NASA'S COMMERCIAL RESEARCH PLANS AND OPPORTUNITIES

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ABSTRACT

One of the primary goals of the National Aeronautics and Space Administration's (NASA) commercial space development plan is to encourage the development of space-based products and markets, along with the infrastructure and transportation that will support those products and markets. A three phased program has been instituted to carry out this program. The first phase utilizes government grants through the Centers for the Commercial Development of Space (CCDS) for space-related, industry driven research; the development of a technology data base; and the development of commercial space transportation and infrastructure. The second phase includes the development of these technologies by industry for new commercial markets, and features unique industry/government collaborations such as Joint Endeavor Agreements. The final phase will feature technical applications actually brought to the marketplace. The government's role will be to support industry required infrastructure to encourage start-up markets and industries through follow-on development agreements such as the Space Systems Development Agreement.

The Office of Commercial Programs has an aggressive flight program underway on the Space Shuttle, suborbital rockets, orbital expendable launch vehicles, and the Commercial Middeck Accommodation Module with SPACEHAB Inc.

The Office of Commercial Program's has been allocated 35% of the U.S. share of the Space Station Freedom resources for 1997 utilization. A utilization plan has been developed with the Centers for the Commercial Development of Space and has identified eleven materials processing and biotechnology payloads occupying 5 double racks in the pressurized module as well as two payloads external to the module in materials exposure and environment monitoring. The Office of Commercial Programs will rely on the Space Station Freedom to provide the long duration laboratory component for space-based commercial research.

Office of Commercial Programs

Presentation to Space Station Freedom Utilization Conference

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Opportunities for Commercial Research in Space

- Objective
  - Conduct industry driven, space based, high technology, applied research and to allow U.S. industry to develop new or improved commercial products
- Goal
  - Increase the private sector participation and investment while diminishing the associated up-front financial and technical risks

Commercial Research Plans and Opportunities

- The Office of Commercial Programs relies on the Space Station Freedom to provide the long duration laboratory component for space-based commercial research
- The Office of Commercial Programs is creating all of the ingredients in the recipe for the success of U.S. private sector leadership in space by providing:
  - Opportunities for focused research
    - Centers for the Commercial Development of Space
  - Basic experimental apparatus
    - Material science furnaces
    - Commercial refrigerator/incubator modules
    - Thermal enclosure systems
  - Precursor experimental space flights
    - Space Shuttle
    - SPACEHAB
    - COMmercial Experiment Transporter
    - Wakeshield Facility

Mechanisms for Commercial Research Relationships with Industry are in Place

- Affiliation with the Centers for the Commercial Development of Space
- Collaborative agreements with NASA
  (Joint Endeavor Agreement, Technical Exchange Agreements)
- Reimbursable flight agreements
  (Space Systems Development Agreement)

The Office of Commercial Programs encourages and supports U.S. private sector leadership in space-related commerce

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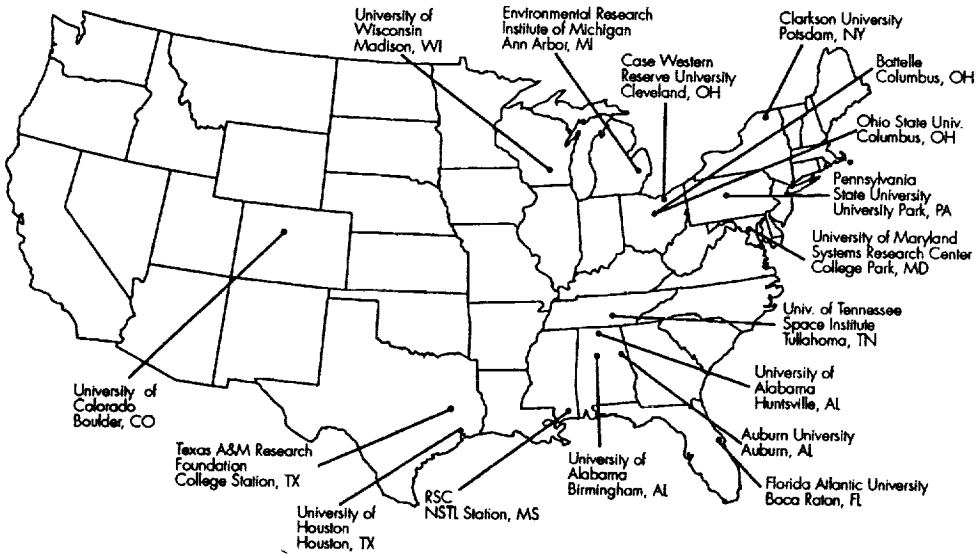
Centers for the Commercial Development of Space (CCDS) Program

- Non-profit consortia of industry, academia and government
- Conduct industry driven space-based, high-technology research and development
- Research areas include materials processing, biotechnology, remote sensing, automation and robotics, space power, space propulsion, space structures and communications
- Created in 1985 to maximize U.S. industry leadership in commercial space-related activities
- Designed to increase private sector participation and investment in the commercial development of space
- Provide a way for U.S. companies to pool resources and expertise while diminishing the associated costs and risks
- To participate in the CCDS program, a company should contact the appropriate CCDS Center Director

Centers for Commercial Development of Space (CCDS)



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Current CCDS Commercial Technologies

Auburn
Solar Furnace Satellite
Crystal Growth of Electronic Materials
Computational Modeling of Casting Processes

Battelle
Solution Crystal Growth
Polymer Composites
Float Zone Crystal Growth - CdTe
Zeolite Crystal Growth
Doped Non-Linear Optic Substrates
Investigations into Polymer Membranes

Bioserve
Plant Growth Apparatus
Blood Rheology Experiment
Generic Bioprocessing Module
Autonomous Biomedical Test Apparatus

Case Western
Materials Exposure - Basic, Advanced, & Applied

Clarkson
Zeolite Crystal Growth
Low-Temp Solidification
Liquid Encapsulated Melt Zone
Directional Solidification - CdTe
Chemical Vapor Transport - CdTe
Commercial Solution Growth Facility

CSTAR
Cryogenic Fluid Management
Electric, Chemical Propulsion
Industrial Laser System Applications

Florida Atlantic
Transmission Techniques

Ohio State
Remote Sensing & Mapping

Penn State
Biomodule
Telemedicine
Bioseparations
Bone Densitometry
Physiological Systems Experiment
Light Stimulator & Photon Detector
Commercial Electrophoresis System

SpARC
Autonomous Rendezvous & Docking
Automated Microgravity Materials Processing

SRSC
Remote Sensing & Applications

SVEC
Chemical, Molecular Beam Epitaxy Growth

Texas A&M
Micro Heat Pipe Evaluation
Frozen Startup of Heat Pipe
Microwave Power Transmission

University of Alabama–Birmingham
Protein Crystal Growth

University of Alabama–Huntsville
Polymer Foam
Atomic Oxygen
Electrodeposition
3-D Accelerometer
Immiscible Polymers
Nuclear Track Detectors
Space Experiment Facility
Non-Linear Optical Materials
Sintered & Alloyed Materials
High-Temp Superconductors
Materials Dispersion Apparatus

University of Maryland
Hybrid Networks

WCSAR
Astroculture™
Bioregenerative Water System

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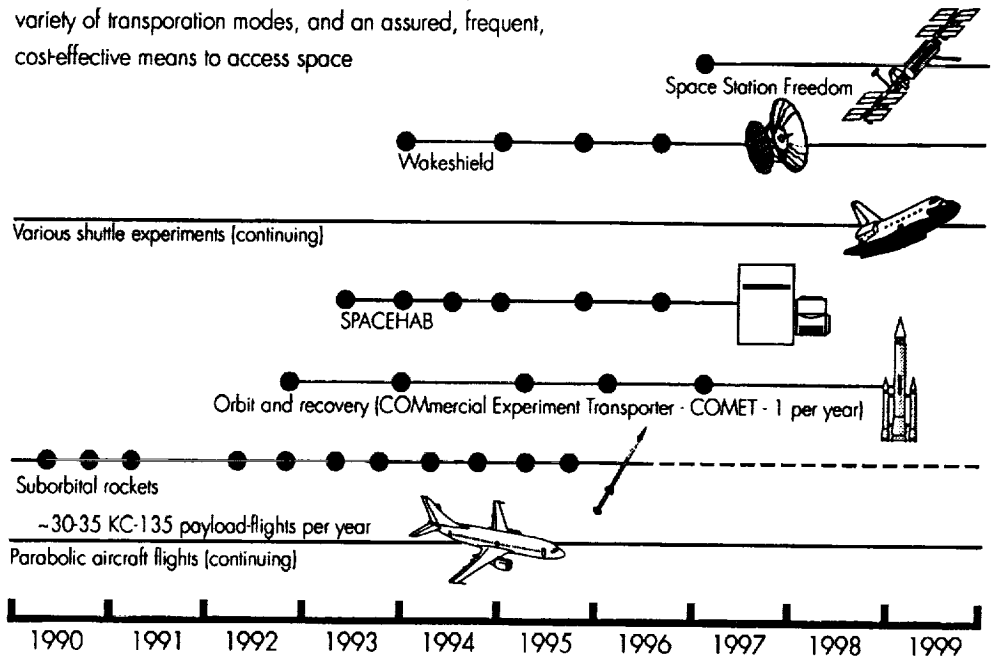
Active Commercial Agreements

Company	Venture	Status	Requirement	Flights Completed
Joint Endeavor Agreements				
Instrumentation Technology Associates	Standardized Experiments Carrier	Hardware under development, first flight TBD	2 flights (cross-bay carrier)	0
3M (10 years)	Reserach in organic and polymer chemistry	First payload (pm) STS-34 (Oct 1989)	62 flights (20 middeck; 42 cargo bay)	3
Boeing Aerospace Company (BAC)	Crystal growth experiments on the shuttle	Hardware under development, first flight planned for STS-52 (Sept. 1992)	3-5 flights (Mar)	0
Technical Exchange Agreements				
Autometric, Inc.	High resolution handheld remote sensors	Signed 4/2/91	Access to NASA Imagery from the Electronic Still Camera developed by JSC	2
Other Cooperative Agreements				
University of Alabama - Huntsville Instrumentation Technology Associates	Materials processing using a minimal dispersion apparatus	First flight planned for STS-52 (Sept. 92)	5 flights 1 locker	0

Flight Planning

Commercial Transportation Modes

Commercial development of space programs require a variety of transporation modes, and an assured, frequent, cost-effective means to access space



* *Many carrier and interface configurations not highlighted here*

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Flights of U.S. Commercial Payloads

	Payload Name	No. of Flights	Missions
1	Astroculture	1	STS 50
2	Automated Generic Bioprocessing Apparatus	2	Consort 3,4
3	Biomodule	2	Consort 3,4
4	Bioserve Instrumentation Materials Dispersion App.	2	STS 37,43
5	Continuous Flow Electrophoresis (I, II, & III)	7	STS 4,6,7,8,12,16,23
6	Demixing of Immiscible Polymers Mixer\	2	Consort 1,3
7	Diffusive Mixing of Organic Solutions	2	STS 14,23
8	Directed Polymerization Apparatus (USML-1 GBX exper.)	1	STS 50
9	Elastomer-Modified Epoxy Resisns Heaters	2	Consort 1,3
10	Electrodeposition Cells	4	Consort 1,3,4, STS 40 (GAS 105)
11	Equipment for Controlled Liquid Phase Sintering	1	Consort 4
12	Fluid Experiment Apparatus	2	STS 30,32
13	Foam-Formation Device	2	Consort 1,3
14	Gelation of SOLS: Applied Microgravity Research	1	STS 42
15	Generic Bioprocessing Apparatus	1	STS 50
16	Protein Crystal Growth (Hand-Held, VDA, PCF, CRIM	14*	STS 16,19,23,24,26,29,32,31,37,43,48,42,50
17	Investigations into Polymer Membrane Processes	2	Consort 3,4
18	Investigations into Polymer Membrane Processing	7	STS 31,41,43,48,42,45,50
19	Materials Dispersion Apparatus	3	Consort 1,3,4
20	Metal Sintering Furnace	1	Consort 1
21	Non-Linear Optical Crystal Growth (DAN)-UAH/IBM	1	STS 40 (GAS 105)
22	Non-Linear Optical Crystal Growth (DAN)-UAH/IBM	1	STS 40 (GAS 105)
23	Physical Vapor Transport of Organic Solids	2	STS 20,26
24	Physiological Systems Experiments	1	STS 41
25	Plasma Particle Generation	1	Consort 3
26	Polymer Curing Experiment	1	Consort 4
27	Polymer Morphology	1	STS 34
28	Polymer Thin Films	2	Consort 3, STS 40 (GAS 105)
29	Separation of Aqueous Phases	1	STS 40 (GAS 105)
30	Space Formed Structural Beam (Foam Foundation Device)	1	Consort 4
31	Yeast Experiment	1	STS 40 (GAS 105)
32	Zeolite Crystal Growth	1	STS 50

Total number of payloads flown - 73** Hardware Items - 32

* *The Protein Crystal Growth experiments were shared between the OCP and OSSA*

** *A payload-flight = one flight of one payload. Therefore, one flight with = 3 payload-flight*

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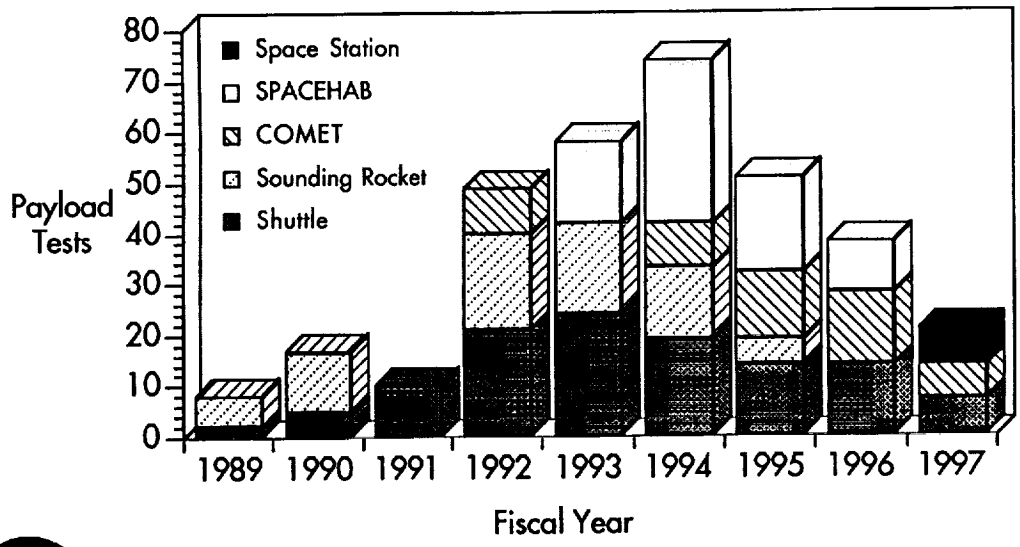
Flight Profile



Office of Commercial Programs Near Term Flight Projection

Flight	Sponsor	Payload	Launch Date
STS-46	Case Western UAH/Los Alamos Natl Labs UAH/Teledyne Brown	Limited Duration Candidate Materials Exposure (3)* CONCAP-II* (CONsortium Complex Autonomous Payload) CONCAP-III* (CONsortium Complex Autonomous Payload)	Jul 1992
CONSORT-05	Penn State UAH Wisconsin	Penn State Biomodule* Organic Separation* Polymer Beam* Equipment for Controlled Liquid Phase Sintering Experiment* Materials Dispersion Apparatus* Polymer Foams and Films* Sintered and Alloyed Materials* Electrodeposition* Performance of Light-Emitting Diodes in Microgravity*	Sept. 1992
STS-47	UAB	Protein Crystal Growth**	Sept 1992
STS-52	Boeing UAB Penn State Univ UAH/ITA	Crystals by Vapor Transport Experiment* Protein Crystal Growth* Physiological Systems Experiment* Commercial ITA Materials Dispersion Experiment*	Oct 1992
STS-54	Bioserve	Generic Bioprocessing Apparatus*	Dec 1992

* *Assigned*
** *OSSA Sponsored - Joint Flight Activity*
Note: Shuttle flight dates are based on internal manifest planning on 6/4/92

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Near Term Flight Projection (continued)

Flight	Sponsor	Payload	Launch Date
COMET-01	Bioserve	Autonomous Biomedical Test Apparatus*	Mar 1993
		Plant Growth Apparatus*	
	UAH	Materials Dispersion Investigations*	
		Non-Linear Optical Materials *	
		Atomic Oxygen*	
		3-Dimensional Microgravity Accelerometer*	
	Penn State	Biomodule*	
	UAB	Protein Crystal Growth*	
	ERIM	Autonomous Rendevous Docking*	
	FAU	Motorola Communications Experiment*	
	Texas A&M	Frozen Startup of a Heat Pipe in Microgravity*	
STS-51		Advanced Communications Technology Satellite	Mar 1993
	Case Western	Limited Duration Candidate Materials Exposure (2) *	
	UAB	Commercial Protein Crystal Growth*	
	Battelle/Amoco	Investigations into Polymer Membrane Processing*	
STS-56	UAH/ITA	Commercial ITA Materials Dispersion Experiment	Apr 1993

* *Assigned*
** *OSSA Sponsored - Joint Flight Activity*
Note: Shuttle flight dates are based on internal manifest planning on 6/4/92

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Near Term Flight Projection (continued)

Flight	Sponsor	Payload	Launch Date
STS-57	Battelle	Spacehab-01	May 1993
		Investigations into Polymer Membrane Processing*	
		Solution Crystal Growth*	
		Zeolite Crystal Growth*	
	Bioserve	Bioserve Pilot Laboratory*	
		Commercial Generic Bioprocessing Apparatus*	
	Clarkson	Liquid Encapsulated Melt Zone-1*	
	Penn State Univ	Physiological Systems Experiment*	
	UAB	Commercial Protein Crystal Growth*	
		Advanced Protein Crystal Growth*	
	UAH	Equipment for Controlled Liquid Phase Sintering*	
		Organic Separation*	
		3-Dimensional Microgravity Accelerometer*	
	Wisconsin	Astroculture*	
	LaRC	Gas Permeable Polymer Material*	
	JSC	Application Specific Preprogrammed Experimental Culture (plus other Space Life Sciences activities)*	
	LeRC	Space Acceleration Measurement System*	
	UAH	CONCAP II	
	UAH	CONCAP IV	

* *Assigned*
** *OSSA Sponsored - Joint Flight Activity*
Note: Shuttle flight dates are based on internal manifest planning on 6/4/92

Commercial Utilization of Space Station Freedom

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Rationale for Commercial Space Station Involvement

- Provides the important long duration laboratory component which will enable commercial technologies to transition to new, space-based markets
- Provides natural evolution from shuttle experience for commercial payloads
- Adequate rack volume and power to support commercial payloads
- Most commercial payloads can operate within Space Station microgravity levels
- Payloads can take advantage of untended periods - free flyer environment
- Allows for commercial infrastructural considerations

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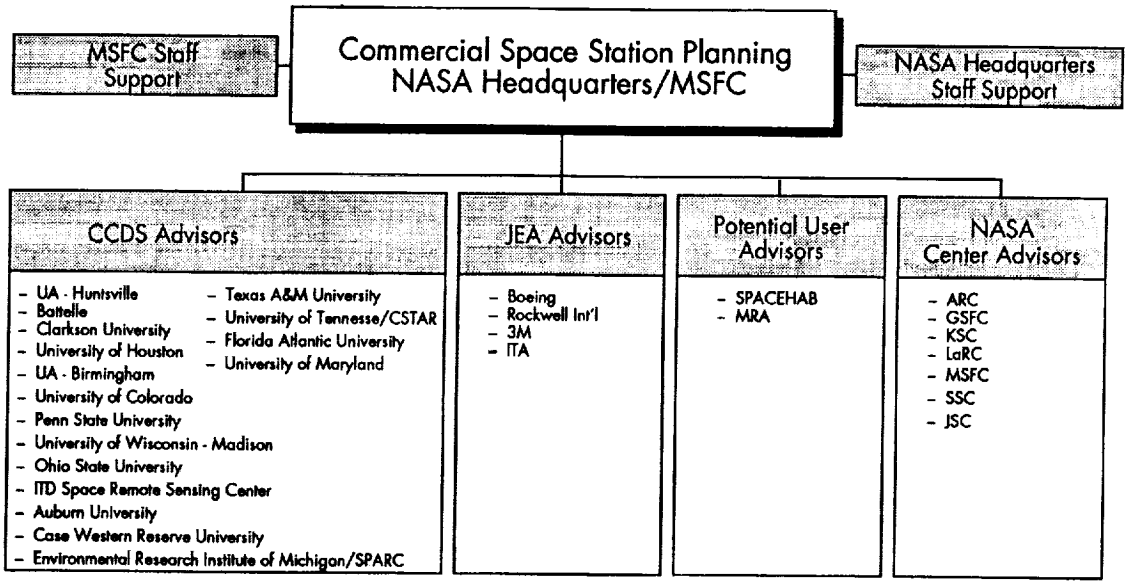
Commercial Space Station Freedom Planning Team



Space Station Freedom Resource Allocations

	NASA U.S.A.	MOSST Canada	ESA Europe	STA Japan
Utilization Resources	71.4%	3%	12.8%	12.8%

OSSA - Science: 65%*
OCP - Commercial: 35%*
OAST - Technology: 15%*
OSF/OSSD - Other: 10%*

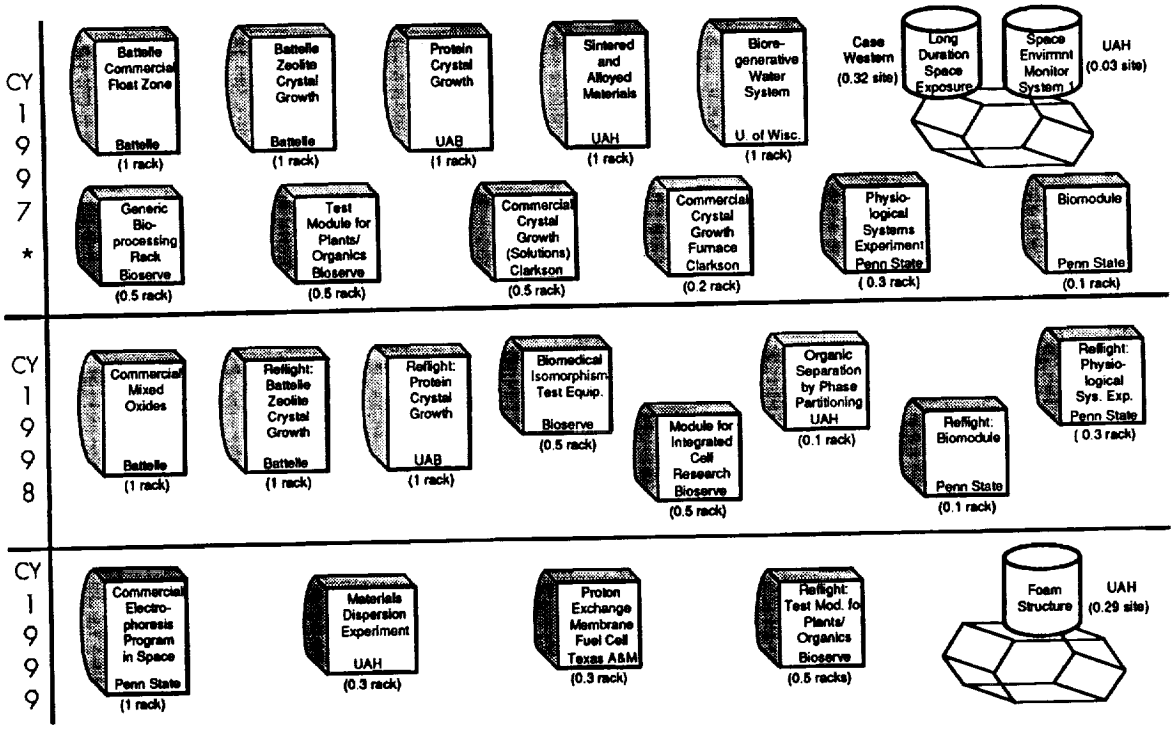
1997 OCP SSF Resources

Pressurized Up Mass: 4,352 kg
Pressurized Down Mass: 3,784 kg
Unpressurized Up Mass: 4,209 kg
Unpressurized Down Mass: 7,073
Volume Up: 9.5 DRE
Volume Down: 7.1 DRE
Power: 3 kW
Downlink: 10,472 kb/s
Crew Time: 436 hours
Data Storage: 92 Mbytes
Racks Occupied On-Orbit: 5 DRE
Truss Attach Points: 0.7 APs

* Utilization planning guidelines allow the total resources used by NASA's User Sponsors to equal 125%, for the launch minus 5 year timeframe.

OCP SSF Utilization Traffic Model

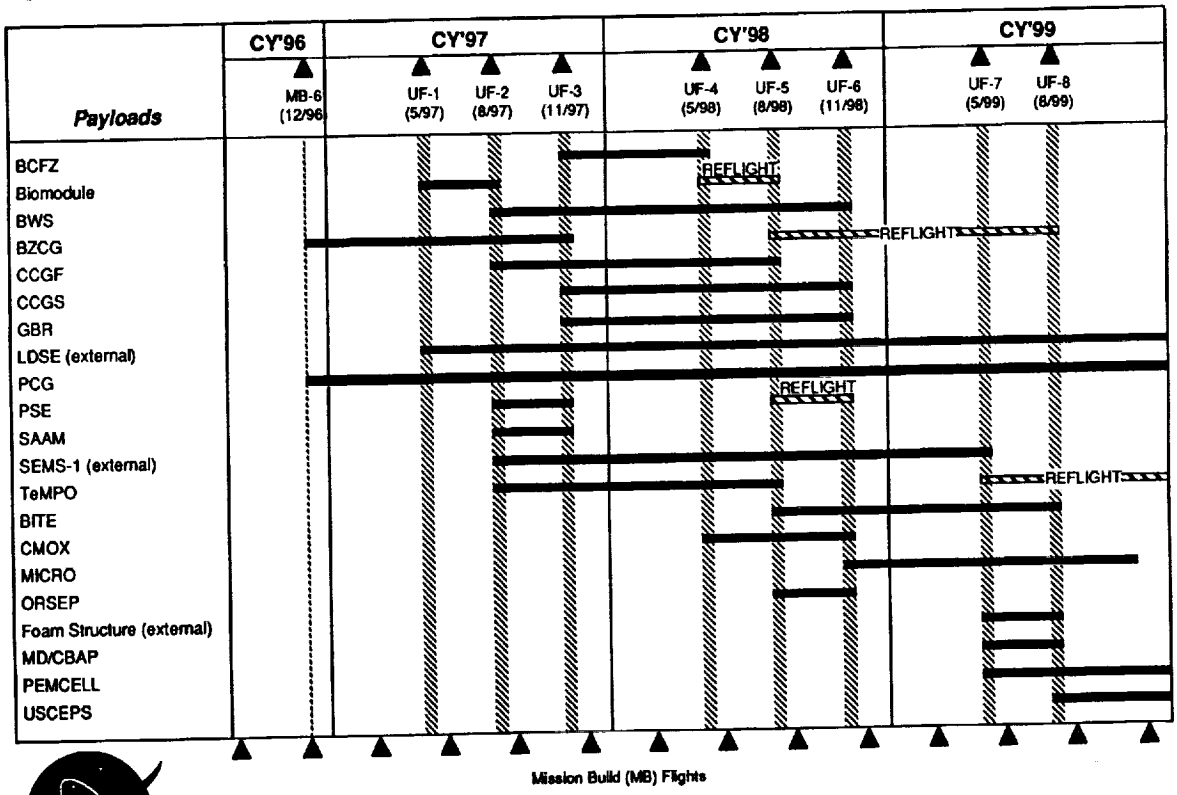
Draft



* *Includes payloads on Mission Build flight 6, currently scheduled for launch in December 1996.*

Space Station Freedom Flight Manifest

Draft



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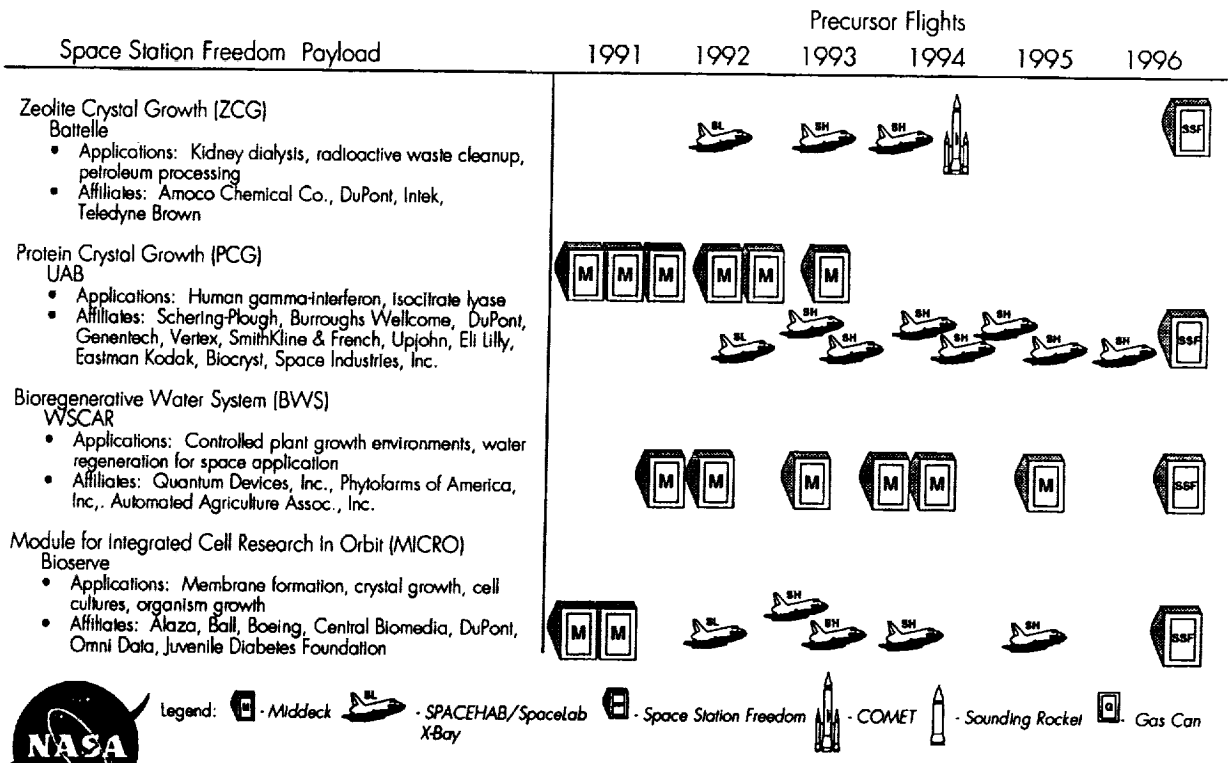
Space Station Freedom Payload Heritage



Legend: Middeck · SPACEHAB/Spacelab X-Bay · Space Station Freedom · COMET · Sounding Rocket · Gas Can

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OCP Payload Development and Transition to Space Station Freedom

- OCP has an active flight program using Middeck, sounding rockets, gas cans, and KC-135s to develop experiments
- OCP intends to extend the flight experiments which are successful on these carriers to the Space Station Freedom
- OCP has a draft traffic model and a flight plan for development flights of payloads on various carriers to get us from the present to the Space Station Freedom time frame
- OCP will rely heavily on the existing carriers plus COMET and SPACEHAB for payload development and transition to Space Station Freedom

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Vision

- Stimulating private sector involvement in space-related activities to enhance the competitiveness of U.S. industry, promote the nation's economic well-being, and improve the overall quality of life

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