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CONSORTIUM FOR MATERIALS DEVELOPMENT IN SPACE INTERACTION WITH SPACE STATION FREEDOM

Presented by Charles A. Lundquist and Valerie Seaquist
Consortium for Materials Development in Space
The University of Alabama in Huntsville

ABSTRACT

The Consortium for Materials Development in Space (CMDS) is one of seventeen Centers for the Commercial Development of Space (CCDS) sponsored by the Office of Commercial Programs of NASA. The CMDS formed at the University of Alabama in Huntsville in the fall of 1985. The Consortium activities therefore will have progressed for over a decade by the time Space Station Freedom (SSF) begins operation. The topic to be addressed here is: What are the natural, mutually productive relationships between the CMDS and SSF? For management and planning purposes, the Consortium organizes its activities into a number of individual projects. Normally, each project has a team of personnel from industry, university and often government organizations. This is true for both product-oriented materials projects and for infrastructure projects. For various of these projects Space Station offers specific mutually productive relationships. First, SSF can provide a site for commercial operations that have evolved as a natural stage in the life cycle of individual projects. Efficiency and associated cost control lead to another important option. With SSF in place, there is the possibility to leave major parts of processing equipment in SSF, and only bring materials to SSF to be processed and return to earth the treated materials. This saves the transportation costs of repeatedly carrying heavy equipment to orbit and back to the ground. Another generic feature of commercial viability can be the general need to accomplish large through-put or large scale operations. The size of SSF lends itself to such needs. Also in addition to processing equipment, some of the other infrastructure capabilities developed in CCDS projects may be applied on SSF to support product activities. The larger SSF program may derive mutual benefits from these infrastructure abilities.

Consortium for Materials Development in Space Interaction with Space Station Freedom

1. Background

The Consortium for Materials Development in Space (CMDS) is one of seventeen Centers for the Commercial Development of Space (CCDS) sponsored by the Office of Commercial Programs of NASA. In addition to NASA, the Consortium receives support from affiliated industries and from the State of Alabama. The CMDS formed at the University of Alabama in Huntsville in the fall of 1985.

The Consortium activities therefore will have progressed for over a decade by the time Space Station Freedom (SSF) begins operation. The topic to be addressed here is: What are the natural, mutually productive relationships between the CMDS and SSF? To answer that question, a basic understanding of the CMDS activities is needed; Section 2 sketches those activities. Section 3 then shows how natural interactions arise between CMDS and SSF.

2. Current Activities of the Consortium

When it formed, the Consortium adopted three fundamental concepts to characterize its scope.(1) These were:

- Commercial materials development that benefit from unique attributes of space
- Commercial applications of physical chemistry and materials transport
- Prompt and frequent experiments and operations in orbit

As intended here, "materials" is a broad term including inorganic, organic and living materials. These concepts have continued to be applicable to this day.

However, during its first years of operation, the Consortium recognized that it needed also to address infrastructure issues such as:

- Processing equipment for space use
- Rocket vehicles for access to space
- Environment measurements in spacecraft

The CMDS added such topics to its activities, as did other Centers for Commercial Development in Space.(2,3,4)

For management and planning purposes, the Consortium organizes its activities into a number of individual projects. Every project must have an appropriate space involvement. Normally, each project has a team of personnel from industry, university and often government organizations. This is true for both product-oriented materials projects and for infrastructure projects.

The materials projects, particularly, are expected to go through a life cycle beginning with exploratory tests of a concept, continuing through development operations, and finally reaching a state of maturity and independence. As individual projects reach a mature, independent status, they can be replaced by new projects starting with a concept to be explored. At each step in a project's life cycle, the project is evaluated for viability and is continued or terminated. The commercial prospects for the project and industrial interest are key factors in the evaluation process.

Equipment for use in space is an essential feature of each project. The Consortium has adopted an evolutionary equipment concept, in which equipment will evolve through several modest, periodic steps from a simple initial form.[4] This approach assures at any time that the subsequent operations are the next logical step[5] to be performed based on experience to date. It also enhances the probabilities of success because each step incorporates the positive features of its predecessors. Specifically, the equipment candidates for flight on SSF would be picked from the evolutionary flow at the time they are needed for flight.

The present Consortium projects and infrastructure services are listed in Table 1. The potential interactions with SSF can be examined on a project by project basis.

3. CMDS Relationship with SSF

Given the characteristics of the CMDS operations as sketched in Section 2, it is now possible to look for the natural mutually productive relationships between CMDS and SSF. The first option follows immediately from the last thoughts in Section 2; SSF can provide a site for commercial operations that have evolved as a natural stage in the life cycle of individual projects. Indeed, the examples offered below have this feature.

Efficiency and associated cost control lead to another important option. With SSF in place, there is the possibility to leave major parts of processing equipment in SSF, and only bring materials to SSF to be processed and return to earth the treated materials. This saves the transportation costs of repeatedly carrying heavy equipment to orbit and back to the ground.

Another generic feature of commercial viability can be the general need to accomplish large through-put or large scale operations. The size of SSF lends itself to such needs.

Also in addition to processing equipment, some of the other infrastructure capabilities developed in CCDS projects may be applied on SSF to support product activities. The larger SSF program may derive mutual benefits from these infrastructure abilities.

To illustrate these general relationships, specific examples can be drawn from the list of projects in Table 1. As a first example, the Organic Separation or the Materials Dispersion and Biodynamics Projects can illustrate the role of SSF as a site for commercial operations. Both of these projects envision eventual service operations on a carrier such as SSF. In such an operation, a service company provides a complement of basic equipment which is left in orbit and upgraded in a modular way from time-to-time. The company provides services to many customers using the equipment on SSF. The human involvement with such equipment and operations offered by SSF is valuable, particularly with living cells which need careful handling. The next speaker in this session will have much more to say about the promise of biodynamics activities on SSF.[6]

A related subject is the infrastructure problem of keeping living cells in a satisfactory environment from the time they are delivered for loading on the Shuttle for transportation to SSF until they are unloaded from the Shuttle upon return to earth. This infrastructure problem is being solved for the Organic Separation Project during its planned flights on Spacehab. Spacehab provides power for environment control to the Organic Separation equipment from delivery, through launch, orbital operations, return to earth and until unloading at the landing site. The same continuous service is needed for living cells on their way to and from SSF. One attractive solution is to used Spacehab as a logistic carrier to and from SSF, in which case the commercial Spacehab infrastructure provision for living cells also becomes the SSF solution. This option is illustrated in further detail in the Spacehab exhibit at this Conference.[7]

TABLE 1

CMDS COMMERCIAL POTENTIAL

PROJECT	INDUSTRY PARTNER	POTENTIAL PRODUCTS/ SERVICES
Electrodeposition	McDonnell Douglas Space Sys. Co.	Improved surface coatings
Physical vapor transport crystal growth	Boeing Aerospace	ZnSe electrooptical devices
Non-linear optical organic materials	Teledyne Brown Engineering	Electrooptical Devices
Materials preparation and longevity in hypothermal oxygen	Physical Sciences, Inc., AZ Technology	Spacecraft surface coatings Atomic oxygen measurement devices
Sintered and alloyed materials	Kennametal, Inc. Wyle Laboratories Teledyne Wah Chang Deere and Company	Composites and alloys of metals and refractory materials
High-temperature superconductors	Lockheed, GE, LANL (AI)	Improved superconducting materials
Materials dispersion and biodynamics	Instrumentation Technology Associates, Inc. RANTEK, Inc.	Materials dispersion and biodynamic services
Organic Separation by phase partitioning of immiscible polymers	Interfacial Dynamics, Corp. Space Hardware Optimization Technology, Inc.	Cell/heavy molecule separation service Partitioning apparatus
Polymer foam formation	Thiokol Corporation	Lightweight space structures

CMDS INFRASTRUCTURE SERVICES

INFRASTRUCTURE AREA	INDUSTRY PARTNER	SERVICE
Space Experiment Furnace (SEF)	Boeing Commercial Space Development Company McDonnell Douglas - Spacehab	In-space furnace service for multiple customers
Equipment for Controlled Liquid Phase Sintering Experiment (ECLiPSE)/ Universal Small Experiment Container (USEC)	Wyle Laboratories	In-space furnace service for multiple customers
Suborbital Launch Vehicles/Services	EER Systems, Inc. McDonnell Douglas Space Sys. Co. Orbital Sciences Corporation Teledyne Brown Engineering Wyle Laboratories	Access to 7-14 minutes microgravity for multiple customers
Accelerometers		Acceleration environment measurements to support investigations
Commercial Materials Dispersion/ITA Experiment (CMIX)	Instrumentation Technology Associates, Inc.	In-space biodynamic services for multiple customers

The Sintered and Alloyed Materials Project (Table 1) provides a further example of the efficiency of leaving equipment in orbit. Furnaces for processing sintered and alloyed materials by their very nature tend to be large or heavy, so it is inefficient to transport them to and from orbit repeatedly. Two furnace systems are candidates for use by this project on SSF: the Space Experiment Facility (SEF) and the Equipment for Controlled Liquid Phase Sintering Experiment (ECLiPSE). Another speaker in this conference will describe SEF, so it is unnecessary to discuss it further here.(8) The ECLiPSE is housed for safety considerations in a Universal Space Experiment Container (USEC) developed by Wyle Laboratories. USEC is explicitly designed to be compatible with Spacehab, SSF and other carriers.

The Polymer Foam Project (Table 1) is an example of a project that eventually will require a large scale operation that could be done outside SSF. An ultimate objective of the project is commercial production of large foamed structures for use in space. A demonstration of production of such a structure is appropriate for SSF sometime late in the 1990's.

Other CMDS developed capabilities of potential infrastructure interests to SSF include accelerometer systems and atomic oxygen flux measurements. An evolving accelerometer system began as a means to measure the low acceleration environment on suborbital rockets managed by the CMDS. It has developed further into a system that will be used on Spacehab and in other Shuttle circumstances. It could find use on SSF to perform similar support services for CMDS and other CCDS investigations.

One objective of the Atomic Oxygen Project is a commercially available instrument to measure the changing atomic oxygen flux that impacts the ram-facing surface of a low satellite. Such an instrument(s) could be mounted on SSF to demonstrate its long term operation and the associated data reduction capabilities.

4. Conclusion

The projects of the Consortium for Materials Development in Space are ongoing activities that employ several means to attain access to space. For some of them, operations on Space Station Freedom offer an attractive option to meet project objectives. Further, some of the infrastructure capabilities developed for the Consortium may find applications on Freedom.

References

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2. Francis C. Wessling and Charles A. Lundquist, "Low Gravity Investigations on Suborbital Rockets," Proceedings of Twenty-Seventh Space Congress, pg. 3-41, Cocoa Beach, FL, April 24-27, 1990.

3. Charles A. Lundquist, "Transportation Requirements for Low Acceleration Conditions," Space Commerce, ed. John J. Egan, Proceeding of the Third International Conference on the Commercial and Industrial Uses of Outer Space, Montreux Switzerland, pg. 279, March 26-29, 1990, Gordon and Breach Science Publishers.

4. Charles A. Lundquist, "Evolution of Payload Equipment for Materials Development," AIAA Space Programs and Technologies Conference and Exhibit, Huntsville, AL, September 25-27, 1990.

5. CMDS Exhibit, NASA booth, Space Station Freedom Utilization Conference Exhibit.

6. Marian Lewis, "Materials Dispersion and Biodynamics Project Research," Space Station Freedom Utilization Conference, Huntsville, Alabama, August 3-6, 1992.

7. Spacehab exhibit, Space Station Freedom Utilization Conference Exhibit.

8. Barbara Heizer, "Crystals for Vapor Transport Experiment," Space Station Freedom Utilization Conference, Huntsville, Alabama, August 3-6, 1992.