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COMMERCIAL SPACE INFRASTRUCTURE: GIVING INDUSTRY A LIFT

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Session: Commercial Space Development

Introduction

Historically, the private sector's involvement in space-related commercial activities has been primarily in the fields of communications and, to a lesser degree, remote sensing and launch systems. But today there are other opportunities for space-oriented, profit-making activities. The provision of commercial infrastructure -- hardware and related integration services to support industrial research and product development activities -- is a potential revenue-producing industry.

The National Space Council defines five principal areas of commercial space activity -- satellite communications, space transportation, remote sensing, materials processing, and commercial infrastructure. This paper, in discussing commercial infrastructure, also addresses commercial space transportation (launch services). Discussed are private sector initiatives directed toward establishing a commercial space sector in the fields of commercial space transportation, upper stages, payload processing, launch facilities, and other facilities and equipment. Not discussed, but recognized as important elements of commercial space infrastructure, are the legal, financial, and insurance industries. Also not included in this paper are private-sector initiatives for financing projects primarily for government use where the government controls the design, development, and management of the project and repays the private sector entity for its initial financial investment.

Background

The government has traditionally developed, owned, and operated the space infrastructure needed to meet its own requirements. The first commercial space industry, commercial satellite communications, relied on the government for the launch vehicles, launch pad, communications, and ground networks necessary to conduct its business.

The development of the Space Shuttle provided both an additional space transportation element and a facility in which private companies could perform experiments, the results of which could have commercial applications. Recognizing the potential importance of such experiments,

and the high financial risk to companies engaged in such activities, NASA developed the Joint Endeavor Agreement (JEA) in the late 1970's. The JEA facilitates the use of Shuttle by the private sector for experiments with commercial potential. It is a no-exchange-of-funds cooperative agreement in which a U.S. domestic corporation and NASA mutually agree to pursue common program objectives and share responsibility and financial risk in a commercially oriented, space-related research and development (R&D) activity. McDonnell Douglas Astronautics Company (MDAC) signed the first JEA in January 1980, and later performed the first commercial research aboard the Shuttle, using their own payload specialist.

Early Efforts to Develop Commercial Infrastructure

It is useful to examine the experience of early commercial space infrastructure enterprises.

Upper Stages. Private sector development of upper stages was one of the earliest commercial infrastructure initiatives. MDAC developed the Payload Assist Module (PAM) which was marketed to commercial communications satellite owners for boosting payloads from Shuttle's low Earth orbit to geosynchronous orbit. Orbital Sciences Corporation (OSC) developed a solid propellant upper stage called Transfer Orbit Stage (TOS) at a time when NASA was considering the development of the stage for itself. TOS was developed under a cooperative agreement with NASA wherein OSC agreed to develop the stage with private funds. NASA agreed to provide technical monitoring of the TOS development and not to develop a competing upper stage. OSC planned to market the upper stage to commercial Shuttle customers with payloads too large to utilize PAM.

In August 1986, the White House announced that NASA would no longer routinely launch private commercial communications satellites on the Shuttle. This policy effectively killed the commercial market for PAM and TOS, and neither MDAC nor OSC was able to recoup its investments in these projects.

Earlier that year, NASA had selected TOS as the upper stage to launch the Mars Observer mission from the Shuttle. The mission was later transferred to the Titan, and TOS was reconfigured accordingly. NASA has also selected TOS for the Advanced Communications Technology Satellite, scheduled for launch in 1992. For all practical purposes, TOS has become an upper stage for government missions only.

Launch Services. During the late 1970's, a ground rule in the development of the Shuttle was that expendable launch vehicles (ELV) would be phased out and eventually terminated and that the Shuttle would be the single transportation system for the Nation. However, President Reagan announced a National Space Policy on July 4, 1982, which called for continuation of ELV activities until the Shuttle was fully operational.

Several private firms expressed interest in providing ELV services on a commercial basis. Eventually the government turned over the Titan, Atlas/Centaur, Delta, and Scout ELV's to their private sector manufacturers. Such transfer of ongoing programs developed by the government to the private sector constitutes "privatization," as opposed to activities in which the private sector funds development.

The private sector was also interested in developing space launch vehicles. Space Services, Incorporated (SSI), a Houston-based company founded in 1979, developed the Conestoga launch vehicle. NASA and SSI signed an agreement in September 1986, allowing use of NASA facilities for Conestoga launches.

Other firms seeking to enter this market in the early 1980's included American Rocket Company (AMROC) of Palo Alto, California (a hybrid rocket utilizing a combination of solid and liquid fuel), Pacific American Launch Services of Redwood City, California (a liquid-fueled fully reusable launch vehicle, the Phoenix), and Third Millennium, Incorporated, of Washington, DC (a reusable single stage spacecraft). These firms faced great difficulty in raising adequate capital to finance the development of their systems.

Platforms. SII, of Houston, Texas, planned the first privately-developed man-tended commercial platform in space. The Industrial Space Facility (ISF), to be launched from the Shuttle, would be available on a lease or service contract basis and provide a man-tended environment for research, development, and production-scale processing in space. ISF was to be 35 feet long and 14.5 feet in diameter, providing 2,500 cubic feet of pressurized working space. Up to 12 kilowatts of power would be provided by 2 solar arrays. ISF would operate at a 230-nautical mile orbit inclined at 28.5 degrees. Ultimately, 6 modules could be lined up and fly together without shadowing of the solar arrays.

NASA and SII signed an innovative first-of-a-kind agreement, which has come to be called a Space Systems Development Agreement (SSDA), in August 1985. Because SII would receive revenue as a result of its operations, it was not eligible for a JEA. But the high cost of Shuttle transportation imposed an up-front cash flow problem. NASA developed the SSDA to help new industries in this position through a deferred payment provision.

SSDA's are offered to eligible customers who are in the late development stage of R&D but who intend to realize revenue from the launch. The fly-now, pay-later aspect of these agreements helps the customer's cash flow problem while allowing NASA eventual recovery of costs. The agreement applies to the first flight(s) of a new industry with significant potential national economic or social benefit.

ISF was intended as a totally private venture. SII neither sought nor was promised a government market in their SSDA with NASA. However, when SII was unable to find a sufficient commercial customer base, it sought the government as an anchor tenant until the market developed. Unable to justify a sole-source procurement, NASA defined specifications for a Commercially Developed Space Facility (CDSF), for which ISF could be a candidate.

At NASA's request, both the National Research Council of the National Academy of Sciences and the National Academy of Public Administration studied the CDSF concept. Their findings, released in 1989, indicated that CDSF might be useful, but not for another 6 to 10 years. They also concluded that concepts of this type tend to grow, and the estimate made by SII that ISF could be built for approximately $1 billion (and leased to NASA for $700 million) would probably grow to $2.5 billion.

The government eventually abandoned the CDSF project. NASA concluded that it did not have an immediate requirement for the facility, and even if the costs did not increase the lease cost of $700 million would have to come out of the already hard-pressed Space Station Freedom budget.

Prior to CDSF, Fairchild Space Company had attempted to launch a commercial space platform business. Its LEASECRAFT concept was based on multimission modular spacecraft technology developed by NASA that would permit a LEASECRAFT to be serviced in orbit. It was the modular design of the Solar Maximum Mission satellite which enabled it to be successfully repaired in orbit in 1984. LEASECRAFT failed to attract adequate market interest and Fairchild delayed the project indefinitely.

Payload Processing Facility. Astrotech International developed a payload processing facility adjacent to the NASA John F. Kennedy Space Center that is capable of providing all prelaunch services required by communications satellites targeted for launch on U.S. launch systems. Obviously, Astrotech was severely impacted by the reduced number of payloads to be processed in the years following the Challenger accident, but they have remained in business.

Current Activities

In the last few years, commercial space enterprise has been characterized by less of the romantic optimism of the early 1980's and a more business-like application of investment criteria. Government is now able to help spread the risks involved in the early stages of new space ventures.

NASA's Efforts to Promote Commercial Infrastructure Development

It is important to encourage the commercial development of space infrastructure. From the government's standpoint, such activities result in new industries that benefit the national economy and provide the potential for the government to be a customer -- at a lower cost -- in the future. From the industry perspective, development and use of commercial infrastructure help relieve commercial space companies of the risk of preemption inherent in government infrastructure.

NASA's program for the commercial development of space helps industries develop commercial space markets and cost-effective commercial space transportation systems and infrastructure. The goal of the program is to create new products and services, leading to new markets and businesses. Activity in these new markets, in turn, stimulates increased demand for new and existing cost-effective space transportation and infrastructure.

The most comprehensive element of NASA's commercial development of space efforts is its Centers for the Commercial Development of Space (CCDS) Program. The 16 CCDS's, each based on a consortium of universities, industrial firms, and non-NASA government entities, are involved in research and testing phases of potentially commercially-viable technologies.

CCDS's, which were competitively selected, are funded partly through a grant program, each receiving approximately $1 million per year. The balance of the resources to operate CCDS's is provided largely by the

industrial affiliates in increasing proportion. Operating outside the normal government structure allows the CCDS's to develop, in a totally commercial fashion, the equipment, technology, supporting infrastructure, and transportation services which they have determined are necessary for their potentially commercial technologies.

Recent Efforts to Develop Commercial Infrastructure

Several interesting examples of low-cost infrastructure which will aid the growth of commercial space follow:

Launch Services. The government remains the primary customer for space launches. The government market provides a strong business base upon which these companies market their launch vehicles to private sector and international customers. It would be difficult or impossible for launch manufacturers to engage in this activity if they depended solely on sales to the private sector.

While the space launch market is dominated by government-developed vehicles, a number of entrepreneurial firms have been started to develop orbital and suborbital launch vehicles. SSI and AMROC have been joined by companies such as E'Prime Aerospace, Microsat Launch Systems, Incorporated, and OSC. Of these, only OSC has been successful in delivering a payload to orbit as of January 1991.

OSC, in partnership with Hercules Corporation, has developed the air-launched Pegasus which will provide a new, low cost launch system for government and commercial payloads. Pegasus flew successfully in April 1990, after being air-launched from a B-52 off the California coast. OSC is now in the process of developing Taurus, a ground-launch version of the Pegasus.

Space Data Corporation, a wholly-owned operating division of OSC, has developed the Prospector vehicle which will launch a sounding rocket mission, Joust-1, for NASA's CCDS's. The Joust-1 launch is scheduled for March 1991, and will provide 12-15 minutes of weightlessness.

In March 1989, the Consortium for Materials Development in Space, a NASA CCDS, successfully launched six CCDS-developed payloads on an SSI sounding rocket, Starfire. Eight members of U.S. industry, two other CCDS's, and three other universities were involved in the project. The suborbital flight, named Consort 1, provided 7 minutes of microgravity.

A second commercial launch, the Consort 2, experienced a second-stage guidance failure within seconds after lift-off in November 1989. Safety personnel were forced to destroy the booster, but the payload module was parachuted to safety and was recovered undamaged. Consort 3, the reflight of Consort 2, was launched in May 1990. It carried 12 major payloads and provided about 7 minutes of low gravity exposure.

The Shuttle is currently the only domestic means by which commercial experiments can be carried into space for long (5 to 7 days) duration and returned. These experiments are thus restricted by the amount of space available on Shuttle flights. Also, the frequency and duration of such

experiments are subject to the scheduling uncertainties of a very large and complex system, of which they are a relatively insignificant part.

The NASA-sponsored COMmercial Experiment Transporter (COMET) Program seeks to overcome this problem for commercial experiments which do not require man-tending. COMET, initiated by NASA's CCDS's, is a transportation system that will launch recoverable experiments into low Earth orbit. COMET will be carried aloft by an ELV. The COMET free-flyer will contain both a service module and a recovery system, which will separate prior to reentering the atmosphere. Experiments requiring return to Earth will be contained in the recovery system while the rest continue their mission in the service module.

CCDS's are totally responsible for system design, fabrication, test, and operations of COMET. Fourteen firms submitted 15 proposals in the competition to develop COMET. In November 1990, the selection board narrowed the list of contending contractors to seven companies. On January 28, 1991, the winners of the COMET competition were announced. SSI will provide the launch vehicle (based on its Conestoga rocket), Westinghouse the service module, and SII the recovery system. The first launch of COMET is planned for mid-1992.

Launch Facilities. Commercial customers currently depend on availability of and access to government launch facilities. While the government makes these facilities available to the commercial sector, the availability is on a noninterference, as-available basis. Recognizing that when business in space becomes commonplace, ample spaceport facilities will be needed to accommodate these businesses, the States of Florida (Spaceport Florida Authority), Hawaii (Hawaiian Space Development Authority) and Virginia (State of Virginia Space Development Consortium) have proposed development of commercial spaceports. Assisted by State governments, these launch facilities would be built and operated by private investors. The commercial spaceports, like municipal or commercial airports, would be supported by fees from users.

Hardware and Facilities. The commercial sector is also supplying hardware and facilities -- large and small -- to the government and private sectors. An example of "small hardware" is that developed by Instrumentation Technology Associates, Incorporated (ITA), of Exton, Pennsylvania, which provides hardware and services for the commercial development of space. For example, ITA produces the Materials Dispersion Apparatus (MDA) which is a device that has the capability of mixing 100 to 200 samples of virtually any 2 fluids in space. MDA has flown in Consort flights and will be used in the Joust-1 sounding rocket flight and in upcoming Shuttle launches.

In August 1988, NASA and SPACEHAB, Incorporated, entered into an SSDA for the encouragement of a commercial venture utilizing the Shuttle. The SPACEHAB module is a commercially developed and manufactured pressurized metal cylinder, approximately 10 feet long and 13 feet in diameter, which fits in the Shuttle payload bay and connects to the crew compartment through the orbiter airlock. SPACEHAB modules may contain up to 50 standard middeck lockers while providing an additional 750 cubic feet of pressurized work space. Not only does SPACEHAB offer industry additional

space for small scale production and experimentation, it gives them an economical intermediate step prior to making a full commitment for commercial use of Space Station Freedom.

When NASA entered into the SSDA with SPACEHAB, Incorporated, there were no known NASA requirements for space in the module. By 1990, the need for additional capacity had become apparent and NASA released a Request for Proposals for a Commercial Middeck Augmentation Module. SPACEHAB was selected to provide the capacity, which is, at a minimum, to be provided over five flights beginning in 1993 and ending in 1995. The ultimate success of SPACEHAB will depend on its ability to market its remaining capacity to private sector customers.

CCDS's are planning and initiating a variety of hardware development projects to provide CCDS researchers with cost-effective means of conducting experiments in space. One such project, in its third year of development by the Space Vacuum Epitaxy Center at the University of Houston, is a "wake shield" facility for space vacuum epitaxy research.

The Wake Shield Facility, to be carried on the Space Shuttle, will provide high ultra pure vacuum by pushing aside stray atoms and molecules found in low Earth orbit. Researchers can use this high vacuum supported by the near infinite pumping capacity of space to grow thin films with hundreds of layers each only a few atoms thick. Such multilayered thin films can be used in opto-electronics, microwave amplifiers, and various electronic applications.

The Shuttle's external tanks are large pieces of hardware which are currently jettisoned, but which could be utilized for commercial purposes. NASA has entered into agreements with two companies -- External Tanks Corporation and Global Outpost Corporation -- to investigate feasibility of using Shuttle external tanks to perform commercial experiments. Ultimately, the external tanks may be boosted into low Earth orbit for long-term use.

Conclusion

Space commerce is already economically significant in the United States, by virtue of the well-established acceptance and broad, expanding daily use of satellite communications, for which new applications continue to be identified. The use of satellites, in turn, has enabled the beginnings of a commercial industry in launch services and related infrastructure.

American businesses are looking to space for new opportunities beyond the commercial communications satellite industry. As new fields of space commerce develop, the resultant new products and services will create increased demand for launch services and related infrastructure. These industries will not only create employment and generate revenues and taxes, but they can also have a significant positive impact on our Nation's competitive posture in a global economy.