g-LIMIT Science Overview

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PR III Kick-Off
November 3, 1999

Introduction

- Many µ-gravity science experiments require an active vibration isolation system to provide a quiescent acceleration environment.
- g-LIMIT is a vibration isolation system optimized for use in the Microgravity Science Glovebox (MSG).

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MSFC History in μg Vibration Isolation

- CDDF:
  - » FY94-95 Project to develop expertise in μ-g vibration isolation
- STABLE:
  - » Successfully flight tested STABLE in October 1995 in partnership with Boeing (formerly McDonnell Douglas)
- ARIS:
  - » Independent Assessment, Technical Support, Peer Review, etc
- Advanced Technology Development:
  - » Developing technology for a small, modular vibration isolation system.
- g-LIMIT:
  - » Selected for flight definition in response to solicitation for Glovebox Investigations

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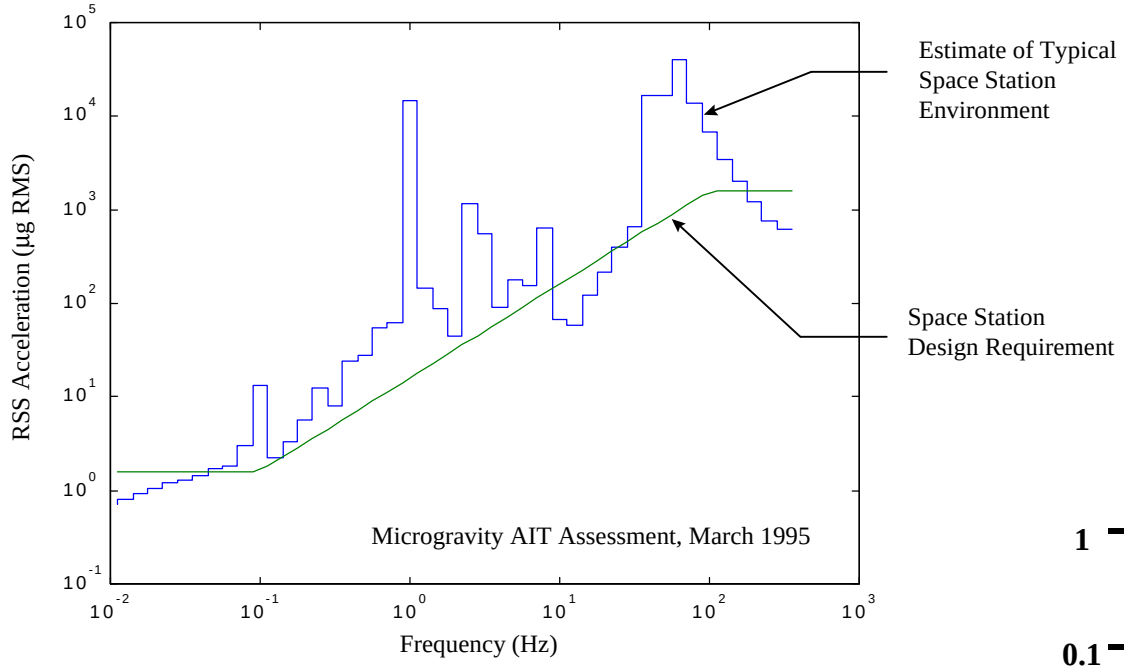
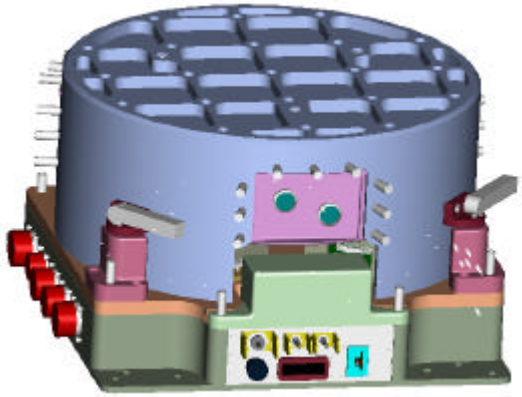
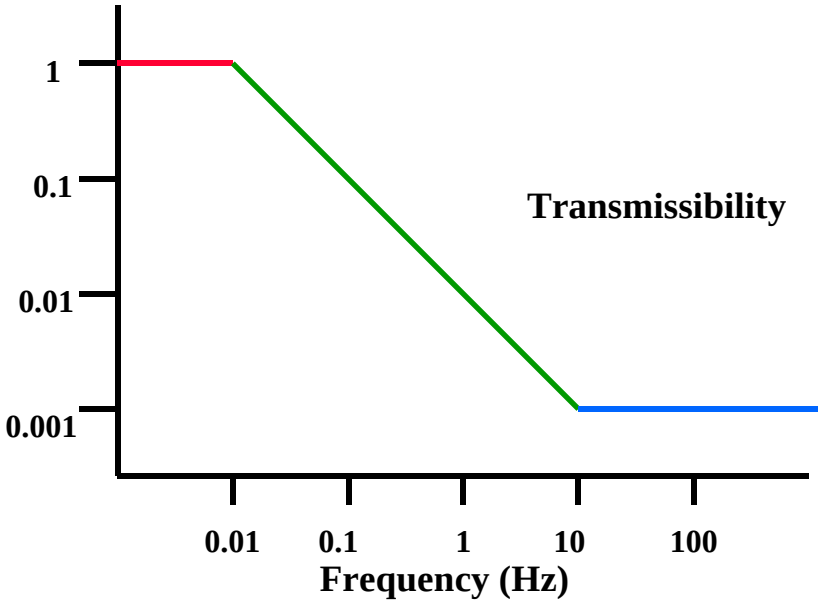
Why is Vibration Isolation Necessary for ISS?







Characterization Test Requirements

- Requirements:
  - » Provide attenuation of MSG accelerations
  - » Generate user-specified pristine excitations to payload
  - » Characterize attenuation of payload-induced accelerations
  - » Evaluate capability to measure quasi-steady accelerations from control law
  - » Evaluate advanced vibration control technology
  - » Validate the dynamic model of g-LIMIT with flight data.
  - » Characterize the acceleration environment of the MSG

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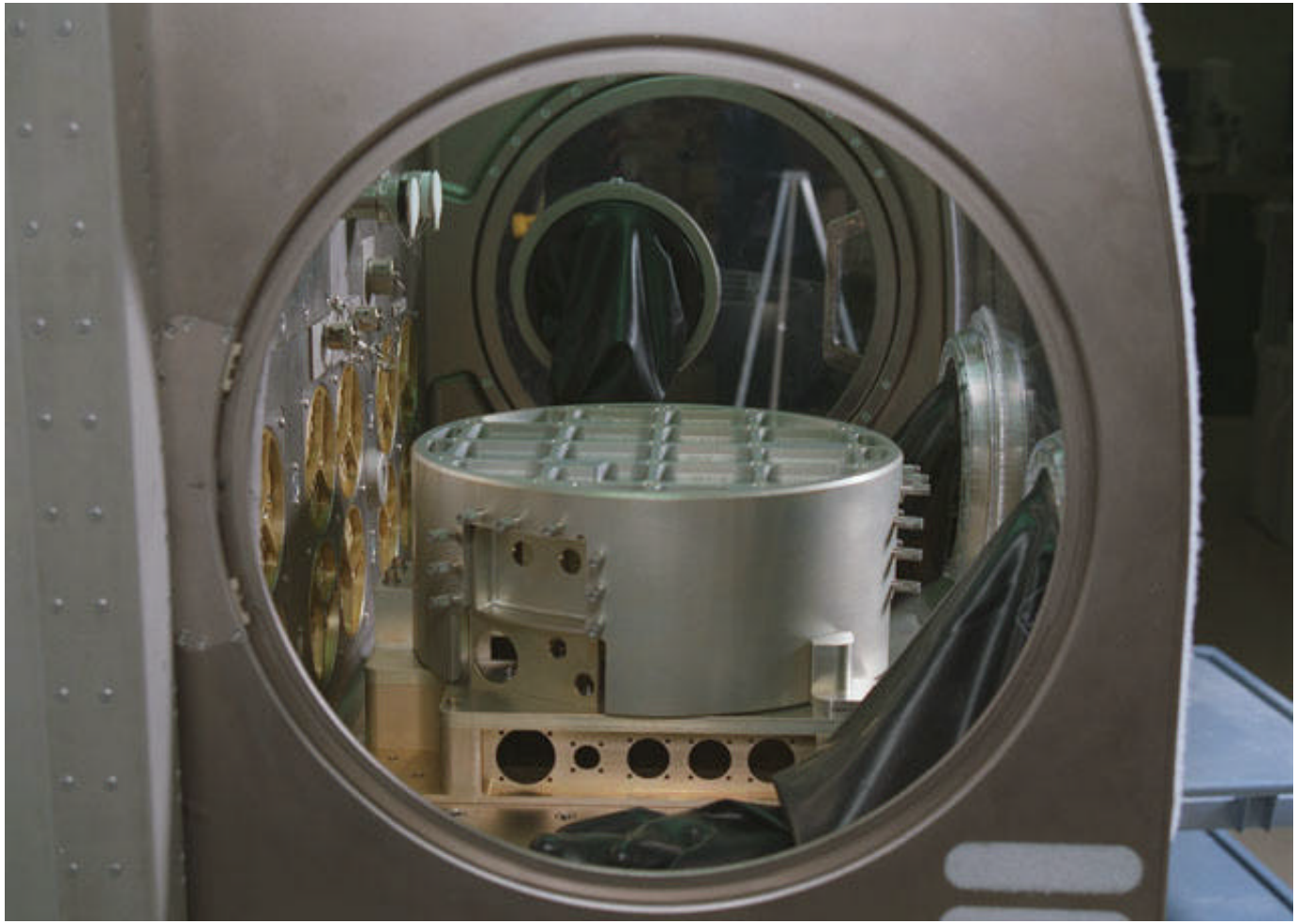
Trainer in MSG



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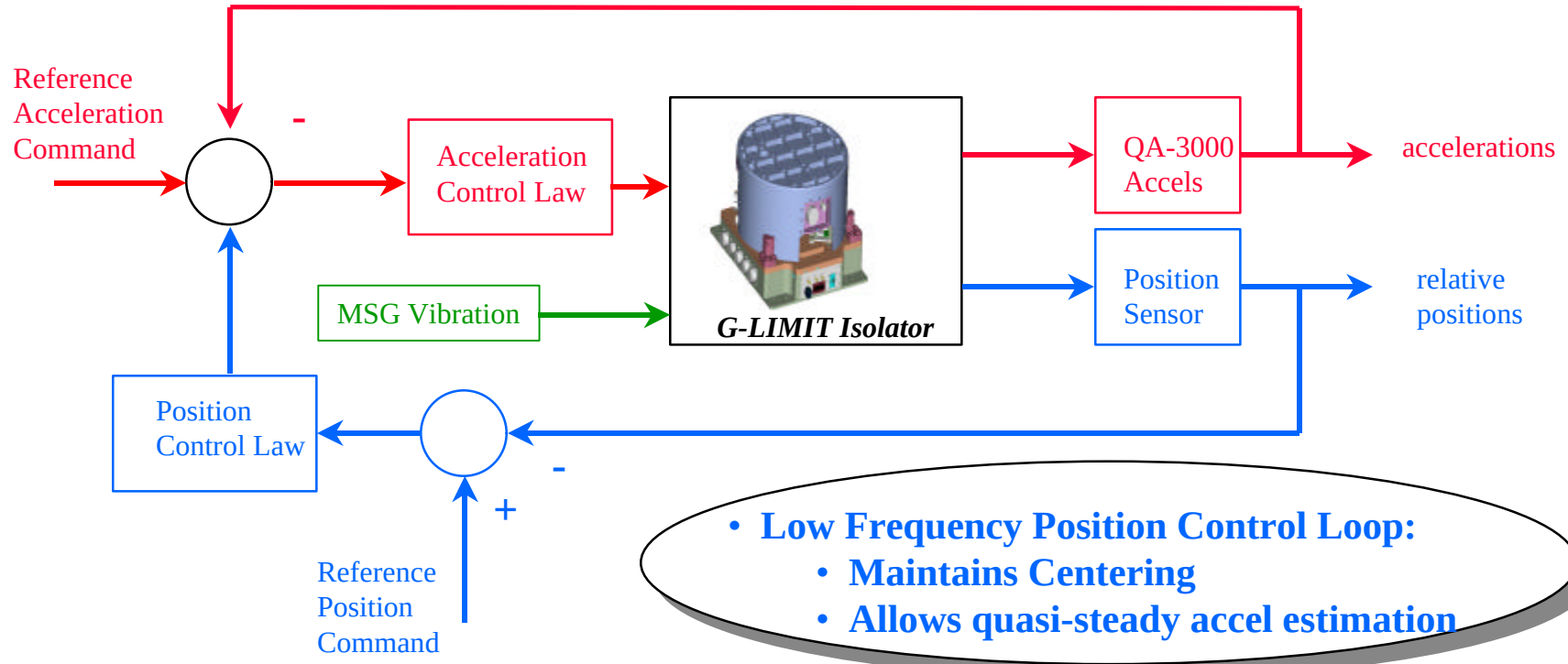
How Does g-LIMIT Isolate from Vibrations?

- **High Frequency Acceleration Control Loop:**
  - **Cancels Inertial Motion of the Platform**
  - **Allows "Good Vibrations"**

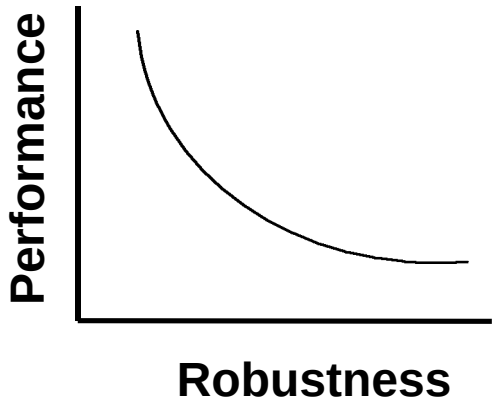


- **Low Frequency Position Control Loop:**
  - **Maintains Centering**
  - **Allows quasi-steady accel estimation**

Key Control Issues

The two key control design issues are ***robustness*** and ***performance***.

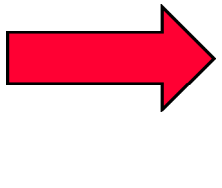
Robustness and **Performance** of a closed loop system are ***always*** in opposition



- Robustness to uncertainties:
  - umbilical properties
  - structural flexibility
  - mass and inertia variations
  - sensor & actuator dynamics
- Performance:
  - base motion attenuation
  - payload disturbances
  - forced excitation

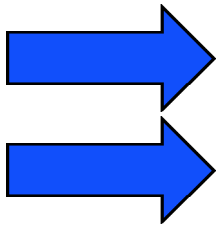
Advanced Control Technology Directions

- Robustness to uncertainties:
  - umbilical properties
  - structural flexibility
  - mass and inertia variations
  - sensor & actuator dynamics



Low Gain &/or
Low Bandwidth

- Performance:
  - base motion attenuation
  - payload disturbances
  - forced excitation



High Gain

High Bandwidth

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Characterization Test Plan

Test No.	Test	Description	Duration (hh:mm:ss)	Data (MB)
1	Position Control Test	Position stability; bias estimation	00:05:00	0.87
2	Umbilical Stiffness Test	Estimate umbilical stiffness	00:22:00	3.83
3	Range Test	Measure range of travel	00:13:00	2.62
4	Mass & Inertia Test	Estimate mass properties	00:13:00	2.62
5	Recovery Test	Verify anti-bump function	00:11:00	1.91
6	Acceleration Control Test	stability of accel control	00:01:30	6.05
7	Quiescent Isolation Test	Isolation performance	01:10:00	282.45
8	Disturbance Rejection Test	Disturbance rejection performance	00:13:20	53.80
9	Forced Response Test	Pristine excitation performance	00:20:00	80.70
10	MSG Isolation Test	MSG induced disturbance rejection	01:45:00	423.68
11	Quasi-steady Acceleration Test	Estimation of quasi-steady acceleration	15:00:00	156.60

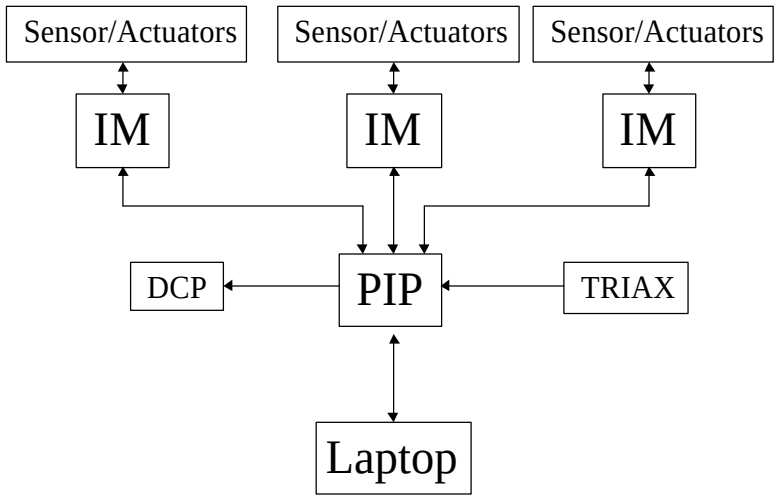
⇒ 15 Days of Testing
⇒ 5 Hours Run Time Per Day
⇒ 11.5 GB Data Collected (Total)

Data Management

- Characterization data for each test will be archived on orbit
  - » 440 MB PCMCIA Flash Disk used for mass data storage
  - » Requires daily crew change-out
  - » A log file will be created for each test
- Two sample rates implemented:
  - » Major frame sampled at 1 kHz, 8 pole filter at 250 Hz
  - » Minor frame sampled at 25 Hz, 4 filter poles at 6.25 Hz
- Real-time low rate data displayed on crew laptop and downlinked via 1553

Control Modes

- Control Modes:
  - » Passive
  - » Standby
  - » Active
- Implementation:
  - » Local
  - » Central
- Architectures:
  - » Classical (SISO)
  - » Multivariable (MIMO)



Distributed Architecture

g-LIMIT Hardware Overview

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g-LIMIT System Assembly

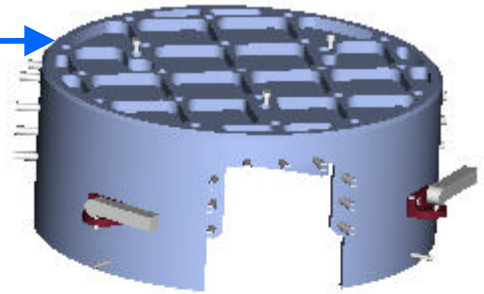
Payload Mounting Structure (PMS)

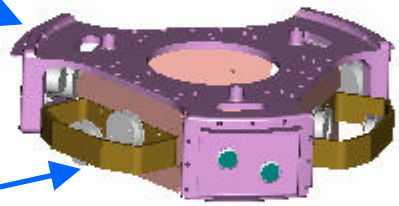
Umbilical Interface Plate (UIP)

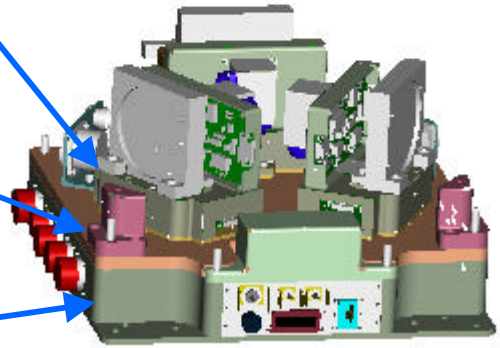
Isolator Module (IM)
- Platform subsystem (TASC*)
- Base subsystem (Base)
- 3 units

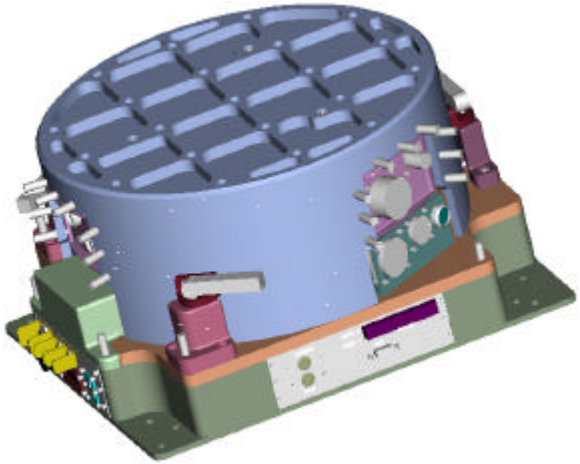
Bumpers (3)

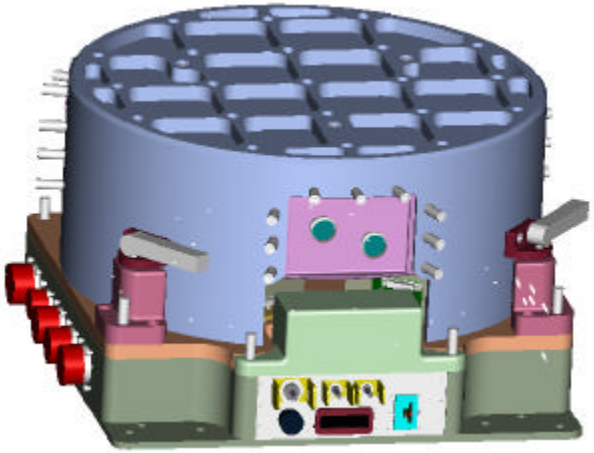
Power & Information Processor (PIP)











OPERATIONAL CONFIGURATION

* Two-axis Accelerometer Signal Conditioning (TASC)

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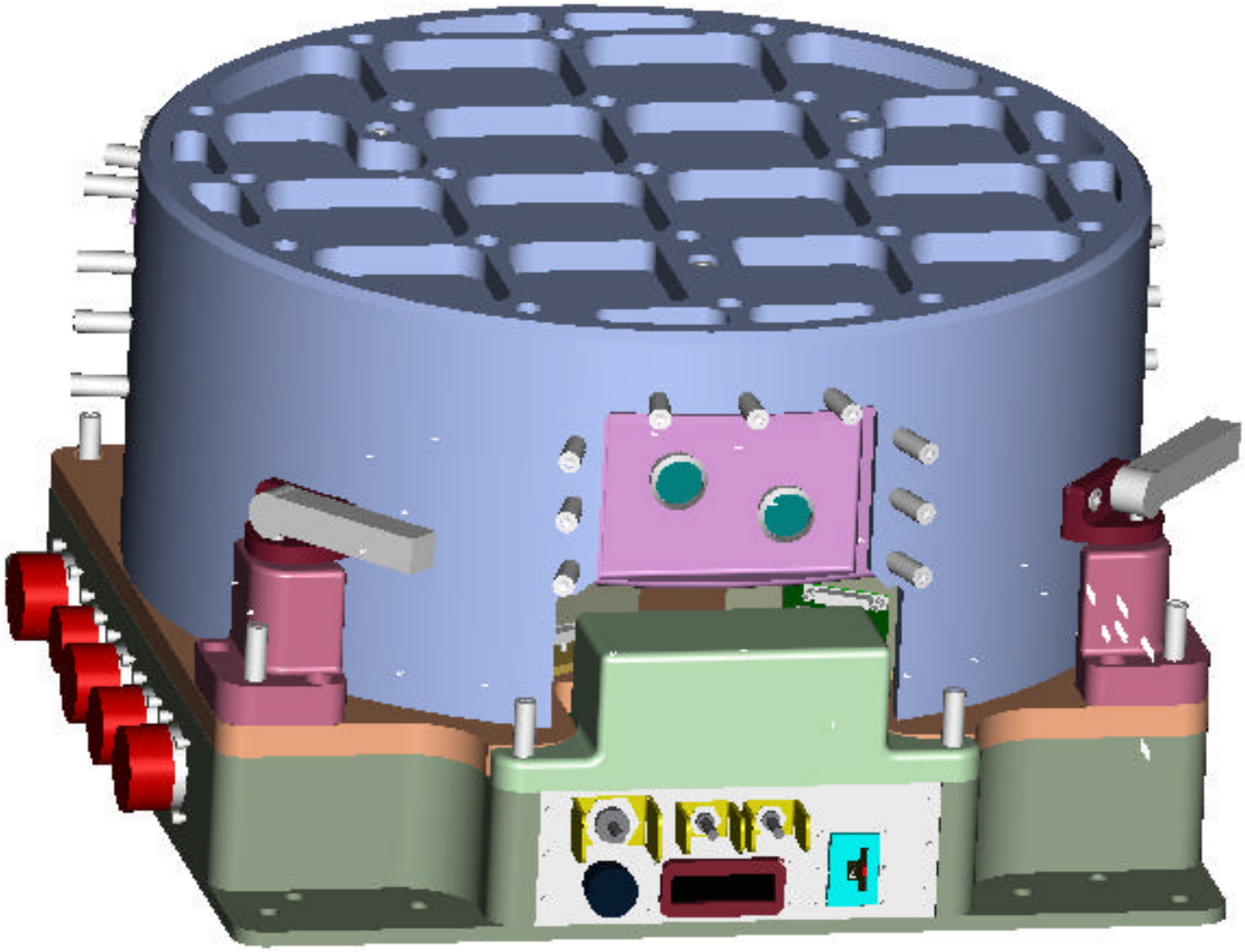
g-LIMIT System Collapsed View



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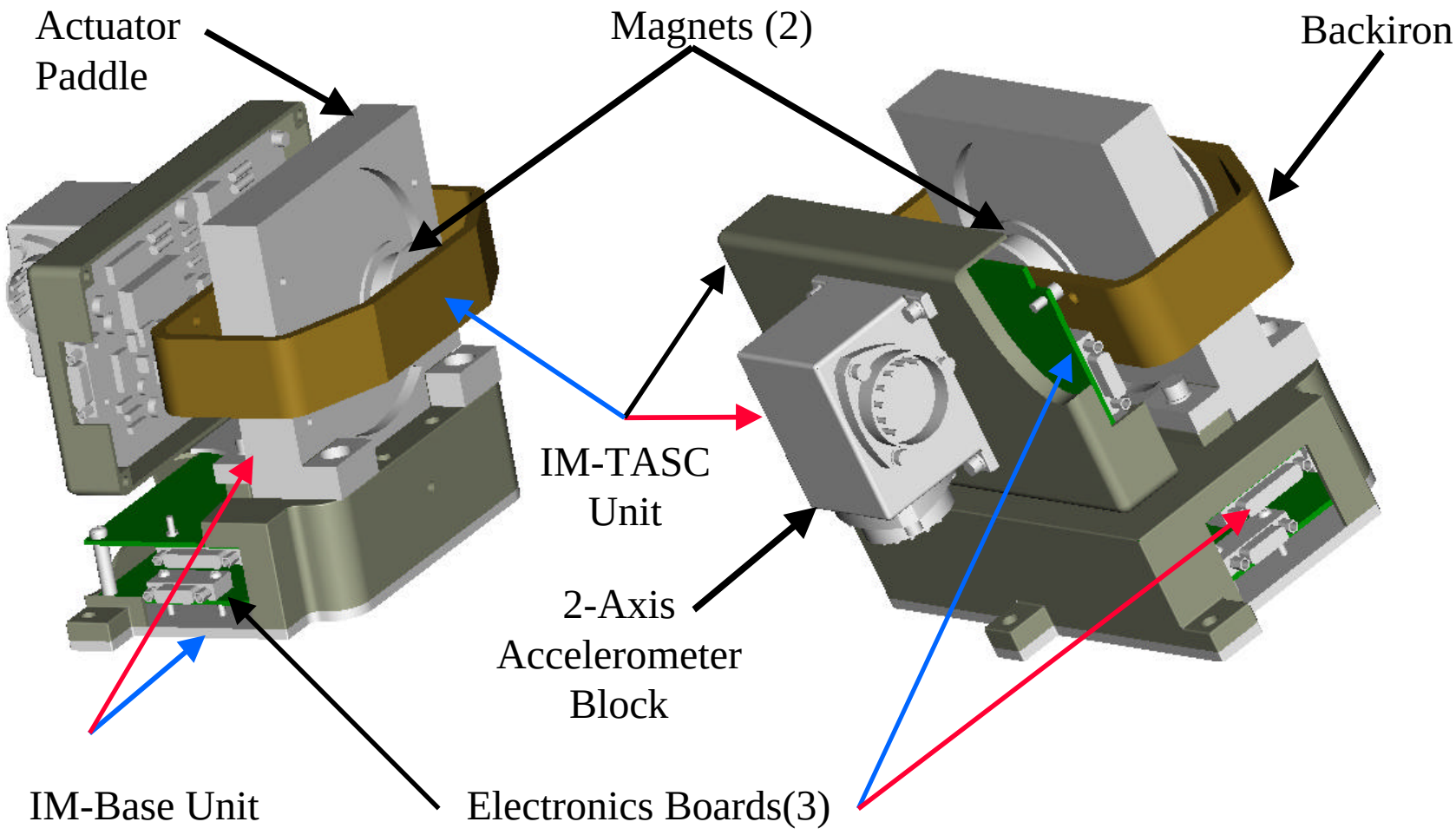
Isolation Module (IM)



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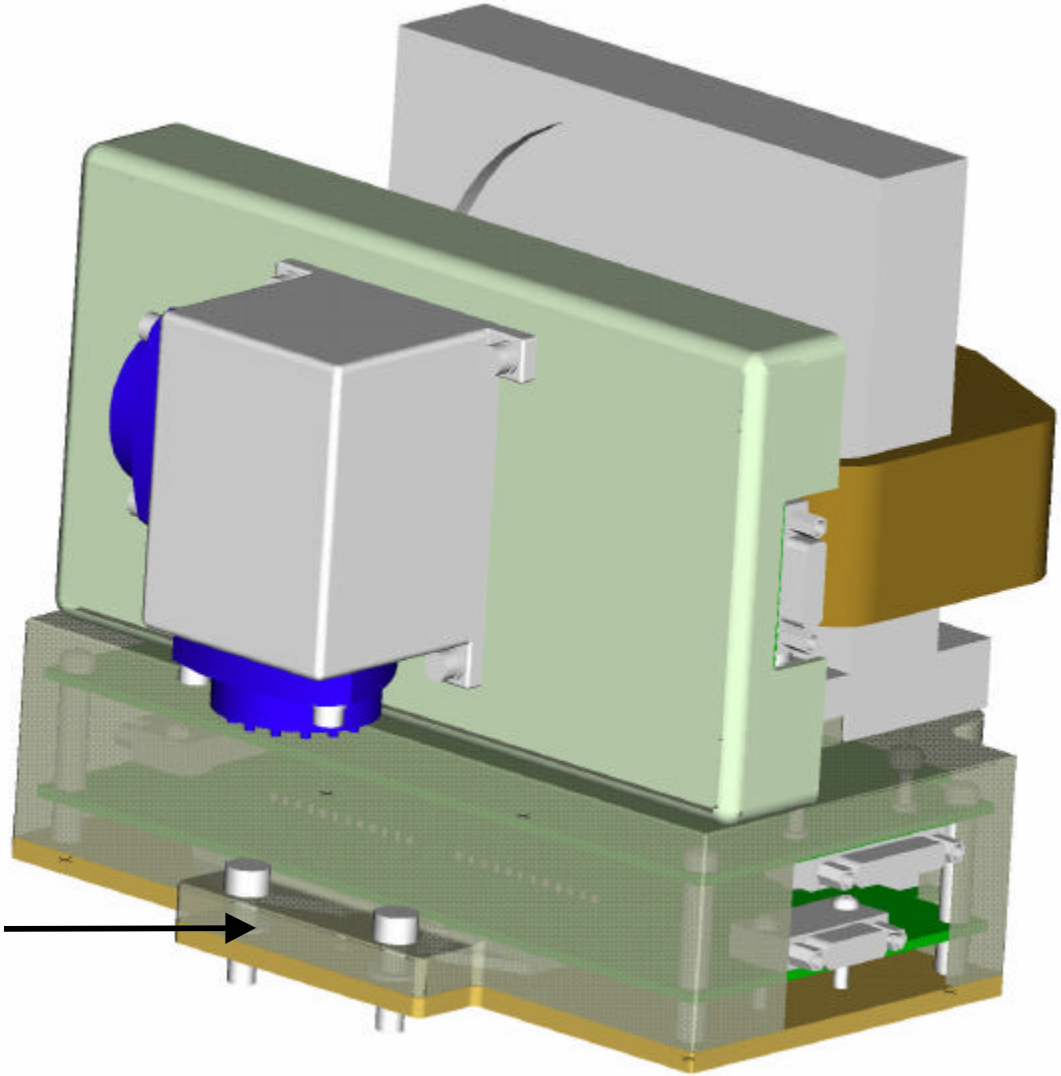
Isolation Module Current Mounting



IM-Base Front Mounting Foot

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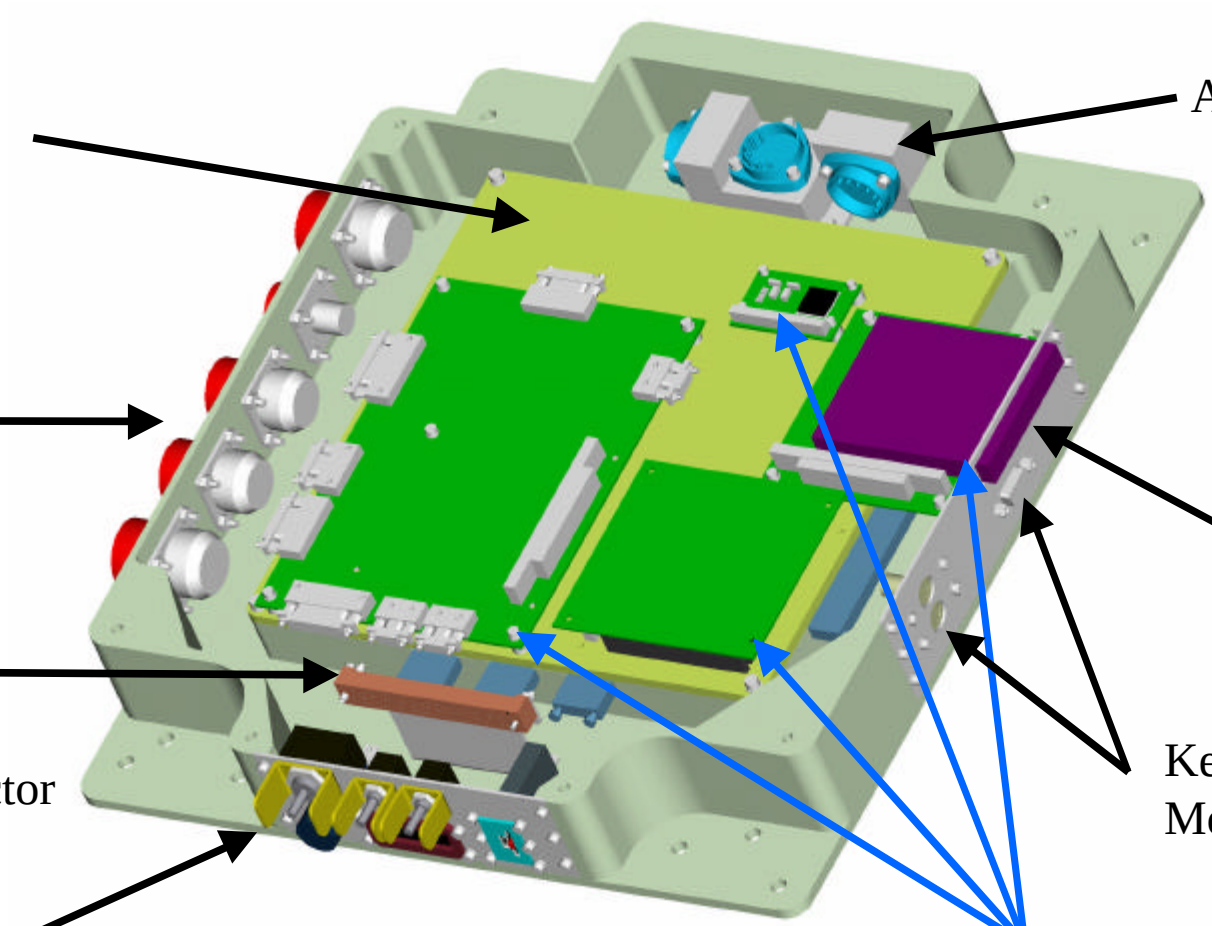
Power and Information Processor (PIP)



Internal Power Converter Box

3-Axis Accelerometer Block

External Connectors

PC-Card Slot

J204 g-LIMIT System Connector

Keyboard Mouse & Video

Front Switch Plate

Electronics Boards(4)

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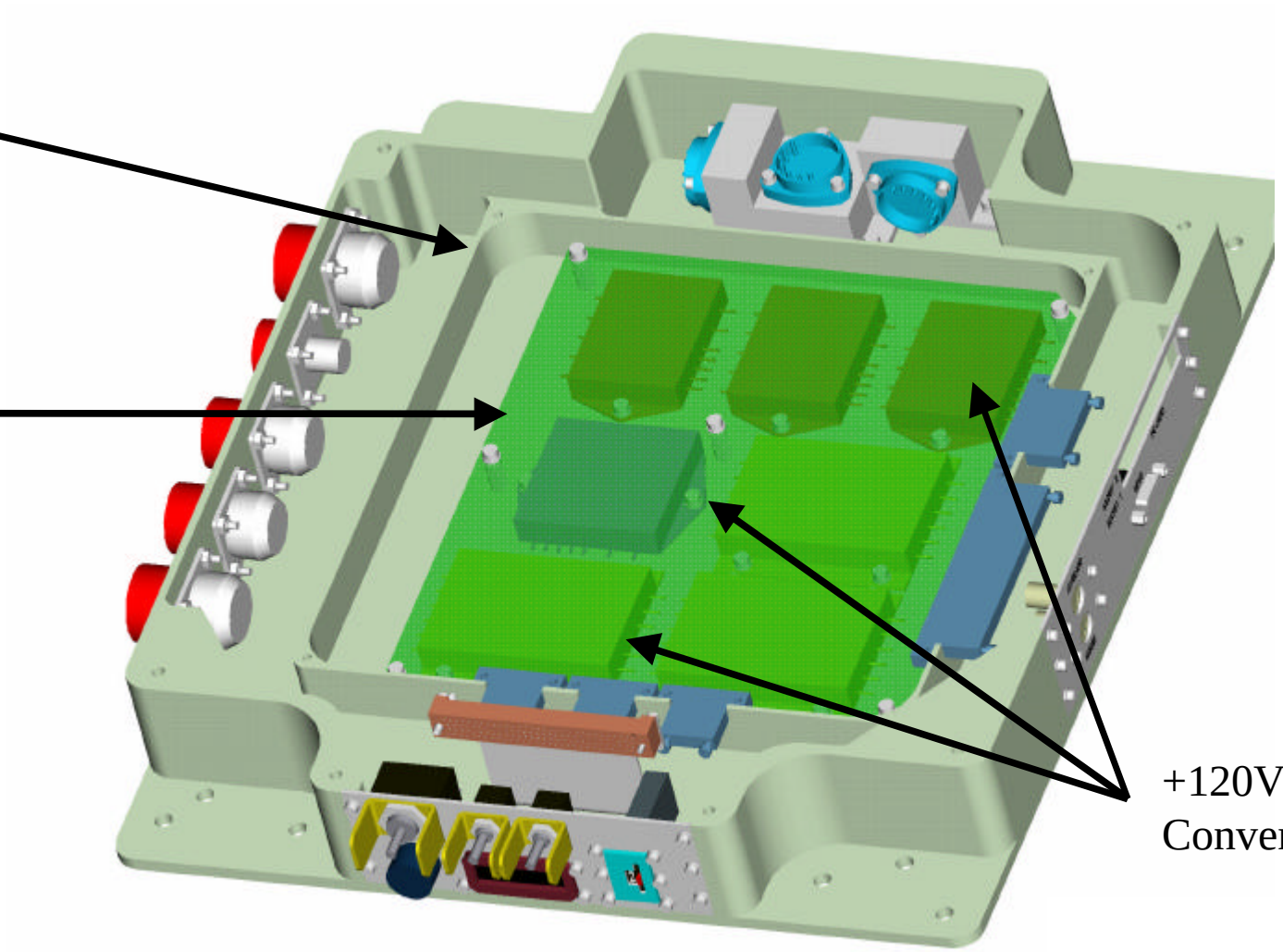
PIP INTERNAL POWER CONVERTERS



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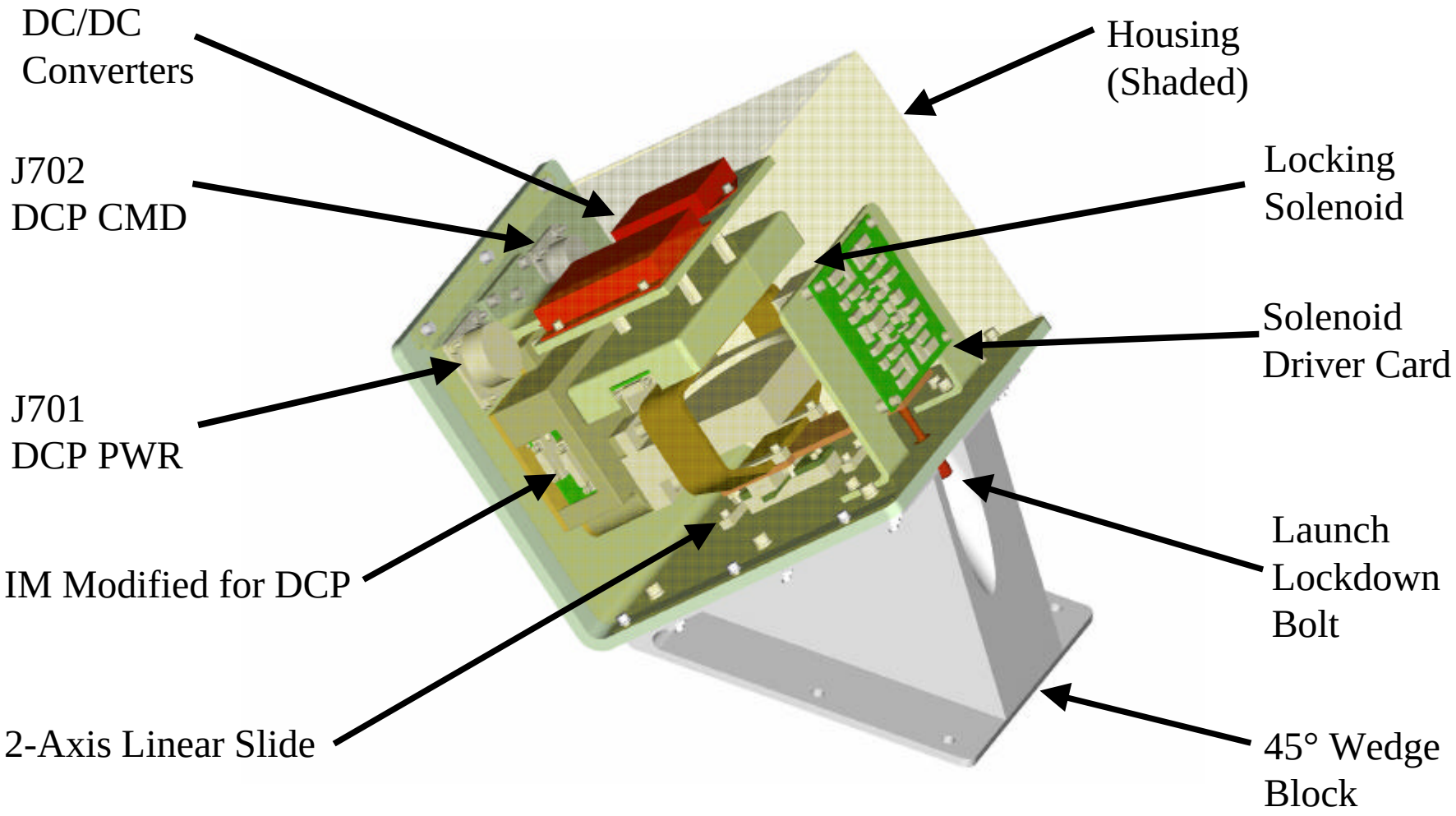
Dynamic Characterization Payload (DCP)



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Three-Axis Accelerometer Package (TRIAX)