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*Microgravity Science Division*

Sixth International Microgravity Combustion Workshop



# Combustion Integrated Rack Status and Plans



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# ***FCF Concept***

- Payload planned for the International Space Station, US Laboratory Module “Destiny.”
- Support a wide variety of investigations in fluid physics and combustion science in a long-duration, microgravity environment.
- System of on-orbit and ground hardware, software, operations, and plans.
- Reuse the majority of on-orbit hardware.



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# ***Fluids and Combustion Facility Goals***

- Accommodate at least eighty percent of new experiments.
- Perform between 5 and 15 combustion experiments per year over 10 year lifetime.
- Develop only a small amount of hardware and software for each investigation.
- Modular to allow upgrades with new hardware and software.



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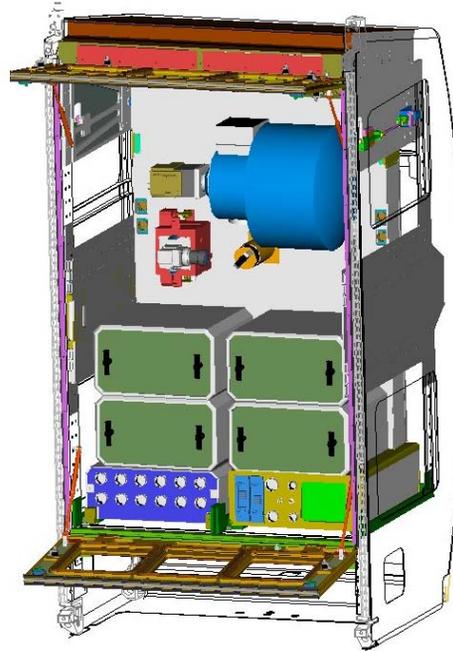
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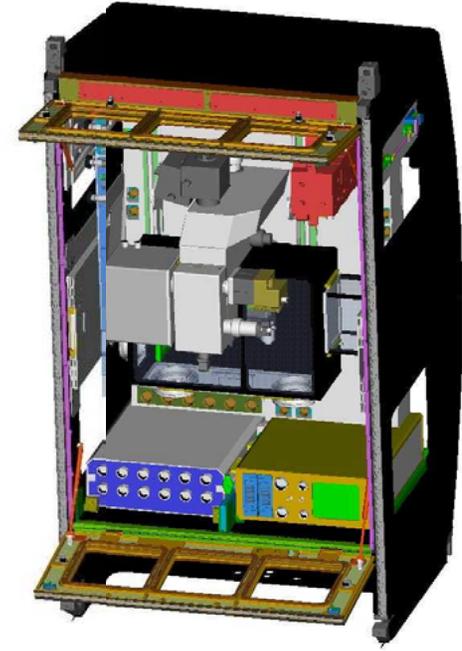
# FCF Deployment



Combustion  
Integrated Rack  
(CIR) UF-3



Shared  
Accommodations  
Rack (SAR) 2005



Fluids Integrated  
Rack (FIR) UF-3



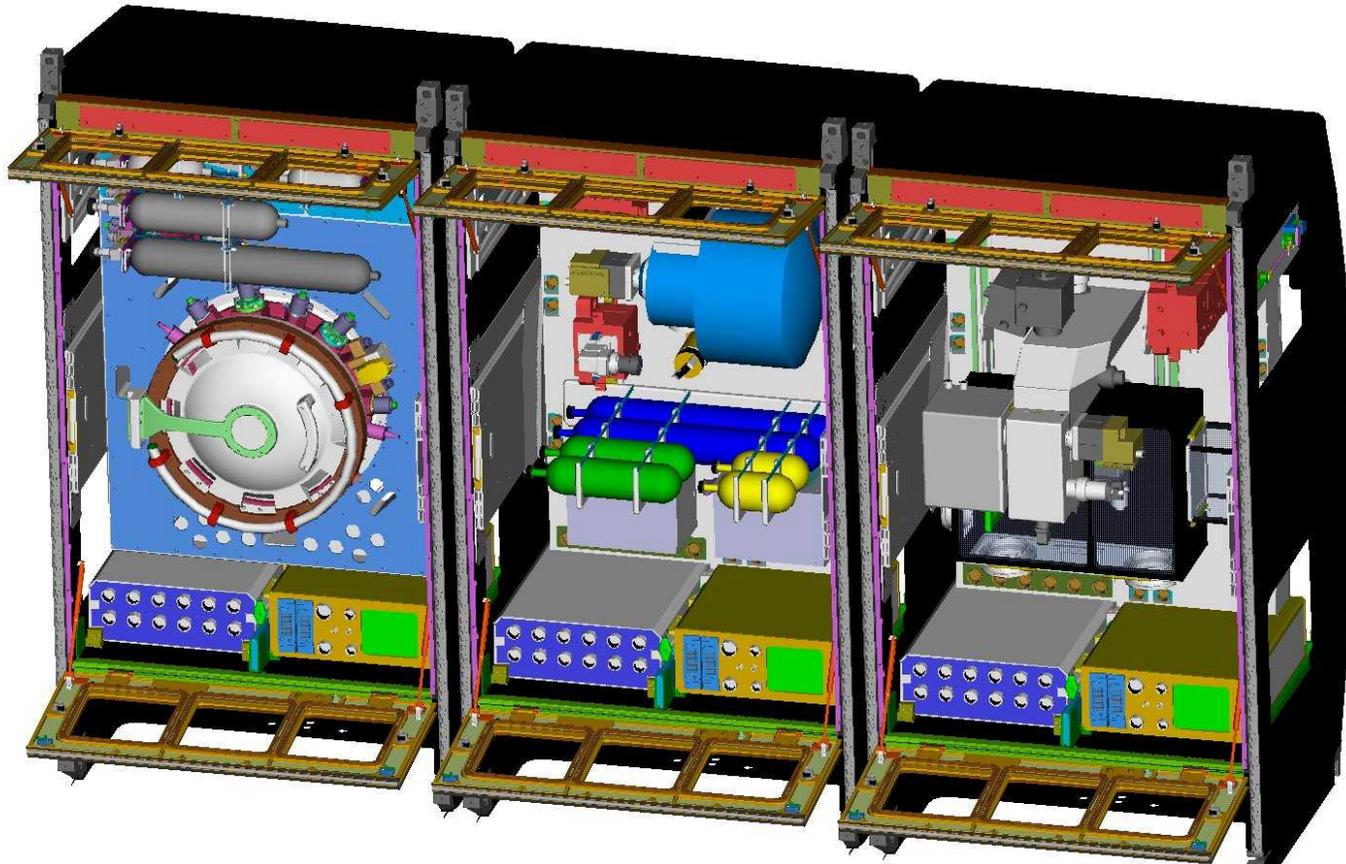
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# FCF Flight Segment



data, commands, and video





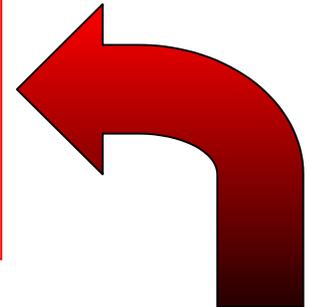
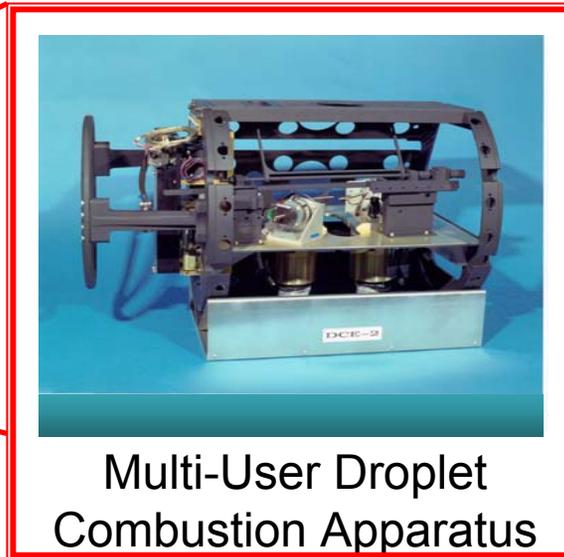
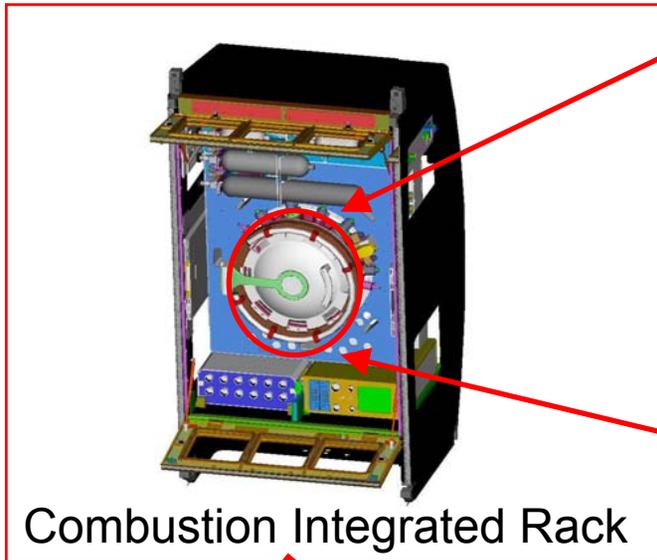
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# CIR, Multi-User, and PI-Equipment





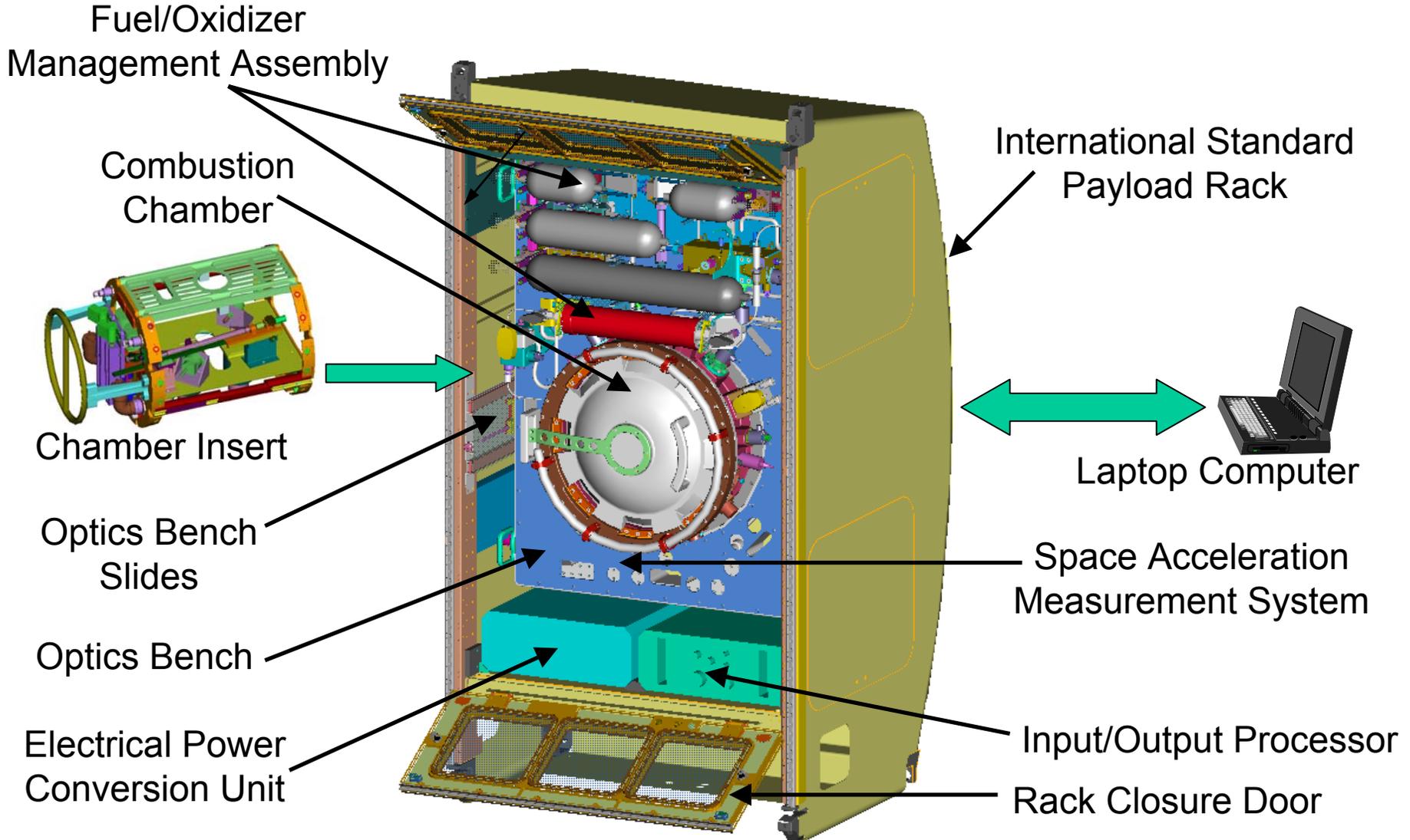
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# Front View





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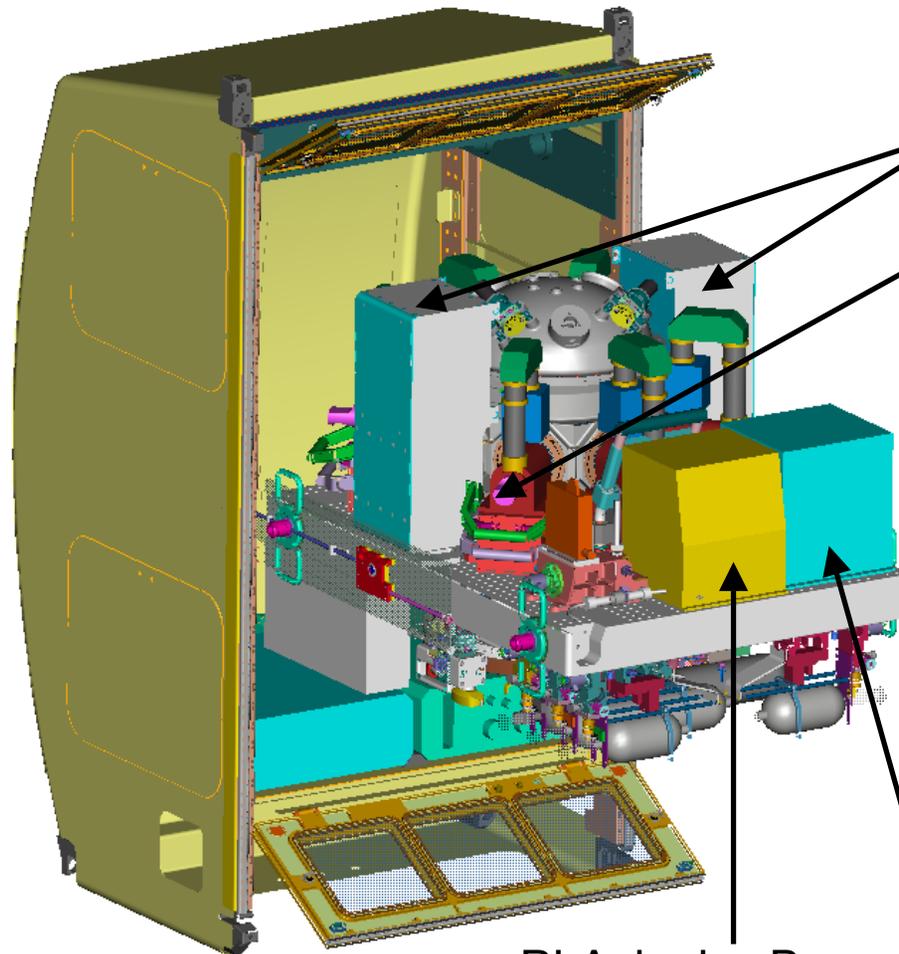
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# Back of Optics Bench

- Environmental Control
- Air Thermal Control
  - Water Thermal Control
  - Fire Detection and Suppression
  - Gas Interfaces
    - ISS Nitrogen
    - Vacuum Exhaust
    - Vacuum Resource



### Science Diagnostics

- Image Processing and Storage Units
- High Frame Rate/ High Resolution Camera
- High Bit Depth Multi-Spectral Camera
- Color Camera
- Low-Light Level UV and NIR Cameras
- Mid-IR Camera
- Illumination

PI Avionics Box

FOMA Control Unit



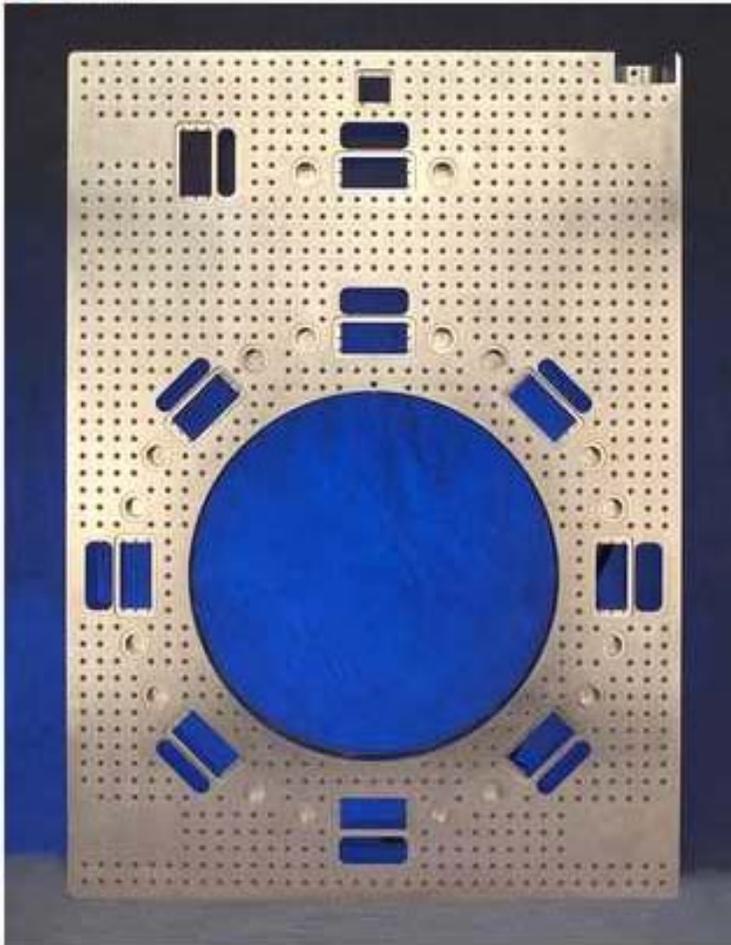
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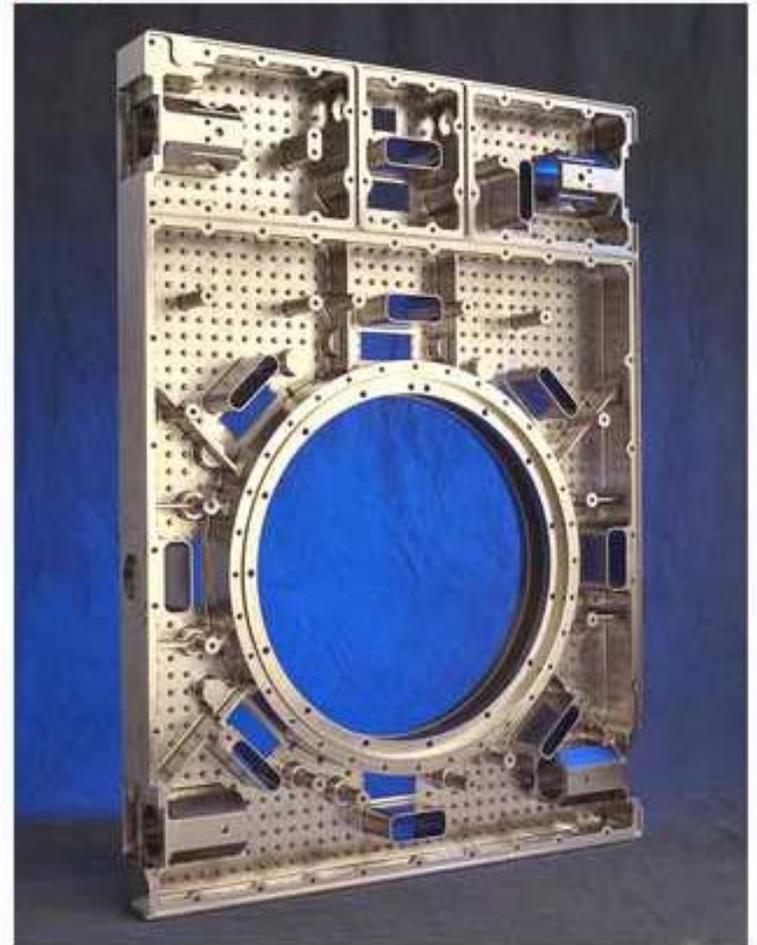
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# Optics Bench



Rear face view



Front internal view



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# Combustion Chamber

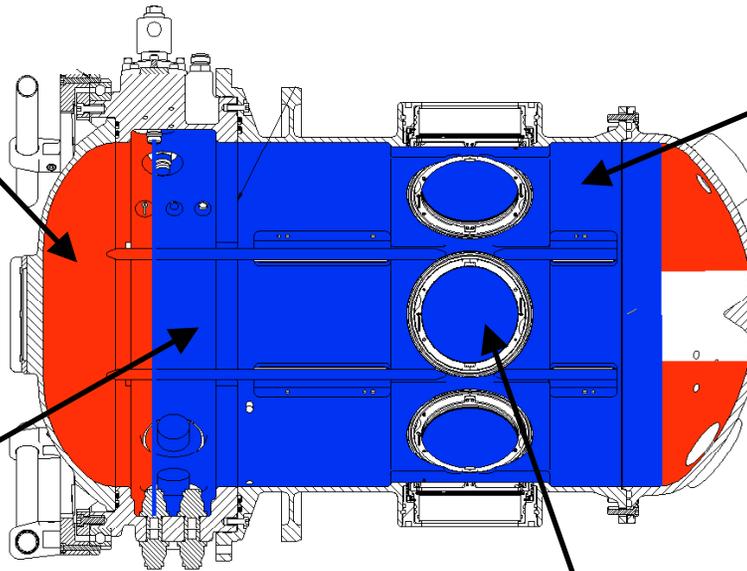
100 Liters free volume,  
90 cm long x 39.6 cm dia.



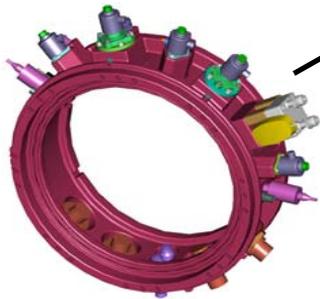
Chamber Front Lid  
with Breech Lock



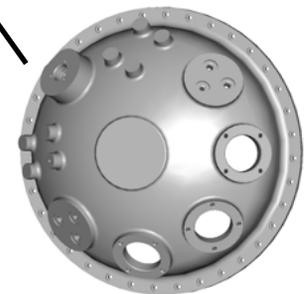
Chamber  
Window Section



Replaceable  
Windows



Interface Resource Ring



Chamber End Cap



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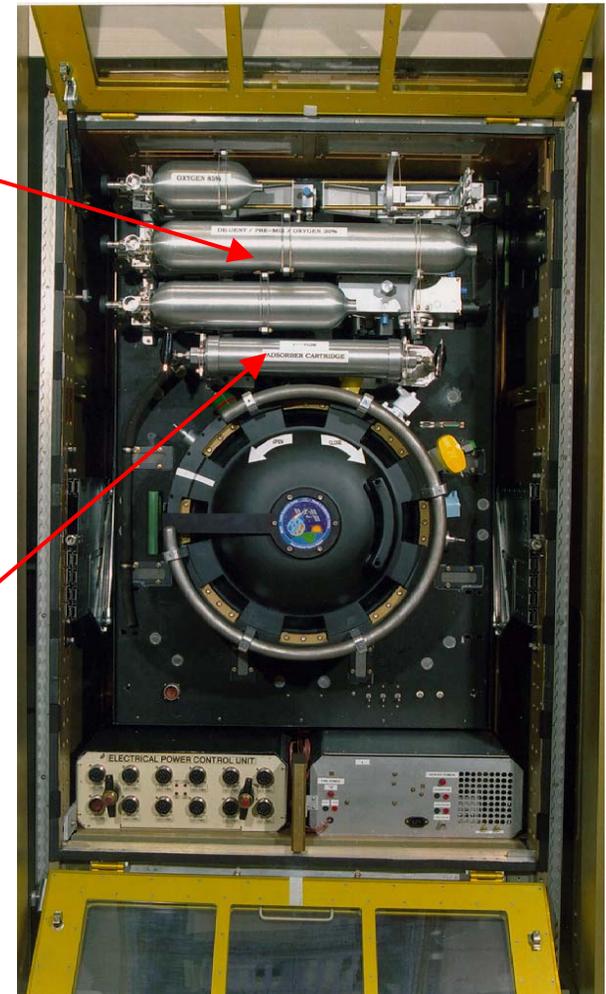
# Fuel/Oxidizer Management Assembly

**Gas Supply and Distribution Package -- delivers gaseous fuels, diluents and oxidizers to the combustion chamber**

- 1.0, 2.25, 3.8 liter removable bottles up to 2000 psi
- On-orbit gas blending of up to 3 gases
- Flow-through with real time venting
- ISS nitrogen supply interfaces

**Exhaust Vent Package -- cleans/vents the chamber gases**

- Adsorber cartridge/ re-circulation loop
- Connects the combustion chamber with the ISS vacuum exhaust system
- Gas chromatograph





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# *Imaging Capabilities*

- Mounted on the Optics Bench using common interfaces for on-orbit changeout
- Diagnostics reconfiguration with Optics Bench folded down
- Design approach emphasizes packaging modularity, reconfiguration, and maintainability
- Digital imaging technology
- Digital image acquisition at up to 40MB/s
- 36.4 Gbytes of image data storage direct to disk at 30 MB/s. Sustained image recording > 20 minutes.
- Image Processing and Storage Units control imaging and illumination packages.
- Real-time image processing for open or closed-loop control of diagnostic packages
- RS-170 analog video output for real-time observation



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# Diagnostics Modules





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# High Frame Rate/ High Res. Camera

High Frame Rate Mode: 512 x 512 pixels at 60 or 110 fps.

High Resolution Mode: 1024 x1024 pixels at 7.5, 15, or 30 fps. Resolution is 20 lp/mm at 50% contrast in HR mode.

Event trigger capability.

Automated Tracking - 9 x 9 mm instantaneous field of view over a total field of view of 37 mm horizontally and vertically. 10 mm/s maximum tracking speed.

Automated focus over 30 mm object depth; 5 mm/s focus speed; telecentric.





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# ***Science Utilization Concept***

- Common PI hardware to be used by multiple investigations for 1) droplet, 2) solid fuel, and 3) gaseous combustion.
- Order of experiments will be determined by scientific maturity and fit with the common experiment structures.
- Commercial and international users supply their own hardware and will fly as negotiated.



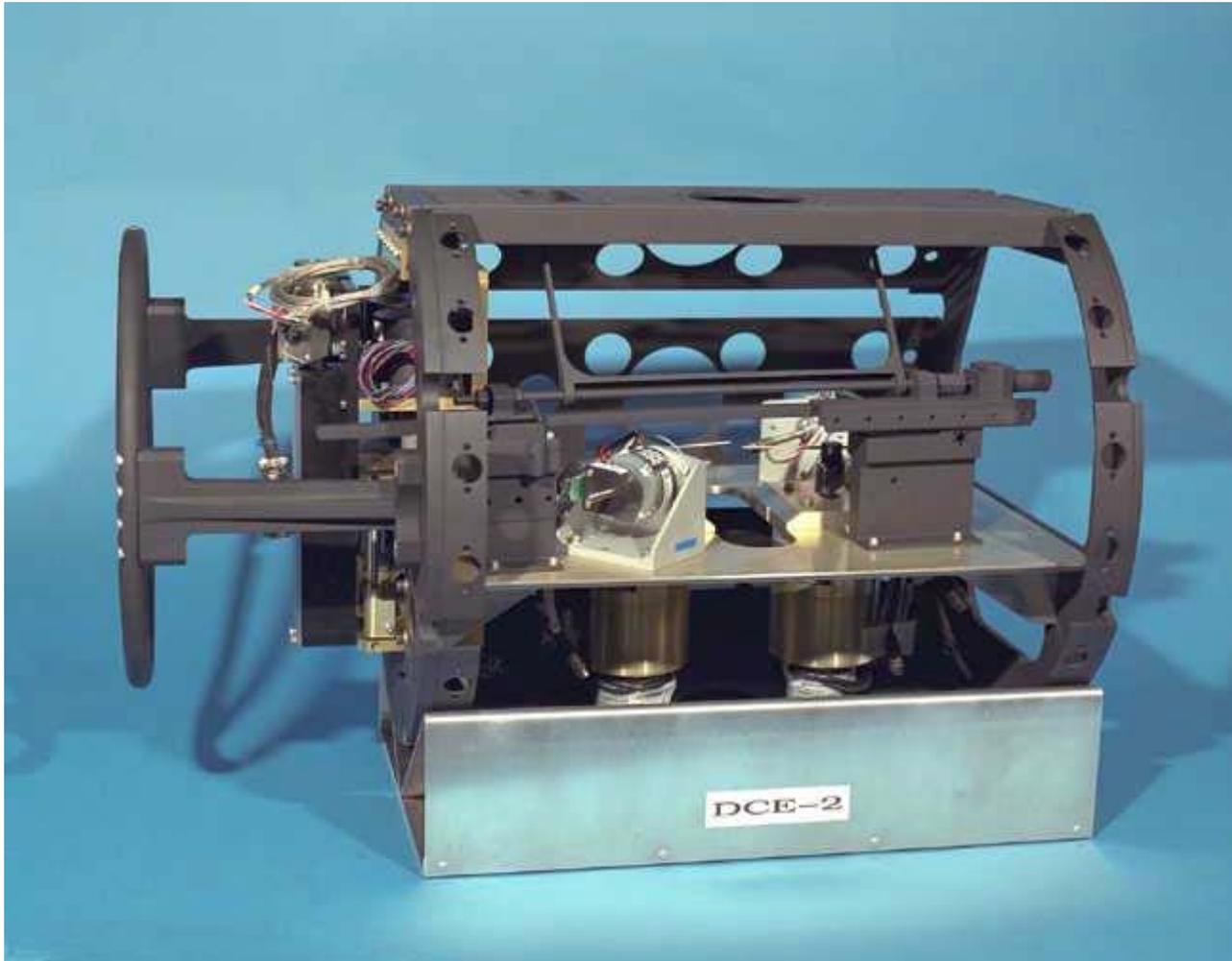
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# ***Droplet Chamber Insert Model***





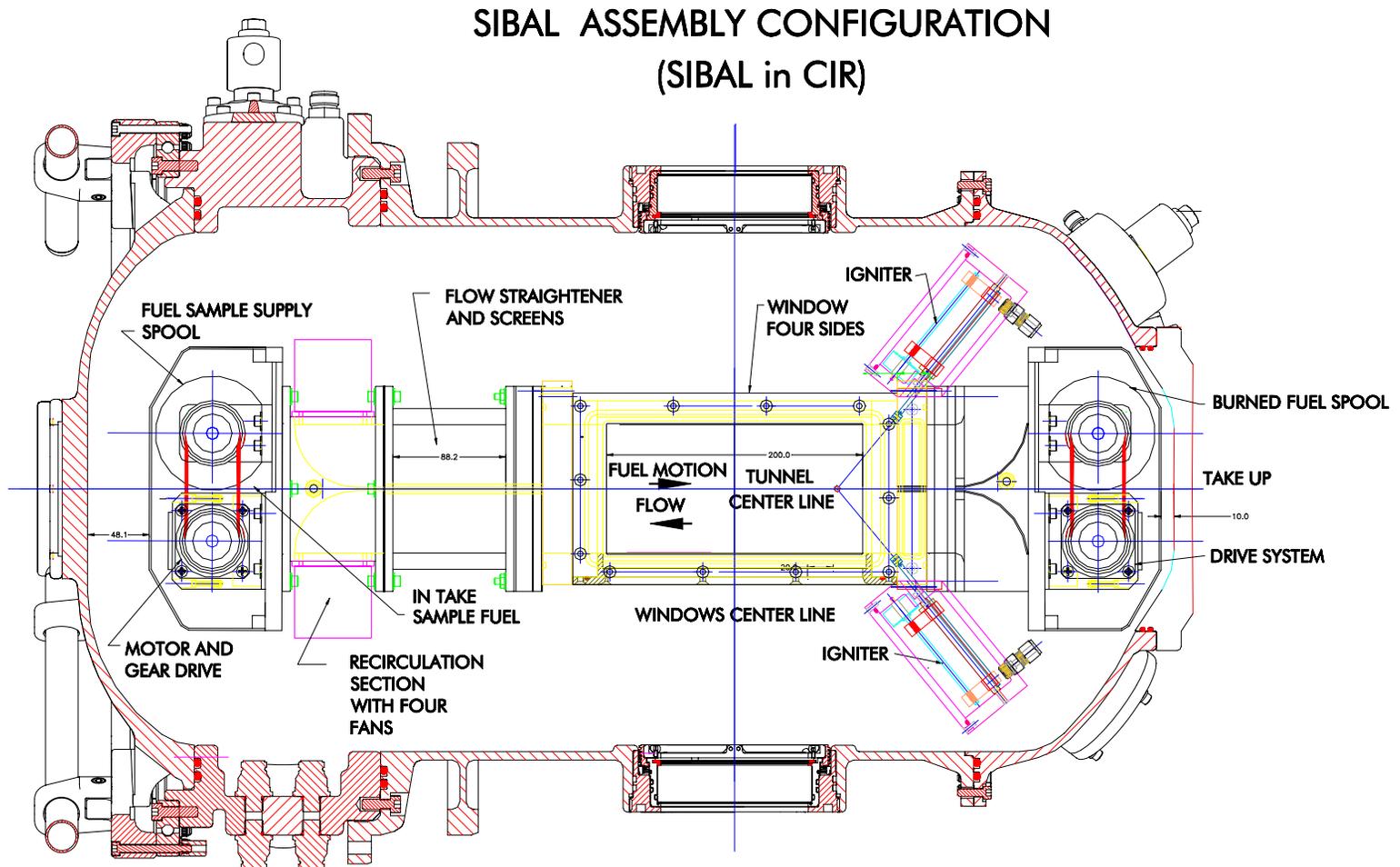
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# Thin Solid Fuels Schematic





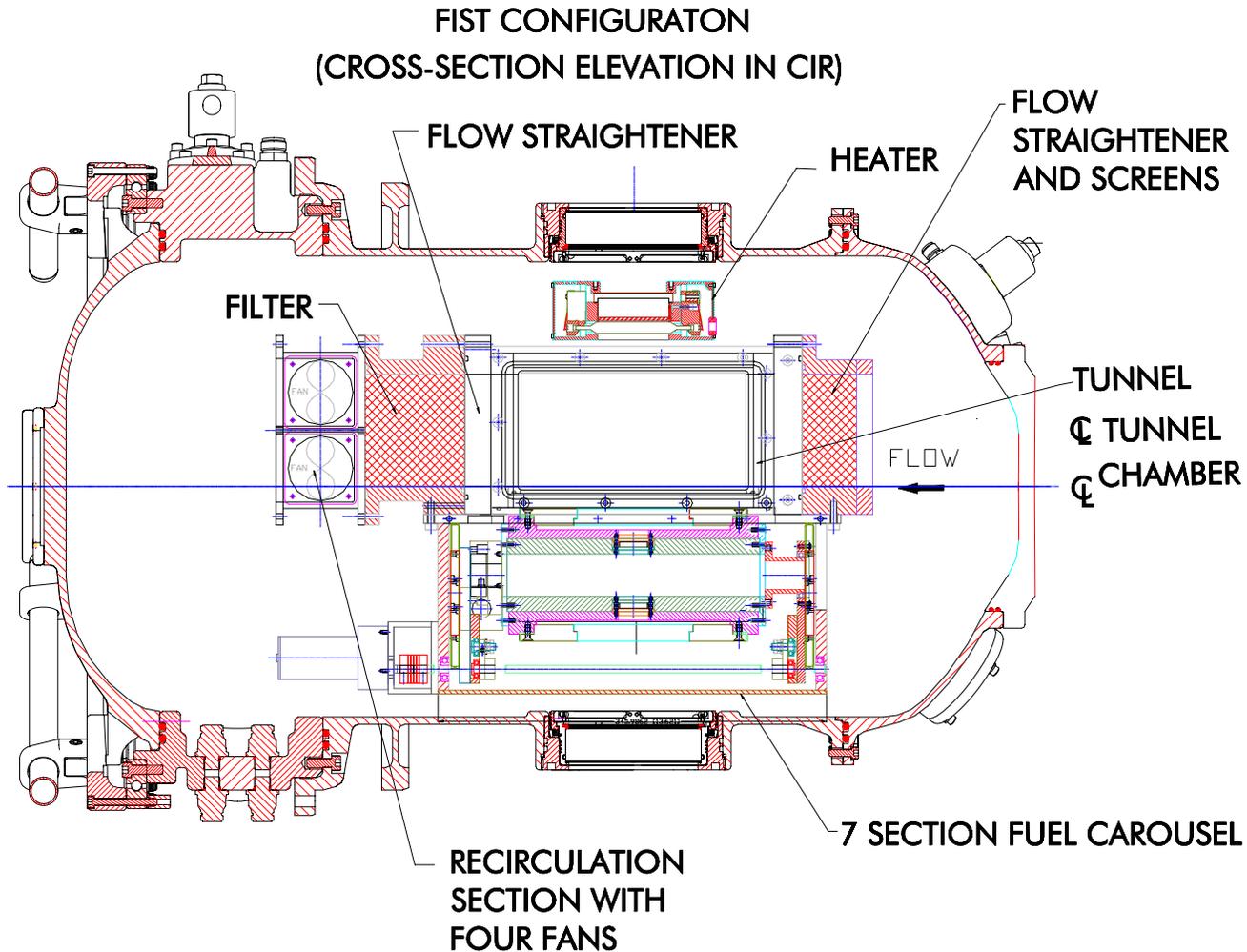
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# Thick Solid Fuels Schematic





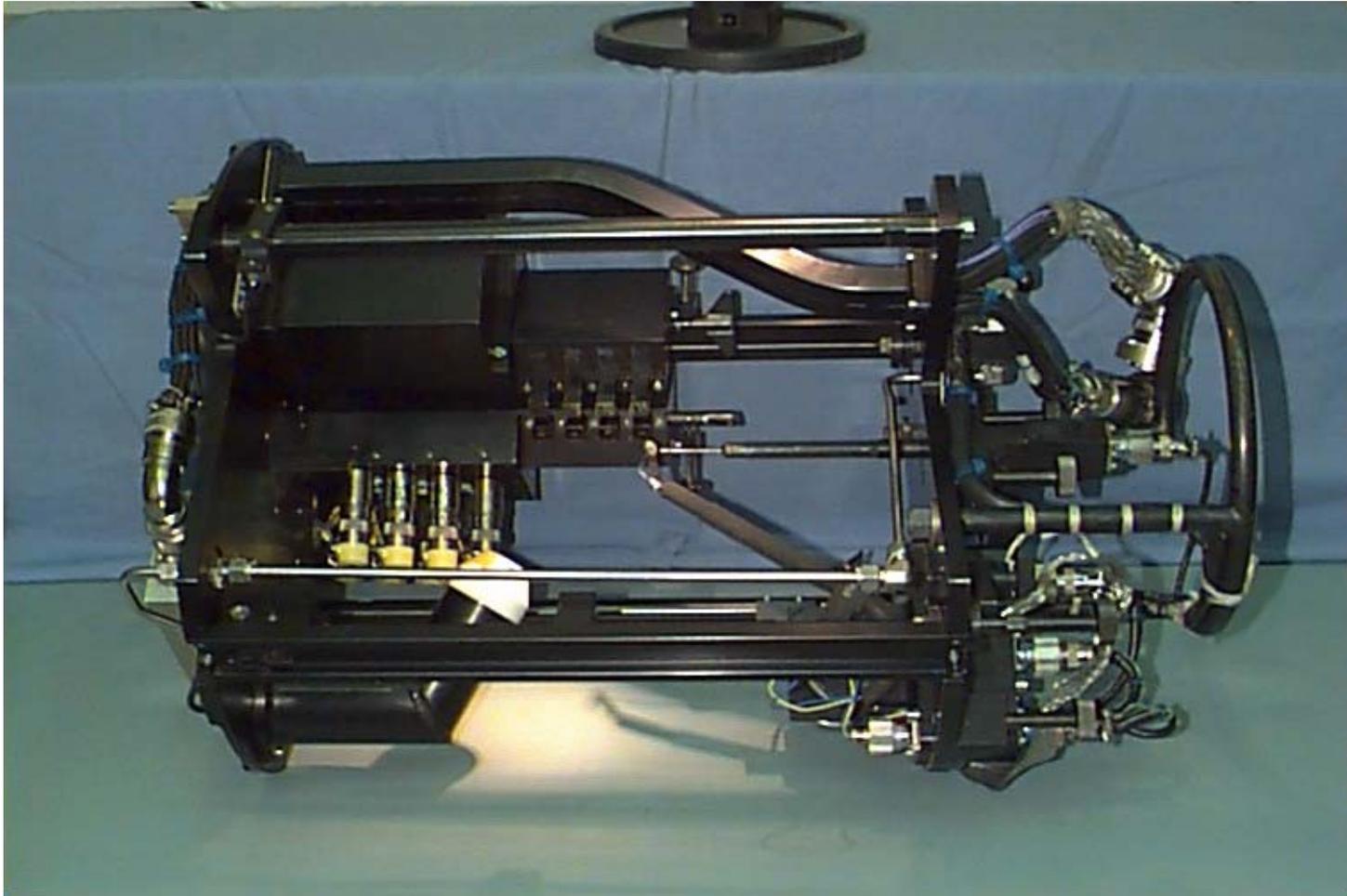
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# *Gas Jet Chamber Insert for CM-2*





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# ***Combustion Integrated Rack Status***

- CIR Preliminary Design Review held in April 1999.
- Microgravity Research, Development and Operations Contract was initiated in April 2000. Firm fixed price contract for the development of the FCF.
- FCF Preliminary Design Review (and CIR delta-PDR) held in February 2001.



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# ***FOMA Oxidizer Bleed-In Capability***

Used for oxidizer velocities greater than 25 sccm.

Experiment fans develop required velocities.

Oxygen sensor inside chamber detects oxidizer level.

Provides oxygen replenishment to match consumption rate while chamber is vented to keep constant pressure.



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# ***FOMA Oxidizer Bleed-In Progress***

Oxygen levels have been maintained within +0.00 to -0.005 mole fraction.

Pressure levels have been maintained within 0.01 atm of desired pressure.

Oxygen consumption rates up to 0.06 g/s have been tested.



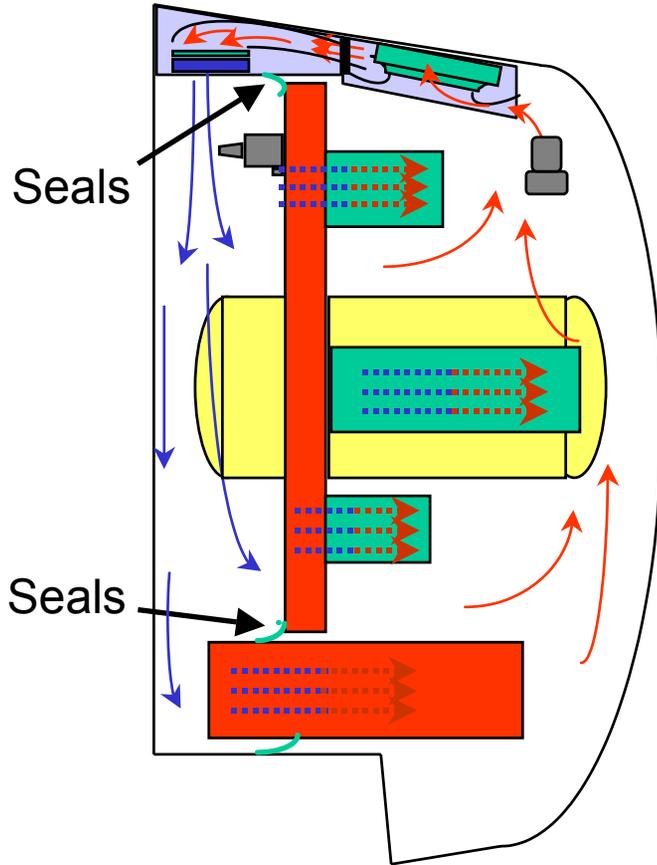
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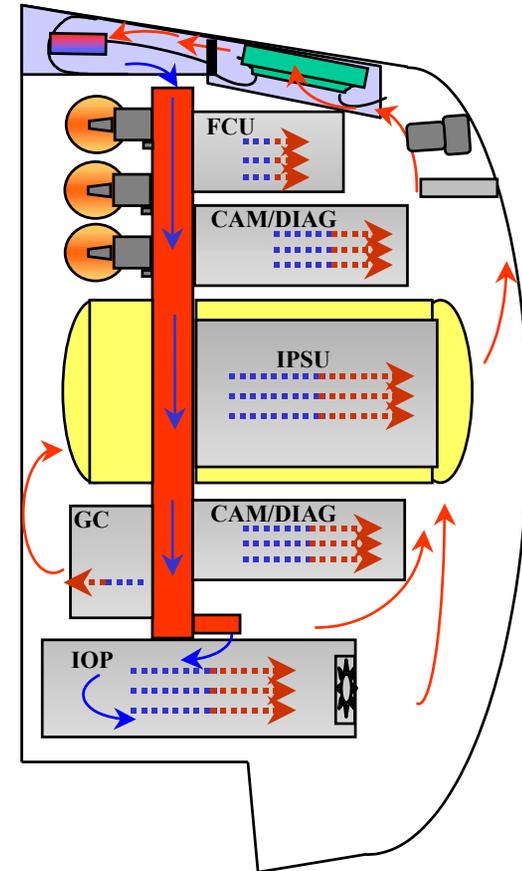
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# Air Thermal Cooling Changes



CIR PDR Design (4/99)



Current CIR Design



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# ***Combustion Integrated Rack Plans***

- CIR is currently in the Engineering Model build. Functional Engineering Model is expected by this summer.
- Contract has a flight hardware availability date of April 2003 that would allow a launch in October 2003.
- The current Space Station planning model (Rev. F) has the CIR launching on Utilization Flight-3 in Sept. 2004.



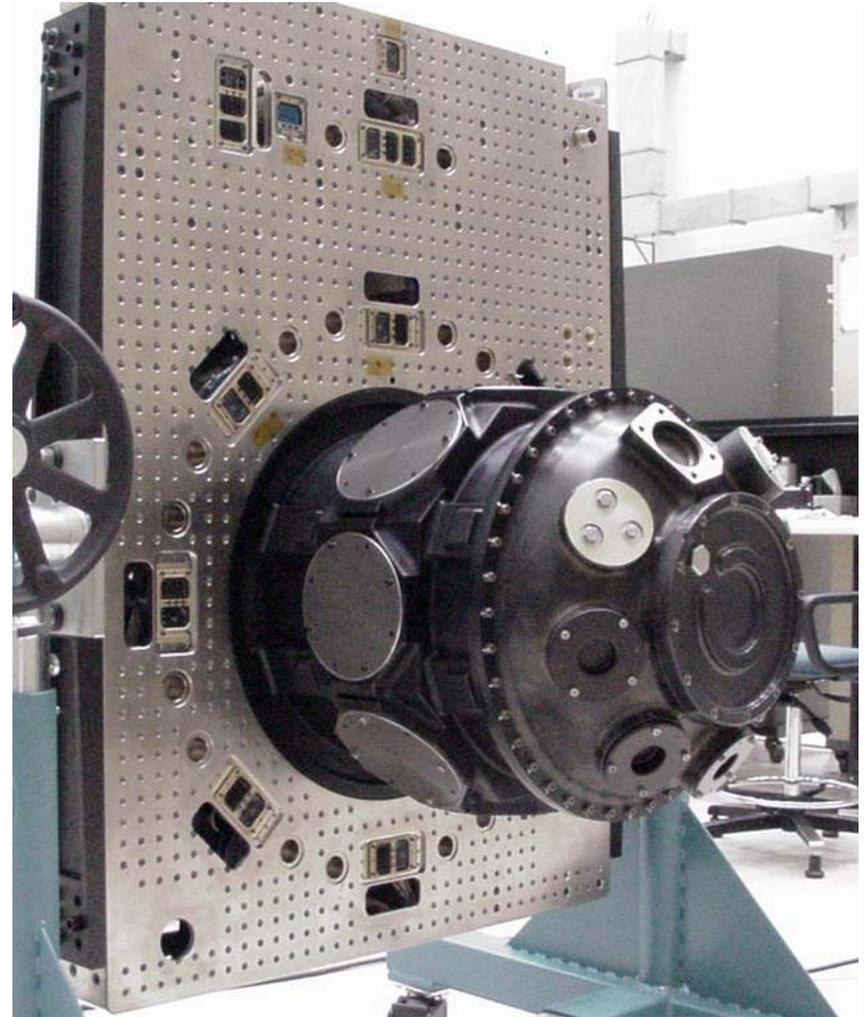
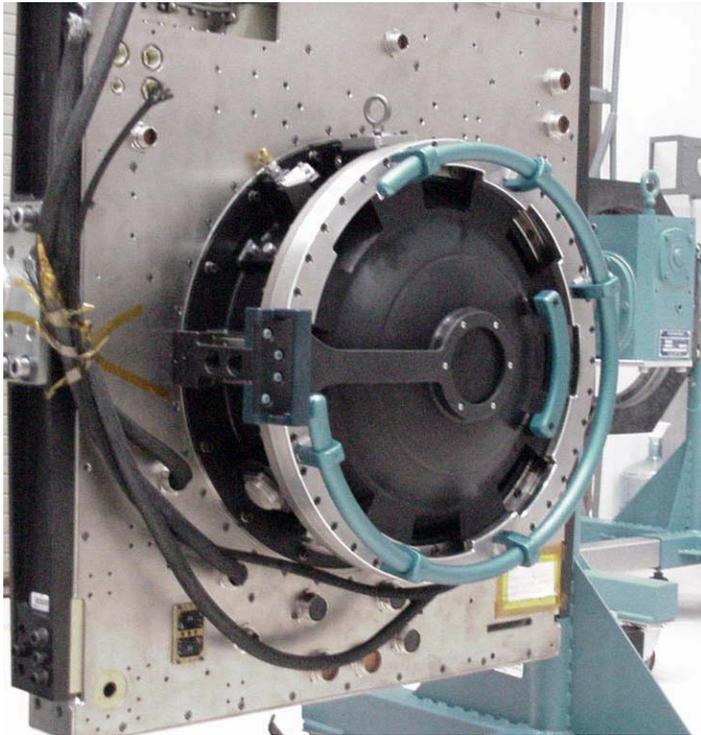
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# *Engineering Model*





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# Our Destiny ....





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# ***FCF Contacts***

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- CIR Integration Manager  
Terry O'Malley                      216-433-2960
- Web sites
  - <http://fcf.grc.nasa.gov>
  - <http://microgravity.grc.nasa.gov/>