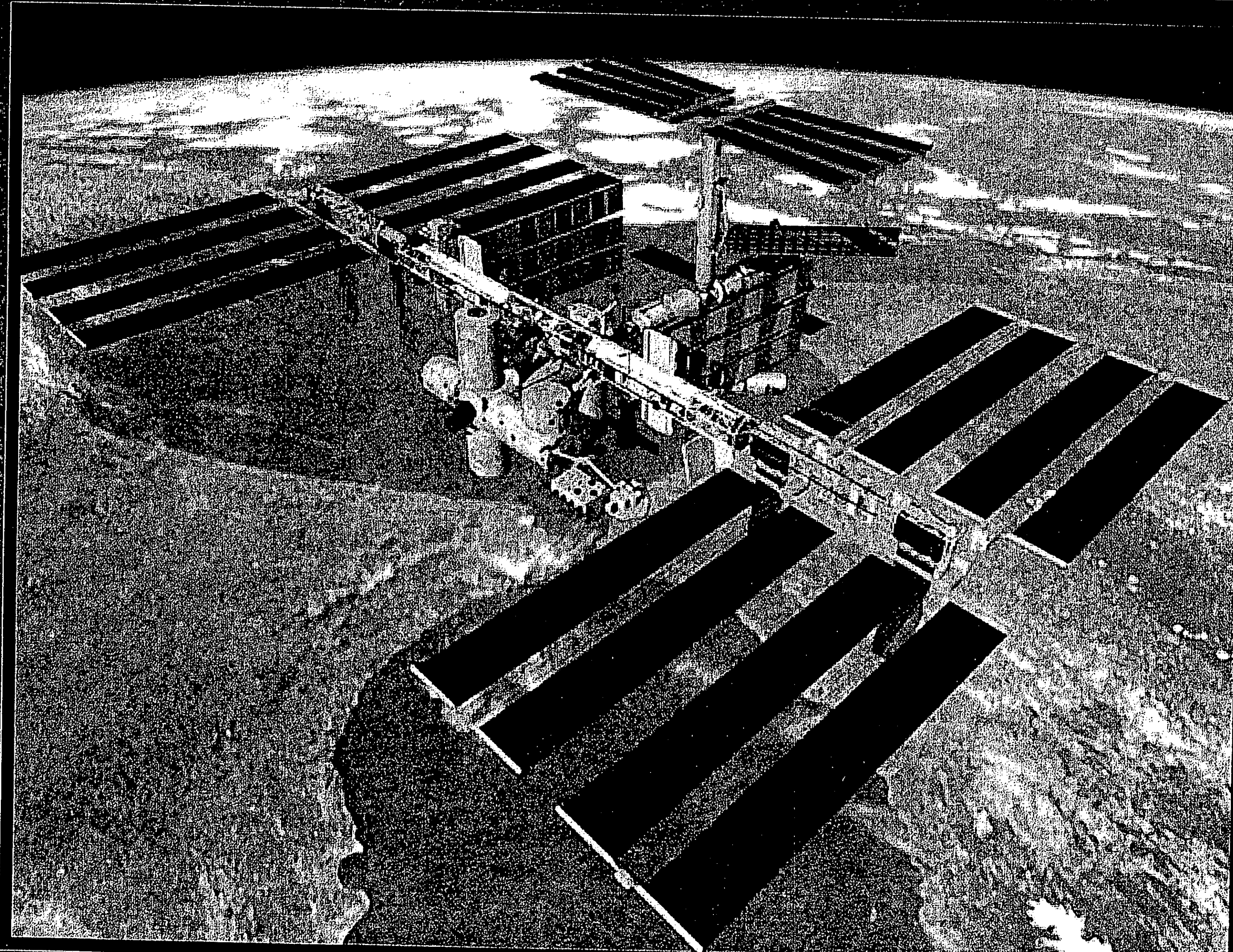
International Space Station (ISS) Nodes 2/3 Thermal Control System Overview & Design



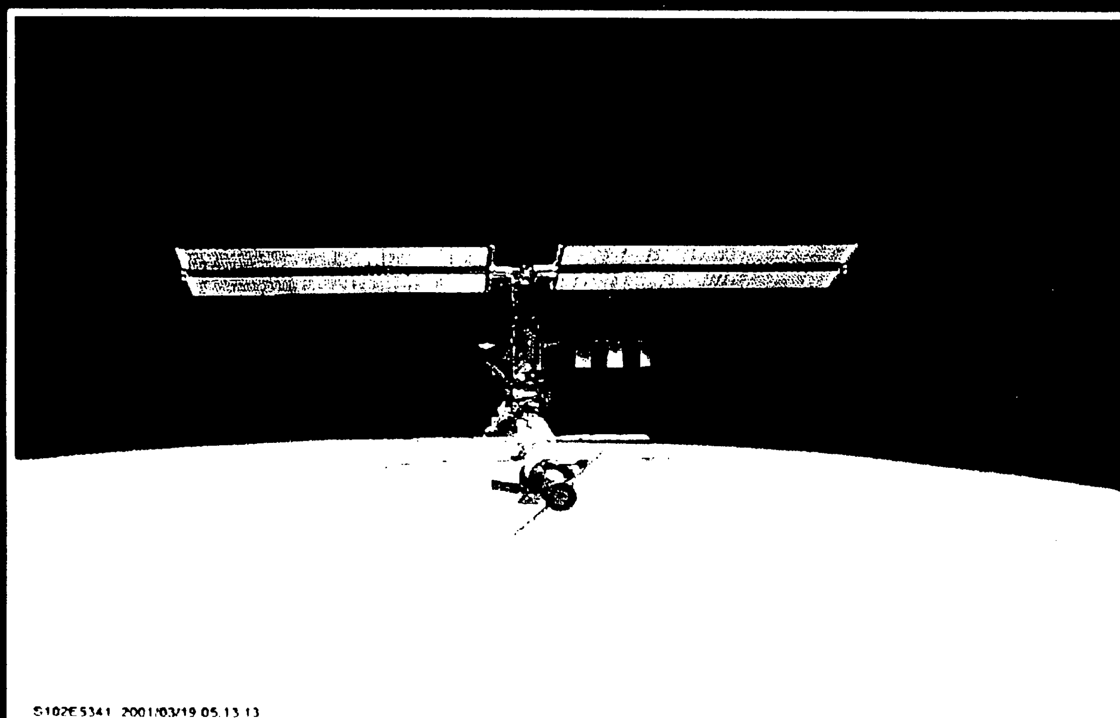
Stephen Clanton

Agenda

- General International Space Station (ISS) & Node 2 & 3 Information
- ISS Thermal Control System (TCS) Design Overview
  - Passive Thermal Control System (PTCS)
  - Active Thermal Control System (ATCS)
    - Internal Active Thermal Control System (IATCS)
    - External Active Thermal Control System (EATCS)
- TCS Components Examples
- Thermal & Hydraulic Analytical Tools Overview

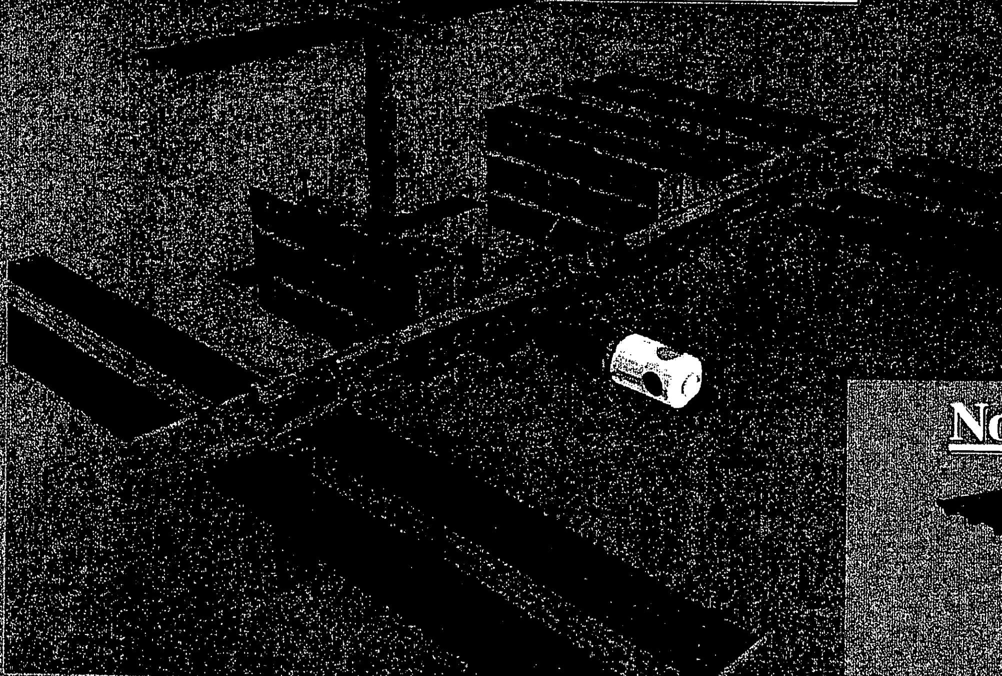
ISS Information

Width	356.4 feet
Length	290 feet
Mass (Weight)	1,005,000 pounds
Altitude	150 – 280 nautical miles
Inclination	+/- 56.0 degrees (results in +/- 75.0 degrees beta angle, without the shuttle)
Internal Pressure	14.25 psi
Crew Capacity	current 3 crew members with capability of 7 crew members after Node 3

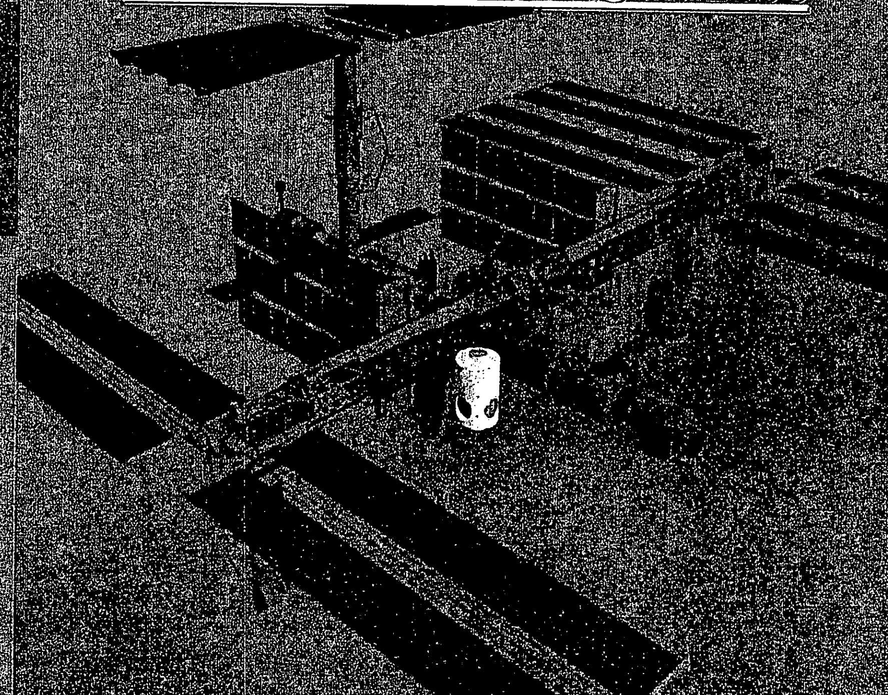


ISS Node 2 & 3 Launch Schedule

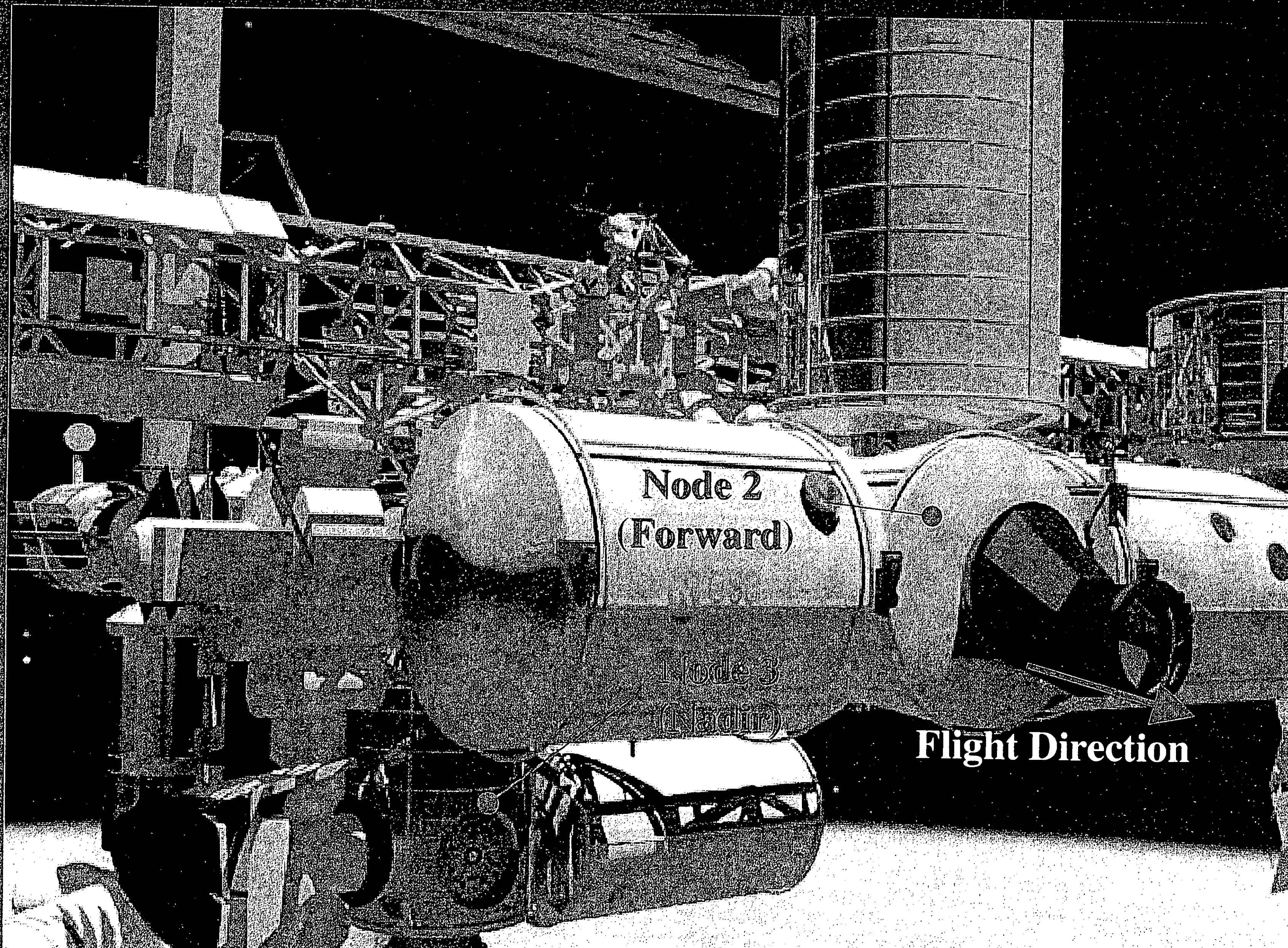
Node 2 – Flight 10A: Sep. 2004



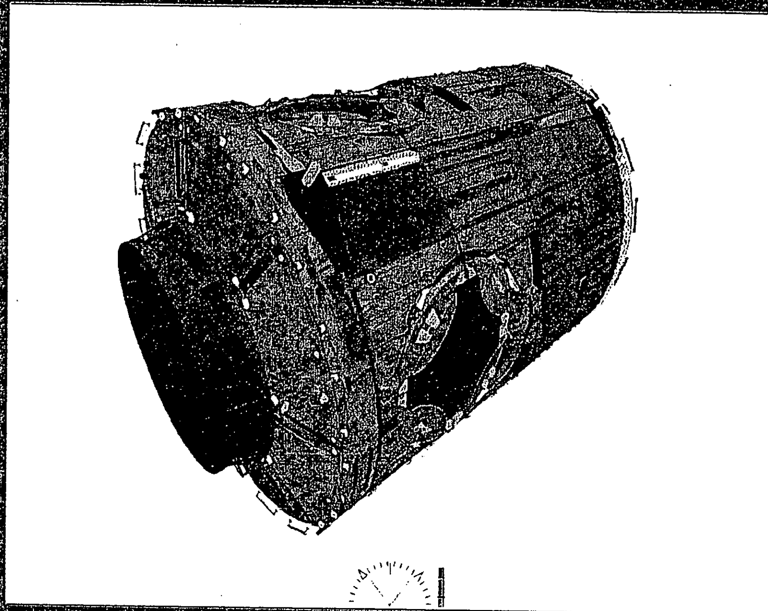
Node 3 – Flight 20A: Jul. 2006

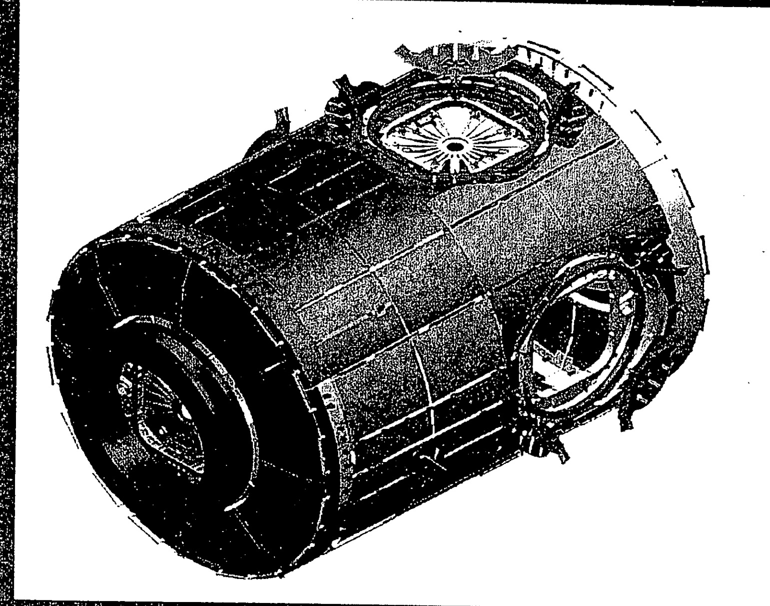


ISS Nodes 2 & 3 Locations



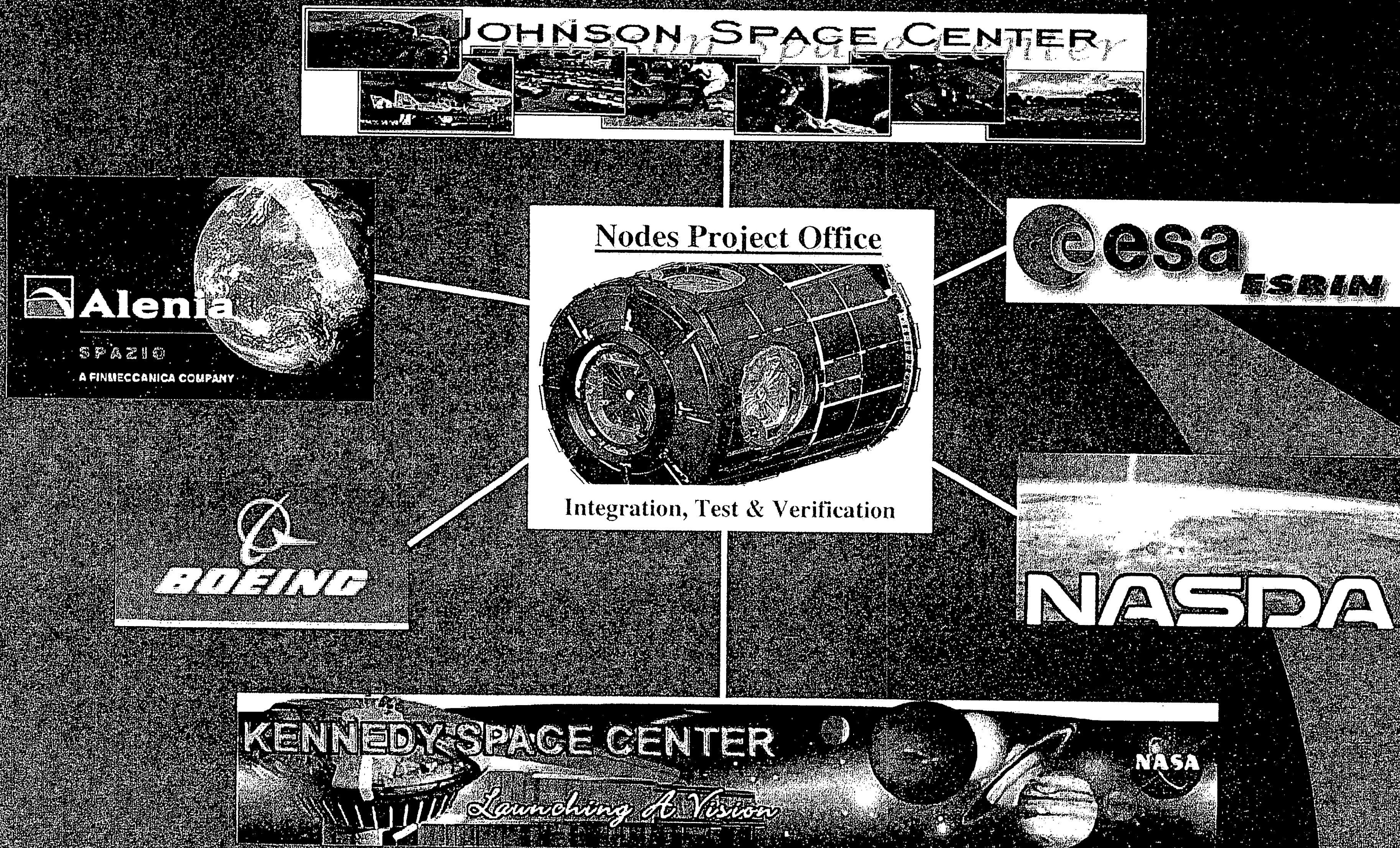
Nodes 2 & 3 Purpose



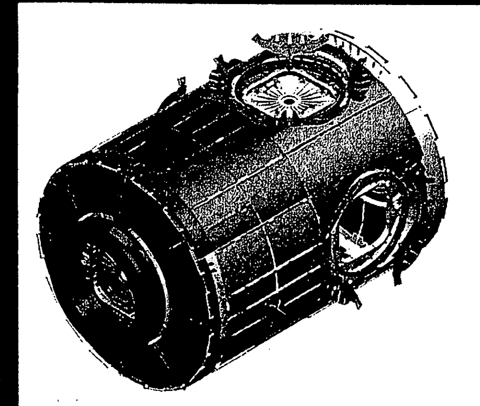


The purpose of the Nodes is to act as building blocks to connect other system elements; provide a pressurized passageway between berthed elements; and distribute/transfer commands and data, audio and video, electrical power, atmosphere, water, and thermal energy to adjacent elements of the International Space Station (ISS).

Nodes 2 & 3 Project: Global Team Work



Nodes 2 & 3 Overview



Both Nodes Include:

- Common Cabin Air Assembly (CCAA)
- Low and Moderate Temp Active thermal control System (ATCS)

Node 2

Node Specific

- Four Avionics Racks
- Crew Quarters

Provides Resources to:

- Japanese Experimental Module (JEM)
- Centrifuge Accommodation Module (CAM)
- Attached Pressurized Module (APM)
- Pressurized Mating Adapter (PMA)
- Multi-Purpose Logistics Module (MPLM)

Node 3

Node Specific

- Two Avionics Racks
- Six Environmental Control and Life Support Support (ECLSS) Racks

Provides Resources to:

- Node 1 Airlock
- U.S. Habitation Module (HAB)
- Crew Return Vehicle (CRV)
- Node 3 and Node 1 Cupolas
- Multi-Purpose Logistics Module (MPLM)

Primary Space Station Thermal Requirements

Distribute Thermal Energy - the Node shall supply moderate and low temperature heat transport fluid for the purpose of heat rejection.

Physical Connectivity of Internal and External Thermal Loops - the Active Thermal Control System (ATCS) design shall define all interface fittings and connections.

Preclude Condensation - surfaces exposed to the cabin air shall preclude condensation of atmosphere moisture (Node 2&3 dewpoint is 60 °F).

Thermal Environments - an integrated thermal analysis shall be performed using System Integrated Numerical Differencing Analyzer (SINDA/FLUINT), Thermal Radiation Analyzer System (TRASYS), or Thermal Synthesizer System (TSS) thermal math models, and Node component qualification data.

Touch Temperature - internal touch temperature limits not to exceed the range between 39° and 113° F and external touch temperature limits not to exceed the range between -45° and 145° F.

ISS/Nodes 2 & 3 Thermal Control Design Overview

Nodes Thermal Control System (TCS) Overview

Internal Active TCS

Low temperature (LTL) (38 deg. F to 43 deg. F) and Moderate Temperature (MTL) (61 deg. F to 65 deg. F) coolant loops. Coolant supplied is software controlled to maximize operational flexibility.

External Active TCS

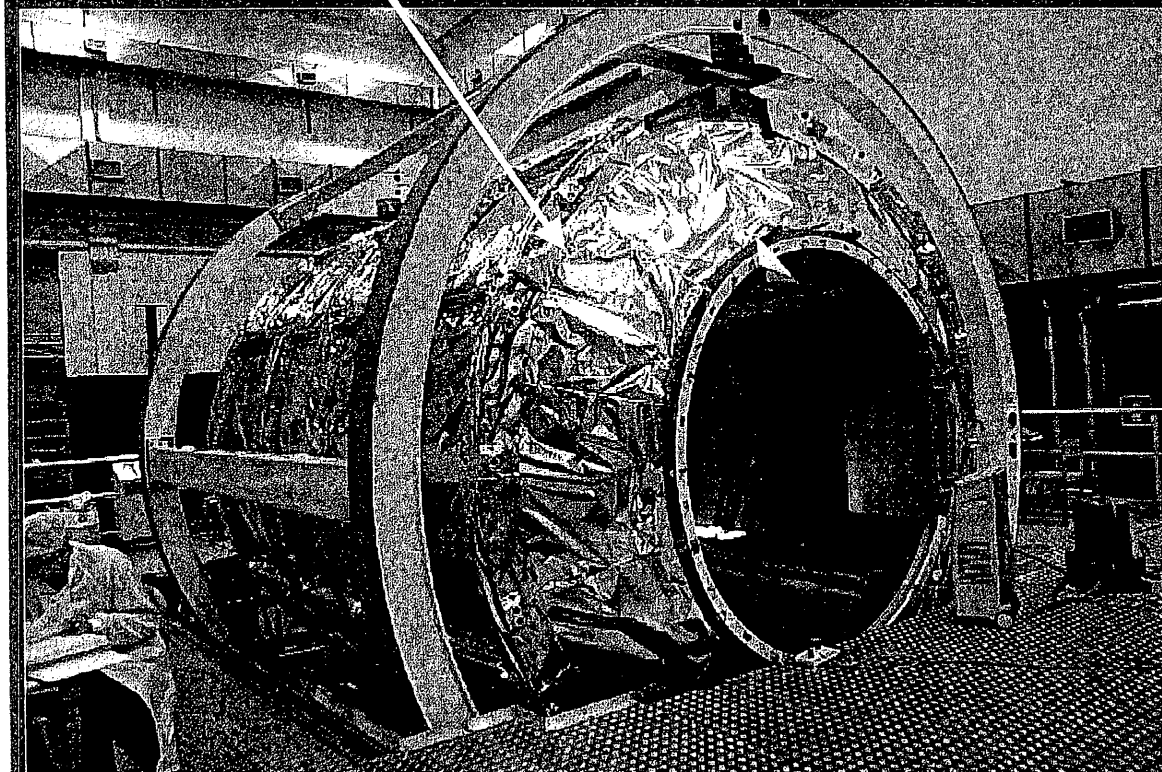
Externally mounted Ammonia/Water Heat Exchangers(6 for N2, 2 for N3); provides heat rejection for Node coolant loops. Liquid ammonia (33 deg. F to 40 deg. F) is supplied by external ISS sources in which to provide heat rejection.

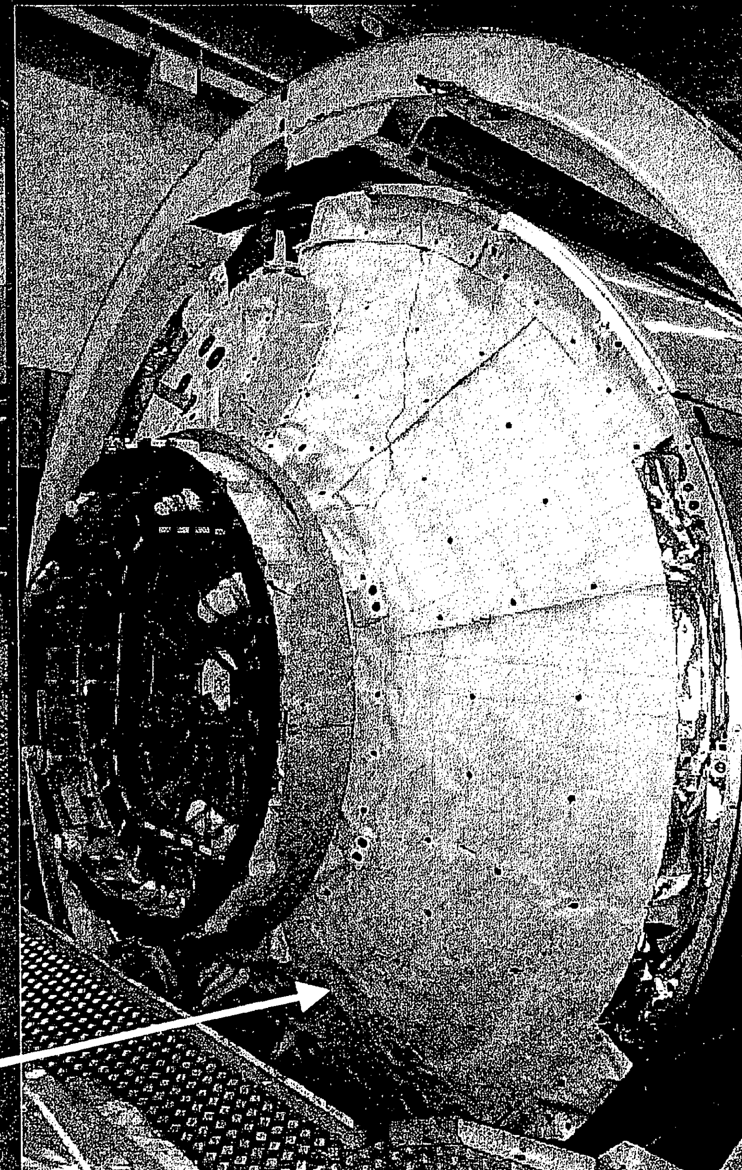
Passive TCS

Multilayer insulation (MLI), thermal control coatings, insulation and heaters. Two (2) types of heaters: thermostatically controlled Launch-To-Activation phase (LTA) heaters, and software controlled On-Orbit heaters which are used following Node activation.

Passive Thermal Control Design (MLI)

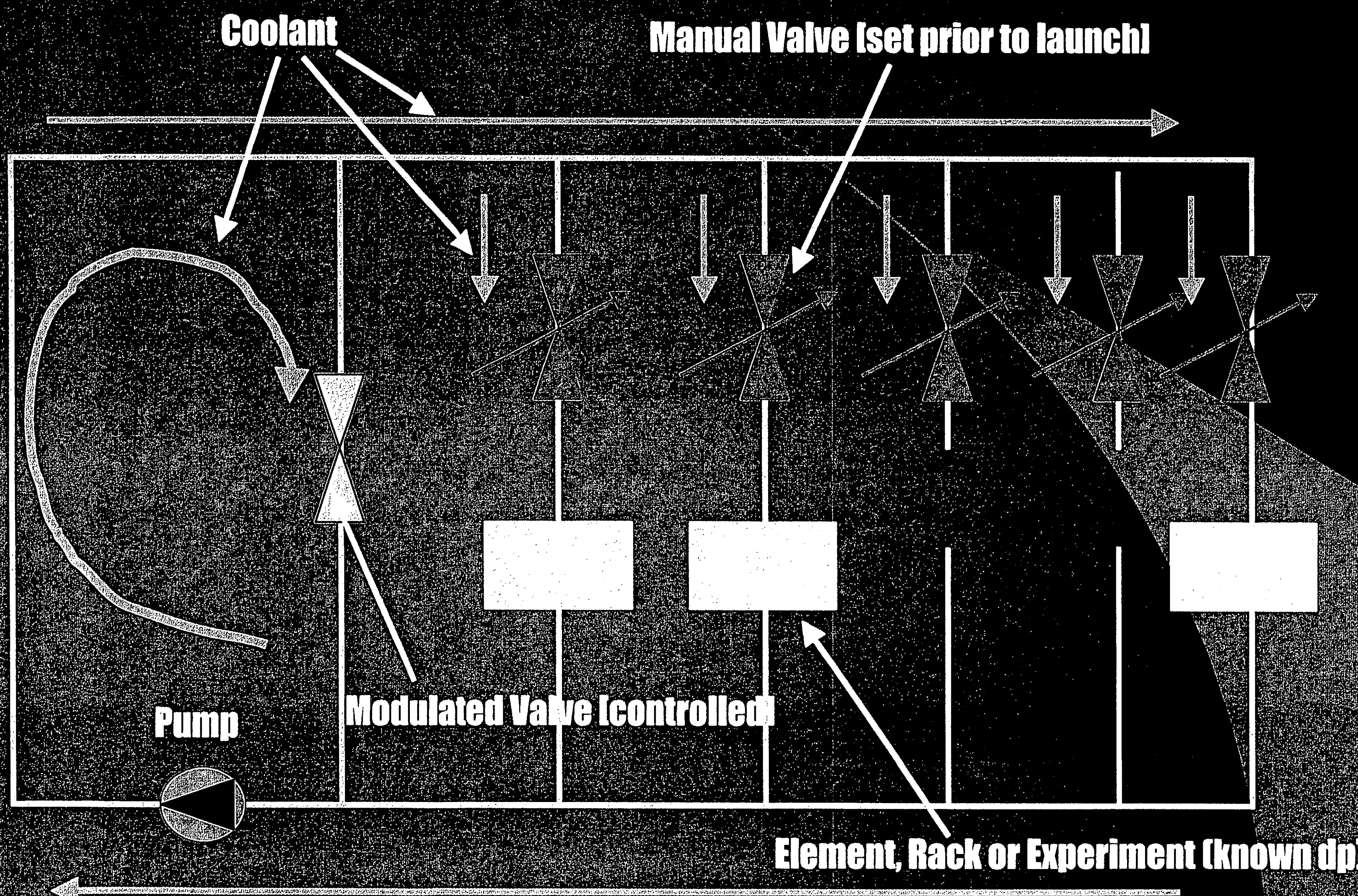
Multi-Layer Insulation without Beta-Cloth
(prior to debris shield)



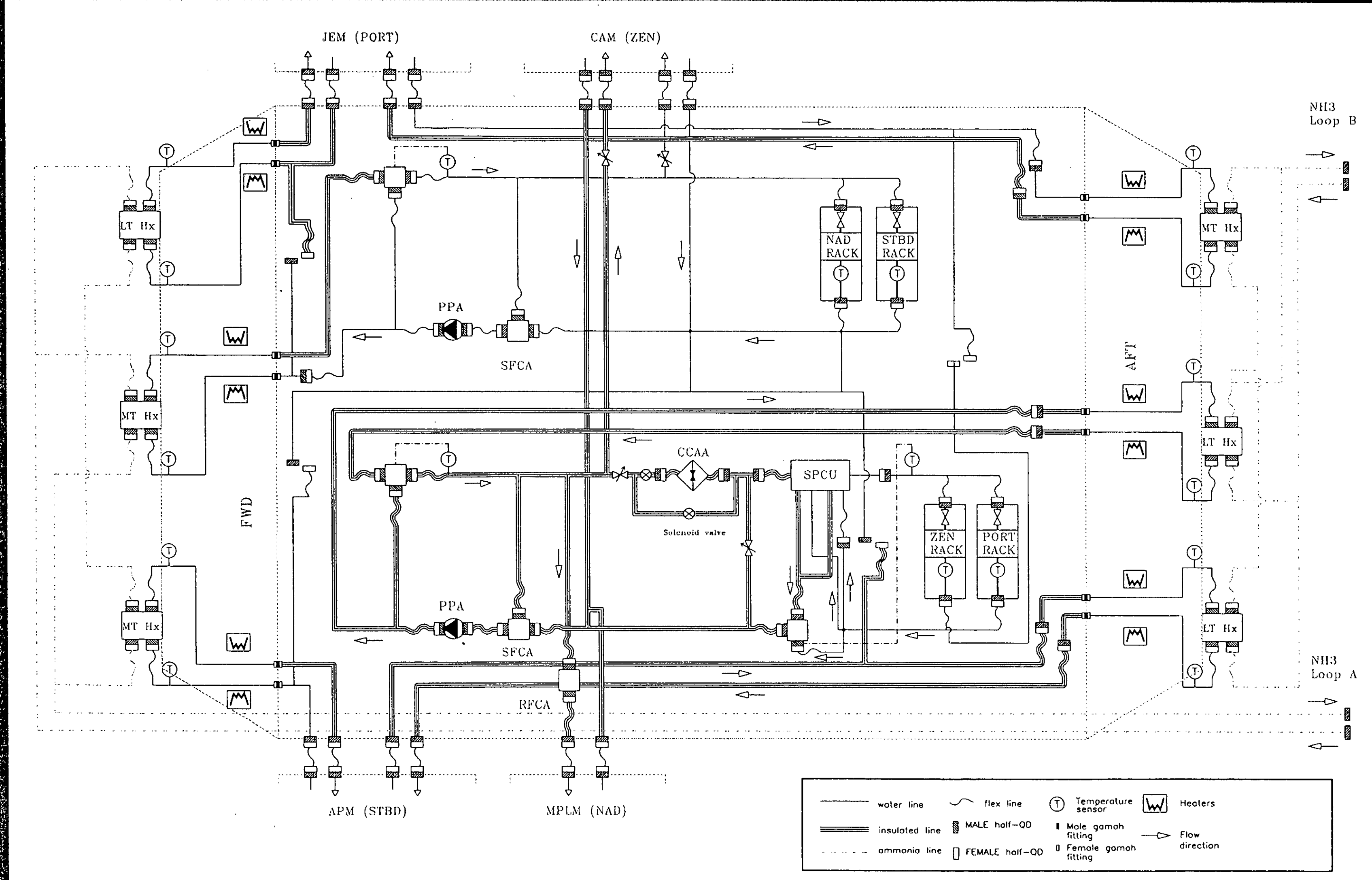


Multi-Layer Insulation with
Beta-Cloth

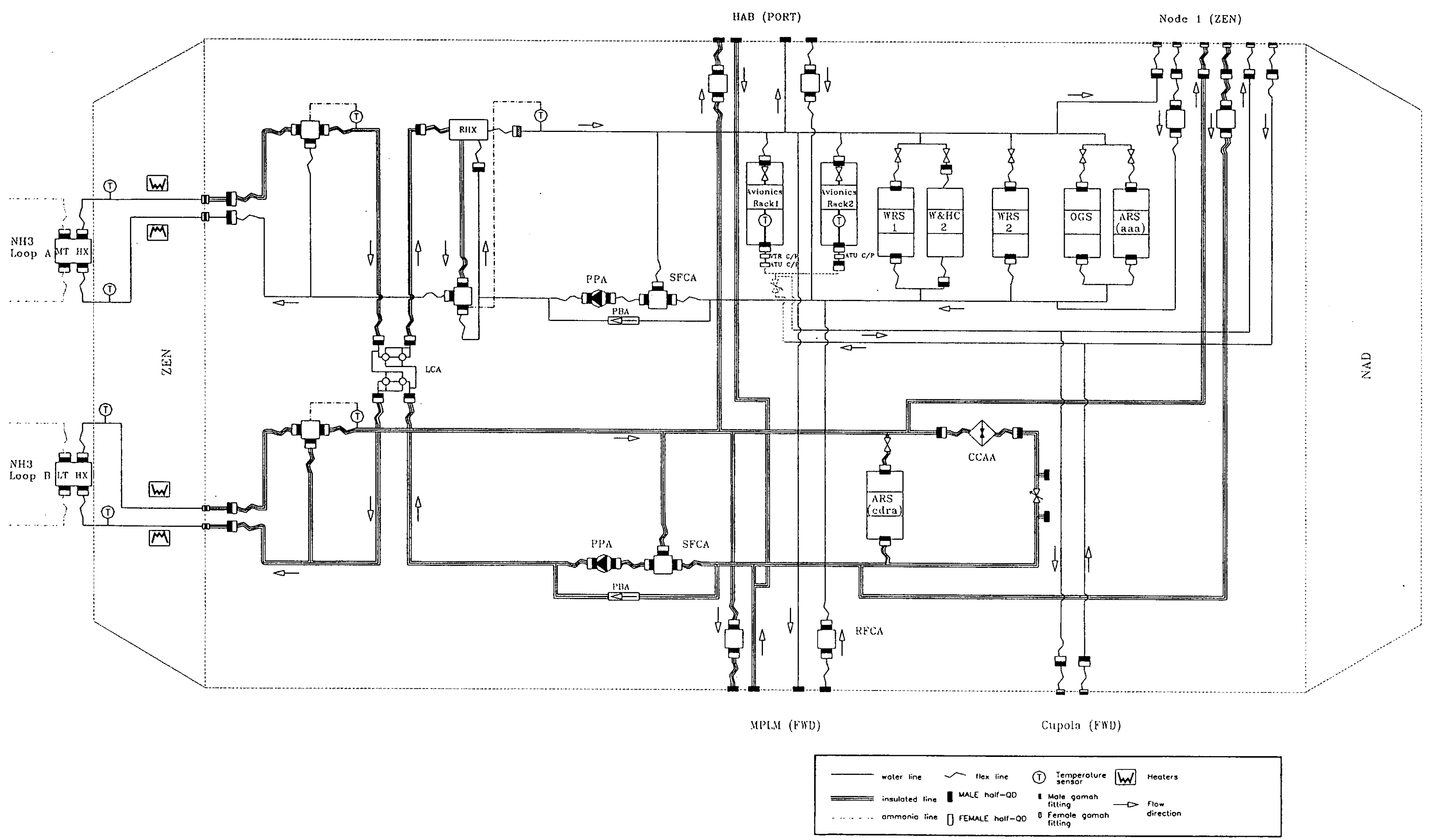
General Active Thermal Control Design



Node 2 Active Thermal Control Design (Internal)

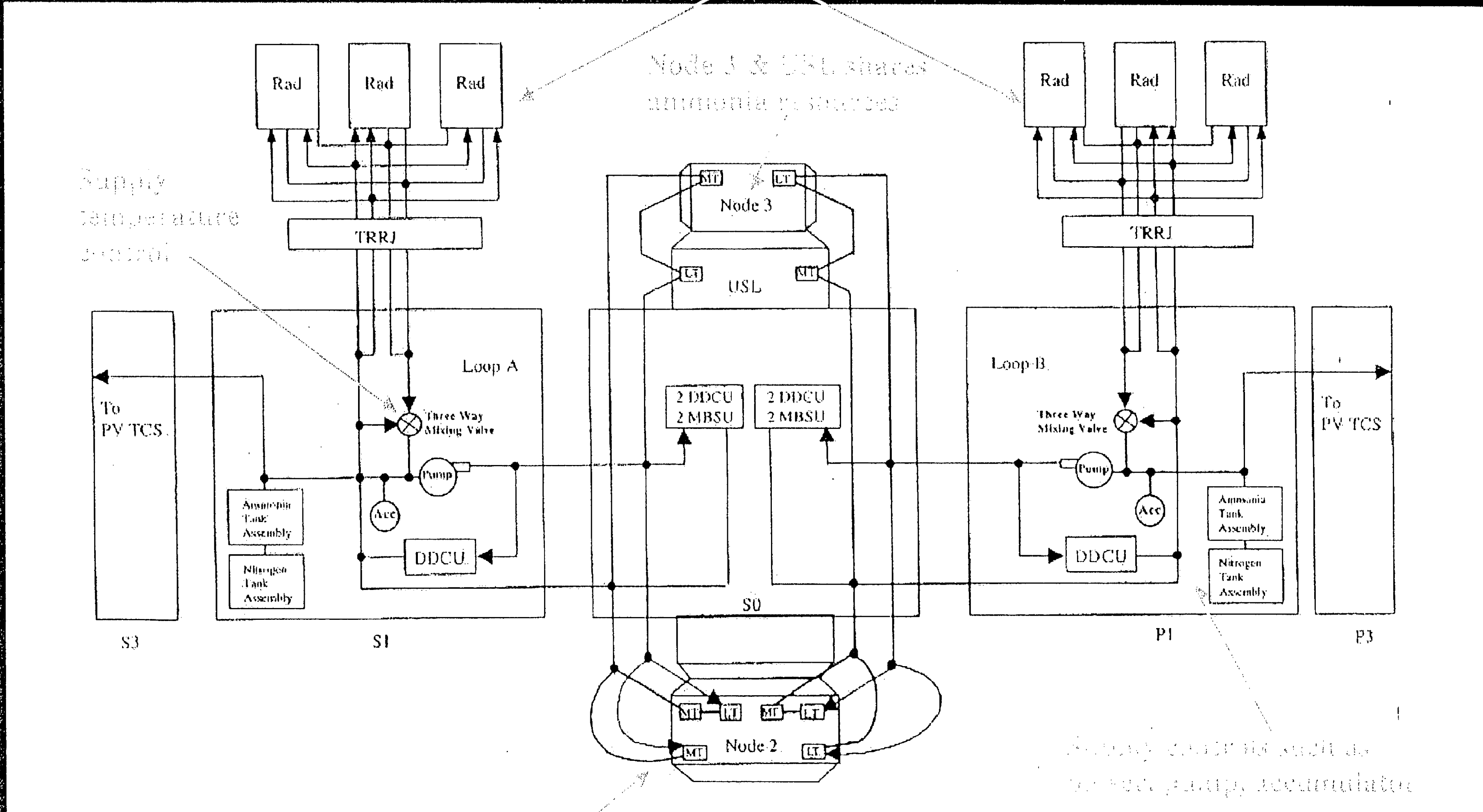


Node 3 Active Thermal Control Design (Internal)



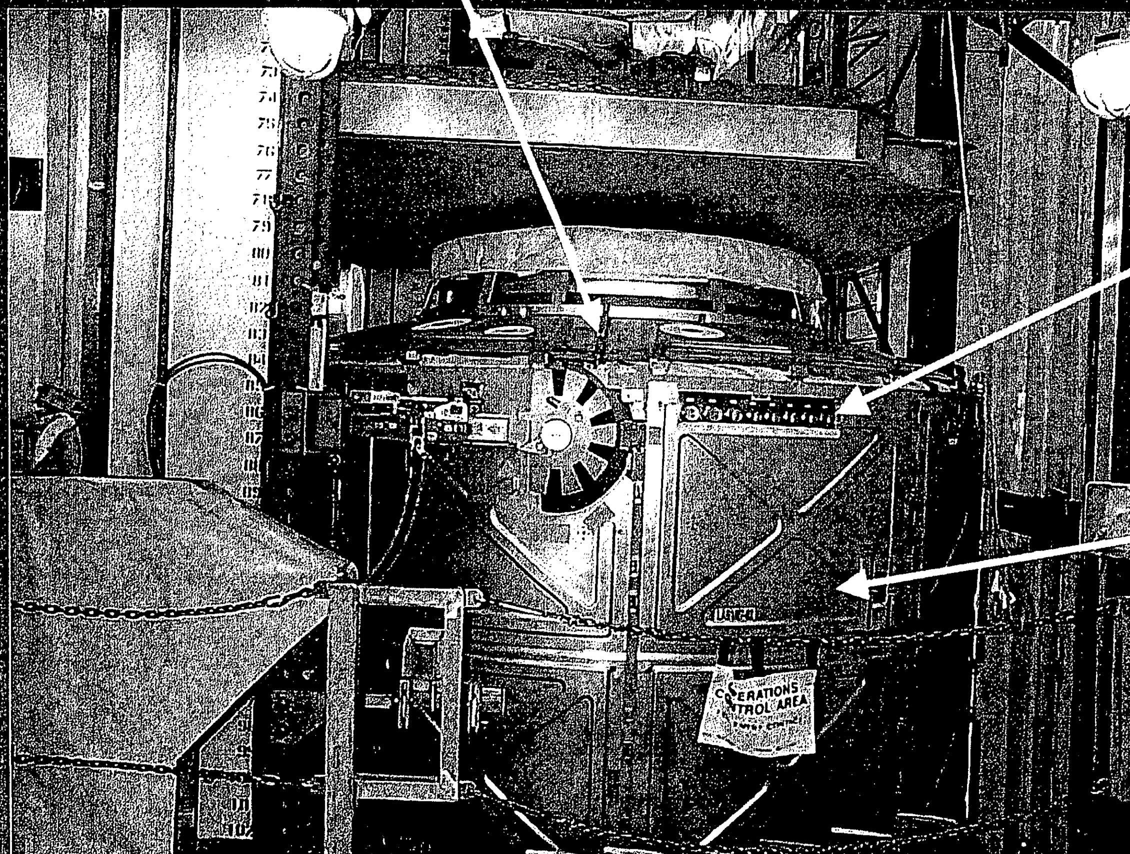
ISS Active Thermal Control Design (External)

Ammonia heat sink to space

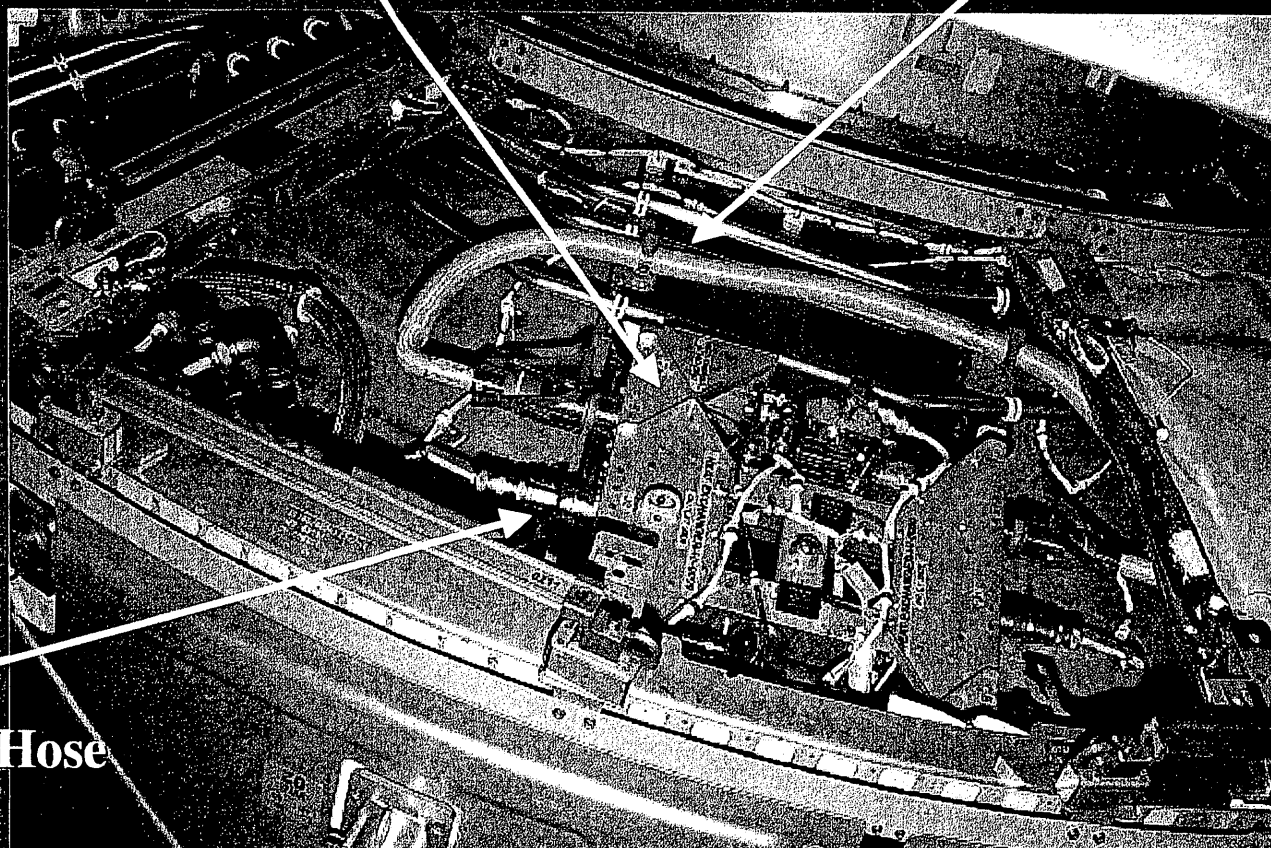


Node 2 receives ammonia directly from source

ISS Active Thermal Control Design (External)

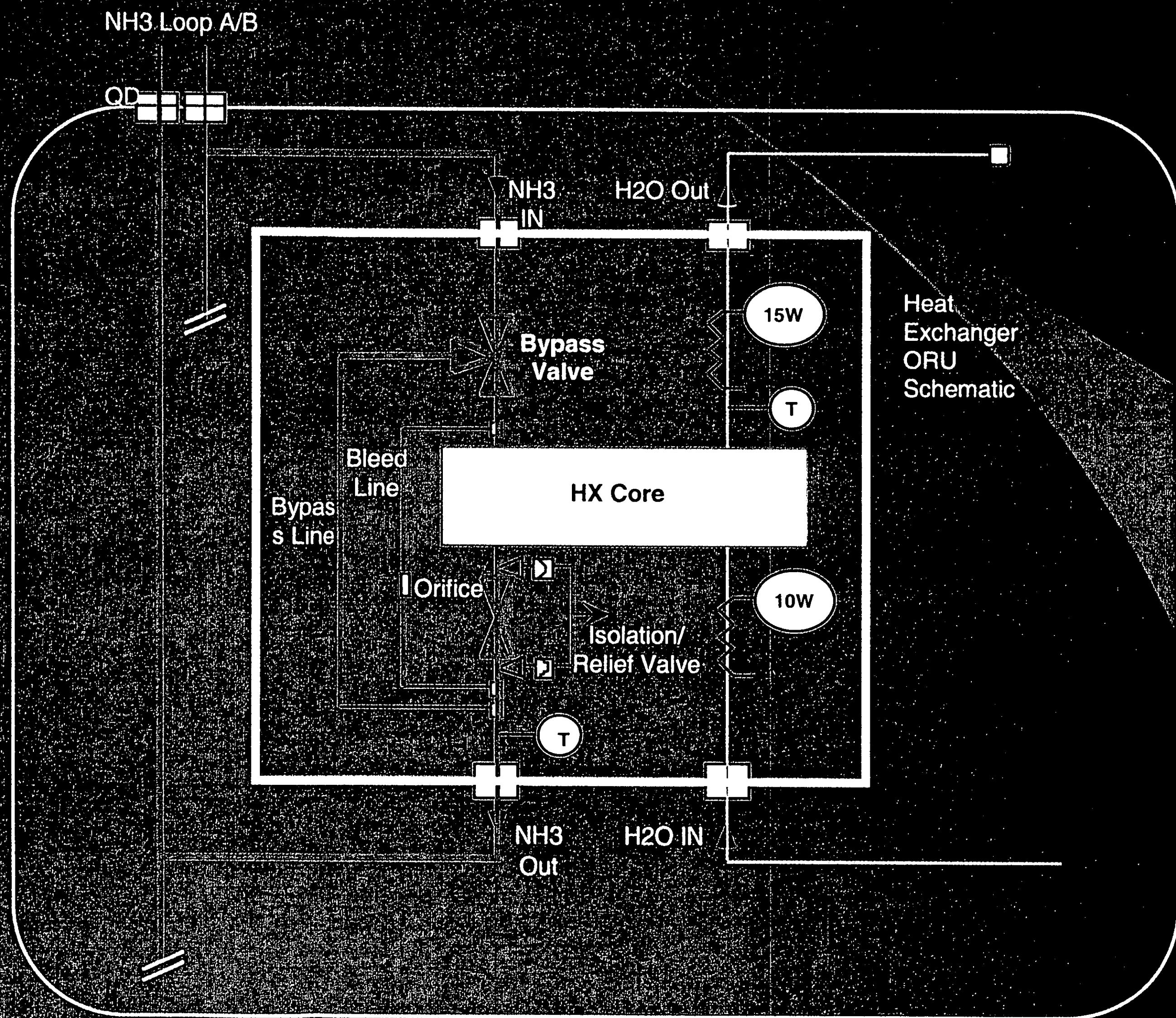


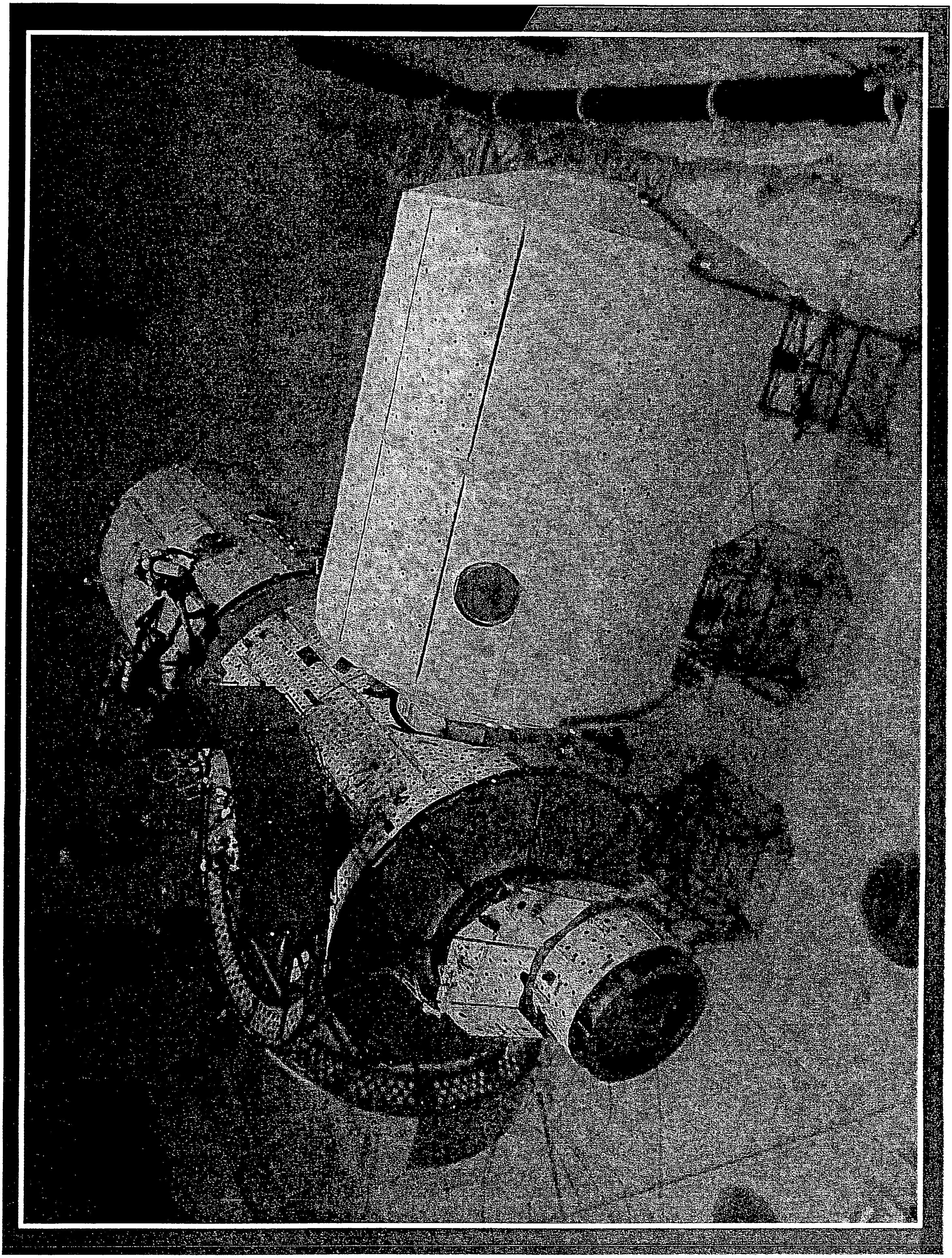
Active Thermal Control Design (External)

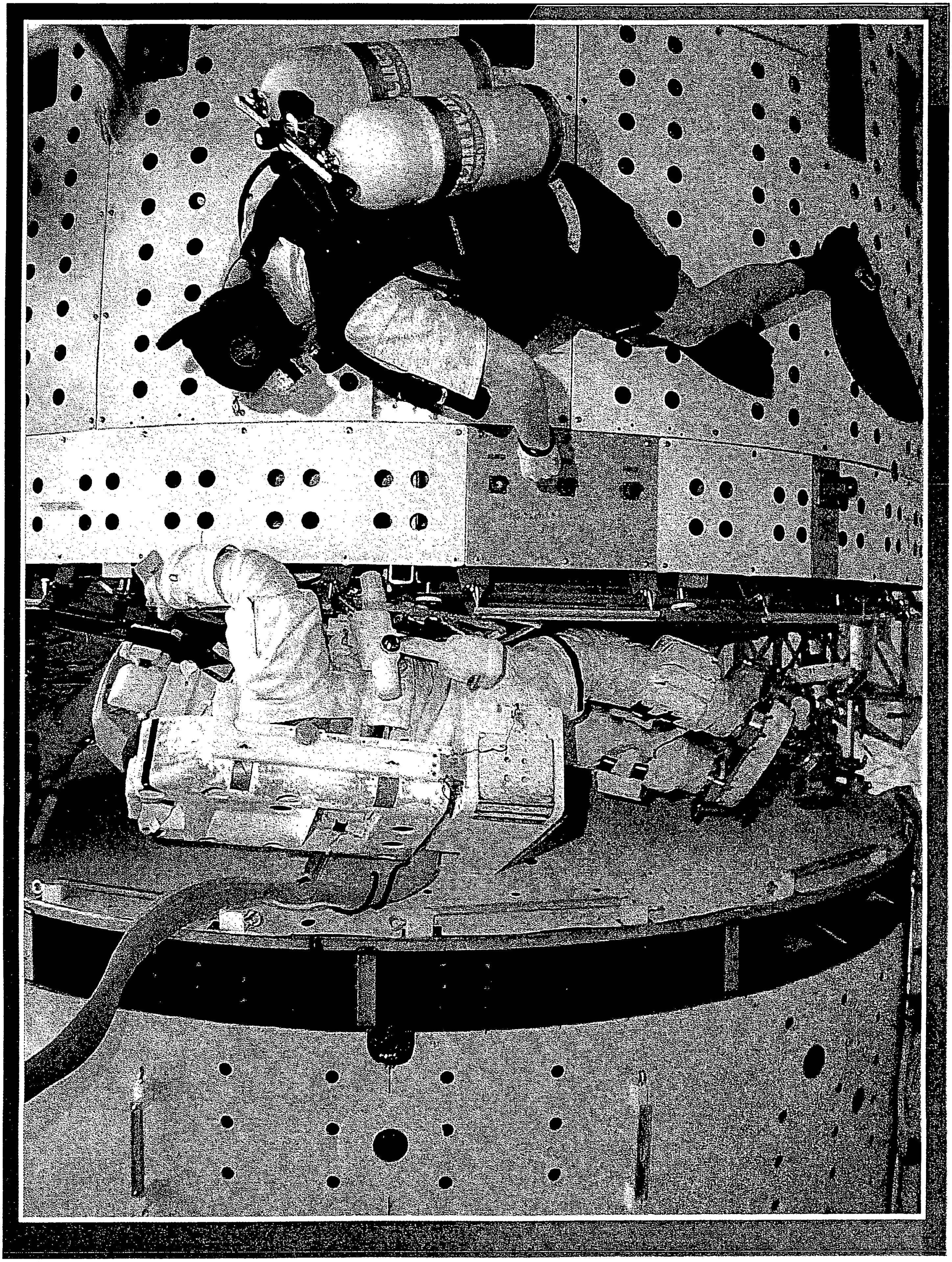


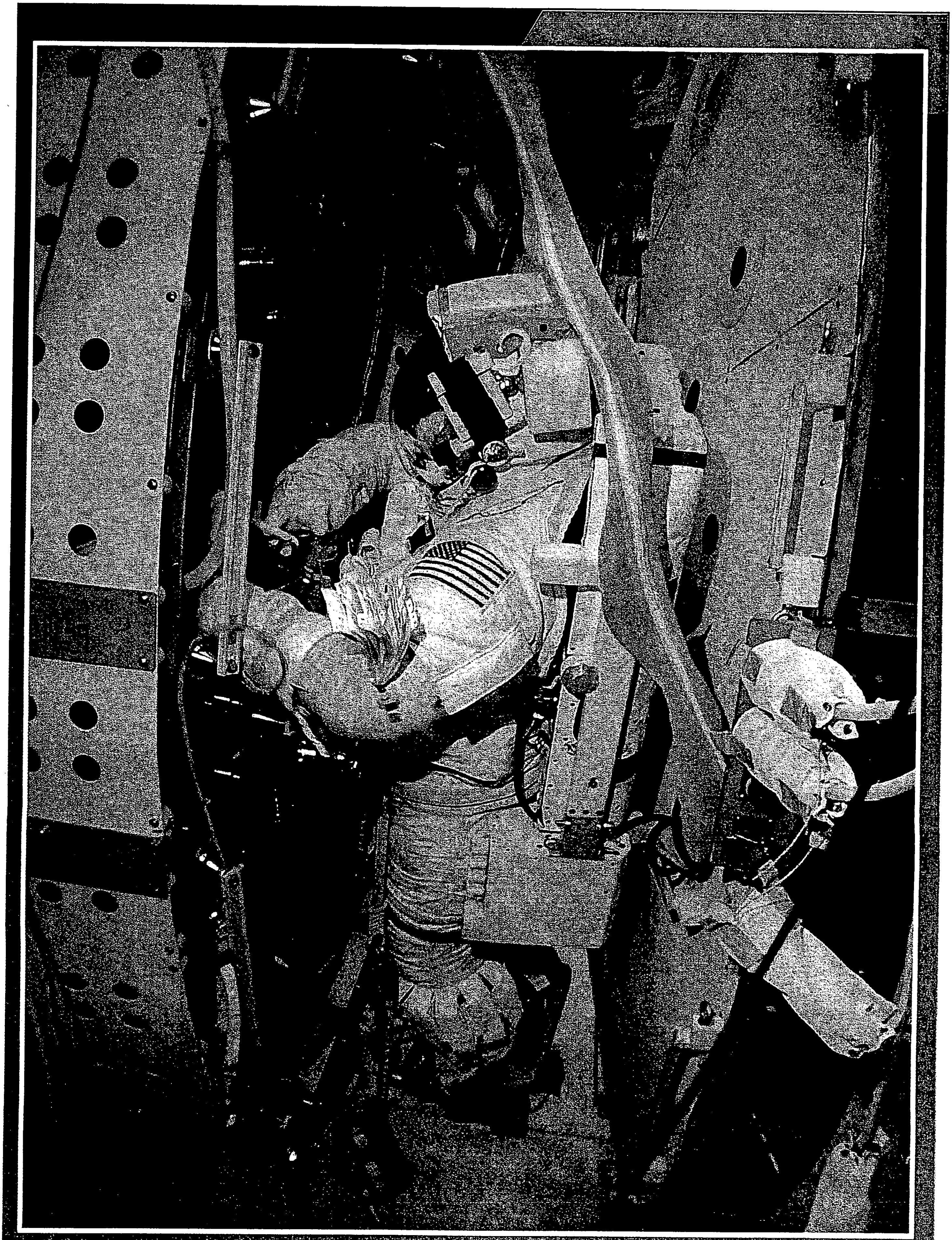
Active Thermal Control Design (External)

Integrated Flight Heat Exchanger (Schematic)





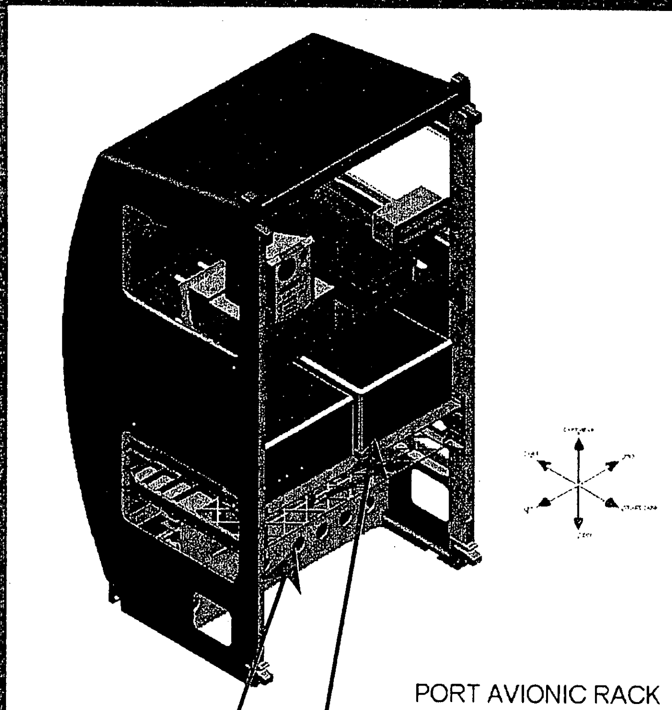




IATCS Thermal Control Component Examples

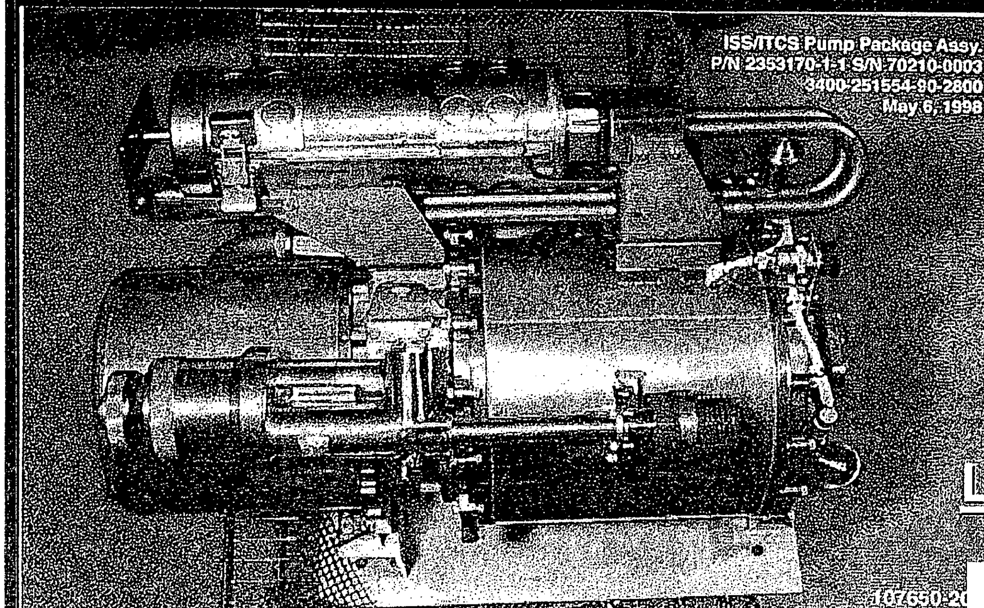
TCS Components

International Standard Payload Rack (ISPR)



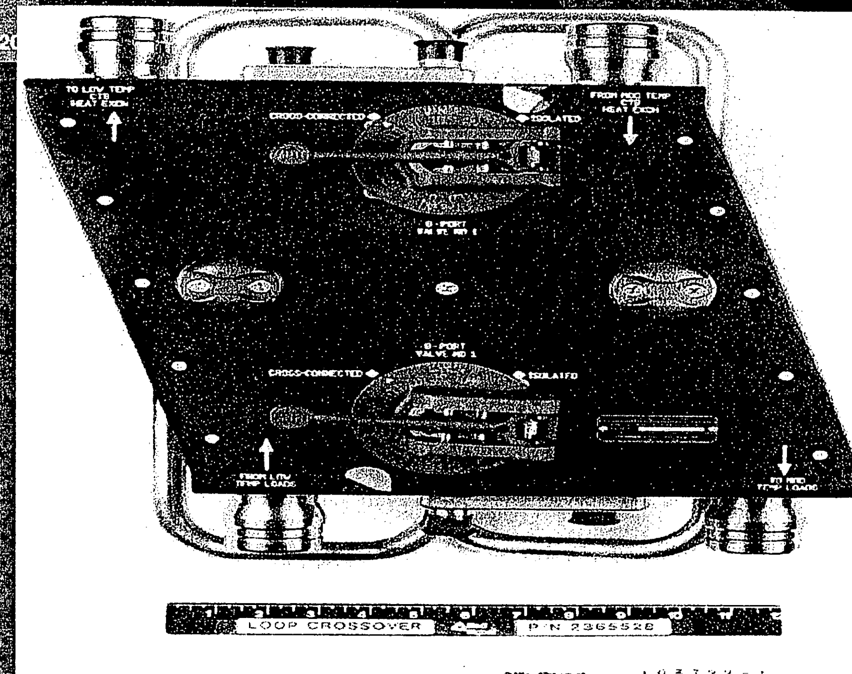
- Racks are structures designed to house electronics and other subsystem equipment, and experiment payloads
- Heat rejected from equipment or experiments within the rack is transferred to the IATCS coolant loops via coldplates, heat exchangers or via direct fluid contact
- Coolant flow to the rack can be either fixed or controlled (based on flowrate or temperature)
- Maximum outlet temperature is 70° F for the LT and 120° F for the MT
- Envelope: 80 in. x 40.5 in. x 40 in. (International Standard Payload Rack (ISPR))

TCS Components

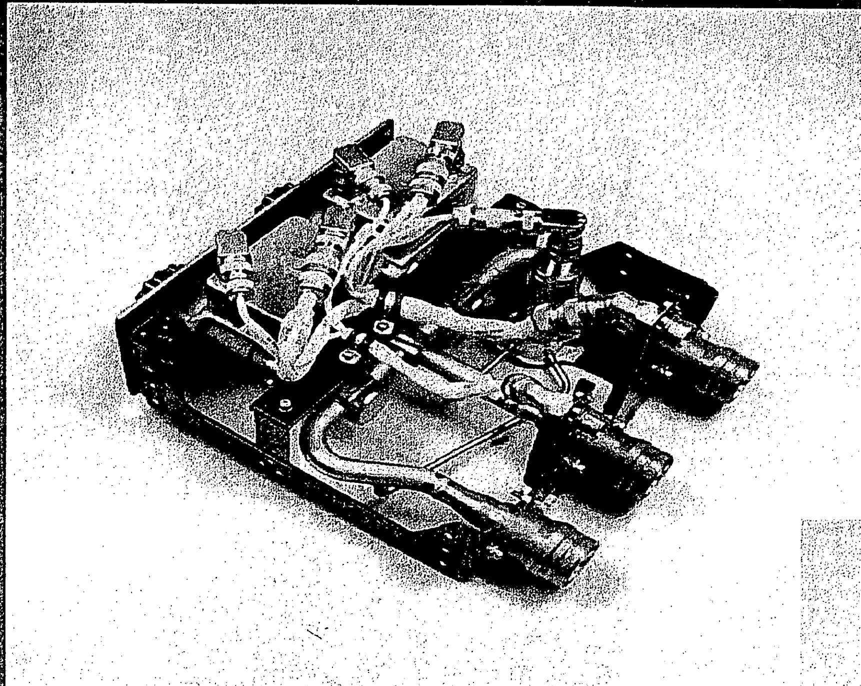


Pump Package Assembly (PPA)

Loop Crossover Assembly (Node 3)

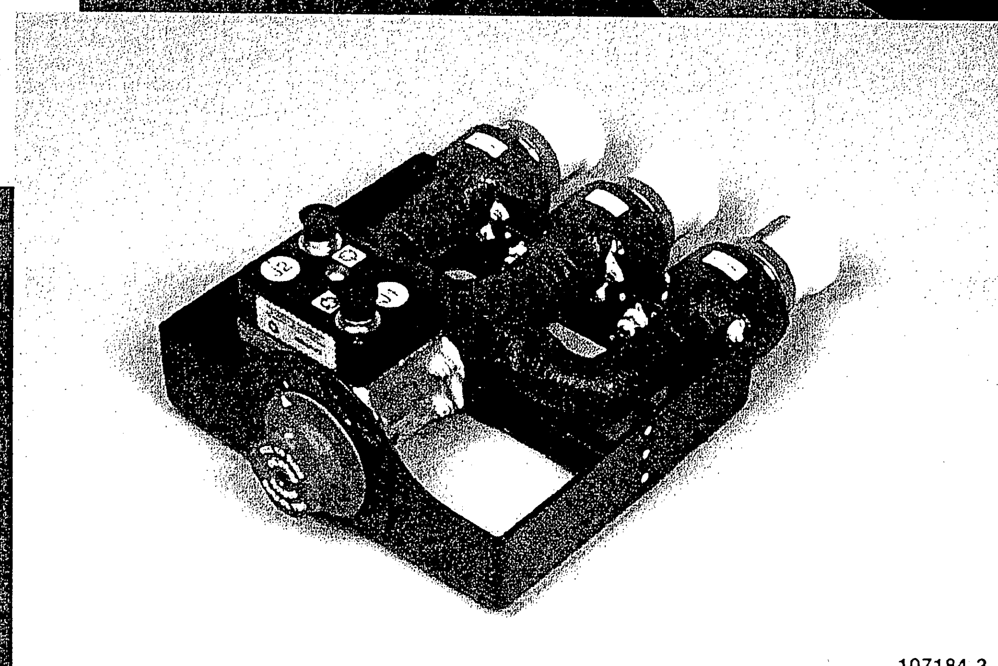


TCS Components



System Flow Control Assembly (SFCA)

Three Way Mix Valve (TWMV)



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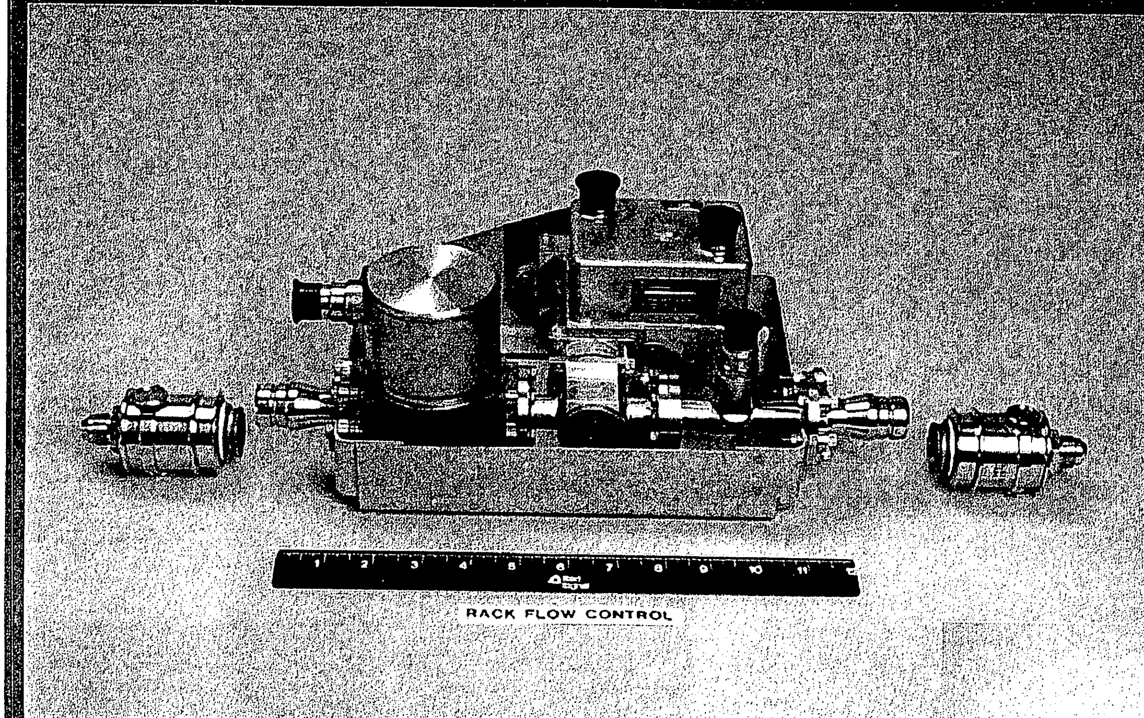
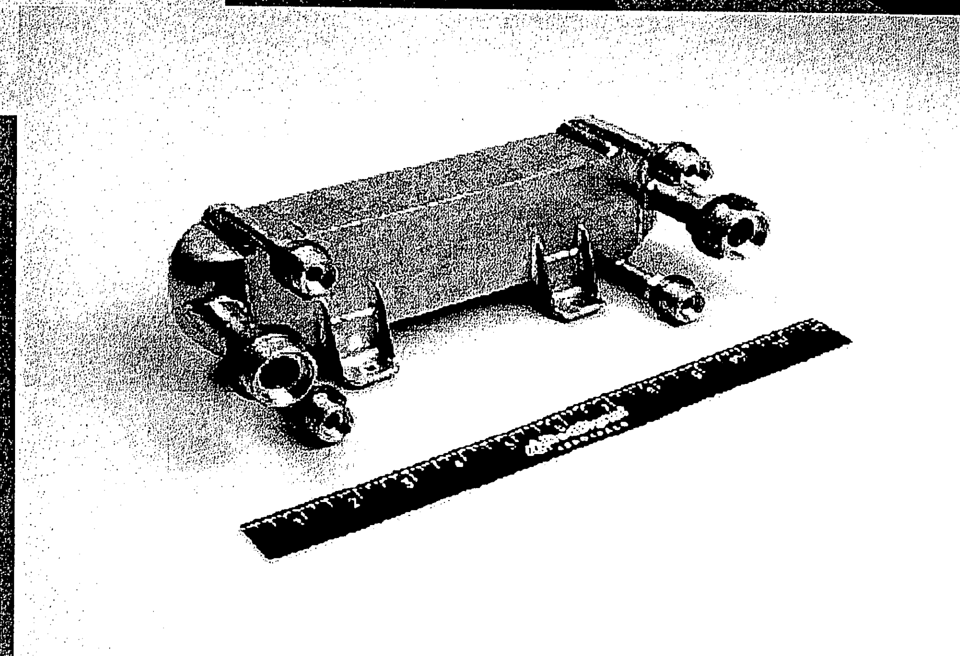
TCS Components



Rack Flow Control Assembly (RFCA)

SPCU Re-generative HX



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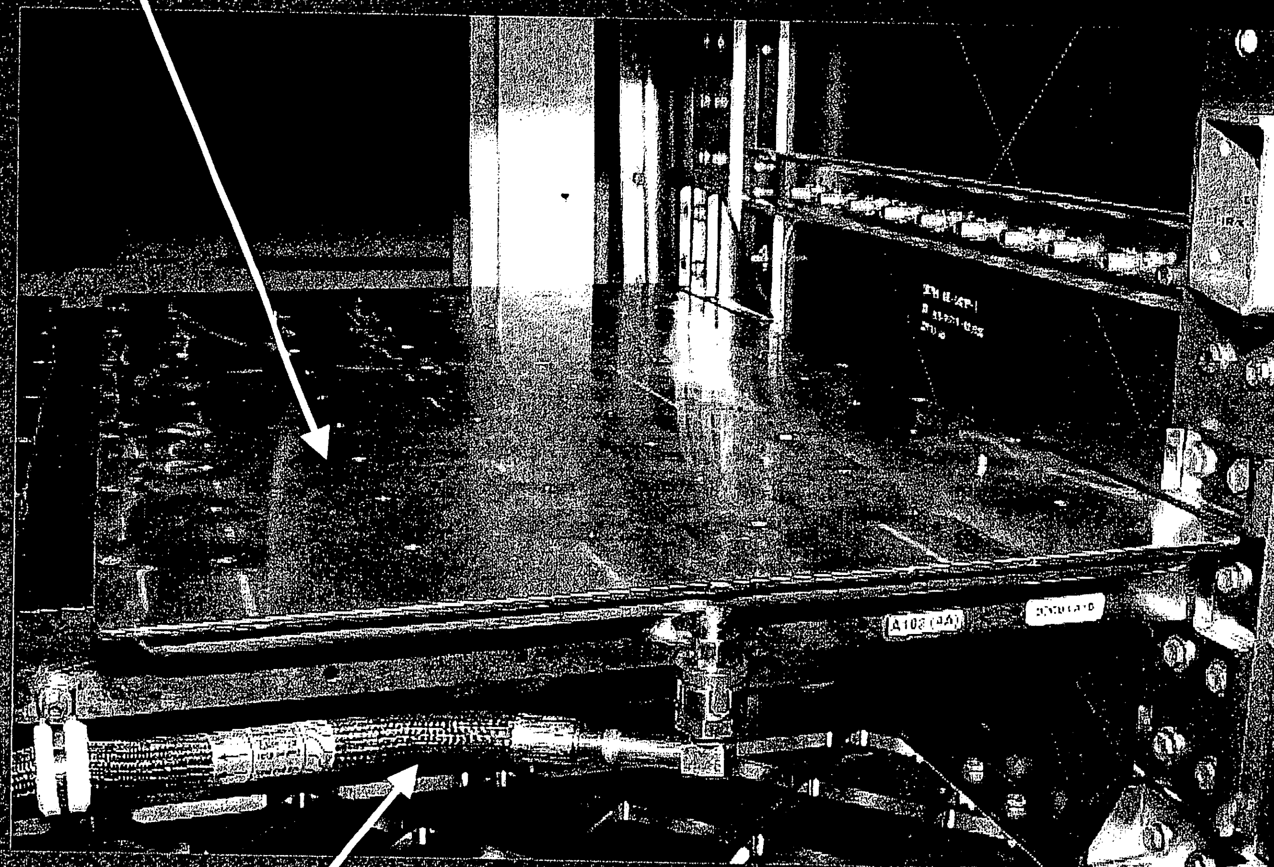
TCS Components

Coldplate Mounting Surface



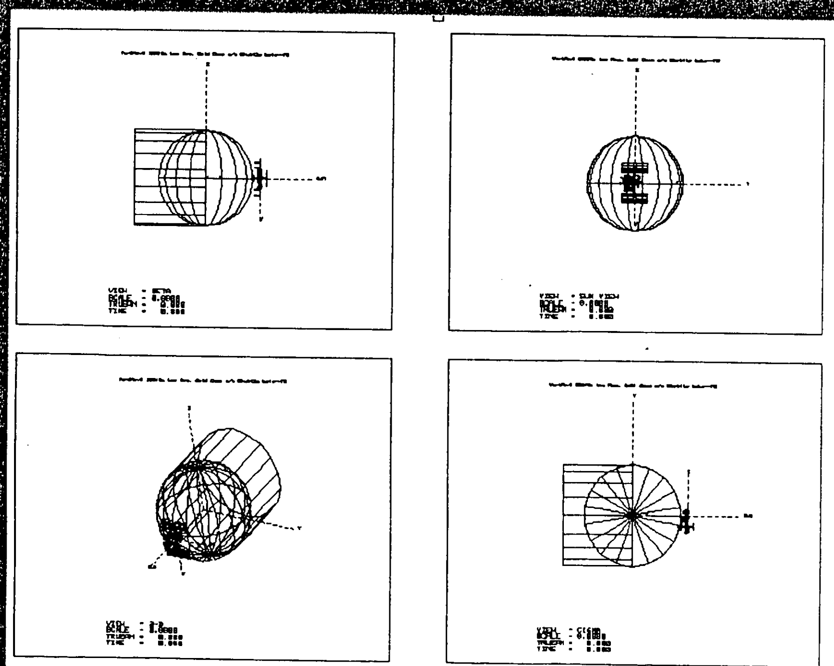
ITCS Coolant Line with Gamah Fitting

Thermo - Hydraulic Analysis Tools Overview

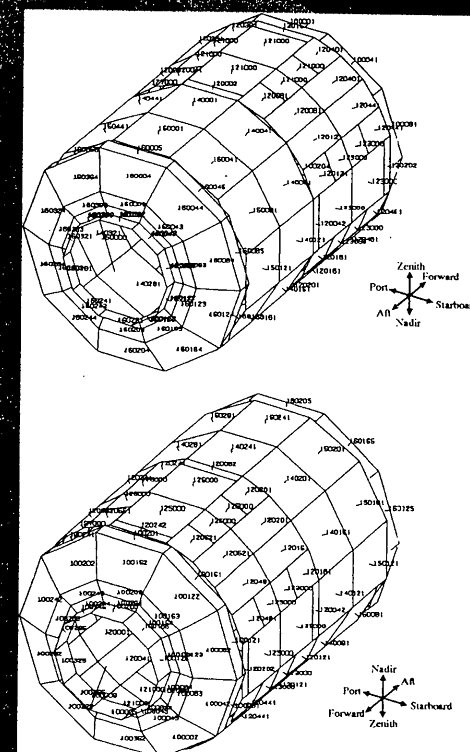
Thermal Analysis

- Thermal Radiation Analyzer System (TRASYS)
- System Improved Numerical Differencing Analyzer (SINDA)

Orbital Heat Flux



Radiation / Conduction

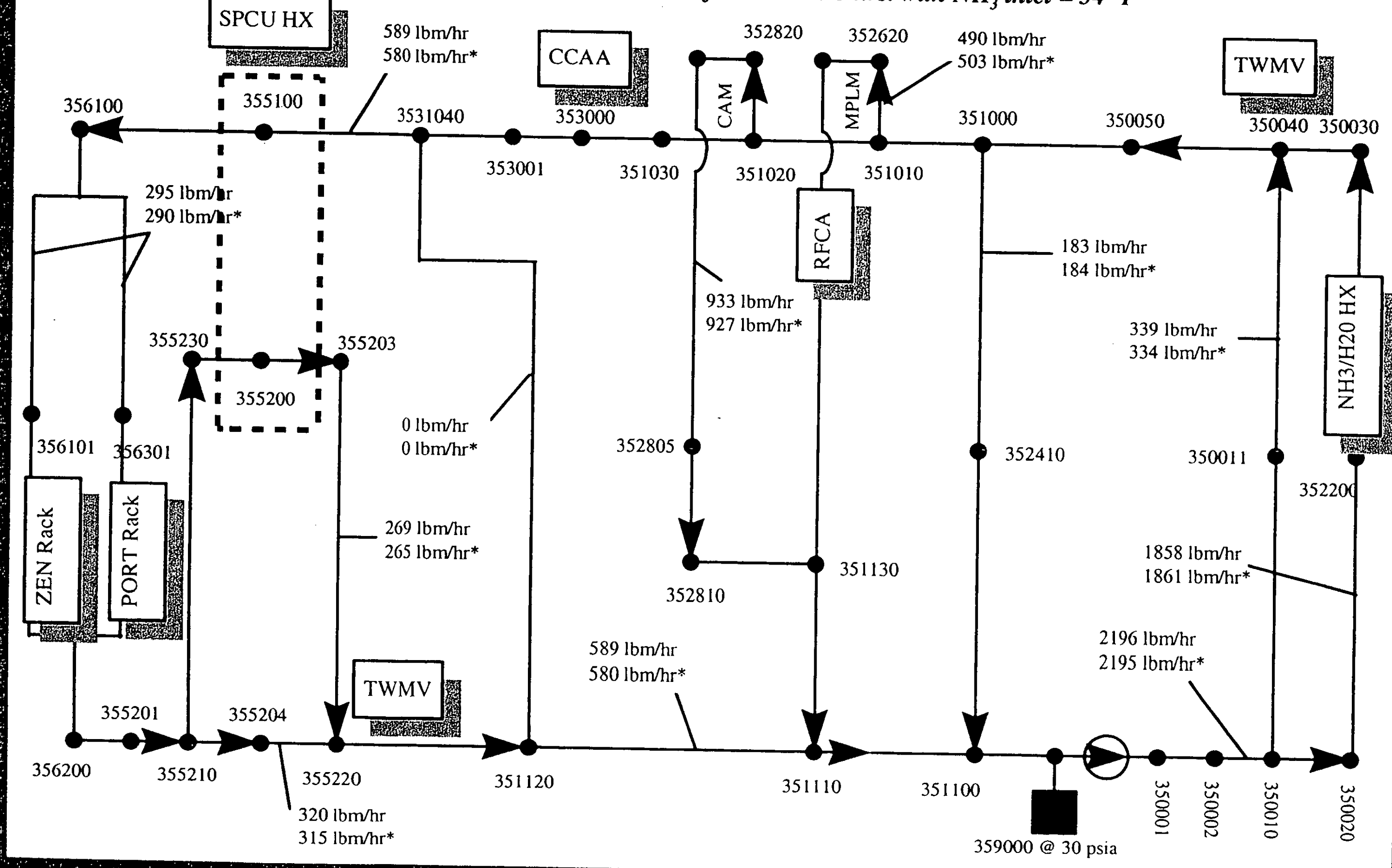


Hydraulic Analysis

System Improved Numerical Differencing Analyzer/Fluid Integrator (SINDA/Fluint)

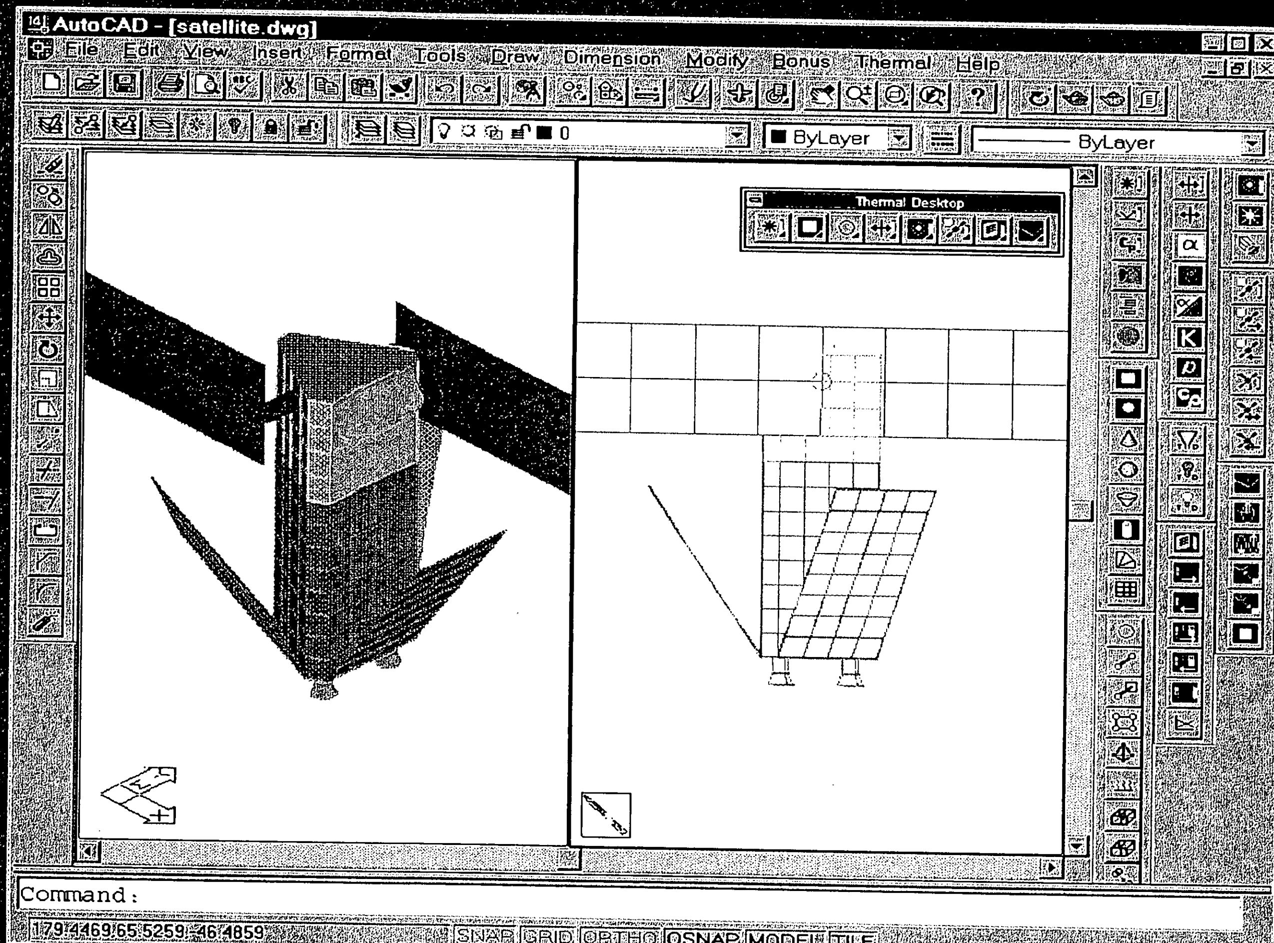
ATCS Nodal Network

** Denotes Alenia IATCS results for time = 0.5 hrs. with NH_3 inlet = 34 °F*



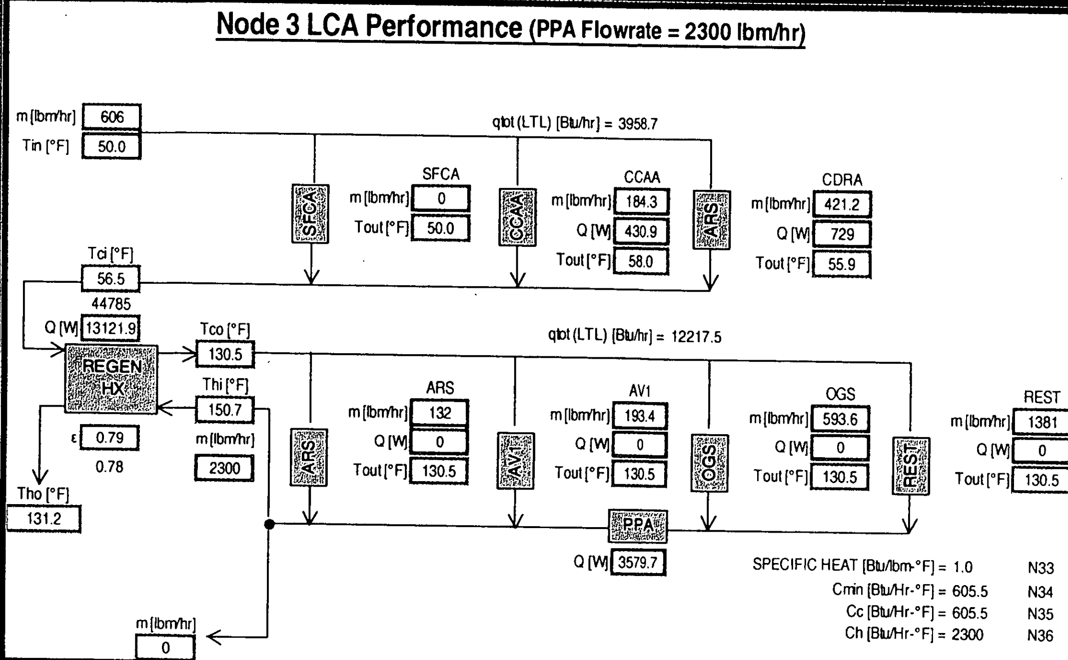
Thermal Analysis

Thermal Desktop



Graphical interface that develops the capacitance and conductance network for input into SINDA/FLUINT

Excel Spreadsheets



Node 3 LCA and regenerative heat exchanger feasibility and performance study