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A CRITICAL REVIEW OF THE STATE OF FOREIGN SPACE TECHNOLOGY

Report to the
National Aeronautics and Space Administration
Prepared by the
American Institute of Aeronautics and Astronautics

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SUMMARY

The papers, panels, and discussions at the 28th International Astronautical Congress revealed a number of foreign technical developments and viewpoints which, in the opinions of the U.S. delegates to the Congress, would be of considerable interest to NASA. The most important of these are as follows:

(1) Communication Satellites. Perhaps the most significant new information presented at the Congress was the detailed discussion of Soviet system capability and technology, both in INTERSPUTNIK and in the domestic EKRAN system. Other foreign technology, notably European, Canadian and Japanese, was considered by our observers to be comparable to that of the U.S., particularly in maritime systems; however foreign public-service satellite technology appears to lag that of the U.S. Key issues of interest to NASA were identified as (a) defining the U.S. role in assisting with the development of regional systems and their coordination with both other systems and INTELSAT; (b) establishing and promulgating a firm U.S. position on frequency allocation policies and plans; (c) formulating a comprehensive computer-based planning model, and (d) defining a U.S. policy for delivering domestic services to neighboring nations. Specific points of concern for NASA were the French call for free use of educational satellites and the potential availability of a FRG-developed 20 kWe solar array, particularly if the U.S. does not proceed with the 25 kWe module which was deleted from NASA's FY 1979 budget request. Although there was little evidence of foreign capability in large structures (except for one instance noted later), a U.S. paper on large antennas elicited considerable foreign interest and enthusiasm.

(2) Spacecraft Power Systems. A detailed description of the thermionic power conversion system used in the Soviet Topaz nuclear space power reactor offered considerable insight into Soviet design of the system which probably powered the COSMOS 954 that recently impacted in Canada. The Congress also indicated a clear Soviet lead over the U.S. in thermionics, verifying the recent (June 1977) visit by U.S. DOE and NASA thermionic specialists to Eastern European laboratories. Soviet emphasis on the simplification of space nuclear reactor control systems was also highlighted.

(3) Space Processing. The 28th Congress revealed that the Soviet Union has an extensive research effort underway, including the utilization of sounding rocket capability which appears to be at least comparable to the U.S. SPAR program and the FRG (which the Congress also showed to have the most advanced European activity in this field). The Soviets also detailed four different classes of space processing experiments performed in Salyut 5 in late 1976 and early 1977 (and evidently continued in Salyut 6 after the 28th Congress).

(4) Bioastronautics. The already well-documented Soviet strength in this field was reemphasized by the Congress presentations, which were overwhelmingly dominated by USSR authors. Topics of specific interest included requirements for remote operators (e.g., for Lunokhod), space-cabin atmosphere contamination, psychological behavior in closed systems, radiation effects, fluid-electrolyte metabolism, effects of gravity on growth and development of living organisms, and the effects of the space environment on vestibular functions. The most interesting new data revealed at the Congress were in the latter area.

Soviet authors reinforced the basic difference between U.S. and Soviet views on whether or not drugs should be used to influence fluid electrolyte metabolism (the Soviets say yes; we say no). The Congress also highlighted continuing U.S. superiority in cardiovascular research and measurement techniques, and again stressed the greater emphasis (as compared with the U.S.) that the USSR places on radiation aspects of space flight.

(5) Space-Based Industry. Although the subjects of large space structures, space-based solar power stations, and nonterrestrial resource utilization were dominated by the U.S., the Soviets (as well as all foreign Congress delegates) evinced extraordinary interest in the papers and sessions on these subjects. The Soviets did demonstrate competent recognition of one key problem: active shape control of large structures, applied to a radio-telescope array.

(6) Propulsion. The Ariane third-stage propulsion system (HM-7) was revealed to utilize technology comparable to languishing U.S. high-performance liquid oxygen/liquid hydrogen upper-stage capability, and may represent a significant area of future European competition. The FRG's ion-propulsion technology was also shown to be comparable to that of the U.S., and may have implications for strong future European capability in large-structure shape control as well as for orbit trimming and station keeping. In plasma diagnostics, the Soviets revealed a somewhat surprising sophistication in their measurement techniques, which might imply that their capabilities in significant new areas such as laser diagnostics could be greater than has been indicated in the past.

Although French solar-sail technology was revealed to be far behind that of the U.S., missions were suggested using the Ariane launcher which could open up another area for European competition, particularly in view of the recent U.S. decision to shelve solar-sail development.

(7) Astrodynamics. Specific subjects of interest were the use of approximations from matched asymptotic expansions (stability analysis of periodic orbits) to estimate the number of star collisions in the galaxy, illustrating the powerful capabilities of the analysis methodology; the use of atmospheric deceleration for Mars orbiter insertion; closed-loop automatic controls (a Soviet specialty); and the combination of passive gravity-gradient attitude stabilization with a gyrodamper system, a particularly important and competent Soviet hybridization analysis. The French, Soviets, and Germans, in that order, demonstrated sophistication in this field comparable to that of the U.S.

(8) Contact with Extra-Terrestrial Intelligence (CETI). The Soviet efforts, although still behind those of the U.S. in quality, may be ahead in terms of the total resources applied. The 28th Congress revealed strong Soviet interest in non-technological aspects of CETI; e.g., the use of intelligence methodology, biological evolution, and the character of messages. Principal Eastern European competence in this field continues to reside in Czechoslovakia's Rudolf Pešek.

(9) Unmanned Solar System Exploration. Lack of NASA support at the 28th Congress, and also lack of support by other governments, reduced the potential effectiveness of international communication in this extremely high-interest area. Despite the enormous impact which the U.S. Viking and

Voyager programs had in unmanned exploration, only the Soviet Venera missions were presented adequately. As in the past, however, whereas the scientific findings were well reported, Soviet engineering information was sparse or nonexistent, particularly their future plans, mission and system design details, spacecraft technology, and spacecraft performance.

(10) Lighter-Than-Air Systems for Space Operations. Considerable data and information were given on the French super-pressure balloon to be utilized as a Venus atmosphere probe on the 1983 Soviet Venera missions, in sharp contrast to the abovementioned Soviet unwillingness to release engineering details. Although buoyant probes were rejected by the U.S. for our Venus orbiter/probe, the 28th Congress information could be useful to NASA in future mission planning vis a vis Soviet and other foreign efforts.

(11) Space Rescue and Safety. Although not discussed by the Soviets at or prior to the 28th Congress (aside from the Apollo-Soyuz mission, which added considerably to USSR capability), specific Earth-surface rescue technologies in several other countries outdistance U.S. capability in a number of cases. However, the U.S. clearly leads in spacecraft safety and rescue technology, due primarily to our extensive manned space flight experience in the 1970's.

Detailed discussions of these foreign developments and viewpoints appear in Section III of this report, along with information on other developments of lesser but nevertheless considerable importance.

I. INTRODUCTION

The Congresses of the International Astronautical Federation are the only international non-governmental forums for world leaders in space technology to meet and exchange technical information. The 28th Congress, held in Prague, Czechoslovakia, during the week of September 26 - October 1, 1977 (see Program, Appendix A), offered an unprecedented opportunity for a critical assessment of the status of foreign space technology in many key areas. Some 900 delegates from 38 nations participated, presenting 296 technical papers. (Appendix B) The AIAA, as one of the member societies of the International Astronautical Federation, utilized a number of its members who attended the Congress as delegates to compile the data upon which to base this assessment, as described in the subsequent sections of this report.

II. METHODOLOGY

One or more AIAA members (Appendix C) attending the Congress were assigned to monitor each of the sessions listed in Apperdix A.

These members, each of whom is a specialist in the subject of the sessions he was asked to monitor, were sent advance copies of the program early in the summer of 1977. They were asked to provide a brief review of the status of foreign technology and to identify those foreign papers which were likely to be of greatest significance. At the Congress, they were asked to select the most important foreign papers and to highlight those portions or aspects of the papers which represented significant advancements in the field. These reports comprised the basic data from which this report was formulated.

Note that this approach resulted in a state-of-the-art review of the technological basis for many of the programs and activities reported in detail in the excellent compendium of Reference 1, and as such this report serves as supplementary material rather than as a reiteration of the information contained in that reference.

III. TECHNOLOGY REVIEWS

The reviews in this section do not purport to present a complete picture of the state-of-the-art in each of the designated disciplines, but rather to identify and summarize the principal areas of either activity or technical achievement which were highlighted by the presentations and discussions at the 28th IAF Congress. Subject breakdowns are in accordance with those of the Congress program; their order is simply that of the program, and does not indicate any prioritization.

A. Space-Based Industry

1. Space Processing

The two most interesting papers in this session (References 2 and 3) were both generated by the Federal Republic of Germany, which is unquestionably the most advanced of all the European nations in this field. FRG has a well-established rocket program comparable to the U.S. SPAR effort, which produces experimental data from a few minutes of zero-g flight.

Dr. K. Hannig of West Germany's Max Planck Institute flew a moderately successful electrophoresis experiment (MA-014) on the 1975 ASTP flight. The experiment attempted to perform separations in a continuously flowing solution, especially suited to preparing materials in useful quantities. It separated samples of lymphocytes and calibrated mixtures of red blood cells. In addition, this experiment processed samples of the types of bone-marrow cells responsible for producing red blood cells. Successful separation would have contributed materially to the work of the Max Planck Institute on transplantation of bone marrow to cure leukemia, radiation sickness, and similar conditions of impaired red-blood-cell production. The development cost for MA-014, it should be noted, was paid by the German government.

Other types of space processing highlighted by Reference 2 were in the relatively routine areas of directional solidification, crystal growing, and a wide range of biomedical studies. Their principal feature of interest was the definite degree of advancement in proposed equipment concepts (2nd generation) as compared with early (1981) Spacelab experimental equipment.

The second paper (Reference 3) discussed innovative and highly promising approaches to the casting of composite materials, utilizing unidirectional solidification of eutectic alloys and preparation of oxide-dispersed superalloys directly from the melt. Both casting methods use skin technology -- the use of a thin-layer coating which can retain the casting shape under zero-g conditions. This approach has been examined by U.S. researchers, but the FRG technology appears to be at least at a comparable level.

The two Soviet papers (References 4 and 5) did not appear to contain any new or up-to-date technology or ideas. Up to the 28th Congress, (*) the most recent known Soviet efforts in space processing were the multiple material melting experiments (MA-150) processed during a single run of the Apollo-Soyuz electric furnace in 1975:

(1) A germanium rod containing 0.5% silicon was partially melted and resolidified and the distribution of the silicon impurity studied, as in Skylab Experiment M 562.

(2) Densely packed aluminum powder containing dispersed tungsten particles was melted and resolidified to demonstrate the feasibility of making cast composites with components of greatly different densities.

(3) A somewhat more porous aluminum powder was melted and frozen to determine how much consolidation takes place when no buoyant forces make bubbles float out of the melt.

MA 150 results were analyzed by a team of investigators from the Soviet Academy of Sciences, but the results were never published in reports available outside the U.S.S.R.

(*) Salyut 5 experiments, revealed at this Congress, are described in Section III C below.

2. The Engineering of Life Science Payloads

This session, as with two other sessions devoted to bioastronautics (to be discussed later) was dominated by Soviet papers. Three of these were of particular interest.

In Reference 6, the Soviet authors make a good case for providing the Earth-based operators of remotely controlled devices studying surfaces of planets with medical support. Standard tests were used to appraise such factors as psychic stress, e.g., heart rate, electric skin resistance, etc. The authors concluded that (a) the operation of remote-control space vehicles requires formulation of careful medical procedures covering operator selection, training, work, rest, optimization, and streamlining of engineering parameters for data, control, and display modules, (b) the high nervous-psychic stress imposed by remote control of self-propelled space vehicles imposes enhanced requirements for the psychological training of operators as well as their regular training, and (c) in order to increase reliability of the remote-control system as a whole, it is necessary to monitor the state of work capacity and neuro-psychic activity of operators both before and during real work.

In Reference 7, the authors reported that investigations conducted during the flight of Soyuz 22 detected the following contaminants: methane, ethane, heptane, methanol, ethanol, n-propanol, acetaldehyde, acetone, and ethylbenzene. The concentrations of these substances were comparable to those recorded during ground-based chamber experiments, and apparently evolved from non-metallic construction material, lubricants, varnishes, paints, rubber, insulators, and human waste. Such investigations are critical to detailed knowlege of the formation of the atmosphere in space cabins during long-term missions.

Reference 8 is a first attempt to develop an approach to study behavior in a closed system. The experiments showed that individual response to physical parameters of the environment is to a large extent determined by psychological factors such as motivation, high spiritual requirements, and social aims. One experiment, for example, revealed that the number of contacts which the subject had with a greenhouse, although very inconveniently located, increased significantly, suggesting a growing need for biological stimuli.

A relatively significant non-Soviet paper, Reference 9, defined a set of standard equipment designed for use in the Spacelab module for bio-medical and physiological investigations in weightlessness. The main characteristics of the environmental control chamber and other equipment which will fly within the first German mission, scheduled for late 1981, were defined in some detail.

3. Large Structures in Space

The 28th IAF Congress revealed practically no non-US effort in this field, aside from derivative German analyses of the type presented at the 27th (1976) Congress (Reference 10) and the paper at this Congress by Harry Ruppe (Reference 11). Neither of these were considered up to U.S. analysis standards, and neither of the other two foreign papers presented at this session (References 12 and 13) indicated significant technology concepts or developments.

There was, however, considerably foreign interest in the extensive U.S. technology presented at this session, particularly on the part of the Soviets (also see Section A-5, below).

4. Fluid Dynamics Aspects of Space-Based Industry

None of the eight papers in these sessions (Number 15 and the first half of 25; see Appendix A) were by U.S. authors. All were related to fluid motions and interactions under low-gravity conditions, and although of some academic interest,

were considered by AIAA delegates not to represent any significant advancement in science or technology over comparable U.S. efforts.

5. Non-terrestrial Mining and Delivery Systems

As in large space structures (Section A-3 above), this area of technology is dominated by U.S. research. The only two non-U.S. papers (References 14 and 15) dealt with exploratory aspects of nonterrestrial soils based on results from Soviet Venera-9 and Venera-10 missions which have been well documented in prior Venera reports, and which will have little bearing on the utilization of nonterrestrial materials for future space industrialization activities.

This session did, however, generate considerable interest among the Soviet delegates. Dr. Petrov, although unable to attend the session, had specifically designated one of his colleagues to attend and to report back to him on the results. There has been subsequent communication between Dr. Petrov and Dr. O'Neill, U.S. co-chairman of the session.

B. Communications Satellites

The 6-session symposium on Communications Satellites held at the 28th IAF Congress constituted a unique opportunity for a truly in-depth, up-to-date world-wide status review of the most advanced area of space activities. The forty-one papers, the panels, and the open discussions by Symposium participants constitute what is probably the most significant and informative body of technical information yet compiled on the international aspects of satellite communications.

In summary, the general state of foreign technology in the satellite communications field was judged by the AIAA delegates to be little, if any, behind that of the U.S., with, of course, certain specific exceptions as outlined in the subsequent discussions. The most important factors which contributed to the closing of the technology gap in recent years are the ESA programs themselves; e.g., OTS, MAROTS, ECS, and the "heavy platform" programs. Also, such national programs as SYMPHONIE

and SIRIO, although not technically advanced, nevertheless helped to close the most important gap of all: the organizational gap. Extensive participation in INTELSAT IV and INTELSAT V was another significant factor. Nevertheless, the U.S. continues to maintain substantial technology leads in launch capability (the Ariane is still very much an untested and therefore unknown quantity), in integrated circuits and data processing, in engineering and production facilities, and to some degree in propulsion and solar-cell technology.

One specific area cited for advanced foreign capability is that of maritime satellite technology. MAROTS is ahead of U.S. technology in a number of areas, particularly its much greater capacity which offers the opportunity to connect many more shore stations than MARISAT proposes. Ship terminal technology in several countries, particularly in Japan and the UK, appears to be more advanced than in the U.S., whereas FRG and the USSR appear to lag the COMSAT General - developed U.S. systems.

During the sessions and the discussion periods a number of topics of direct concern to NASA were highlighted, and are identified in the subsequent paragraphs.

1. Issues

Of the six papers presented in Session 3 (See Appendix A), by far the most significant was the paper by Y. Krupin on INTERSPUTNIK (Reference 16). Quoting from Reference 17, "The paper presented on INTERSPUTNIK is probably one of the most comprehensive summaries to date on this Soviet-instituted system". In addition to its unprecedented coverage of the technical detail of the INTERSPUTNIK system, a particularly interesting feature of Mr. Krupin's presentation was his statement that the complete technical data on INTERSPUTNIK system capability are available for the asking. Are these data known to NASA? Mr. Krupin also stated the Soviet intention for INTERSPUTNIK to provide "free-feeds" of the 1980 Olympics

to any and all telecommunications systems. Should NASA attempt a comparable "public relations" coup?

In addition to descriptions of the Molniya-3 (elliptical-orbit) satellites and the Statsionar (geostationary) system, Krupin outlined R&D efforts currently underway to increase the capacity of the system via (a) low-noise receivers in the Earth stations, (b) wideband low-noise amplifiers, (c) improved antenna and waveguide systems, transmitters, and receivers, (d) standardization of equipment, and (e) satellite transponders having higher power and wider bandwidths.

Important areas covered by the other papers in this session were the extensive activities in regional and domestic satellite systems for Europe, serving telephone, telegraph, and video needs (Reference 18); a comprehensive update of the INTELSAT system (Reference 19), which reported two new members in the 99-nation system -- Angola and the People's Republic of China; and an emphasis by ITU (Reference 20) that broadcast frequencies are valuable international resources, and must be so treated by all nations.

Key issues raised during the panel discussion were as follows:

. Political issues appear to pose the major barriers to increased cooperation between the various international and regional systems. A particular concern is the need for a mechanism to interface proposed regional systems (e.g., INTERSPUTNIK, EKRAN, Europe (ESA), Middle East Indonesia, etc.) with INTELSAT. Key points for NASA consideration are to define the U.S. role in assisting with the development of such regional systems and their coordination with other systems and INTELSAT.

. Frequency allocation policies among the various systems need to be coordinated, and also correlated with long-range system plans. A major concern for NASA is to establish and promulgate a firm U.S. position relating to WARC so that decisions (to be rendered in two years) do not work against current U.S.

frequency policies and long range plans. Europeans and others are already "politicking" for their positions; it is necessary to promote a firm U.S. position.

. A planning model which incorporates technical, geographic, political, and social data is needed to accommodate the increasing international activity in satellite development and use. Such a computer-based model could be used by NASA and other U.S. policy makers to ascertain trends, potential "traffic jams", overlaps or interferences among the various systems, etc., and thereby to maintain U.S. leadership in the field of communications satellites.

. There are good prospects for domestic systems to provide service links to neighboring nations. During the session, Mexico indicated a definite interest in U.S. capability to provide domestic service to Mexico, either commercial or non-commercial. NASA's reaction to such a request, which Mexico expects to file with the FCC, needs to be formulated.

2. Operational Systems

Again, the most significant revelations in this session appeared in the Soviet presentation (Reference 21 and the subsequent discussion). In addition to the general increase in the use of satellite transmissions in the USSR, the Soviets indicated increased application of digital techniques and a movement away from dependence on analog systems, including digital voice, facsimile, and television transmission, as well as computer communications (Reference 22). It was also pointed out that although the Molniyas (elliptical orbit) now have a capacity of only 200 channels due to Earth station limitations, the introduction of a "new satellite" (Statsionar?) in 1979 will increase capacity to 4,000 channels.

Another significant development is the rapid growth of Canadian TELESAT domestic satellite service (Reference 23), which now provides local English, French, and native language programs across over 70 Arctic communities, with

cooperative interfacing between TELESAT Network Central and the Canadian Broadcasting Corporation. However, TELESAT Canada's plan for expanded service has been slowed by a recent Canadian government decision not to allow TELESAT to merge with other Canadian communications entities, a decision which TELESAT Canada is appealing. NASA's position on this matter, if any, needs to be defined.

One key area highlighted by this Symposium was the relation between the MARISAT and MAROTS programs for services to seafaring vessels and their relationship to INMARSAT. NASA and the U.S. Maritime Administration (MARAD) should be keenly aware of the critical need for coordination between MAROTS and MARISAT activities (References 24 and 25). Reference 25 stated that the MAROTS satellite will use the 6/4 GHz frequency band compatible with the MARISAT system, and proposed that MAROTS satellites be sold to INMARSAT rather than leased, as soon as the INMARSAT organization is formed and ready to function. The discussion of these papers highlighted the urgent need for improved communications between the interested national, regional, and international groups in order to make INMARSAT a reality.

3. Future Systems and Planning

This session (No. 12; see Appendix A) was dominated by U.S. papers, but several of them contained international implications which could be of interest to NASA. There were however, two foreign papers of considerable significance to NASA (Reference 26 and 27).

Reference 26, which dealt with a global public-service system, raised several important philosophical points. In a section on education, Muller noted the catalytic effect of satellites; i.e., although airmail exchange of videotapes could have been used with little or no sacrifice in communications effectiveness, the use of SYMPHONIE generated unusual interest and excitement among educational administrators. This is true in the U.S. also, but is often overlooked.

This paper offers clear evidence that French technology in public service systems is technically far behind that of the U.S. The teleconferencing experiments described are much more modest than those undertaken or planned for CTS. But perhaps most significant, Muller's criteria for Earth stations clearly point in the direction of broadcast systems like ATS-6 or CTS rather than fixed service satellites such as SYMPHONIE.

An important policy matter raised by this paper was its call for free use of educational satellites. In the discussion, SYMPHONIE broadcasts to Africa were challenged as a violation of original agreements with NASA. The sense of the discussions was that the French were perhaps "testing the water" to see how far they would be permitted to violate earlier agreements. The policy and technical issues are critical, since this may set an unfortunate precedent.

Reference 27 highlighted a point of major concern to NASA's FY 1979 budget proposal by reporting on the technical advances, partial implementation, and potential availability of an FRG 20-kW solar array for advanced communications satellites. This is of direct concern to the U.S. -- and hence to NASA -- in world-wide competition, since a comparable 20-kW module, which is probably further advanced technically than the FRG system, has just been deleted from NASA's Advanced Programs FY 1979 budget proposal (in the Office of Space Transportation Systems).

With regard to the impending battle over frequency allocation mentioned earlier, Reference 28 warns that the 12 GHz band plan evolved at the February 1977 WARC Conference can only be useful if a number of countries utilize it within the very near future; otherwise the Geneva plan will hinder development of broadcast satellites using this band and also other shared services.

Two U.S. papers (References 29 and 30) addressed methods for reducing costs to users of public service and aeronautical/maritime satellite systems, both of which could be of some interest in developing or aggregating foreign markets.

Since this work is well known to NASA, it will not be elaborated upon here; it is of interest, however, that AIAA Congress delegates considered these subjects to be of international significance.

Another U.S. paper, Reference 31, evoked a great deal of foreign interest, since it dealt in considerable detail with reliability and performance of the five INTELSAT series satellites, highlighting specific trouble spots (e.g., rotating bearings, traveling-wave tubes, batteries, and solar cells). The author's prediction of 20-year lifetimes for high-capacity satellites by 1990 was of particular interest to foreign delegates.

4. Experimental Systems

This session (No. 18, See Appendix A) emphasized the wide and increasing range of activities in progress by a number of nations. Perhaps the most interesting was a Soviet paper (Reference 32) describing the geostationary EKRAN domestic satellite, which has been operating since October 1976, serving about 40% of the land area of the USSR with multi-program television broadcasting. Sixty receiving stations are in operation; eventually there will be a thousand. The satellite uses a phased array of Yagi elements for transmission.

In an important paper on the OTS (Reference 33), Barthmann reported for the European Post and Telegraph Research Group on the importance of minimizing overlap with existing ground capabilities. Europe's unique requirements for satellite use, which must take into consideration the relativity short geographic distances between points in Europe and the need to complement an existing excellent ground telecommunications system, constitute a major technical and political challenge for a European direct-broadcast satellite. The recent OTS launch failure aborted the Europeans' opportunity to examine, in a pre-operational mode, concerns relating to Earth stations, flux density, and propagation.

It is worth noting that the 28th IAF Congress saw the first public documentation of the OTS range of experiments, although they are probably already well known to NASA (References 33 and 34).

A further note of interest: NASA's successful launch (August 25, 1977) of the Italian SIRIO-SHF (Reference 35), which went into operation on September 12 with TV news programs between Rome and Fucino, Italy, helped to "brighten the gloom" cast by the French report on the OTS launch abort.

In another example of a U S. paper with significant foreign implications, COMSAT's N. Helm (Reference 36) pointed out the important role that satellite communications can play in providing disaster communications through the use of small transportable Earth stations. Although NASA is well aware of this technology, it is important to note the extremely high level of international interest and concern in this type of service. It should receive careful attention by NASA.

5. Technology

The two principal foreign-technology features of this session were the performance data presented on a 100-150 watt, 12 GHz traveling-wave take tube. The Soviet presentation on this latter subject (Reference 39) provoked considerable discussion as to whether their design approach for multibeam communication satellite antennas might be better than that currently in use in the U.S.

But perhaps the most significant paper in this session in its impact on foreign technology development was the U.S. presentation by C.L. Cuccia (Reference 40), which publicly introduced the international community for the first time to the concepts of large space structure development, deployment, and utility made possible by the space shuttle. His discussion of such potential innovations as spot-beam service to 40 cities, the use of large shuttle-deployed antennas to replace traveling-wave tubes, and the novel concept of the orbital antenna "farm" (Reference 41) elicited considerable enthusiasm on the part of delegates from many nations. Japan, for example, has partially demonstrated how the multiple spot-beam

public-service system might be accomplished via their present experimental satellite program utilizing multiple 2 to 3-degree bandwidths.

The two maritime system papers (References 42 and 38) were of some interest in that they indicated comparable technology to that of the U.S.; e.g. the solid-state L-band amplifier described in Reference 42 and the MAROTS/New Spacecraft comparison data cited in Reference 38. Multiple-beam antenna design data from Reference 39 were also pertinent; e.g., the table on P.20 of that reference.

6. Transmission Techniques

Five of the seven papers in this session (see Program, Appendix A) were by non-U.S. authors. No significant technical innovations were cited by AIAA delegates, but the general high quality of these papers indicated the comparable technical level of U.S. and European/Japanese communication satellite capability cited previously in the summarization of this Symposium.

C. Scientific Spacecraft

Of the sixteen papers in the two Scientific Spacecraft sessions (Numbers 4 and 14; See Appendix A), only one was by a U.S. author; another had joint U.S. authorship.

Two of the Soviet papers are particularly worthy of note. Reference 43, although solely theoretical, deals with the automatic control of the shape of large space structures -- a subject which has been clearly recognized in the U.S. and elsewhere as a key technical requirement for the eventual utilization of structures such as large antennas and solar power modules. But the recognition of the key nature of this problem in the West has been relatively recent. Thus the principal significance of the Soviet paper is that the importance of the need for automatic shape control was recognized sufficiently long ago to have spawned an elaborately detailed theoretical analysis in time to be completed, reviewed for release by Soviet authorities, and translated into English by July 1977 (the manuscript deadline date).

Reference 44 is perhaps even more significant, in that it reveals for the first time in public that the Soviets are actively continuing the space processing experiments which were begun by V. Kubasov in Soyuz-6 in the late 1960's, renewed in 1975 by P. Klimuk and V. Sevastyonov in Salyut 4, and, insofar as public knowledge was concerned, ended with the multiple-furnace tests of Apollo-Soyuz described earlier in this report (Since the Congress, of course, apparently extensive space processing experiments aboard Salyut 6 have been revealed).

Reference 44 notes continuing USSR sounding-rocket experiments comparable to the FRG and U.S. SPAR efforts (but claiming 10-minute low-gravity conditions -- far in excess of the 5-7 minutes for SPAR operations). The authors then provide elaborate detail in four different types of space-processing experiments conducted an Salyut 5 missions.

Three separate crystallization experiments were conducted using the "Crystal" experimental aparatus. The first of these, from July 7 to August 1, 1976, grew crystals both as seeds and in solution. In the second experiment, from August 9, 1976 to February 11, 1977, spontaneously segregated crystals up to 3mm diameter were obtained, with extremely interesting crystal intergrowth phenomena observed. The third crystallization experiment, from February 11 to 23, 1977, succeeded in growing a 5 mm crystal on a seed, but with fewer gas inclusions than on earlier crystals.

The diffusion process was studied with an experiment called "Diffusiya" to establish such important physical data as diffusion coefficients under low-gravity conditions.

Containerless melting, solidification, and remelting of multicomponent alloys were studied in a device named "Sphera", raising a number of extremely interesting prospects for future experiments and analyses. Similar phenomena associated with soldering and melting processes were studied in an experiment called "Reaktsiya", which was performed not only at low orbital gravity but also in space vacuum conditions. A particularly important result was obtained: space-soldered joints were not

inferior to ground-prepared joints and, indeed, surpassed them in several characteristics.

Much of the remaining material in the Scientific Spacecraft session was either of no great significance or is relatively well known. An interesting concept was proposed for direct sounding of the bottom of the ionosphere (E-region) via a "dive and ascent "satellite (Reference 45), and a rather detailed feasibility study indicated some promise. This project could be worthy of NASA monitoring. But perhaps the most illuminating philosophical concept to many of the older space-wise delegates from all nations was the view expressed in Reference 46:

> "The Challenge of the Spacelab Era. The first Spacelab mission begins a new era in space exploration. It marks the beginning of the operational use of the Space Shuttle where scientific and technological research can be conducted in space using experimental hardware designed, developed and tested to less stringent environmental and reliability requirements. This ability to fly hardware designed, manufactured and tested to less demanding standards than those required in previous manned space flight programs will permit more space research for the limited resources available. Compliance with the safety requirements and verification of peaceful purposes are the only prerequisites for payloads to fly on the Space Transportation System.
>
> The challenge to the project team for the first Spacelab mission, and to all participants in this and subsequent Spacelab payload missions, is to break away from doing business as in the past where anything less than 100 percent performance was considered unacceptable. The payload capacity of the Spacelab and the frequency of flights offers opportunities for corrections or adjustments to experimental hardware and for reflight. This places NASA, ESA and the scientific community in a better position to trade off their confidence in successful hardware performance against cost. The challenge is to reorient our thinking so that this mode of space research is exploited".

D. Cost Effectiveness in Space Operations

The Seventh International Symposium on this subject was generally dominated by U.S. papers and U.S. programs discussed with little real insight by foreign authors. Papers such as References 47 and 48, which purported to deal with useful and interesting subjects, turned out to be little more than idealized theoretical exercises having little or no bearing on real systems. Reference 49, in fact, stated an unequivocal conclusion that space-based solar power stations would ruin space communications. This is certainly a possibility which requires considerable study, as has been well established in all U.S. program planning, but Sarkar's absolute conclusion in Reference 49 was drawn on the basis of no supporting data whatsoever, according to AIAA delegates. In summary, these sessions contained little of real interest to NASA.

E. Communication with Extra-terrestrial Intelligence (CETTI)

The two sessions of the Congress devoted to CETI introduced few novel concepts or ideas not already well recognized by the U.S. SETI program (SETI stands for Search for Extra-Terrestrial Intelligence). Despite the high scientific and popular interest generated by this subject (e.g., a string of recent Science Magazine articles, a popular book by Timothy Ferris, and, most recently, a major N.Y. Times Magazine article, Reference 50), the growth of real technology in CETI continues to be slow.

A key factor in SETI (or CETI) technology is that no radio telescope antennas of any magnitude have been constructed solely for the purpose of SETI; all that are used for SETI are also used for conventional radio astronomy. The essence of sophistication in SETI at the present stage is the development of very low noise receivers, multi-channel spectral analyzers, and signal recognition devices. No foreign papers have appeared in the literature describing such developments; the U.S. seems to have a clear lead in its embryc program.

The Soviet efforts seems to rank second to the U.S. in quality; but perhaps they lead in the total resources being applied to SETI. The Soviets have an intense interest and are clearly listening more than us, although details are sketchy. At present they tend mostly to be doing sky surveys looking for very strong extra-terrestrial signals using small antennas, but larger antennas are coming on line. Outside the Soviet Union and the U.S., only the Canadians have actually carried out the search. Soon the French will follow suit.

The system designed to search for radio signals can be looked upon as consisting of five major subsystems: the antenna, the detector, the signal processor, and the system controller.

(a) The Antenna. For the lower plausible frequencies (1 to 10 GHz) the world's premier current capability is that of the antenna at Arecibo, Puerto Rico, a 1000 foot spherical dish. However, because of the intrinsic noise caused by the spherical design, the limited sky coverage possible, and this design's peculiar requirements for site topography, this design is not expected to be extended for future low-frequency Earth-based systems. Instead, what is envisioned is a small earth-bound array of the largest possible steerable paraboloids, or possibly one vast aperture in space.

The former case, the array, the largest steerable paraboloid extant is the 100 meter dish of the radio astronomical observatory at Effelsburg, West Germany. Claims for increased area have appeared with the construction of the Soviet RATAN 600 facility, but in actual fact the performance of this strange antenna appears to be equivalent to not much more than a 26 meter dish.

The U.S. has the capability of building antennas the equivalent of or superior to that of the Germans, should funding materialize, but until this capability is demonstrated, the Germans are the ones who have done it, and indeed the design which they implemented was a substantial advancement over previous construction.

In array technology, Europe has long been using large antenna arrays, but with the advent of the United States VLA (Very Large Array), we can probably claim to be the current champion.

The Soviets and some U.S. researchers have proposed CETI programs using large apertures in space. At the moment, there is little question that the U.S. has a substantial lead in the technologies that might enable such a structure to be built, including an extrapolation of the Arecibo design to a space-based configuration which would not have the topographical limitations of its Earth-based counterpart.

For high frequency searches (10-100 GHz) the U.S. is clearly outstripping any rivals both in ground-based instruments and in consideration of space-based devices free from the substantial atmospheric degradations which appear at these frequencies.

(b) The Receiver. In the microwave window (1 to 100 GHz) there is one type of receiver which is clearly of pre-eminent performance: the cryogenically cooled maser amplifier. The U.S. is the unquestioned leader in this technology and seems likely to remain so in the current funding environment. These receivers may ultimately be required for space-based operation which will require long-lived closed-cycle cryogenics. Here again, the U.S. is probably well ahead in such developments, although there is no particular reason to suppose that others could not advance to this level rather quickly if they so desired.

(c) The Detector and (d) The Signal Processor. The key requirement for both of these devices is accommodating enormous complexity at reasonable cost and power. For example, the most promising type of detector is a spectrum analyzer of millions or billions of channels, and the signal processor is then a device which can handle this large output and discern which data are worth saving. In order to do this at reasonable cost the most promising current technology involves the

heavy use of large scale integrated circuits (LSI). Here again the U.S. is the unquestioned leader in the appropriate technology, both in circuit and system design.

(e) The System Controller. For a search system to operate efficiently over the many years required for some substantial hope of success, the system must be automated. The system controller is defined here as that device which will permit such operation. At that moment, control of a large antenna facility and its associated equipment is being developed by the U.S. Deep Space Network. Thus, this is probably the system furthest along for this effort. However, there is reason to believe that many others would be capable of this technology, as the automation processes are straightforward and can be implemented with any of a number of technologies, if space, mass, and power are not particular problems.

Intense interest in the Soviet Union in non-technological aspects of SETI was evidenced at the Congress; e.g., the use of intelligence technology, biological evolution, the character of messages, etc. Many papers have appeared in this area, but they seem to be rather soft and speculative. Elsewhere, as in the U.S. publications cited earlier, there is also considerable interest because of the general appeal of the subject, but little substantive work. The papers from Eastern European countries are highly speculative, difficult to follow, and do not contribute very much to the science of technology of CETI or SETI, with the possible single exception of Dr. Rudolf Pešek of Czechoslovakia, who has a firm theoretical handle on SETI as a whole.

F. Bioastronautics

The IAF 8th Invited Lecture, presented by Professor O.G. Gazenko of the USSR on the subject "Man in Space Today and Tomorrow", gave some general results of the scientific information gathered from a broad USSR program of pre- and post-

flight cosmonaut examination. Gazenko reviewed the reactions of the body's functional systems during the adaptation process; e.g., in cardiovascular activity; in the muscular systems; in bone tissue (including the calcium deficit); and the decrease in erythrocyte count, as well as prophylactic measures, medical supervision, and flight safety. This excellent review paper unfortunately did not establish the characteristics of man as a subsystem having some very real frailties. We need to understand this subsystem better if man is to do all the things that the engineers expect him to do in space.

Of the remaining 18 papers in the two Bioastronautics sessions (Nos. 13 and 19; see Appendix A), 15 were by Soviet authors and two by Czechoslovaks. The eleven most significant of these are summarized briefly below.

In Reference 51 the author suggests that the well-known differences in radiation resistance may be due to individual functional characteristics of organisms. Experiments had already been reported aimed at establishing correlations between the functional state of the organism prior to irradiation and the subsequent differences in radiation resistance The report summarizes the results obtained in the author's laboratory with experiments with animals. He concludes that "the experiments presented in this paper showed that the functions of urine, electrolyte, excretion, corticoadrenal activity, and intensity of metabolism on the one hand and manifestations of radiation resistance on the other hand are related by nonlinear relationships suggesting an unfavorable prognostic significance of the extreme values of spontaneous valuability of the functional parameters used".

The author has published only one paper which does not seem related to the present article. We are not aware of any serious attempts in the U.S. to follow this line of research, nor do we feel that it would be of particular value. The USSR has typically placed more emphasis in the radiation aspects of space flight and should be competent.

The main author of Reference 52 has published eleven previous papers dealing with vascular responses to space flight. The other authors have contributed approximately thirty-six papers in the area of space cardiovascular physiology. Although the USSR has followed the lead of the U.S. Skylab experience, their total capability still does not match ours. We have continued to develop new measurement techniques, and it is expected we will remain ahead in this area.

Reference 53 presents an attempt to correct the changes in fluid and electrolyte metabolism using drugs. The paper contains some new and useful drug reaction information. The authors of this paper have published many previous papers related to the subject matter. The U.S. has had a continuing program of pharmacological agents as applied to calcium loss and orthostatic tolerance with bed rest, but not overall fluid and electrolyte metabolism. Since we are not sure of the mechanisms or adaptive significance of some of the changes in fluid-electrolyte metabolism, it would seem risky to apply pharmocological correction. It appears that the USSR does not agree and has conducted many experiments with pharmacological countermeasures.

References 54 and 55 deal with specific aspects of the overview paper, Reference 56. The experiments were made on Wistar rats who had spent twenty days on board the Cosmos 782 space biosatellite. Results obtained with these animals were compared with results obtained with various control groups. The authors conclude that "the weightless state does not represent a severe stress stimilus, since the activation of both cortex and medulla by the adrenal failed to show the characteristic signs of a chronic and severe stress. The weightless state as a component of space flight can be considered as a stress stimulus with no great final impact in the activation of the adrenal-cortical and medullary system".

The main task of the experiments carried out during this flight was to further the study of mechanisms of the effect of zero-g and altered g on the morphogenesis, structure, and physiology of animals and plants. The biosatellite Cosmos 782 was equipped with a centrifuge which made it possible for the first time to carry out in space an experiment to study weightlessness and artificial gravity effects on a comparative basis.

Genetic investigations were conducted on fruit flies, and the findings demonstrated that weightlessness cannot be an obstacle for normal growth and development of drosophila flies. One of the four US/USSR joint experiment on Cosmos 782 was a study of Fundulus heteroclitus eggs and fry. The study found that embryogenesis of fish has demonstrated that weightlessness may influence the embryonic development at the very early stages that precede gastrula; however, abnormalities, if they have developed, disappear in the course of subsequent growth. Experiments with the higher plants, including pine and crepis seeds, were also conducted to examine the spatial orientation of over and underground organs of plants grown in weightlessness, and to study the anatomy of support tissues and the state of nuclear structures in meristematic cells. These experiments have vividly demonstrated that geotropism is not a genetically determined property. It is of exogenous nature and may manifest in response to environmental changes. However, it seems very likely that polarity of the primary growth of roots and shoots is genetically determined or programmed.

Reference 57 describes experiments with male rats which were irradiated by 220 and 800 rad of gamma rays within 24 hours during the flight aboard the biosatellite Cosmos 690. In the terrestrial modeling experiments, animals were irradiated with the same doses and examined in the same way. The increasing triglyceride and total cholesterol concentration in tissues, the increase of liver triglycerides, and especially the increase in bone marrow triglyceride concentration were more intensive

in animals irradiated aboard the biosatellite. On the other hand the reparative processes in these groups, as compared with the terrestrial experiment in animals, were more perfect.

In the experiment described in Reference 58, the authors report that a long-term (20 days) space flight of rats on board the biosatellite indicated some biochemical changes in their skeletal muscles as compared with ground-based synchronous and vivarium controls. In fast skeletal muscles there has been an increase of GP "a" activity, while total and enzymic catalytic activity was retained. The change of GP "a" activity was irreversible and was maintained on the 25th postflight day. Dehydration of m. plantaris and m. phrenicus disappeared on the 25th postflight day. The authors conclude by saying "an analysis of data leads to a conclusion about necessity of creation on board the spaceship of artificial load on slow-twitch antigravitational skeletal muscles".

Reference 59 concludes that neither the space flight nor the irradiation of rats by 220 and 800 rads for 24 hours caused any substantial changes of deoxyribonucleoprotein and nucleic acid amount in liver. In contrast, a considerable decrease in nucleic acid amount and increase in the level of soluble polydeoxyribonucleotide occurred in spleen of rats exposed in space flight environment, probably as a result of so-called gravity stress. No accumulation of effects was observed in rats irradiated in space, though the damage is a little more pronounced in comparison with the effect of single space flight factors.

In Reference 60, detailed data are presented on the reparative processes in spleen, bone marrow, and peripheral blood of adult mice after continuous irradiation with daily dose rates of 50, 100, and 500 rads, up to a total dose of 1000 rads. The white pulp in all groups was more aged than the red pulp. The bone marrow similarity appears to be almost normal within 28 days after outset of irradiation, and the changes in peripheral blood after irradiation and during recovery were similar to the changes in spleen.

In Reference 61 determination of the activity of enzymes involved in animoacid metabolism in liver showed the marked increase of thyrosine, amino, transpherase, and tryptophen pyrolasc activity in postflight rats killed 6 to 10 hours after landing. The authors suggested the results indicate that immediately enhanced enzyme activity in liver could be the consequence of the exposure to acute stress factors.

Perhaps the most interesting new data in these sessions appeared in Reference 62, an "add-on" paper by the Soviets. Its purpose was to study the effects of the space flight environment on vestibular function (otolithic and that of semicircular canals) as well as spatial perception function of the cosmonauts that participated in the ASTP, Soyuz 21 - Salyut 5, and Soyuz 22 missions. The paper gave new, exciting data relating space flight reactions to several vestibular tests done pre- and post-flight. Some unusual asymmetries in vestibular function noted in the testing might have predictive value for space motion sickness. This was an excellent paper of new data.

G. Unmanned Solar System Exploration

The U.S. and U.S.S.R. are, of course, the only two nations who have conducted solar system exploration missions. Nonetheless, there is interest and activity in Europe and Japan in this area.

Western Europe: ESA has excellent capability in spacecraft technology and is developing a sound low-level capability for all aspects of unmanned exploration missions. Their mission design/software/operations state-of-the-art is rudimentary, but by working with the U.S. they will be able to conduct missions. ESA continues to study other missions on the forefront of technology including the solar probe, possibly solar sailing, Mercury orbiters, etc. In particular, the technology required to shield the solar probe and still maintain communications represents a significant contribution to probe construction techniques (Reference 63).

West Germany is building the orbit insertion motor for the U.S. Jupiter Orbiter Probe mission. France continues to work on balloons and experiments for the Russian Venera program. The Netherlands is involved in a joint U.S. venture for an infrared astronomy satellite. Britain and other European countries are developing synthetic aperture radar capability and other instruments for planetary application.

In summary, Western Europe is remaining active and involved in planetary missions. The usual problem of limited resources and uncertain commitment prevents what is possible from being realized. Technology advances in particular hardware areas (instruments, spacecraft subsystems, etc.) seem to be continuing. Europe will continue to be behind in software, mission design, celestial mechanics, and navigation technologies, and this will probably prevent them from being an independent force in deep space exploration for the near future.

Eastern Europe (other than the USSR): Little work is being done in solar system exploration except for occasional papers tying U.S. and U.S.S.R. results to theoretical and/or Earth observational studies. Several papers from Eastern Europe at this Congress reflect some specialized work on such topics; e.g., References 64, 65, and 66.

Japan: Japan has considerable electronics capability and is developing a capability for building spacecraft subsystems. They showed some specific interest (at the University of Tokyo) in working with the U.S. on the Jupiter Orbiter Probe mission, but nothing materialized. Beyond their interest in some subsystem areas, there has been no Japanese contribution in this topic; it is possible that some will be forthcoming in 5-10 years.

U.S.S.R.: The Russians continue to maintain an active and significant planetary program. Their Venera program is an outstanding success--both in engineering and in science. Many papers analyzing, utilizing, and elucidating results from

Veneras 9 and 10 are appearing in the scientific literature, including several at this Congress; e.g., References 67 and 68 in the Unmanned Solar System Exploration session. In addition to the invaluable methodology descriptions in these papers, which are important in future mission planning, Reference 67's results are significant in adding to the understanding of Venus atmospheric turbulence, which ultimately will give us a complete picture of Venusian (and later Earth) climatology and meteorology. The success of the Soviet landings on Venus cannot be overemphasized--it is an advance of technology. Indications are that the Russians will carry these advances further in the continuing Venus exploration program.

At Mars the Soviet Union failures are as great as their success at Venus. This is somewhat mystifying, since the technology requirements are not as great. Russian subsystem technology, especially electronics, seems to be less than it should be. Their mission design ability appears sound and is probably backed with excellent analytical capability.

While Russian science is well reported, their engineering is not. A ridiculous paranoia about revealing future plans seems to exist, and details on mission and system design, spacecraft technology, and performance capabilities are almost always unreported. The USSR program is far less broad than the United States, and outer planet missions, comet rendezvous, and other ideas do not seem to be getting much attention. There does appear, however, to be a large number of workers in their planetary program, and about once every three months a paper or two appears on advanced ideas (low thrust propulsion, gravity assist, outer planet mission ideas, etc.). The Russian secrecy prevents us from knowing whether this is the tip of an iceberg or random individual interest.

An important matter for NASA attention is the fact that although the subject of unmanned solar system explanation is perennially one of the highest - interest subjects at the IAF Congresses, the sessions this year were considered

wholly inadequate by the AIAA delegates, principally because of the marked lack of U.S. support of the Congress in this area. It necessitated a number of inadequate or inappropriate "fill-in" papers; e.g., References 69 and 70. In the light of the unqualified Viking successes, this was one of the most discussed subjects at the Congress.

H. Fluid Dynamics

The bulk of the papers in fluid dynamics at the IAF Congress appeared in the session on Fluid Dynamics Aspects of Space-Based Industry (See section A-4 above). Of the remaining five papers in Session 25 (see Appendix A), none of which incidentally were by U.S. authors, all were highly theoretical. Three of the five dealt with subjects having little to to with space technology, and there appeared to be no significant new information developed by the other two, which were largely academic exercises.

I. Earth and Ocean Dynamics

Of the six foreign papers presented in this session (see Appendix A, Session 26) only two were considered by the U.S. delegates to contain advanced technology elements. Reference 71 demonstrated a successful technique for determining orbit perturbations (it was able to detect a 25 cm orbit perturbation, as compared with the usual $\sim$ 2 m resolution), by analyzing sequential passes of GEOS-3, and Reference 72 presented what appears to be a valuable procedure for high-accuracy calibration of satellite altimeters. Developed for Seasat, it is to be tested using a Black Sea site.

J. Earth Observations

The sessions devoted to this subject at the 28th IAF Congress Nos. 29,42, and 47; see Appendix A) included no less than 20 non-U.S. papers; and it has been decided by the Programme Committee for the 29th Congress (in 1978) to make Earth Observations one of the major Symposia, with perhaps 5 or 6 sessions at Dubrovnik

in 1978. Yet, despite the extremely high international interest in this subject, which is perhaps the most important practical application of space technology to follow communications and meteorology satellites, there was a disappointingly meager show of foreign technology at the 28th Congress.

Several of the papers simply presented summaries of specific uses of Landsat (References 73-75), all of which are familiar to NASA. The only substantive USSR papers (References 76-83) were all theoretical studies, and although they demonstrate an excellent understanding of microwave sensing theory, the Soviets have released little or no data since Cosmos 243, which first flew a passive microwave sensor in 1968 (prior to the U.S.). The French papers (References 84-87) dealt with relatively primitive technology vis a vis both current Landsat and the forthcoming Landsat C and D efforts. Perhaps the only innovative foreign paper in the three sessions was Reference 88, (*) which, although technically naive, nevertheless raised an interesting prospect for determining first-order ozone concentration estimates.

K. Lighter-than-Air Systems for Space Operations

The only significant foreign technology in this session (Reference 89) is the French superpressure balloon design to be utilized as a Venus atmosphere probe in a 1983 Soviet Venera project. The design is well established as to mission requirements; systems data such as Earth/Venus transit requirements, deployment and inflative sequences, flight conditions (e.g.; gas loss due to diffusion and leakage, thermal flux, vertical-wind variations, overloading due to skin particulate collection, etc.); and specific reference design features such as balloon size, material and structural design, sensors, pressure regulation devices, inflation subsystems, etc.

Although buoyant probes were considered for the U.S. Venus orbiter/probe system, they were not selected. This paper could be of some interest for subsequent

(*) This paper was added at the Congress

U.S. mission consideration. Note also that some of the technical data utilized for the reference design are discussed in a general French survey paper (Reference 90).

L. Propulsion

Papers presented in these sessions (Nos. 31 and 36) which were identified as having particular significance are listed here as References 91-97. Key elements of significance in these papers were as follows:

(1) Reference 91: The review of HM-7 (Ariane third-stage propulsion system) highlighted a number of developments comparable to U.S. efforts on high-performance liquid oxygen/liquid hydrogen rocket engine systems. In view of reduced U.S. (NASA) efforts in this discipline, this development represents a potential area for future European competition; e.g., in the sorely-needed advanced orbit transfer vehicle application.

(2) Reference 92: This paper introduces an interesting theoretical approximation to the POGO instability characteristic, permitting simplified preliminary engine design approaches to avoid this bothersome phenomenon.

(3) Reference 93: Again, an interesting theoretical approach to the truly difficult (but critical) problem of liquid-propellant engine startup. Should the hydrodynamic model proposed in this paper be validated experimentally, it could offer significant reductions in preliminary development testing requirements.

(4) Reference 94: Another theoretical analysis aimed at modeling cooldown requirements, with potentially significant implications for reducing experimental requirements to establish these parameters.

(5) Reference 95: This paper indicates a high level of development in ion propulsion engine technology, which will be required extensively for future large-structure development, configuration control, and station-keeping as well as for present geostationary satellite station-keeping requirements. The technological capability indicated by this paper is comparable to current U.S. developments in ion propulsion.

(6) Reference 96: This paper, which bears on plasma propulsion, demonstrates a rather sophisticated Soviet capability in experimental dense-plasma diagnostics, indicating some value in searching for comparable sophistication in plasma diagnostic techniques not propulsion-related; e.g., gas lasers.

(7) Reference 97: This paper is a relatively simplistic solar sail study, indicating a level of capability far below that of recent JPL studies. However, the application cited as an example in the paper, a Mercury mission using the Ariane launcher, suggests a potential area of competition for NASA now that the U.S. solar sail project (for a cometary rendezvous) has been shelved.

M. Space Rescue and Safety

The state of foreign technology in space rescue and safety is basically several years or more behind that of the U.S., principally as a result of the much more intensive and broad-scope U.S. effort in manned and unmanned space missions during the 1970's. Missions such as Apollo and Skylab placed man in space for continuous periods as long as 84 days and at distances as far away as the Moon. As part of these unique program accomplishments the safety and rescue technology was advanced considerably more in the U.S. than in other countries, although the Soviet participation in the Apollo/Soyuz mission, which illustrated potential space rescue capability, obviously added considerably to their space-rescue technology. Currently, the space shuttle program is building on the U.S. technology base. Future foreign development will probably continue to lag those of the U.S. in space rescue and safety.

Space rescue efforts and capabilities per se have not been discussed by the USSR to date, other than in the Apollo/Soyuz mission. One receives the impression that the value of life and comfort in the USSR system is reflected in the reduced attention given to the duress to which cosmonauts may be exposed; e.g., less

elaborate treatment on landing as well as total unconcern about potential problems which led NASA to impose medical quarantine examinations.

With respect to recovery following Earth surface touchdown, Japan and Europe are quite active in international rescue efforts. The USSR is a comparatively new member of ICAO. Safety statistics and accident prevention are cloudy areas, and the USSR does not discuss them There is little USSR activity in response to emergency situations involving vehicles/personnel of other nations, although they have participated in international maritime rescue discussions.

Foreign methods in several specific rescue technologies outdistance those in the USA in a number of cases; e.g., mountain rescue techniques carried out by overflying aircraft or rescue operations involving touchdown on mountainsides; fishing vessel fleet response (communications possibilities and mother ship); emergency transmission equipment on vessels; organized volunteer response to shipping difficulties; and organization of medical assistance communications to vessels.

Foreign developments discussed at the 28th Congress (Session Nos. 37, 48 and Current Events III) represent some excellent systems, some of which have the same objectives as those addressed by NASA in several experimental projects, particularly Satellite-Aided Search and Rescue. The development reported by FRG for maritime purposes (Reference 98) (*) may in the future be applied to aircraft search and rescue operations. It is receiving good attention and is appropriate to this report because it transmits directly to satellites for maritime use on L-band frequencies and does not involve the more complex accommodations that would be required if the frequency 406.0-406.1 MHz were used for the "ground" transmitter.

Other papers of interest included Reference 99, in which Beregovoy's approach to identifying 50 common words is innovative and professional. He had earlier pointed to the need for a simple universally understood space language to

(*) This paper was added at the Congress

avoid misunderstandings. In general, it seems that the USSR devotes much more effort to means of evaluating potential degradation in human performance aboard spacecraft. It might be interesting to consider why this may be so; less rapport with the individual? In Reference 100, Popov, whose work bears following, reported how he conducted "voice signature" possibilities for detecting unadmitted difficulties in spacecraft cockpits.

N. Materials and Structures

Papers in this session (No. 34) concentrated on three principal areas: (1) The Ariane launcher (References 101-102), which is of decreasing interest to the U.S. with its current deemphasis on expendable launch vehicles; (2) thin-wall cylindrical structures, of which the first paper (Reference 103) deals with the Spacelab module and is undoubtedly quite well known to NASA (it uses NASTRAN for its computations); the second (Reference 104) is a rather classical treatment of the USSR radiotelescope parabolic antenna as rigid or flexible anisotropic shells of resolution; and (3) thermal problems with several different kinds of space structures (References 105-107), none of which go beyond known U.S. research and technology capabilities in thermal stress and thermal vibration analysis using both semi-coupled and fully-coupled theories and, for complex structures, finite-element methods. In summary, there was little of innovative interest to NASA in this session.

O. Astrodynamics

The three "classical" sectors of astrodynamics have characteristically been treated in three separate sessions at IAF Congresses: (1) Natural Motion and Orbit Estimation (Session 35; see Appendix A); (2) Optimization, Transfer and Rendezvous, and Station-keeping (Session 41); and (3) Attitude Dynamics (Session 45). Recent progress in all three of these sections as evidenced at the 28th Congress in Prague has been summarized in Reference 108, which identified the two principal

new areas (both in the Attitude Dynamics section) as (a) flexibility and shape control, required for large solar arrays, radiotelescopes, and large communication-system antennas, and (b) the coupling between the motion of liquids contained in satellite tanks with the overall motion of the satellite, particularly in spinning satellites.

Specific papers of interest in these and other areas of astrodynamics presented at the 28th Congress are described in the subsequent paragraphs.

Five foreign papers (References 109-112) were identified by the AIAA delegates as being of some significance. Reference 109 utilized approximations from matched asymptotic expansions, used in the stability analyses of periodic orbits, for the estimation of the number of star collisions in the galaxy. This is a result of considerable scientific interest to astronomers, but it is also of interest to NASA in that it demonstrates the extremely broad applicability of new analytical developments in periodic orbit stability analysis.

The use of atmospheric decleration for Mars orbiter insertion as described in Reference 110 was considered by AIAA delegates as being quite feasible, and this paper was identified as a typical example of high-quality Soviet astrodynamic analysis capability.

Reference 111 was identified by several delegates as being a particularly significant development in the analysis of large-structure deployment mechanics, especially stability criteria. Reference 112, which treated the problem of optimum gyrodamper orientation, was considered by the AIAA delegates as one of the analytical highlights of the astrodynamics sessions (it has since been invited to appear in the Journal of the Astronautical Sciences), as a prime example of hybrid attitude control concepts, i.e, combination of passive gravity-gradient stabilization with a gyrodamper system. Reference 113 was identified as a good analysis of the

complex astrodynamic system of a satellite with solar panels, but suffered from its neglect of radiation pressure effects.

To summarize the state of foreign capability in astrodynamics vis a vis the U.S., the French, Russians, and Germans show the greatest degrees of sophistication, in that order. The Russians are hampered by poor computational equipment, although the gap seems to be closing. The French strength is greatest in applied mathematics; they are weakest in the guidance area. Both European and Soviet abilities in analytical trajectory optimization and orbital analysis and estimation procedures are comparable to those of the U.S.; their numerical optimization techniques are catching up to us. European attitude control capability is abreast of that in the U.S., but information about the Soviets in this area is poor.

More specifically, the French, particularly Marchal and Marec (who was, incidentally, trained in aerospace science at Princeton's graduate school), are leading authorities in celestial mechanics and trajectory optimization, and also have very advanced and innovative spacecraft control hardware (CALTUS low-level accelerometer, magnetically suspended reaction wheels, etc.). Soviet theoreticians, especially Sarychev and Beletski, are very advanced. Sarychev's practical analyses support spacecraft design, but he does not appear to interface with the design engineers. Beletski does highly original theoretical work.

In the specific area of attitude dynamics and control highlighted by Reference 108 as the primary area for current astrodynamic innovation, emphasis in Europe, as well as in the U.S., Canada, and Japan, seems to be on the attitude dynamics and modeling of spacecraft with flexible and/or deployable movable members, as well as on the application of modern control theory and computers to provide expanded on-board control capability to accommodate such vehicle flexibility. Three recent international symposia (besides the 28th IAF Congress) have been held on this specific subject (References 114-116).

The Soviets have not produced many papers on the effect of flexibility on satellite attitude dynamics and control, but have emphasized closed-loop active control systems and also hybrid-type control systems (e.g., Reference 112). Reference 117 demonstrates the importance they place on closed-loop automatic control systems; Petrov's authorship of this paper is significant.

P. Space Observations of Long-Term Climatic Changes

The subject of possible climatic change due to fossil-fuel combustion-generated carbon dioxide and particulates, as well as powerplant thermal dissipation, has become one of considerable global interest and concern. This new Symposium (Session 38) was instituted at the 28th IAF Congress to explore the applicability of satellite observation programs for definitive monitoring of such changes, to improve on the ability to detect and identify them early enough to implement corrective policies.

The bulk of the effort in climatic-change analysis has been in the U.S., with the notable exception of the Austrian-based internationally staffed International Institute of Applied Systems Analysis. Although no technology, foreign or U.S., yet exists in the utilization of space-based observation techniques for monitoring of such changes, one of the two foreign papers given at this Symposium (Reference 118) is of special interest because of the primary role its author (W. Häfele) played in developing world-wide recognition of the near-term potential magnitude of the CO_2 problem.

Q. Spacecraft Power Systems

By far the most significant paper in this session, in the light of subsequent developments, is the quite detailed Soviet description (Reference 119) of the Topaz space nuclear reactor's thermionic generating system. Technical papers on this system have appeared regularly in the Soviet journals since the late 1960's,

along with equally detailed descriptions of the thermoelectric Romashka reactors, but publication of so detailed a description at an international meeting is relatively rare. Topax, incidentally, was probably the power system in the satellite which impacted in Canada recently.

It is particularly interesting to note that the Soviets continue to develop the in-core thermionic concept, whereas the only recent U.S. efforts (at Los Alamos and JPL) have considered only out-of-core thermionics. Clearly, thermionic technology is one area in which the Soviets seem to have a good lead over the U. S.

A second Soviet paper of significance (Reference 120) suggests a relatively direct approach to the control of a space nuclear reactor, utilizing a mechanical-thermal servo system to "un-complicate" the normally complex automatic control system needed for such reactors. One U.S. delegate considered this a major step forward in the kind of thinking the U.S. nuclear engineering community needs to be exposed to.

The only other new concept suggested by non-U.S. authors in this session (Reference 121) was the use of hydrogen and oxygen as an energy storage medium for interplanetary missions, with replenishment by electrolysis of water during planetary-flight periods. Although the concept does not appear viable as a storage mechanism, it is interesting because of its conceptual similarity to recent U.S. (General Dynamics) proposals which utilize excess shuttle mass capability to ferry water to a solar-powered space-based electrolysis facility located in a modified shuttle propellant tank carried all the way to orbit.

A post-deadline paper, (Reference 122) suggested the idea of using high-temperature radiators on the backs of solar-cell power modules employing concentrators. The author's projected specific mass of 5 to 6 kg/kWe does not seem likely, however, in view of the reduced efficiency of photovoltaic cells at higher temperatures.

R. Space Relativity

The consensus of U.S. delegates to the Congress was that aside from the US/FRG Helios mission, there was little foreign activity in space relativity research, and essentially none in advance of U.S. work in this field. Only one paper (Reference 125) was highlighted as having some significance. This solar probe concept suggested unique technology approaches for shielding the probe and maintaining communications in the near-solar environment, which could represent significant contributions to solar-probe construction methodology.

None of the other three foreign papers (References 124-126) were considered to represent advanced technology or concepts.

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APPENDIX A

PROGRAMME

Twenty-Eighth International Astronautical Congress

Prague, Czechoslovakia

September 26 - October 1, 1977

28th Congress of the International Astronautical Federation

Hotel International
Prague, Czechoslovakia
September 25-October 1, 1977

International Programme Committee for the XXVIIIth IAF Congress

Chairman: J. Grey (USA)
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S.N.B. Murthy (USA)
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R. Pesek (Czechoslovakia)
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J. Singer (Israel)
F. Sonnenschein (The Netherlands)
F.O Vonbun (USA)
D. Winter (USA)
O Wolczek (Poland)
IAF Bureau Ex officio Members

Congress Location

The Czechoslovak Academy of Sciences and its Commission on Astronautics are the hosts for the 28th International Astronautical Congress of the International Astronautical Federation. The Congress (except for the opening ceremony) will be held in the Hotel International, Praha 6, namesti Druzby 1, telephone 32 10 51, telex 121 055. The hotel is located 7 km from the center of Prague.

Registration

The registration and information center, located in the Hotel International, will be open daily from 8 AM to 6 PM, Saturday September 24 through Sunday October 2. Information services will be provided there daily till 8 PM.

Registration fees for the Congress must be paid in advance and are as follows:

Full Participants: $80.00

Accompanying persons: $50.00

Students: $40 00 if accommodated in student hotels. This will cover accommodations and luncheons in student canteens for the duration of the Congress. Otherwise $10.

No fee is to be paid by accredited journalists.

The participants attending the Congress for two days only will pay 50% of the registration fee. The day of arrival to Prague and departure are included.

The registration form is to be filled out and *sent in duplicate as soon as possible* to:

28th IAF Astronautical Congress
The Astronomical Institute
Czechoslovak Academy of Sciences
Budecska 6
12023 Praha 2, Czechoslovakia

Registration forms may be obtained from AIAA, 1290 Avenue of the Americas, New York, N.Y., 10019

Note that in the event of your cancellation after August 25th, a cancellation fee of fifty dollars ($50 00) will be charged. If your cancellation reaches Prague after September 24, no refund will be made

Languages

Simultaneous interpretation in English, French, Russian and Czech will be available for the opening ceremony, the forum session on Monday, and the IAF General Assemblies

Group Flight Itinerary

Saturday, September 24, 1977 – Departure at 9.15 PM from New York JFK Airport on Pan Am Flight 44 to Copenhagen

Sunday, September 25 – Arrive Copenhagen at 9 50 AM, transfer to SAS Flight 743 departing at 12 10 PM for Prague, arriving at 1:35 PM Transfer by bus to the Hotel of your selection

Sunday, October 2 – Bus transportation to the airport for departure on Lufthansa Flight 351 at 11 05 AM, arriving in Frankfurt at 12 10 PM. Transfer to Pan Am Flight 73, departing at 1:55 PM and arriving at JFK New York at 4.20 PM Cost for the airfare only is $493 (subject to change). This compares to $757 for the regular round trip economy fare

Social and Cultural Events

Sunday, September 25—7:30 to 10 PM – Informal gathering at the Hotel International (no charge).

Monday, September 26—8 to 10 PM – Reception (no charge)

Tuesday, September 27—8 PM – Concert by the Czech Philharmonic Orchestra in the Municipal House, Smetana Hall. (no charge)

Wednesday, September 28—1:30 PM – Bus trip to the Observatory of the Astronomical Institute of the Czechoslovak Academy of Sciences at Ondrejov. Return around 6 PM. (no charge)

Thursday, September 29—Evening performance at Laterna Magica. ($4 to $5, seating limited.)

Thursday, September 29—Concert of chamber music in the Mirror Hall, Klementinum. ($4 to $5, seating limited).

Friday, September 30—Closing dinner at the Hotel International. ($25 per person, seating limited).

Requests for tickets for functions with limited seating capacity should be indicated on the registration form. All social functions are informal.

In addition to the above social events for all participants, there will be a program planned for accompanying persons without charge.

Travel Arrangements and Hotel Accommodations

AIAA has appointed Capital Travel International, Suite 455, 4340 Connecticut Avenue, Washington, D.C. 20008, Tele: (202) 362-1922, to handle all travel arrangements for the Congress. AIAA, in cooperation with Capital Travel International, is organizing a one week group flight to the Congress. Capital Travel will also handle individual trips for those persons who cannot travel with the group. It will also handle visas that are needed to travel to Czechoslovakia.

Land Arrangements

Hotel International ($250.00 – Double; $290.00 – Single); Park Hotel ($160.00 – Double; $190.00 – Single); Park Olympic II ($125.00 – Double; $145.00 – Single).

These prices are per person and include visa fee, seven nights at the hotel of your choice, breakfast and one other meal daily, roundtrip airport/hotel transfers, half-day tour of Prague, and baggage handling at the airport.

Visas

U.S. citizens are required to have a visa to enter the Czechoslovak Socialist Republic. Special visa forms stamped by the Astronomical Institute of the Czechoslovak Academy of Sciences will be needed in order to be exempted from the otherwise compulsory exchange of $10 per person per day for the duration of the stay when crossing the border.

IMPORTANT NOTE. Please make sure to make your travel arrangements early to get the accommodation you request. We strongly suggest that you use the travel agent appointed by AIAA to receive the special visa form exempting you from the travel fee. For further information on travel arrangements, contact Ms. Mireille Gerard at AIAA Headquarters.

Monday/September 26
9:00 AM

Opening Ceremony

Using Space—Today and Tomorrow

Monday/September 26
10:00 AM

Session 1

8th IAF Invited Lecture

"Man in Space Today and Tomorrow"
O G. Gazenko, *USSR Academy of Sciences, Moscow, USSR*

Forum

Space Exploration—
The Golden Decade

Co-Chairmen
H. CURIEN (France)
J. FLETCHER (USA)
J. KOZESNIK (Czechoslovakia)
B.N. PETROV (USSR)

Monday/September 26
2:00 PM/Room B

Session 2

Symposium on Space-Based Industry

Opening Lecture

77-75
Spacelab Development and its Operational Verification
M. Bignier, *Director, Spacelab Program, European Space Agency, Paris, France, and* D. Lord, *Spacelab Program, NASA Headquarters, Washington, D.C.*

Monday, September 26
2:30 PM/Room B

Session 2 (Continued)

Space Processing

Co-Chairmen
J. BREDT (USA)
V. KUBASOV (USSR)
G. SEIBERT (ESA)

77-53
Space Technology Laboratory
Binnenbruck, *DFVLR, Cologne Porz Wahn, FRG, and* Zimmermann, *Messerschmitt Bolkow Blohm GmbH, Ottobrun, FRG*

77-54
Studies of Technological Processes of Material Treatment by Solar Energy Under Cosmic Simulated Conditions
I.N. Frantsevich, V.I. Trefilov, V.S. Dvernyakov, V.V. Paschny and I.E. Kasich Pilipenko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-55
A Radiation Furnace for Zone Crystallisation Experiments in Space
A. Eyer, *Crystallography Institute, University of Freiburg, Freiburg, FRG*

77-56
Space Factories
D.M. Waltz and Hammel, *TRW Systems, Redondo Beach, Calif., USA*

77-57
The Italian Experiment on the Fluid Physics Module
G.M. Carlomagno, L.G. Napolitano and P. Vigo, *Institute of Aerodynamics, University of Naples, Naples, Italy*

77-58
Skin Technology -
An Industrial Application of Space Processing
H. Sprenger and E. Erben, *MAN Neue Technologie, Munich, FRG, and* J. Wortmann and K. Schweitzer, *MTU, Munich, FRG*

77-59
An Evaluation of the Economic Benefits of Processing Biological Materials in Space
B.P. Miller, *ECON, Inc., Princeton, N.J., USA*

77-60
Transforming Welded Shells for Space Systems
B.E. Paton, V.M. Balitskii and V.N. Samilov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

Monday, September 26
2:30 PM, Room C

Session 3

Communications Satellites Symposium

Symposium Chairman
B.I. EDELSON (USA)

Co-Chairman
W. LUKSCH (ESA)

1. Communications Satellite Issues

Co-Chairmen
E.V CHITNIS (India)
M.C NILSON (USA)

77-02
Growth of the INTELSAT System
S Astrain, *INTELSAT, Washington, D C , USA*

77-03
European Communications Satellite Systems
R Gibson, *European Space Agency, Paris, France*

77-04
International Space Communications Organization - INTERSPUTNIK
Y Krupin, *Intersputnik, Moscow, USSR*

77-01
U.S. Domestic Communications Satellite Systems
A Washburn, *Federal Communications Commission, Washington, D C*

77-05
World Administrative Radio Conference for the Planning of the Broadcasting Satellite Service in Frequency Bands 11.7-12.2 GHz (in regions 2 and 3) and 11.7-12.5 GHz (in region 1)
M. Mili, *International Telecommunication Union, Geneva, Switzerland*

77-06
Cooperation Between the Different Satellite Communications Systems
J Busak, *Prague, Czechoslovakia*

Monday/September 26
2:30 PM/Room D

Session 4

Scientific Spacecraft 1

Co-Chairmen
P G ACKERMAN (USA)
H J FISCHER (DDR)
V I SEVASTIANOV (USSR)

77-178
The Possibilities of Plasmasphere-Magnetosphere Studies Using Low Orbiting Mother-Daughter Satellite System
P Triska, *Geophysical Institute of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-179
Electron Temperature Measurements on Board Intercosmos Satellites
J Smilauer, *Geophysical Institute of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-180
Design Problems and Scientific Results of V-9 and V-10 Spacecraft
V S Avdujevsky, S I Morozov and V G Perminov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-181
RADUGA-Experiment: Multizonal Photography of the Earth from the Soyuz-22 Spacecraft
USSR DDR group of authors, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-182
Some Results of the Intercosmos Cooperation
H J Fischer, *Electronics Institute, DDR Academy of Sciences, Berlin, DDR*

77-183
Realization and Technical Parameters of MKF-6 and MSP-4
B Volter, W Tschoppe, H Mottig, R Casper, *VEB Carl Zeiss Jena, Jena DDR*

77-184
Satellite-Fourier-Spectrometer for Meteor 25.—Design Problems and Mission
V Kempe, *Academy of Sciences, Berlin, DDR*

77-185
The Dive and Ascent Satellite Program for Lower Ionosphere Research
T Godai and H. Nagasu, *National Aerospace Laboratory, Tokyo, Japan*

Monday/September 26
2:30 PM/Room E

Session 5

7th International Symposium on Cost Effectiveness in Space Operations 1

Organized by the International Academy of Astronautics

General Chairman
B D Haber (USA)

Socio-Economic Benefits of Space Operations

Chairman
K A Ehricke (USA)

77-A 61
Some Aspects of Economically-Effective Forecasting of Space Systems Optimal Program Elaboration
D N Shcheverov and V N Novikov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 62
Evaluating the Benefits of Government Funded Research and Development Aimed at the Private Sector
J S Greenberg, *ECON, Inc , Princeton, N J , USA*

77-A 63
Applications of Space Technology in Marine Science
K R Stehling, *U S Department of Commerce, NOAA, Rockville, Md , USA*

77-A 64
Economic Problems of Effective Application of Space Techniques for Studying Earth's Natural Resources
S A Sarkisyan, S S Korunov, A G Gurov and I I Samoilova, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 65
Space Solar Power Versus Space Communications
S K Sarkar, *General Directorate of Swiss PTT, Bern, Switzerland*

77-A 66
Social-Economic Determination of a Program for Lunar Industrialization in Support of Space Light Development Lunetta and Soletta
K A Ehricke, *Rockwell International, Downey, Calif , USA*

77-A 67
Cultural Engineering in Space
S C Eilenberg and S I Eilenberg, *Rockwell International, Downey, Calif , USA*

Monday September 26
5 00 PM Room A

Current Events Session I

Space Shuttle Flight Test Report
Myron S Malkin, *Space Shuttle Program, NASA, Washington, D C , USA*

Tuesday September 27
9 00 AM Room C

Session 6

Communications Satellites Symposium

2: Communications Satellites – Operational Systems

Co-Chairmen.
R C COLLETTE (ESTEC)
A GROMOV (IFRB)

77-08
Canadian Satellite Telecommunications Plans for the 1980's
P Chinnick, *TELESAT Canada, Ottawa, Ontario, Canada*

77-09
Future INTELSAT System (Post-1985) Planning, A Status Report
H L Van Trees, *Communications Satellite Corp., Washington, D C , USA*

77-10
Multi-Destination (Circular) Transmissions in the Satellite Communication Systems in the USSR
L Ya. Kantor, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-11
The European Regional Communications Satellite System
J C Raison, *CEPT, Centre National d'Etudes Spatiales, Issy-les-Moulineaux, France, and* P Bartholome, *European Space Agency, ESTEC, Noordwijk, The Netherlands*

77-12
Operational Systems - MARISAT
T J Kelly, *Scientific Atlanta, Atlanta, Ga , USA*

77-13
The MAROTS Programme
O J Haga, *Norwegian Telecommunications Administration, Oslo, Norway; and* J A Vandenkerckhove, *European Space Agency/ESTEC, Noordwijk, The Netherlands*

77-14
The ECS Satellite and Possible Operational Derivatives
C Wearmouth, *Hawker Siddeley Dynamics Ltd , Stevenage, Herts , U K*

Tuesday/September 27
9 00 AM/Room B

Session 7

Symposium on Space-Based Industry

Bioastronautics I—The Engineering of Life Science Payloads

Co-Chairmen
R S JOHNSTON (USA)
H OSER (ESA)

77-241
Methods of Increasing Efficiency of Servicing Long-Term Life Support Systems of Manned Spacecraft
B A Adamovich, B B Egorov, G G Ter-Minassian and G S Ratner, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-242
Biomedical Aspects of Mastering of Outer Space With the Aid of Remotely Controlled Devices
O G Gazenko, V I Myasnikov and V P Nektasov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-243
A Study of the Crew Metabolic Contribution into the Space Cabin Atmosphere During Space Flights
V P Savina, K N Mikos, V V Ryzhkova, A I Gorshunova, Yu G Nefedov, V V Lepsky and V V Aksenov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-244
Problems of Ecological Psychology During Prolonged Enclosures
A A. Losev, V.I. Myasnikov and M.A. Novikov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-245
On the Problem of Radiation Danger in Prolonged Manned Space Flight
A.D Bonov, *Faculty of Physics, University of Sofia, Sofia, Bulgaria*

77-246
Definition of Standard Equipment for Biomedical Spacelab Equipment
M Dietrich, *ERNO, Bremen, FRG*

77-247
Space Sled—A Multiple Purpose Facility for Research in Spacelab
P Junk, *ERNO, Bremen, FRG*

77-248
Engineering and Simulation of Life Science Spacelab Experiments
B. Bush, J Rummel and R S Johnston, *NASA Johnson Space Center, Houston, Texas, USA*

Tuesday/September 27
9:00 AM/Room A

Session 8

Symposium on Space-Based Industry

Large Structures in Space

Co-Chairmen
R. KLINE (USA)
E M KNOERNSCHILD (FRG)

77-63
Planning for Construction Projects in Space
J Disher, *NASA Headquarters, Washington, D C , USA*

77-64
Space Power Stations: Space Construction Transportation and Pre-Development, Space Project Requirements
R Piland, *NASA Johnson Space Center, Houston, Texas, USA*

77-65
Composites for Large Space Structures
J F Garibotti, R J Rack and A J Cwiertny, *McDonnell Douglas Astronautics, Huntington Beach, Calif , USA*

77-66
Power Satellites: An Evaluation
H O Ruppe, *Technical University of Munich, Munich, FRG*

77-67
Infinitely Built-Up Space Radio Telescope
V I Bujakas, A S Gvamichava, I A Gorshkov, et al *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-68
Infra-Red Space Interferometer
G B Sholomitsky, O.F Prilutsky and V G Rodin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-69
Vibrations aleatoires d'une structure spatiale. Principes et applications de l'approche dynamique statistique
A Bourgine, *ONERA, Chatillon-sous-Bagneux, France*

Tuesday/September 27
9.00 AM/Room D

Session 9

6th International Review Meeting on Communication with Extra-Terrestrial Intelligence (CETI 1)

Organized by the International Academy of Astronautics

Co-Chairmen:
J BILLINGHAM (USA)
R. PESEK (Czechoslovakia)

77-A 44
The Design of Ground-Based Antennas for SETI
S. Von Hoerner, *National Radio Astronomy Observatory, Green Bank, Va , USA*

77-A 45
Kinematics and Dynamics of the Interstellar Flight Project Icarus
A A Filyukin and U.N Zakirov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 47
Elements of Strategy in the Proposed Initial Phases of SETI
C.L. Seeger, *San Francisco State University, San Francisco, Calif , USA*

77-A 46
An Experimental Protocol for a Search for Radio Signals of Extra-Terrestrial Origin in the Presence of Man-Made Radio Frequency Sources
R E Edelson, *Jet Propulsion Laboratory, Pasadena, Calif , USA*

77-A 48
On the Active and Passive CETI from the Earth Satellite Orbit
M Subotowicz et al , *Polish Astronautical Society, Warsaw, Poland*

Tuesday/September 27
9 00 AM/Room E

Session 10

7th International Symposium on Cost Effectiveness in Space Operations 2

Organized by the International Academy of Astronautics

General Chairman
B D HABER (USA)

Cost Reduction in Space Operations

Chairman
H H KOELLE (FRG)

77-A 55
Organizing for Low-Cost Space Transportation
C Lee, *NASA Headquarters, Washington, D C , USA*

77-A 56
Double Payloads Launch with Ariane on Geostationary Orbit
R Hergot, *Centre National d'Etudes Spatiales, Evry, France, and* M Thoby, *Centre National d'Etudes Spatiales, Toulouse, France*

77-A 57
Future Low-Cost Space Transportation Systems Analysis – Part III: Preliminary Size Optimization
D E Koelle, *Messerschmitt-Bolkow Blohm GmbH, Ottobrunn, FRG, and* H H Koelle, *Technical University of Berlin, Berlin, FRG*

77-A 58
Reliability Trade-Off for Cost-Effective Satellite Systems
R Chauffrasse, *Centre National d'Etudes Spatiales, Toulouse, France*

77-A 59
Maintainability and Maintenance Optimization Techniques for Reusable Spacecraft
I Leupen, *Amsterdam, The Netherlands*

77-A 60
Concepts and Procedures for Low-Cost Production of the Shuttle Tank
G E Smith, *Martin Marietta Corp , New Orleans, La , USA*

Tuesday/September 27
9:00 AM/Room F

Session 11

Round Table on Scientific and Legal Aspects of International Cooperation in Remote Sensing

Organized by the International Academy of Astronautics

Co-Chairmen
P CONTENSOU (France)
V KOPAL (Czechoslovakia)

Speakers:

M.C.M. Bignier, *Spacelab Program, European Space Agency, Paris, France*

V.D. Bordunov, *Institute of State and Law, USSR Academy of Sciences, Moscow, USSR*

S.E. Doyle, *International Program, NASA Headquarters, Washington, D C , USA*

M.A. Ferrer, *Institute of Air and Space Law, University of Cordoba, Cordoba, Argentina*

K.Y. Kondratyev, *Department of Atmospheric Physics, University of Leningrad, Leningrad, USSR*

G. Lafferranderie, *European Space Agency, Paris, France*

I . Perek, *Outer Space Affairs Division, United Nations, New York, N Y , USA*

S. Saito, *Institute of Industrial Science, University of Tokyo, Tokyo, Japan*

Tuesday/September 27
2:00 PM/Room C

Session 12

Communications Satellites Symposium

3. Communications Satellites – Future Systems and Planning

Co-Chairmen
H L VAN TREES (USA)
V M KRYLOV (USSR)

77-16
Health, Education, Culture: Study for a Global System by Satellite
J Muller, *Centre National d'Etudes Spatiales, Toulouse, France*

77-17
Satellite for Joint Maritime and Aeronautical Services
W L Pritchard, *Satellite Systems Engineering, Washington, D C , and* R Stamminger, *Future Systems Inc , Gaithersburg, Md , USA*

77-18
Steps for Development of an Operational Tele-Health System
I J Pinson, *Auburn University, Auburn, Ala , USA*

77-19
Communications Satellite for Public Service
J P Witherspoon and F W Norwood, *Public Service Satellite Consortium, San Diego, Calif , USA*

77-20
Broadcast Satellite Plan at 12 GHz Band
S K Sarkar, *General Directorate of Swiss PTT, Bern Switzerland*

77-21
Design Factors Affecting Communications Satellite Lifetimes
R Strauss, *COMSAT Laboratories, Communications Satellite Corp , Clarksburg, Md , and* J R Owens, *INTELSAT, Washington, D C , USA*

77-22
Past Experience – Basis for Future Advanced Power Systems for Communications Satellites
B. Gohrbandt and J. Rath, *AEG-Telefunken, Hamburg, FRG*

Tuesday/September 27
2:00 PM/Room B

Session 13

Bioastronautics 2

Space Medicine and Applications

Co-Chairmen:
A. EGOROV (USSR)
D. WINTER (USA)

77-250
On the Possibilities of Prediction of Differences in the Tolerance of Individuals to the Effect of Ionizing Radiation
M. Pospisil, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-251
One the Role of the Diurnal Variation of Physiological Functions for the Tolerance of the Subject to the Factors of Space Flight
A. Vacek, Ju P. Druzinin, A.M. Podluznaia and J. Slotova, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-252
Cardiovascular Responses in Space Flights
I.I. Bryanov, A.D. Egorov, V.A. Degtyarev and A.P. Polyakova, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-253
Problems of Rehabilitation and Recovery of Altered Physiological Functions After Space Flight
T.N. Krupina, B.M. Fyodorov, Kh. Kh Yarullin, N A. Belaya, V.T. Olefirenko and E.I Matsnev, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-254
Pharmacological Correction of Changes in Fluid-Electrolyte Metabolism During Prolonged Bed Rest
V.S. Shashkov, L.I. Kakurin, B.B. Egorov, A I. Grigoriev, G.I Kozyrevskaya, V I. Bogdanov and Yu Yu. Osipov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-255
Remote Delivery of Health Care—"Starphac"
N Belasco, J Stonesifer and R.S. Johnston, *NASA Johnson Space Center, Houston, Texas, USA*

77-256
Experience in Utilization of Preventive Load Providing Suit for Prolonged Space Flights
A S. Barer, G.I Severin, V.I. Stepanzev and Ye P Tikhomirov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-257
Electric Dynamic Catathermometer as a Tool for Automatic Measurement of Factors Determining the Cooling Effect of Space Cabin Microclimate
L. Novak, *Institute of Biophysics, Czechoslovak Academy of Sciences, Brno, Czechoslovakia*

Tuesday/September 27
2:00 PM/Room F

Session 14

Scientific Spacecraft 2

Co-Chairmen:
R.E LO (FRG)
A REMONDIERE (France)
P TRISKA (Czechoslovakia)

77-187
Spacelab Onboard LIDAR Instrument for Atmosphere Study
J. Runavot, *Centre National d'Etudes Spatiales, Toulouse, France*

77-188
A Cooperative NASA/USAF Investigation of Spacecraft Charging in the Magnetosphere
M.H. Bunn, *Los Angeles Air Force Station, Los Angeles, Calif., USA*

77-189
The Shuttle Pallet Satellite Concept (SPAS)
H. Kellermeier and D. Davidts, *Messerschmitt-Bolkow-Blohm, Ottobrunn, FRG*

77-190
The Assess Programme – Preparing for the First Spacelab Flight
D.J. Shapland, J. de Waard and B. Noland, *European Space Agency, Paris, France*

77-191
The First Spacelab Payload – A Joint NASA/ESA Venture
R. Kennedy, *NASA Headquarters, Washington, D.C., USA; and* R. Pace, *NASA Marshall Space Flight Center, Alabama; and* J. Collet and J.P. Sanfourche, *European Space Agency, Paris, France*

77-192
The Faint Object Camera for NASA's Space Telescope
H. Schwille, A. Ortil and G. Rausch, *Dornier Systems, Friedrichshafen, FRG*

77-193
AK/KP, Airborne Commutation-Distribution System with Intermediate Analog-to-Digital Conversion
B.I. Blazhkevich, V.A Pogribnoy and I.V Rozhankovsky, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-194
Automatic Control of Large Space Radiotelescope Surface Shape
V.I. Bujakas, A.S. Gvamichava, L N. Lupichev and Yu. V Chekulaev, *Institute of Control Sciences, Moscow, USSR*

Tuesday/September 27
2:00 PM/Room E

Session 15

Symposium on Space-Based Industry

Fluid Dynamics Aspects of Space-Based Industrial Activities

Part 1: The Spacelab Fluid Physics Module Experiments

Co-Chairmen
J BOUTTES (France)
L G. NAPOLITANO (Italy)

77-196
Positioning and Damping of Liquid Spheres in Microgravity
H Rodot, *CNRS, Meudon, France*

77-197
Wetting of Solids by Liquids in Zero Gravity Experiments
J M. Haynes, *University of Bristol, Bristol, U K*

77-198
Some Problems on the Structure of the Floating Zone
I da Riva and J Meseguer, *Escuela Tecnica Superior Ingenieros Aeronauticos, Madrid, Spain*

77-199
Thermally Induced Convection Flows in Low Gravity Environments
L.G Napolitano and G Carlomagno, *Institute of Aerodynamics, University of Naples, Naples, Italy*

77-200
Solid-Liquid Interactions in Gravity Free Menisci
J.F. Padday, *Research Div., Kodak Ltd., Harrow, UK*

77-201
Liquid Motions in Containers in Zero-Gravity
J.P.B. Vreeburg, *National Aerospace Laboratory, Amsterdam, The Netherlands*

(For Part 2, see Session 24, Thursday, AM).

Tuesday/September 27
2:00 PM/Room D

Session 16

6th International Review Meeting of Communication with Extra-Terrestrial Intelligence (CETI 2)

Organized by the International Academy of Astronautics

Co-Chairmen
J. BILLINGHAM (USA)
R. PESEK (Czechoslovakia)

A Review of CETI Activities in North America, with a Description of the Algonquin Search for Extraterrestrial Beacons at the 22 GHz Frequency of Water Vapor
P.A Feldman, *Herzberg Institute of Astrophysics, National Research Council of Canada, Ottawa, Canada*

77-A 49
Review of Contemporary Opinions on the Problem of the Origin of Life
L M Muhim, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 50
To the Problem of the Definition of Intelligence
I.M. Krein, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 51
Advanced CETI Techniques
A T. Lawton, *Shepperton, Middlesex, U A*

77-A 52
Title to be announced
N S. Kardachev, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 53
Natural Law for All Sentient Beings
E Fasan, *Neunkirchen, Austria*

Tuesday/September 27
2:00 PM/Room A

Session 17

20th International Space Law Colloquium 1

Organized by the International Institute of Space Law

Part A: Should There be a World International Space Agency?

77-SI. 01
Introductory Report
E Galloway, *USA, and* V S Vereshchetin, *USSR*

77-SI. 02
Observations on ICAO and an Eventual World Space Agency
I H Ph Diederiks-Verschoor, *The Netherlands*

77-SI. 03
Le probleme des agences internationales
I Herczeg, *Hungary*

77-SI. 04
Observations sur une agence spatiale mondiale
F W Mori, *Portugal*

77-SI. 05
The Project of an International Space Agency and the Bogota Declaration
M Marcoff, *Switzerland*

77-SI. 06
An Old Proposal for the Establishment and Operation of a World Space Law Center
S Gorove, *USA*

Part B: Matters Relating to the Definition and/or Delimitation of Outer Space and Outer Space Activities

77-SL 07
Introductory Report
N.M. Matte, *Canada*

77-SL 08
Matters Relating to the Definition and/or Delimitation of Outer Space and Outer Space Activities
P.P.C. Haanappel, *Canada*

77-SL 09
Why the NASA Space Shuttle Will Not Require a Specific Altitude to be Chosen as the Legal Boundary Between Air Space and Outer Space
G.P. Sloup, *USA*

Tuesday/September 27
5:00 PM/Room A

Current Events Session II

Dynamic Testing of Structures with Rocket Engines
B. Ruzicka, *Brno, Czechoslovakia*

Wednesday/September 28
9:00 AM/Room C

Session 18

Communications Satellites Symposium

4. Communications Satellites – Experimental Systems

Co-Chairmen
A.H. DaCOSTA (Brazil)
R. SERRADEIL (France)

77-25
The Programme of Experiments Planned for the Orbital Test Satellite
P. Bartholome, *European Space Agency/ESTEC, Noordwijk, The Netherlands*

77-26
Results of the SYMPHONIE System Operations
J. Muller, *Centre National d'Etudes Spatiales, Toulouse, France*

77-27
Results of ATS-6 AIDSAT Experiment
J.K. Wilhelm et al., *Agency for International Development, Washington, D.C., USA*

77-28
Communications Technology Satellite Mobile Terminal Disaster Communications Experiment
N.R. Helm, *COMSAT Laboratories, Communications Satellite Corp., Clarksburg, Md., USA*

77-29
Technical Experiments with CTS
G.R. Thoma, *Lister Hill National Center for Biomedical Communications, Bethesda, Md., USA*

77-30
Experimental System of Japanese Satellite, Engineering Test Satellite Type II (ETS-II) (KIKU-21)
J. Tabata, M. Ohara, Y. Ishizawa, T. Ishida and N. Fugono, *National Space Development Agency, Tokyo, Japan*

77-31
Satellite TV Broadcasting System "ERAN"
S.V. Borodich, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-32
The SIRIO-SHF Experiments, Pre-Launch Test Results and Further Propagation Experiments – Description
S. Tirro and L.S. Ciaboli Cortelli, *Telespazio, Rome, Italy*

Wednesday/September 28
9:00 AM/Room B

Session 19

Bioastronautics 3

Space Biology

Co-Chairmen
O.G. GAZENKO (USSR)
H. PLANEL (France)

77-259
Study of Mechanisms of Physiological Effects of Weightlessness in the COSMOS 782 Experiment
N.N. Gurovsky, O.G. Gazenko, I. Ahlers, J. Baranski, D. Winter, A.M. Guenin, E.A. Ilyin, L. Macho, V.V. Portugalov, L. Sabo, L.V. Serova and R.A. Tigranian, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-260
Mechanism of Development of Morphological Changes in Mammals Flown on Board Biological Satellites
V.V. Portugalov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-261
The Reaction of Adrenal Cortex and Medulla to Prolonged Space Flight in Rats
V. Murgas, I. Kvetnansky, R.A. Tigranian, J. Torda, A. Repcekova and K. Janova, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-262
Some Results of Biological Studies Carried Out on Biosatellite COSMOS 782
G.P. Partenov, R.N. Platonova, M.G. Tairbekov, V.N. Beleney, V.P. Olkhovenko, A.V. Rostopshina and E.A. Ogenblick, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-263
Plasma and Tissue Lipid Changes in Rats Irradiated in Cosmic Space
I. Ahlers, R.A. Tigranian, I. Ashlersova, Ju. G. Grigoriev, M. Praslicka and I. Paulikova, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-264
Effect of Space Flight Factors on Enzyme Systems of Carbohydrate Phosphoric Metabolism in Skeletal Muscle of Rats
V.P. Nesterov, Z.P. Zheludkova and I.V. Kuznetsova, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-265
Influence of Irradiation and Space Flight Factors on Nucleic Acid and Deoxyribonucleoprotein in Liver and Spleen of Rats
E. Misurova, R.A. Tigranian, K. Kropacova, Ju. G. Grigoriev and M. Praslicka, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-266
Reparative Processes in Spleen After the Outset of Continuous Irradiation
N. Slacka-va and M. Praslicka, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-267
The Effect of Prolonged Space Flight on Liver Enzyme Activity and on Lipogenesis in Adipose Tissue of Rats
L. Macho, Z. Nemeth, J. Palkovic, O. Strbak and R.A. Tigranian, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-268
Results of Investigations on Lettuce Seeds, Tobacco Seeds and Artemia Cysts Flown in COSMOS 782
H. Planel, Yu. G. Grigoriev, M. Delpoux, Y. Gaubin Blanquet, I.V. Nevzgodina, B. Planel, G. Gasset, V.I. Popov, A.M. Marenny, Yu. A. Vinogradov, R. Pfohl and C. Jacquot, *Groupe de Recherches Biologiques Spatiales, Toulouse, France (and Intercosmos, USSR)*

Wednesday/September 28
9:00 AM/Room D

Session 20

Unmanned Solar System Exploration 1

Co-Chairmen:
L.D. FRIEDMAN (USA)
O. WOLCZEK (Poland)

77-151
The Pioneer Venus Mission and Future Exploration Implications
L. Colin, *NASA Ames Research Center, Moffett Field, Calif., USA*

77-152
Results of Investigations of Venus Atmosphere and Surface by the Method of Radiosounding Using Artificial Venus Satellites "Venera 9" and "Venera 10"
M.A. Kolosov, O.I. Yakovlev, A.I. Efimov, S.S. Matyugov, T.S. Timofeeva, E.V. Shub, A.G. Pavelyev, A.I. Kuchervavenkov, I.E. Kalashnikov and O.E. Milehin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-153
Some Preliminary Results of Simultaneous Utilization of the Two Satellites "Venera 9" and "Venera 10" for Dual Frequency Radio Occultation Measurements of the Night-Time Ionosphere of Venus
M.B. Vasilyev, A.S. Vyshlov, M.A. Kolosov, A.P. Mesterton, N.A. Savich, V.A. Samovol, L.N. Samoznaev and A.I. Sidorenko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-154
Ten Years of "Intercosmos" Solar Space Research in the Astronomical Institute of the Czechoslovak Academy of Sciences
B. Valnicek, *Astronomical Institute of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-155
Development of Information Possibilities of Scientific Satellite Experiments
K.B. Serafimov, S.K. Chapkunov, I.N. Ivanova and I.B. Ivanov, *Bulgarian Academy of Sciences, Sofia, Bulgaria*

Wednesday/September 28
9:00 AM/Room E

Session 21

Symposium on Space-Based Industry

Non-Terrestrial Mining and Delivery Systems

Co-Chairmen
A. DUPAS (France)
G.K. O'NEILL (USA)

77-72
Systems Analysis of Space Manufacturing
G.R. Driggers, *Southern Research Institute Birmingham, Ala., USA*

77-73
Packaging of Lunar Materials for Transport
D. Criswell, *Lunar Science Institute, Houston, Texas, USA*

77-74
Mass Driver: For Lunar Transport and as a Reaction Engine
G.K. O'Neill and H. Kolm, *Massachusetts Institute of Technology, Cambridge, Mass., USA*

77-75
On the Physical and Mechanical Properties of Venusian Soil
A.K. Tcenovich, V.V. Gromov, P.S. Semyonov, Yu. A. Surkov, V.G. Perminov and A.D. Dmitriev, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-76
Automatic Devices for Studying the Physical and Mechanical Properties of Planetary Soil
A.K. Alexandrov, I.B. Borisova, V.V. Gromov, V.V. Zakharov et al., *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-77
Asteroidal Resources for Space Manufacturing
B. O'Leary, *Princeton University, Princeton, N.J., USA*

77-78
Economics of Non-Terrestrial Mining and Delivery Systems
K.P. Heiss, *ECON, Inc., Princeton, N.J., USA*

Wednesday/September 28
9:00 AM/Room A

Session 22

20th International Space Law Colloquium 2

Organized by the International Institute of Space Law

Part C: Ways of Coordinating Space Sciences and Technology with Space Law

77-SL 10
Introductory Report
M.G. Bourley, *France*

77-SL 11
The 1974 Brussels Convention Relating to the Distribution of Program-Carrying Signals Transmitted by Satellite: Its Strengths and Weaknesses
C.Q. Christol, *USA*

77-SL 12
Consensus as a Basis for International Space Cooperation
E. Galloway, *USA*

77-SL 13
Space Operations and Radio Regulations. Ways to Coordinate Space Science and Technology with Space Law
S.K. Sarkar, *Switzerland*

Part D: Various Subjects

77-SL 14
Settlement of Disputes Regarding Activities in Space
K.H. Bockstiegel, *FRG*

77-SL 15
Cooperation Among States in the Exploration and Use of Outer Space and International Organizations
E.P. Kamenetskaya, *USA*

77-SL 16
Position of International Organizations in the Corpus Juris Spatialis
G.C.M. Reijnen, *The Netherlands*

77-SL 17
International Space Law as a Branch of International Law
P.I. Lukin, *USSR*

77-SL 18
The Impact of Selected United States Municipal Laws Upon the Space Shuttle Program, and Their Relationship to International Space Law
G.P. Sloup, *USA*

Wednesday/September 28
9:00 AM/Room F

Session 23

11th International History of Astronautics Symposium

Organized by the International Academy of Astronautics

Co-Chairmen
E.M. EMME (USA)
V.N. SOKOLSKY (USSR)

77-A 09
Kepler's "The Dream, or Lunar Astronomy" as a Predecessor of Space Research
Z. Horsky, *Astronomical Institute of the Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-A 10
First USSR Rocket Experiments for Short-Wave Solar Radiation Research
G.S. Ivanov-Cholodny, L.A. Vedeshin and A.B. Yakovleva, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 11
On Computer-Oriented Dynamic Modeling of Spacecraft: Historical Evolution of Eulerian Multibody Formalism Since 1750
R.E. Roberson, *University of California, La Jolla, Calif., USA*

77-A 12
Development of Soviet Rocketry from 1945-1957 and Preparations for Launching the First Artificial Earth Satellite
A.A. Eremenko and Yu. V. Biryukov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 13
Organization and Results of Early Work at the USSR Science Centre for Rocketry
I.A. Merkulov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 14
Albert Fono: A Pioneer of Jet Propulsion, 1881-1972
I.G. Nagy, *Budapest, Hungary*

77-A 15
S.P. Korolev and Soviet Rocketry
B.V. Rauschenbach, *Institute of Control Sciences, Moscow, USSR*

77-A 16
Genesis of Liquid Hydrogen Propulsion Through 1945
J.L. Sloop, *Bethesda, Md., USA*

Thursday/September 29
9:00 AM/Room C

Session 24

Communications Satellites Symposium

5. Communications Satellites – Technology

Co-Chairmen
S.H. HUBBARD (USA)
G. QUAGLIONE (Italy)

77-34
Communication Satellite Technologies in the 1990's – A Projection into the Post-INTELSAT V Era
C.L. Cuccia, *Ford Aerospace and Communications Corp., Palo Alto, Calif., USA*

77-35
Acquisition and Tracking of Laser Beams in Space Communications
I.M. Teplyakov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-36
Orbit Control of Large Communication Satellites with the RIT 10-Ion Thruster
J. Bassner, *Messerschmitt-Bolkow-Blohm GmbH, Munich, FRG, and* H.W. Loh, *University of Giessen, Giessen, FRG*

77-37
A High-Efficiency 100 to 150 W, 12 GHz Helix Traveling-Wave Tube for Satellite Use
G. Fleury and J.C. Kuntzmann, *Thompson CSF, Boulogne Billancourt, France*

77-38
Impact of Shuttle on Technology and Utility of Communication Satellites
H.S. Braham, *General Electric Co., Philadelphia, Pa., USA*

77-39
The MAROTS Satellite Communications Payload and Its L-Band Solid State Multicarrier Power Transmitter
W.R. Wignall, *Marconi Space and Defence Systems Ltd., Stanmore, Middlesex, U.K.*

77-40
Multi-Beam Array, Designed for Use in a Maritime System Using an OTS Platform
Ph. Charas and L.M. Ericsson, *Molndal,Sweden*

77-41
Design Considerations for Multibeams Communication Satellites Antennas
B.I. Churkov, G.K. Halimov, M.B. Vysotskaya and A.A. Snesareyev, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

Thursday/September 29
9:00 AM/Room E

Session 25

Fluid Dynamics Aspects of Space-Based Industrial Activities: Part 2

Co-Chairmen:
J. BOUTTES (France)
L.G. NAPOLITANO (Italy)

77-202
Significance of Fluid Dynamics Aspects for Material Science Experiments
Pabst, *Max-Planck Institute, Stuttgart, FRG; and* Oertel, *University Fridericana Karlsruhe, Karlsruhe, FRG*

77-203
A Micro-Gravity Simulation of the Marangoni Convection
W. Wuest, *DFVLR, Gottingen, FRG*

77-204
Migration of Bubbles Under Various Force Fields
J. Siekmann and J. Johann, *Technische Hochschule Darmstadt, Darmstadt, FRG*

(For Part 1, see Session 15, Tuesday, PM.)

Thursday/September 29
10.30 AM/Room E

Session 25 (Continued)

Fluid Dynamics

Co-Chairmen
S. BERNDT (Sweden)
V.V. SYCHEV (USSR)

77-145
Numerical Simulation of External and Internal Gasdynamic Problems
M. Ja. Ivanov and A.N. Kraiko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-146
Investigation of Mass Loss and Shape Change Actuated by Radiative Flux While Entering a Hydrogen-Helium Atmosphere
E.A. Gershbein, E. Ya. Sukhodol'skaya, S.I. Sukhodol'sky and G.A. Tirsky, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-147
Theoretical and Experimental Investigation of the Diffusion Flame on Plane Jet Pairs and Fan Jets as Applied to Air Breathing Engines
G.N. Abramovich and V.B. Butovsky, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-148
On the Theory of Drag Calculation and Profile Optimization in Shockless Near Free Molecular Flow
R. Monaco, *Istituto di Meccanica Razionale, Politecnico di Torino, Turin, Italy*

77-149
Similar Solutions for the Compressible Laminar Boundary Layer with Diffusion Controlled Combustion
E.Y. Chen, *Tamkang College, Taipei, Taiwan, China*

Thursday/September 29
9:00 AM/Room B

Session 26

Earth and Ocean Dynamics

Co-Chairmen:
K.Y. KONDRATYEV (USSR)
J.W. ROUSE, JR. (USA)

77-82
New Portrait of Earth's Continents
V.D. Skaryatin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-83
The Derivation and Use of Satellite Gravity and Magnetic Fields for Modeling Geodynamic Processes
J.P. Murphy, *NASA Headquarters, Washington, D.C.; and* F.O. Vonbun, *NASA Goddard Space Flight Center, Greenbelt, Md., USA*

77-84
Multiband Survey as a Method to Study Suspension Distribution in the Sea
I.A. Labutina and G.A. Safyanov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-85
Observation of Transient Upwellings in the Mediterranean Sea with the NOAA WHRR Imagery
M. Crepon, *Laboratoire d'Oceanographie Physique du Museum, Paris, France*

77-86
Satellite Imagery in the Study of the Danube Delta Dynamics
V.I. Kravtsova, L.A. Ushakova and T.I. Chekalina, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-87
The Role of Geodetic Techniques in Remote Sensing the Surface Dynamics of the Oceans
R.S. Mather, *University of New South Wales, Kensington, Australia*

77-88
Fundamentals and Design of a Calibration Procedure for High Precision (+ 10 cm) Satellite Altimetry
D. Leigemann, *Institut fur Angewandte Geodasie, Frankfurt, FRG*

77-89
Mesoscale Sea Ice Dynamics by Sequential Radar Imagery
W.J. Campbell, *University of Puget Sound, Tacoma, Wash., USA*

Thursday/September 29
9:00 AM

Session 27

International Student Conference

To be announced

Thursday/September 29
2:00 PM/Room C

Session 28

Communications Satellites Symposium

6. Communications Satellites – Transmission Techniques

Co-Chairmen:
T. SEKIMOTO (JAPAN)
D.J. WITHERS (UK)

77-44
Digital Single-Channel and Multi-Channel per Carrier Transmission for Satellite Service
A.M. Werth, *Digital Communications Corp., Gaithersburg, Md., USA*

77-45
Comparison of Different Types of Redundancy Microwave Switch Matrices for TDMA System
R. Funck, *Thomson-CSF, Meudon-la-Foret, France*

77-46
Propagation Experiment with Japanese Satellite, Engineering Test Satellite Type II (ETS-II)-(KIKU-21)
I. Ishida, N. Fugono, T. Tabata, M. Ohara, and Y. Ishizawa, *Ministry of Posts and Telecommunications, Tokyo, Japan*

77-47
HO-DPCM Encoding of NTSC Color TV Signal for Satellite Communications
N. Suzuki, Y. Iijima, T. Ishiguro and T. Oshima, *Nippon Electric Company, Ltd., Tokyo, Japan*

77-48
Performance Analysis of a Direct QPSK Modulator on a Communications Link Using Satellite
A. Ribes et al., *Centre National d'Etudes Spatiales, Toulouse, France*

77-49
Digital Modulation Methods for Use in Satellite Communications
J. Simsa, *Czechoslovak Academy of Sciences, Prague, Czechoslovakia*

77-50
Design of Phase-Locked Loop for Multiple Access Communication System Via Boards Signal Processing Satellites
V.I. Moguchev, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-51
Future Outlook for Satellite Switched TDMA Satellites
T. Muratani, Y. Ito and K. Koga, *Kokusai Denshin Denwa Company, Ltd., Tokyo, Japan*

Thursday/September 29
2:00 PM/Room B

Session 29

Earth Observations (William Nordberg Memorial Session)-1: Systems

Co-Chairmen:
L. LAIDET (France)
F.O. VONBUN (USA)

77-109
An Operational LANDSAT
A.P. Colvocoresses, *U.S. Geological Survey, Dept. of the Interior, Reston, Va., USA*

77-110
Le systeme SPOT d'observation de la Terre par satellite
G. Brachet, *Centre National d'Etudes Spatiales, Paris, and* A. Cazenave and M. Courtois, *Centre National d'Etudes Spatiales, Toulouse, France*

77-111
Radiation Field of a Spherical Atmosphere in the Visible Spectral Region According to Theoretical Calculations and Measurements from Manned Spacecraft
K.Y. Kondratyev, G.I. Marchuk, A.A. Buznikov, G.A. Mikhailov, Sh.A. Nazaraliev and O.I. Smotky, *University of Leningrad, Leningrad, USSR*

77-112
Analyse de la qualite des images multispectrales issues d'un instrument a balayage mecanique monte sur le satellite d'observation SPOT
A. de Leffe, *Centre National d'Etudes Spatiales, Toulouse, France*

77-113
Comparison of the Discriminate Possibilities of Some Transformations of the Spectral Reflective Characteristics
D. Mishev and T. Yanev, *Central Laboratory for Space Research, Sofia, Bulgaria*

77-114
Choice of Spectral Intervals for Aerospace Survey of Natural Formations in the Range of 0, 4-2, 5 dm.
Al.A. Grigoryev, G.A. Ivanyan and G.A. Petrosyan, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-115
Camera multispectrale a haute resolution spatiale pour l'observation de la terre
G. Otrio, *Centre National d'Etudes Spatiales, Toulouse, France*

77-116
Cosmonauts—Operators of Experiments on Terrestrial Studies
G.A. Ivanyan, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

Thursday/September 29
2:00 PM/Room E

Session 30

Lighter-Than-Air Systems for Space Operations

Co-Chairmen
N.J. MAYER (USA)
L.G. NAPOLITANO (Italy)

77-163
A Review of Lighter-than-Air Progress in the United States and Its Technological Significance
N.J. Mayer, *NASA Headquarters, Washington, D.C., USA; and* R.H. Krida, *Naval Air Systems Command, Washington, D.C., USA*

77-164
Progress in Scientific Balloon Technology in 1977
M. Audebert, *Centre National d'Etudes Spatiales, Toulouse, France*

77-165
ATMOSAT-A Progress Report
T.F. Heinsheimer and P.C. Neuschul, *Aerospace Corp., El Segundo, Calif., USA*

77-166
Tethered Balloons as Remote Sensing Platforms to Study the Diffusion of Pollutants in the Sea
L.G. Napolitano, S. Vetrella and C. Tripodi, *Institute of Aerodynamics, University of Naples, Naples, Italy*

77-167
A Mathematical Model of Transcontinental Balloon
C.D. La Padula and C.F. Polcaro, *Laboratorio Astrofisico Spaziale, Centre Nazionale delle Ricerche, Frascati, Italy*

77-168
Study of a Balloon Drifting in Venus Atmosphere
P. Fouchard, *Centre National d'Etudes Spatiales, Toulouse, France*

Thursday/September 29
2:00 PM/Room F

Session 31

Propulsion I

Co-Chairmen:
R. BUHLER (FRG);
S. ROSEN (USA)

77-91
Development Progress of hm7 LOX/LH2 Rocket Engine for the Ariane Third Stage Propulsion System
M. Pouliquen, *Societe Europeenne de Propulsion, Vernon, France*

77-92
The Main Engine Program to Support POGO Prevention on the Space Shuttle Vehicle
J. R. Fenwich and G. H. Karigan, *Rockwell International, Rocketdyne Division, Canoga Park, Calif, USA*

77-93
Contribution a l'etude du phenomene POGO
D. Lourme, J. J. Dordain and D. Schmitt, *ONERA, Chatillon-sous-Bagneux, France*

77-94
Hydrodynamic Modeling of the Operation Process in the Liquid-Propellant Engine Systems on the Steet Operation
V. M. Kalnin and V. A. Sherstiannikov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-95
Cooldown of Cryogenic Systems
E. K. Kalnin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-96
Parametric Evaluation of a Vortex Valve for Thrust Modulation of Solid Propellant Rockets
A. Burk and H. Wolfl, *Technion – Israel Institute of Technology, Haifa, Israel*

77-97
Thrust Augmentation by Secondary Oxidizer Injection into Rocket Nozzles
A. I. El-Sharkawy, *Virginia Polytechnic Institute, Blacksburg, Va., USA*

77-98
Reliability and Compatability Considerations and Testing of the R1T-10 Electric Propulsion System
G. Kruelle and F. Zeyfang, *Institut fur Technische Physik, DFVLR, Stuttgart, FRG, and* W. Klein, *BPT, DFVLR, Cologne-Porz, FRG*

Thursday/September 29
2:00 PM

Session 32

International Student Conference

To be announced

Thursday/September 29
2:00 PM/Room A

Session 33

20th International Space Law Colloquium 3

Organized by the International Institute of Space Law

Part D—Various Subjects (continued)

77-SL-19
Some Legal Aspects of the Remote Sensing of the Earth
V.D. Bordunov, *USSR*

77-SL-20
Remote Sensing and International Law
T. Kosuge, *Japan*

77-SL-21
Les aspects juridiques des satellites d'application
J. Bu...ak, *Czechoslovakia*

77-SL-22
A Draft Treaty on the Moon and Legal Status of Its Natural Resources
R. V. Dekanozov, *USSR*

77-SL-23
The Correlation of Air and Space Law
J.M. Kolosov, *USSR*

77-SL-24
Customary Law Rules in Regulating Outer Space Activities
D. Krstic, *Yugoslavia*

77-SL-25
Some Legal Problems of Applied Usage of Outer Space Technology
V.N. Kulebyakin, *USSR*

77-SL-26
1) Teledetection et Introspection: 2)Bix ans du Traite Spatial
P. Magno, *Italy*

77-SL-27
Responsabilite et assurances dans le domaine spatial
P. Magno and E. Sottoni, *Italy*

Thursday/September 29
5:00 PM/Room A

Current Events Session III

Worldwide Disaster and Rescue Programs

(Extension of IAA Space Rescue and Safety Symposium)

Panel Discussion: Toward selection of optimum terrestrial and space elements for disaster and rescue response systems (land, sea, and air)

Introduction to Panel Discussion: Annual Supplement to Survey of Recovery Capabilities: G.W. Heath, SAR-ASSIST, Inc., USA

Panelists:

77-A-70
Requirements for Transportable Earth Station for Disaster Response Coordination
J.C. Nichols, *Communications Services, United Nations*

77-A-71
Rescue-Related Response Capabilities of Maritime Aeronautical Communications Satellite System
C. Dorian, *Maritime Operations, COMSAT (USA)*

77-A-72
Distress Communications Link with International Communications Systems
N. Helm, *COMSAT (USA)*

77-A-73
A Space-Based Public Service Platform for Terrestrial Rescue Operations
R. Fleisig and J. Bernstein, *Grumman Aerospace Corp. (USA)*

77-A-74
Satellites for Distress Alerting and Locating
W.N. Redisch, *Communications & Navigation Div., NASA Goddard Space Flight Center (USA)*

77-A-75
Disaster Detection Location and Communications Using Advanced Space Technology
W.E. Sivertson, Jr., *NASA Langley Research Center (USA)*

77-A-76
Significance of Individual Space and Terrestrial Elements in Respect to Disaster/Rescue Response (Cost, Performance, User Requirements)
S.N. Sivo, *Applications Div., NASA Lewis Research Center (USA)*

77-A-77
Distress Response Limitations Imposed by Geophysical Features, Communications Capabilities, Rescue Force Equipment and Personnel Capabilities
D. Indarto, *SAR, Ministry of Communications (Indonesia)*

Friday/September 30
9:00 AM/Room B

Session 34

Materials and Structures

Co-Chairmen:
J.S. PISARENKO (USSR)
P. SANTINI (Italy)

77-233
Etude du comportement dynamique des charges utiles sur le lanceur Ariane
A. Girard and J. F. Imbert, *Centre National d'Etudes Spatiales, Toulouse, France, and* M. Vedrenne, *Centre National d'Etudes Spatiales, Evry, France*

77-234
Jettison Dynamics of Ariane Nose Fairings
M. Boutin and B.P. Rao, *Centre National d'Etudes Spatiales, Evry, France, and* B. Schneider and M. Macchiussi, *Contraves A.G. Zurich, Switzerland*

77-235
Spacelab Module Structure Development
E. Valleran, *Aeritalia, Turin, Italy*

77-236
Static and Dynamic Analysis of Space Radiotelescope Thin Wall Structure Elements
V.I. Usyukin and V.A. Tereshchenko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-237
Thermostructural Problems of High Accuracy Antennas Mounted on Telecommunication Satellites
P. Santini, *Istituto di Tecnologia Aerospaziale, Rome, Italy*

77-238
The Influence of Outgas on the Performance of Multilayer Insulation Blank ts with Perforated Shields
J.F. Heemskerk and A.A.M. Delil, *National Aerospace Laboratory, Emmeloord, the Netherlands*

77-239
Variation of Properties of Reinforced Plastics Under Repeated Thermal Loads, Occuring in Operation of Shuttle-Type Spacecraft
E.S. Umansky, E.A. Eskin and A.S. Petrov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-240
Numerical Analysis for a Comparative Study of the Pointing Accuracy of Flexible Satellites
T.C. Huang and A. Das, *University of Wisconsin, Madison, Wisc., USA*

Friday/September 30
9:00 AM/Room E

Session 35

Astrodynamics 1 – Natural Motion and Orbit Estimation

Co-Chairmen
J.V. BREAKWELL (USA)
J.P. MAREC (France)
V.A. SARYCHEV (USSR)

77-207
Collision of Stars by Oscillating Orbits of the Second Kind
C. Marchal, *ONERA, Chatillon-sous-Bagneux, France*

77-208
On the Motion of a Test Body in an External Gravitational Field
V. Mileva and Y. Popov, *Bulgarian Academy of Sciences, Sofia, Bulgaria*

77-209
Luni-Solar Perturbations in the Extended Phase Space Representation of the Vinti Problem
B. Kaufman, K. T. Alfriend and R. R. Dasenbrock, *U.S. Naval Research Laboratory, Washington, D.C., USA*

77-210
Analytical Ephemeris Prediction for Moderate Altitude Satellites
D.L. Richardson and D.W. Dunham, *Computer Sciences Corp., Silver Spring, Md. USA*

77-211
Non Gravitational Perturbations in Artificial Satellites
E.P. Aksenov, S.N. Vashkovjak and V.N. Noskov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-212
Orbit Determination When the Knowledge of Error Expectation and Covariance Matrix is Incomplete
B.T. Bakhshian, R.R. Nazirov and T.E. Eliasberg, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-213
Systeme d'observation de la terre a double rythme
J. Petitfourt, *SNIAS, Les Mureaux, France*

Friday/September 30
9:00 AM/Room F

Session 36

Propulsion II

Co-Chairmen
J.J. DORDAIN (France)
R. MONTI (ITALY)

77-100
In Orbit Propulsion: ESA's Present, Planned Activities
E. Slachmuylders, *European Space Agency/ESTEC, Noordwijk, The Netherlands*

77-101
Advanced Space Engine for the Space Tug
H. Diem, *Rockwell International, Rocketdyne Div., Canoga Park, Calif., USA*

77-102
Analyse du fonctionnement d'un propulseur a propergol solide a ejection modulee
M. Barrere, *ONERA, Chatillon-sous-Bagneux, France*

77-103
Plasma Accelerators for Space Apparatus
L.V. Leskov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-104
Experimental Research of Oscillations in the Discharge Gap of a Plasma Accelerator
K.V. Evdokimov and V.P. Shabov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-105
Ion Engine Status by Hughes Research
J. Molitor, *Hughes Research Laboratory, Malibu, Calif., USA*

77-106
Propulsion par pression de radiation – Criteres d'efficacite d'un voile solaire – Application a un vehicule lance par Ariane
J. Caubel, A. Cazenave, G. Riviere and J. Runavot, *Cen. e National d'Etudes Spatiales, Toulouse, France*

77-107
Etude des phenomenes de collision et de photofragmentation qui interviennent pendant la combustion
B. Petropoulos, *Hellenic Astronautical Society, Athens Greece*

Friday/September 30
9:00 AM/Room D

Session 37

10th International Space Rescue and Safety Symposium I

Organized by the International Academy of Astronautics

Co-Chairmen
P.H. BOLGER (USA)
P.A. CAMPBELL (USA)

77-A-31
Space Shuttle Approach and Landing Test Project
D.K. Slayton and T. McElmurry, *NASA Johnson Space Center, Houston, Texas, USA*

77-A-32
The Non-Specific Training as a Factor to Ensure Space Flight Safety
G.M. Kolesnikov, N.V. Krilova, V.A. Popov and I.D. Solovyeva, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A-34
The Synthesis of a Control Algorithm for Maneuvering the Space Shuttle Vehicle
A.A. Zhevnin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A-35
Survey of Space Flight Safety Systems
N.E. Brown, *McDonnell Douglas Corp., Seabrook, Texas, USA*

77-A-36
Designing Payloads for Safety on the Space Transportation System
G.S. Canetti, *Rockwell International Downey, Calif. USA*

Friday/September 30
9:00 AM/Room C

Session 38

1st International Symposium on Space Observations of Long-Term Climatic Changes

Organized by the International Academy of Astronautics

Co-Chairmen
M. BARRERE (France)
S.S. PENNER (USA)

77-A-01
Introductory Remarks: Space Observations of Long-Term Climatic Changes Produced by Escalating Energy Use
S.S. Penner, *University of California, San Diego, La Jolla, Calif., USA*

77-A-02
Energy Use and Climate Changes
W. Hafele and J. Williams, *International Institute for Applied Systems Analysis, Schloss Laxenburg Austria*

77-A-03
Energy Use and Climate Change
S. Schneider, *National Center for Atmospheric Research, Boulder, Colo., USA*

77-A-04
Satellite Monitoring of Global Air Pollution and Climate Change
W. Bach, *Center for Applied Climatology and Environmental Studies, University of Munster, Munster, FRG*

77-A-05
Monitoring of Thickness Changes of the Continental Ice Sheets by Satellite Altimetry
R.L. Brooks and H.R. Stanley, *Washington Analytical Services Center, Inc., Wolf Research and Development Group, Pocomoke City, Md., USA*

77-A-06
Space Observations of Long-Term Climate Changes
L. Jaffe, *NASA Headquarters, Washington, D.C., USA*

Friday/September 30
9:00 AM/Room A

Session 39

20th International Space Law Colloquium IV

Organized by the International Institute of Space Law

Part D—Various Subjects (continued)

77-SL-28
Telecommunications and the Common Heritage of Mankind
F. Galloway, *USA*

77-SL-29
Sovereign Rights in Outer Space
S. Gorove, *USA*

77-SL-30
Legal Ties of a Space Community to Earth
S. Gorove, *USA*

77-SL-31
Sovereignty and the Outer Space Treaties
T.F. Wolcott, *USA*

77-SL-32
Liberte et controle dans la television directe
P. Magno and C. Verdacchi, *Italy*

77-SL-33
Legal Impacts of WARC-77 on DBS
W. von Kries, *FRG*

77-SL-34
Modern International Legal Problems of the Use of the Geostationary Orbit
B.G. Dudakov, *USSR*

77-SL-35
The Geostationary Orbit
I. Perek, *US*

77-SL-36
Geostationary Orbital Positions for Space Stations
S.K. Sarkar, *Switzerland*

77-SL-37
Exceptions "Explanation" and "Use" of the Natural Resources of Celestial Bodies
E.G. Vassilevskaya, *USSR*

77-SL-38
The Program "Intercosmos" A New Intergovernmental Agreement
V.S. Vereshchetin, *USSR*

77-SL-39
INMARSAT—International Organization of the Maritime Satellites
M.I. Voloson, *USSR*

77-SL-40
a) International Legal Aspects of the Use of Solar Energy.
b) International Legal Problems of Remote Sensing
G.P. Zhukov, *USSR*

Friday/September 30
2:00 PM/Room C

Session 40

Spacecraft Power Systems

Co-Chairmen
E HOLLAX (DDR)
J P LAYTON (USA)
G M ULANOV (USSR)

77-137
A Prospectus for the IAF Working Group on Space Energy and Power
J P Layton, *Princeton University, Princeton, N J , USA*

77-138
High Reliability Control—Information Systems for Space Power Plants
V V Bugrovsky, Yu V Kovachich, B N Petrov and A A Sheviakov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-139
Development of an Improved Rigid Solar Array for Point to Point Communication Satellites
G Barkats and G Leguilly, *Societe Nationale Aerospatiale, Cannes, France, and* J N Giraudbit and G Moulhayrat, *Centre National d'Etudes Spatiales, Toulouse, France*

77-140
Gaseous-Fuel Nuclear Reaction Research for Multimegawatt Power in Space
K Thom, NASA *Headquarters, Washington, D C , USA,* R T Schneider, *University of Florida, Gainesville, Fla , USA, and* H H Helmick, *University of California Los Alamos Scientific Laboratory, Los Alamos, N M , USA*

77-141
A New Cycle for Optimum Energy Storage in Interplanetary Missions
E Igenberg, *Technische Universitat Munchen, Munich, FRG*

77-142
Automatic Optimization of Operating Modes for Thermoemission Energy Systems
L M Galkin, B N Petrov and G M Ulanov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-143
Geomobile Space Electric Power Station with a Horizontal and Vertical Self-Balanced Space Electric Distribution Line
N Koley, *Faculty of Transport at the Higher Institute of Mechanical & Electrical Engineering, V I Lenin Sofia Bulgaria*

Friday/September 30
2:00 PM/Room E

Session 41

Astrodynamics II

Optimization, Transfers and Rendezvous, Station-Keeping

Co-Chairmen
J V BREAKWELL (USA)
J P MAREC (France)
V A SARYCHEV (USSR)

77-214
An Optimum Regime of the Flight of the Space Devices Moving on a Curvilinear Trajectory
A K Simeonov, *Higher Institute of Mechanical and Electrical Engineering, V I Lenin Sofia, Bulgaria*

77-215
Bitangential Kepler's Orbits
K Mison, *Prague, Czechoslovakia*

77-216
Constrained Impulsive Trajectory Optimization for Orbit-to-Orbit Transfer
R G Brusch, *General Dynamics Convair, San Diego, Calif , USA*

77-217
Targeting with Fixed Propellant Load
G S Gedeon, *TRW Systems, Redondo Beach, Calif , USA*

77-218
Changing Inclination for Shuttle Payloads
G Porcelli, *Fairchild Space and Electronics Co , Germantown, Md , USA, and* T M Spencer, *Ball Brothers Research Corp , Boulder, Colo , USA*

77-219
Changement de poste de symphonie A. Optimisation, realisation et evaluation des corrections d'orbites
M Esterle and M Legendre, *Centre National d'Etudes Spatiales, Toulouse, France*

77-220
Mars Orbiter Insertion by Use of Atmospheric Deceleration
D E Okhotsimsky, Yu S Golubtsov and Yu G Sikharulidze, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

Friday, September 30
2:00 PM, Room B

Session 42

Earth Observations II

Microwaves and Systems

Co-Chairmen
L LAIDET (France)
F O VONBUN (USA)

77-117
New Developments in Microwave Remote Sensing
J W Rouse, Jr , *Texas A&M University, College Station, Texas, USA*

77-118
The Progress in Microwave Radiation Investigations of Continental Covers During 1967-1977
N A Armand, A E Basharinov and A M Shutko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-119
On Microwave Remote Sensing of Precipitation Intensity
V E Borisenko, V V Melentyev and S N Sevastyanov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-120
Passive Microwave Remote Sensing of Soil Moisture
K Y Kondratyev, V V Melentyev, Yu I Rabinovich and E M Shulgina, *University of Leningrad, Leningrad, USSR*

77-121
NOAA Satellite Monitoring of Snow Cover in the Northern Hemisphere during the Winter of 1977
D R Wiesnet, M Matson and D F McGinnis, Jr , *NOAA, NESS, Washington, D C , USA*

77-122
Radiative Characteristics of Clouds as Inferred from Spacecraft and Aircraft Observations
I V Morozova, N P Pyatovskaya and G G Sakunov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-123
Variation of Temperature Field and Outgoing Radiation Depending on Cloud Amount
L N Ovatchenko and N I Baranova, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-124
Resultats d une simulation de poursuite de satellite (a deux orbites basses) entre Spacelab et un sous-satellite
P Roucher, J Castel and G Balmino, *Centre National d'Etudes Spatiales, Toulouse, France*

77-125
A Multidisciplinary LIDAR-System Missions, Aims and Technology
E J Achtermann and E Weber, *Dornier Systems, Friedrichshafen, FRG,* B Hermes, *DFVLR, Bonn-Bad Godesberg, FRG, and* W Wiesemann, *Battelle Institut, Frankfurt, FRG*

Friday/September 30
2:00 PM/Room D

Session 43

Supervised Experimental Model Rocketry

Co-Chairmen
G S JAMES (USA)
O SAFFEK (Czechoslovakia)

77-171
The Influence of Fritz Von Opel's Experiments Upon Rocket Propelled Model Aircraft Developments During the 1930's
F H Winter, *National Air and Space Museum, Smithsonian Institution, Washington, D C , USA*

77-172
Rockets, from Design to Launch: Student and Teachers' Manuals for a One Semester High School Course
D J Malewicki, *Tustin, Calif , USA, and* D C Schwenn, *San Clemente High School, San Clemente, Calif , USA*

77-173
Liquid Rocket Test Programs at the Rocket Research Institute Perkins Center
C Piper III, K Mason and G S James, *Rocket Research Institute, Glendale, Calif , USA*

77-174
A Review of the French National Youth Aerospace Club Program 1962-1977
H Lebaron, *Centre National d'Etudes Spatiales, Paris, France*

77-175
Model Rocketry in Czechoslovakia
O Saffek, *Prague, Czechoslovakia*

Friday, September 30
2:00 PM, Room F

Session 44

4th International Space Relativity Symposium I

Organized by the International Academy of Astronautics

Co-Chairmen
F ESTABROOK (USA)
Z HORAK (Czechoslovakia)
W WRIGLEY (USA)

77-A 19
Geodesy Information in a Modified Relativity Mission with Two Counter-Orbiting Polar Satellites
J V Breakwell, C W F Everitt, D Schaechter and R A Van Patten, *Stanford University, Stanford, Calif , USA*

77-A 20
An Optical Determination of the Gravitational Deflection of Light by the Sun
E Handler and R Matzner, *University of Texas, Austin, Texas, USA*

77-A 21
Testing Gravity Theories by a Solar Probe
E A Roth, *European Space Agency, Darmstadt, FRG*

77-A 22
Gravity Research at Cottrell Observatory
A S Tuman, *California State College, Stanislaus, Turlock, Calif , USA,* T D Anderson and E L Lau, *Jet Propulsion Laboratory, Pasadena, Calif , USA, and* R Chabanniere, *University of California, Berkeley, Calif , USA*

Saturday/October 1
9:00 AM/Room E

Session 45

Astrodynamics III

Attitude Dynamics

Co-Chairmen
G N DOUBOCHINE (USSR)
M H KAPLAN (USA)

77-224
Unusual Maneuvers on Nimbus and Landsat Spacecraft
S H Siegel and A Das, *General Electric Co., King of Prussia, Pa., USA*

77-225
Transient Attitude Dynamics of Satellites with Deploying Flexible Appendages
V J Modi and K W Lips, *University of British Columbia, Vancouver, B C., Canada*

77-226
Rotation of a Flexible Spacecraft About the Eigenaxis
K T Alfriend and D Grant, *U S Naval Research Laboratory, Washington, D C., USA*

77-227
The Use of a Movable Telescoping End Mass System for the Time-Optimal Control of Spinning Spacecraft
P M Bainum and R Sellapan, *Howard University, Washington, D C., USA*

77-228
Possible Informational Approaches to Transport Spacecraft Angular Motion Control at Various Stages of Flight
B N Petrov, A B Krymov and E I Mitroshin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-229
Gyrodampers in Passive Attitude Control Systems
V A Sarychev and S A Mirer, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-230
Etude de la stabilite d'attitude d'un satellite muni de pannesux solaires
M Pascal, *Universite Pierre et Marie Curie, CNRS, Paris France*

Saturday/October 1
9:00 AM/Room A

Session 46

Unmanned Solar System Exploration II

Co-Chairmen
L D FRIEDMAN (USA)
O WOLCZEK (Poland)

77-156
Possible Planetary Missions Using the "Ariane" Launcher
G Riviere, A Ammar, A Cazenave, J Runavot, J Caubel, J P Dulout, R Hergot, A Perret and J C Pieplu, *Centre National d'Etudes Spatiales, Toulouse, France*

77-157
About the Study of the Radio Wave Propagation in the Turbulent Solar Plasma with Mars-2, 7 and Venera 10
O I Yakovlev, A I Efimov, W M Razmanov and W K Strykov, *Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow, USSR*

77-158
Future Thrusts in U S Planetary Exploration
L D Friedman, *Jet Propulsion Laboratory, Pasadena, Calif., USA*

77-159
Jupiter's Red Spot Sounding
M Subotowicz and O Wolczek, *Polish Astronautical Society, Warsaw, Poland*

77-160
The Investigation of Meteors by Artificial Satellites and Space Probes
V Guth, *Ondrejov Observatory, Ondrejov, Czechoslovakia*

77-161
Airglow Applications for Atmospheric Investigation of the Planets and Their Satellites
M Gogoshev and K B Serafimov, *Bulgarian Academy of Sciences, Sofia, Bulgaria*

Saturday/October 1
9:00 AM/Room B

Session 47

Earth Observations III Applications

Co-Chairmen
L LAIDET (France)
F O VONBUN (USA)

77-127
Application of the Theory of Radiation Transfer to the Interpretation of the Earth's Brightness Measurements from Space
K Y Kondratyev and O I Smokty, *University of Leningrad, Leningrad, USSR*

77-128
Applications of LANDSAT Satellite Imagery in Assessing the Regional Geological, Structural, Environment and Groundwave Conditions in the Quattara Depression Area, Egypt
I M El Shazly, M A Abdel Hady, M A El Ghawaby, S M Khawasik and M M El Shazly, *Remote Sensing Center, Cairo, Egypt*

77-129
Weather Satellite Imagery as an Aid in the Assessment of Rainfall: Lessons Learned from a Detailed Case Study in the Sultanate of Oman
E C Barrett, *University of Bristol, Bristol, UK*

77-130
Remote Sensing Methods of Interpretation of Anthropogenic Changes of Environment
V P Burov, I V Glushko and I G Ermakov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-131
Environmental Pattern Change as Revealed by LANDSAT MSS Data
K Tsuchiya, *National Space Development Agency, Tokyo, Japan, and* H Ochiai, *Tobat National Merchant Marine College, Tokyo, Japan*

77-132
The Determination of the Relation Between Tectonic Structures and Water Points in Southeast Anatolia by Using LANDSAT, Aircraft Black and White and Color Composites
N Atuk, *Devlet Su Isleri, Ankara, Turkey*

77-133
Remote Sensing of Clouds Against Snow Background
I I Tchapursky and A P Tchernenko, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-134
Application of the CARTI Remote Sensing System to Land Use in Campania
S Vetrella, F G Napolitano and C Tripodi, *Institute of Aerodynamics, University of Naples, Naples, Italy*

Saturday October 1
9:00 AM Room D

Session 48

10th International Space Rescue and Safety Symposium II

Organized by the International Academy of Astronautics

Co-Chairmen
P H BOLGER (USA)
P A CAMPBELL (USA)

77-A 37
Principles to Develop a Model of Danger in Space
G T Beregovoy, G P Shibanov, V I Yarpolov and I I Baranetsky, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 38
Shuttle Remote Manipulator System Safety and Rescue Support Capabilities
G D Whitehead, *Spar Aerospace Products Ltd., Toronto, Ont., Canada, and* J W Brown, *NASA Johnson Space Center, Houston, Texas, USA*

77-A 39
Radiation Protection for Manned Orbital Stations
N N Gurovsky, E E Kovalev and V M Petrov, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 40
Advanced Vehicles for Space Rescue and Other Space Operations in Far Orbits
R Salkeld, *System Development Corporation, Malibu, Calif., USA, and* R S Skulsky, *Northrop Aircraft Div., Hawthorne, Calif, USA*

77-A 41
The Probability of Decompression Sickness as a Result of Going Out in a Pressure Suit from a Spacecraft with an Atmosphere Close to That on Earth
A A Barer, I G Golovkin, S N Filipenkov, I N Chernyakov and A A Sheikin, *Intercosmos Council, USSR Academy of Sciences, Moscow, USSR*

77-A 42
Advanced Vehicle Concepts for Earth-Orbit Transportation and Rescue
R C Haefeli, *Martin Marietta Aerospace, Denver, Colo., USA*

77-A 43
Survey of Recovery Capabilities—International Disaster Response—Space Systems and Terrestrial Elements
G W Heath, *SAR-ASSIST, Inc., Greenwich, Conn., USA*

Saturday October 1
9:00 AM Room F

Session 49

4th International Space Relativity Symposium II

Organized by the International Academy of Astronautics

Co-Chairmen
F ESTABROOK (USA)
Z HORAK (Czechoslovakia)
W WRIGLEY (USA)

77-A 23
Inertial Frames Determined from the Rotation Laws Observed in Spiral Galaxies
Z Horak, *Technical University of Prague, Prague, Czechoslovakia*

77-A 24
Method for Verification of the Time Dilatation of the Special Theory of Relativity by Means of Lasers
Ir J Leupen, *Amsterdam, The Netherlands*

77-A 25
The Results of the Gravitational Redshift Rocket Probe Experiment
R F C Vessot and M W Levine, *Smithsonian Institution Astrophysical Observatory, Cambridge, Mass., USA*

77-A 26
The Technical Feasibility of a General Relativity Experiment Extending to the Sun
R F C Vessot, M W Levine and K Nordtvedt, Ir *Smithsonian Institution, Astrophysical Observatory, Cambridge Mass., USA*

77-A 27
Long Wires in Space As Gravitational Wave Detectors
B Bertotti, *University of Pavia, Pavia, Italy*

APPENDIX B

Breakdown by country of Technical Papers Presented at the 28th International Astronautical Congress, Prague, Czechoslovakia, September 26 - October 1, 1977.

28th International Astronautical Congress

Total Number of Technical Papers Presented
(excluding Student and Space Law Papers): 296

Countries	Number of Papers
United States	87
USSR	85
France	30
Federal Republic of Germany	23
Czechoslovakia	13
Italy	9
Bulgaria	7
The Netherlands	7
Japan	6
Switzerland	4
United Kingdom	4
German Democratic Republic	3
Canada	3
European Space Agency	2
Poland	2
Austria	2
Spain	1
Sweden	1
China (Taiwan)	1
Australia	1
Israel	1
Indonesia	1
Norway	1
Greece	1
Egypt	1
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APPENDIX C

List of Contributors to the Report

28th International Astronautical Congress

List of Contributors

Bainum, Peter M.	-	Howard University
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Bunn, M.H.	-	SAMSO
Cook, Frank	-	University of California-Irving
Diem, Harold G.	-	Rockwell International
Dowdall, G.F.	-	Rockwell International
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Edelson, Robert F.	-	Jet Propulsion Laboratory
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