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R. Ruiz and U. Israelsson
California Institute of '1 echnology
Jet Propulsion Laboratory

M. Lee
NASA Headquarters
Washington, DC

R. Reinker
Ball Aerospace and Technologies Corporation

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R M. Ruiz[1], U. Israelsson[1], M Lee[2], and Richard Reinker[3]

1 California Institute of Technology/Jet Propulsion Laboratory
2 National Aeronautics and Space Administration
3 Ball Aerospace and Technologies Corporation

The low temperature science community, Industry and the Jet Propulsion Laboratory have proposed a multiple cryogenic experiment facility for flight on the International Space Station on the Japanese Experiments Module's Exposed Facility. This self contained attached payload will provide 6 months cryogenic lifetime, reduce the complexity for investigator participation, reduce the cost of going to space, and provide frequent flight opportunities for National and International Microgravity Physics Experiments.

Background

Two decades of experimentation in low temperature microgravity physics have yielded tests of Nobel prize winning theory, new discoveries in critical point phenomena, and development of new technologies for use in Industry and Space. In 1985 the Superfluid Helium Experiment, developed by the Jet Propulsion Laboratory, demonstrated the containment arid control of liquid helium in space and the feasibility of supporting a science instrument insert within a liquid helium dewar [1]. In 1992 the Lambda-Point Experiment, developed by Stanford University, JPL and Elan Aerospace, added high resolution thermometry (5 X 10-10 kelvin) to this capability which allowed a precise test to be performed of the Nobel Prize winning Renormalization Group Theory (RGT) of critical phenomena [2]. In 1997, the Confined Helium Experiment (CHeX) will use the unique properties of liquid helium to pcl-fern-r a high resolution test of the theory of finite size effects [3]. The last of the Shuttle based experiments in 2000, Critical Dyrla/nits in Microgravity (DYNAMX) will study dynamic critical-point phenomena driven far away from equilibrium by introduction of a heat current heat [4]. While necessary and productive these Space Transportation System (STS) based experiments were short term, lasting no longer than several days; expensive, expending tens of millions of dollars; and required up to 7 years for development.

In the early eighties this program was supported by a small community of investigators supported by NASA's Physics And Chemistry Experiments Program

(PACE). This community expanded in the late eighties and early nineties to involve many major Universities across the United States. -1 oday, nearly 100 National and International Investigators (U. S., Japan, Germany, the U.K. and Canada) have defined Microgravity Physics Science objectives in critical point phenomena, relativity, and low temperature physics laser cooling of atoms. These objectives are in the process of being combined into world class goals for testing fundamental principals of physics, exploring the range of validity of universality principals, and determining scaling laws only possible in the microgravity of space. These objectives require longer duration experiment times than possible on the STS and both NASA's Space Studies Board (SSB) and the Low Temperature Science Steering Group (LTSSG) has recommend these experiments be conducted on the International Space Station.

I-his paper presents a status report on the evolving requirements defined by this community, describes how the LTMPF addresses these requirements; discusses the simple approach for transport, attachment, service and operation; and describes the Science Community's, Industry's, and NASA's low cost implementation approach.

Science Community and NASA Requirements

In determining the requirements for a space station facility the community and NASA evaluated the strengths and weaknesses of the S-f S program. Strengths included reuse of major hardware and software components by an experienced infrastructure of people and facilities. Weaknesses were few flight opportunities with long development times complicated by the involvement of too many NASA Centers resulting in redundancy and cost growth; complex interfaces between investigators, industry, and NASA which resulted in a deterrent to potential Investigators willingness to undertake the responsibility for a flight experiment; limiting experiments to a single instrument for each flight; anti the high cost per experiment. A summary status of requirements for an ISS Facility using this background follows:

1) Support broad range of fundamental physics and applied science experiments;
2) Support multiple experiments/instruments per flight;
3) Provide longer cryogenic duration (30 to 90 days per experiment);
4) Simplify mechanism for Investigators involvement and interlaces;
5) Provide for remote operation at PI facility;
6) Isolate experiments from 1SS accelerations;
7) Monitor acceleration and radiation environments;
8) Reduce development time to 3 years;
9) Significantly reduce cost per experiment;

10) Simplify reflight and provide more frequent access to space; and
11) Archive data to provide access to a wider research community.

Description

LTMPF is a reusable self-contained cryogenic facility designed for 7 months of cryogenic lifetime operating as an attached payload to the Japanese Experiment Module's Exposed Facility. An illustration of the facility and its key features is shown on Figure 1.

Low Temperature Microgravity Physics facility

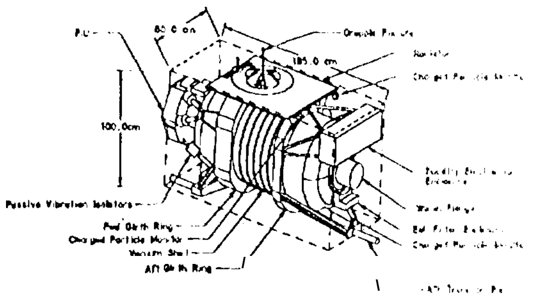

Figure 1

The two hundred sixty-seven liter dewar provides 7 months of on-station cryogenic lifetime for two instrument inserts as illustrated on Figure 2.

Multiple Instrument Dewar

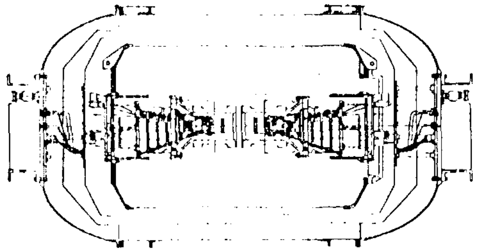

Figure 2

The Facility provides vibration isolation, instrument control, data collection, acceleration and radiation environment monitor and all interfaces with the JEMEF.

Transport is effected through use of the Shuttle Orbiter from the Kennedy Space Center. The dewar is last serviced on the Pad prior to payload bay door closure and flies passively attached to the Japanese Experiment Logistics Module (ELM).

Transfer from the Orbiter to the JEMEF is accomplished by crew Internal Vehicle Activity **(IVA)** using Orbiter and Space Station Remote Manipulator Systems (f-?MS). The Facility and its attach point on the JEMEF are illustrated on Figure 3.

LTMPF Attachment On JEMEF

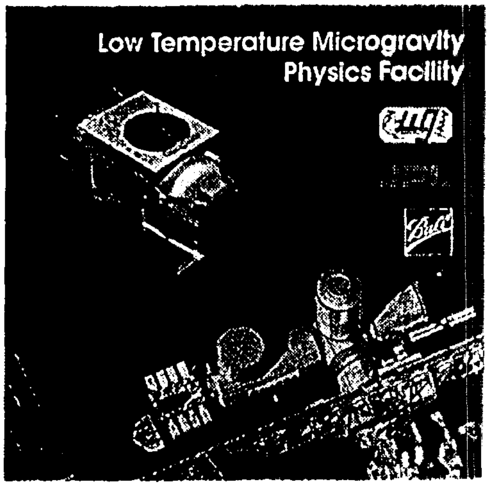

Figure 3

Turn-on and check-out will be performed at the ISS Payload Operations Control Center (POCC) and routine operations will be conducted from individual remote POCCs located at Investigator facilities using "Bent Pipe" Telemetry and Command services from the ISS POCC. The ISS/JEMEF services are limited to minimal telemetry (24 Kbps) and command (600 · 5 byte commands/day) processing and downlink, power (500 Watts), and attach/detach crew operations. The Facility wiii operate continuously for 6 months or until the cryogen is expended then it passively awaits the next opportunity for transport back to earth.

During the 6 months operation of one fright, a second pair of instruments would have been developed, integrated and tested with another flight dewar in preparation for the next flight, Upon return to Earth, the Facility will proceed through a brief checkout and the instruments and dewar from the first flight will be removed and replaced with the flight ready instruments and dewar for the next flight, This exchange of instruments and dewars will allow reflight as often as every 20 months.

Implementation And Cost

LTMPF will be implemented by a science, industry and JF'L partnership where partnership is defined as joint participation through all phases of definition, development and test with contractual responsibilities which share the risk anti the rewards. Science participants will be determined through the NASA Research Announcement (NRA) process. Initial experiments will be competitively peer evaluated and selected in FY'96 followed by a final selection in FY'98. Subsequent NRAs will be issued at two year intervals for future experiment selections. The Industry partner, Ball Aerospace and Technology Corporation (BATC), responsible for development of the Facility, was selected through a competitive technical selection process developed by JPL for this program. JPL is the NASA Center of Excellence for Microgravity Physics and is responsible for development of the instruments and management of the overall activity.

Ball and JPL will be involved early in the process when the science anti the Space Station interfaces are under definition. This will allow science, Ball and JPL to co-engineer the instruments and the facility consistent with a good understanding of science requirements prior to instrument and facility development planned to begin in FY'99. The development, integration and test program will be complete in three years providing for delivery for ELM integration in FY'02 and launch in November 2002.

The usual role of contract monitor and ponderous reviews will be replaced with a JPL and Ball team working to produce the best product in terms of cost, schedule and performance. Specific examples of this teaming approach are resident working team members as opposed to contract monitors, use of Ball's product assurance, review, and test approach as opposed to one dictated by JPL, and an open policy regarding financial status including remaining reserves and their utilization.

Previous single experiments flying on the STS typically cost about $30 Million dollars and required 5 to 7 years of development. LTMPF will reduce the development time to 3 years and the amortized cost over three flights to $19 Million per experiment.

Summary

A Low Temperature Microgravity Physics Facility under definition for the International Space Station satisfies or exceeds the recommendations of the Science Community and NASA Advisory Boards. LTMPF supports long term multiple experiment modules at low cost with frequent flight opportunities as often as every 20 months. Development, transport, ISS service, and operation have been simplified by using the relative strengths of the science community, Industry, and the NASA Centers in a partnering environment of shared risks and rewards. An international science community and Industry eagerly await the demonstration of this better way for returning more science for less dollars.

Acknowledgments

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[2] Lambda-Point Experiment; Principal Investigator : J. Lipa, Stanford University

[3] Confined Helium Experiment; Principal Investigator: J. Lipa, Stanford Unversity.

[4} Critical Dynamics in Microgravity Experiment; Principal Investigator: R. Duncan, Sandia National Laboratories.