

# Economic Development of the International Space Station\*

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**Abstract.** Assembly of the International Space Station (ISS) has already begun on orbit and deployment of the world's first continuously operating, full service laboratory in the microgravity environment is rapidly approaching. The station and its laboratories will represent an unprecedented opportunity in the years to come for economic development of products and services available only through space. In recognition of this unique comparative advantage the United States Congress and the National Aeronautics and Space Administration (NASA) have recently taken important steps toward enabling industrial ventures to be undertaken on-board the station, or in conjunction with the associated ground segment. This paper reports on progress achieved in 1999, and discusses release of the price structure and schedule for the US share of station resources and accommodations. It will be accompanied by a notice in the *Commerce Business Daily* inviting offers to form public-private partnerships for station-based business enterprises.

## Introduction

The *Commercial Space Act of 1998* was passed “to encourage the development of a commercial space industry in the United States”.<sup>1</sup> The Act included specific provisions for “Commercialization of Space Station” as a high priority in the overall policy for economic development of low-Earth orbit (LEO).<sup>2</sup> NASA responded with strong support by releasing a commercial plan for the station which articulated a pathfinder strategy for identifying and advancing feasible business ventures.<sup>3</sup> This plan sought to position the agency in 1999 so that a vigorous economic development program could be pursued in parallel with the delivery of the United States Laboratory to the station in 2000.

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\*\* Opinions expressed herein are those of the author and do not necessarily represent the policy of the National Aeronautics and Space Administration.

<sup>1</sup> United States Congress, *Commercial Space Act of 1998*, Public Law 105-303, 28 October, 1998.

<sup>2</sup> *Ibid.* (1), Section 101.

<sup>3</sup> NASA, *Commercial Development Plan for the International Space Station*, 16 November, 1998.

The Act also required NASA to submit reports on certain aspects of commercial development. These reports have been completed and were submitted in 1999; the findings are reviewed below.

Before setting up the architecture for station economic development it was clear the shortfalls encountered during attempts to commercialize space through the shuttle fleet over the past twenty years needed reconsideration. During this era various independent and contractor studies found firm pricing, process reform and intellectual property protection to be persistent barriers to a successful commercial program.<sup>4 5 6 7 8 9 10</sup> For this reason NASA prioritized these three areas and launched specific new initiatives to resolve the prior issues. The outcomes are discussed below; all initiatives have been successfully completed.

Finally, it was suggested that over the long term it could be more effective to have a non-government organization (NGO) manage utilization of the US share of the station, in order to streamline personnel and procurement actions and, more importantly, revamp the expensive and time-consuming payload integration process for all users. The following discussion addresses this challenge in the context of critical tasks completed in 1999 related to NGO concept advancement.

The evolution of human endeavor in space includes many stakeholders. Government, industry and academic participants each have valuable perspectives which must be treated judiciously and equitably if the full capacity of the nation's intellectual resources are to be brought to bear on developing space resources. Each recent policy, report, and procedure referenced in this discussion is now also available at an internet web site: <http://commercial.nasa.gov/>. NASA is in the process of upgrading the site to include provisions for public comment and will welcome the perspectives of the public at large in what may become the most exciting challenge of the new millennium -- the economic development of space.

### **Reports Pursuant to the Commercial Space Act of 1998**

Three reports to Congress were required by the Act and NASA submitted the first two in May 1999. The first requested that NASA conduct a study to identify commercial opportunities on the station. This report was used to define important terms in the "commercialization" arena. With respect to commercial opportunities, NASA suggested there are possibilities across the entire station spectrum, including utilization, operations, and evolutionary development; the agency welcomed offers in all areas. But, it was

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<sup>4</sup> McDonnell Douglas Astronautics Co., *Feasibility Study of Commercial Space Manufacturing*, 1977.

<sup>5</sup> Hudson Institute, Inc., *Long Term Prospects for Developments in Space*, 1977.

<sup>6</sup> Rockwell International Space Division, *Space Industrialization: Final Report*, 1978.

<sup>7</sup> Science Applications Inc., *Space Industrialization: An Overview*, 1978.

<sup>8</sup> Center for Space Policy, *Commercial Space Industry in the Year 2000: A Market Forecast*, 1985.

<sup>9</sup> Potomac Institute for Policy Studies, *International Space Station Commercialization Study*, 1997.

<sup>10</sup> KPMG, LLC, *NASA: Commerce and the International Space Station*, 1999.

important to elaborate on the content of valid proposals. The regulatory definition for an “unsolicited proposal” is:

*“a written proposal for a new or innovative idea that is submitted to an agency on the initiative of the offeror **for the purpose of obtaining a contract with the government**”.*<sup>11</sup>

Although NASA will continue to be receptive to unsolicited proposals, we believe the Congressional vision for economic development entails far more than the provision of further government contracts involving public funding. For this reason we suggested that proposals which involve privately financed ventures be distinguished as “entrepreneurial offers” and defined as:

*“a written offer for a new or innovative idea, involving ISS assets, that is submitted to NASA on the initiative of the offeror **for the purpose of creating value-added products or services for sale in private markets**”.*<sup>12</sup>

With this important distinction the tide has turned. In 1999, for the first time, NASA began receiving offers involving substantive private investment as opposed to requests for public money. This is in sharp contrast with history, as illustrated by the second report to Congress which asked that NASA identify all station-related commercial proposals received during the period 1997-98.<sup>13</sup> First, there were only five formal submissions; the remainder of the station “commercialization” proposals were limited to informal concepts and were largely lacking in cost, schedule and technical performance detail. Second, and more important, *all were requests for government funding*.

In the future, as the space station assembly progresses and the economic development program matures, we expect to see growth in privately financed enterprises. In fact, the first several ventures may be announced later this year based on the offers received in 1999. Since these are all proprietary in nature it is not possible to discuss the contents, or even the names of the offerors, at this time; however, it is fair to note the markets involve biotechnology, engineering technology development, and multimedia products and services -- we are confident more will follow.

### *Independent Market Study*

The third report requested by Congress was an “independent market study” which NASA procured from KPMG, LLC and submitted in December 1999. As pointed out by the authors:

*“... it became clear that the future commercial markets for the ISS are still too premature and any market study would be wholly speculative. In the larger sense, markets for the ISS must be nurtured, rather than studied.”*<sup>14</sup>

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<sup>11</sup> Federal Acquisition Regulations (FAR), Subpart 15.601.

<sup>12</sup> NASA, Report to Congress on *Opportunities for Commercial Providers on the International Space Station*, May 1999.

<sup>13</sup> NASA, Report to Congress on *Commercial Proposals Concerning Operation, Servicing, Utilization or Augmentation of the International Space Station*, May 1999.

<sup>14</sup> *Ibid.* (10), p. 1.

The report suggested that the station held strong potential for research and development of economically viable products or services in the long run; but, in the near term the return-on-investment potential was limited to areas such as education, entertainment and advertising. Since the latter two represent virtually unprecedented areas of application for space craft, NASA is proceeding carefully to assess the policy implications associated with various aspects of these markets, particularly the relationship of private exclusivity to public assets. This work should be completed soon and may lead to innovative public-private partnerships in the future.

The potential for an “independent asset manager” was also discussed in the report.<sup>15</sup> This view is congruent with the NASA concept of an NGO which could manage the US share of station utilization. Further details on our progress toward this objective are provided later in this discussion.

### **Pricing Policy**

Resolution of pricing for the US share of station accommodations and resources became a top priority in 1999. Determined discussions among NASA, the Office of Management and Budget, and the Office of Science and Technology Policy, outside of the normal legislative cycle, led to a White House initiative which was sent to the Congress in July.<sup>16</sup> The proposed bill sought to amend the Commercial Space Act of 1998 by including a demonstration program which would function as a proving ground for innovative approaches to accelerating economic development of LEO space.

The demonstration program included a comprehensive pricing policy based on fundamental principles of microeconomics. Four primary components were included in the policy: (a) value-based pricing; (b) a marginal cost floor; (c) cost waiver authority; and, (d) a revenue re-investment plan. The rationale and a brief synopsis for each of these provisions is summarized below.

#### *Value-Based Pricing*

The private sector has long recommended that station pricing should be “value-” or “market-based” (i.e., priced according to whatever the market will bear). Since the station involves multiple potential markets, the perception of value is necessarily market-unique. For instance, the price an entertainment company is willing to pay will be significantly different from that a private research laboratory can bear. Nonetheless, value-based pricing was selected as the foundation for the policy. Methods of objectively establishing the perception of value in the various markets are now under consideration. These include (a) comparable prices for currently available related services; (b) precedent prices offered

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<sup>15</sup> Ibid. (10), p. 27.

<sup>16</sup> Letter from the NASA Administrator (Dan Goldin) to the President of the Senate (Al Gore) regarding a draft bill to amend PL 105-303 to include a *Space Station Commercial Development Demonstration Program*, July 27, 1999.

and taken under prior space projects and programs; (c) auctioned prices in an open marketplace; and (d) proposed prices from the market in the context of specific business offers.

Each method may be pursued as the station program evolves with the intent to establish value-based price histories in specific markets over time. In the case of auctions, we are actively considering the possibility of conducting markets tests by offering an internal, pressurized payload rack site, as well as an external, exposed payload adapter site, on an alternating periodic basis at some time in the future. In the near term, most pathfinder agreements are being negotiated based on method (d) above, while the published benchmarks for premium pricing have been derived from methods (a) and (b) above.

### *Marginal Cost Floor*

For those markets where the perception of value is less than the cost associated with operating the station we have established a marginal cost floor.<sup>17</sup> This is essential in order to ensure that, over the long run, profitable private enterprises are not created which are wholly dependent upon government subsidies for their sustained operation. To do otherwise would be in contrast with our successful capitalist economy.

We have employed the same approach as is used in the private sector for determining the marginal cost floor; however, it is important to acknowledge that the station is an atypical production system. In privately operated production systems where the number of units produced is extremely low and the unit cost is extremely high, pricing is based on the average of all marginal costs across the operating system. For these unique production models the average of marginal costs equals the total average cost. Therefore, we have followed suit and derived the marginal cost floor from the annual average US operating cost of the station. Since the cost is estimated at this time, and will become more clear as greater operating experience is gained, the prices represent a benchmark and will be updated periodically.

### *Cost Waiver Authority*

We recognize that some markets may not be able to bear the marginal cost floor in the near term during the formative stage of business development. As a result there are provisions for waiving part, or all, of the cost in the short run. Over the long run business ventures must be prepared to cover the marginal cost floor, not necessarily before, but at least in parallel with profit growth. This is why the business plan is such an important element of every NASA-industry partnership. The plan must project a future point at which production and revenue levels are sufficient to privately cover cost and still achieve profitable operations. A sliding scale is anticipated so that businesses can grow successfully as federal subsidies gradually fall away -- the objective is to truly establish a new economy in LEO space that is independent of government support.

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<sup>17</sup> As is consistent with the historic role of government investment in new frontiers of science and technology, there will be no attempt to recover through future pricing the estimated \$24 - 26 billion US in sunk costs associated with station development.

Cost waivers may be granted for primary uses of the station such as scientific and technological R&D and education. Non-primary uses such as entertainment and advertising, if pursued, will not be granted waivers; but, since these are the markets where the perception of value is greater than cost, the value-based pricing is appropriate and waivers will not be necessary

*Revenue Re-Investment Plan (New Legislation)*

As markets develop and the perception of value exceeds the cost revenues can emerge. At this stage, which may be early in some high-value markets such as entertainment, the intent is to re-invest any revenue after expenses directly back into the station economic development program. Such investments will benefit all US users of the station by increasing the available resources and accommodations. For instance, the communications system could be upgraded or the capacity for transporting biological materials could be increased -- both are rate-limiting steps to higher productivity.

The opportunity to reinvest revenue is also the first significant step toward evolving a NASA culture that will be consistently receptive to business development enterprises. It creates an incentive that has never before existed. In the past “commercialization” has generally meant public funding re-directed toward select private interests; but, in the future, economic development could come to mean expansion of the space station infrastructure without growth in public appropriations.

These important principles were legislated in late 1999 when Congress approved the key elements of the White House bill.<sup>18</sup> Although NASA preferred all aspects of the originally proposed demonstration program be included in one place, with clear Congressional endorsement, the finding was that the original Space Act which created NASA already provided authority to establish prices with cost floors and grant waivers.<sup>19</sup> As a result, Congress enacted only the administrative and revenue reinvestment provisions of the proposed bill.

Although there has been considerable controversy and misinterpretation regarding objectives of the new legislation, it is intended to be used solely as a stimulus for station economic development. Suggestions that it will lead to a “slush fund” are unfounded because a detailed accounting of both revenues and reinvestments must be reported to Congress on an annual basis. The notion that NASA will be “picking winners and losers” is also invalid, since the selections will essentially be made by the capital markets -- the ratio of private to public investment as the principle figure-of-merit in the selection process is rapidly gaining broad understanding and acceptance.

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<sup>18</sup> United States Congress, H. R. 2684 (Appropriations Act, 2000), *Sec. 434. Space Station Commercial Development Demonstration Program*, Public Law 106-74, 20 October, 1999.

<sup>19</sup> United States Congress, *National Aeronautics and Space Act of 1958 as Amended*, Public Law 85-568, 1958.

### *Further Details*

The specific price structure and schedule are discussed in greater detail in a companion paper.<sup>20</sup> The prices are applicable to the 30% share of the US resources and accommodations on the station which have been specifically allocated for commercial development by the completion of station assembly. This inventory includes eight International Standard Payload Rack sites within the station laboratories and seven external Payload Adapter Sites located outside the station. These fifteen sites include the utilities, crew support and communications resources necessary to operate each site productively.

### **Process Reform**

In the past commercial concepts have been introduced to the Agency through a variety of channels both at NASA Headquarters in Washington, DC and across the field centers at all levels. Identifying, tracking and advancing every single concept through some central clearing house is highly impractical. NASA should, and will, continue to entertain conceptual discussions at all levels; however, in the future, when such discussions are prepared to advance to a formal level of agreement the process has been reformed.

### *ISO-9000 Office Work Instruction*

In 1998 NASA undertook an agency-wide initiative to achieve compliance with ISO-9000 specifications for standardization of management processes. This step provided an opportunity to add systematic rigor and create an auditable record for how the Agency treats offers involving new business ventures in NASA-industry partnerships. Since the space station represents the next frontier in human exploration and development of space, we elected to develop an ISO-9000 compliant Office Work Instruction (OWI) specifically tailored to the station. This will permit us to test out reform of the commercial development process. In September 1999 this OWI was formally approved by the Associate Administrators for Space Flight, and for Life and Microgravity Sciences and Applications.<sup>21</sup>

The OWI is now available to assist the business community in advancing potential privately financed ventures from the concept stage to the formal offer stage in pursuit of a Space Act Agreement with NASA. Information to be included in the offer, initial evaluation criteria, and details of the process are all provided. The Johnson Space Center has concurred in the OWI and is also in the process of developing and linking a local work instruction to the process in order to ensure full flow down of requirements and consistency in application.

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<sup>20</sup> Flaherty, C., *Pricing Policy, Structure and Schedule for US Resources and Accommodations on the International Space Station*, STAIF-2000, 2 February, 2000.

<sup>21</sup> NASA, *Registration and Disposition Process for ISS [International Space Station] Entrepreneurial Offers*, HOWI 7020-U019 Baseline, 27 September 1999.

### *Further Details*

The specific attributes of the OWI are discussed in greater detail in a companion paper.<sup>22</sup>

## **Intellectual Property Protection**

NASA has exhibited an outstanding history of success in protecting the intellectual property of parties involved in Space Act Agreements. There have been few cases to date where a party has sought legal recourse for violation of rights pertaining to protection of proprietary data. Considering the number of civil service and contract personnel involved in preparation for space flight, and later operation and recovery of space craft and payloads, it is evident that, although numerous individuals may handle sensitive information, policies and procedures are working effectively.

With this experience NASA negotiators entered the global arena and completed a multilateral Intergovernmental Agreement (IGA) and series of bilateral Memoranda of Understanding (MOUs) with the space station partners which established the legal principles related to intellectual property protection. In support of our commercial development plan for the station, the NASA Office of the General Counsel has completed a reference guide which reviews, and interprets in layman's terms, the contents of the international agreements and how they affect intellectual property protection.<sup>23</sup> This guide was developed to demonstrate the adequacy of existing agreements and to dispel the myth that intellectual property could be at greater risk on the space station than is normally incurred in business practice.

### *Further Details*

The specific contents of the intellectual property guide are discussed in greater detail in a companion paper.<sup>24</sup>

## **Non-Government Organization (NGO) Concepts**

The concept of an independent organization with responsibility for day-to-day management of space station utilization was first introduced to the public in 1995.<sup>25</sup> This concept later became part of the station commercial development plan when a reference

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<sup>22</sup> Bush, L., *Registration and Disposition Process for Space Station Entrepreneurial Offers*, STAIF-2000, 2 February, 2000.

<sup>23</sup> NASA Office of the General Counsel, *Intellectual Property and the International Space Station: Creation, Use, Transfer, and Ownership and Protection*, September, 1999.

<sup>24</sup> Broadwell, M., *Intellectual Property Protection on the International Space Station*, STAIF 2000, 2 February, 2000.

<sup>25</sup> Uhran, M., *Orbital Research Institute Concept for the International Space Station*, International Forum on Scientific Uses of the Space Station, Noordwijk, The Netherlands, 17 May, 1995.

model was attached as the point-of-departure for stakeholder exploratory discussions.<sup>26</sup> The latter model attempted to expand the original concept by including all three missions of the space station: (a) scientific research; (b) technological advance; and (c) economic development. The extraordinary challenge associated with effectively integrating these often competing missions, while also ensuring upward compatibility to a global scale of user operations, was quickly recognized. As a result we took two critical steps in 1999 to further progress. An independent assessment was necessary, so we enlisted the National Research Council, and an objective trade study was needed to understand the range of options and precedents.

#### *National Research Council Task Group Report*

In January 1999 the National Research Council, under the auspices of the Space Studies Board and the Aeronautics and Space Engineering Board, took steps to establish a task group to review alternative Institutional Arrangements for Space Station Research (IASSR). The group consisted of fourteen individuals with wide-ranging expertise in the operation of academic, industrial and federal laboratories, as well as sound experience in formulating science and technology policy. They conducted an eight month study to assess the feasibility of employing an NGO approach to managing space station utilization and completed their report in December 1999.<sup>27</sup>

The report recommends that NASA “should plan on establishing an NGO in three phases” representing the near term, a transition phase and a long term phase.<sup>28</sup> The report also provides conclusions and recommendations on guiding principles related to the mission of the organization, structure and governance, location and staffing, relations with commercial users, budget authority, and specific roles and responsibilities. These findings represent a critical step in the process of further defining and implementing an NGO as part of the overall architecture for station utilization, operations and maintenance.

#### *Trade Study on Options and Precedents*

In June 1999 NASA initiated a trade study on the statutory and legal constraints associated with various forms of NGOs, as well as the advantages and disadvantages related to each. For every option, NGO precedents were identified and unique attributes evaluated. A series of evaluative factors were developed to assist in measuring the relative effectiveness of each option in meeting objectives. This study was completed in November 1999.<sup>29</sup>

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<sup>26</sup> Uhran, M., *Reference Model: A Non-Government Organization for Space Station Utilization Management*, Commercial Development Plan for the International Space Station, Attachment 3, 16 November, 1998.

<sup>27</sup> National Research Council, *Report of the Task Group on Institutional Arrangements for Space Station Research*, December, 1999.

<sup>28</sup> *Ibid.* (27), Recommendation 12, pp. 46-47.

<sup>29</sup> Sobieski, S. and Simon, M., *Options for Managing Space Station Utilization*, Swales Aerospace, Inc., Contract \_\_\_\_\_, Task Order \_\_\_\_\_, November, 1999.

No conclusions were drawn as a result of the trade study. The objective was intentionally limited to thoroughly describing the options and the enabling steps in each case. Our intent was to gather objective and accurate information from which to support an informed decision in close cooperation with the White House and Congress. This information represents a second critical step on the path toward implementation.

### *Next Steps*

In January 2000 the NASA Office of Space Flight commissioned an independent *ISS Operations Architecture Study*. Over the next five years all major operations and development contracts involving human space flight will either terminate or come up for renewal via contract options. The objective of the study is to provide an independent recommendation for a space station operations architecture with the justification and a cost benefit analysis. The study will also provide an acquisition strategy that details impacts to current government organizations and existing operations contracts. The already completed work on NGO options for managing the station utilization component therefore represents a timely input to the overall operations architecture study.

The study is planned for completion in the Summer 2000 timeframe. While underway, we will conduct parallel discussions with executive and legislative branch staff on NGO variants. Through this concurrent effort the Agency will be fully prepared to take the key operations contracting decisions necessary as the station on-orbit assembly process scales up during 2000. The focus will be on a consistent evolution toward increasingly private operation of human space flight assets in LEO over the next decade, while NASA turns its public resources toward advancing the human horizon.

## **Global Dimensions**

The magnitude of human endeavors in space has grown to the stage where all space faring nations must work cooperatively in order to marshal the resources needed to further exploration and development. There is little question that the power of the expanding global economy must be sustained and directed, in part, toward the space frontier if we are to continue pioneering the human presence.

In scientific pursuits over the past twenty-five years NASA has enjoyed consistent success in collaborating with international partners. The space station assembly and operation will represent a new milestone for engineering pursuits, also based on international collaboration -- it represents the largest cooperative civilian engineering project ever undertaken. The use of multilateral consultative working groups (MCWGs) has been pivotal in past scientific and engineering programs. In recognition, NASA recommended to the space station partners in June 1999 that an MCWG in Commercial Programs (CP) be formed.<sup>30</sup> All partners responded affirmatively.

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<sup>30</sup> Letter from the NASA Deputy Associate Administrator for Space Development, Office of Space Flight, (Michael Hawes) to counterparts in Canada, Europe, Japan and Russia regarding recommendation to

In November 1999, one year following the passage of the Commercial Space Act, the MCWG-CP met for the first time in Washington, DC. Although it was acknowledged that each partner's primary obligation is to economic development of their respective member nations, it was also recognized that there is distinct merit in coordinating programs so that economic benefits could be compounded and growth in the global space economy encouraged on all fronts. The group set out an agenda for the coming year which included: (a) definition of the markets relevant to the station; (b) achievement of agreement on the responsibilities of each partner for sponsoring commercial ventures; and (c) coordination of national pricing policy effects at the macroeconomic level. Thus the stage has been set for productive international collaboration in the economic dimension.

### **Conclusion**

During 1999 we carefully put in place the necessary management systems and processes with which to conduct a vigorous economic development program for the International Space Station. The most persistent barriers -- price stability, process reform and property protection -- have been addressed. Through insightful legislative action an incentive has been created to evolve the NASA culture toward a more responsive commercial posture with time. The concept of an NGO for station utilization management has been advanced to the point where decisive dialog with the White House and Congress can proceed. Finally, our international partners have joined in establishing a global forum for discussions on economic cooperation.

A few more key ingredients remain necessary.

There is a critical need to broaden the general public awareness, in particular the non-aerospace industry, of the exciting prospects which beckon as the station is assembled and the operational era begins. A NASA-industry partnership, or several, in multimedia communications could be extremely effective and mutually rewarding. We are hopeful the response to our recent public announcement will prove successful in this regard.<sup>31</sup>

The time has also now come for the private sector at large to respond -- with reactions to our initiatives of the past year and with substantive offers to privately invest in new business enterprises. For this reason, we are releasing another announcement in the *Commerce Business Daily*, as well as a variety of business trade journals, inviting NASA-industry partnerships in space station related ventures.

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designate a representative to a *Multilateral Consultative Working Group - Commercial Programs*, 16 June, 1999.

<sup>31</sup> NASA, *Notice of Intent to Negotiate Partnership Agreement(s) for the Development of Multimedia Products and Services Related to the Exploration and Development of Space*, *Commerce Business Daily*, December 10, 1999.

Finally, we must keep our “eyes on the ball”. Economic development will not be successful unless we complete the station as planned and that means achieving the full seven crew capability that is afforded by a permanent habitation element. Let us not allow any decision to be taken which might risk the achievement of this most crucial milestone.

With these three ingredients, and with the United States Laboratory deployed on orbit later this year, *the whole game will change*.

### **Acknowledgements**

The progress achieved during the past year could not have occurred without the consistent encouragement and support of Dr. Arnauld Nicogossian and Mr. Joseph Rothenberg, Associate Administrators for the NASA enterprise in human exploration and development of space. The sound counsel of Mr. Michael Hawes, Deputy Associate Administrator for Space Development, was also instrumental at critical junctures in strategy formulation and execution, as was the field assistance provided by Mr. Tom Cremins, coordinator for commercial development at the Johnson Space Center. Finally, the staff of NASA, the members of the NRC Task Group, and the Directors of the Commercial Space Centers have made invaluable contributions through their dedication to the understanding and development of a new LEO space economy.