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Paper Session I-C - Building an Intellectual Infrastructure for Space Commerce

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BUILDING AN INTELLECTUAL INFRASTRUCTURE FOR SPACE COMMERCE

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ABSTRACT

To be successful, American industries engaged in space commerce must be based on sound infrastructure foundations. To serve industry effectively, building such infrastructure requires thoughtful attention not only to hardware but also to people. People are the "intellectual infrastructure" required for success. Competition in the international marketplace requires a work force with extensive scientific and technical knowledge, and a thorough understanding of the business world. The focus of this paper is the development of the intellectual infrastructure required to make space commerce a reality. The contributions to this development by the Centers for the Commercial Development of Space Program and a conceptual Space Business Development Center are described.

AMERICA'S CRISIS IN GLOBAL HIGH TECHNOLOGY LEADERSHIP

High technology products and services are vital to a nation's economic strength. The United States has been faced with erosion of its competitiveness in global high technology markets for over a decade. A frequently cited solution to this problem is to erect barriers to the international flow of high technology. In today's world, this is at best an ineffective, short-term solution. A more effective solution is to improve the capacity of American industry to use the high technology (developed here and abroad) to generate and market high-quality, commercially successful products and services.

The United States enjoys a high level of competence in research and development in a wide range of disciplines, but is matched in many of them by the rapidly growing industrial and academic sectors of other nations. More than half the graduate students in technical programs in American universities are foreign-born, and many are returning home after graduation. It is clear

that failure to maintain a position of leadership is not due to the quality of U.S. research universities which, as a group, are recognized as the best in the world. Rather, the failure lies in the relative inability of American industry to transform discoveries in a number of areas into high-quality products and into processes for designing, manufacturing and marketing, and distributing such products competitively. This failure may be due in part to lack of strong university affiliations with industry.

THE SPACE PROGRAM'S CONTRIBUTION TO THE HIGH TECHNOLOGY RACE

The U.S. space program has long been a source of high technology. This technology can contribute to economic growth only if it is translated into improved production processes and marketable, innovative products. Because of this potential benefit, the Unites States Government encourages the commercial use and exploitation of space technologies and systems.

True space commerce results in the development of new commercial space-derived products and services and, hence, new private sector markets. As new fields of space commerce develop, the resultant new products and services will form the basis for new industries which will create employment, generate taxable profits, and have a significant positive impact on our Nation's competitive posture in a global economy. As space commerce develops, the infrastructure -- including hardware, systems, and a highly skilled work force -- must be available in order for it to reach its full potential. This requires education of technically sophisticated workers who can recognize the potential value of technologies and adapt them continuously to new products and processes. In short, a workforce that includes professionals with highly developed technical and business capabilities, and the ability to merge these two areas of expertise.

NASA has long recognized the long-term educational needs of the space work force. There are over 150 separate NASA education programs, targeted primarily at students and teachers from elementary school through high school. At the university level, NASA assists some 400 institutions and thousands of students through its National Space Grant and Fellowship Program, its space science and applications programs, and several categories of Centers of Excellence. These programs are aimed at overcoming the shortage of scientific and engineering talent to run the space program of the 1990's and beyond. However, space commerce requires not only scientific and technical education, but also business education and understanding.

This paper discusses two initiatives which contribute to meeting this need. NASA's Centers for the Commercial Development of Space Program has become a driving force in the development of the needed intellectual infrastructure since its inception in 1985. The Centers for the Commercial Development of Space involve universities and companies in identifying and exploiting potentially commercially significant technologies. The Space Business Development Center is a concept which can be valuable in building a partnership between the commercial space program and some of the Nation's

leading graduate schools of business, including both graduate business students and faculty. SBDC can be a valuable catalyst in the combining of academic expertise and access to networks of professionals in the financial and insurance markets with entrepreneurial drive that is directed to the commercial development of space.

CENTERS FOR THE COMMERCIAL DEVELOPMENT OF SPACE

The cornerstone of NASA's commercial development of space effort is the Centers for the Commercial Development of Space (CCDS) Program. Each CCDS is based on a consortium of universities, industrial firms, and government entities involved in research and testing phases of potentially commercially viable technologies. CCDS's are funded by leveraged NASA grants coupled with increasing funding and in-kind support from their university and industry affiliates. The CCDS's have come to be a most promising means of identifying potentially commercially significant technologies, and assisting in making them viable.

There are currently 17 CCDS's, of which 15 are university-based; they are conducting commercially oriented research in 8 specialization areas:

Automation and Robotics. This area includes robotic technologies to enhance living, traveling, and exploring in space and development of machine vision and sensing systems, and biological technology for life-support systems. There are two CCDS's conducting research in this area: the Space Automation and Robotics Center, Environmental Research Institute of Michigan, in Ann Arbor, Michigan, and the Wisconsin Center for Space Automation and Robotics, University of Wisconsin - Madison, in Madison, Wisconsin.

Remote Sensing. Research is conducted in this area to determine faster and more reliable ways to produce and update maps for satellite imagery, improving productivity and efficiency of land use planning using remote sensing, image processing, and information systems. The two CCDS's conducting research in this area are the Center for Mapping, The Ohio State University, in Columbus, Ohio, and the ITD (Institute for Technology Development, Inc.) Space Remote Sensing Center, in John Stennis Space Center, Mississippi.

Life Sciences. This area includes space-based biomedical and agricultural research, the study of cell functions for disease treatment, and crystal growth. Three CCDS's are conducting research in the life sciences area: BioServe Space Technologies, University of Colorado - Boulder, in Boulder, Colorado; the Center for Cell Research, Pennsylvania State University, in University Park, Pennsylvania; and the Center for Macromolecular Crystallography, University of Alabama in Birmingham, Alabama.

Materials Processing in Space. Materials processing includes development and growth of crystals, thin-film growth and materials purification, and the effects of microgravity on metals, alloys, ceramics, and glasses. Four CCDS's are currently working in this area: the Advanced Materials Center, Battelle

Columbus Laboratories, in Columbus, Ohio; the Center for Commercial Crystal Growth in Space, Clarkson University, in Potsdam, New York; the Consortium for Materials Development in Space, University of Alabama - Huntsville, in Huntsville, Alabama; and the Space Vacuum Epitaxy Center, University of Houston, in Houston, Texas. A fifth Center, the Center for Space Processing of Engineering Materials, Vanderbilt University, in Tullahoma, Tennessee, announced that it would discontinue its operations in October 1991. Because of a decline in research by large metals fabricators and producers, the Center was unable to generate the level of corporate support to meet NASA's requirements for cash contributions by industry members.

Space Power. Space power research includes development of power systems for space-based platforms and identification of critical technological impediments to economic use of power systems in space. The Center for Space Power, Texas A&M University, in College Station, Texas, and the Center for Commercial Development of Space Power and Advanced Electronics, Auburn University, in Auburn, Alabama, are performing research in this area.

Space Propulsion. This area includes advanced propulsion research, encompassing computational fluid dynamics analysis of rocket engine performance and fault diagnosis. Work is being performed by the Center for Space Transportation and Applied Research, University of Tennessee Space Institute, in Tullahoma, Tennessee.

Space Structures and Materials. Research is performed on materials for space structures capable of being made and/or assembled in space. This work is being carried out by the Center for Materials for Space Structures, Case Western Reserve University, in Cleveland, Ohio.

Advanced Satellite Communications. In October 1991, NASA announced the formation of two new CCDS's. The Centers will specialize in the commercial development of advanced satellite communications technologies and other space-based telecommunications technologies. Selected were the Center for Satellite and Hybrid Communication Networks, University of Maryland Systems Research Center, in College Park, Maryland, and the Center for Space Communications Technology, Florida Atlantic University Research Corporation, in Boca Raton, Florida.

The CCDS Program has been successful in attracting both university and industry participation. Some 71 universities and 241 companies are currently participating. When the Program first started with five initial Centers in 1985, there were only five professors involved, no undergraduate students, five graduate students, and four post-doctorates. By 1991, the Program involved 153 professors, 169 undergraduate students, 319 graduate students and 85 post-doctorates working on space application projects.

Nearly 200 degrees have already been awarded to students involved in CCDS-related projects. Significantly, a great many of these graduates are now working in space-related industries. These graduates form a cadre of

professionals who have both technical and practical business training needed to help America's commercial space industries compete in the global marketplace.

SPACE BUSINESS DEVELOPMENT CENTER

However revolutionary may be the anticipated impact of commercial space businesses in the marketplace, such businesses should rarely have to "go where no one has gone before" in gaining insight into generic space commercial development issues or the pioneering risks of commercially developing advanced technology. It would be tragic indeed if the development of United States space commerce were impeded by a lack of basic knowledge of the lessons learned by others who have faced common and continuing issues. The United States has already developed a significant base of experience with space commerce. The pace of commercial space activity has accelerated markedly during the last decade. Commercial activities are underway, emerging, or proposed in nearly every major area of space activity. Some have begun with less than full success to date. The experience from this record of past successes and failures is available, but diffuse. As with scientific research and generic technology, all space businesses benefit from such basic business research, but few can afford or justify the adequate conduct of such research solely on their own behalf. A mechanism to conduct research into key business issues and aggregate the results of past research would enable tomorrow's space businesses to stand upon the shoulders of all who have gone before.

The Space Business Development Center (SBDC) concept is aimed at addressing a variety of barriers common to the development of space commerce. It can aid the advancement of space commerce through a strategic linkage between the United States space program and some of the Nation's leading educational institutions. SBDC is envisioned to be a not-for-profit entity affiliated with one or more graduate schools of business.

SBDC would aid nascent or emerging commercial space ventures by conducting research on key space business issues. It would encourage and provide real experience opportunities for the next generation of space business professionals and entrepreneurs, conduct research on business issues uniquely common to space business, and provide advice to a broad spectrum of potential or emerging space businesses in addressing the unique problems and issues associated with space commerce. SBDC can help nascent commercial space businesses to more readily span the range of required skills and experience from the outset, and to address the need for effective concurrent relationships with and between each sector.

In addition, SBDC can help businesses address the pioneering risks associated with the commercial development of advanced technologies. The prevalence of such risks is a common aspect of space commerce. The space program is known for its pioneering achievements. Commercial space businesses seeking to apply advanced technologies of high promise face risks that can stymie even the largest corporations. Examples of such risks include long lead times, large

investments, uncertain periods of payback, difficult access to capital and insurance, immature or underdeveloped markets, and new or unproven products and services. SBDC will help space businesses to develop for themselves strategies which may best overcome, ameliorate, avoid, or delay such risks.

Whether engaged in training, networking, advising, achieving, or research, SBDC will be inherently a holistic, multidisciplinary activity. Business issues are inextricably related to the advanced character of the technologies involved, and to the public policy issues, legal issues, and international policy and trade environments. An effective SBDC must span the range of clinical assistance to emerging commercial space businesses, structuring of relationships between commercial space "players," developing a better understanding of common issues and solutions, and/or training the next generation of space professionals and entrepreneurs.

SBDC would offer a number of important tools to space businesses and space entrepreneurs. Tapping their graduate training expertise, SBDC would help space entrepreneurs and prospective space entrepreneurs develop the fundamental skills associated with young high technology businesses. SBDC would help to provide efficient networking and structuring of relationships between space businesses and sources of funding, insurance, programmatic, regulatory, technology information, and other resources. And, SBDC would aggregate and make available the fruits of research conducted by SBDC and others on barriers, solutions, and lessons learned in the development of space commerce.

SBDC could be initiated in a manner similar to the establishment of one of NASA's CCDS's, with its initial activities supported through a multiyear grant. SBDC would be competitively selected based on the quality of its program, experience, people, and resources relative to the mission of aiding the development of space commerce. Quality and commitment must be emphasized in every aspect of SBDC, including its personnel, its educational, research and other resources, and its ability to network with client organizations, governmental agencies, and professional and resource organizations.

SBDC is intended to complement and strengthen the synergistic partnership of research, educational, and outreach activities essential to a robust United States space program. In addition, SBDC could assist and provide trained manpower to NASA's CCDS's and their affiliates. In this context, one function of SBDC may be to help structure effective business arrangements or evaluate arrangements for transitioning technologies from a CCDS multisector research environment to a proprietary environment of self-sustaining business growth.

SBDC must plan for both long-term and short-term results and be measured accordingly. In the short run, it must be measured according to it its contributions to improving the likelihood of success of its clients. In the longer term, SBDC must also be measured by its contribution to the number of professionals trained to serve the specialized needs of space business, both through its own direct efforts and its leveraging of the efforts and resources

of others. Elements of SBDC's efforts which can become viable self-sustaining activities in their own right may, in time, be best measured by their success in the marketplace.

The United States is blessed with the strongest network of graduate research and training institutions in the world. Many of these institutions have not historically been heavily involved in the space program, especially those outside of the aerospace-related technical disciplines. The SBDC concept draws upon these high quality but under-represented national resources to better understand and address the barriers impeding the growth of United States space commerce and, thereby, to help the United States more fully realize the benefit of the space program for our economy and national welfare.

SUMMARY

Other nations of the world are making rapid strides in moving technology from the laboratory to the marketplace. For the United States to remain competitive, the Nation must make full use of its world renowned university sector in moving technology from the laboratory to the marketplace.

NASA has long recognized the importance of robust linkages between the space program, the academic sector, and the business sector in bringing the full benefits of advanced technology to the Nation. Through such relationships, NASA has generated over 30,000 spinoffs from NASA advancements in virtually every scientific and technological discipline.

The 17 NASA-sponsored CCDS's are a major means by which NASA is continuing its history of successful development of strong linkages between America's universities, its businesses, and the space program. Moreover, through the CCDS's, NASA's efforts are now yielding a cadre of professionals with both technical and business training to help America's commercial space industries compete in the global marketplace.

The SBDC concept would further develop the intellectual infrastructure needed for our future space program. SBDC would strengthen the development of cohesive relationships between the space program and the commercial and academic sectors by providing a holistic multidisciplinary, university-based center for training, networking, and research. Through these mechanisms, SBDC would amplify the production of qualified space professionals and entrepreneurs. And, it would reduce risks associated with space commerce by making lessons-learned available to all qualified participants.

Through its CCDS Program, its many other ongoing educational programs, and such new concepts as SBDC, NASA will continue to make full use of one of the Nation's greatest assets, its intellectual capital, to bring the full benefits of advanced technology to the economy and the welfare of the Nation.