N91-21332

Office of Space Science and Applications
Microgravity Science and Applications Division

Charge of

the Containerless Experimentation in Microgravity

Workshop

Pasadena Hilton
Pasadena, California
January 17-19, 1990

Mark C. Lee
NASA Headquarters

90-1-12-WHW

SSA

Containerless Experimentation in Microgravity

1. Elimination/Reduction of Surface Contamination
   - Adequate Earth-based technology

2. Reduction of dynamic nucleation
   - Paucity of reliable data

90-1-12-1-WHW

Containerless Experimentation in Microgravity

Objectives

- To delineate scientific justification for the U.S. Containerless Experimentation Program in Microgravity for the next decade and beyond
- To guide NASA to define the next generation of containerless experimentation instruments in microgravity

90-1-12-2-WHW

Containerless Experimentation
in Microgravity

Pre-Workshop Panel Meeting

Held at Caltech on August 16, 1989

Chairman: Professor John Perepezko

Members:	Prof. R. Bayuzick	Vanderbilt University
	Prof. H. Brody	University of Pittsburgh
	Dr. A. Cezairliyan	NIST
	Dr. D. Elleman	JPL
	Dr. E. Ethridge	MSFC
	Dr. R. Hauge	Rice University
	Dr. W. Hofmeister	Vanderbilt University
	Prof. W. Johnson	Caltech
	Dr. M. Lee	NASA Headquarters
	Dr. P. Nordine	CPI
	Dr. E. Trinh	JPL
	Prof. T. Wang	Vanderbilt University
	Dr. M. Weinberg	University of Arizona

90-1-12-3-WHW

Containerless Experimentation
in Microgravity

Objectives of Pre-Workshop Panel Meeting

1. To recommend to full workshop pertinent science and technology areas for discussion

2. To organize and structure full workshop

3. To take ownership of the full workshop

90-1-12-4-WHW

Recommendations for Discussion from Pre-Workshop Panel

1. Fluid dynamics (surface tension/thermocapillary at $T < 200$ °C)
2. Thermophysical properties (diffusion at extremely high temperatures, viscosity and surface tension)
3. Benchmark materials
4. Very high temperature chemistry for nonconducting materials
5. Quiescent undercooled melt nucleation study
6. Exploratory growth of protein and other novel crystals
7. Diffusional interactions of gas-particle dispersion
8. Development/verification of processing modeling

90-1-12-5-WHW

Ten Suggested Questions to be Addressed by the Workshop and Splinter Sessions

1. Is the removal of surface contamination alone enough to justify containerless experimentation in microgravity?
2. If not, then what are the other primary scientific justifications for performing containerless experimentation in microgravity?
3. What is the sensible way to acquire data for the purpose of verifying science justifications not currently available?
4. What should future containerless flight instruments look like if they are developed to meet those scientific justifications?
5. Does NASA need to develop a next generation electromagnetic manipulator?

90-1-12-12-WNW

Ten Suggested Questions (continued)

6. Does NASA need a high temperature acoustic program?
7. Is there any advantage to electrostatic positioning for space applications? Is it useful for melt undercooling study? Is it useful for low temperature protein crystallization applications?
8. Is there any need for a heavy-ion beam positioning scheme in space?
9. Can containerless manipulator capability be better achieved through a hybrid system such as acoustic-electromagnetic or acoustic-electrostatic?
10. How much investment is reasonable for the NASA containerless program? What percentage of the budget is adequate to cover high risk and, if successful, high yield areas?

90-1-12-13-WHW

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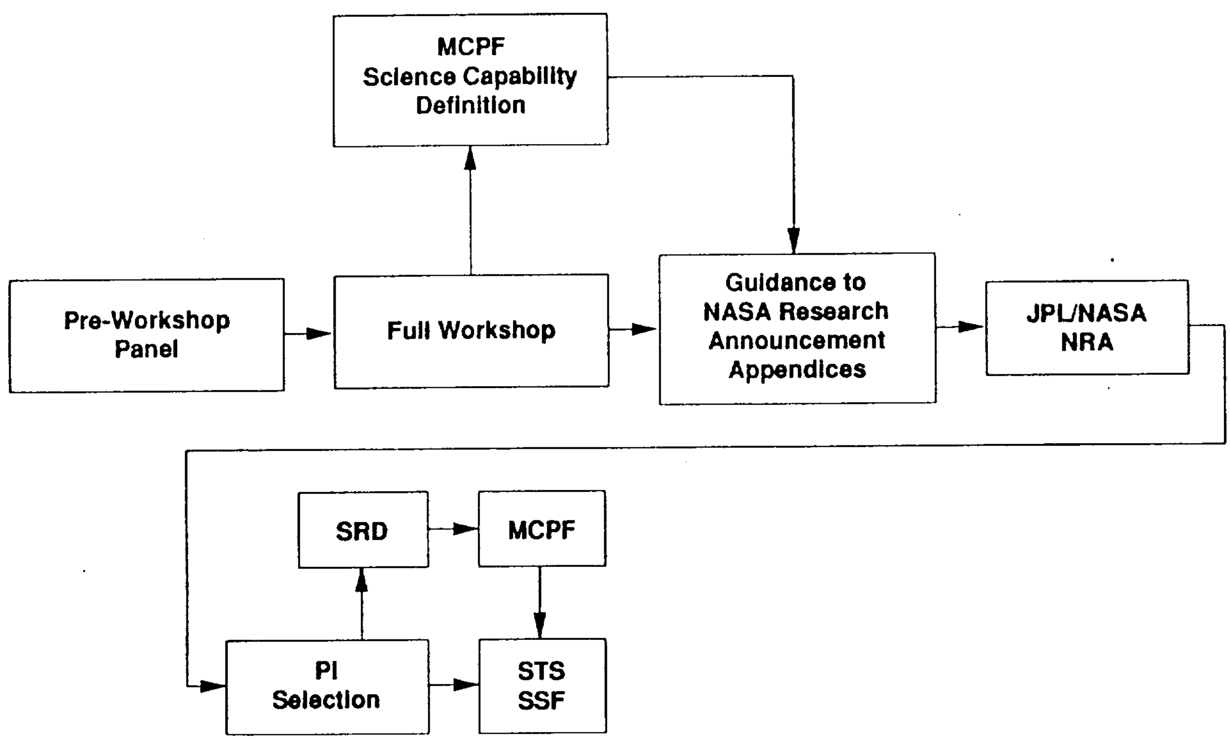
Containerless Experimentation
in Microgravity

The Process



90-1-12-10-WHW

Multiuser Hardware
"The Double NRA Approach"

NRA Selections ▼

PI Funding Starts ▼

minimum 2 years

definition studies with approved proposals

▼ Release 2nd NRA

ISSUE: Time Required for Double NRA

MCPF	√
Materials Science	X
Fluids	√
Combustion	√
Fundamental Science	TBD
PCG	√

Advantages: Multiuser HW better defined in 2nd announcement

All Science community has an equal chance for flight opportunities

90-1-12-7-WHW

NRA and AO Phasing

	Center Submission					
	90	91	92	93	94	95
1. Combustion		√			√	
2. PCG		√			√	
3. Containerless		√			√	
4. Materials Science		√			√	
5. Fluids			√			√
6. Biotechnology		√	√		√	
7. Fundamental Science					pending	

90-1-12-9-WHW

Products of Workshop

1. Information to guide JPL/NASA in putting together a Containerless NRA to be released in FY90

2. Information to guide JPL/NASA in defining a Modular Containerless Processing Facility (MCPF) for Space Station Freedom

90-1-12-8-WHW

The Challenge

Containerless experimentation in microgravity must be based on sound scientific justification. As NASA and this nation's investment in this area increases, it is even more critical to do so. Without strong scientific justification, it is increasingly difficult for NASA to maintain the current level of effort needed for the Space Station era in the face of mounting criticism voiced by the scientific community at large.

The challenge of this workshop is to provide this scientific justification, and to guide NASA in developing the next generation of flight instruments.

90-1-12-11-WHW

NASA Headquarters
Office of Space Science and Applications
Microgravity Science and Applications Division

Status and Outlook of the Microgravity Science and Applications Program at NASA

Presentation to

Containerless Experimentation in Microgravity Workshop

Larry Spencer
January 17, 1990

9001-008-01CW 01/10/90

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NASA Microgravity Program Goals

- Develop comprehensive research program in fundamental sciences, materials science, and biotechnology
- Develop understanding of gravity-dependent physical phenomena as basis of reliable predictive capability for processing operations/ technological issues in Earth/non-Earth environments
- Foster growth of an interdisciplinary research community
- Encourage international cooperation
- Explore new materials and processes relevant to basic research and commercial applications
- Develop permanently manned, multi-facility national microgravity laboratory in low-Earth orbit
- Promote industrial application of space research

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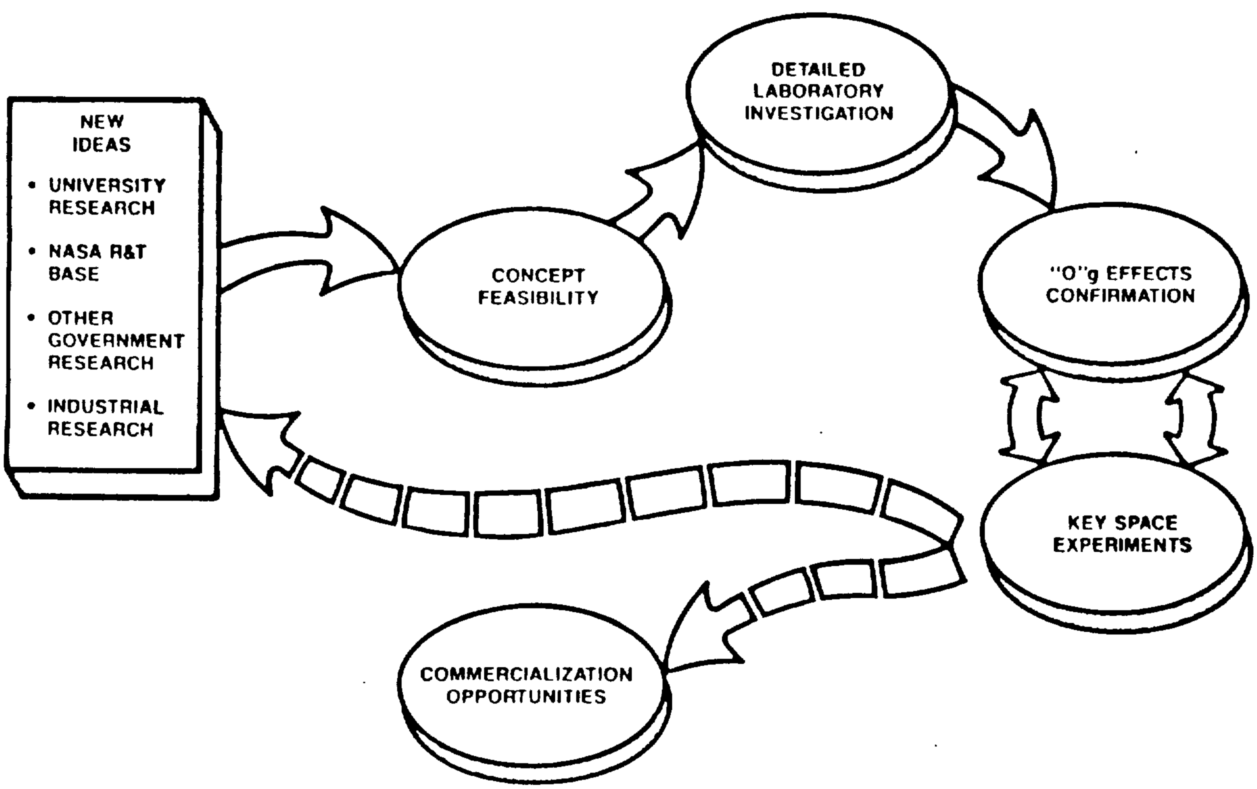
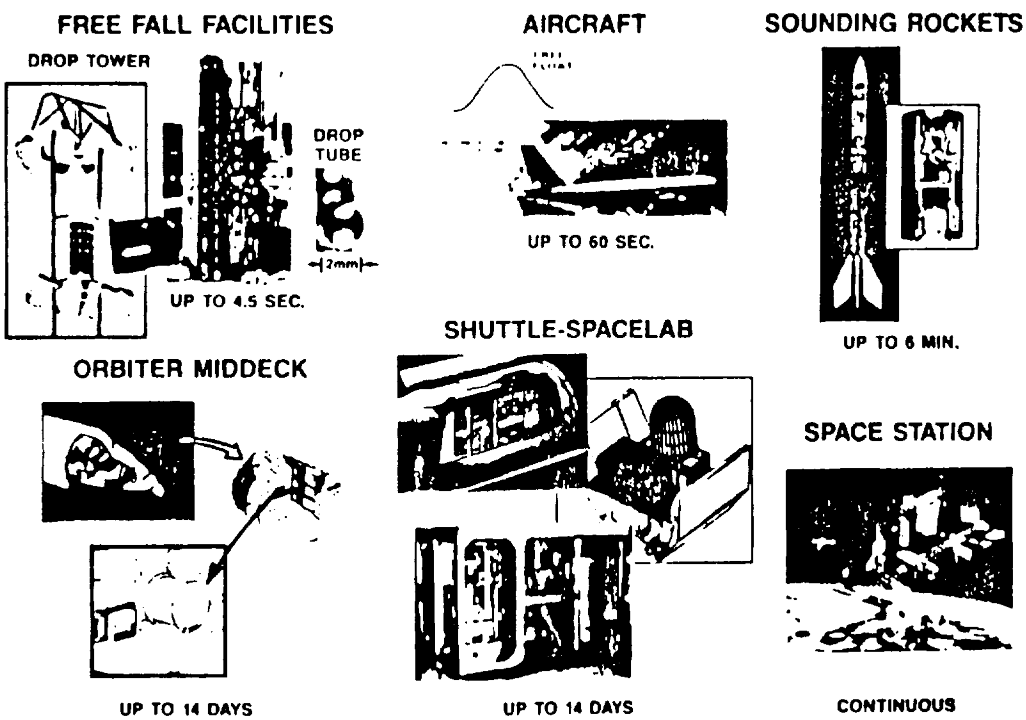
NASA OFFICE OF SPACE SCIENCE AND APPLICATIONS
MICROGRAVITY SCIENCE AND APPLICATIONS DIVISION

THE APPROACH



MICROGRAVITY SCIENCE AND APPLICATIONS EXPERIMENT CAPABILITY



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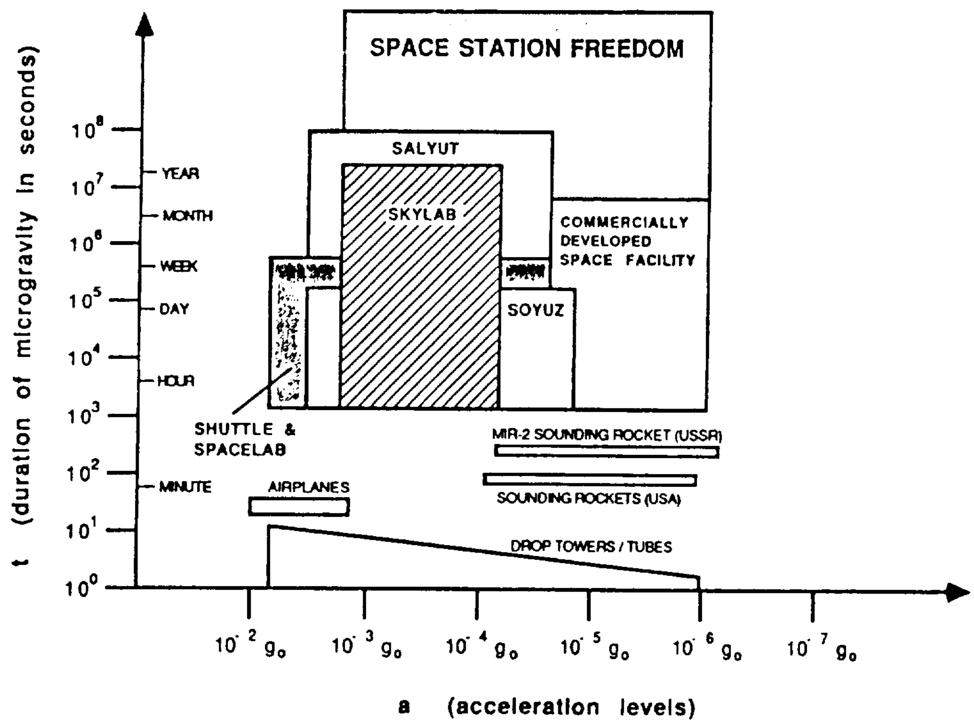
Microgravity Science and Applications
Characteristic Duration and Acceleration Levels

MSAD



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Microgravity Science and Applications Program

Fundamental Science

- Fluid Physics
- Combustion Science
- Critical Phenomena
- Relativity Theory

Materials Science

- Electronic Materials
- Metals and Alloys
- Glasses and Ceramics

Biotechnology

- Cell Physiology
- Cell Differentiation
- Protein Crystal Growth
- Biological Separations

9001-008-03CW 01/10/90

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Announcements Outlook

Release Date	Proposals Due	Announcement
9 Nov 89	31 Dec 89	ESA AO for Materials and Fluid Science Experiments: IML-2
26 Dec 89	26 Mar 90	NASA NRA for Microgravity Combustion Science: Research and Flight Opportunities
FY90 *	TBD	Protein Crystal Growth Announcement
FY90 *	TBD	Solidification Research Announcement
FY90 - 91 *	TBD	Containerless Research Announcement
FY91 *	TBD	Fluids Research Announcement
FY91 *	TBD	Foreign Hardware IML-3 Announcement
FY92 *	TBD	Fundamental Phenomenal/Critical Point Research Announcement

*** Dates identified are tentative pending budget availability**

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

Flight Systems Division

OSSA

INTERNATIONAL MICROGRAVITY LABORATORY (IML) -1

PAYLOAD COMPLEMENT

EXPMT No.	OV LOC	EXPERIMENT / FACILITY TITLE	ACRONYM	HQ CODE SPONSOR	EXPERIMENT / FACILITY DEVELOPER
2	SPACELAB RACK	FLUIDS EXPERIMENT SYSTEM	FES	EN	MSFC
3		VAPOR CRYSTAL GROWTH SYSTEM	VCGS	EN	MSFC
4		MERCURIC IODIDE CRYSTAL GROWTH	MICG	EN	CNES
19		CRITICAL POINT FACILITY	CPF	EN	ESTEC
13		ORGANIC CRYSTAL GROWTH FACILITY	OCGF	EN	NASDA
17		SPACE ACCELERATION MEASUREMENTS SYSTEM	SAMS	EN	LeRC
10		MICROGRAVITY VESTIBULAR INVESTIGATIONS	MVI	EB	JSC
16		RADIATION MONITORING CONTAINER/DOSIMETER	RMCD	EB	NASDA
15		MENTAL WORKLOAD AND PERFORMANCE EVAL.	MWPE	EB	JSC
14		BIOSTACK	BSK	EB	DLR
...		IMAX	IMAX	MC	JSC
6		GRAVITATIONAL PLANT PHYSIOLOGY FACILITY	GPPF	EB	ARC
7		BIORACK SYSTEMS	BR	EB	ESA/ESTEC
5	SMIDEX / MIDDECK	PROTEIN CRYSTAL GROWTH	PCG	EN	MSFC
18		CRYOSTAT	CRY	EN	DLR
8		SPACE PHYSIOLOGY EXPERIMENTS	SPE	EB	CSA

IML-1-C EM 11/89

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First United States Microgravity Payload (USMP-1)

Payload Complement

No.	Experiment/Facility Title	NASA HQs Sponsor	Developer
1	Lambda Point Experiment	Code EN	JPL
2	MEPHISTO	CNES	CNES
3	Advanced Automated Directional Solidification Furnace (AADSF)	Code EN	MSFC
4	Space Acceleration Measurement System (SAMS)	Code EN	LeRC

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First United States Microgravity Laboratory (USML-1)

Baseline Payload Complement

No.	Experiment/Facility Title	NASA HQs Sponsor	Developer
1	Crystal Growth Furnace (CGF)	Code EN	MSFC
2	Crystals, Monomers, Deposition and Separation Facility (CMDSF)	Code C	UAH CCDS
3	Drop Physics Module (DPM)	Code EN	JPL
4	Surface Tension Driven Convection Experiment (STDCE)	Code EN	LeRC
5	Glovebox (GBX)	Code EN	TBD
6	Space Acceleration Measurement System (SAMS)	Code EN	LeRC
7	Solid Surface Combustion Experiment (SSCE)	Code EN	LeRC
8	Zeolite Crystal Growth (ZCG)	Code C	Battelle CCDS
9	Protein Crystal Growth (PCG) (3 R/IM's)	Code C	MSFC
10	Generic Bioprocessing Apparatus	Code C	Bioreserve
11	Solution Crystal Growth (SCG)	Code C	Battelle CCDS
12	Astroculture (ASC)	Code C	Wisconsin CCDS

9001-008-15CW 01/10/90

NASA

Second United States Microgravity Payload (USMP-2)

μg Microgravity

Payload Complement

No.	Experiment/Facility Title	NASA HQs Sponsor	Developer
1	Critical Fluid Light Scattering Experiment	Code EN	LeRC
2	Isothermal Dendritic Growth Experiment	Code EN	LeRC
3	MEPHISTO	CNES	CNES
4	Advanced Automated Directional Solidification Furnace (AADSF)	Code EN	MSFC
5	Space Acceleration Measurement System (SAMS)	Code EN	LeRC

9001-008-18CW 01/10/90

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OFFICE OF SPACE SCIENCE AND APPLICATIONS

Flight Systems Division

OSSA

INTERNATIONAL MICROGRAVITY LABORATORY (IML) -2
CANDIDATE PAYLOAD COMPLEMENT

EXPMT No.	OV LOC	EXPERIMENT / FACILITY TITLE	ACRONYM	HQ CODE SPONSOR	EXPERIMENT / FACILITY DEVELOPER
	SPACELAB RACK	BIORACK (W/O CLR/FZR)	BR	EB	ESTEC/NASA JSC
		AQUATIC ANIMAL ENVIRONMENTAL UNIT	AAEU	EB	NASDA
		PERFORMANCE WORKSTATION	PWS	EB	NASA JSC
		VESTIBULAR & SENSORI-MOTOR EXPERIMENT	VSE	EB	CNES
		SLOW ROTATING CENTRIFUGE WITH MICROSCOPE	NIZEMI	EB	DLR
		REAL-TIME RADIATION MONITORING DEVICE	RRMD	EB	NASDA
		BACK PAIN IN ASTRONAUTS	BPA	EB	CSA
		BIOSTACK	BSK	EB	DLR
		VIBRATION ISOLATION BOX EXPERIMENT SYSTEM	VIBES	EN	NASDA
		ELECTROMAGNETIC CONTAINERLESS PROCESSING FAC.	TEMPUS	EN	DLR
		BUBBLE, DROP & PARTICLE UNIT	BDPU	EN	ESTEC
		APPLIED RESEARCH ON SEPARATION METHODS USING SPACE ELECTROPHORESIS	RAMSES	EN	CNES
		FREE FLOW ELECTROPHORESIS & THERMO-ELECTRIC INCUBAT.	FFEU/TEI-HT	EN	NASDA
		QUASI-STEADY ACCELERATION MEASUREMENT	QSAM	EN	DLR
		ADVANCED GRADIENT HEATING FACILITY	AGHF	EN	ESTEC
		LARGE ISOTHERMAL FURNACE	LIF	EN	NASDA
	SPACELAB AISLE	CANADIAN MINI-SLED	CMS	EB	CSA
		LOWER BODY NEGATIVE PRESSURE DEVICE	LBNPD	EB	NASA JSC
		DOUBLE RACK ADAPTOR PLATE	DRAP	EB	NASA JSC
		EDOMP EXERCISER	- - -	EB	NASA JSC
		SPACE ACCELERATION MEASUREMENT SYSTEM	SAMS	EN	NASA LeRC
	SMIDEX/ MIDDECK	SLEEP MONITORING EXPERIMENT	SME	EB	NASA JSC
		ADVANCED PROTEIN CRYSTALIZATION FACILITY	APCF	EN	ESA

IML-2-C EM 11/89

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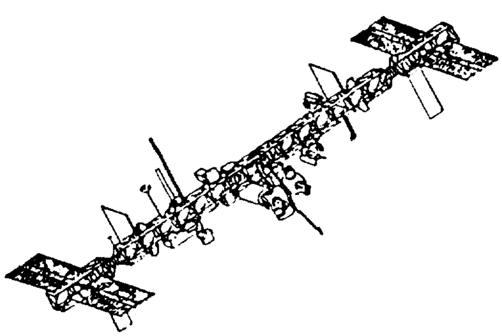
1989 Highlights
Advanced Programs



- **Space Station:**
  - Joint Science Utilization Study Support
  - May 1989: Modular Combustion Facility Assessment Workshop
  - June 1989: Space Station Furnace Facility One Year Conceptual Design Study awarded to Teledyne Brown Engineering
  - August 1989: Deployment dates for multi-user facilities rephased
  - November 1989: Request out to all MSAD investigators to provide model experiment scenarios for Space Station
  - December 1989: Microgravity Requirement addressed at combined Level I/Level II Space Station Control Board meeting at Reston, Virginia
- **Human Exploration Initiative**
  - Preliminary Program Plan developed for Microgravity Science and Applications in response to call for 90-day NASA report to Vice-President Quayle

9001-008-17CW 01/10/90

OSSA

Microgravity Science and Applications Plans for Space Station

- **Six multi-user experimental facilities planned for Space Station Freedom**
  - Advanced Protein Crystal Growth Facility
  - Space Station Furnace Facility
  - Modular Containerless Processing Facility
  - Fluid Physics/Dynamics Facility
  - Modular Combustion Facility
  - Biotechnology Facility

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Microgravity Science and Applications Evolution Strategy

- **Initial Strategy: Deploy six facilities prior to SSF Assembly Complete**
- **Current Strategy: Rephased developments in order to resolve issues with:**
  - Phasing of Space Station
  - Budget and schedule incompatibilities
  - Technical capability constraints
- **Rephasing allows MSA Program time to:**
  - Enhance research base
  - Strengthen project management base
  - Gain more on-orbit experience

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Human Exploration Initiative

- **Basic approach**

1990's		2001 - 2010		Beyond 2010
Space Station Freedom	⇨	Lunar Outpost	⇨	Mars Exploration
Lunar Orbiter	⇨	Mars Robots		Lunar Operations

- **Long-range exploration goal is Mars**
- **Moon is justified on its merits, as well as a stepping stone toward Mars**
- **90-day study will develop a baseline option and analyze impact of variations on milestones and program scope**
- **Baseline and options will be approved by NASA Administrator**

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Human Exploration Initiative
MSAD Program Strategy

MSAD's Role in the Human Exploration Initiative

- **Determine influence of gravity and other extraterrestrial environments on fundamental processes/phenomena. Emphasis on:**
  - Processes/phenomena significantly altered or affected by gravity variations and other unique attributes of the extraterrestrial environment
  - Processes/phenomena whose understanding under extraterrestrial conditions will benefit planned HEI activities
- **Support basic research activities which can clearly benefit from exploiting the unique attributes of the lunar environment**

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Initiative Research Areas

- **Fluid Dynamics and Transport Phenomena**
  - Multiphase flow
  - Phase change heat transfer
  - Fluids management
- **Mechanics of Granular Media**
  - Soil mechanics
  - Rheology
- **Combustion**
  - Fire safety
  - Power
- **Materials Processing**
  - Resource utilization/chemical processes
  - Materials manufacturing

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Strategic Planning Summary

- **Aggressive hardware development program to take advantage of a number of opportunities**
  - Shuttle
  - Space Station
  - Free Flyers
  - Human Exploration Initiative
- **Increased emphasis on Research Announcements**
  - Ground-Based Program
  - Flight Program
- **Planned program augmentations**
  - Ground-Based Program
  - Fundamental Science (Flight Program)
  - Sounding Rocket Opportunities

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