Integrated Thermal Energy Management System (ITEMS)

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Outline

- Introduction
  - The Benefits of Two-Phase Flow
- Description
  - What is ITEMS
  - Schematic
- Hardware
- Conclusion

Introduction

- Two-Phase Flow Versus Single Phase Flow for Space Applications Has Many Advantages
  - Ability to Carry More Energy Per Unit Mass
  - Higher Heat Transfer Coefficients Than Single Phase Flow, Therefore, Small Heat Transfer Equipment
  - Require Less Pumping Power Per Unit Thermal Energy Carried
  - Transfer Energy Isothermally; Reduced Radiator Area
- Reduced Gravity Two-Phase Flow has a Perceived Low Level of Technological Readiness
  - Accurate Thermal-Hydraulic Models
  - Flow Regime Prediction
  - Phase Separation

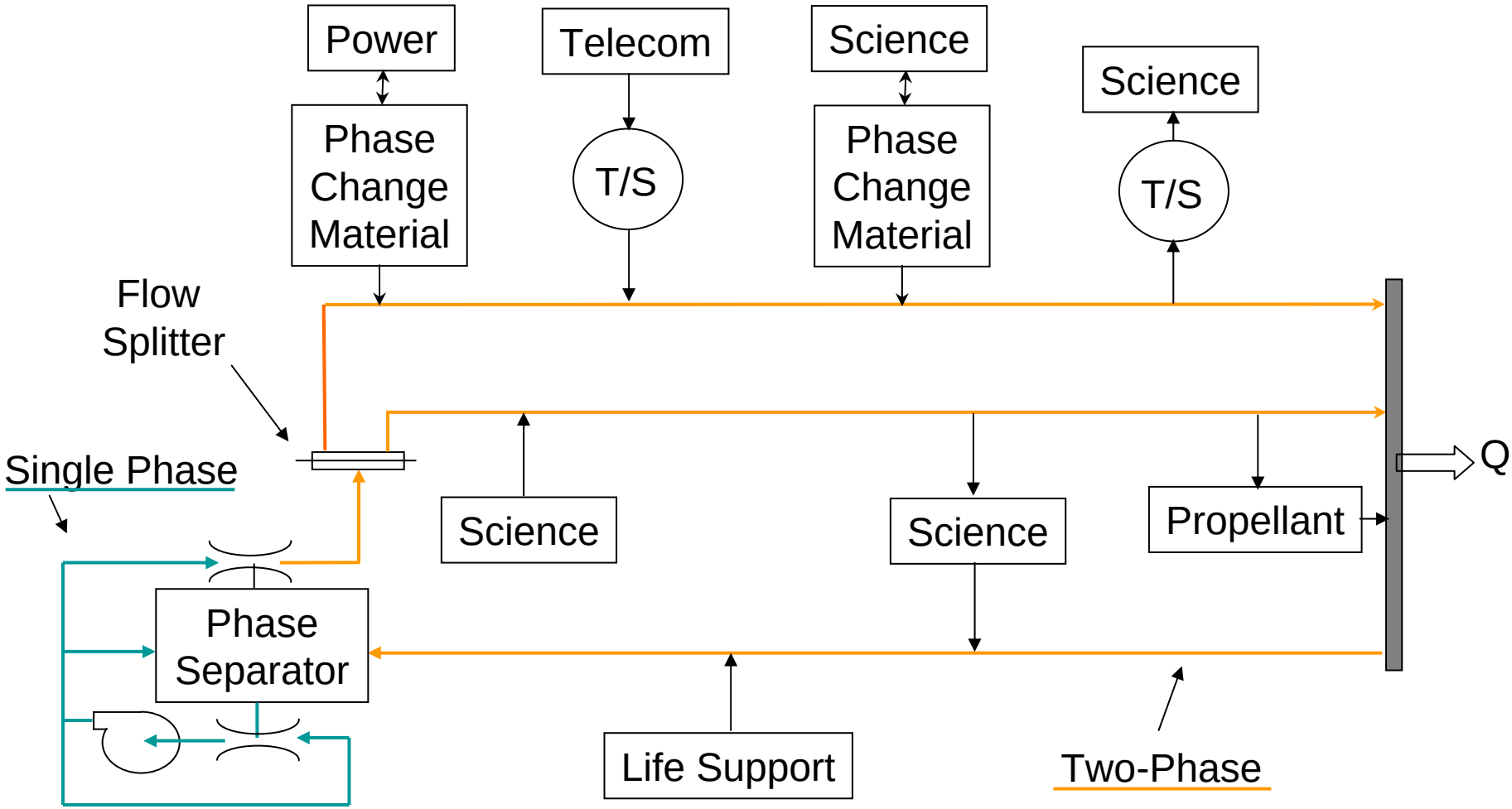
Two-Phase Flow

- Alpha Magnetic Spectrometer (AMS-2) Tracker Experiment
  - CO2 Two-Phase Thermal Control Loop
- Russian Segment of ISS
  - NH3 Two-Phase Thermal Control Loop
- Several LHP/CPL Thermal Systems
- Advanced Life Support Systems

Integrated Thermal Energy Management System (ITEMS)

- **I**ntegrated **T**h**E**rmal **M**anagement **S**ystem was proposed by JPL and Texas A&M for Small Spacecraft Thermal Management.
  - Scalable for Small to Large Spacecraft
  - Thermal Bus Configuration to Allow Components to Share Thermal Energy
    - Reduce Heater, Pump, and Electrical Power
    - Potential Reduction in Radiator Area

ITEMS


Power
Telecom
Science
Science
Phase Change Material
T/S
Phase Change Material
T/S
Flow Splitter
Single Phase
Q
Science
Science
Propellant
Phase Separator
Life Support
Two-Phase

ITEMS

- ITEMS Architecture Allows Freedom in Locating Components
  - Two-Phase Loops Provide Distributed Thermal Bus
- Thermal Energy Shared Along Two-Phase Flow Path
  - Heat Dissipating Components Share Energy with Components Requiring Thermal Energy

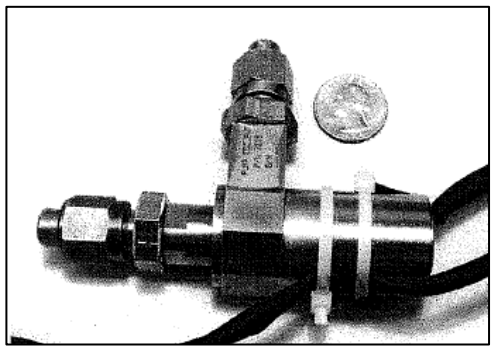
Integrated Thermal Energy Management System (ITEMS)

- Two-Phase Flow Throughout Energy Transport System
  - Reduced Pumping Power
  - Higher Heat Fluxes and Reduced Heat Transfer Equipment Sizes
  - Improved Radiator Performance
  - Near Isothermal Working Fluid Temperature
  - Single Phase Only Required for Phase Separator Operation
    - Replace with Two-Phase Pump

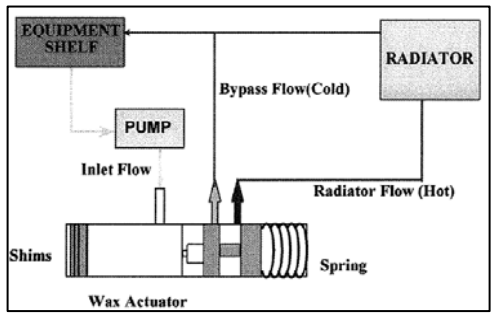
ITEMS Development

- Technology Development

Mechanical pump

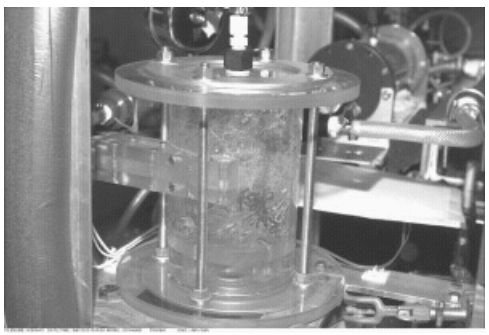


Thermal Control Valve

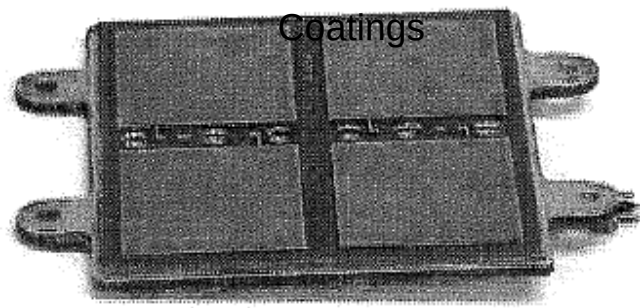


- Flow quality meter
- Two-phase accumulator
- High heat flux heat exchanger

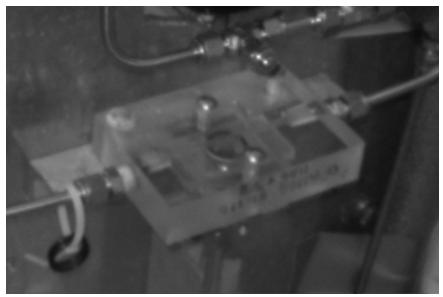
Phase separator



Lightweight Radiator & Variable Emittance Coatings



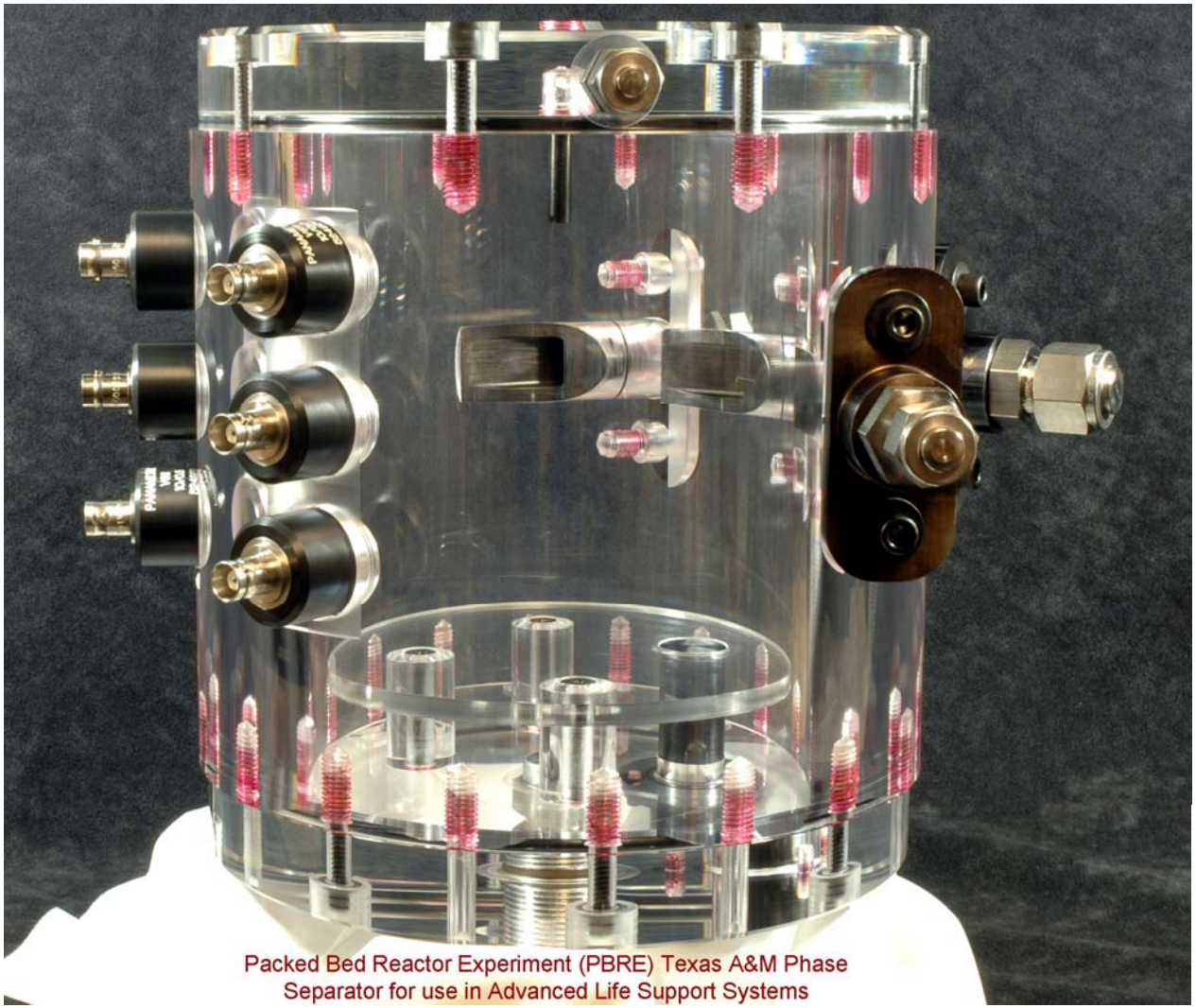
Flow Splitter



Integrated Thermal Energy Management System (ITEMS)

- Components
  - Phase Separator
    - Texas A&M Vortex Phase Separator has over 5,000 Parabolas of 0g Operation
    - Selected for Multiple Flight Experiments
    - Can Operate Successfully from All Liquid to All Vapor Input – Act as Accumulator/Heat Exchanger
    - Low Power Consumption
    - Validated Prediction Models
    - Demonstrated Inventory Instrumentation
    - Demonstrated Operation with Eductor Pumps

Vortex Phase Separator



Packed Bed Reactor Experiment (PBRE) Texas A&M Phase Separator for use in Advanced Life Support Systems

Vortex Phase Separator

Integrated Thermal Energy Management System (ITEMS)

- Components
  - Flow Splitter
    - Device that Takes Advantage of the Axisymetric Orientation of Vapor and Liquid to Split a Two-Phase Flow into Separate Flow Streams of Equal Quality but Potentially Different Mass Flow Rates
    - Simple Prototype Operated Successfully in Reduced Gravity
    - Modeling Ongoing

Integrated Thermal Energy Management System (ITEMS)

- Instrumentation
  - Void Fraction Sensor
    - Developed by Creare and Successfully Operated in Microgravity with Texas A&M Two-Phase Flow Loop
    - Measure Bulk Void Fraction and Film Thickness Using Difference in Dielectric Values of the Vapor and Liquid
    - Used as a Power Meter in ITEMS System

Integrated Thermal Energy Management System (ITEMS)

- Scoping Calculations Done with JPL as Part of the New Millennium Program Resulted in an Overall Reduction of:
  - Spacecraft mass (5%)
  - Required electrical power (20%)
  - Supplemental electric heaters (up to 80%)

Performance	MER Space-craft with traditional thermal control	MER with Proposed ITEMS based thermal control	% Change from tradi-tional design
Spacecraft mass, kg	1000	950	-5%
Supplemental heater, W	80	10	-88%
Power system, W	300	240	-20%
Power system & other related mass, Kg	200	160	-20%
Total space-craft Cost, $M	$300M	$270M*	-10%

Conclusion

- Novel Integrated Thermal Management System Provides a Substantial Increase in System Performance over Existing Thermal Management Configurations
  - Reduced System Mass and Power
- Demonstrated Experience Base at System Level and Component Level
  - AMS-2, ISS Russian Segment
  - TRL-6 Level of Components Used in System