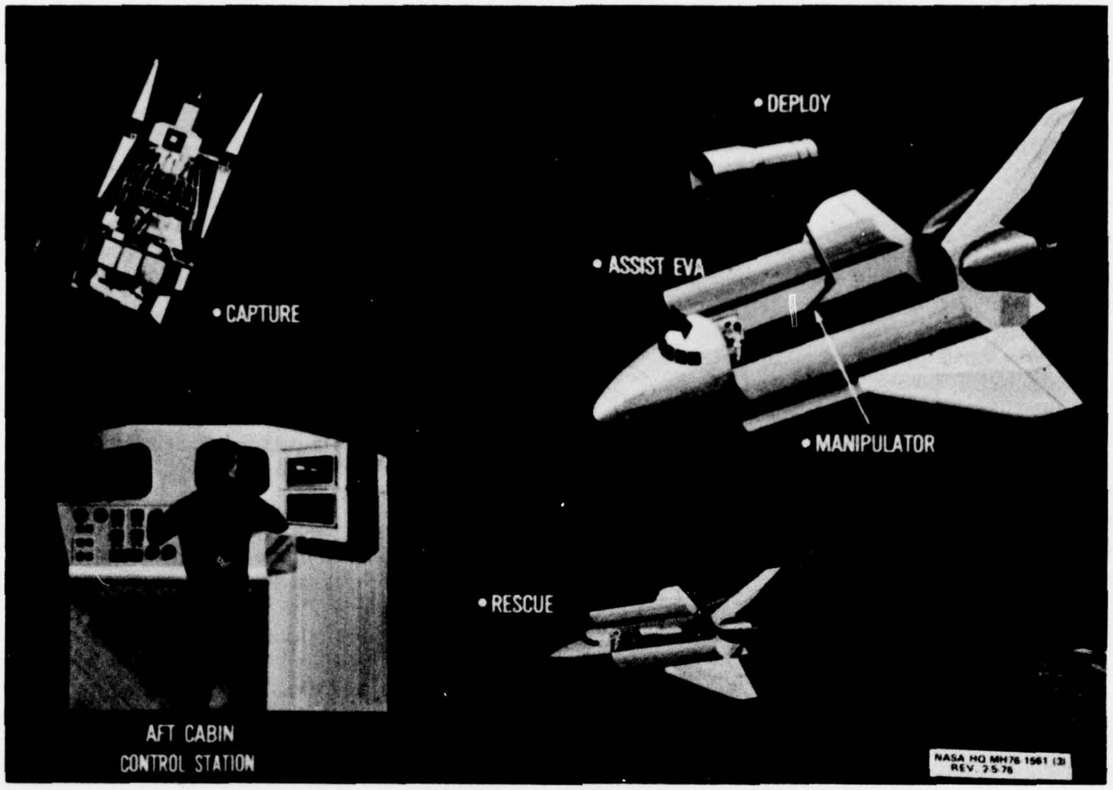

Fig.11 Shuttle manipulator system

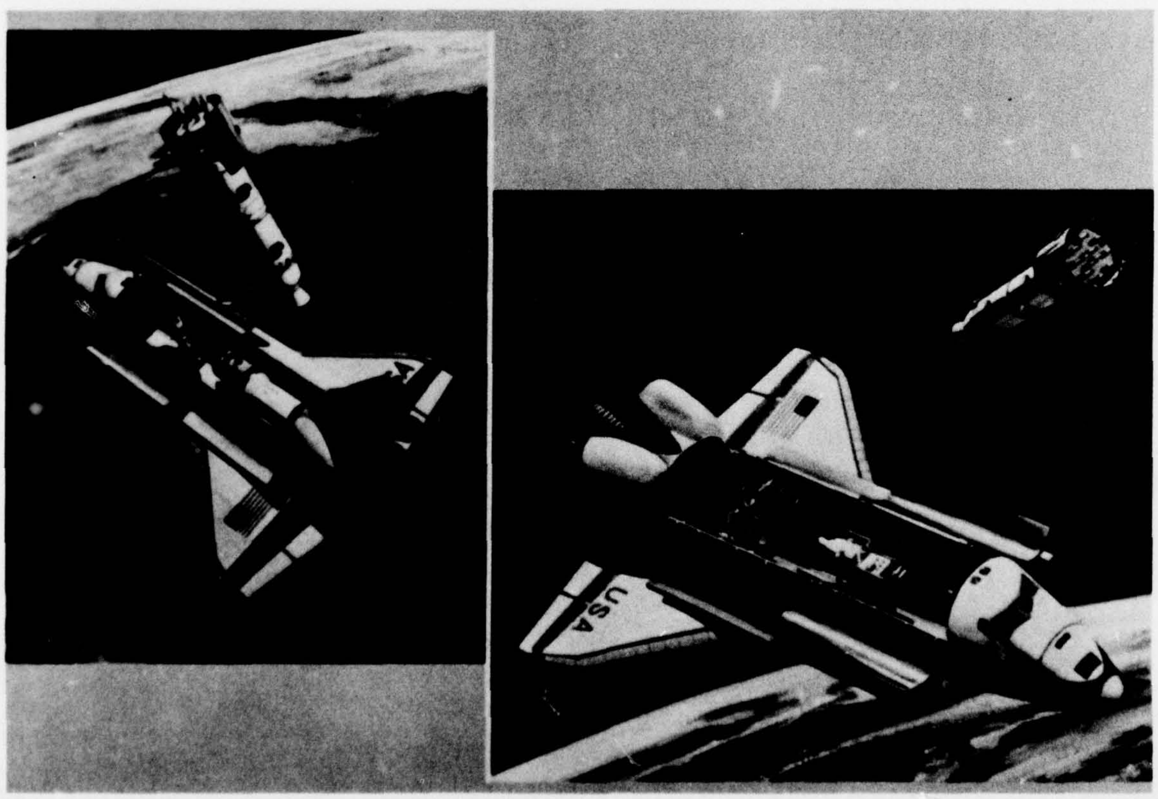

Fig.12 Mixed/multiple payload cargoes

and reuse of complex flight hardware of the type that formerly was used only once.

The Space Shuttle orbiter, after landing airplane-style on the runway (15,000 feet long), will be towed to the Orbiter Processing Facility (OPF). Following the maintenance and checkout period, a payload will be installed and the orbiter moved to the VAB for assembly with the external tank and solid rocket booster on a Mobile Launch Platform. The integrated Space Shuttle will then be moved to the launch pad for another trip into space.

The orbiter has a thermal protection subsystem (TPS) which consists of materials applied externally to the primary structural shell of the orbiter vehicle and maintains the airframe outer skin within acceptable temperature limits. (Figure 15) (Internal insulation, heaters, and purging facilities are used to control interior compartment temperatures but are not part of the TPS system.) The TPS supports mission requirements by maintaining acceptable primary structure temperatures. The peak heating rates and the longest exposure to those rates occur during entry but the maximum temperature the structure is exposed to occurs after landing because of thermal lag.

TPS materials and their application areas include: (Figure 16)

1. Coated Nomex felt (FRSI), which is used in areas where temperatures are less than 750°F for entry and 830°F for ascent, i.e., upper cargo bay door, mid and aft fuselage sides, upper wing, and APS pod;
2. Low temperature reusable surface insulation (LRSI) which is used in those areas where temperatures are below 1200°F and above 750°F, nominal, under design heating conditions;
3. High-temperature reusable surface insulation (HRSI) which is used on those areas exposed to temperatures below 2300°F and above 1200°F under design heating conditions:
4. Reinforced carbon-carbon (RCC) which is used on areas such as wing leading edge and nose cap where predicted temperatures exceed 2300°F under design heating conditions;
5. Thermal window panes and metal (forward RCS fairings and elevon seal panels); and
6. Thermal barriers are installed around operable penetrations (main egress hatch, landing gear doors, etc.) to protect against aerothermal heating.

The TPS has been designed for ease of maintenance and flexibility of ground and flight operations while satisfying its primary function of maintaining acceptable airframe outer skin temperatures.

The transporting of the orbiter (Figure 17) from its final assembly site (Palmdale, California) to the operational sites (KSC or VAFB) or between the operational site, (or retrieving the orbiter from an auxiliary landing field after an emergency landing) will be accomplished on top of a specially modified Boeing 747-100 aircraft. Prior to mounting the orbiter on the carrier aircraft, the orbiter subsystems are deactivated to a dormant condition, a tail cone is added to reduce wake turbulence and base drag, and control locks are

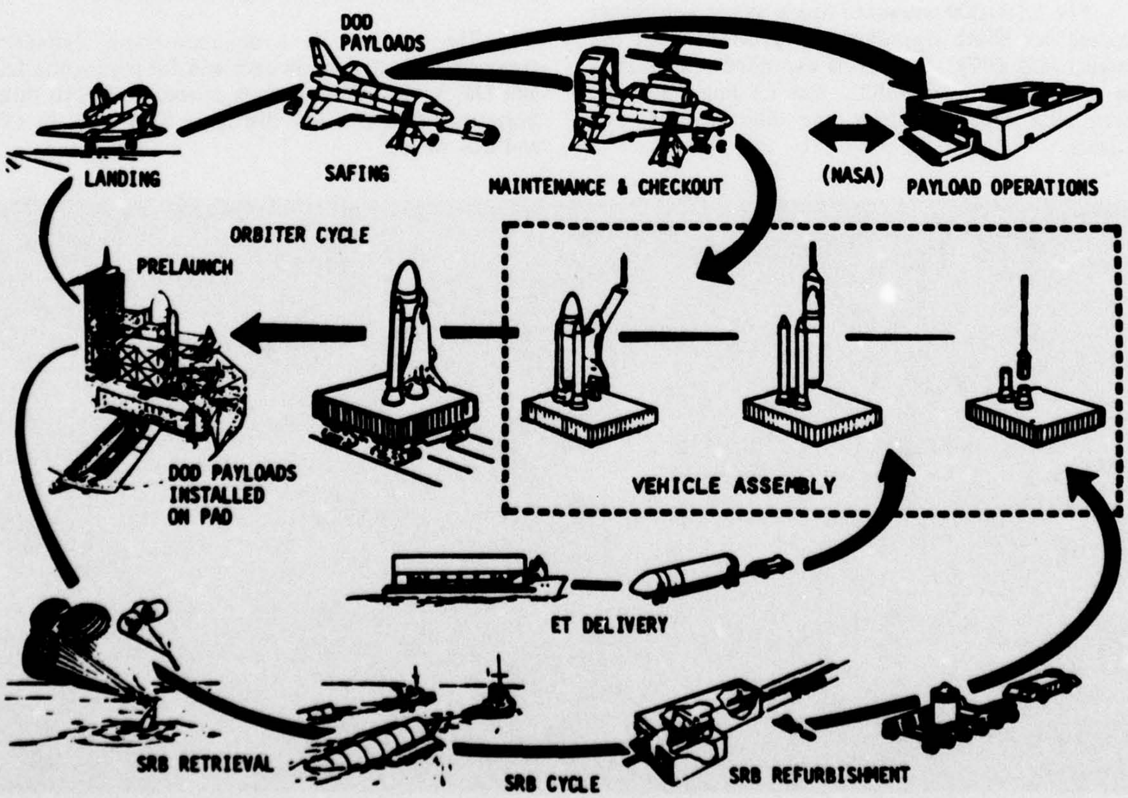

Fig.13 Space shuttle system ground flow

placed on the orbiter's aerodynamic control surface. The orbiter is then erected on top of the 747 and the combined aircraft take-off, fly, and land as a unit.

A Boeing 747 aircraft is currently being modified for use as the carrier aircraft for the orbiter. Modifications include structural reinforcement of the fuselage to carry the orbiter induced loads and modifications for directional stability (i.e. a larger vertical fin and tip fins on the horizontal stabilizer). The aircraft-to-orbiter structure attaches to the orbiter fittings that are normally the orbiter-to-external tank fittings; thus, there is no change or addition to the orbiter for this transport capability.

The orbiter main propulsion engines (Figure 18) burn for approximately eight minutes. For the first two minutes, the engines of the main propulsion system burn in parallel with the SRB motors. These two systems provide the velocity increment necessary to almost achieve the initial mission orbit. The final boost into the desired orbit is provided by the orbit maneuvering system (OMS).

Each of the three Space Shuttle main engines (SSME) operates with a fix nozzle area ratio of 77.5:1 at a mixture rate (LO_2/LH_2) of 6:1 and a chamber pressure of 3000 psia to produce a rated sea-level thrust of 470,000 pounds (Figure 19). The engines can be throttled over a rated range of 50 to 109 percent of the rated thrust level. This allows orbiter acceleration to be limited to 3 g's. The engines are capable of being gimbaled for flight control during the orbiter boost phase (Figure 20).

The 1,550,000 pounds of usable ascent propellants required for SSME operations are provided from the external tank (ET). The ET is expended after MECO but prior to achieving orbit. The ET impacts in the ocean after separating from the orbiter and is not reusable.

Five Main Propulsion System fluid lines interface with the ET through disconnects located at the bottom of the orbiter aft fuselage. The three hydrogen disconnects are mounted on a carrier plate on the left side of the orbiter (facing forward), and the two oxygen disconnects are mounted on the right side. Ground servicing of the MPS is accomplished through umbilicals on both sides of the aft fuselage.

The external tank (ET) (Figure 21) supplies the orbiter main propulsion system with liquid hydrogen (LH_2) and liquid oxygen (LO_2) at prescribed pressures, temperatures, and flow rates. Both the LH_2 and LO_2 tanks are equipped with a vent and relief functions. Tank level sensors provide for propellant loading and shutdown signals. The ET is thermally protected with a nominal one-inch thick spray-on foam insulation (SOFI), employing additional SOFI and a charring ablator (SLA 561) to withstand localized high heating. Since the ET is an expendable element, the ET subsystems are designed for single usage to minimize costs.

The ET reacts to the solid rocket booster thrust through its intertank structure and provides attachment fittings to the orbiter. At liftoff the ET contains 1.55 million pounds of usable propellant. At MECO, the ET is separated from the orbiter, before orbital velocity is achieved. The ET then proceeds on a ballistic reentry path for a safe impact in the ocean.

The ET consists of a forward LO_2 tank, an unpressurized intertank structure and an LH_2 tank. (Figure 22) The LO_2 tank (volume – 19,500 ft^3) is an aluminum alloy monocoque structure composed of a fusion-welded assembly of preformed, chem-milled gores, panels, machined fittings, and ring chords.

The intertank is a semimonocoque cylindrical structure with flanges on each end for joining the LO_2 and LH_2 tanks. The intertank contains the SRB thrust beam and fittings which distribute SRB loads to LO_2 and LH_2 tanks.

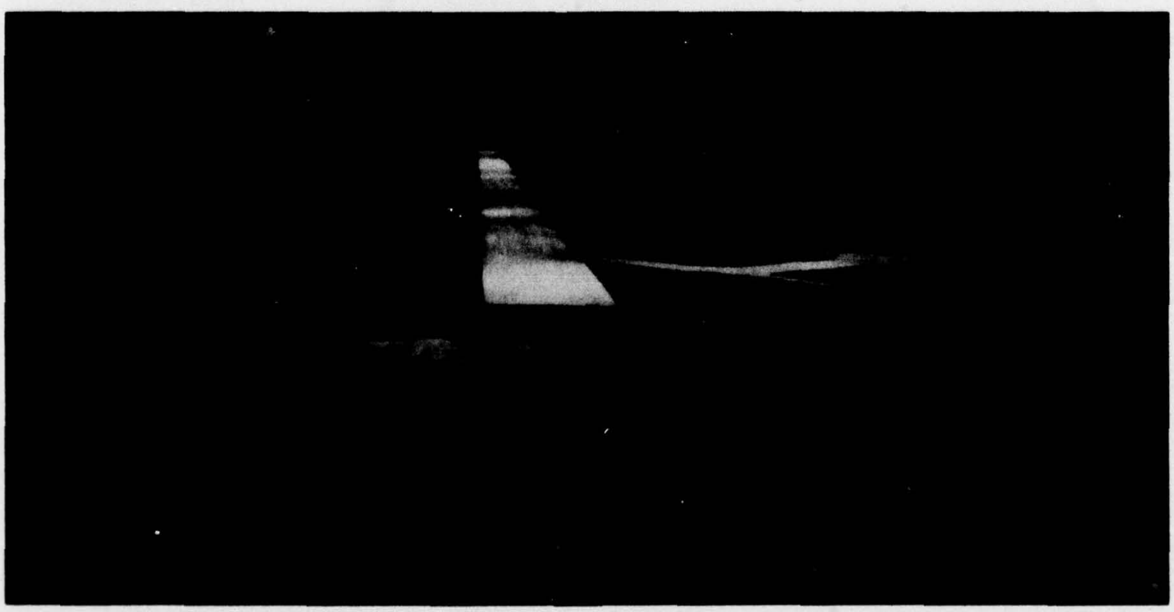

Fig.14 Shuttle runway KSC

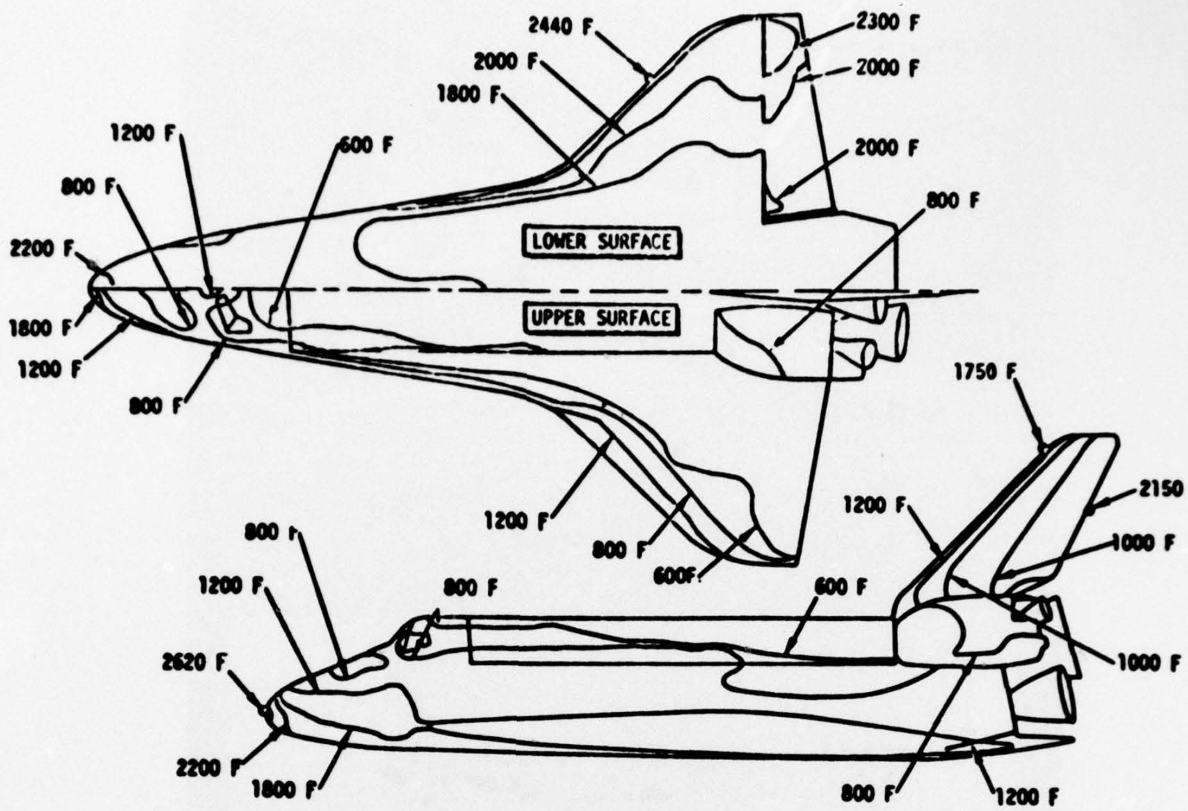

Fig.15 Orbiter isotherms

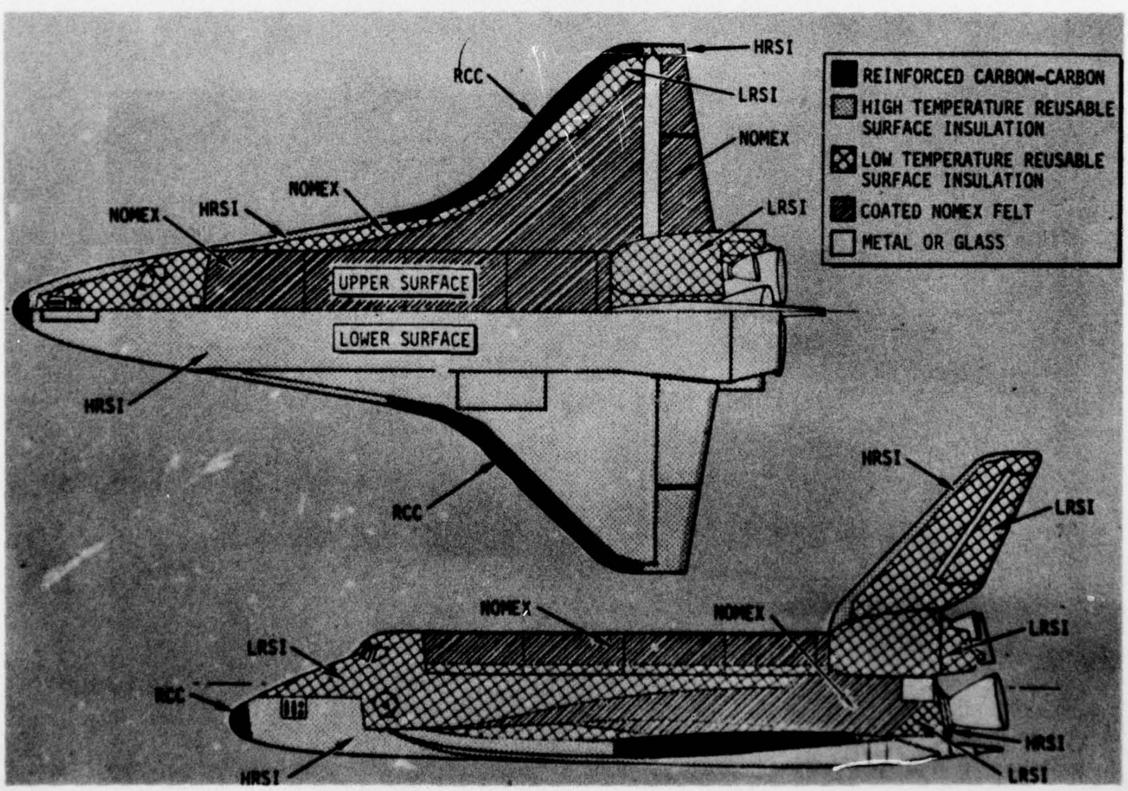

Fig.16 Thermal protection system (TPS)

Fig.17 Shuttle carrier aircraft

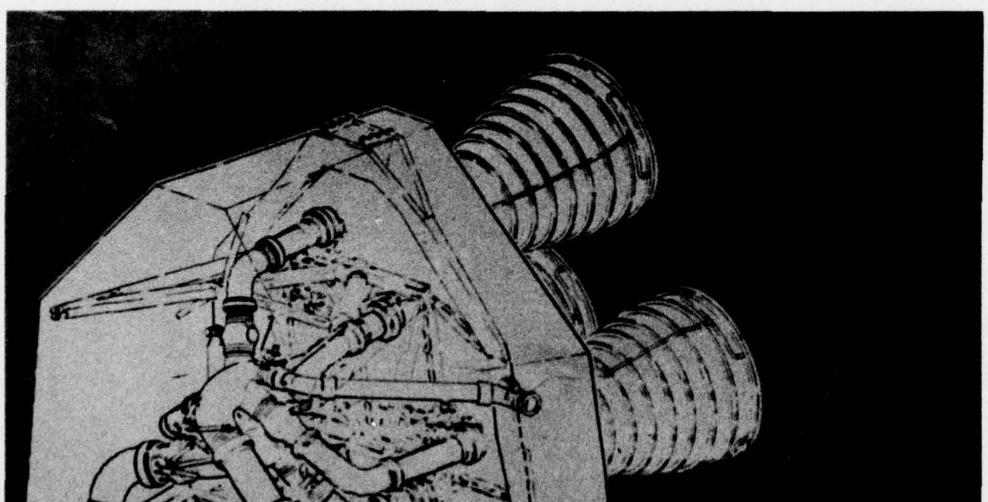

Fig.18 Shuttle main propulsion engines/subsystem

The LH_2 tank (volume – 55,552 ft^3) is a semi-monocoque structure composed of fusion welded barrel sections five beam ring frames, and forward and aft 0.75 ellipsiodal domes. (Figure 23) The LH_2 tank is designed to operate at a nominal pressure of 32 to 34 psia.

Two solid rocket boosters burn in parallel with the orbiter main propulsion system to provide initial ascent thrust. Primary elements of the booster (Figure 24) are the motor, including case, propellant, igniter, and nozzle; structural systems; separation, operational flight instrumentation, and recovery avionics; separation motors and pyrotechnics; deceleration system, range safety destruct system, and thrust vector control subsystems. Each SRB weighs approximately 1.293 million pounds and produces 2.90 million pounds of thrust at sea level. The propellant grain is shaped to reduce thrust approximately one-third 55 seconds after liftoff to prevent over-stressing the vehicle during the period of maximum dynamic pressure.

The SRB thrust vector control subsystem, which is a closed loop hydraulic system with power provided by redundant Auxiliary Power Units and hydraulic pumps, has a maximum omni-axial gimbaling capability of 7.1 degrees which, in conjunction with the orbiter main engines, provides the flight control during the Shuttle boost phase. (Figure 25)

A segmented case design affords maximum flexibility in fabrication, ease of transportation, and handling. A cone shaped skirt at the aft end of the SRB's supports the loads between the SRB and the mobile launch pad. Two lateral sway braces and a diagonal attachment at the aft frame provide the structural attachment between the SRB and the tank. The SRB forward attachment to the tank is by a single thrust attachment at the forward skirt and is used also for attaching the main parachute riser attachments.

The SRB's are released by pyrotechnic separation devices at the forward thrust attachment and the aft sway braces. Eight separation rockets on each SRB, four aft and four forward, separate the SRB from the orbiter and tank.

The forward section provides installation volume for the SRB electronics, recovery gear, range safety destruct system and forward separation rockets. The parachute deceleration subsystem consists of a pilot parachute, a ribbon drogue parachute, and ribbon main parachute.

The Space Transportation System consists of the Space Shuttle, Spacelab, and Upper Stages. The Spacelab, being developed by the European Space Agency (ESA), is an essential part of the STS. Dr David Shaplan, ESA, Spacelab Program Director, will present the Spacelab portion of t. is briefing.

The Upper Stages are necessary for the delivery of payloads to orbits that are beyond the capability of the Shuttle alone. The Upper Stages are an integral part of the STS. (Figure 26)

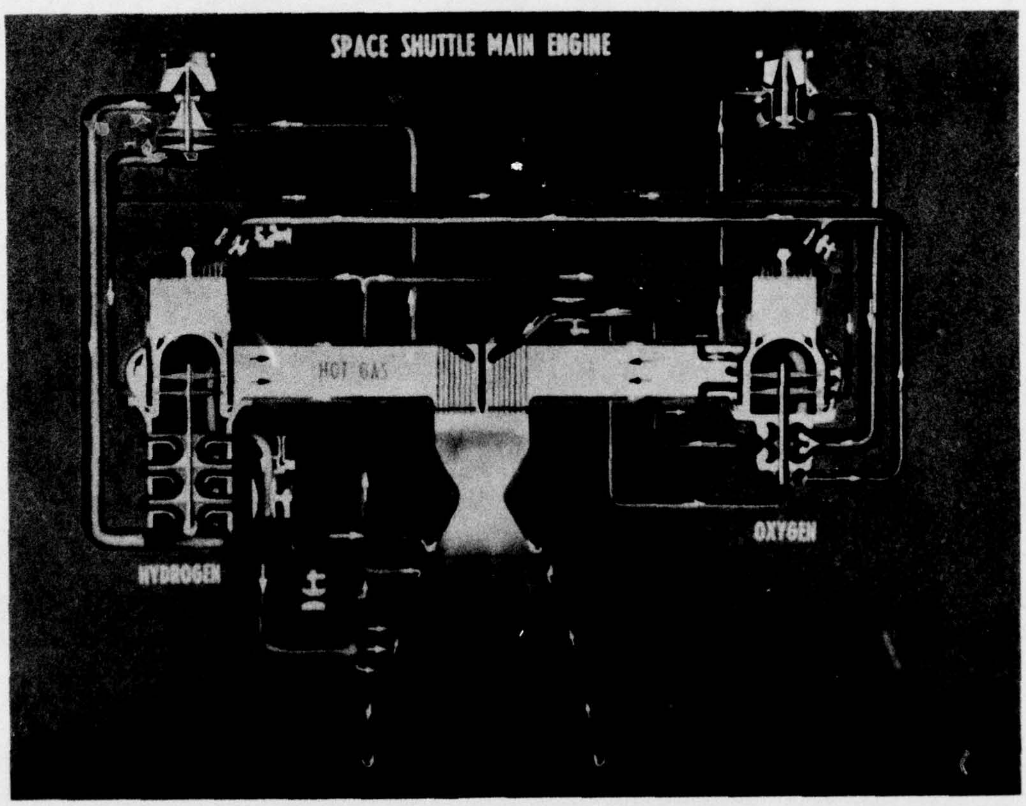

Fig.19 Space shuttle main engine

NASA and the Department of Defense (DOD) have agreed that the USAF will develop an Interim Upper Stage (IUS) for use with the Space Shuttle. A solid propellant IUS configuration (Figure 27) will be developed on the basis of low cost, low risk, stage simplicity, simple Shuttle interfaces and growth potential. It is planned to be available in mid 1980 for use by both agencies.

The Spinning Solid Upper State (SSUS) (Figure 28) is an essential part of the STS. The goals of the SSUS are to provide very low cost transportation of spacecraft of altitudes beyond Shuttle capability and to provide easy transition from expendable launch vehicles to the STS. A Delta class SSUS will contain 3300–3500 pounds of propellant. A larger SSUS for Atlas Centaur class spacecraft is expected to contain about 6500–7000 pounds of propellant. Two Atlas Centaur class SSUS or four Delta class SSUS could be flown with their spacecraft in a single Shuttle flight.

The SSUS and its payload are carried into low earth orbit (150–160 NM) just as any other Shuttle payload. (Figure 29) Once on orbit, the SSUS is rotated upward to an angle out of the cargo bay. After alignment by the orbiter to the proper altitude for perigee burn, the SSUS and its payload are spun-up by a spin table mounted in the orbiter bay. The SSUS and payload are separated from the orbiter by a simple spring mechanism. After a separation distance of from 2–5 NM has been attained, (up to 45 min. coast) the stage is ignited by a timer. The stage is separated from the payload after burnout, thus completing the STS portion of that mission. The payload user then assumes command for tracking, apogee stage ignition, and payload on-orbit operations.

In summary, the Space Transportation System is being developed to achieve the capability for lower cost space operations in the 1980's and beyond, permit an orderly transition, be price competitive, and develop low cost operational concepts. The system must accommodate all classes of users – Science, Applications, Civilian, Government, Commercial, and Military, and US and foreign.

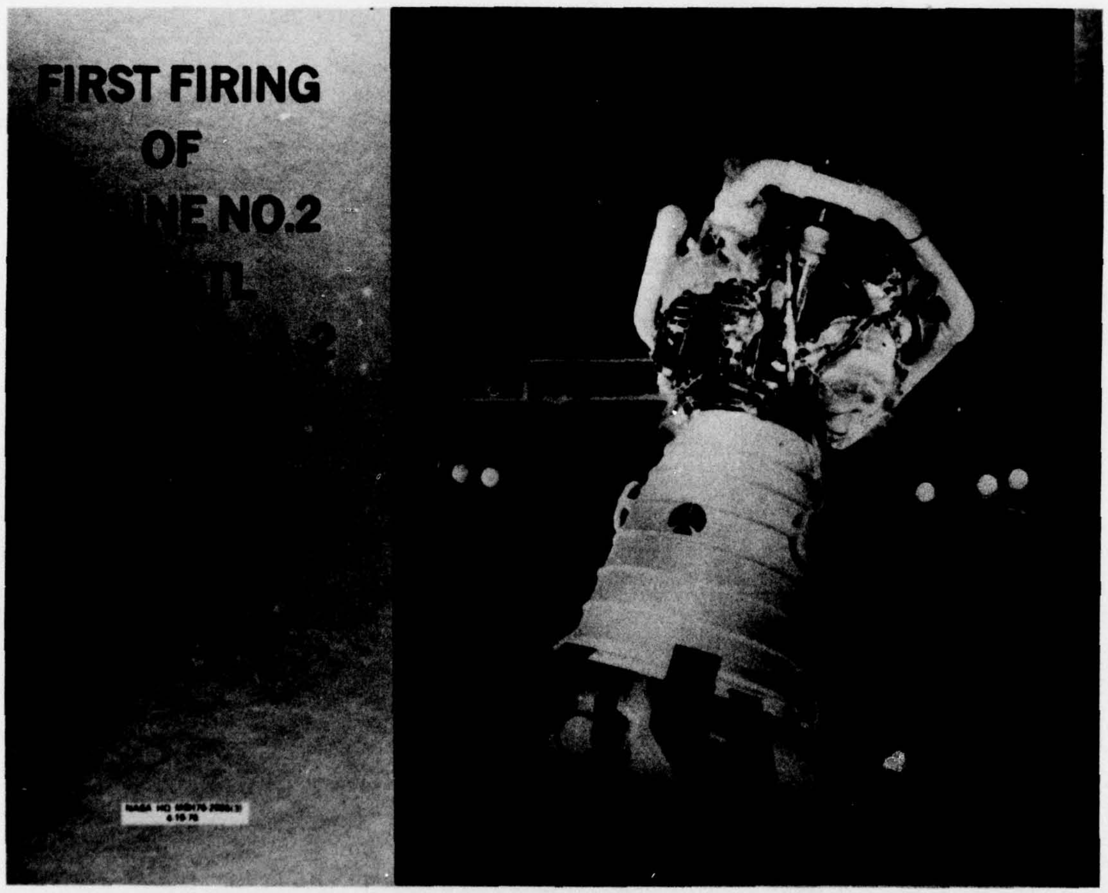

Fig.20 Shuttle engine test

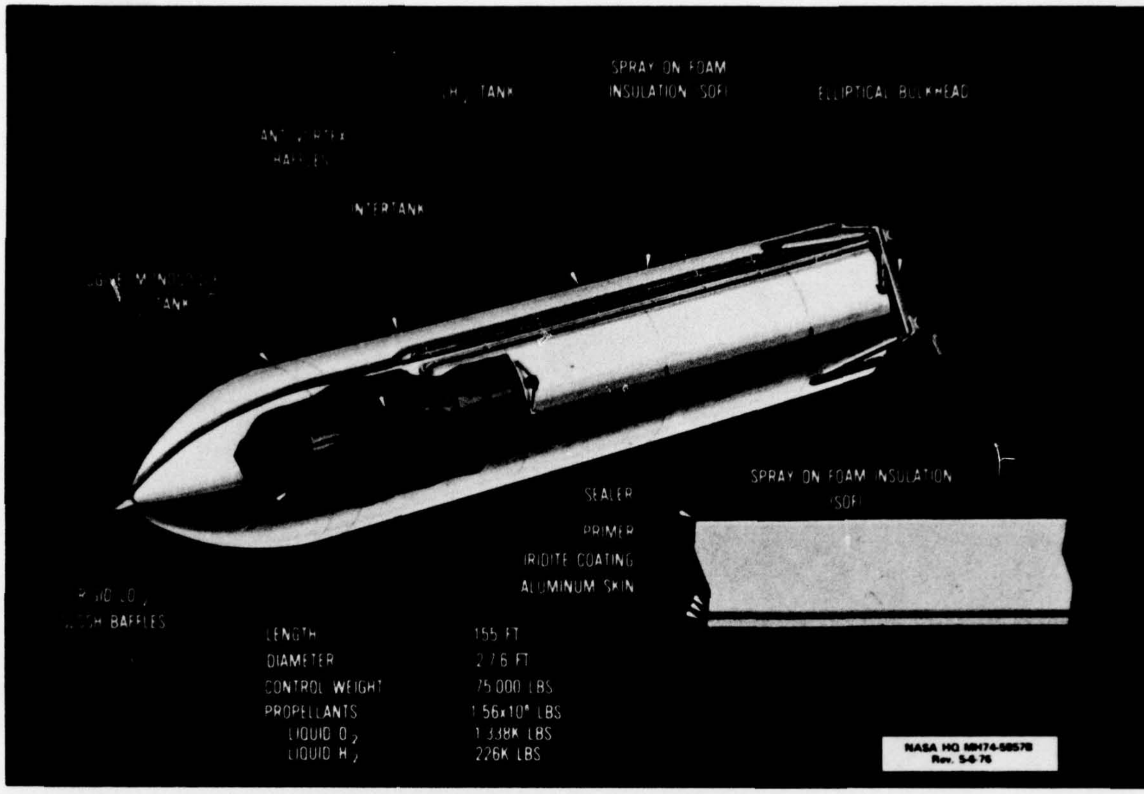

Fig.21 External tank

Fig.22 External tank LO_2 and LH_2 tank fixtures

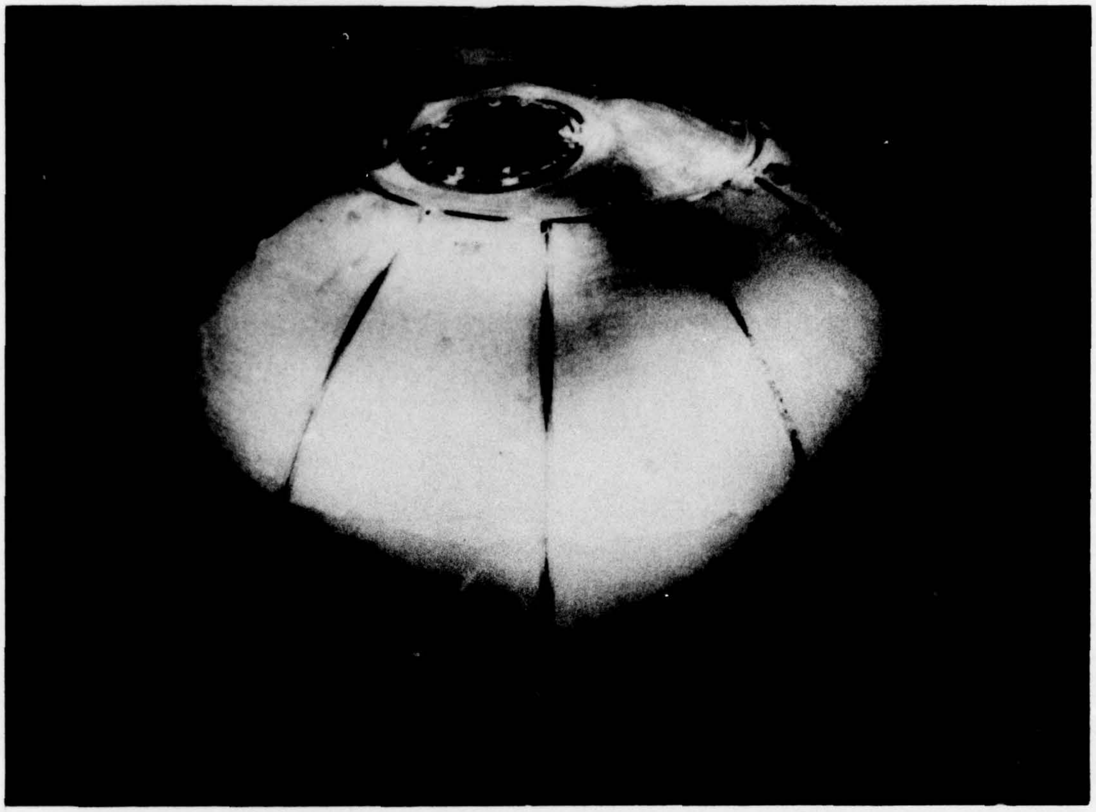

Fig.23 Ellipsiodal dome

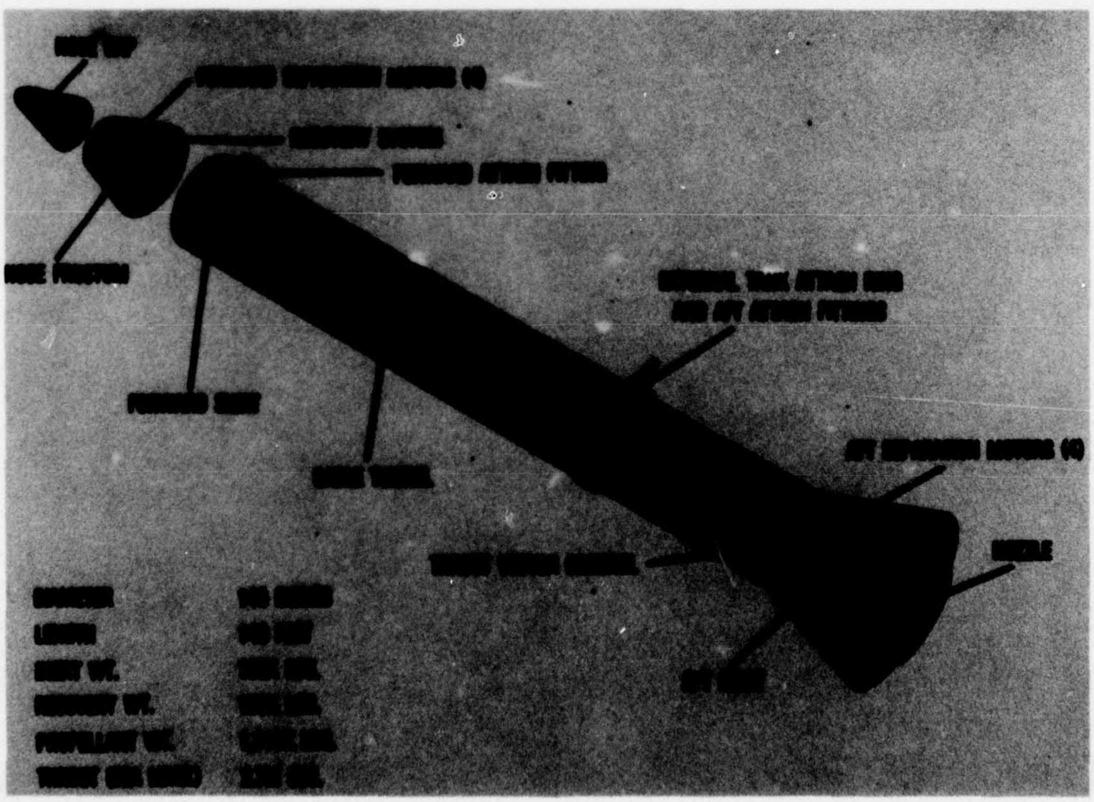

Fig.24 Solid rocket booster (SRB)

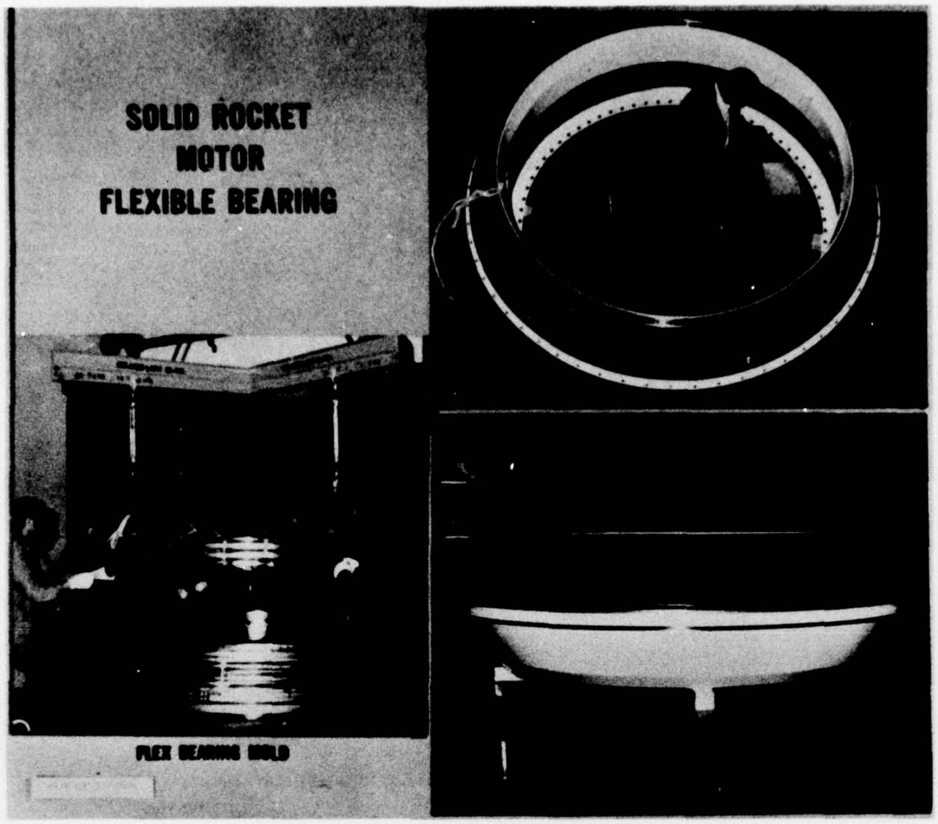

Fig.25 Solid rocket motor

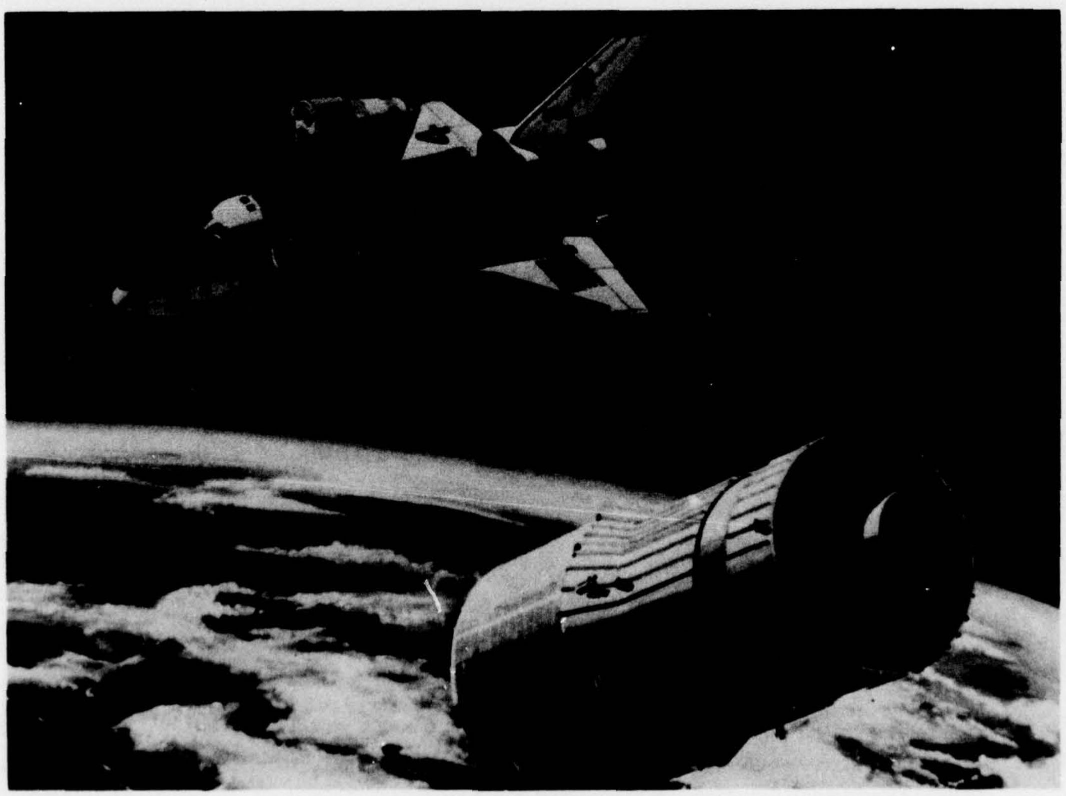

Fig.26 Interim upper stage

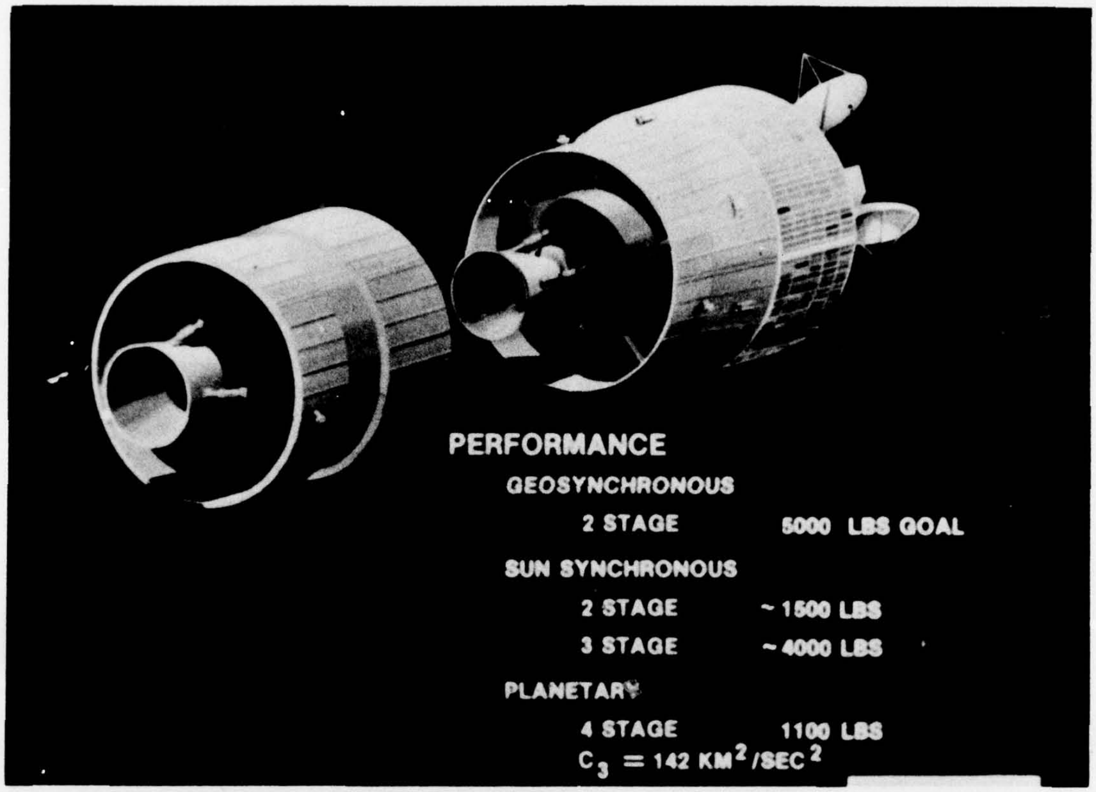

Fig.27 Solid propellant IUS

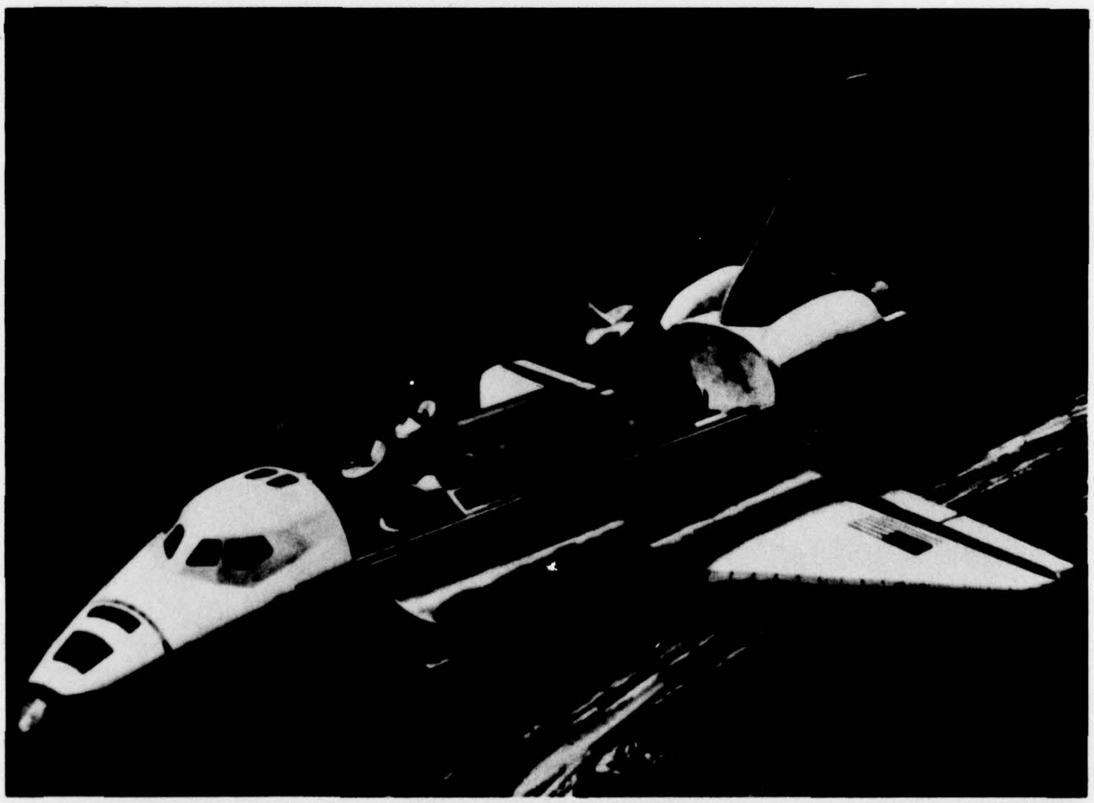

Fig.28 Spinning solid upper stage

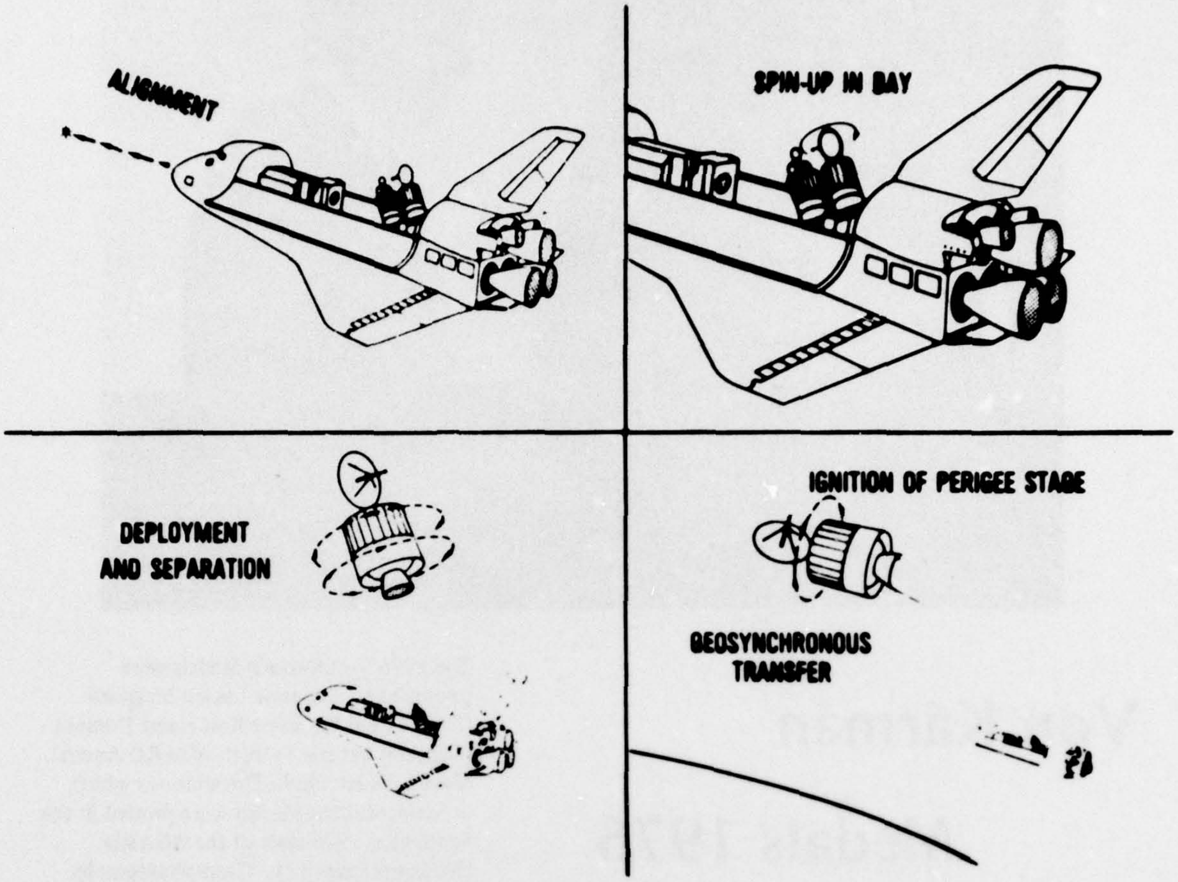

Fig.29 Spinning stage concept

Von Kármán Medals 1976

The 1976 Von Kármán Medals were presented to Professor Lucien Malavard (France) and Professor Karl Heinz Doetsch (Germany) at the Twelfth AGARD Annual Meeting in Istanbul. The citations which accompanied the Medals were printed in the September 1976 issue of the AGARD Highlights (page 11). These photographs show the presentations being made by Mr Frank R.Thurston, Chairman of AGARD.

Economics of Research and Development Expenditures and Technical Progress

by

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INTRODUCTION

No valid or credible projection of the course of technological developments over long periods of time can be made without consideration of economic trends. There will necessarily be substitutions of lower cost for higher cost technologies in all applications over the long term. And the relative costs of materials, labor and capital will inevitably influence the choices not only in the large but in the relative emphasis which will be given to pursuing different technologies. This discussion is mainly exploratory and illustrative. It is intended to point the way to the recognition of the cost factor as important in the long-range scheme of things often overriding the so-called "technological imperative" ("if it is technically feasible, we must do it"), which, according to much of the conventional socio-economic wisdom, has supposedly been the main driving force for technology since World War II.

CLASSICAL MACROECONOMICS

Classical macroeconomics, although acknowledging the role of technology as a mechanism for increasing productivity and for generating investment opportunities (e.g., See Slichter[1]), has little to tell us as to how to fit research and development input/output relationships into macroeconomic models. An overall appraisal of the situation in economic theory for non-specialists given by Jan Pen, the British economist, characterizes the situation in terms of the dubious status of production functions by which macro-economists describe output in terms of inputs of labor and capital[2]. Speaking of the new views emerging from recent investigations into the production function, he states:

"The view, confirmed by many other investigators, stresses activities quite different from saving and investing. Education, research, communications, learning by doing, these unorthodox subjects suddenly come much more to the fore. And that means to say that the economists have to turn their attention elsewhere. They may no longer regard technical progress as something which is given, which falls like manna from heaven, but as a man-made phenomenon that should be systematically examined. And, in fact, such examination has since started but this kind of research is in its infancy. It is busy changing the face of economic science though that has not yet penetrated to the textbooks."

As for applications of the emerging new theoretical views of technical progress in macroeconomic theory, Pen summarizes by saying:

"... we do not know exactly what is going on and what exactly determines technology. Here we are at the limits of economic science – limits delineated by question marks."

Although a useful analytical representation of research and development in macroeconomic models does not yet exist, the influence of macroeconomic factors may be considered, at least insofar as trends in other economic factors may influence research and development. The growing trend in all Western economies to increase economic allocations to various social programs constitutes a definite restraint on the growth of expenditures on national defense, research and development and related procurement activities. Figure 1[3] shows for the United States the trends in expenditures on national defense, civilian space (NASA), health, total education, higher education and aerospace industry sales. Since health and education in the US are far from entirely socialized, the expenditures shown include both public and private spending. The steady growth in expenditures for health and education continues in the US and is probably paralleled or exceeded in most other NATO nations. On the other hand defense spending is increasing, on average, more slowly although there are discontinuous changes associated with US involvement in military actions, crises, perceptions of lead and lag in arms races, etc. Of interest, too, is the way in which the inexorable trend of increases since 1950 in the costs of higher education has resulted in these costs catching up with and exceeding sales in the aerospace industry. Also of interest is the relative decline of NASA expenditures. It is clear that these trends are generally continuing so that defense, space, research and development and aerospace activity, separately and in combination, represent a steadily decreasing share of the economic activity of the US.

The trends in research and development expenditures (government and private) also show in most Western nations a leveling or declining trend as a percentage of gross national product as illustrated in Figure 2[4]. Another perception of the trend in R&D expenditures which, although not corrected for inflation, more nearly reflects an internal view of the national budgeting process is the annual index of R&D expenditures as a ratio of national totals in national currencies; this is shown in Figure 3[3]. The relative flatness of the slope of increase in the nations with the most mature and highly developed national R&D establishments is striking.

It is clear that exponential growth of R&D often pointed to as an almost natural phenomenon[5] in the period 1945–1965 has, at least temporarily, come to an end in most NATO nations. And although the energy supply problem may and should stimulate more R&D effort in this sector, it will probably be at the expense of other sectors so that the total R&D effort in terms of the total economic effort may not be greatly affected.

As De Solla Price has pointed out, most activities of humans and other biological species only seem to be growing exponentially at their inception but actually eventually turn and follow an "S"-shaped or "logistic" curve. Predicting the parameters associated with the "S"-shaped curve turns out, in practice, to be much more difficult than finding the one parameter (e.g., "e" folding time) of an exponential curve. As has already been indicated, these parameters depend not only on the state of technological development but also on the state of the economy as a whole and indeed on the entire socio-political value systems of nations.

The Soviet Union which is often slower than most Western nations to grasp any new perception of socio-political technology import, once it does grasp the new perception integrates it into the Marxist-Leninist ideological and philosophic structure (which purports to be able to rationalize all knowledge into a planning methodology for human affairs). Thenceforth, the Soviet bureaucracy and the five-year planning process with its rigid allocation of resources tend to produce an unstoppable Juggernaut and it appears that this may have happened to science and technology in the Soviet Union in terms of planned exponential growth.

Thus having absorbed De Solla Price's conceptions of the exponential growth of science, they have this to say about the levelling-off process:

"A number of bourgeois scientists have gone even farther. Without believing in the progress of human society, they feel that the exponential growth of science in the near future should lead to a slowdown of its development, and then to its 'suppression' (these views have been called the 'theory of saturation'). Of course, one cannot agree with such pessimistic views concerning scientific progress.

"At the same time, the exponential growth of the quantitative indicators of science leads one to the conclusion that the organization of scientific research should undergo fundamental changes. At present, the basic results of science show a trend to double every 45 years. But its external indicators double significantly faster, every 7–15 years. In order to double the number of scientific results, at present it is essential to increase the number of scientists by 16-fold, and to raise the level of allocations on scientific research and experimental designing by more than 30-fold. Understandably, at a certain level of development, it will be more and more difficult to allocate the funds which fully satisfy the needs of science. At present there are various viewpoints concerning the optimum amounts of resources allocated for science. Thus, Academician N.N.Semenov feels that in the future up to 50 percent of mankind will be engaged in scientific labor, for Professor D.Bernal the figure is 20 percent, and for Academician P.L.Kapitsa, 10–20 percent. . . .

"The new organization of the activities of science and scientific research institutions and the planning of scientific development are an important aspect in the research of the philosophy of science. This aspect in scientific development shows a clearly expressed socio-political casualty. It is most fully disclosed under socialist conditions with an economy which develops proportionately and according to a plan, and a social interest in the greatest possible development of science and universal education for the members of the society. Socialism creates exceptionally favorable opportunities to direct the entire diversity of scientific research according to a statewide plan. Science has become an immediate productive force."[6]

It would be all too easy to dismiss as stupid and wasteful such a doctrinaire approach to the allocation of human and economic resources as is evidenced in these statements. Yet, in application, Soviet economic planners must inevitably be more practical than their ideological theoreticians and even great waste in some efforts will not in itself preclude effective utilization of substantial fractions of these resources in other efforts. Therefore, the possible ultimate effects of the trends illustrated in Figure 2 in driving the technological as well as numerical arms race cannot be discounted and must be considered as at least one of several contingencies in any NATO long-range technology forecast.

MICROECONOMICS

At the microeconomic level, there is much better quantitative understanding of the input/output relationships involving research and development, although such understanding, and particularly any quantitative basis for such understanding, is usually quite limited in scope to one industry, one product or even one firm[7]. Such data often provide valuable insights and analogies which may be extended to investigations of other industries, products and firms but it can hardly be said that a general framework for quantitative analysis exists. There do exist frameworks (principally based on Leontief's input-output matrices[8]) in which major elements of a national economy can be represented in terms of microeconomic factors reflecting the constitutive products and commodities. However, except as it may be inserted by the workings of a "*deus ex machina*" through using subjective estimates from experts on each product or commodity to project changes in the factors with time which can be attributed to technology, input-output analysis as currently practiced has little to say about the interaction between technical progress and economics. The "open loop" approach used takes no account at all of the long-term influence of changes in economic factors on technical development.

It is through microeconomic approaches largely of an empirical or *ad hoc* nature that we must address the influence of economics on the future of defense R&D and its implications for military force structures.

The recent trends in the cost of military weapons systems in advancing from one generation to another are illustrated in Figure 4[9]. On the other hand cost trends in improvements to existing systems are shown in Figure 5[9]. The cost growths in the latter case are less than half those of new generation systems. Similar trends for new generations of electronic subsystems and for improved versions of existing electronic subsystems are shown in Figures 6 and 7 respectively[9].

Examination of some of the US cost trends for selected products of the civilian economy, as in Figure 8[3], shows that the increase of average prices of civil piston-engine-powered non-transport aircraft has consistently increased more rapidly than the gross national product over the past several decades. Similar trends are shown for the most advanced models of transport aircraft over more than forty years. These trends parallel those for military aircraft in Figure 4. Large-scale electronic computers show the same trend in Figure 9[3] and ostensibly for the same reasons. It is evident that for aircraft and large-scale electronic computers, at least until very recently, the growth of utility, efficiency and productivity made possible by advancing technology has apparently overridden the incentives for cost reduction in favor of capability increases. On the other hand, consumer products such as automobiles, refrigerators, TV's and electronic calculators have a slower rate of price growth than the gross national product, indicating that new technology and the "learning" process in manufacturing have been turned toward reducing relative costs in an expanding inflationary economy.

CASE HISTORIES OF CAPABILITIES/COST COMPROMISES

Obviously, continuing exponential cost growth rates in excess of the rate of growth of gross national product cannot be continued indefintely in either the civil or military economic sectors. We have recently seen a reemphasis on the concept of "high-low" force mixes in which not all military operational aircraft are required to have the greatest capability which technology has to offer and a slowing down in the rate at which advanced technology is introduced into even the most advanced aircraft procured. Examples of the latter process are the decisions not to go to Mach 3.0 capability in the latest models of fighters such as the F-14, F-15, F-16, Mirage F-1 and MRCA. This change of pace in development was not at all anticipated in 1960 when the F-108 Mach 3 fighter aircraft had already entered active development in the US and the Mach 3 B-70 bomber which it would have to intercept was also in full-scale development.

There are other examples of abstention of even the most advanced nations from the development or operational deployment of attractive new technologies on grounds of cost. Among them are the suborbital and orbital hypersonic aircraft (such as the US Dynasoar) which could be forecast in 1960 as technically feasible and hence likely to be operational in the 1970's. Another technological area which received much emphasis in engineering studies, experiments and prototype construction and testing is that of vertical takeoff and landing aircraft (V/STOL aircraft). Numerous AGARD meetings, symposia and conferences of almost all the panels over the past fifteen years dealt with the technical aspects of such aircraft. At one time in the early 1960's, NATO was optimistic enough as to the prospects of V/STOL fighters to contemplate a NATO-wide competition for such an aircraft. Yet as of this date in NATO such aircraft are operational in very small numbers in UK Harrier units. The same aircraft is used, also in limited numbers, by the US Marine Corps for support of their amphibious landing mission. In the Soviet Union the YAK-36 V/STOL aircraft has also found limited use in operation from light aircraft carriers. Interest in V/STOL aircraft from both the technical and operational standpoints remains high but the day when vertical takeoff aircraft attain major importance in operational forces seems to remain obscure in the distant future. Certainly the limitation is not and has not been technical feasibility of such aircraft. Operational suitability and advantages have just not been sufficient in relation to cost (procurement and life-cycle) to warrant mass deployment.

These case histories (and many others which can be similarly interpreted) provide more than sufficient evidence that technological forecasting without consideration of both macroeconomic and microeconomic factors is likely to lead to highly unrealistic projections of future technology utilization even if the estimates of technology availability may be reasonably good.

REFERENCES

1. Slichter, S., *Economic Growth in the United States*, pp.106-110, Collier Books, New York, 1963.
2. Pen, J., *Income Distribution*, pp.200-208, Penguin Books, London, 1971.
3. Flax, A.H., *Aeronautics – A Study in Technological and Economic Growth and Form*, Aeronautical Journal, pp.537-552, December 1974.
4. *Science Indicators 1974*, US National Science Board, 1975.
5. De Solla Price, D.J., *Little Science, Big Science*, Columbia University Press, New York and London, 1963.
6. Lomov, N.A., *Scientific-Technical Progress and the Revolution in Military Affairs*, Moscow 1973. (English Translation published under auspices of the US Air Force.)
7. See, for example, Mansfield, E., *The Economics of Technical Change*, W.W.Norton and Company, New York, 1968.
8. Leontief, W., *Input-Output Economics*, Oxford Univ. Press, New York, 1966.
9. IDA Report R-195, *Electronics-X: A Study of Military Electronics with Particular Reference to Cost and Reliability*, 1974.

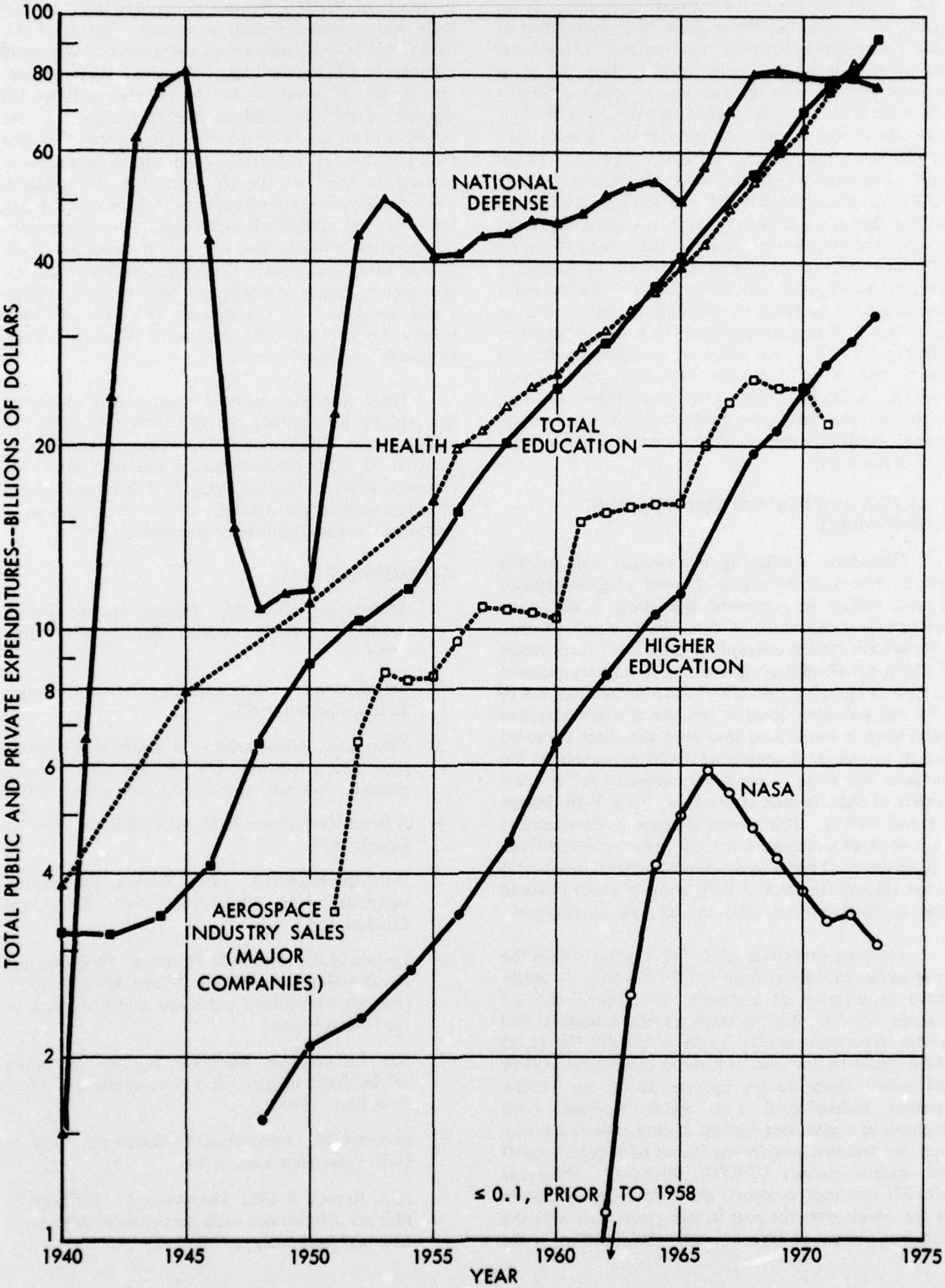

Fig.1 US national expenditures in selected areas since 1940

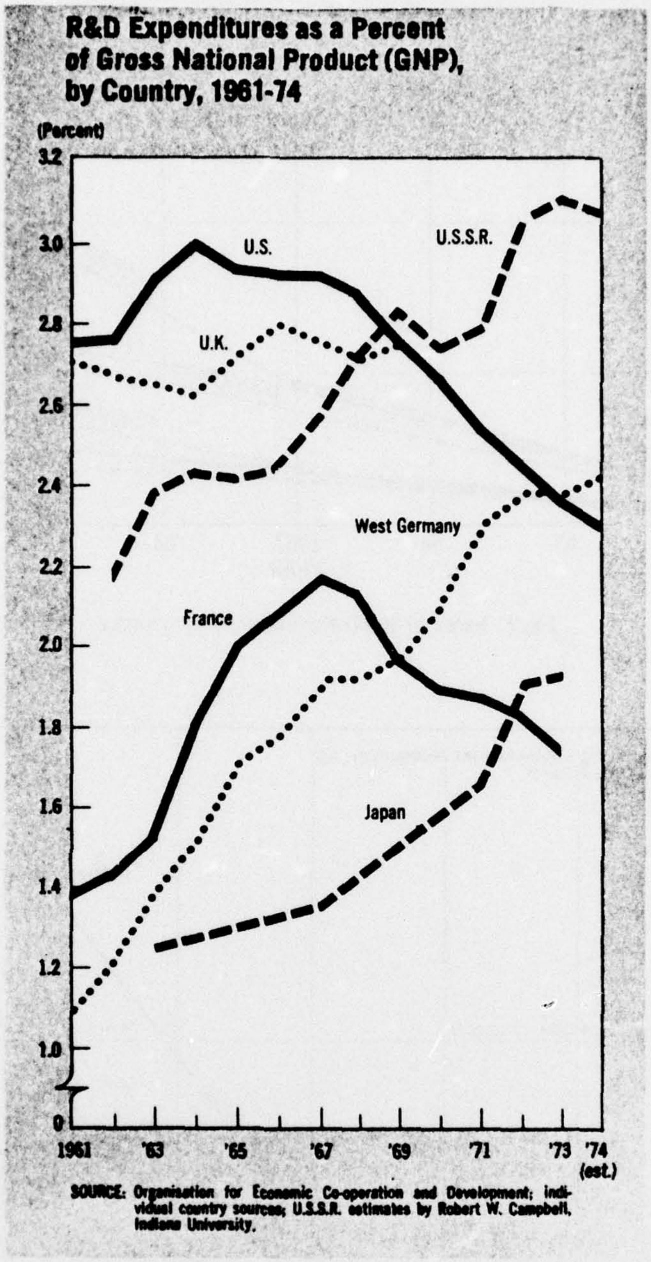
R&D Expenditures as a Percent of Gross National Product (GNP), by Country, 1961-74
(Percent)
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0
U.S.
U.S.S.R.
U.K.
West Germany
France
Japan
1961
'63
'65
'67
'69
'71
'73
'74 (est.)
SOURCE: Organisation for Economic Co-operation and Development; individual country sources; U.S.S.R. estimates by Robert W. Campbell, Indiana University.

Figure 2

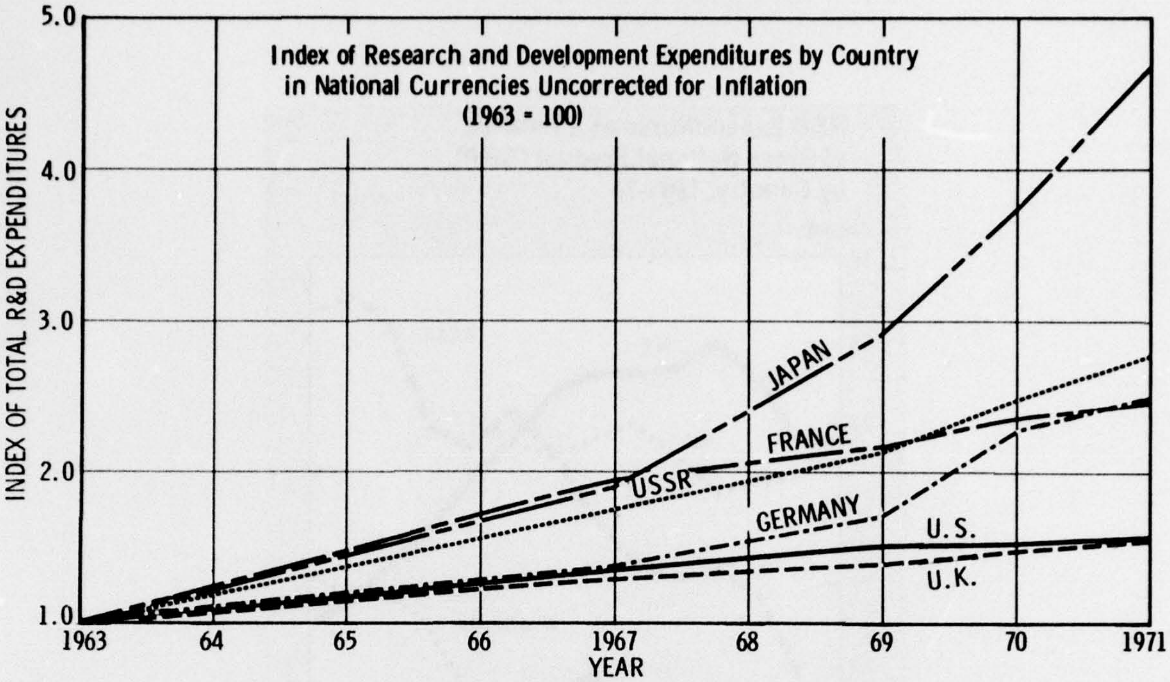

Fig.3 Index of R&D expenditures by country

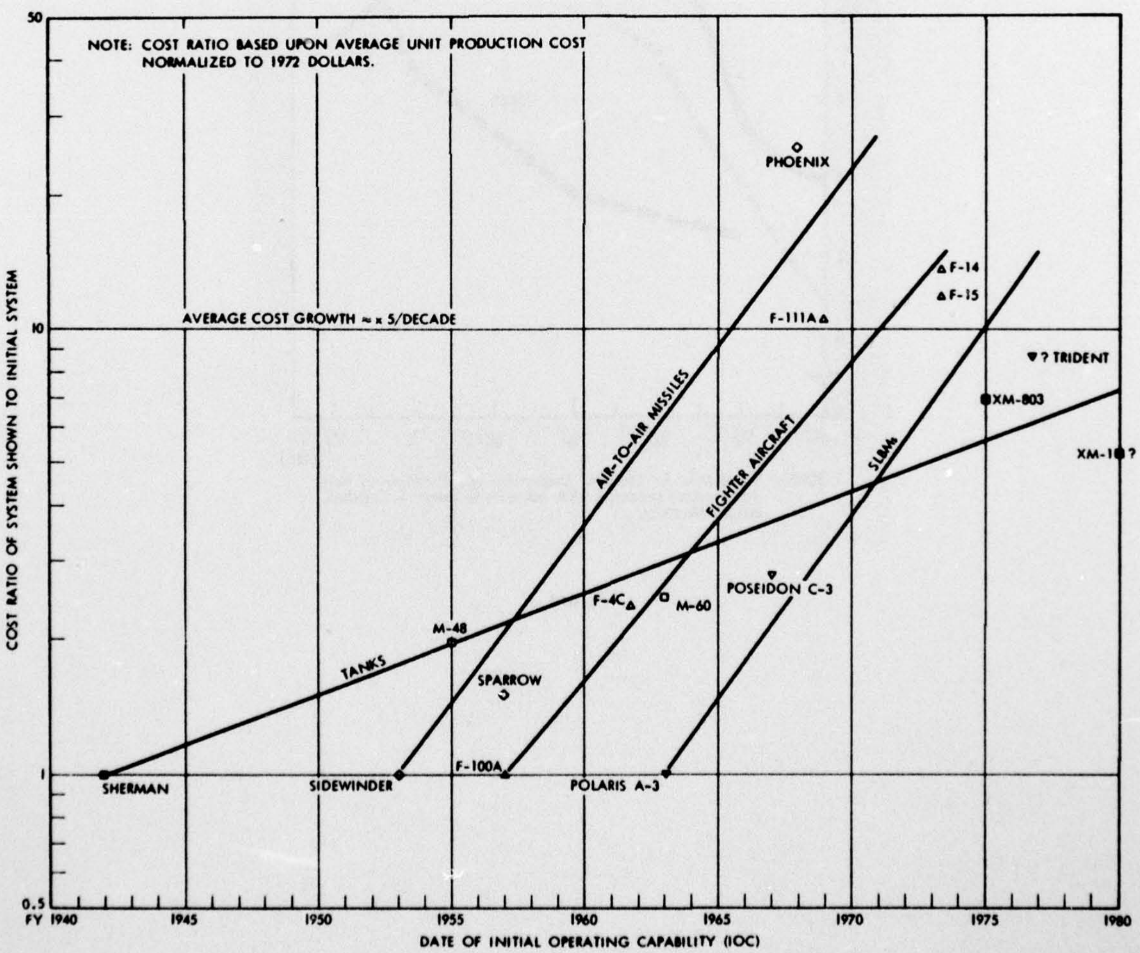

Fig.4 New-generation cost progression for systems shown[19]

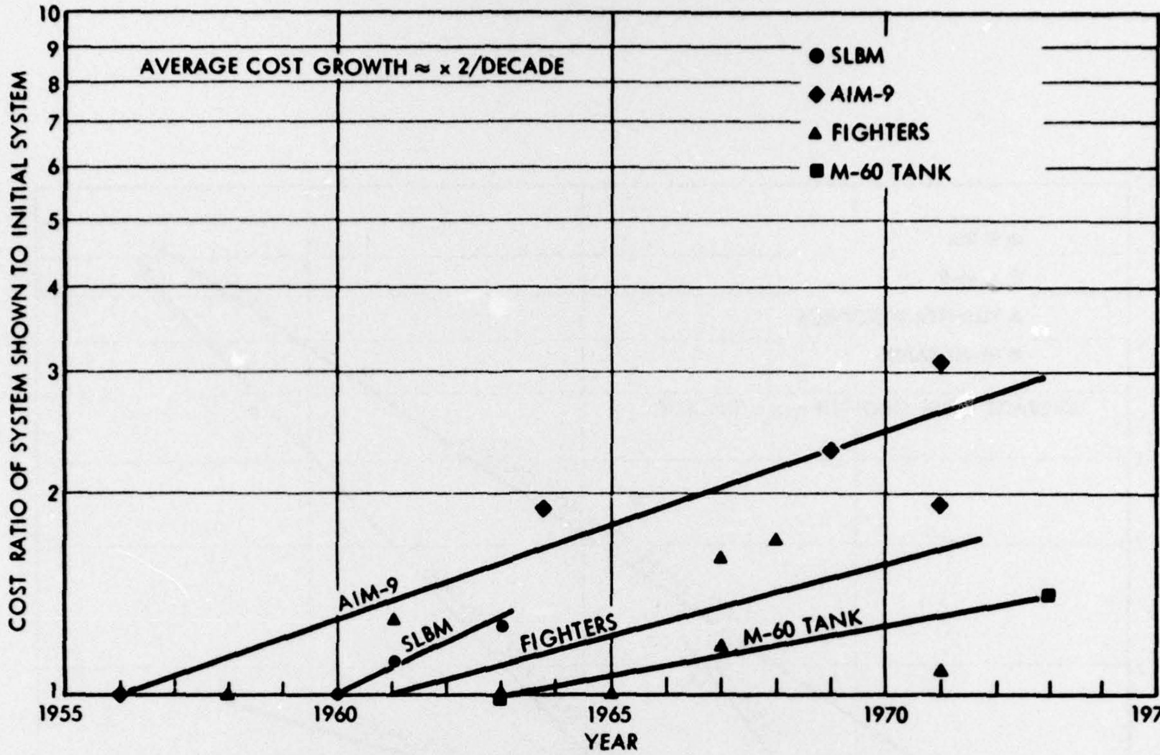

Fig.5 Within-generation cost progression for systems shown, total system[19]

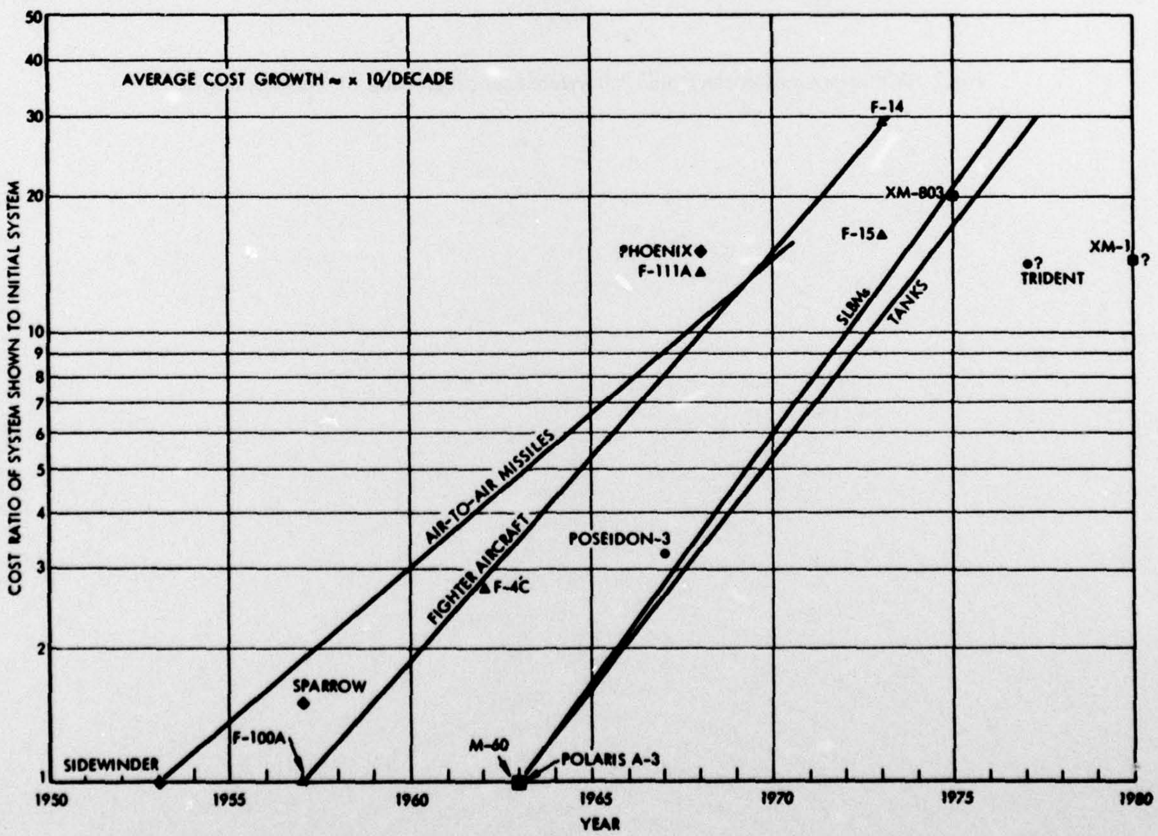

Fig.6 New-generation electronic subsystem cost progression for systems shown[19]

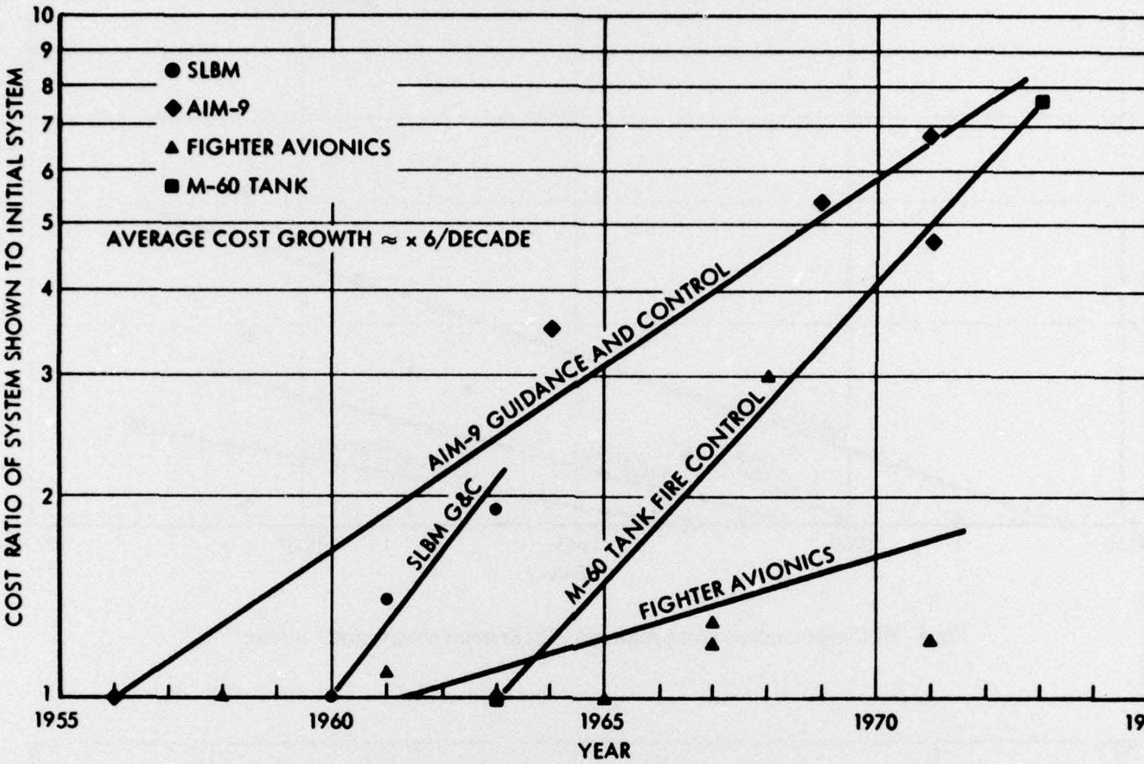

Fig.7 Within-generation electronic subsystem cost progression for systems shown[19]

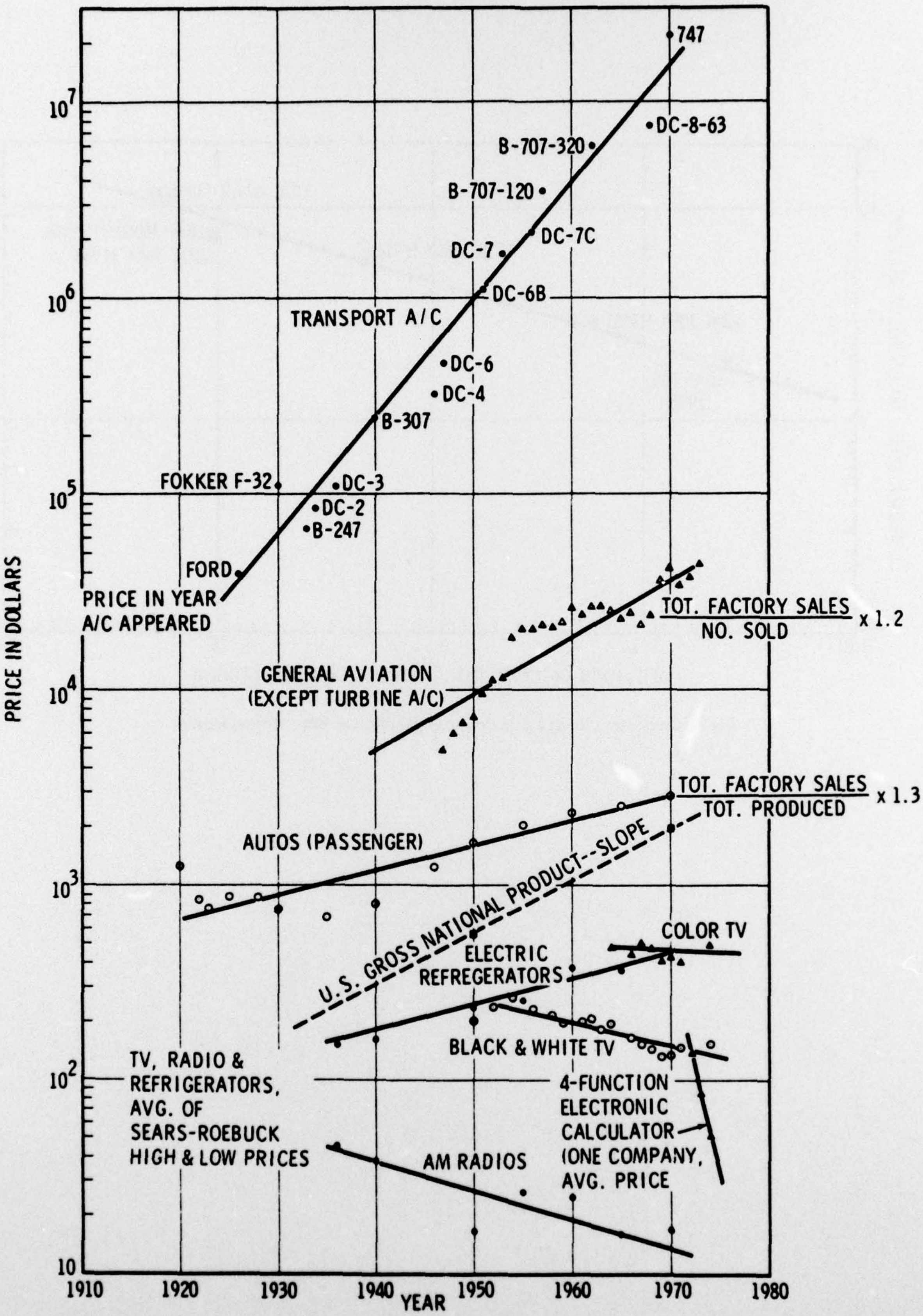

Fig.8 Cost trends for aircraft and other products since 1920

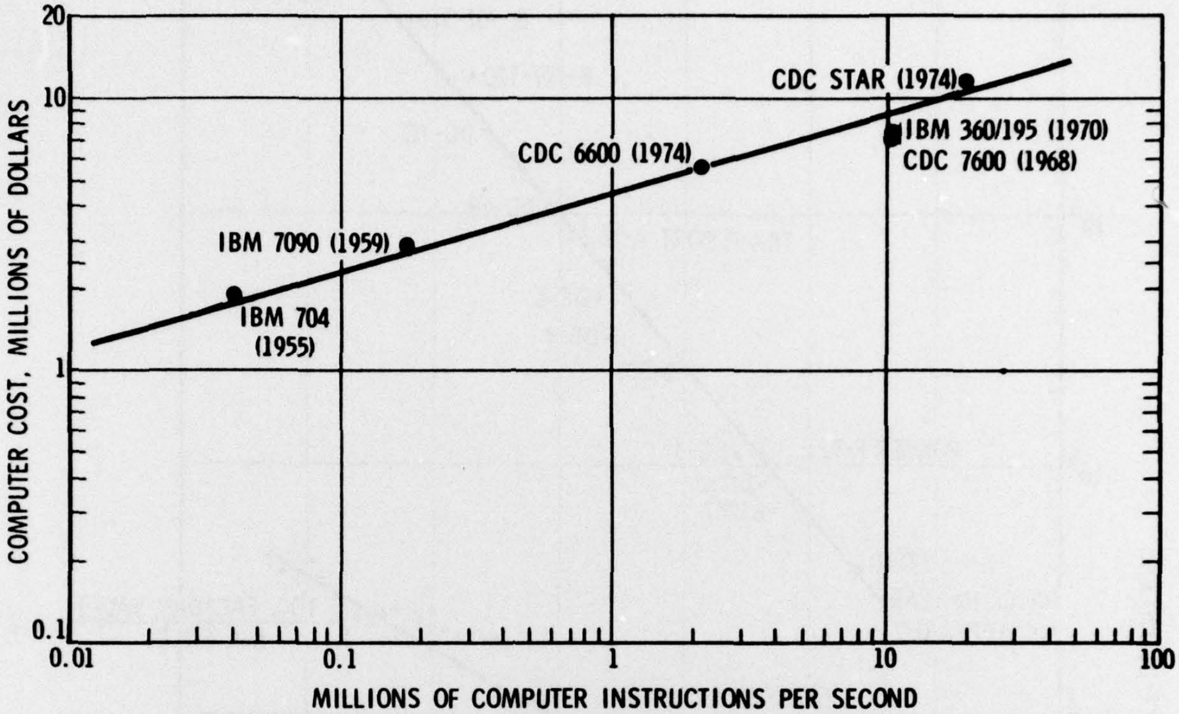

Fig.9 Computer cost as a function of capability and date of first delivery

SUMMARY OF 1977 MEETING THEMES

AEROSPACE MEDICAL PANEL

Specialists Meeting: **Methods to Assess Workload. Studies on Pilot Workload. The Use and Abuse of Social Drugs.**
18–22 April 1977, DFVLR, Linderhöhe 5000, Cologne 90, Germany.

Methods to Assess Workload – With the evolution of advanced aircraft and the emergence of multi-mission concepts and roles, pilot workload has become of increasing concern: the measurement of workload poses many problems. A wide variety of methods are employed, frequently in an interdisciplinary setting. This meeting will cover the full spectrum of aerospace medical sciences on the topic of methods to assess aircrew workload. The papers will be method-oriented, but will include studies which illustrate the way in which the methods work. Particular emphasis will be given to reliability, validity, sensitivity to workload parameters, inflight and simulator study methods, and to those methods yielding data directly applicable without further translation to operational problems.

Studies on Pilot Workload – Pilot workload is a continuing area of concern in the NATO research community because it can be a limiting factor in the more demanding missions. Factors which are significant include type aircraft, mission profiles, multiple operational stresses, workload demands compounded by the stresses of the flight deck/cockpit environment, unique workloads and performance demands posed by the avionics, navigational, and weapons delivery systems. The meeting will deal with these topics and with techniques to reduce workload or ameliorate the combined effects of workload and stress. Particular interest will be given to inflight and simulator studies.

The Use and Abuse of Social Drugs – The individual nations' experience differs on the incidence of drug-taking in their military organizations though there is undoubted knowledge that there is some use of drugs in all. This may vary from an extensive use of alcohol and tobacco to the minimal consumption of illegal substances. It is considered that the exchange of information could lead to the identification of problems hitherto thought to be non-existent and that those nations without a problem may point the way to its alleviation in others. Should drug use or abuse occur in flying personnel or ground crew, flight safety will be adversely affected. The meeting may bring to light effective measures to reduce morbidity and even mortality from the use of these social drugs.

The meeting will cover: the use and abuse of drugs which are taken for their social effect (∴ such as alcohol, stimulants, tobacco, marijuana, addictive, hallucinogenic, psychogenic substances and combinations), pharmacology and epidemiology in the human subject, social changes and behavioral patterns in users; the effects of poly drug use; long term effects of drug administration; problems of the detection of drug users and abusers; preventive action and resolution of the habit.

34th Panel Meeting
24–28 October 1977, Church House, London, England
Specialists Meeting: **Prospective Medicine Opportunities in Aerospace Medicine. Specific Findings in Cardiology and Pulmonary Function with Special Emphasis on Assessment Criteria for Flying.**

Prospective Medicine Opportunities in Aerospace Medicine – The purpose of prospective medicine is to identify the propensity for disease development at a stage long before clinical pathology can be detected and then to intervene in the process to positively modify prognosis. These goals offer an excellent opportunity to extend the delivery of medical care in the military well beyond the current concepts of preventive medicine, the routine physical examination, and the treatment of existing disease states despite marginal medical manpower resources. Proper utilization of currently available data related to readily identifiable risk factors would allow concentration of medical interest within the relatively small segment of the population from which the majority of medical problems will become manifest without sacrifice of good medical care for the remainder and without detriment to flying safety.

In addition, prospective medicine promotes intervention in disease process before the disease becomes clinically significant and thus offers a real opportunity to significantly reduce manpower losses from disease. Specific identification of risk factors in the individual offers greater motivation to modify risk through specific educational and clinical efforts than do broad, general guidelines as usually practiced. The prospective medicine approach could also form the basis for significant revision of selection and retention criteria for the military aircrewman.

This meeting will cover applications of prospective medicine techniques to aerospace medicine; studies in the special population of military aircrew on the prevelance/incidence of findings; correlation of findings with disease risks; results of multiple risk assessment, epidemiologic studies; natural history of findings; and the results of educational and clinical efforts to modify risk for disease.

Specific Findings in Cardiology and Pulmonary Function with Special Emphasis on Assessment Criteria for Flying – Cardiopulmonary diseases constitute the most significant health problem in the military forces of the NATO countries in terms of deaths and premature disability. The cost of these diseases to the military forces is very significant when viewed either in monetary terms or in mission capability. And yet, because of the select nature of the military population much of the medical information gathered in civilian hospital populations concerning the significance of medical findings is not directly applicable to the military population. There has been excellent progress made over the past several years in definition of the significance of medical findings with respect to continued military duty. This topic should produce a review and update of specific problems in the cardiopulmonary arena and improve application of new information by each country. The meeting will deal with normal values in the military population for cardiovascular and pulmonary function; correlation studies of common findings with disease states; studies of the natural history of findings along with their influence on military performance and the effect of special aspects of military duty upon the disease process.

AVIONICS PANEL

Symposium: **Optical Fibres, Integrated Optics and Their Military Applications**
Joint AVP/EPP
16–20 May, London, UK

Rapid developments in laser semiconductors and low loss optical fibres are responsible for new applications in the areas of communication, imaging and data transmission in general. Optical fibres provide a high degree of communication security, freedom from electronic interference, large length-bandwidth product, and system miniaturization through their small size. The combination of all these features leads to new concepts and unique applications in military hardwares.

The purpose of this conference is to review and present the latest developments in fibres and integrated optics, stressing their military applications and emphasizing the topics of major interest to the Avionics and Electromagnetic Wave Propagation Panels: End Devices, Coupling and Propagation Mechanisms, Optical Cables and Systems.

34th Panel Meeting – Symposium: **Impact of Charge Coupled Devices and Surface Accoustic Wave Devices on Signal Processing and Imagery in Advanced Systems**
10–14 October 1977, Ottawa, Canada

In recent years the technology of charge coupled devices and surface acoustic waves has expanded rapidly leading the way to new concepts in imagery and signal processing techniques.

Several symposia have been held in the past on each subject and others are planned. The Symposium will make a general survey of both techniques and their applications and of assessing their impact on the design of advanced systems.

The symposium will be mainly devoted to practical applications and achievements. The authors will make specific efforts to answer the following questions:

- Why these new techniques have been preferred to digital techniques in their specific applications,
- Generally speaking, are these techniques competing with digital techniques and in which field,
- What are the advantages to be expected from their extensive use,
- Are CCD and SAW techniques competing or complementary – What are the most appropriate areas of application for each,
- Are further improvements and developments expected in the near future?

The impact of these new techniques on the design of systems will be strongly emphasized. Fields of particular interest are signal processing and imaging in radar, communications, television, forward-looking infra-red, linescan, computers and other military systems.

ELECTROMAGNETIC WAVE PROPAGATION PANEL

Symposium: **Optical Fibres, Integrated Optics and Their Military Applications**
Joint EPP/AVP
16–20 May 1977, London, UK

Rapid developments in laser semiconductors and low loss optical fibres are responsible for new applications in the areas of communication, imaging and data transmission in general. Optical fibres provide a high degree of communication security, freedom from electronic interference, large length-bandwidth product, and system miniaturization through their small size. The combination of all these features leads to new concepts and unique applications in military hardwares.

The purpose of this conference is to review and present the latest developments in fibres and integrated optics, stressing their military applications and emphasizing the topics of major interest to the Avionics and Electromagnetic Wave Propagation Panels: End Devices, Coupling and Propagation Mechanisms, Optical Cables and Systems.

24th Panel Meeting – Symposium: **Aspects of Electromagnetic Scattering in Radiocommunications**
3–7 October 1977, Cambridge, Mass, USA

Scattering and reflections of electromagnetic waves by the inhomogeneities and discontinuities of the troposphere and of the ionosphere has been studied intensely in the last quarter of a century. Besides the interest of such studies from a geophysical point of view, a strong motivation has been to make use of scatter propagation for communicating over the horizon at mainly VHF and UHF frequencies normally unsuitable beyond optical and diffraction range.

The Symposium will be concerned with the theory of scattering and reflections from irregularities in the troposphere and the ionosphere including the prediction of short and long-term signal characteristics, and with the characterization of radio channels using such modes of propagation. It will also cover the effects of terrain, meteorological and other environmental factors on propagation as well as the methods and techniques which may be used in the design of scatter communications which are efficient, both in the usage of power and frequency spectrum. The Symposium is thus intended for geophysicists, communication system planners and designers as well as for the user.

FLUID DYNAMICS PANEL

40th Panel Meeting – Symposium: **Laminar-Turbulent Transition**
2–5 May 1977, Copenhagen, Denmark

The physical fluid mechanical phenomena involving the process of transition of a fluid from a laminar state through a transitional regime and ultimately to a fully developed turbulent flow has been the subject of numerous research studies and activities.

The primary purpose of the meeting will be to review the progress achieved in the past several years relating to experimental and theoretical studies and analysis of the transition phenomena. Particular emphasis will be centered on calculation methods for predicting the onset and transitional development of shear flows, including stability parameters, criteria and initial conditions.

Recent and innovative instrumentation and measurement techniques for determining flow parameters in the laminar-transitional regime will be discussed, as well as visual observation methods. The influence of suction, pressure gradients, roughness and other factors on the stability of incompressible and compressible flows will be discussed.

41st Panel Meeting – Symposium: **Unsteady Aerodynamics**
26–30 September 1977, Ottawa, Canada

The increased requirement for high performance, high lifting, maneuverable aircraft and other aerospace vehicles results in aerodynamic flow conditions with severe pressure gradients, shock wave boundary-layer interactions, and non-linear effects with resultant unsteady boundary layers and inviscid flows. This unsteadiness can have a pronounced effect on the aerodynamic characteristics of lifting surfaces (including controls).

Specific areas to be addressed include unsteady subsonic and supersonic inviscid flows (including non-linear effects) unsteady transonic flows, unsteady non-separated and separated boundary layers, viscous-inviscid interactions, and associated unsteady aerodynamic problems of rotating surfaces.

FLIGHT MECHANICS PANEL

50th Panel Meeting – Symposium: **Rotorcraft Design**
16–20 May 1977, Moffett Field, California, USA

By late 1977 a whole new generation of rotorcraft will be in the advanced stages of development flying and new high-speed research craft will be in the various stages of flight test. In the past it has been customary for the military to provide the development costs necessary for the production of an economic, operational product. However, the advent of greater and more diverse civil usage of rotorcraft, with very high utilization rates, offers the military user the opportunity of gaining new experience quickly, and of reducing development costs by the procurement of off-the-shelf hardware or adaptions. To do this effectively, the military will need a better understanding of the civil market, including its criteria and requirements. This Symposium will, therefore, have two major objectives: to review the emerging technology and operational experience base and assess the potential for further technical improvements in rotorcraft, and to identify what must be done to encourage greater co-ordination of civil and military programmes, so that the cost reduction potential of such co-ordination is maximized.

The Symposium programme will consist of a Keynote Address on "Trends in Rotorcraft Design and Development", 5 Sessions and a Round Table Discussion on the "Opportunities for Co-ordinating Military and Civil Requirements and Specifications". Session I will deal with military experience and requirements and will also examine the major new rotorcraft systems under development or planned to meet these requirements. Session II will review recent civil experience and requirements for improved capabilities which have grown out of this experience. It will also report on major programmes by the manufacturers directed toward meeting these requirements. In Session III the capabilities of existing and new rotorcraft research vehicles will be examined and a report made on major programmes to investigate new rotorcraft configurations. Session IV will review the direction of major research programmes aimed at improving rotor systems, and Session V will address the differences between military and civil requirements and specifications, and will explore the potential for co-operative development of rotorcraft and the sharing of operational experience.

51st Panel Meeting – Symposium: **Fighter Aircraft Design**
3–7 October 1977, Florence, Italy (Classified)

The AGARD Multi-Panel Symposium on Fighter Aircraft Design will be led by the FMP. By the time the Symposium is held all the new strike fighters will either have entered service or be well through their development cycle. It will, therefore, be appropriate to review what has been learned from these new aircraft and compare the likely requirements of the 1980s with what technology promises. Eight sessions, each covering a particular aspect, will be presented by the Panel most appropriate to the area being covered. In the first session keynote speakers will set the theme of the meeting by making an assessment of the threat and the requirements to contain it, taking into account the potential of RPVs and the need to balance costs and complexity. The interpretation of these requirements for technology development will also be discussed. The second session will cover experience gained with the latest fighters already in service and will include aircraft armament and the pilots view of air combat. The remaining sessions will examine the various, possible applications of new technology to meet the requirements, based on recent reliable cost effectiveness experience. The subjects discussed will include system design approaches to meet the requirements, aerodynamics and configurations, propulsion, structures, avionics, guidance, and human factors. Finally, a round table discussion will explore the major issues that emerge from the meeting.

Specialists Meeting: **Performance Prediction Methods**
11–13 October 1977, Paris, France

This Specialists' Meeting will concern advances in Performance Prediction Methods and will show their practical application to modern conventional and V/STOL aircraft. Papers will describe point-performance prediction methods, integral-performance prediction methods for flight segments, airfield performance prediction methods, and methods of performance evaluation and data verification from flight tests. Following the Specialists' Meeting, the Panel will discuss the value to be gained from sponsoring the publication of an AGARDograph on Performance Prediction Methods incorporating the new techniques to be described.

GUIDANCE AND CONTROL PANEL

24th Panel Meeting – Symposium: **Applications of Advances in Navigation to Guidance and Control**
9–13 May 1977, Stuttgart, Germany

Positioning and Navigation are vital elements of Guidance and Control Systems. Within the last decade there have been significant advances in navigation techniques, making possible great improvements in guidance and control systems, and in the resulting mission performance and capabilities. The purpose of the Symposium is to promote constructive ideas and discussions on applications of advances in navigation to Guidance and Control Systems.

It can be argued that, apart from the appearance in the near future of global positioning systems, not even the existing advances in navigation have yet been fully exploited. These include advances in Inertial Navigation and advances in Radio and Radar Navigation. These will be treated in appropriate sessions of the Symposium.

In addition, there is the reasonable certainty of achieving, in the 1980's, global positioning by satellite correct to about 10 metres in three axes. This must affect the design of guidance and control systems, and there will be a session on that subject, followed by an extended discussion period.

The Symposium will also cover specific and general improvements in guidance and control capabilities related to the general theme.

25th Panel Meeting – Symposium: **Guidance and Control Design Considerations for Low-Altitude and Terminal Area Flight**
17–21 October 1977, Dayton, Ohio, USA

Future operational needs dictate that conventional and VTOL aircraft and helicopters will be operated close to the ground in a wide range of operational tasks and weather conditions. The proximity of the ground produces many common factors that apply in all such situations. In particular, these relate to the precision and modes of control of the aircraft subject to special environmental conditions near the ground, the requirements for sensing position relative to ground features and the high importance of establishing the necessary safety, integrity standards commensurate with the vulnerability to enemy defenses. It is the purpose of this Symposium to review the current state-of-the-art in actual operations and the future trends leading to cost effective solutions to these difficult problems. Sessions will address the following aspects:

- Operational problems and considerations for low-altitude flight, such as: optimization for pilot effectiveness; flight control system design for performance, safety, turbulence effects and weather conditions; display systems and requirements; ride qualities and gust alleviation needs and techniques; vulnerability to anti-aircraft systems.
- Terrain following systems problems and considerations including: design for integrity and safety; pilot display aspects for tracking and monitoring; navigation and positioning; noval design approaches.
- Weapon delivery problems and considerations including: transition from terrain following to weapon delivery mode; curved trajectory to reduce vulnerability; turbulence effects; delivery accuracy.
- Low visibility landing considerations including: operational procedures for fixed wing, helicopter and V/STOL aircraft; shortfield design considerations; effects of V/STOL techniques on low-visibility operations.
- Systems integration problems and considerations: augmentation of ground guidance systems with on-board sensors for low-visibility operations; capability to achieve low-visibility landing using on-board sensors; potentials for GPS and other navigation systems to reduce or eliminate ground guidance system for austere sites or emergencies; air traffic control at austere sites.

PROPULSION AND ENERGETICS PANEL

49th Panel Meeting – Specialists' Meetings: A. Secondary Flows in Turbomachines. B. Power Plant Reliability
28 March/1 April 1977, The Hague, Netherlands

This Panel Meeting will comprise two Specialists' Meetings, the first will be on Secondary Flows in Turbomachines and take two and a half days.

As further increase of the performance of turbomachines is demanding more and more sophisticated analysis of the flow in these machines, this meeting will be devoted to secondary flow phenomena such as those introduced in corners, through gaps, as well as by wall boundary-layer development and which are of increasing importance at the tip region of stator and rotor blades. Starting first with a survey on both theoretical and experimental state of research, various recent studies on secondary flows in compressors, linear cascades, and turbines will be presented. At the end, after a reflecting and resuming discussion, a Round Table Panel will draw conclusions and might recommend the direction of future work.

The following two-day meeting will be concerned with reliability of gas turbine engines. These aero propulsion systems have reached a high standard of technology and sophistication. Being rather complex they are very reliable too. But for a number of reasons like fuel saving and performance range adaptation to new missions further development of the aero gas turbine engine is required. As at the same time attention is more and more being focussed on cost effectiveness as it is on safety level, it becomes necessary to achieve:

1. high reliability at the very early stage of engine development and operation
2. long service life without prejudice to reliability at the final stage of utilization.

The success of efforts towards this end will depend on the knowledge of phenomena and the effect of actions on the reliability level. It seems to be valuable to define appropriate design, development, and testing methods.

This meeting will provide a forum for an exchange of views between civilian and military users and manufacturers from various countries. The aimed pooling of experiences might prove the starting point of definition of common guidelines to be used by engine designers.

50th Panel Meeting – Symposium: **High-Temperature Problems in Gas Turbine Engines**
19–23 September 1977, Ankara, Turkey

A major factor influencing the performance of turbojet engines is the operating temperature. Increase in operating temperature reduces fuel consumption and, at the same time, raises the thrust to weight ratio, leading to worthwhile reductions in frontal area and nacelle drag. However, high working gas temperatures pose formidable problems in terms of component life and reliability, especially for the high-pressure turbine blade where failure may occur through oxidation, thermal fatigue, corrosion or creep. Progress towards alleviating these problems is being made by the development of new materials and protective coatings, and by advances in cooling systems for both stationary and rotating components using air taken from the compressor delivery.

The purpose of this meeting is to review and highlight the main problems associated with the attainment of high temperatures in aircraft gas turbines. Attention will be focussed on methods of cooling components in the hot portion of the engine, notably the combustor and reheat liners, nozzle guide vanes and turbine components. The advantages of air cooling will also be examined alongside any penalties or compromises that may be incurred in terms of weight, cost, aerodynamic efficiency and overall engine performance. Progress in new materials and protective coatings will be discussed. Consideration will also be given to fuel and combustion problems associated with operation at high gas temperatures. Furthermore, new measuring techniques and heat transfer prediction methods will be discussed.

STRUCTURES AND MATERIALS PANEL

44th Panel Meeting – Specialists' Meeting: **(A) Unsteady Airloads in Separated and Transonic Flow, (B) Structural Aspects of Active Controls**
17–22 April 1977, Lisbon, Portugal

(A) The first session will be on the subject of "Airframe Response to Separated Flow" and will review the prediction and description of the separated flow environment and the essential effects of airframe response on individual aircraft components. These effects may lead to failures of primary or secondary structures when exceeding design stress limits, or design fatigue loads. This is of special concern for military aircraft where flight operation at extreme maneuver conditions associated with flow separation frequently occurs. The scope of study will include analytical approaches, wind-tunnel tests, as well as flight test techniques and data evaluation. Emphasis will be given to the following areas:

– Prediction of *separated flow unsteady airloads* on aeroelastically responding structures; assessments of the comparability of unsteady pressures measured on rigid and flexible structures; assessment of the practical significance of Reynolds Number effects and other similarity rules on unsteady loads due to separated flow in terms of the effects on airframe response.

– Prediction of tail vibrations induced by separated flow; assessment of flow separation from the tail, and afterbody on horizontal and vertical tail.
– Strength and fatigue design for *secondary structures* like airbrakes, spoilers, direct lift control, etc. which produce separated flow; prediction of load spectra and evaluation of the response of secondary structures.
– Definition of level of buffet and its effect on inducing fatigue failures in primary structural components of the wing.
– Prediction of the aeroacoustic environment of blown flaps, open cavities, and associated flow regimes and their effect on structural components.
– Flight test data identification of the above.
– An investigation of the present capability of the state-of-the-art to: safely predict the limitations caused by separated flow; reduce fatigue failures and maintenance costs; and improve future operational capabilities of aircraft, is of overall interest.

The second session on "Transonic Unsteady Aerodynamics for Aeroelastic Phenomena" will treat flutter, aeroservoelastic instabilities involving coupling with active control systems, and other static and dynamic aeroelastic problems, which can be dangerous flight safety phenomena and which must therefore be predicted with accuracy and prevented. Margins of safety are least in the transonic speed range which is consequently the most critical speed regime. However, no dependable theoretical methods are yet available for predicting unsteady transonic airloads on lifting surfaces and control surfaces. Accurate prediction of the latter becomes more important for active control systems used in load alleviation, flutter suppression and ride control. Measurement of unsteady airloads on models can be performed but are expensive for routine applications. Some noticeable progress is being made in the development of two-dimensional theory and in the measurement of unsteady aerodynamic pressures in Europe and more recently in the US. Also some three-dimensional methods are being explored. A timely exchange of the latest information would point out most promising methods, delineate gaps and opportunities, accelerate mutual progress, and define common configurations and conditions for experimental tests and for comparing and evaluating various methods developed. Perhaps empirical methods based on test results and theory can be suggested which will predict transonic aeroelastic phenomena and define optimum structural characteristics with improved accuracy. In addition to improving analytical confidence, a dependable approach could reduce the cost of aeroelastic model and flight flutter tests. This meeting will be coordinated with FDP and joint participation on programs of mutual interest will be strongly recommended.

(B) The theme of this meeting will deal with the philosophy and approach on the use of active control to realize structural improvements. The question of what constitutes a good balance of effort to achieve a successful active contro system will be examined. Specifically dealt with will be the techniques for evaluating the system transfer function, with the relative roles of ground vibration testing, bench testing of component parts, and the merits of open and closed loop testing being examined. The question of what constitutes an appropriate index of performance will be of central significance. Preparation of this Meeting will be coordinated with FMP.

45th Panel Meeting – Specialists' Meeting: **Non-Destructive Inspection (NDI) Relationships to Aircraft Design and Materials**
25–30 September 1977, Geilo, Norway

The objectives of the meeting are:

1. To establish which information obtainable through the various NDI methods is relevant when applied to the control of defects present in metallic and composite structures or mechanical components, either dismantled or in aircraft service.

2. To establish the relationships among materials suppliers, NDI experts, design engineers between:
   (a) the various kinds and density of defects generated in the course of manufacturing and fabrication,
   (b) the various kinds and density of defects detectable by the NDI techniques, their sensitivity, precision and powers of resolution,
   (c) the relevance of above information for the needs of design engineers.

3. To point out needs, limits of validity and reliability of the various NDI methods which are used and the necessity of developing new ones to obtain more detailed and/or pertinent information, mainly in the case of new materials and composites.

4. To evaluate the incidence of costs on NDI controls during manufacturing and maintenance as a function of the relevance of the information obtained.

TECHNICAL INFORMATION PANEL

30th Panel Meeting – Specialists' Meeting: **The Impact of Future Developments in Communications, Information Technology and National Policies on the Work of the Aerospace Information Specialist**
22–24 June 1977, Lysebu, Norway

The rapid development of new communication techniques, combined with greatly reduced unit costs of communication hardware, has led to easier access to more information for larger segments of the population. In the area of aerospace scientific and technical information, this development should provide greater opportunities for making systematic use of mankind's aggregated experience and knowledge, collected and stored over time. However, good use can only be made of these opportunities if preparations are begun now.

The role of the information specialist is undoubtedly changing with the advent of these developments, and it may also be desirable for him to influence their future course. The theme of this Meeting is to identify the main trends in communications and information technology, to assess their impact on the information specialist, and to consider what other developments might be desirable, particularly in relation to aerospace scientific and technical information. To this end, it is proposed to bring together those in the forefront of these technologies and the information specialists who will have to make use of them, or provide complementary services, in order that each may benefit from the other's knowledge and experience.

A number of papers will also be given outlining national plans for the future of their Scientific and Technical Information activities.

LECTURE SERIES

Lecture Series 86: **Computational Fluid Dynamics** (with the von Kármán Institute and Fluid Dynamics Panel)
21–23 March 1977, von Kármán Institute, Belgium
25–27 April 1977, Wright-Patterson Air Force Base, Dayton, Ohio, USA

This Lecture Series is devoted to recent developments in numerical methods to solve complex problems in fluid dynamics with high-speed computers.

It is proposed that the following topics should be treated in detail:

- the foundations and development of the finite-element method to solve the partial differential equations of inviscid and viscous fluid mechanics. Various applications in different speed regimes will be considered.
- numerical turbulence modelling. Recent developments will be presented with the aim of assessing the state-of-the-art.
- flow representation, including separated regions, with numerical methods using discrete vortices.
- fast numerical methods to solve steady-state inviscid and viscous problems in fluid dynamics.

Lecture Series Director: Professor H.J.Wirz, von Kármán Institute, Belgium.

Lecture Series 87: **Microprocessors and Their Applications** (with Avionics Panel)
14–15 April 1977, Griffiss Air Force Base, USA
18–19 April 1977, London, UK
21–22 April 1977, Munich, Germany

The microprocessor (miniaturized processor) has recently become a viable proposition and promises a revolution in system design, flexibility, volume and cost in the data and signal processing areas of all types of avionics systems.

Microprocessor hardware available on the market is rapidly evolving with the employment of alternative technologies such as Silicone Oxide Semi-conductor and Schottky Bipolar to enable operation at clock rates orders higher than the early capability. In addition, manufacturers are developing realistic hardware to enable rapid vectored interrupt handling which is often necessary in real-time applications. As usual, hardware is running ahead of software and although most applications are currently written in symbolic assembler code, there is increasing awareness of the advantages of efficient high-level compilers and effort is now being expended on the implementation of such languages.

One of the problems with microprocessors is the necessity to design both hardware and software configurations for a particular problem, a task more appropriate to a computer systems designer rather than to one versed in avionics. In two years time, the potentialities of the microprocessor will be fully established and that would seem to be the appropriate point at which to present the new technology to a wider Avionics audience in an AGARD Lecture Series. The following topics will be covered:

– Programming languages and basic programming techniques,
– Microcomputer design and future trends in microcomputer components,
– Motorola's microcomputer families and advanced plans,
– Microprocessor support software,
– Interaction between LSI process technology and the design of microprocessor systems,
– A microcomputer based process control computer,
– The M68 in a practical system environment,
– A civil aviation microprocessor application – The delayed flap approach,
– Using a microprocessor as a computer interface controller,
– Interaction between microprocessors and custom LSI.

Lecture Series Director: Mr R.C.Sloan, EMI Electronics Ltd, Hayes, United Kingdom.

Lecture Series 88: **Applications of Remote Sensing to Ocean Surveillance** (with Electromagnetic Wave Propagation Panel)
3–4 October 1977, Oslo, Norway
6–7 October 1977, The Hague, Netherlands
11–12 October 1977, Rome, Italy

The sea covers more than three quarters of the earth and the concealment it provides to military forces will make it the area of major activities in the next decade. The defence of land and sea is vital to the NATO alliance. Land surveillance has been covered in several AGARD meetings while the oceans thus far have received little attention. Techniques for ocean surveillance from satellites and aircraft reached a high degree of sophistication as the result of the combined efforts in space and military programs. The limitations of these techniques come not so much from technology itself but rather from the propagation medium, air and sea. These techniques and the interpretation of results are totally different for land and sea.

This lecture series will therefore present the mathematical tools and their applications to the problems of resolving, recognizing and identifying targets and sources of activities in the ocean. This series should be of interest to physicists and engineers who want to learn the mathematical methods applicable to ocean surveillance, to military users who want to interpret results and infer tactical and strategic implications and to industries interested in developing future generation hardware.

The lecture topics cover two broad categories of surveillance:

– Ocean targets, for instance ships (Imaging),
– Ocean phenomena indicative of military activities, for instance changes in biology or surface temperatures (Radiometry).

The lectures will cover eight topics:

1. Operational requirements and problems: problems, needs, priorities.
2. Radiation and environmental physics refresher: processes, sources, noise, parameters and units, atmospheric and oceanographic phenomena.
3. Microwave scanning radiometry.
4. Infrared and visible radiometry and imaging systems.
5. Radar imaging systems.
6. Electric and magnetic sensing systems.
7. Systems applications and problems panel: overview of existing systems and audience interactive discussion.
8. Concluding remarks: recap of military needs and scientific and engineering highlights. Problems and issues and future direction.

A Round Table Discussion will conclude the presentations.

Lecture Series Director: Dr W.Keeler, Naval Material Command, Washington, USA.

Lecture Series 89: **Task Oriented Flight Control Systems** (with Guidance and Control Panel)
6–7 June 1977, Bolkesjø, Norway
9–10 June 1977, London, UK
14–15 June 1977, Dayton, Ohio, USA

The use of electrical control paths in the flight control systems of manned aircraft has now become established practice for a wide range of aircraft types. Recent developments in data processing are establishing the viability of high integrity, high authority full-time electrical control systems. This in turn offers the possibility of designing the control systems characteristics to match particular operational tasks, and of varying the control characteristics during or between flights according to operational needs. At the same time it becomes possible to blend together the control of additional degrees of freedom such as may be provided by direct lift and direct side-force generators.

The aim of this Lecture Series is to discuss the benefits, problems, design and engineering aspects of these new developments. It will commence with a broad review of the state-of-the-art in modern flight control theory and practice, discuss the new concepts of task-oriented control systems, and review some recent relevant simulator and flight trials. It will conclude with a Round Table Discussion during which an exchange of view between speakers and participants will be encouraged.

The following topics will be covered:

1. Introduction and Overview.
2. Control law design techniques. Basic control law theory, stability criteria for low-order and high-order systems. Frequency response, root locus and transient response techniques. Optimization procedures, digital control law theory.
3. Pilot control system interaction, handling qualities criteria, pilot models, simulation and flight test techniques. Stick feel characteristics. Crew workload implications.
4. Engineering of control systems and implications on control law design. Sensors, processors and actuators, structural and aerodynamic interactions.
5. The need for task-oriented control laws. Examples of operational tasks, and basic requirements in terms of total aircraft system performance. Effect of weapon characteristics in weapon aiming tasks.
6. Implementation of task-oriented control laws. Design aspects. Coupling of degrees of freedom. Compromises between design criteria. Effects of external disturbances. Sensor and processor implications.
7. Additional degrees of freedom. Aerodynamic and structural aspects of providing direct lift, direct sideforce. Control systems design. Piloting problems and ways of blending to reduce workload.
8. Display and crew station implications. Arranging displays to be compatible with the control laws. Mode selection and verification techniques. Integration of navigation and guidance information. Miniature control sticks.
9. Current programmes. Each speaker will give a brief account of relevant simulator and flight test work in his own country. Areas to be stressed are correlation between predicted and test results, limitations and potential pitfalls.

Lecture Series Director: Dr G.Hunt, Royal Aircraft Establishment, Farnborough, Hampshire, UK.

Lecture Series 90: **Laser Optical Measurement Methods for Aero Engine Research and Development** (with Propulsion and Energetics Panel)
25–26 August 1977, Trenton, New Jersey, USA
30–31 August 1977, London, UK
5–6 September 1977, Urbino, Italy

In recent years many optical measuring methods, most using lasers, for determining flow velocity (with turbulence and fluctuations), temperature, and species concentration have been studied. The main advantage is that the flow is not disturbed. They are of great value for research and development on engines and components and for the understanding of fundamental flow processes.

This Lecture Series will inform propulsion specialists of the techniques that are currently available, how to use them and their limitations. It will review experience to date in practical applications. Laser-velocimetry will be emphasized since it is the only technique which has achieved practical importance up until now. Raman-scattering and holography interferometry will also be addressed. Commonly-used techniques and qualitative type methods such as infrared for surface temperature and Schlieren techniques will not be addressed.