

**Redesign of the Mars Pathfinder  
Heat Rejection System  
for the Mars Exploration Rover Project**

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# Agenda



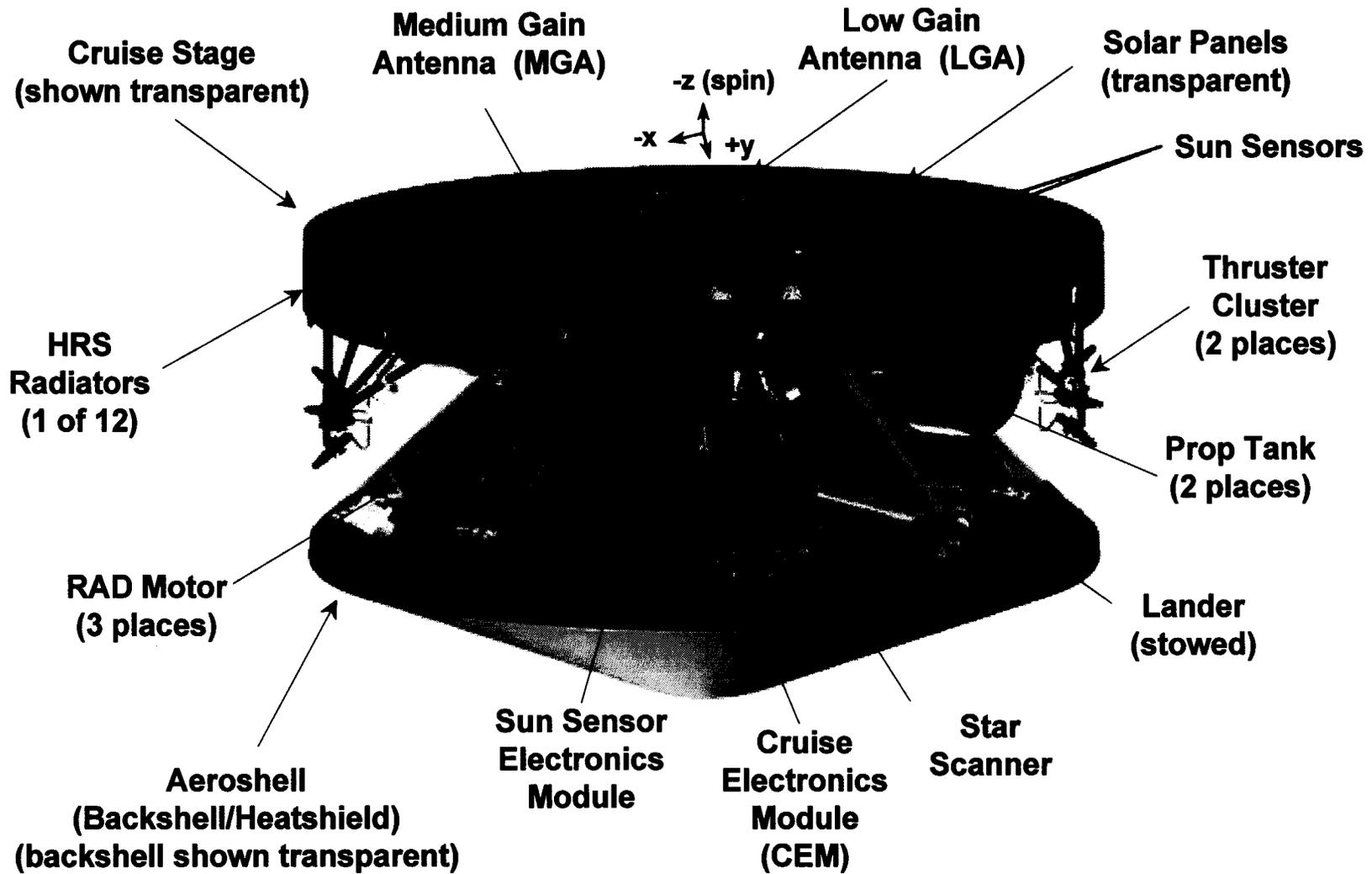
*Mars Exploration Rover*

- **HRS Overview**
- **MPF vs MER**
- **Redesign philosophy and final implementation**
- **Cruise and EDL simulation results**
- **Status**

# Spacecraft Cruise Configuration



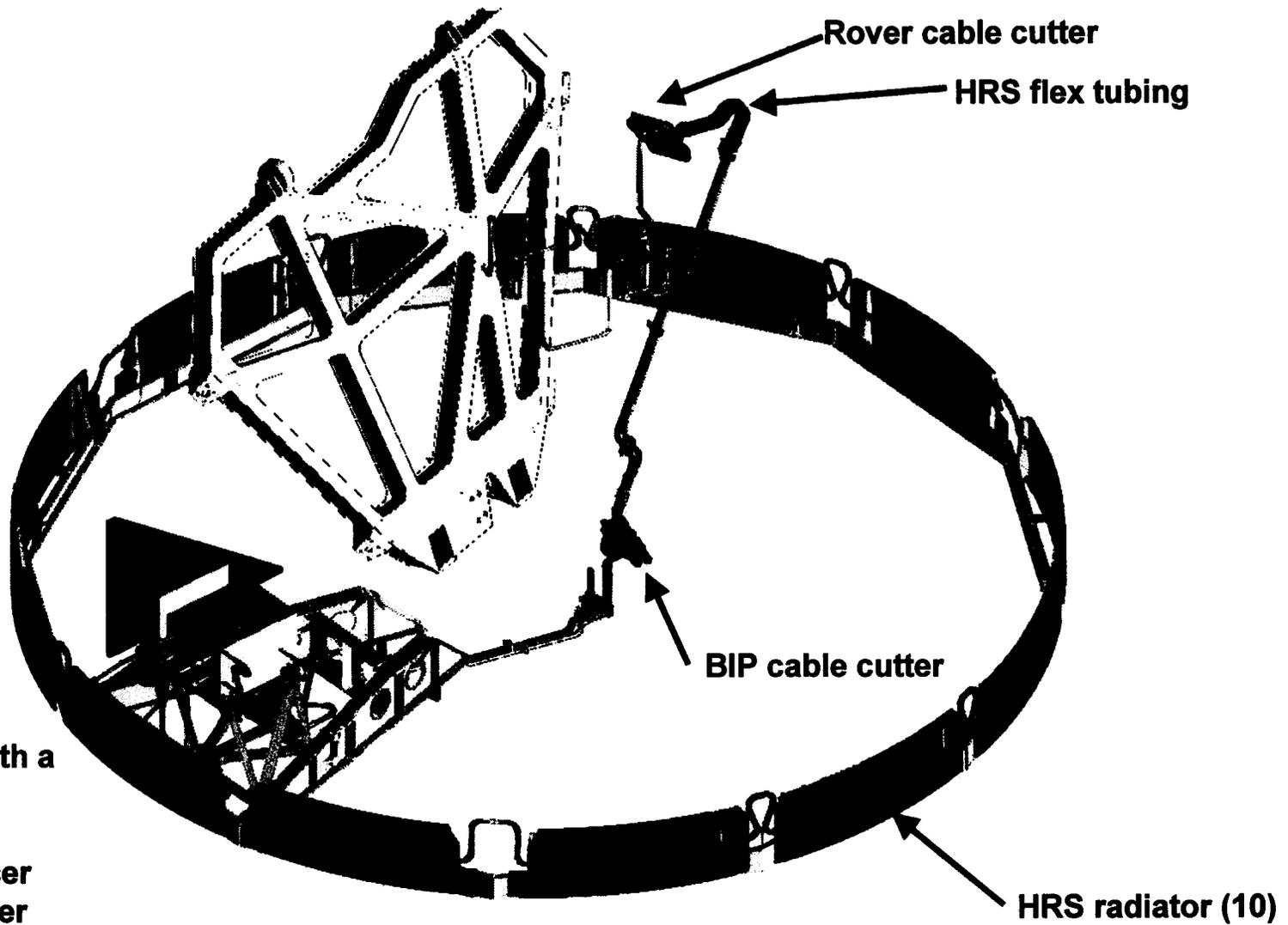
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# Heat Rejection System Overview



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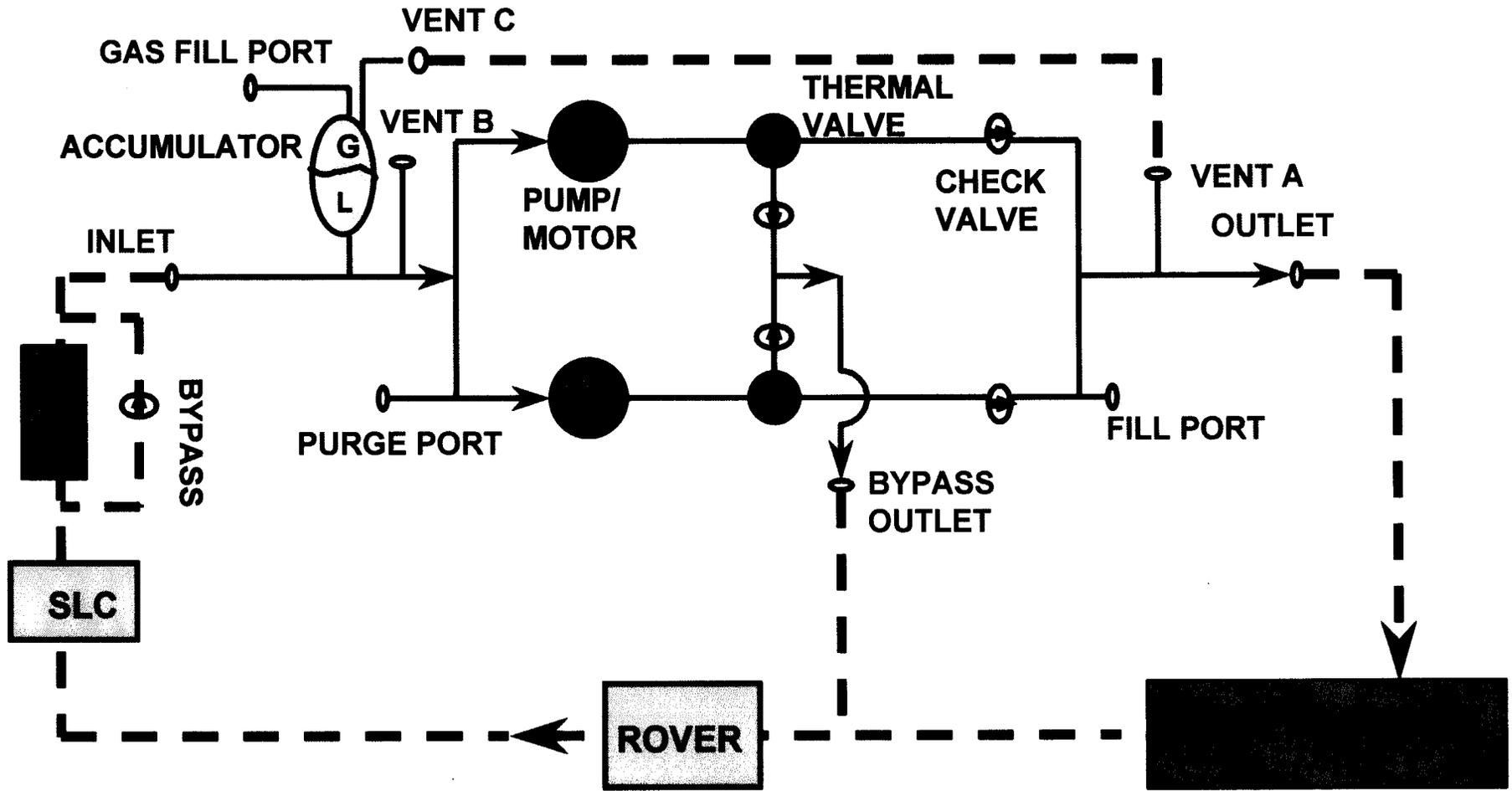


- IVSR consists of:
- IVSR structure
- IPA
- 2 Pyro valves
- Filter in parallel with a relief valve
- Vent outlet
- Pressure transducer
- CSL heat exchanger
- CSL "shark fin" radiator

# MER HRS Schematic

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— IPA FLOW PATH      - - - FLOW PATH EXTERNAL TO IPA

# MPF vs MER



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- **HRS to accommodate changes in MER with adequate margin on accumulator volume,  $\Delta P$ /flow rate, margin on equipment temps.**
  - **Changes from MPF impacting HRS sizing include:**
    - › **MER Electronics as scab-on to REM vs. MPF electronics on lander equipment shelf**
    - › **2 SSPAs on MER vs 1 on MPF (no additional power though)**
    - › **REM power (42W) vs MPF IEM power (32W)**
    - › **REM RHU Holder (6.5W) vs MPF RHU (<1W)**
    - › **New Shunt Limiting Controller power rating (25W vs 60W for MPF)**
    - › **IPA flight allowable temp (lower limit) increased from -40 to -30 °C**
  - **As a result, HRS tubing changes include**
    - › **modified cruise stage to lander interface tube routing**
    - › **modified lander to rover interface tube routing**
    - › **completely new routing on REM**
    - › **No rover cold finger as in MPF**
  - **Total Heat rejection requirement for MER HRS increased to 160W from 150W (MPF)**

# MER HRS Requirements



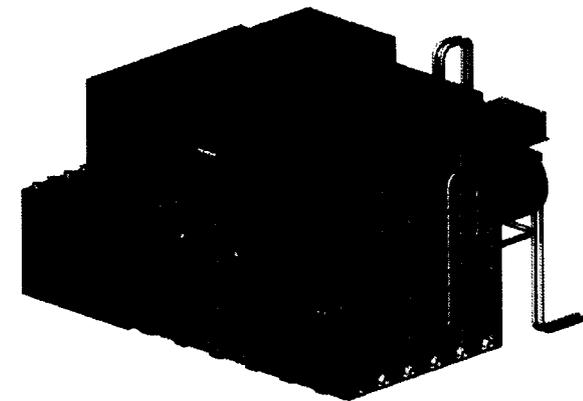
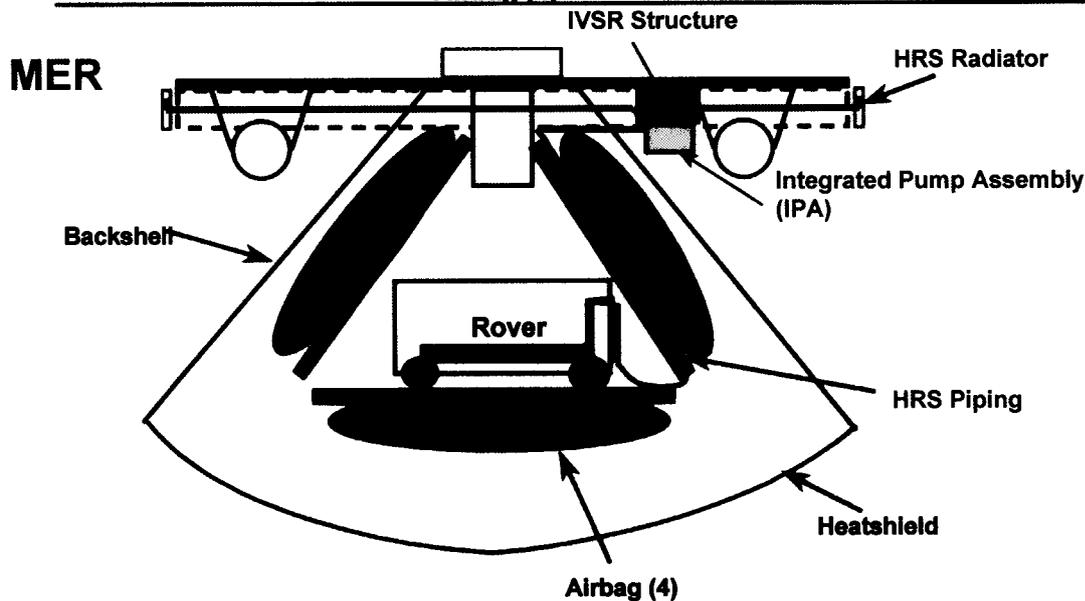
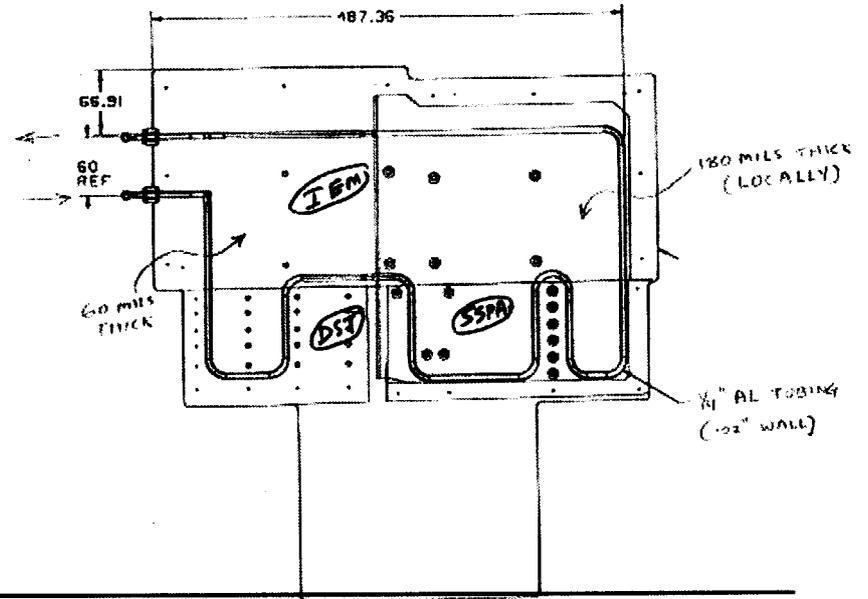
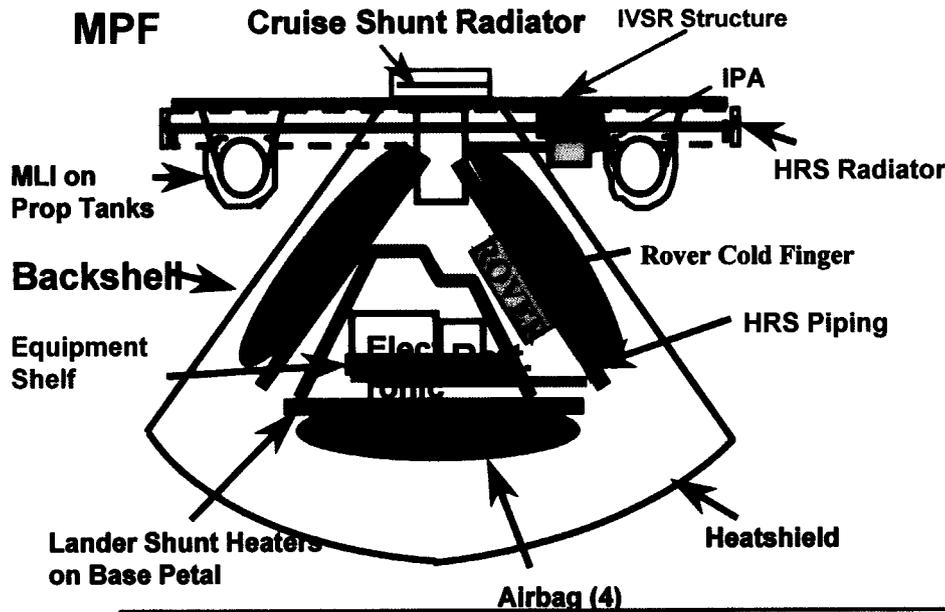
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MER Component	Flight Allowable Temp (°C) Op Min/Max	Flight Allowable Temp (°C) Non-Op Min/Max	Head Loads (w/growth) (watt)
REM I/F	-40/+50	-40/+50	46.1
SSPA I/F	-25/+50	-40/+50	37.8
SDST I/F	-25/+50	-40/+50	15.07
IMU I/F	-39/+51	-47/+65	14.8
Battery (cruise)	-20/+10	na	<1
Battery (charge)	0/+30	na	<1
Battery (discharge)	-20/+30	na	<1
REM RHU	-100/+300	na	3.6
Battery RHU	-100/+300	na	6.5
Cruise Shunt Limiter	-25/+40	na/+50	25
IPA electronics			10.6
		Total	159.47

# MPF vs MER Layout



## Mars Exploration Rover



Rover Electronics Module (REM) and scabbed-on telecom

GBG & HA - 7

- **Design approach**
  - **Primary driver is to keep IPA design invariant**
    - Accumulator bellows design new, but performance very close to MPF
  - **Higher heat dissipation levels (compared to MPF) in the REM leading to exploring alternate tube dimensions for radiator and transfer lines**
    - Change radiator tube dia from 3/8" to 5/16" (0.028" thick)
    - Change all transfer lines to 1/4" (0.028").
  - **Post-PDR power level changes led to longer tube lengths on the REM HRS routing leading to lower flow rates**
    - For CDR, changed most of the 1/4" (0.028") to 1/4" (0.020")
    - Current design has mix of 3/8" (0.028") in IVSR, 1/4" (0.028") in heat exchangers, 1/4" (0.020") in transfer lines
  - **Radiator paint changed from NS43G to Hincom.**
  - **Number of radiator panels reduced from 12 to 10.**
  - **REM HRS design brand new**
    - Flow performance verified

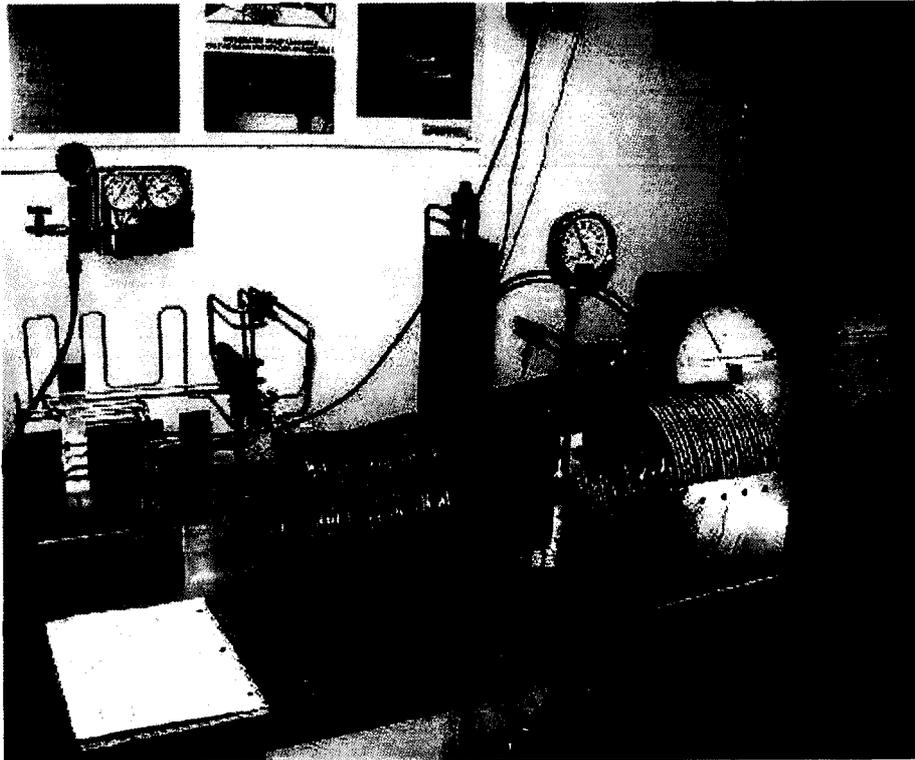


# $\Delta P$ /Flow Design Verification

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## Hydrodynamic Test Setup

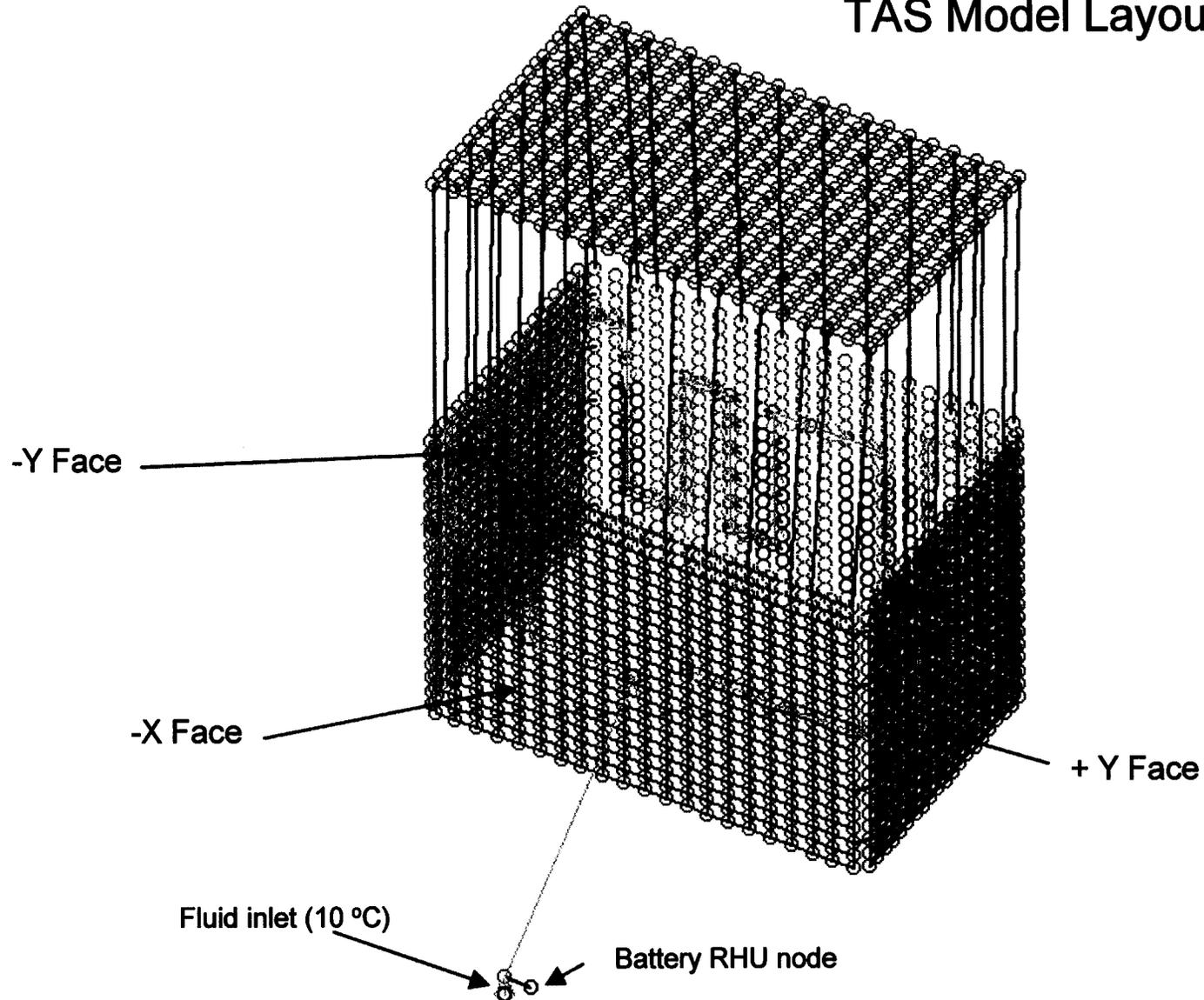


Front View of Test Stand



Side View of Test Stand

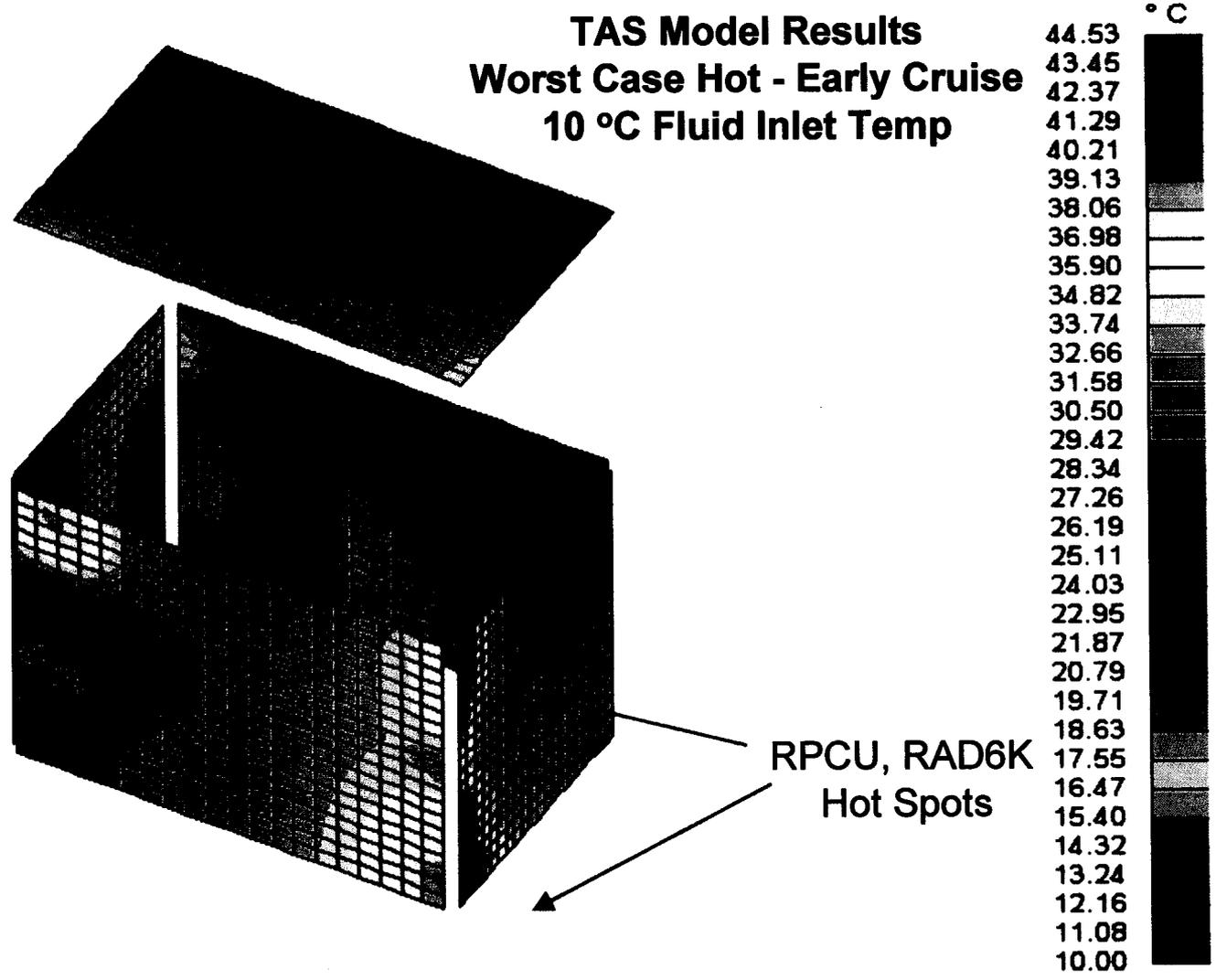
## TAS Model Layout



# Early Cruise Model Results



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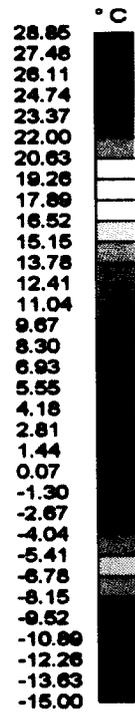
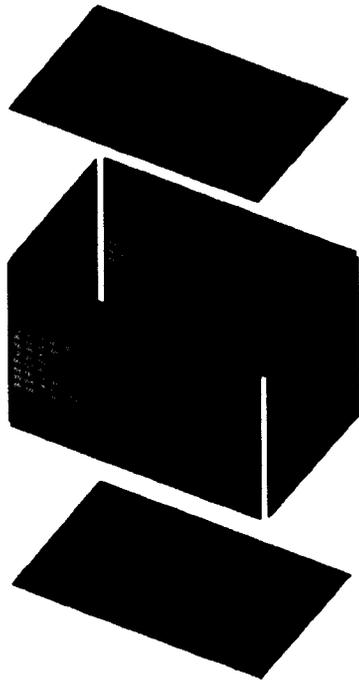


**NOTE: Actual inlet fluid temperature will be cooler than used in simulation (~ 0 °C)**

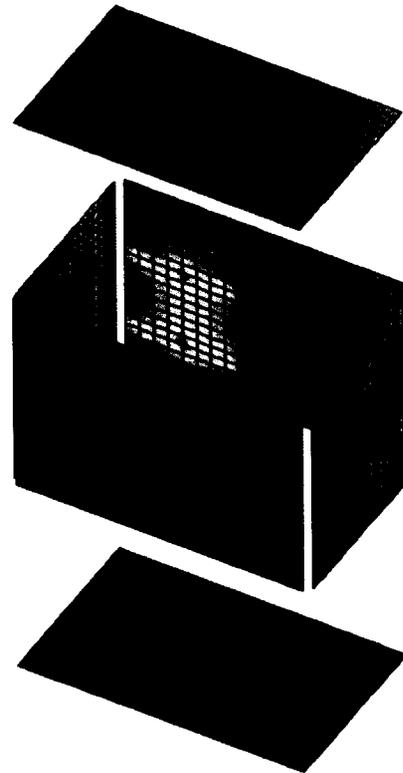
# EDL Model Results



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T = 0 sec (HRS pump off)  
Inlet fluid temp = -15 °C

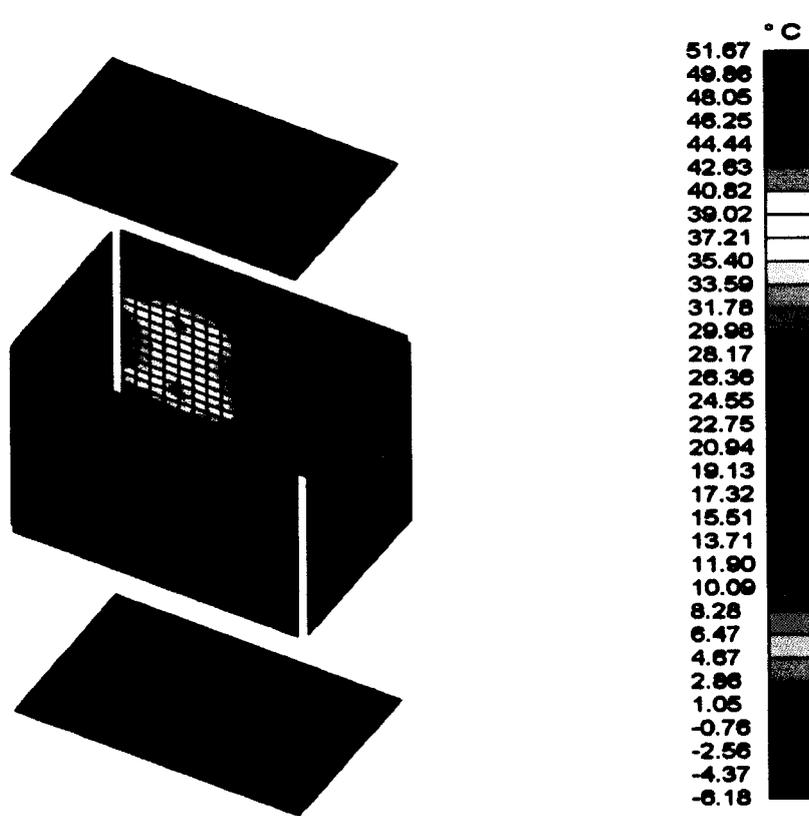


T = 2100 sec (Entry)

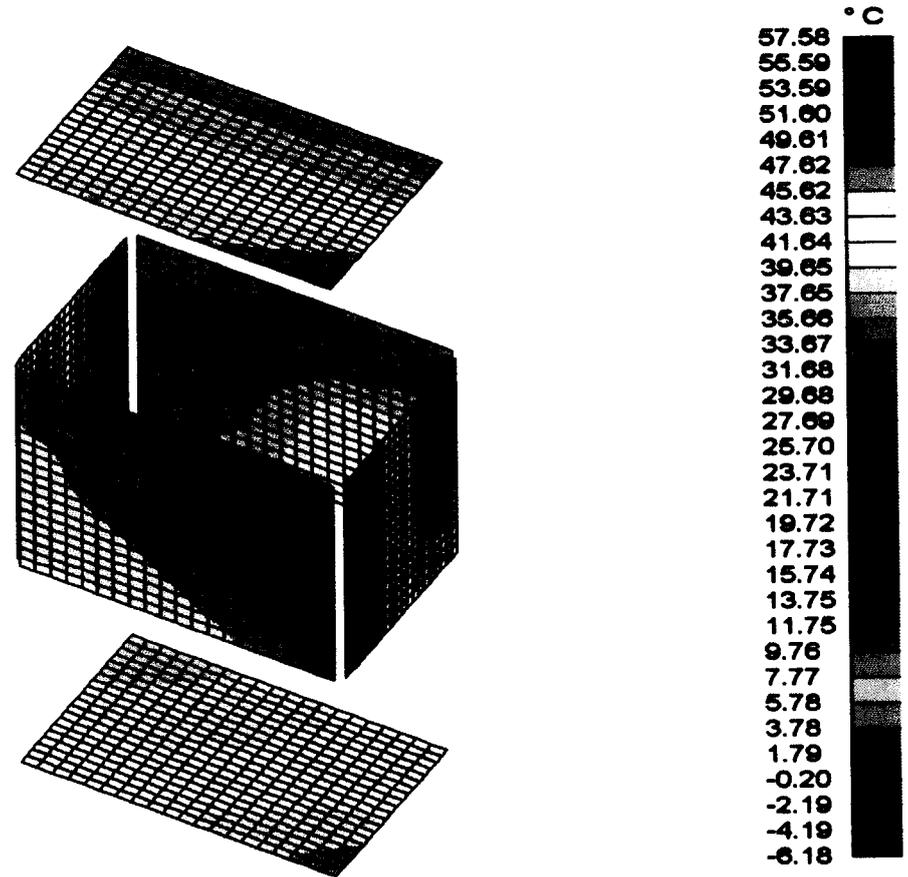
# EDL Model Results



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T = 3054 sec (Roll Stop)



T = 13174 sec (Avionics Sleep)

- **Design phase mostly over with the exception of vent design**
- **2 sets of REM tubing bent and bonded onto REM**
- **Flow tested REM tubing in test bench to verify flow/ $\Delta P$  characteristics**
- **HRS/Rover test to be conducted in April/May 2002 to verify design**
  - **Thermal mass models and HRS radiator mock-up with bypass wax valve inside vacuum chamber and pump assembly outside.**
  - **Design verification for cruise and landed phases**