final technical report

SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS

volume II - book 1

part III - manned space station relevance to commercial telecommunications satellites

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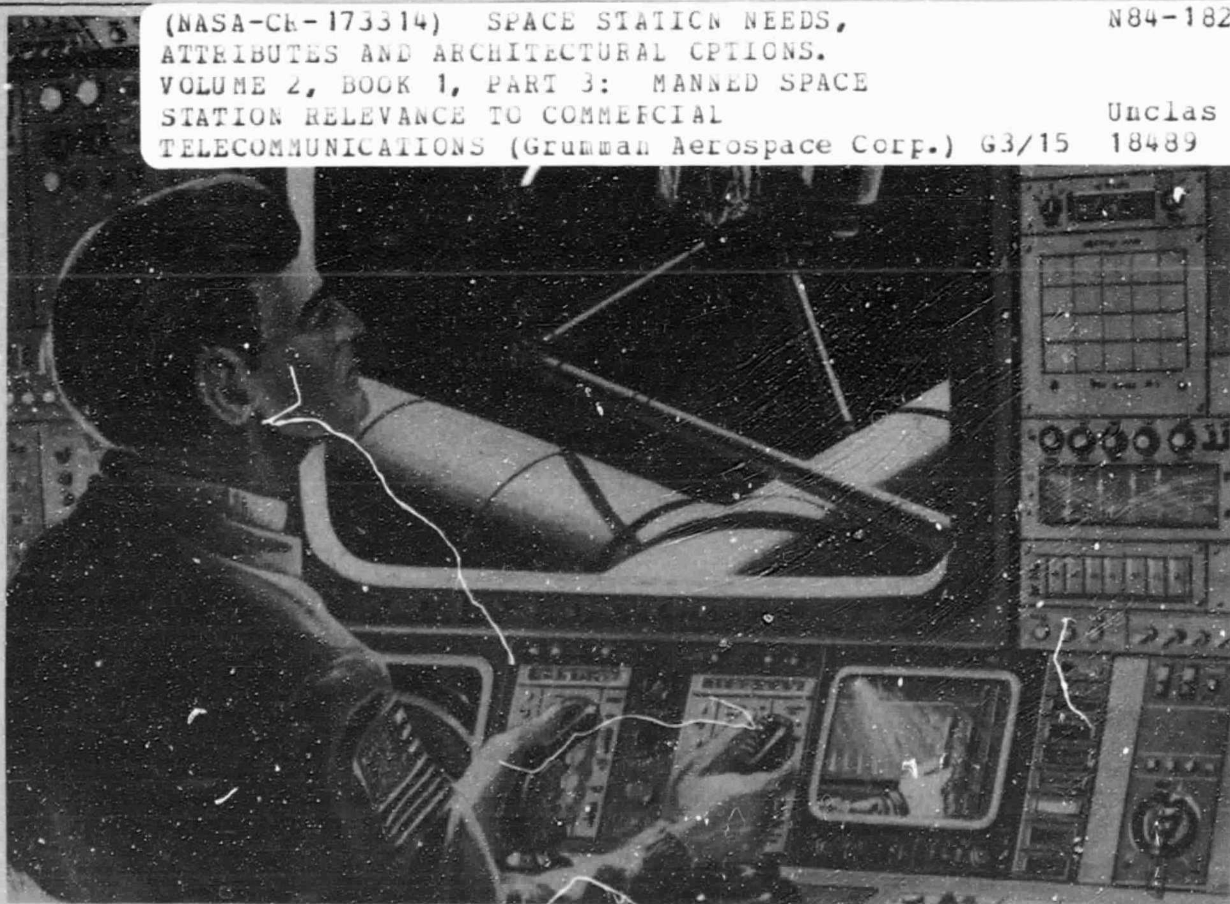

GRUMMAN

COMSAT GENERAL

GENERAL ELECTRIC

final technical report

SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS

volume II - book 1

part III - manned space station relevance to commercial telecommunications satellites

prepared for

National Aeronautics and Space Administration
Headquarters
Washington, D.C. 20546

under contract NASW-3685
Space Station Task Force
Contracting Study Project Manager — E. Brian Pritchard

by

Grumman Aerospace Corporation
Bethpage, New York 11714

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11/1/111

MANNED SPACE STATION RELEVANCE TO

COMMERCIAL TELECOMMUNICATIONS SATELLITES

A Prospectus to Year 2000

Prepared by

COMSAT General Corporation

CONTENTS

INTRODUCTION

1 - INTRODUCTION

Because all telecommunications spacecraft operate at geostationary orbit, one might conclude that a low-orbit Space Station is not useful for commercial satellites. A technically cautious industry could reach this conclusion despite promises of satellite low-earth-orbit testing before commitment to GEO orbit, orbital testing of large antennas, orbital assembly of satellites with orbital transfer vehicles, etc.

In order to realistically assess the importance of manned Space Stations, COMSAT General prepared a document containing a forecast of satellite traffic and relevant technology trends to the year 2000. We included those Space Station capabilities and characteristics that should be provided to make the station useful to commercial satellite owners. The document was circulated to key representative organizations within the commercial telecommunications satellite and related communities of interest, including spacecraft manufacturers, commercial satellite owners, communications carriers, networks and risk insurers.

Our purpose in developing this prospective was to:

- Provide NASA with a forecast of future commercial satellites and those Space Station capabilities that would be beneficial to U.S. commercial satellite builders, owners and the public which uses the services provided
- Provide COMSAT General's views of the circumstances under which those capabilities are likely to be used
- Obtain an endorsement from the commercial telecommunications community of the prospectus as written, or identify points of major disagreement.

Section 2 contains the COMSAT General prospectus document as it was sent out for comment. Section 3 contains a copy of the transmittal letter and the mailing list of the people and companies that were asked to review the document. Section 4 contains a summary of key commercial telecommunications comments. Section 5 contains the actual response letters from the industry.

COMSAT GENERAL PROSPECTUS DOCUMENT

MANNED SPACE STATION RELEVANCE TO COMMERCIAL TELECOMMUNICATIONS SATELLITES: A PROSPECTUS TO YEAR 2000

I. FUTURE COMMERCIAL COMMUNICATIONS SATELLITE PROJECTIONS:

In formulating future projections for the free world's commercial communications satellites to the year 2000, three categories of communications satellites were considered: International Communications, U.S. Domestic Communications, and other countries' Domestic and Regional Communications.

A. International Communications - Services will be provided by INTELSAT and INMARSAT satellites. The following are future estimated projections of market growth and satellite mass and communications system characteristics:

1. Average annual growth rate of 15% per year in user demand.
2. A total of 44 new and replacement INTELSATs may be launched, as indicated in Table 1, over the period 1982-99. Approximately 30% of the utilized capacity is expected to be leased for domestic and regional uses.

Table 1. INTELSAT Launch Forecast

Period	Number and Generation	Mass in Orbit
1982-84	8 INTELSAT V's	1050 kg
1983-85	4 INTELSAT VA's	1100 kg
1986-91	4 INTELSAT VI's	2250 kg
1988-90	15 INTELSAT VIA's	2250 kg
1992-99	13 INTELSAT VII's	3000 kg

3. The total capacity of all INTELSAT satellites in orbit will increase by a factor of five by the year 2000. The capacity of a single INTELSAT VII satellite may be as high as a quarter million one-way voice channels.

4. The first generation INMARSAT space segment, consisting of two MARECS satellites and 5 specially equipped INTELSAT V satellites, will service maritime (mobile) communications requirements until 1990.

5. Nine new second generation INMARSAT satellites (700 kg class) will be launched beginning in 1988 to meet demands of the international market in each ocean region up to the turn of the century.

6. Increased capacities in INTELSATs during the 1990s will be achieved through the use of frequencies no higher than K-band and their reuse with multiple spot beams, together with increasingly sophisticated signal processing techniques such as source coding, DSI, FEC, and satellite-switched TDMA.
7. INTELSAT satellites in the late 1990s may achieve global connectivity without multihop operation through the use of intersatellite links.

B. U.S. Domestic Communications - The following summarizes forecasts for U.S. domestic services market growth and satellite mass and communications system characteristics:

1. The average annual growth rates over the period 1982-90 for voice, video, and data services are estimated to be 10%, 11%, and 17%, respectively.
2. A total of 148 new and replacement U.S. spacecraft may be launched between now and the year 2000 to meet demands of the U.S. market, distributed with respect to mass class as follows:

28% ~700 kg in orbit

12% ~1000 kg in orbit

44% ~1500 kg in orbit

16% ~2300 kg in orbit

3. The trend toward heavier, higher capacity satellites promises to provide an abundance of high-speed data and video channels at increasingly lower costs.
4. Between 1986 and the turn of the century, a total of three or more ventures in direct broadcasting may be established, each with several satellites for time zone and regional coverages.
5. In the 1990s, enhanced services, including electronic banking, electronic mail, teleconferencing, and land mobile vehicle communications, may have sufficient demand to justify their own satellites. However, there will be no routine use of satellites for personal communications services such as radio paging and wrist radio.
6. In the 1990-95 time period, C- and Ku-band satellite capacity for fixed-satellite service will be saturated and the next higher bands will have to be utilized.

7. The total capacity in orbit will increase approximately fourfold from now to the year 2000.
8. Geosynchronous satellite orbit spacing of 2.5° and 2° will be routine in the late 1990s.
9. INTELSAT satellites will connect with large U.S. domestic systems by intersatellite relay links in order to avoid double-hop connections and to increase the efficiency of earth-to-space spectrum use.
10. One or two precursor large geostationary platforms servicing diverse communications payloads may be constructed by the year 2000 to achieve efficient connectivity and conservation of the frequency spectrum and geostationary arc. This approach could provide operational flexibility and, eventually, cost savings over the traditional single mission launch approach.

C. Other Countries' Domestic and Regional Communications - This category includes satellites put up by single countries (private or government sponsored) and satellites sponsored by a group of countries within a geographic region.

1. About 60% of these satellites will provide conventional fixed services, e.g., voice communications, TV distribution, and data transfer; about 40% will be used primarily for direct broadcast service.
2. It is estimated that 176 domestic and regional communications satellites in this category may be launched in the period 1982-99, distributed with respect to mass class as follows:

   35% ~700 kg in orbit

   23% ~1000 kg in orbit

   32% ~1500 kg in orbit

   10% ~2300 kg in orbit

D. <u>COMSAT General's Conclusions</u>

1. All the 377 spacecraft identified in the traffic projections up to the year 2000 can be launched by the Space Shuttle or Ariane III or IV.
2. Various signal processing techniques and frequency reuse schemes, as well as the use of higher frequencies, will be utilized to reduce the impact of saturation at C- and Ku-band in the mid-1990s.
3. Intersatellite link development is important for improving satellite connectivity during the 1990s.

II. FUTURE TECHNOLOGY TRENDS THAT IMPACT COMMERCIAL COMMUNICATIONS SATELLITES

1. Efficiency and lifetime of microwave amplifiers between now and the year 2000 should increase as follows:

Frequency Band	Efficiency, %		Life, Years	
	1983	2000	1983	2000
C	40	60	7-10	15
Ku	40	55	7-10	15
Ka	25	40	3-5	10

2. Development of multibeam antenna technology for 30/20 GHz fixed services in the mid-1980s.
3. Development of intersatellite relay technology in the optical and millimeter band in the mid- to late 1980s.
4. Development of technology for 50/40 GHz in the late 1990s for fixed-satellite service.
5. Development of feed arrays using distributed solid-state monolithic module amplifiers at C-band and TWTA modules at Ku-band for phase and/or amplitude control of antennas in the mid- to late 1980s.
6. Development of solid-state field emission cathodes capable of current densities of 50 A/cm^2 in the 1990s.

7. Development of Ni/H_2 batteries that have energy densities of 45 W-H/kg in the 1990s and sodium sulfur batteries that have energy densities of 80 W-H/kg by the year 2000.

8. Increase in heat pipe thermal transport capacity between now and the year 2000 from $<$ 1000 W-m to $<$ 30,000 W-m.

9. Development of lightweight gallium arsenide solar cells which have higher conversion efficiency (36% as compared to silicon cells $\approx$22%) and less susceptibility to radiation damage.

III. SUMMARY OBSERVATIONS

1. Key technology improvements, including development of GaAs solar cells; more efficient, longer life microwave power amplifiers; and high energy-density batteries, will increase in-orbit reliability and average spacecraft lifetimes, thus reducing satellite replacement rates.

2. Other technology developments, including use of multiple spot beams, frequency reuse, intersatellite links, advanced materials, monolithic antenna feeds, and VLSI circuits, allowing full exploitation of the C- and K-bands, will yield very substantial increases in the

traffic capacity of communications satellites with only modest increases in satellite masses.

3. All of the 377 spacecraft identifed above can be launched by the Space Shuttle and complementary upper stage rockets, either mated to the communications payload (e.g., PAM, Centaur) or integrated with it, as planned for INTELSAT VI or Ariane III or IV.

4. NASA is expected to enhance its multiple spacecraft launch services once the Centaur is integrated into its Shuttle-based transportation system in the late 1980s. Since the Centaur places satellites into geostationary orbit without requiring apogee motors, this will provide more flexibility in the design of commercial satellites in the 1990s.

IV. SPACE STATION CAPABILITIES

The low earth orbit manned Space Station, as envisioned by NASA, is part of the overall space transportation system which includes the Shuttle, various expendable upper stages, a teleoperated maneuvering system (TMS), reusable orbital transfer vehicles (OTV), and ultimately a manned orbital transfer vehicle (MOTV). This facility is seen by NASA as:

1. An orbital transportation base or harbor for assembly of upper stages including orbital fueling

and checkout of satellites before their deployment to higher orbits.

2. An in-orbit support base for attached and retrieved payloads including the provision of satellite servicing of retrieved satellites.

3. An R&D test and evaluation facility for in-orbit evaluation of advanced concepts and systems.

V. SPACE STATION CAPABILITIES OF POTENTIAL INTEREST TO COMMERCIAL COMMUNICATIONS SATELLITE OWNERS

There are a number of Space Station capabilities of potential interest to commercial satellite owners, provided that the benefits and costs savings associated with those capabilities can be demonstrated. The most interesting possibilities are:

1. Orbital launch support services that reduce risk factors and total transportation system costs to geostationary orbit.

2. An orbital launch facility with capabilities to service propulsion systems and provide for spacecraft payload/launch system integration.

3. A facility to permit large satellites to be assembled, tested, repaired, and even modified, if necessary, before launch to geostationary orbit.

4. A facility to conduct orbital testing of advanced technology components and subsystems to establish proof of performance prior to their use in an operational satellite.
5. A space-based R&D laboratory to support test and evaluation of advanced communications technology.

VI. PROJECTED UTILIZATION OF SPACE STATION CAPABILITIES

Three key factors are likely to influence utilization of Space Station capabilities by the commercial satellite community:

1. The lack of any absolute requirement for development of such a facility,
2. Uncertainity with respect to facility user charges (vis-a-vis known costs of existing means to assemble and launch satellites), and
3. The practical value of anticipated benefits.

The following are observations pertinent to these factors:

A. Requirement for Space Station Capability

1. Communications satellites for fixed and broadcast services over the next 10-15 years can be directly

launched to geosynchronous orbit by STS with appropriate apogee stages or by Ariane III or IV.

2. New commercial satellite services to provide narrowband broadcast or land mobile communications, because of their possible requirements for large antennas (50-150 meters) and large power systems (10-20 kW), could benefit from the use of a space station for in-orbit assembly and test before transfer to geosynchronous orbit. This requirement is not likely to occur before the late 1990s.

3. Advanced technology demonstrations by NASA of large antennas may be required around 1990 to secure commercial support for new services.

B. Costs for Use of Space Station Capabilities

1. The currently envisioned STS and Ariane systems can adequately provide the launch capability required for projected future fixed and broadcast satellites at least to the mid-1990s. Thus NASA's use of the Space Station as a low-orbit transportation node should not result in increased costs for launch services to geosynchronous orbit.

2. Without a significant cost or risk advantage, the only operational missions likely to stop at the Space Station are those of the late 1990s that have physically large and complex communications or power subsystems.

3. The total pricing for use of the Space Station as an orbital R&D laboratory by the commercial sector must be kept low to encourage its use.

C. Potential Benefits

1. A low earth orbit U.S. space station program may have a major effect on future satellite orbital operations, orbit-to-orbit transportation, and eventually the configurations of future specialized satellites. While the space station capabilities described earlier are not required to meet future commercial communications needs currently anticipated through the late 1990s, the ultimate benefits could be significant. It is therefore believed that the wide range of operational services that will be developed as part of the U.S. space station program will ultimately have favorable impact on communications satellite configurations, capabilities and costs, to the

benefit of the commercial sector. The commercial sector should maintain an awareness of and an involvement in the determination of orbital services that will be developed.

2. Assessment of benefits and future uses is influenced to a large degree by the costs of space station services, such as in-space assembly, repair, checkout, and launch, to the commercial sector. NASA must define such economic philosophies and pricing structures.

3. There must be demonstrations of orbital services and cost benefits before the characteristically conservative commercial communications industry will commit to their operational use.

4. Until transportation and service cost benefits are demonstrated, the low earth orbit space station is likely to be used mainly as an R&D test facility.

5. By the late 1990s, the benefits available from satellite servicing, in-space assembly, repair and checkout, and satellite fueling could allow much greater flexibility to the industry in developing new communications satellite configurations, architectures and services.

PROSPECTUS DOCUMENT TRANSMITTAL LETTER & MAILING LIST

COMSAT GENERAL CORPORATION

February 3, 1983

WILLIAM D. HOUSER
Vice President
Systems Technology Services

SAMPLE

Mr. Lee Paschall
President
American Satellite Co.
1801 Research Blvd.
Rockville, MD 20850

Dear Mr. Paschall:

As a part of a NASA study team, COMSAT General has been asked to provide a realistic assessment of permanent, manned Space Station(s) in low earth orbit for commercial communications satellites. To that end, we generated the attached "prospectus" which forecasts relevant future trends in satellite technology and identifies Space Station capabilities that could provide benefits to the telecommunications industry.

Because of the potential importance of the Space Station program to the nation, it is important that our material be as accurate as possible. For this reason, we would like to solicit from you your views and comments on the projections made, which we will forward to NASA. We have been given a very short time to complete this task, so that your response by February 21, 1983 is requested.

Your cooperation and assistance in this matter is greatly appreciated.

Sincerely,

William D. Houser

Attachment

February 1983

CGC SPACE STATION PROSPECTUS MAILING LIST

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II/1/III

SUMMARY OF COMMERCIAL TELECOMMUNICATIONS SATELLITE INDUSTRY RESPONSES TO COMSAT GENERAL'S PROSPECTUS

4 - SUMMARY OF COMMENTS

The prospectus was sent to 42 organizations (including 15 representing the insurance industry). Replies were received from 23 of the organizations as of March 10, 1983. It is significant that the response percentage was over 50%. The general consensus of the responses was an overall endorsement of the future satellite projections and possible uses and benefits that could be derived from the existence of a Space Station.

The following are the more significant reactions and comments received as a result of the Space Station Prospectus mailing:

1) General agreement with forecasts, observations, and conclusions (70% of respondents).

2) Reinforcement of the idea that economic access to geostationary orbit is of overriding importance to commercial communications satellite owners and that the impact of low-orbit Space Stations will depend on whether they contribute to lower total system transportation costs and reduced mission risk.

3) Confidence that the Space Station, operating in combination with the shuttle, will eventually reduce costs of future systems.

4) Skepticism that Space Stations will benefit the commercial satellite community before the turn of the century.

5) The view that the Space Station is not useful or applicable in any respect to the commercial communications satellite business as it is now known.

6) Acknowledgement of the apparent ambiguity between the eagerness with which the industry talks about pushing new technology and the cautiousness with which it actually takes risks.

7) Doubt that there is any cost or risk advantage of using a Space Station as a way station for operational satellites.

8) The view that a requirement for communications satellite missions "stopping" at the Space Station for checkout may exist in the early 1990s.

9) Confirmation of an industry "show-me" attitude, strongly suggesting that NASA should take the initiative with exploratory development of Space Station concepts and demonstrate their value to prospective business users.

10) The view that private industry may have to do much of the R&D work leading to Space Stations, if they are to be built, in view of little congressional support of NASA for the program and undemonstrated cost/benefits.

11) The observation that new earth station technologies need also to be addressed and that many of these may need to be developed by NASA and/or DoD before finding their way into commercial use.

12) Support of the idea that man can contribute significantly to the reliability and flexibility of the Space Station.

13) Confirmation of the view that the primary value of a station will be as an orbital R&D laboratory until such time as very large and complex systems, especially antennas, need to be assembled in space.

14) Disagreement with the assumption that no new launch vehicles, other than the Shuttle and Ariane III or IV, need to be developed, in view of recent discussions regarding commercialization of the U.S. expendable launch vehicles. (It was suggested that the Titan and Atlas II Centaur programs being proposed, together with Delta, can launch all the projected satellites.)

15) Doubt that precursor large geostationary platforms will be required and/or constructed by the year 2000.

16) Concern that projections of satellite demand take into account potential off-loading of traffic to competitive technologies, notably optical fiber cables.

17) The view that 10% annual growth would be a better figure than 17% to use in forecasting the growth of data traffic in the U.S. for the remainder of the 1980s.

18) The view that the forecast of 148 new and replacement U.S. spacecraft may be optimistic by as much as 50%.

19) The view that for foreign domestic and regional communications the ratio of fixed service to direct broadcast service satellites should be 80/20 rather than 60/40.

20) The view that the forecast of 377 communications satellite missions up to the year 2000 may be overly optimistic, may not be accommodated by the geosynchronous arc, and would entail extremely high levels of system investment cost.

21) Uncertainty as to whether the forecast volumes of 2300 to 3000-kg satellites will materialize before the year 2000.

22) Concern that technology forecasts recognize that recent advances in domestic satellite modulation techniques, such as compounded single sideband, which is capable of quadrupling the capacity of the FM systems now in use, may also be economic for overseas satellite communications.

23) Uncertainty as to whether any substantial use of the Ka band will be required in this century for either U.S. domestic or international satellite services.

24) Reservations about whether, in the 1990s, enhanced communications services, including electronic banking, electronic mail, teleconferencing and land mobile communications, may have sufficient demand to justify their own satellites, rather than be provided via multi-purpose satellites.

25) Uncertainty about the important of developing inter-satellite links to improve satellite connectivity in the 1990s.

26) The view that there is no theoretical advantage in separating the transfer-orbit fuel from the communications satellite during an STS ascent to low orbit, providing that the satellite in GEO is below the 4500-kg STS/Centaur limit.

27) The view that a large aperture land mobile satellite may not be required, if ground cellular systems are implemented to reach all but mobile users located in the most remote regions, in which case a conventional satellite with a 4.5-m antenna could suffice to complete national coverage.

28) The view that, in the 1990s large, complex, multiantenna K- and C-band satellites with extensive frequency reuse and very precise tolerance requirements for beamwidth, etc, may require orbital assemble to achieve acceptable risk.

29) Strong doubt that the development of 50/40 GHz technology in the late 1990s for fixed satellite service will be necessary.

30) The view that orbital demonstrations of large antenna deployment may be required before 1990 in order to develop technology for frequency reuse at C-band via multibeam antennas.

31) Mention of various minor points of divergence in regard to the detailed technology forecast parameters.

32) The view that the capacity of the world insurance industry to underwrite the commercial satellite launch forecast at affordable rates depends on continued development of technology to reduce mission risk and the Space Station capabilities cited could be beneficial in this respect.

33) The view that the insurance industry will be less inclined to acknowledge the Space Station mission reliability enhancement benefits until it has been fully tested supporting noncommercial satellites (i.e., government or military).

34) The view that effective use of the manned Space Station for communications satelites will in time have favorable effects on insurance costs related to launch, deployment and in-orbit failure insurance.

II/1/III

RESPONSE LETTERS FROM TELECOMMUNICATIONS INDUSTRY

11/1/111

ORIGINAL PAGE IS
OF POOR QUALITY

GTE

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[illegible]
[illegible]

[illegible]
[illegible]

Mr. William D. Houser
Vice President-Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

February 23, 1983

Dear Mr. Houser:

We appreciate the opportunity to respond to your request of February 3, 1983, for comments on the "prospectus" on future trends in satellite technology and manned Space Station capabilities. We have limited our comments to supply and demand trends for U.S. domestic communications.

As to Section I, we agree generally with the forecast contained in Section I.B. of the prospectus, but have some reservations about the conclusion in item 5 of that section. We think it more likely that enhanced services will be served through multi-purpose satellites. As to Section I.D., we question how important inter-satellite links will be in the 1990's. You will note that these differences are a matter of degree rather than of substance.

As to Sections II, III, V and VI, we have no basic disagreement with the trends cited or the conclusions reached.

Thank you for giving us the opportunity to comment on the "prospectus".

Sincerely,

David F Piske

David F. Piske

DFP/jeu

intelsat

INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION
ORGANISATION INTERNATIONALE DE TELECOMMUNICATIONS PAR SATELLITES
ORGANIZACION INTERNACIONAL DE TELECOMUNICACIONES POR SATELITE

23 February, 1983

Mr. Willian D. Houser
Vice President
Comsat General Corporation
950 L'Enfant Plaza S.W.
Washington D.C. 20024

Dear Mr. Houser:

Thank you for the "prospectus" which forecasts trends in satellite technology received under cover of your letter dated 3 February 1983.

We have reviewed the information provided and would like to offer the following comments with reference to paragraph I.A.2 of the prospectus.

A. In formulating satellite projections for the INTELSAT system to the year 2000, three timeframes should be considered:

i. 1983-1987;

ii. 1988-1994;

iii. 1995-2000.

B. In the 1983-1987 timeframe four INTELSAT-V, six INTELSAT V-A, and five INTELSAT VI spacecraft will be launched. The launch forecast and the mass in orbit at beginning of life (B.O.L) are shown in Table 1. The launch forecast accounts for launch failures.

Table 1 1983-1987 LAUNCH FORECAST

YEAR	NUMBER AND TYPE OF SATELLITE	B.O.L. MASS IN ORBIT (KG)
1983	4 INTELSAT V's	1,000
1984-85	6 INTELSAT V-A's	1,100
1986-87	5 INTELSAT VI's	2,200

C. In the 1988-1994 timeframe INTELSAT expects to launch 9 to 11 spacecraft. Two basic classes are under consideration: INTELSAT-VI class spacecraft of about 2.2 ton in-orbit mass (B.O.L) and a smaller class of 1.0 to 1.25 ton in-orbit mass (B.O.L). The mix of spacecraft would vary depending on the particular system configuration chosen; the two extreme scenarios being:

- o 7 two ton plus 2 one ton spacecraft;
- o 1 two ton plus 10 one ton spacecraft.

D. In the 1995-2000 timeframe INTELSAT expects to have at least two different sizes of spacecraft in orbit. The largest version, which may prove suitable for primary roles and which could include payloads for the provision of maritime, business and other services, could be as large as a full Shuttle bay. Two other spacecraft types are also under consideration whose in-orbit mass (B.O.L) would be 1 and 2 tons respectively. The mix of spacecraft would vary depending on the particular system configuration chosen. The number of launches could vary from 13 to 22.

II/1/III

k. A total of up to 48 INTELSAT spacecraft may be launched over the period 1983-2000.

Sincerely

N.K.M. Chitre
Director
System Planning Division

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AMERICAN SATELLITE COMPANY

1801 RESEARCH BOULEVARD, ROCKVILLE, MARYLAND 20850 (301) 251-8311

Lee M. Paschall
President
Chief Executive Officer

February 22, 1983

Mr. William D. Houser
Vice President
COMSAT General Corporation
950 L'Enfant Plaza, S. W.
Washington, D. C. 20024

Dear Mr. Houser:

In response to your letter of February 3, 1983, we have reviewed "Manned Space Station Relevance to Commercial Telecommunications Satellites: A Prospectus to Year 2000". American Satellite Company supports, in principle, the concept of a national, permanent manned space station in Low Earth Orbit (LEO).

As you know, our Company utilizes unmanned, moderate-sized, communications satellites launched by expendable launch vehicles or the Shuttle to provide services to our customers. Since these satellites are completely assembled, tested, and fueled prior to launch, we concur with your overall view that the space station will probably not serve a necessary or meaningful function for this class of satellites. In the 1983-2000 time period, the communications satellites that we envision for our Company will be launched in much the same fashion as they are today. Manned intervention by either the Shuttle crew or the crew of a space station in LEO prior to application of the perigee kick impulse is not likely to be required.

However, for much larger payloads destined for high or geosynchronous orbits, on-orbit assembly, check-out, and fueling in LEO by a Shuttle or space station crew could be invaluable. In fact, for payloads that have to be lifted to LEO by multiple Shuttle flights, this would be essential. For example, very large (e.g., 50-300 meter diameter) erectable parabolic or array antennas could be used for microwave radiometry of the earth's resources, a space-based, earthward-pointing radar, or an outward-pointing radio astronomy observatory.

A large multi-user, multi-service (e.g., communications, meteorology, navigation, earth resources, and space science) platform could be assembled in LEO and gently boosted with a yet to be fully developed low-thrust propulsion system to geosynchronous orbit.

One interesting application which probably would not require manned intervention in LEO would be an 800 MHz Land Mobile Satellite System (LMSS) which could employ up to a 50-75 meter diameter wrap-rib, mesh-deployable parabolic antenna similar to the one flown on ATS-6 and now under advanced development by Lockheed.

The following additional comments on the material in the "prospectus" are offered for your consideration.

Section I., Future Commercial Communications Projections, deals with estimates of the number of international (44), U. S. domestic (148), and other countries' domestic and regional satellites (176) to be launched between 1982-99 divided into various classes by mass in orbit. The projection which totals 368 (rather than 377 in the text) seems to be exceptionally optimistic. It may be very difficult to find orbital slots for all of these satellites in Geosynchronous Equatorial Orbit (GEO), since most will overlap in time. The investment in 148 U. S. domestic satellites alone could well exceed $10 billion, not to mention the corresponding investment in the earth segment. It appears to be questionable whether the larger satellites (2300-3000 Kg mass in orbit) will materialize in this time period in the large numbers you indicate.

We concur with your paragraph I.D.1. which states that all of these projected spacecraft up to the year 2000 can be launched by the Shuttle or Ariane, independent of the presence or absence of a space station.

Section II., Future Technology Trends That Impact Commercial Communications Satellites, seems to deal with spacecraft, and does not address the important area of new earth station technologies between now and 2000. NASA and/or DOD may well have to fully develop many of those new technologies before they find their way into commercial use. In item 1, the efficiencies and lifetimes quoted for unspecified "microwave amplifiers" seem to apply more to TWTA's rather than GaAs FET SSA's which would have lower efficiencies but probably higher reliability and longer lifetimes, and which are likely to increasingly replace TWTA's in satellite applications. In item 3, the first intersatellite links may well be at 23 GHz rather than 60 GHz (millimeter) or optical frequencies. The 44/20 GHz frequency pair to be used for MILSTAR and the NASA-sponsored 30/20 GHz frequency pair which may be used on DSCS III Block E should arrive far in advance of the 50/40 GHz frequency pair cited in item 4. The feed arrays cited in item 5 are likely to be all solid state at C, Ku, or Ka-band and not involve TWTA's. The conversion efficiency percentages cited in item 9 seem to be high. However, GaAs solar cells will provide a substantial improvement over silicon solar cells in efficiency and in radiation resistance if they can be mass produced economically.

None of the technologies cited are directly related to the presence or absence of a space station.

Section III., <u>Summary Observations</u>. Items 1 and 2 seem to restate previous technology trends. Items 3 and 4 address the perigee impulse and apogee impulse functions required to reach geosynchronous orbit. The wide-bodied Centaur, if successfully developed and integrated into the Shuttle, may well provide too much performance at too high a cost for the majority of communications and meteorological geosynchronous satellite missions. However, with its large payload capability (e.g., 12,000 to 15,000 lbs. to geosynchronous orbit) plus its multiple firing and high escape velocity capability, it should be invaluable for boosting large, compact payloads (e.g., a space platform into geosynchronous orbit, a military satellite into a 12 hour orbit, or an interplanetary probe).

In summary, while we agree with your main thesis regarding the need for a space station, the commercial communications satellite community will probably apply several tests such as the following, to evaluate and determine the need for manned intervention in LEO by either a shuttle or a space station crew:

1) Is manned intervention essential to or will it greatly enhance the success of the mission?

2) Will manned intervention actually reduce mission risk?

3) Can manned intervention reduce total mission cost?

4) Can men provide sufficiently unique services to overcome unmanned spacecraft autonomy performance/cost advantages?

Page Four
William D. Houser
February 22, 1983

For the bulk of the commercial communications satellites in the 80's and 90's, it may not be possible to answer these questions affirmatively. However, for the exceptionally large spacecraft, manned intervention in LEO may become essential for mission success.

Very truly yours,

Lee M. Birchall

AT&T Long Lines
Bedminster, New Jersey 07921
Phone (201) 234-4500

B. B. Oliver
Vice President
Planning and Design

February 24, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
COMSAT General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Mr. Houser:

This is in reply to your letter of February 3, 1983 addressed to Mr. Villiere concerning the use of manned space stations in low earth orbits for commercial communication satellites. You asked for our views concerning the projections made in the attachment.

We believe that your international satellite forecasts are based on the latest Intelsat Global Meeting, which was attended by people from both of our organizations. Mr. R. B. Nichols, Vice President, Overseas, furnished our circuit requirements at this meeting. We are not in a position to comment on U.S. Domestic or other countries' Domestic and Regional projected satellite communication requirements.

However, we would like to point out that recent advances in domestic satellite modulation techniques, such as compandored single sideband, are capable of handling four times the capacity of FM systems now in use. We believe that they may also be economic for overseas satellite communication. These techniques should be considered in your future satellite forecasts if this has not been done.

We wonder if the costs of a "man rated" space vehicle in low orbit might not add more to the costs than several conventional satellites operating in a cluster. Finally, we would suggest that the impact of other modern transmission systems on future satellite systems requirements be examined if this has not been done.

You have taken on an ambitious job in helping NASA determine the requirements for this undertaking, and we wish you luck in this endeavor.

Sincerely,

B. B. Oliver

ASTRO

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William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington D.C. 20024

February 23, 1983

Dear Mr. Houser:

Your telex to Mr. J. B. Howe of RCA in Camden has been forwarded to me for response.

The Comsat General "Prospectus" has been carefully reviewed by several of us at Astro and by Americom. Our consensus is that the document is fundamentally sound and is extremely well written. We are substantially in complete agreement with the observations and conclusions. The conclusions also are in line with the outputs of a number of National Research Council Summer Study Groups dealing with related questions.

I believe that RCA might voice even stronger emphasis to the point expressed in Section V(1.) and numerous other places, namely, that economic access to geostationary orbit is of overriding importance to commercial communications satellite owners. If low orbit space stations contribute to lower total system transportation costs, then they will have an impact on the commercial satellite world. It seems highly unlikely, however, that this will come to pass before the turn of the century.

Sincerely,

Charles A. Schmidt

RCA

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TRW

17 February 1983

William D. Houser
Vice President
Systems Technology Service
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington D.C. - 20024

Dear Mr. Houser,

George Solomon asked me to provide the TRW response to your recent request for comments on your "prospectus" that describes potential contributions to commercial communications satellites provided by low-orbit manned space station(s).

First let me compliment your group on its excellent prospectus. Our few comments herein are relatively minor and primarily suggest elaboration on your main conclusions, all of which seem consistent with our own views.

We concur with your conclusion that an important eventual operational benefit of using the space station for commercial communications satellites may be in assembly and checkout of large antennas. Along that line, you may find it desirable to add some brief statement to your prospectus that reflects the results from relevant recent TRW studies carried out for NASA Lewis, and extensions thereof, described in the attachment herein.

As a second point, the prospectus mentions potential benefits from fueling the geostationary communications satellite at the low-altitude space station node. It may be desirable to clarify the intent of this point, since there is no theoretical advantage in separating the transfer-orbit fuel from the communications satellite during an STS ascent to low orbit, just so long as the communications satellite in geostationary orbit is below the approximately 10,000 lb limit of the STS/Centaur.

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William D. Houser
17 February 1983
Page 2

As an added bonus, your projection of the types, numbers and technology of commercial communications satellites through the end of this century should be a landmark reference to be widely utilized for several years.

We will be most happy to assist you further in any way you may desire.

Very truly yours,

Harold S. Braham
Manager, Communications Satellite Systems

Attachment

cc: G. E. Solomon
R. G. Williams

ATTACHMENT

• LAND MOBILE. Our current NASA study "Requirements For Mobile Communications Satellite Systems" has shown the following potentially attractive alternative to the long-discussed MOBILSAT that requires the 50 to 150 meter antenna cited in your "prospectus". This alternative is based on cellular radio and associated terrestrial systems soon to be deployed. Cellular radio is expected to cover 10% of the U.S. land mass in densely populated areas that comprise 60% of the U.S. population, while using terrestrial long-distance interconnect from each base station. A similar system of mobile terminals is expected to later cover an additional 50% of the U.S. land mass in areas of modest population that comprise virtually all the remaining 40% of the U.S. population, where the long distance interconnect from the base station could be provided by conventional existing satellites. These systems are expected to be deployed long before the large MOBILSAT. If one insists on later serving the remaining small number of mobile users located in the most rural areas not covered above, a low-capacity, direct-to-user MOBILSAT could achieve this employing power and antenna size used in conventional commercial comsats, or about 4.5 meters and 1800 watts. Hence you may wish to add a sentence acknowledging that while the large-aperture, high-power MOBILSAT might advantageously utilize the space station for assembly, such potential benefits evaporate if long-distance mobile communications is implemented primarily from a cellular-type system that is augmented by a MOBILSAT of conventional spacecraft size for the relatively few mobile users located in the most remote regions.

• FIXED SATELLITE SERVICE. TRW has over the last three years conducted studies for NASA on characteristics of potential operational Ka-Band satellites that would provide frequency re-use via scanning-beams and trunking spot-beams. Representative spacecraft antenna parameters are 0.3° beams, each covering 1/200 the U.S., using 4 meter offset antennas at 20 GHz and 3 meter offset antennas at 30 GHz. To achieve the low sidelobes required for frequency re-use, two transmit and two receive antennas seem necessary to limit scan angle to acceptable values. This system of four 3 to 4 meter offset antennas, though complex, seems not to require assembly in orbit.

On the other hand, it is entirely possible that a similar system using about the same beamwidths at Ku and/or C-Band might be deployed in the 1990's in order to both avoid the rain outage problems of Ka-Band and to utilize the large investment in existing terminals. Each individual offset antenna of this four-antenna system now becomes about 7 meters at Ku-Band, and 13 and 20 meters for receive and transmit at C-Band. These large, complex, multiple-antenna systems with very precise tolerance requirements may well find great advantage from assembly in orbit.

H. S. Braham
Attachment
Page 2

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The need of assembly in orbit is greatly accentuated if one reduces the spacecraft antenna beamwidth by another factor of two (say to 0.15° to permit complete frequency re-use by spatial isolation between nearby eastern metropolitan areas). This requires a doubling of aperture size and a possible quadrupling of number of antennas. The result at any frequency is a 16 antenna system, 8 of which are 40 meters at C-Band, 13 meters at Ku-Band, and 8 meters at Ka-Band. All these complex antenna systems, even the Ka-Band system, may require orbital assembly to achieve acceptable risk.

To summarize, there has been a dramatic previously-unforseen growth in demand and capacity in domsats since their inception about a decade ago. If services such as teleconferencing become heavily utilized in the next decade, greatly increased orbital channel capacity will be needed. While Ka-Band may be a partial solution, heavy frequency re-use of C and Ku-Band may be needed, with attendant large complex antenna systems that may find great advantage using orbital assembly from a low-altitude space station. We think it is worthwhile that this possibility be briefly captured in a sentence or two in your prospectus.

TELEPHONE CALL FROM MR. ROSEN, VICE PRES.-ENGRG.,, SPACE AND COMMUNICATIONS, HUGHES AIRCRAFT CORPORATION, CALIFORNIA: (Tel: 213-648-4782)

REF: MAILGRAM SENT RE: NASA SPACE STATION

"I HAVEN'T FOUND ANYONE IN MY GROUP WHO CAN THINK OF ANYTHING USEFUL TO DO WITH THE SPACE STATION. NONE OF US FEEL IT IS APPLICABLE IN ANY RESPECT TO THE COMMERCIAL COMMUNICATIONS SATELLITE BUSINESS AS WE SEE IT NOW."

B.

2/23/83 - 2:15 p.m.

REPLY VIA WUI-TIME TO
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0729 EST.
COMSAT 6 WSH

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NICATIONS

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GREENWIC

ATTENTION: MR W D HOUSER
VICE PRESIDENT
SYSTEMS TECHNOLOGY SERVICES

FROM: O LUNDBERG

REF: 121/SD316A/RCP/CP

DATE: 2 MARCH 1983

SUBJECT: FUTURE COMMERCIAL COMMUNICATIONS SATELLITE PROJECTIONS

THANK YOU FOR THE OPPORTUNITY TO COMMENT ON YOUR DRAFT SUBMISSION TO NASA WHICH WE HAVE READ WITH INTEREST.

I WOULD LIKE TO SUGGEST SEVERAL SMALL CHANGES SO AS TO REFLECT MORE ACCURATELY THE CURRENT AND ANTICIPATED FUTURE NEEDS OF INMARSAT.

PAGE 2, SECTION 4:
;;;;;;;;;;;;;;;;;;
THE FIRST GENERATION INMARSAT SPACE SEGMENT, CONSISTING OF THREE MARISAT, FOUR SPECIALLY EQUIPPED INTELSAT V SATELLITES AND TWO MARECS SATELLITES, WILL SERVICE MARITIME MOBILE COMMUNICATIONS REQUIREMENTS UNTIL THE END OF THE 1980'S.

PAGE 2, SECTION 5
;;;;;;;;;;;;;;;;;;
A MINIMUM OF SIX NEW SECOND GENERATION INMARSAT SATELLITES (700 KG CLASS) WILL BE LAUNCHED BEGINNING 1988 TO MEET THE PROJECTED DEMAND UP TO AROUND 1995.

I HOPE THE ABOVE COMMENTS WILL BE USEFUL TO YOU AND ARE NOT TOO LATE TO BE TAKEN INTO ACCOUNT.

REGARDS
NNNN.
COMSAT 6 WSH

297201 INMSAT G

STC **Satellite Television Corporation**
A COMSAT Subsidiary
1301 Pennsylvania Avenue, NW, Suite 1201
Washington, D C 20004
(202) 626-3540

RICHARD S. BODMAN
President

February 18, 1983

Mr. William D. Houser
Vice President, Systems Technology Services
COMSAT General Corporation
950 L'Enfant Plaza, S. W.
Washington, D. C. 20024

Dear Mr. Houser:

Thank you for giving me the opportunity to review COMSAT General' "prospectus" of the benefits that a manned Space Station would have for communications satellites. My principal reaction is that I am fully in accord with your conclusions -- namely, that a Space Station will be of interest to commercial satellite owners only if there are demonstrable benefits and cost savings. I also found the paper accurate, readable and informative; the forecasts presented for communications satellite services and technology provide a strong base for the conclusions reached in the paper.

There are a few comments or questions which may improve the paper. They are listed below and, as you will note, are all of a minor nature:

a) Section I.B.1. Does the 11% growth for U.S. satellite video include DBS?

b) Sections I.B.2 and I.C.2. Do the satellite mass distributions take into account the new PAM-D-II?

c) Section I.B.6. I would recommend that the 1990-1995 period for C- and Ku-band saturation be changed to 1990-2000. Given the gross uncertainty in demand and also the uncertainty in the capacity growth of these bands due to closer satellite spacing, saturation may not occur until the late 1990's.

d) Section I.B.10. I would recommend softening the direct relationship between geostationary platforms and conservation of the orbit/spectrum resource. There is considerable debate and uncertainty on this subject,* and I believe that a more prudent approach would be to say ".... may be constructed by the year 2000. Such platforms would achieve efficient connectivity and may provide conservation of the frequency spectrum and geostationary arc. The approach...."

e) Section VI.B.1. The relationship between the first and second sentence may be clearer if the words "should not result in" are replaced by "should be performed in a manner which does not lead to".

Again, I want to thank you for giving me the opportunity to review this material.

Sincerely,

Richard S. Bodman

*For example, the AIAA Space Systems Technical Committee recently elected not to prepare an AIAA Position Paper in support of geostationary platforms, in large measure because of this uncertainty.

GENERAL ELECTRIC
COMPANY
SPACE SYSTEMS DIVISION
VALLEY FORGE SPACE CENTER
P O BOX 8555 PHILADELPHIA, PA 19101

February 16, 1983

A. J. ROSENBERG
VICE PRESIDENT AND
GENERAL MANAGER

Mr. William D. Houser
Vice President
System Technology Services
Comsat General Corporation
950 L'Enfant Plaza (SW)
Washington, DC 20024

Dear Mr. Houser:

We are pleased to respond to your letter of February 3, 1983 requesting our views and comments on the projections made in your "prospectus". We regard the permanent, manned Space Station to be an important national objective, and also particularly important to the communications, manufacturing, and scientific communities of which General Electric is a part. As you may know, General Electric's Space Division has supported NASA studies for utilization of man in space for the past 10 years and currently is teamed with Grumman and Comsat on the NASA Space Station Needs and Attributes Study.

Our response to your inquiry is contained in the following paragraphs which present views and comments keyed to the specific paragraphs of your prospectus entitled "Manned Space Station Relevance to Commercial Telecommunications Satellites: A Prospectus to Year 2000".

I. Future Commercial Communication Satellites Projections

Your projections of (A) 44 new and replacement INTELSAT satellites and 9 new INMARSAT satellites, (B) 148 new and replacement C-Band and K-Band satellites for the U.S. communications market (fixed and broadcast services) and (C) 176 "Other Countries" domestic and regional communications satellites for a (D) total of 377 spacecraft by the end of this centruy presents a truly extensive commercial market and a thought provoking situation.

Although we do not have detailed INTELSAT or INMARSAT planning information, it appears that the INTELSAT, INMARSAT, and U.S. Communicatioins Satellite market that you portray is a realistic estimate, and historic data and growth projections support these predictions at least on a macroscopic scale.

Mr. William D. Houser
February 16, 1983
Page 2

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Item B10, a prediction of use of one or two large geostationary platforms servicing diverse communications payload, must be treated with some caution. Present trends in the satellite communications industry are to continue separate ownership roles for these facilities and to improve, as necessary, the satellite capacity assigned to each orbital slot. In the future these individual satellites will make use of the technology you have identified in A6 and A7 to increase the capacity per orbital station, and to maintain orbital diversity which is believed to be in the public interest. We perceive no discernible trend in the U.S. away from the present arrangement of separate ownership of multiple satellites to a concentration of services on one or two large capacity geostationary platforms with ownership by a consortium or carriers carrier.

It is worthy of note that we specifically believe that the Space Station would be useful in serving as the base for the OTV and Manned-OTV, which will undoubtedly be used to service the Large Geosynchronous Platforms, as referred to in Item #B-10 of the subject letter. (Reference for Platform Concepts: "Experimental Geostationary Platform System Concepts Definition Study", Report No. GDC/GPP-79-015.)

Your conclusions in Paragraph D are well stated and GE agrees with them.

II. Future Technology Trends that Impact Commercial Communications Satellites

(2) Our comment here is that multibeam antennas at 6/4 GHz and 14/12 GHz are used extensively by INTELSAT but have only begun to be used at 14/12 GHz for U.S. satellites. We expect more extensive use of multibeam antennas in the U.S. market, first at K-Band, and finally at C-Band. This use by "other countries" will likely follow after the U.S. use.

In addition to the technology trends which are listed as having an impact on the communication satellite evolution, I would suggest the use of laser optical communication for space-to-space communication relay links.

(4) Our comment here is that the introduction of high capacity 30/20 GHz systems in the 1990-1995 time frame will surely delay introduction of 50/40 GHz fixed-satellite service systems to the next century rather than the late 1990's.

Mr. William D. Houser
February 16, 1983
Page 3

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IV. Space Station Capabilities and V Space Station Capabilities of Potential Interest to Commercial Communication Satellite Owners

As we understand it, Item IV-2 defines a space station capability to service retrieved satellites (without specifying the orbits from which these satellites are retrieved). However, V, which concerns "Space Station Capabilities of Potential Interest...", makes no mention of application of this retrieval and repair capability. We believe this capability would be of benefit to the system owners, may be cost effective, and can be developed in an evolutionary manner starting, for example, with selected satellites in or near the Shuttle Orbit but also could extend to large geosynchronous platforms as mentioned previously.

VI-A2 -- We suggest that frequency reuse at C-Band via multibeam antennas also will require deployment of large antenna apertures and need may occur in the late 1980's to early 1990's. Consequently, in 3, NASA orbital demonstrations of large antenna deployment may be required earlier than your stated 1990 time period.

B2 -- We believe the timing of those missions "stopping" at the Space Station may occur sooner than the late 1990's. Certainly large, high powered broadcast satellites, C-Band satellites with deployable antennas and land mobile satellites can have needs for Space Station services before the late 1990's.

C1 -- We suggest that the timing in the paragraph should be the early 1990's.

We commend Comsat General on its thorough comprehensive report and your commitment to support this important national objective. We at General Electric appreciate this opportunity to participate and hope that our comments are a positive contribution.

Sincerely yours,

American Broadcasting Companies, Inc. 1330 Avenue of the Americas New York, New York 10019 Telephone 212 887-7777

Dear Mr. Houser:

Your recent letter to Mr. Barnathan has been forwarded to me for appropriate consideration.

ABC is pleased to be asked to comment on the draft of "Manned Space Station Relevance to Commercial Telecommunications Satellites: A Prospectus to Year 2000."

Please accept our compliments on the thoroughness of your study. We have taken the liberty of making some suggestions to the language to improve clarity. These have been incorporated on the draft.

We note that this proposal will probably complement a report we had the pleasure of reading on a space platform which was advanced some time ago by Dr. Satyendranath Das of the Office of Science and Technology of the F.C.C.

It seems to us, we should plan now for the potential benefits available in the late 1990's from satellite servicing, in-space assembly, repair and checkout, and satellite fueling.

John Serafin
Manager, Allocations and Licensing

Mr. William D. Houser
Vice President, Systems Technology Service
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

February 8, 1983

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Attachment.

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PUBLIC SERVICE SATELLITE CONSORTIUM

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CORPORATE HEADQUARTERS

Suite 907

TELEX 4991315

TECHNICAL CENTER

Avenue

7 February 1983

William D. Houser
Vice President
Systems Technology Services
COMSAT General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Bill,

I am replying to your letter of 3 February, requesting our review of your assessment regarding manned space stations in low earth orbit for commercial communications satellites.

In general, we agree with your projections of satellites and services.

We see little evidence, however, that (note paragraph #10, p. 5) -- "One or two precursor large geostationary platforms servicing diverse communications payloads may be constructed by the year 2000 . . . ." There seems to be little Congressional support for NASA to being work on space stations, and there is little evidence that the costs would be outweighed by the benefits. If space stations are going to be built, it seems increasingly likely that even the initial research and development work will have to be done by private industry.

One of the critical questions that remains unanswered (and to which your paper does make reference) is that we do not know whether there are likely to be significant shifts in costs of launching and operating domestic communications satellites with the advent of LEO space stations. Some economic justification will have to be provided before large investments are likely to be made, in our opinion.

Thank you for giving us the opportunity to comment on COMSAT General's analysis.

Sincerely,

Elizabeth Young

Elizabeth L. Young
President

21 February 1983

Space Services Inc. of America
P.O. Box 4
Houston, Texas 77001

Mr. William D. Houser
Vice President, Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza S.W.
Washington, D.C. 20024

Dear Mr. Houser:

David Hannah, Jr. asked me to respond to you directly relative to your prospectus regarding Manned Space Station relavance to Commercial Telecommunication Satellites.

The subject prospectus is considered to be very well prepared. With regard to projections of future commercial communication satellites the numbers and masses are considered reasonable, as is the discussion of future technology trends.

We concur with the discussion of space station capabilities of potential value to commercial communication satellites. It is very difficult to envision any cost or risk advantage of using a space station as a way station for the operational satellites that you have projected. It's value will be in its use as an orbital R & D laboratory until such time as very large and complex systems need to be assembled in orbit.

In several places the report refers to use of "Space Shuttle or Ariane III or IV " with the apparent reason to show that no new launch vehicles need be developed. In view of the fact that very active discussions are currently underway regarding commercialization of the United States expendable launch vehicles you may wish to modify this phase. It is believed that the Titan and Atlas II-Centaur programs being proposed can also launch all of your projected satellites and Delta can handle 103 of them.

Thank you for providing us the opportunity of commenting on your prospectus.

Sincerely,

Lee Scherer

Lee R. Scherer

LRS/kr (Consultant to Space Services Inc. of America) pme

Office of the Chairman
P O Box 4
Houston Texas 77001
713-524-4676

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Dallas, Texas 75201
214-698-9722

Government and Public Affairs
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2550 M Street N W
Washington D C 20037
202-659-0988

SPACE SERVICES INC OF AMERICA

18 February 1983

William D. Houser
COMSAT General Corporation
950 L'Enfant Plaza SW
Washington, D.C. 20024

Dear Mr. Houser,

I am responding to your letter of 3 February 1983 requesting our comments on your prospectus to NASA regarding permanent, manned space stations. I had a conversation today with your office in an attempt to clarify exactly what you wish from us. As you know, we have no plans to get into the space station business and were not sure we had anything to contribute to the document you submitted to us. I understood your prime interest was an indication of support of lack thereof for a manned NASA space station.

As I am sure you would presume I am an avid supporter of manned space operations, having spent 23 years in the business myself. I believe man can contribute significantly to the reliability and flexibility of any space system. I would also expect that a combination of Shuttle and a large orbiting base would result in decreased costs for most future systems. If this was the vote of confidence you were looking for, you have it. I believe your document adequately addresses projected capabilities and your analysis of this relationship to commercial communications satellites obviously requires no comment from us.

Sincerely,

D K Slayton

Donald K. Slayton, President
Space Services, Inc., of America

DKS/bo

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SATELLITE SYSTEMS ENGINEERING, INC.

Suite 520E
7315 Wisconsin Ave.
Bethesda, Maryland 20814
Tel: (301) 652-4660
TWX (710) 824-0096

February 9, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Bill:

I think your space station report is a pretty good job. Some pencilled comments are in the margins.

Will you send us a final copy as it is submitted? Glad to be of help.

Cordially,

Bill /dd

Wilbur L. Pritchard
President

WLP/dd/2870

Enclosure

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CITIBANK

February 23, 1983

Mr. William D. Houser
Vice President
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Mr. Houser:

Your letter of February 3 1983, to Anthony Howkins has been forwarded to me for comment.

Upon review of the document attached "Manned Space Station Relevance to Commercial Telecommunications Satellites: A Prospectus to Year 2000" we are generally in agreement with your projections of satellite requirements through the mid 1990's. Furthermore, your projection of 15% annual growth in telecommunications usage is consistent with our own projections.

We must agree with you that there is no quantitative demonstration of commercial validity of low-orbit earth stations. As you state, the case has to be proven to the business community, and we would think that exploratory efforts in this area would be extremely beneficial.

The only comments we could make concerning the future of satellite demand is that alternative technologies must be considered in the analysis. Optical cable is an example of technology which could potentially off-load satellite traffic.

Should you require any further assistance, please contact me directly.

Yours truly,

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95 WALL ST., NEW YORK, N.Y. 10005
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March 8, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Mr. Houser:

RE: MANNED SPACE STATION PROJECT
<u>INSURANCE EVALUATION</u>

Thank you for your letter of February 18, 1983 regarding the captioned project. The Johnson & Higgins Space Systems Group has reviewed the documents you forwarded and would like to offer the following comments:

1. Forecasting in telecommunications is a risky business at best. Demand variations, as well as the potential for new or developing technologies, such as fiberoptics, make accurate domestic and international projections difficult. However, we are in agreement with COMSAT's 377 satellite traffic projection up to the year 2000 and suggest that recent trends towards launch vehicle commercialization (i.e. Titan, Atlas-centaur, Delta) could facilitate near-term deployment of materials processing spacecraft in addition to Telecom satellites.

2. We agree with COMSAT's mass in orbit projection indicating a constant increase in spacecraft weight. Future use of bandwidths beyond the present C and KU bands will demand increased satellite power and, hence, increased weight.

3. Capacity demand, both Internationally and in the U.S., will necessitate the exploration of all types of frequency use and re-use. Inter-Satellite links, such as those to be used by TDRSS, will be required to facilitate efficient satellite use. Space platforms could easily serve as switching centers for such inter-satellite traffic.

JOHNSON & HIGGINS

Mr. William D. Houser
Systems Technology Services

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4. To speed up in-orbit (LEO) check-out of satellites bound for final geosynchronous orbit, a manned platform - preferably coupled with either the OTV or MOTV - will be required and is desirable. From a launch insurance viewpoint, check-out/inspection of satellites at LEO would have a very significant effect on launch insurance costs. The use of an orbital transfer vehicle would further reduce rates if enhanced performance/reliability can be demonstrated.

5. Since the majority of losses have occurred within the launch phase - usually during the period from intentional ignition through 90 days at Geosynchronous orbit. By utilizing an intermediate check-out point, a satellite operator could reduce the overall launch exposure by allowing the satellite to be re-examined before movement from LEO to final station.

6. In-orbit failure (or satellite life insurance) has remained a loss-free area since the first "life" policy was placed in 1975. Intermittent transponder failures, however, have occurred and system planners still rely heavily on spare TWTA/Transponder and in-orbit satellite spares. A space station, able to reach and repair defective satellites in Geosynchronous orbit, represents an alternative loss-control option to satellite system operators. In-orbit insurance could be tailored to respond to the cost of repair as opposed to the cost of launching an entire replacement spacecraft.

7. In developing such a project, NASA must adhere to a "demonstration policy" to the private sector. If commercial involvement in space platform use is desirable, NASA must verify the overall utility and reliability of space station use. The insurance industry, in particular, must be shown the risk-reducing effect of LEO check-out. Exclusive use of one facility, for example, could aggregate underwriters exposure to risk (i.e. - a single platform catastrophe could cause the loss of a number of visiting satellites).

8. Large off-shore oil platforms, when first introduced, were looked on with suspicion by both potential users and the insurance industry. Before demonstration and analysis by insurance companies, property limits of only $30-40 million were the maximum available in the world market for these platforms. Today, Johnson & Higgins has been able to place up to $1 billion in coverage for individual oil platforms in the North Sea.

Through the same educational/testing procedure, we believe NASA can achieve support from both commercial users and the world insurance community.

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Mr. William D. Houser
Systems Technology Services

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I hope these comments are helpful Please do not hesitate calling on us if further input is required. We are very enthusiastic about this project and feel such a station could provide both new opportunities (i.e. - materials processing) and a potential risk reducing element for the Satellite Telecommunications industry.

Very truly yours,

JOHNSON & HIGGINS

Alden M. Richards
Vice President
Manager - Space Systems Group

AMR/ab

Hartmut Hesse
Handlungsbevollmächtigter der Munchener Ruckversicherungs-Gesellschaft

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Datum 2.28.83

Dear Mr. Houser,

Many thanks your kind letter dated February 18, 1983 and the attached forecast of future trends in space technology, which I have read with great interest.

Being a member of the insurance industry, however, our knowledge about the growth potential of space flight activities is very limited and therefore I only can assure you that, from a layman's point of view, your forecast seems to be very realistic to me.

Sincerely yours,

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza SW

Washington, D.C. 20024

USA

P.S. We certainly consider ourselves to be one of the leading companies in the field of space flight insurance and if you have any specific queries in this area don't hesitate to contact me again.

Inspace
Corroon & Black/Inspace, Inc.

March 2, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Mr. Houser:

Thank you very much for your letter of February 18, regarding the use of manned Space Stations in support to commercial communications satellites.

I would very much like to support your effort, even as part of the study team, but do not believe that we can do justice to your request in the short time available.

Regretfully therefore I cannot offer any constructive advice at this time, although from a personal viewpoint your system and technology projections both seem very reasonable to me.

Yours sincerely,

Corroon & Black Inspace, Inc.

BRIAN STOCKWELL
President

BS:ades

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Telephone (202) 479-4100 International Telex 440073 INSPC UI
A SUBSIDIARY OF CORROON & BLACK CORPORATION

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STEWART SMITH EAST INC.
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123 WILLIAM STREET NEW YORK NY 10038 TELEPHONE 212 964-2929
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March 1, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'Enfant Plaza, S.W.
Washington, D.C. 20024

Dear Mr. Houser:

Pursuant to your letter of February 18, 1983, concerning permanent, manned Space Stations, this letter briefly sets forth our thoughts with respect to your projections and their implications for the insurance underwriting community.

At present insurance capacity levels, given ever increasing insurable values, your traffic projections alone will challange our industry to generate the needed capacity at an economic rate level. We see our industry meeting this challange in the future for two basic reasons:

1) Improved Technology
2) The reliability of STS

The creation of a low earth orbit space station with the ability to perform satellite servicing, in-space assembly, repair and checkout and satellite fueling, if demonstrated to be beneficial from a risk reduction standpoint, would give our industry the necessary incentive to continue providing insurance capacity (at higher levels) at affordable rates. The proviso here is that over the next decade, due to improved technology and STS successes, insurance loss experience hopefully will improve from its current state and a healthy insurance market will be available to meet future needs.

Very truly yours,

Corrado E. Mezzina
Vice President-Aerospace

CEM:jb

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FROM AVN DEPT

ATT DR WILLIAM D. HOUSER

SUBJ. MANNED SPACE STA. FOR COMM. ACTIVITY

MANY THANKS FOR YOUR LETTER FEB 18 AND THE ATTACHED STUDY. REGRET FOR DELAY IN ANSWERING, BUT SAME RECEIVED ONLY TWO DAYS AGO. I HAD YOUR DOCUMENT STUDIED BY OUR EXPERTS AND THEY FOUND IT VERY COMPREHENSIVE AND BASED ON ANY POSSIBLE OBJECTIVE ASSUMPTIONS WHICH CAN BE AT PRESENT MADE.
THE OUTCOMES OF MANY REPORTS PRESENTED DURING MAR 3-4 CONFERENCE, WE ORGANIZED IN ROME, CONFIRM IN THEIR MAIN LINES THE PERSPECTIVES INDICATED IN YOU STUDY.
I HOPE TO HAVE AN OPPORTUNITY TO MEET YOU AND EXCHANGE OUR VIEWS ON PARTICULAR SUBJECTS IN THE NEAR FUTURE.
BEST REGARDS
PAGNANELLI / GENERALI

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Alexander & Alexander

March 4, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Corporation
950 L'enfant Plaza, SW
Washington, DC 20024

Dear Mr. Houser:

Thank you for your letter of February 18, 1983 addressed to Richard E. Lynn. In Mr. Lynn's unexpected absence, I am responding in order that we may comply with your requested response date.

Given that our area of expertise is in insurance, the following comments have been made based on the technical projections set forth in your Prospectus.

Should you wish that we expand any of our comments or wish to discuss same, please do not hesitate to contact us. Thank you for this opportunity to be of assistance to Comsat.

Yours truly,

Robert J. Tirone
Vice Presient

RJT/ts

MANNED SPACE STATION
IMPACT ON INSURANCE CONSIDERATIONS
FOR COMMERCIAL TELECOMMUNICATION SATELLITES

1. General Insurance Considerations to Year 2000

The insurance market for commercial Telecommunication Satellites is currently in its early development stages. Both the Space Shuttle and Ariane are, in insurance terms, relatively untried launch systems. As a result, insurance costs constitute a significant percentage of the cost of launching a commercial Telecommunications Satellite.

This situation will certainly change over the next decade and it can be expected that insurance costs directly related to the Launch Risk will be greatly reduced by the 1990's. This reduction will manifest itself in the rate charged to the owner of the Satellite and not necessarily in the amount paid in premium. Current rating as well as insurance capacity restrictions have so far precluded any satellite owner from insuring its satellite for its full commercial value. As rates fall and capacity increases in the future, we will see a very significant increase in the insured value of satellites.

We expect that due to the continued technological advances as well as the increasing frequency of launch of insured satellites and the resultant reduction in insurance rates that insurance cost considerations will not be of the same magnitude in the year 2000 that they are today.

2. Specific Impact of Manned Space Station on Future Insurance Considerations

Having established that insurance cost considerations will not be as important in the future, our subject here is Commercial Telecommunication Satellites and as such all cost considerations will be of importance to the owner/operation.

Before discussing the specific impact of the Manned Space Station, the following overriding consideration must be noted. The insurance industry has shown little inclination to participate in the experimental stage of any type of program. This can be best illustrated in today's Aerospace Market by comparing the launch insurance rates available to users of the proven Delta vehicles (e.g. 8-9 percent) with those available to users of the Ariane vehicle (e.g. 12.5 - ? percent). Accordingly it can be expected that if the Manned Space Station is immediately put to use in the commercial arena, without a full testing period involving non-commercial (i.e. Government, or Military) satellites, the insurance industry may treat it as an experimental operation with resulting high rates for the first few satellites until the insurers are prepared to accept the Manned Space Station as proven technology in insurance terms.

A. **Launch**

The Launch phase of any operation, which is in insurance terms the period from intentional ignition until arrival at the assigned orbital slot, is the largest rating component. This rating can be further broken down into the initial launch and the AKM Burn.

The use of a Manned Space Station would have little impact upon the rate component assigned to the initial launch risk. It would obviously allow an inspection of the satellite to determine if any damage was suffered during the launch thereby inproving the possibility of placing the satellite in its final orbit but would not change the actual launch exposure.

The use of the Manned Space Station to assemble satellites could favorably impact launch rates in that the launch of partially assembled satellites and/or spare parts would reduce the catastrophic loss possibilities. In summary, the use of the Manned Space Station would have a marginal but positive effect on the initial Launch Phase.

There would be a more favorable effect on the rating component for the AKM stage of the operation. As mentioned above, this would result primarily from the opportunity to inspect the satellite and repair any launch damage. In addition, the use of a Manned Space Station to assemble and/or fuel satellites would reduce insured risk.

B. **Deployment**

The Deployment of solar arrays, antennae, etc. is one of particular concern to insurers in this phase of operation the use of the Manned Space Station could have significant favorable impact on insurance costs. Deployment and/or assembly of these and similar parts of the satellite while still under control and before transfer into Geosynchronous Orbit would eliminate most of this exposure for underwriters and thereby eliminate most of the rating component assigned to Deployment.

C. **In-Orbit Failure (Satellite Life Insurance)**

Insurance rating applicable to in-orbit failure (either partial or total) is predicated on the fact that the vast majority of such events are not repairable. The use of the Manned Space Station, integrated with a method of retrieving damaged or malfunctioning satellites would force a change in the approach to insuring in-orbit failure. While the precise reaction of insurers to the use of a usable orbital transfer vehicle or a manned orbit transfer vehicle is impossible to predict, it would certainly significantly reduce insurance rates that would be applicable in the absence of such systems.

D. Summary of Potential Benefits

The use of a Manned Space Station as outlined above would have a favorable effect upon insurance costs to the operator of a commercial Telecommunications Satellite. This favorable effect will be felt in each specific area of risk (as now interpreted by Insurers) to differing degrees with a significant commulative reduction in rate.

In addition and perhaps ultimately of more importance is the increased confidence the insurance industry has shown when dealing with a Manned System. While the only example to date is STS, there can be no question that the use of a Manned System, to the maximum extent possible, in the establishment of Commercial Telecommunications Satellite Systems, is a development of extreme importance to the Aerospace Insurance Industry.

Lexington Insurance Company

100 Summer Street
Boston, Massachusetts 02110
(617)/956-4200

A Member Company of
American International Group

March 8, 1983

Mr. William D. Houser
Vice President
Systems Technology Services
Comsat General Coporation
950 L'Enfant Plaza S.W.
Washington, D.C. 20024

Dear Mr. Houser:

Mr. T. Levandowski has asked me to prepare a response to your February 18th letter to him re: Manned Space Station Relevance to Commercial Telecommunications Satellites. It's unfortunate that the time constraints are so tight as the projections in your prospectus deserve a thorough review and careful consideration both as to scope and implications. However a few observations can be made readily.

1. Cost base which communication satellite service prices would have to cover, would be affected by other manned station missions. Other ventures such as orbiting "factory" development and support could impact prices both through competition for scarce resources and through providing a revenue contribution toward fixed costs. Thus a review based solely on commercial telecommunications considerations risks erroneous conclusions based on too narrow a focus.

2. In a satellite population as large as you project there will inevitabley be some partial or total failures. The possibility of orbital service/repair will affect the price and availablity of satellite insurance. To aid in evaluating this factor consider the following order-of-magnitude calculation:

   Assume: ½ of projected 377 satellites are in orbit and "alive" in a given year (say 1990).

   Average insured value per satellite is $50 M (this is a very conservative figure).

   In orbit annual premiums of 1% of insured value.

With these assumptions, the 1990 premium volume for in-orbit coverage would be:

$$\tfrac{1}{2}\ (377)\ (50,000,000)\ (.01) = 94,250,000$$

The impact of evern a 0.1% change in rates would shift this figure by more than $9 million dollars.

The much more expensive launch insurance for the same year might easily bring the total for the year to $150 million. Clearly these sums provide strong financial incentive to seek methods to reduce risks, and consequently, rates. To the extent that the Station affects rates the communications satellite industry stands to realize a significant benefit by virtue of its existance. Please keep in mind that the above calculation is not intended to be a prediction of 1990 rates or premium, there are too many influencing variables to permit easy estimation. Rather, the above is a means of picturing the scale of magnitude of one financial element in the satellite economic equation.

3. The rate of technological development may well make retrofit of satellites a desirable option. With the manned stations and "modular" satellite design this option would be come a very real possibility. In addition to other benefits this approach would avoid the great expense of launch and insurance of a replacement spacecraft. The delivery and installation charges for a retrofit module would, reasonably, reflect a substantial savings over launch casts.

I hope the above proves of some value in your project. If you'd like to discuss these or other factors please feel free to call me.

Regards,

Robert Provost

Robert Provost
Space Technology Dept