National Aeronautics and Space Administration

An Overview of Biotechnology Payloads

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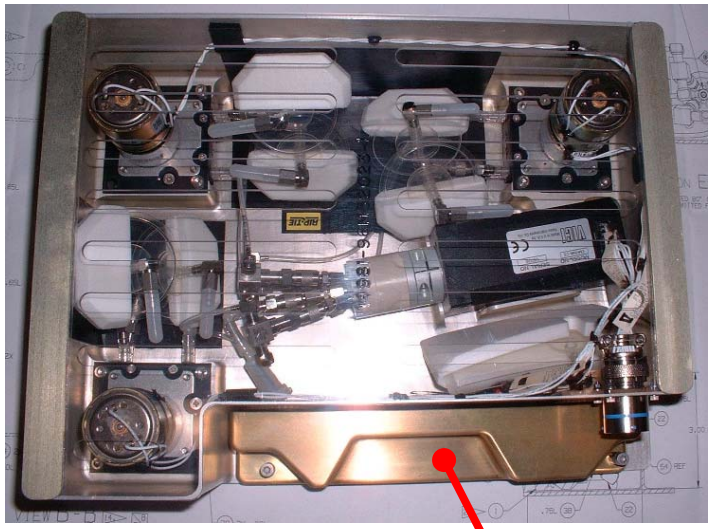
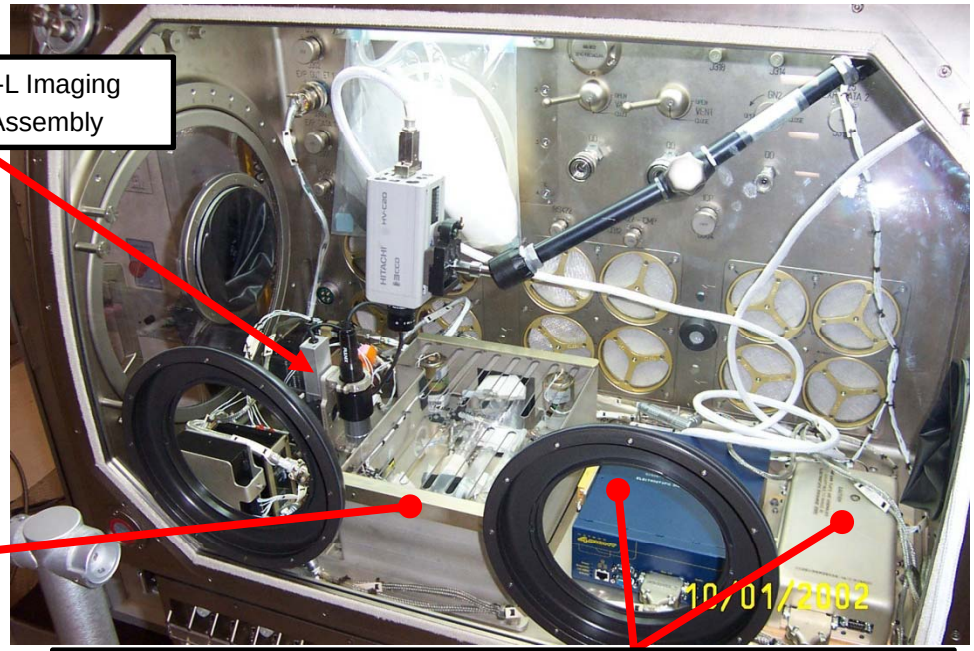
Delta-L Overview (Installed within MSG)





Delta-L Imaging Unit Assembly

Delta-L Fluid/Growth Cell Assembly (mounted on Imaging Unit Assy)

Delta-L Control Unit Assembly: Data Acquisition & Control Unit (blue) & Thermal Control Unit (tan)

Objective → Measure macromolecule crystal growth rates in microgravity and measure the variation in macromolecule crystal growth rates (growth rate dispersion) in microgravity.

Rationale → Strongly diffracting high quality macromolecule crystals of suitable volume are keenly sought for X-ray diffraction analysis so that high-resolution molecular structure data can be obtained. Such data is of tremendous value to medical research, agriculture and commercial biotechnology. In ground-based research with the protein lysozyme, it has been shown that a population of crystals grown under the same solution conditions, exhibit a variation in X-ray diffraction properties (Judge et al., 1999).

Operations → Nucleation initiated by expressing first solution pair into Growth Cell. After 18-24 hours, astronaut checks Growth Cell for crystals of suitable size to begin. When the crystals are of an observable size, the astronaut will locate 10 crystals, growing attached to the Growth Cell wall, using the computer controlled translation stages. The images will be stored and down-linked when enabled.

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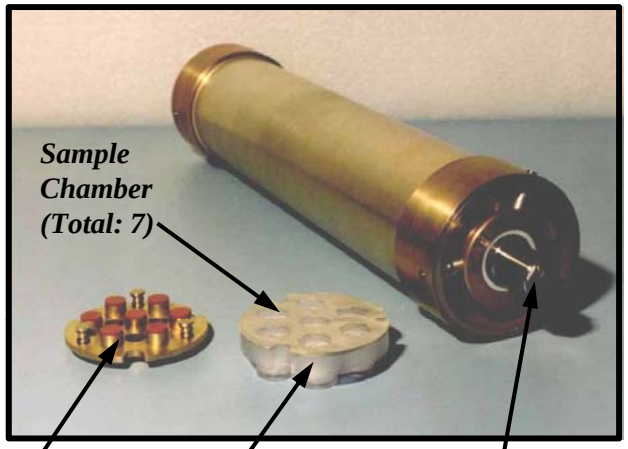
Protein Crystallization Apparatus for Microgravity (PCAM) Overview

PCAM Training at JSC – Astronaut Daniel Bursch Activating PCAM

PCAM Loading & Assembly at KSC

PCAMs in Middeck Stowage Configuration



Fully loaded PCAM < 4.0 pounds
[Each cylinder contains nine trays and each tray has seven sample wells; hence, each cylinder supports 63 protein crystal growth experiments]

Objective → The production of protein crystals with improved size and perfection in support of macromolecular structure determination by x-ray methods. Suitable crystal size and perfection is often a limiting step in macromolecular structure determination. Historically, the hardware was used in support of the basic research of numerous and diverse co-investigator science programs.

Rationale → The PCAM was developed as a multi-user facility with the advantage of a disposable interface concept in support of pre-flight sample loading and post-flight logistics. The crystals are grown by the vapor diffusion. In microgravity ,crystal growth is diffusion-limited which in many cases can result in crystals of greater size and perfection for application in structural molecular biology.

Operations → Crew interaction is minimal – Transfer to/from ISS and activation/deactivation by turning knob until hard stop reached. After crew activation, crystal growth occurs via vapor diffusion.

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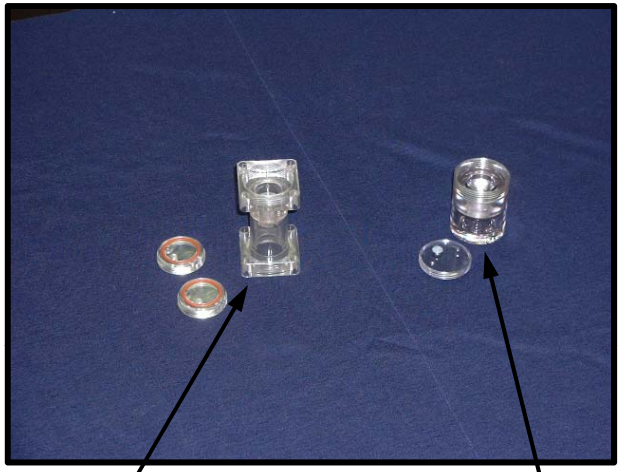
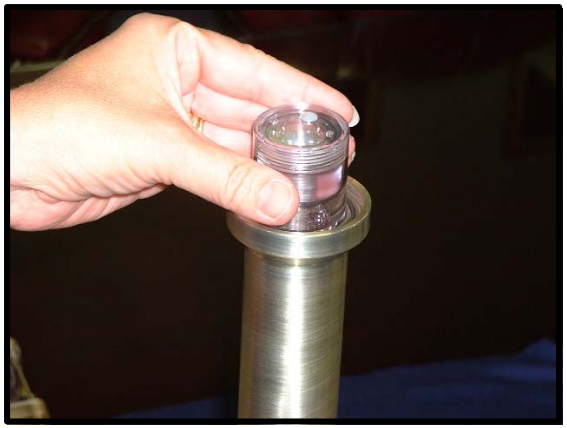
Enhanced Diffusion controlled Crystallization Apparatus for Microgravity (EDCAM) Overview

Generic Enclosure System (GES) & Counter Diffusion Cell (CDC)





Insertion of CDC into GES –
Total of 8 CDCc are loaded into 1 GES
Fully loaded EDCAM < 1.9 pounds

Objective → Production of protein crystals with improved size and perfection in support of macromolecular structure determination by both x-ray and neutron crystallographic methods. Suitable crystal size and perfection is often a limiting step in macromolecular structure determination. Historically, the hardware was used in support of the basic research of numerous and diverse co-investigator science programs.

Rationale → EDCAM was developed to take advantage of long duration experiment opportunities available on Mir and ISS. Individual counter-diffusion cells can be individually programmed to control the rate of approach to supersaturation over periods from several days to months. Crystals are grown by liquid-liquid diffusion or dialysis methods. The hardware is particularly suited for the growth of large multi-millimeter crystals required for application in neutron diffraction. In microgravity, crystal growth is diffusion-limited ,which in many cases can result in crystals of greater size and perfection for application in structural molecular biology.

Operations → Crew interaction is minimal – Transfer to/from ISS and no activation required as EDCAMs are self-activating. Multiple GESs can be loaded in an ambient stowage locker.

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Payload Process

	Manifesting	HW Development	Operations	Safety
Driving Document	ISS Increment Definition and Requirements Document - Annex 1 - Annex 5	ISS Payload Interface Requirements Document Investigation Interface Requirements Document	POIC Payload Operations Handbook Volume 1 Volume 2	Safety Policy And Requirements for Payloads Using the Space Transportation System
Payload Developer	– IR Sheets – Crew Overview – Science Description	– Hardware – Software – Standalone test data – Verification	– Procedure inputs – Trainer hardware – Training Course – Resource Needs	– Standalone Safety Data Package – PSRP Review(s)
Integration Team	– PTP Inputs – CEF Inputs – PDL – Documentation Delivery Schedule	– Integrated Testing – Human Factors Testing – Integrated Verification – CoFR – Interface Control Document	– Crew Procedures – Training – Operations Nomenclature – URC Inputs – Schedule Operations – Console Ops	– Integrated Safety Data Package – PSRP Review

Teledyne Brown Engineering (TBE) Mission Support

- Teledyne Brown Engineering (TBE) is the primary contractor supporting NASA's science and mission systems research and development, which includes the integration, testing, and operation of Delta-L, PCAM, and EDCAM

- TBE presently has a vital role in operating the International Space Station and provides space-qualified hardware for on-board research and support of cargo integration

- Teledyne Brown Engineering, Inc, is a key business segment of Teledyne Technologies, a confederation of commercial and government-supporting companies

- Headquartered in Huntsville, Alabama, with operations and offices throughout the United States and representation in several other countries, Teledyne Brown is a recognized leader in providing solutions in Space, Defense, Environmental, and Homeland Security programs.

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Teledyne Brown Engineering (TBE) Mission Support

•TBE has supported and integrated numerous Shuttle, SpaceLab and Space Station missions as depicted at the left.

•A partial list of other missions supported, but not illustrated, includes:

- STS-106
- STS-108/ISS UF-1
- STS-110
- STS-111/ISS UF-2
- STS-112/ISS 9A
- STS-113/ISS 11A
- STS-114/ISS ULF-1
- STS-116/ISS 12A.1
- STS-117/ISS 13A
- STS-118/ISS 13A.1
- STS-119/ISS 15A
- STS-120/ISS 10A
- STS-121/ISS ULF1
- STS-121/ISS ULF1.1
- STS-123/ISS 1JA
- STS-126/ISS ULF 2
- STS-128/ISS 17A
- STS-128/ISS 20A
- Soyuz 6, 7, 8, 9, & 10
- Progress 10,11,12,13,14,15, & 17

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TBE's Payload Integration Support To NASA

- Skylab
  - Payloads: 1
  - Hardware: 1
- Spacelab
  - Missions: 24
  - Payloads: 140+
  - Hardware: 14
- International Space Station
  - Increments: 8
  - Facilities: 6
  - Payloads: 22 EXPRESS/17 MSG
  - Hardware: 4
- CMC (ISS)
  - Flights: 27 (7 US, 20 Russian)
  - Hardware: 6 delivered to date
    53 scheduled thru 2009

TBE Has Been Supporting Payload Development, Integration, And Operations For Over 30 Years

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