THE LARGE GEOSTATIONARY PLATFORM AND THE REAL WORLD

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ABSTRACT

The Space Shuttle will make it possible to place large complicated structures in orbit. The large geostationary platform is a prime candidate for Shuttle launch. A single communications platform placed in geostationary orbit over the United States could alleviate the growing problems of orbit and spectrum congestion by providing communications capacity equal to a large number of conventional satellites at substantially lower cost.

A variety of nontechnical and institutional problems such as platform ownership and control, user participation, financial support, and political acceptance must be resolved along with the technical issues of platform/payload design, fabrication, and integration. This paper discusses the institutional aspects of large geostationary platform implementation; presents important economic and political tradeoffs; and identifies potential legal and social problems likely to influence acceptance of the multi-payload, multi-mission concept.

INTRODUCTION

With the advent of the Space Shuttle and its vastly increased low earth orbit payload capacity and potential for large Space System construction, the concept of a Geostationary Communications Platform becomes attractive and feasible. Such a platform offers enormous traffic handling capabilities based on extensive frequency reuse by means of large multiple spot beam antennas, and maximum connectivity from on-board switching and signal processing. One platform would be the equivalent of many conventional satellites while providing greatly increased efficiency of spectrum and orbit utilization.

Before the geostationary communications platform can become an accepted substitute for conventional satellites, a wide range of nontechnical issues and concerns must be addressed along with the immediate project, system, and design engineering problems.

Some of these concerns are listed in Table 1. The platform must demonstrate easily recognizable cost benefits which will make it a significantly more attractive revenue producing proposition than an equivalent array of conventional communication satellites. Satellite communications is well established as a growth industry, but traffic projections are a matter of controversy. Potential platform users need assurance that the platforms will be adequately utilized and that the economic break even point can be reached with a moderate load factor. The technological risks must be reduced to a level which will encourage taxpayer support and investor participation.

Institutional problems must be resolved; e.g., national and international regulation; methods of platform/system ownership, management, and control; and monopolistric versus competitive platform operations. Of prime importance are the attitudes and future plans of existing communication satellite system operators (government and commercial). They are all potential participants in platform financing, design, and operation. Their acceptance of this new approach to satellite communications is essential to a successful operational program.

The Geostationary Platform Concept

Basically, the concept of a geostationary platform is an extension of the capability to launch conventional single purpose satellites into geostationary orbit. The Space Shuttle, combined with high energy upper stages will be able to place payloads weighing upwards of 5000 kg in geostationary orbit. These payloads can be structures that are initially deployed/assembled/erected in low earth orbit and subsequently transferred to geostationary orbit. Examples of the type of structural configuration that might be employed as space platforms are shown in Figure 1. A representative platform would carry a variety of antennas, sensors, transmitters, receivers, etc., suitably configured to perform functions ranging from fixed and mobile communications to earth observation and scientific data collection. Housekeeping support would be provided as a common service to all platform payloads with functions analogous to those supplied in a conventional satellite.

Studies performed[1, 2], in the recent past suggest that the multi-service geostationary platform would provide a number of advantages over conventional single purpose satellites in terms of performance and cost. Such inherent gains would include:

a) Vastly increased communications traffic capacity through the use of large diameter antenna systems with multiple fixed and scanning spot beam patterns. A typical large geostationary platform weighing 10,000 kg would have the capability to relay 500,000 one-way voice channels.

b) Common attitude/velocity control power supply, thermal control, and avionics services with associated savings in weight and volume.

c) Considerable cost saving from the location of groups of payloads with diverse missions on a single platform compared to implementation by individual spacecraft. Recent analyses [3, 4] have shown that space segment costs can be reduced 50 to 70% by the platform approach.

d) More efficient utilization of available radio frequency spectrum and geostationary orbit space.

e) Interconnection of payloads and on-board signal processing leading to greater availability, connectivity, and transmission bandwidth utilization efficiency.

f) Fewer constraints on antenna size and complexity which will permit more, extensive frequency reuse in the preferred 1 GHz to 10 GHz bands, with adaptive control of antenna pattern characteristics for accurate beam pointing and sidelobe suppression.

There are significant technical and institutional problems to be solved before these important advantages can be realized. System reliability is crucial to the success of a geostationary platform program. Performance in this area must be at least as good as for conventional satellites and expected lifetime should preferably be longer. Realization of high levels of reliability and availability for design lifetimes in excess of 10 years with systems of this size and complexity presents a major challenge to space system designers. In addition to the increased amounts of fuel for attitude control and stationkeeping, larger solar panels, and longer life batteries are required. There will also be need for greater subsystem and component redundancy, further derating of critical components to allow for aging and radiation effects, and special switching configurations designed to ensure gradual performance degradation rather than catastrophic failure.

The increase in operational freedom offered by the Space Shuttle makes possible a new concept of satellite life extension. It has been suggested that satellite lifetimes up to 20 years might be feasible if the concept of on-orbit servicing is accepted. One approach would be to utilize an unmanned teleoperator designed for long-term occupation of a geosynchronous orbit. The teleoperator would periodically service geostationary platforms with consumables and replacement equipment modules. Obvious benefits would include increased satellite reliability and availability, decreased life cycle costs, replacement of failed or worn-out equipment, correction of design faults, and installation of more advanced subsystems and components. Implementation of the on-orbit servicing concept would significantly change conventional satellite payload design techniques and would require a very considerable initial capital outlay to develop the teleoperator, the servicing techniques, and the easy-change platform and payload equipment module designs.

The geostationary platform is the logical goal of the trend towards inverted complexity, i.e., large number of inexpensive ground stations linked to large, complex, highly flexible long-lasting, multipurpose satellites. A program of studies has been sponsored by NASA (Table 2) with the object of identifying and developing the technologies needed to implement a geostationary platform. The chronological projections for the development of the platform and ancilary equipment is shown in Table 3.

Missions and Markets

The concept of the geostationary platform has generated substantial interest within the aerospace community. Implementation of a platform program would provide an opportunity to try out new areas of advanced space technology such as electric propulsion, large diameter multi-beam antennas, on-orbit construction, assembly, and checkout, in space maintenance, repair, and retrofit, on-board signal processing and interplatform communications links. Major space activities which have received widespread public recognition and support are satellite communications, and earth observation for weather prediction and resource monitoring. Satellite communications has expanded rapidly since its inception and shows no sign of slowing down. Table 4 indicates the projected requirements for national and international satellite communications traffic by the end of the century, based on demographic and economic data. These figures do not allow for accelerated development of data communications, electronic mail, video conferencing, etc. A major area of concern is the limited availability of radio spectrum and geostationary orbit space. Requirements for minimum angular spacing between satellites operating at the same frequencies to limit radio interference, and competition for slots giving optimum national and regional coverage will lead to difficult regulatory decisions as more countries and commercial organizations seek orbit space for their satellites. The most desirable operating frequencies are in the 1 GHz to 10 GHz region of the radio spectrum which is least subject to atmospheric propagation losses. This region is heavily used for terrestrial transmissions and satellite operations at these frequencies are severely restricted. Frequency bands above 10 GHz have been allocated for satellite use and suitable equipment is being developed. Precipitation noise and attenuation at these frequencies can cause severe fades which increase in depth with frequency and require large link margins or diversity operation to maintain acceptable levels of link availability.

Geostationary platforms could alleviate spectrum and orbit congestion in satellite communications by avoiding unnecessary satellite proliferation in the geostationary orbit, providing access to the most popular orbit locations, and permitting operation of diverse communication payloads in the preferred frequency ranges through the use of large multiple beam antennas and on-board switching. Earth observation and data collection payloads could also be accommodated, together with any other missions that would benefit from the platform's particular location. A representative, but not exhaustive, selection of candidate geostationary platform missions is listed in Table 5. It would be neither feasible nor desirable to attempt to accommodate all the missions on a single platform. Missions could be grouped according to community of interest and allocated to platforms with specific objectives, i.e., fixed communications, mobile communications, earth observation, navigation/tracking, etc.

As an indication of the type of traffic growth that is anticipated in the INTELSAT and U.S. domestic systems, it has been estimated that the INTELSAT Atlantic Ocean System satellites will need a total of 500 equivalent 40 MHz transponders to meet the demands for domestic, regional, and international services in 1996. Estimates of U.S. domestic traffic show a requirement for 700 equivalent 40 MHz transponders in the same time period. If one assumes availability of conventional satellites with capacities of 72 equivalent 40 MHz transponders at least ten would be required in orbital slots spread over a 50° arc above the U.S. Intersatellite links would be essential to maintain system connectivity. The above estimates must be considered conservative since the impact of new services such as electronic mail, video conferencing, computer networking and other possible developments could considerably expand the demand for satellite communications.

Institutional Issues

Many of the technologies needed to implement geostationary platforms currently exist or are in an advanced state of development. It is not unreasonable to predict that given the necessary institutional commitment and financial support large multi-mission platforms could be placed in geostationary orbits within 10 years. A typical development program would be much less ambitious and expensive than those undertaken for Apollo moon shots.

However, desirable geostationary platforms may be technically their future depends primarily on public acceptance and institutional support. One of the most important issues to be resolved is the question of platform ownership and control. If one considers a platform developed to serve the North American continent, several options exist for ownership and management, including: A U.S. governmental agency, a monopoly corporation, a consortium of private sector entities, or, a regional organization. Canada and Mexico may wish to participate in the program and contribute to the costs if the social and economic benefits can be shown to be substantial. Thus, ownership might then become a matter of international agreement with control shared between government agencies and/or quasi-private corporations. Such an arrangement was devised for the operation of the "AEROSAT" aeronautical satellite system in which COMSAT as an agent of the U. S.

government was designated to join with the European Space Agency in developing and implementing the system.

A strong precedent exists for the government to take the lead in the development of a new communications concept, as exemplified by the CTS and ATS 6 Satellite programs. These were essentially experimental vehicles with limited lifetimes and no commercial objectives other than demonstration of technological capability. A successful platform program must demonstrate technological capability, and social and commercial benefits. The burden of platform financial support initially carried by a government agency must eventually be transferred to a suitable organization which can operate the platform as a monopoly or a competitive enterprise (dependent on the political climate) capable of financial independence.

In addition to management and ownership, the following issues will need careful consideration:

(a) Responsibility for Platform Design and Development — Since the primary geostationary platform objective will be to provide communication services at competitive prices, payload designs must be commercially oriented. Potential users, e.g., ATT, Western Union, RCA, ITT, should be closely involved in the design process to ensure that their needs are met both technically and economically.

(b) Platform Operation — The platform will contain payloads with different missions designed to serve a range of user communities. Questions will arise concerning payload operation and control. Certain payload operators may prefer autonomous control via their own ground stations. Others may rely on the platform operator to provide housekeeping services and contingency support. Platform management must provide a degree of flexibility which will accommodate differing payload operator/user needs and philosophies.

(c) Cost Sharing — It is likely that most, if not all, the costs of platform development, fabrication, and launch will be borne by NASA in the initial phases of the program. When the revenue producing capabilities have been demonstrated, participating users will be expected to contribute financial support based on utilization of services and return on investment. These payments should, as a minimum, meet annual operation and maintenance costs and contribute towards depreciation. One possible approach would be to establish leasing arrangements in which the platform operator sells payload leases to potential users. The process could be somewhat similar to that employed in shopping center development. An investment approach analogous to that used to develop condominium communities could also be used.

(d) National and International Regulations — The communications industry is closely regulated and subject to national laws and international treaties. Frequency spectrum and orbital slot allocation are controlled by FCC regulations and international agreements worked out at periodic meetings of the International Telecommunications Union. Platform location, operation, control and ownership will become subject to regulations not yet formulated. As vacant orbit slots become scarce, cooperative usage of large platforms by organizations which cross national boundaries will seem natural, and binding contractual agreements will be needed to protect the interests of the platform participants.

(e) Military Participation — Military establishments have important and widespread command and control networks which can utilize geostationary platform payloads, thus a question arises concerning military participation. Commercial payload operators may not be comfortable sharing a platform with military agencies. They may feel that military participation makes the platform a possible target for attack or sabotage; or that the platform may be preempted for military service in the event of an emergency. Thus, it appears preferable for military-sponsored payloads to be accommodated on a military or government-owned platform to minimize management and operational conflicts.

(f) The Transition Period — Assuming there is general acceptance of the geostationary platform as a natural evolutionary step in satellite development, there will be an extended period of coexistence between platforms and conventional satellites. Existing satellite communication systems represent a considerable technical and financial investment built up over the years. Thus, it is essential that platform payloads be compatible with existing ground segments. Transition from conventional satellite to multi-payload platform must be orderly, painless, and financially attractive. It must be a credible path to reduced costs, increased profits, and greater growth potential. The conventional satellite owner/user must be able to transfer operations to a platform payload with minimal impact on services, equipment, and operations.

Economic Considerations

The primary consideration in the development of any commercial product or service is return on investment. Entrepreneurial interest in communication satellites did not develop until their capability to provide reliable, low cost, high quality, wideband, distance in sensitive communications had been effectively demonstrated by SYNCOM and EARLY BIRD. The role of government (NASA) was to provide the financial support and design initiatives which resulted in the successful launch and operation of these pioneer geosynchronous satellites. The expenditure of the large sums of public money needed to implement advanced concepts in space communications implies a strong commitment at high levels of government and industry and a firm belief in the benefits that will ensue.

Such commitment must be soundly based on economic and technical feasibility studies which have made detailed and unprejudiced examination of the issues, the potential benefits, the penalties, the trades, and the risks, and have found no insurmountable obstacles to program acceptance and success.

Once the commitment has been made and technical feasibility has been established, a very considerable capital investment will be needed to implement an operational platform program. Decisions are required as to the method of financing, i.e. , government only, joint government and private enterprise, or exclusively private enterprise. Government-exclusive financing is unlikely to be popular with Congress and the general tax paying public in view of the platforms' quasi-commercial objectives. Business organizations which expect to profit from the platform will be expected to share the risk. Good examples of this philosophy are the lease-back programs such as MARISAT and TDRSS in which the satellites are built by private enterprise using government-backed loans. Some facilities are leased to the government (Navy Department and NASA) by agreement, while others are used to provide commercial services. Such an approach might be appropriate for platform financing since it could provide equitable risk and benefit sharing coupled with joint agreement on platform objectives, and implementation policy.

Investment banking circles appear quite receptive to this approach provided the following criteria are met:

1) The project is state-of-the-art and utilizes proven technology.
2) The system is flexible in operation and will provide a range of services.
3) The system will be managed by experienced operators.
4) The system users are credit-worthy.
5) The system objectives are acceptable to institutional investors.
6) Financial coverage is available for the development phase of the program.

The geostationary platform is potentially able to meet all the above criteria since comparatively few technology advances are needed for implementation. The single most important area of uncertainty is "on-orbit servicing." However, on-orbit servicing is not an essential part of system design. Early platforms could well be unserviced and achieve extended lifetimes and high reliability by increasing consumables and providing extensive component redundancy. Another important economic consideration is system insuraility. It is now common practice for satellite system operators to insure against launch vehicle and satellite failures. Insurability is a measure of the maturity of communication satellite technology, the relatively low operational risks, and the outstanding reliability record. There is good reason to believe that the platforms could achieve comparable performance.

Social and Political Acceptance

New ideas, applications, or approaches to the solution contemporary communication problems are always questioned and frequently resisted because they represent a departure from past principles and practices. The concept of a geostationary platform is unlikely to be an exception of this rule. Conventional satellites have become a proven and accepted means of long distance communications. Their use has resulted in significant rate reductions over the years. The noticeable delays in voice communication due to the 40,000-mile "hop" between earth stations were originally thought to be a serious obstacle to public acceptance. This has proven not to be the case. Also, echo cancellers have been developed which can work effectively with satellite circuits.

The concept of progressively larger communication satellites has been widely accepted as an inevitable consequence of rapidly increasing traffic and the desire for smaller and less expensive earth stations. If platforms can be regarded as very large satellites which employ proven designs and technologies, then their adoption is a natural evolutionary step towards improved spectrum and orbit utilization and greater operating economies. By contrast, some of the more exotic aspects of platform design such as on-orbit construction, servicing by remote control, and upgrading or replacement of payloads cause potential users to have reservations about platform technical feasiblity and doubts about economic gains. There is also a tendency for the public to regard such projects as expensive scientific experiments with little immediate practical value. Until the Space Shuttle becomes a proven, reliable and economic form of space transportation and demonstrates its clear superiority over expendable launch vehicles, the concept of the geostationary platform may continue to be difficult to sell as a practical vehicle for satellite communications.

While the social and economic value of satellite communications is not in doubt, distribution of social services by satellite has languished with the demise of ATS-6 and CTS. The communities served by a Public Service Satellite do not have the financial resources needed to procure, operate and maintain a dedicated system. Almost their only hope for the future is a geostationary platform. A platform designed for revenue producing commercial communications could have some transponder capacity available for lease at economic rates to public service organizations. The power levels should be compatible with a network of small inexpensive earth stations. The platform management organization could acquire a socially responsible image by providing low cost public service communications.

Current manufacturers and operators of conventional satellites may be initially hostile to the development of geostationary platforms seeing them as a threat to their current investment in equipment, skills, and technology. It must be made apparent that platforms are not a threat but an opportunity to participate in the development of a new generation of space vehicles with almost unlimited potential for growth.

Conclusions

The rapidly increasing demand for satellite communications, coupled with the keen competition for available frequency spectrum and geostationary orbital slots, is providing a strong incentive to increase satellite capacity, size and complexity. Examples of this trend include the INTELSAT V and TDRSS satellites. When the Space Shuttle becomes operational, the present limitations on satellite size and weight will be removed and the concept of a large geostationary platform will become feasible and economically attractive.

The major obstacles to platform implementation are institutional rather than technical. The economic advantages of a platform need to be clearly demonstrated and the financial risks minimized. Questions of ownership, liability, and control must be resolved. The configuration and organization of an acceptable and successful geostationary platform will be a compromise between technical, legal, economic, and political factors.

A platform can support large complex payloads, alleviate congestion of the orbital arc and facilitate multiple reuse of frequencies in the preferred 1 to 10 GHz band. A wide range of services can be provided at half the cost of the same services from conventional satellites. Such incentives will encourage mission sponsors to combine with platform developers to make the necessary institutional arrangements and resolve the inherent technical problems.

REFERENCES

- Edelson, B. O., and Morgan, W. L., (1977), Orbital Antenna Farms, Astronautics and Aeronautics, 20-29 September.
- Fordyce, S. W., and Jaffe, L., (1978), Future Communications Concepts; The Switchboard in the Sky. Satellite Communications, 22-26 February and 22-27 March.
- Future Systems, Inc. (1979), Large Communication Platforms Versus Smaller Satellites, Report No. 221, prepared for NASA Headquarters Office of Communication Programs.
- Castleman, M. W., "Geostationary Platform Cost Comparison Analysis," George C. Marshall Space Flight Center, November 1978.
- Filep, Robert T., (1979), "Issues Relating to User Concerns and Requirements for a Geostationary Communications Platform," General Dynamics Technical Memorandum, 2 February.

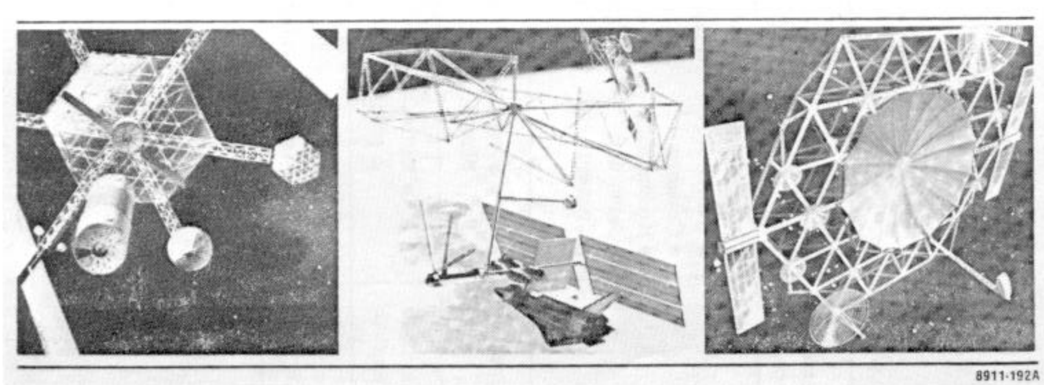

Figure 1. Geostationary Platform Concepts.

Table 1. Platform Participant Concerns (Reference 5)

Participant Function	Concerns			
	Technical	Economic	Legal/Political	Social/Environmental
User	• Performance • Utilization • Capacity • Redundancy • Servicing • Connectivity • Reliability • Flexibility • Interference • 30/20 GBz	• Undersea cable analogy • Saturation • Condominium analogy • Market for platform services	• Competition vs monopoly • FCC policy • Platform Vs terrestrial	• Message quality • Traffic growth projections
Regulator	• Support for Shuttle	• Cost to consumer	• Regulation policy	• Operator training & support
Management Consultant	• Motivation & priority	• Demonstrate • Cost-effective	• Program priorities	• Public image • Health hazards
Investor	• Proven technology • Flexibility in ops	• High return on investment	• Consortium of users/investors	• High user/public acceptance
Insurer	• Reliable performance	• Need for insurance	• Period of NASA involvement	• Risk to taxpayers & investors

Table 2. Current NASA Studies

- Geostationary Platform Feasibility Study (by Aerospace Corporation for MSFC-NASA, Contract NAS8-32881)
- Geostationary Platform Mission and Payload Requirements Study (by COMSAT Laboratories for MSFC-NASA, Contract NAS8-33226)
- Communications System Service Demand Assessment (parallel studies by Western Union ITT for Lewis Research Center)
- 18/30 Satellite Communication System Concepts (parallel studies by Hughes Aircraft and Ford Aerospace for Lewis Research Center)
- Large Communication Platforms versus Smaller Satellites (by Future Systems Inc. for the office of Communication Programs
- Geostationary Platform Systems Definition Study (by General Dynamics Convair for MSFC-NASA, Contract NAS8-33527)

TABLE 3
GEOSTATIONARY PLATFORM PROGRAM MILESTONES

MILESTONE	DATE
1. Experimental/Demonstration Geostationary Platform — Contract Award	1982
2. Demonstration Teleoperator — Contract Award	1982
3. First Teleoperator Flight	1984
4. Demonstration Platform Launched	1987
5. First Operational Geostationary Platform Launched	1991
6. Second Operational Geostationary Platform Launched	1992
7. First In-Orbit Servicing Mission	1993

Table 4. Projected Satellite Transponder Requirements for the Year 2000 (Equivalent C-band Transponders, 33 dBW, 35 MHz, 1000 Channels)

Region	Telephony	New Data Services	TV Transmission	Total
Group 1				
North America	560	190	35	765
Western Europe	435	195	35	665
USSR	380	100	20	500
Eastern Europe	85	33	5	125
Japan	155	60	10	225
Total	1,615	578	105	2,280
Group II				
Latin America	240	43	8	290
Middle East*	190	35	6	230
China	280	61	11	350
Asia**	280	60	11	350
Africa***	70	13	2	85
Total	1,060	212	38	1,305
Other	70	16	3	90
World Total	2,745	806	146	3,675

* Includes North Africa
** Excludes Japan and China
*** Excludes South Africa and North Africa

Table 5
Candidate Geostationary Platform Missions

Aeronautical Communications	Land Mobile
Bush Voice	Low Orbit Relay
Cable TV	Military Comm. & Data Collection
Data (> 9600 bit/s)	Navigation
Data Collection	Network Television
Government	Maritime Communications
Direct Television Broadcast	Paging
Domestic Trunk Telephone	Personal Communications
Earth Exploration	Private Lines (AVD)
Educational Television	Public Safety
Electronic Funds Transfer	Remote Printing
Electronic Mail (Facsimile)	Search and Rescue
Electronic Office	Teleconference
Information Retrieval	Tele-health
International Communications	Time Standard
Intersatellite	Weather Pictures