



Mars Exploration Rover

Reflight of the Mars Pathfinder Integrated Pump Assembly for the Mars Exploration Rover 2003 Project

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Agenda



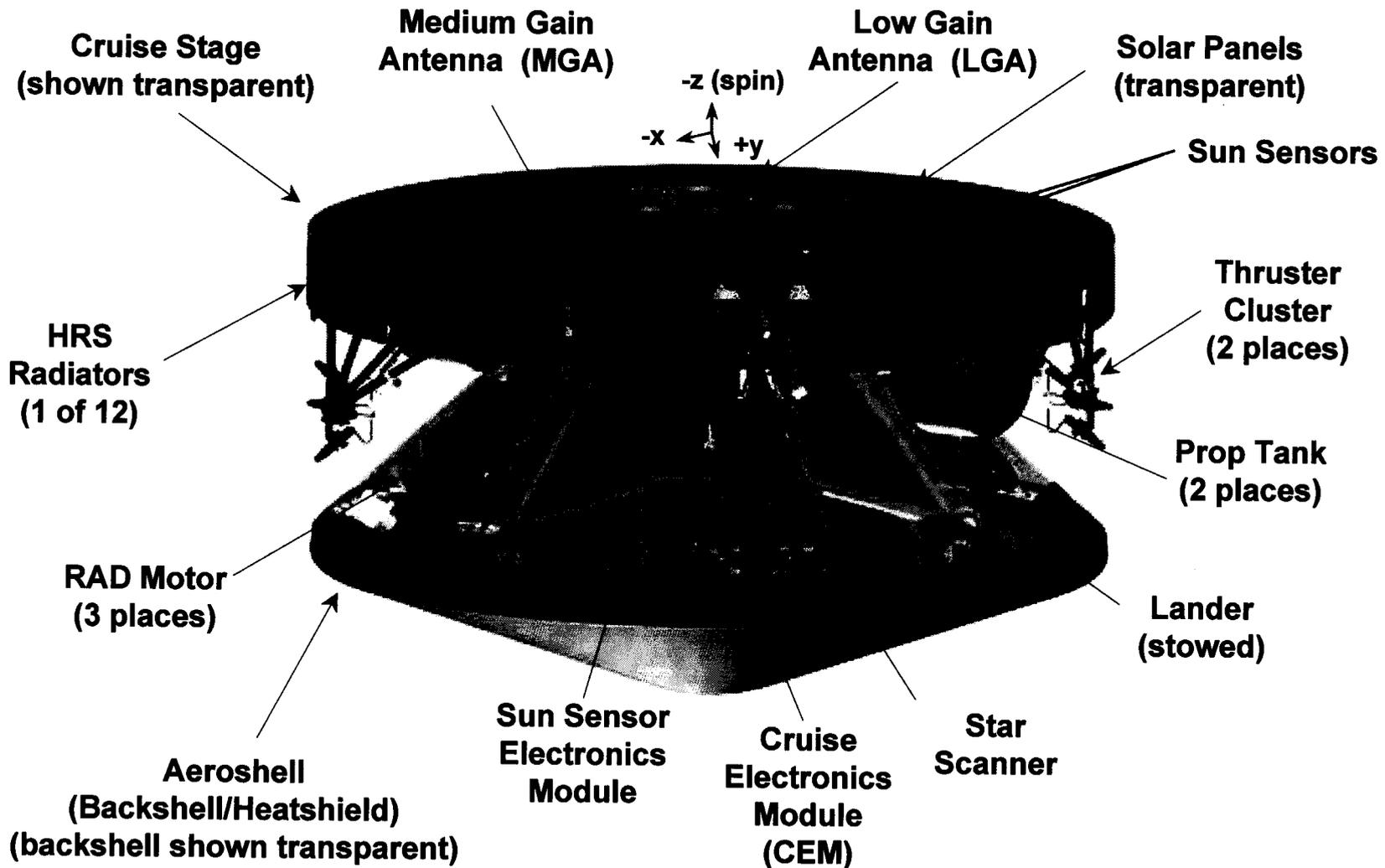
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- **Configuration Overview**
- **Implementation Approach**
- **Design Challenges**
- **Status**
- **Lessons Learned**

MER Spacecraft Cruise Configuration

JPL

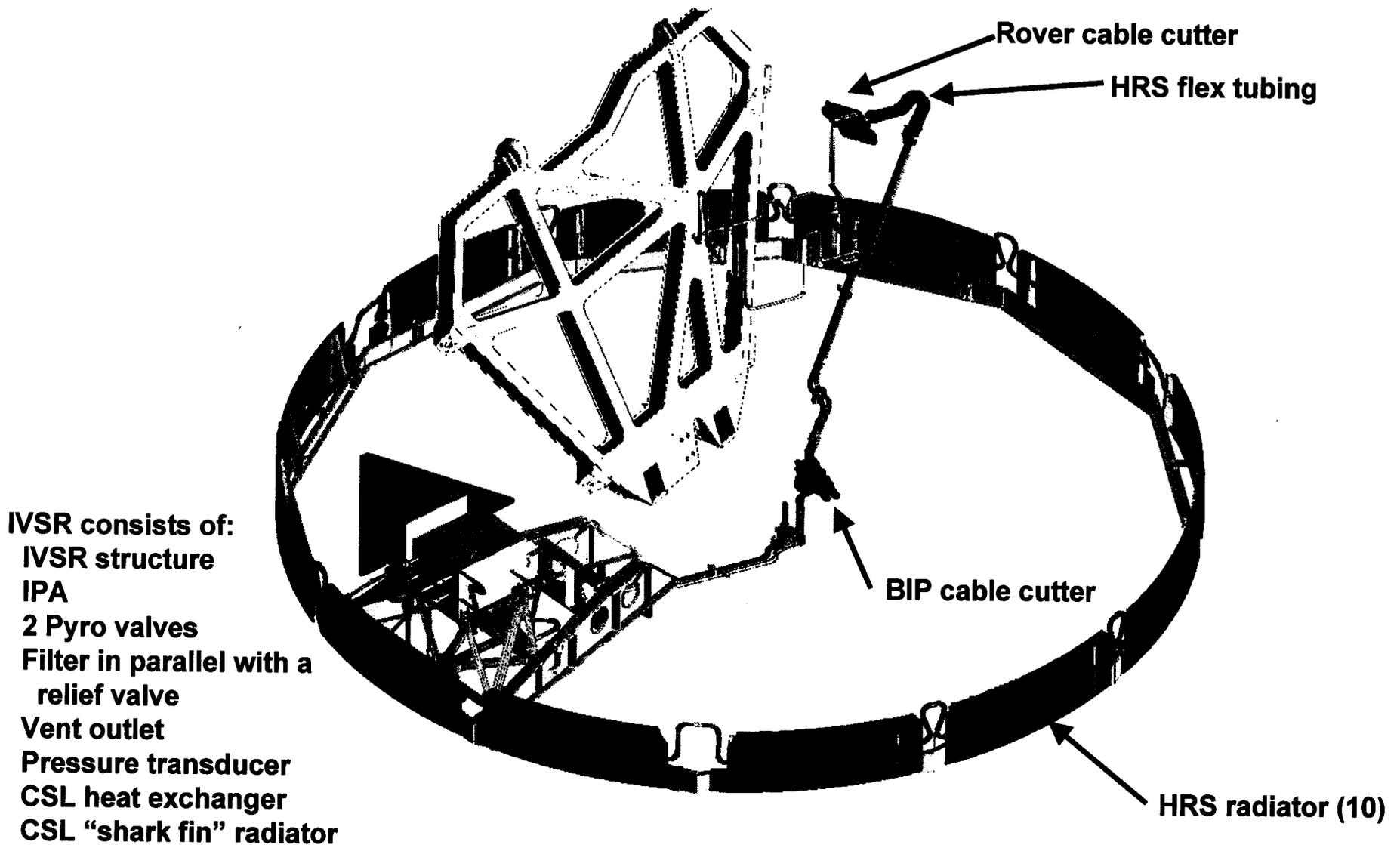
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Heat Rejection System Overview

JPL

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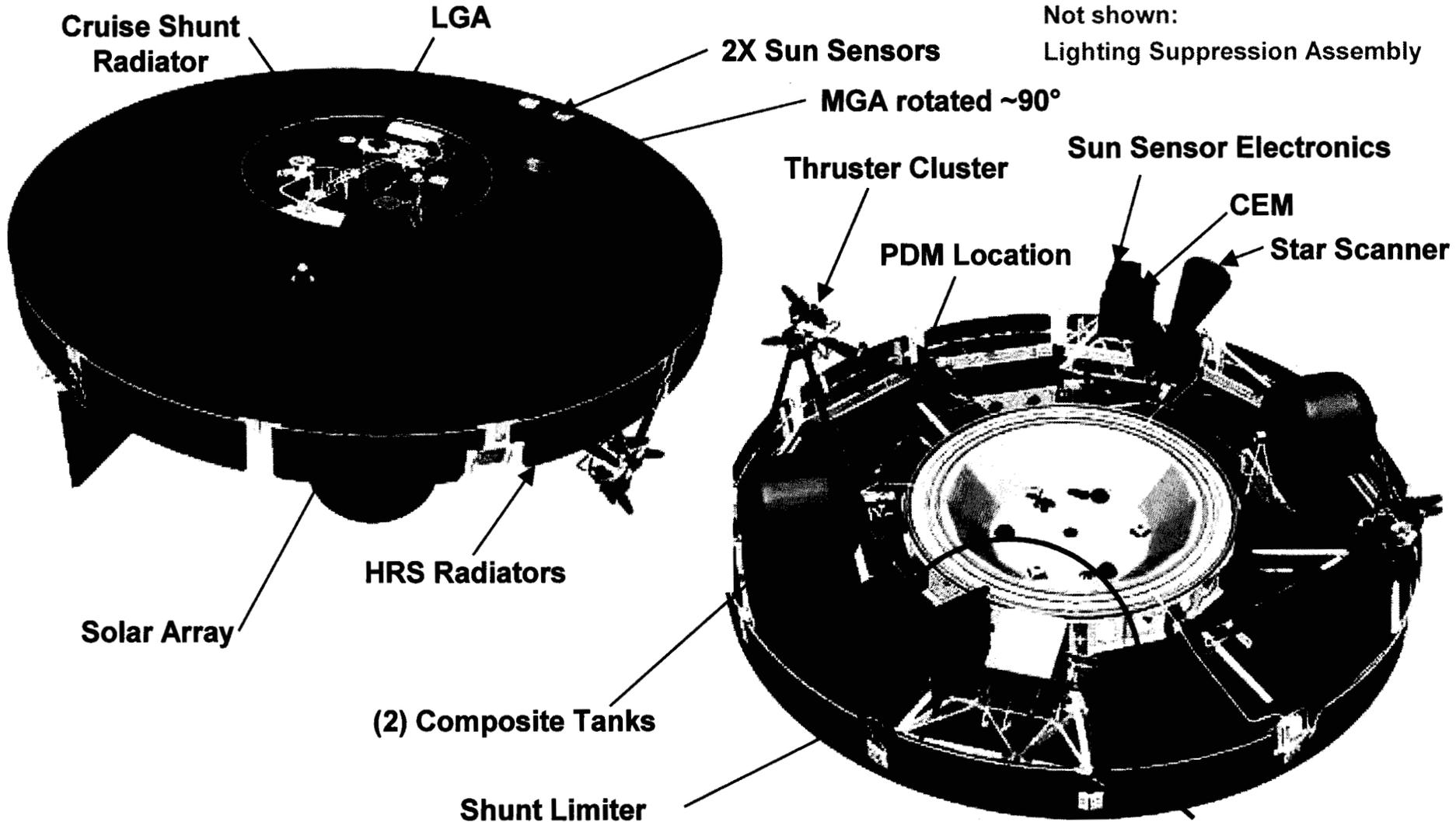


Integrated Pump Assembly Location



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Not shown:
Lighting Suppression Assembly



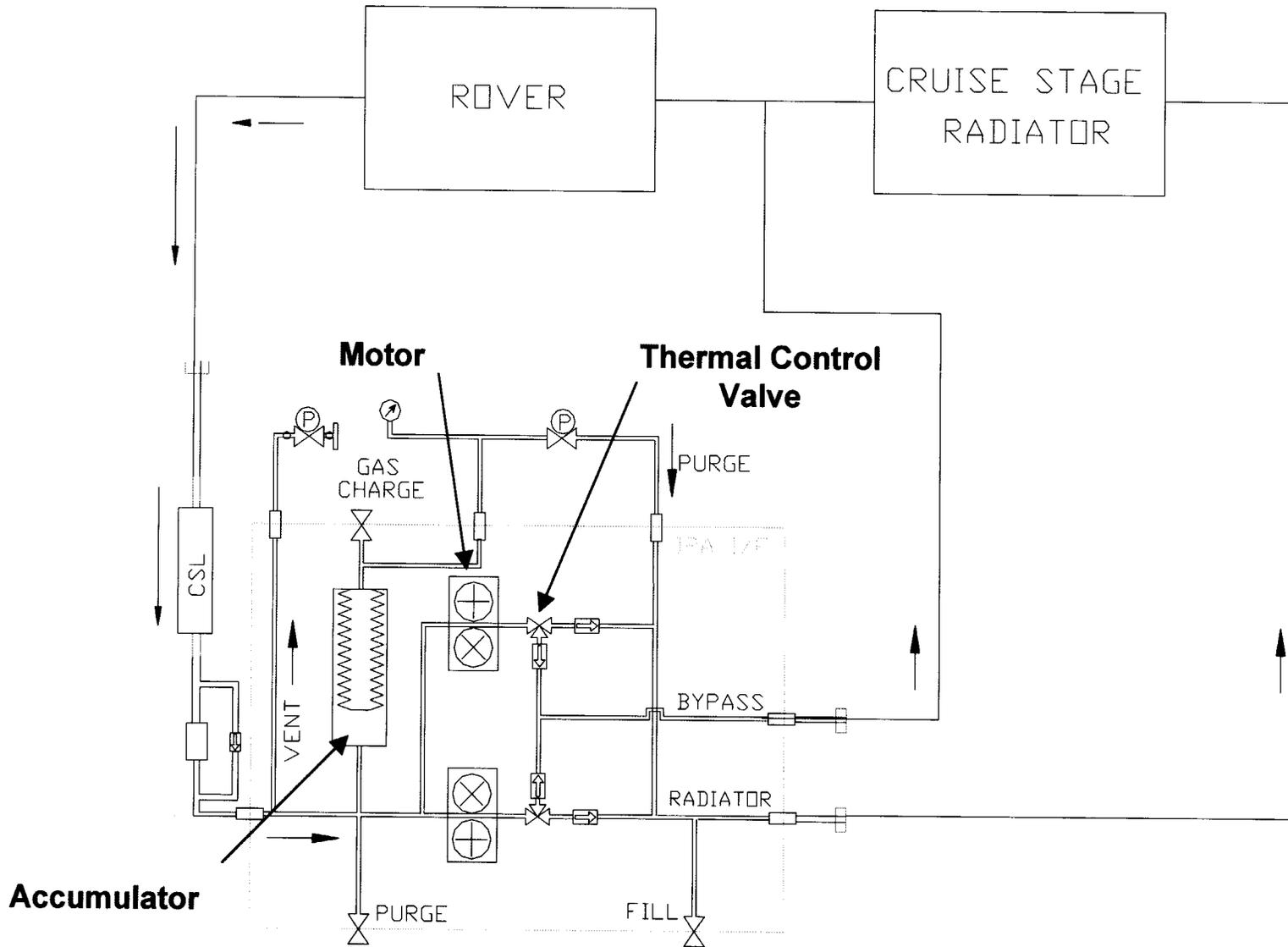
Integrated Pump Assembly

PLM/GB/GTT- 4

HRS Schematic



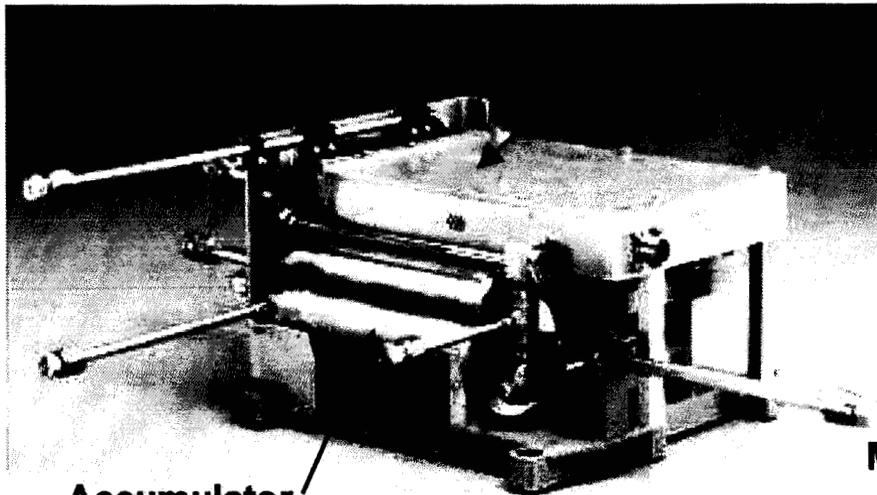
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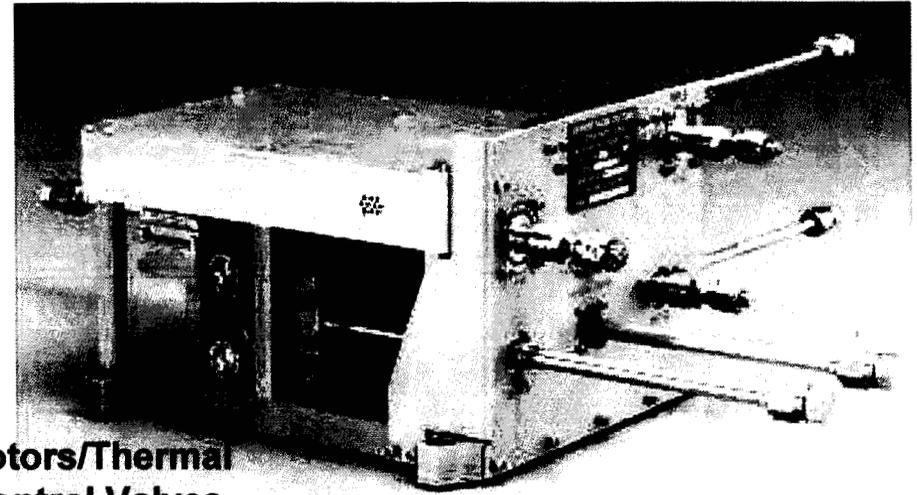
Integrated Pump Assembly

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Accumulator



Motors/Thermal
Control Valves

- **The IPA is a critical part of the Heat Rejection System (HRS)**
 - HRS used primarily to transfer and reject Rover internal heat dissipation during cruise from Earth to Mars (~7 months)
- **Mars Pathfinder IPA shown**
 - Working fluid is CFC-11 at a nominal pressure of 55 psia
 - IPA has block redundancy (motors, thermal control valves, & electronics)

Implementation Approach



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- **Build to MPF print**
 - 2 flight units and 1 spare
- **Select same MPF contractor for schedule and cost risk reasons**
- **Deliver flight hardware prior to start of Assembly, Test, & Launch Operations (ATLO)**
 - MPF IPA was a late decision and hardware delivered during ATLO

Design Challenges (1/4)



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- **MPF Vendor no longer in business**
 - **Howden Fluid Systems (HFS) in Goleta, CA built MPF IPA in 1995**
 - **Howden's parent company consolidated HFS with Western Design, Inc. & relocated to Irvine, CA**
 - **HFS subsequently closed business in Goleta, CA**
 - **Western Design was uninterested in building IPA for the MER Project**
 - **Western licensed MPF IPA drawing package and assembly procedures to JPL**
 - **Former HFS employees started Pacific Design Technologies, Inc. (PDT) in Goleta, CA**
 - **Moved into same HFS office facilities**
 - **PDT retained majority of HFS MPF IPA team**
 - **PDT awarded MER IPA contract in March 2001**
 - **Initial delivery schedule: IPA 1 on 1/1/02 & IPA 2 on 1/29/02**

Design Challenges (2/4)



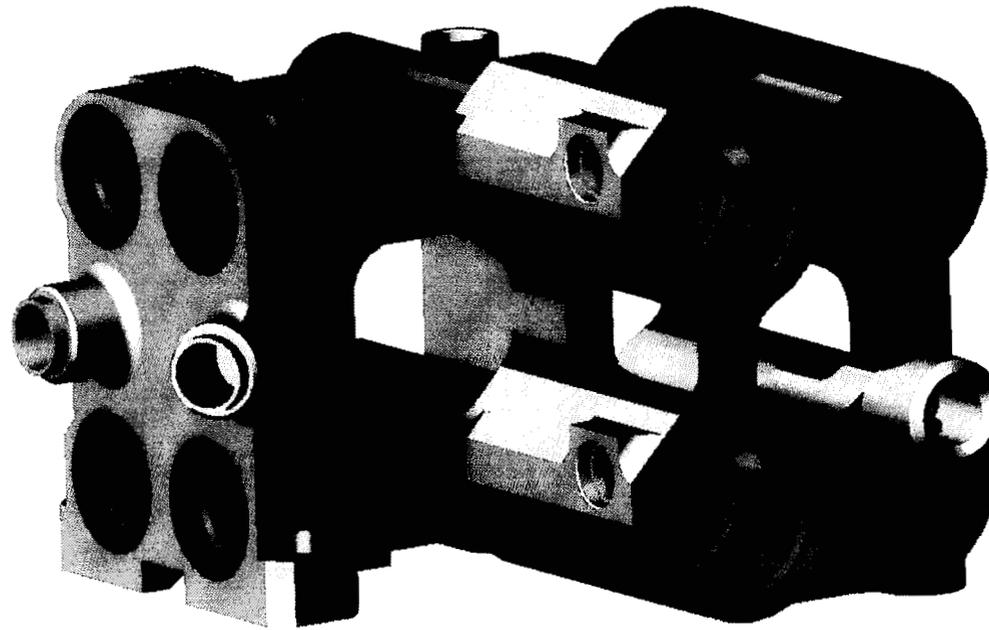
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- **IPA mass reduction**
 - **In October 2000, the MER Project undertook an intensive effort to reduce mass**
 - **IPA was a prime focus since it was directly across from CS ballast mass**
=> a 1 kg IPA mass savings could save 1kg of CS ballast mass
 - **Two approaches considered**
 - **Thinning of component housings**
 - **Separation & relocation of controller electronics**
 - **About 1.2 kg savings realized from reducing housing wall thicknesses**
 - **Relocation of controller electronics discarded**
 - **Minimize schedule & cost risk by retaining build-to-print approach**

IPA Mass Reduction (1/3)



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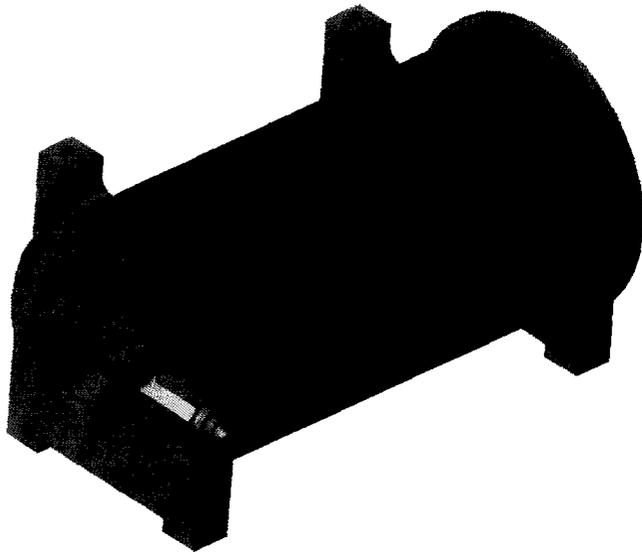


Pump / Valve Body
(Red shading depicts mass reduction)

IPA Mass Reduction (2/3)



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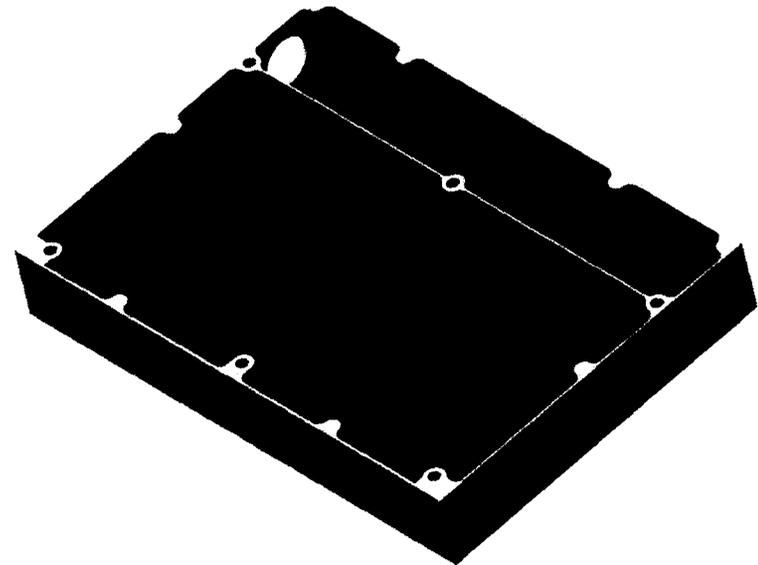
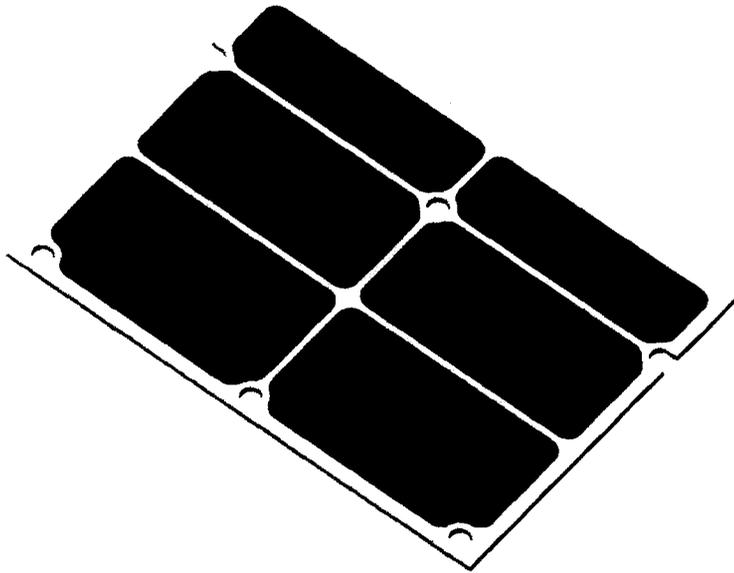


**Accumulator Housing - pressure transducer removed
(Red shading depicts mass reduction)**

IPA Mass Reduction (3/3)



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**Controller Electronics Housing
(Red shading depicts mass reduction)**

Design Challenges (3/4)



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- **IPA accumulator bellows redesign**
 - **MPF IPA accumulator bellows subcontractor, Metal-Fab, merged with Senior Flexonics Aerospace, Inc. (SFA)**
 - **SFA reviewed and scrutinized MPF accumulator bellows design with more thorough structural analysis than MPF**
 - **Implementation of SFA engineering practices led to change in bellows materials and convolution design**
 - **PDT subjected qualification accumulator bellows unit to 10,000 full-stroke life test without any evidence of leaking**
 - **Projected number of flight cycles is less than 100**
 - **Qualification unit leak-tested after every 2,000 cycles**

Design Challenges (4/4)



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- **Electronic Parts**
 - **Controller electronics used discrete parts (e.g., flat pack integrated circuits)**
 - **For schedule reasons, JPL procured and furnished electronic parts to PDT**
 - **JPL presumed surface mount parts were being used, and consequently procured a few incorrect parts**
 - **6 weeks of schedule lost awaiting a reorder**
 - **The MER electronic part screening was more rigorous than MPF**
 - **Some parts required upgrading because of this rigor**
 - **Some parts were upgraded because the MPF part was no longer available**
 - **Some parts required radiation and single event effects testing beyond MPF**
 - **3 months of schedule lost awaiting procurement & testing of 3 parts**
 - **PDT has completed assembly of controller electronics (boards and assembly)**

Status



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- **EM motor fabricated and performance testing completed**
 - **Flight motor assembly underway**
- **Flight accumulator assembled**
- **Controlled electronics PCBs populated and assembled**
 - **Environmental testing in progress**
- **Assembly-level environmental testing schedule in March at JPL**
- **Flight 1 & 2 deliveries on 4/18/02 & 5/20/02, respectively**
 - **First delivery occurs 13 months after contract start**

Lessons Learned



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- **Build-to-print approach eliminated any development effort, but presented new business partnering challenges**
 - **Dynamic business environment where previous subcontractors may be unavailable**
- **Implementation of build-to-print becomes more difficult when project requirements differ from previous application**
 - **Electronics part screening**
 - **Environmental test requirements**
 - **System resource constraints**