NASA's New Millennium Program, The Space Technology 8 (ST8) Mission

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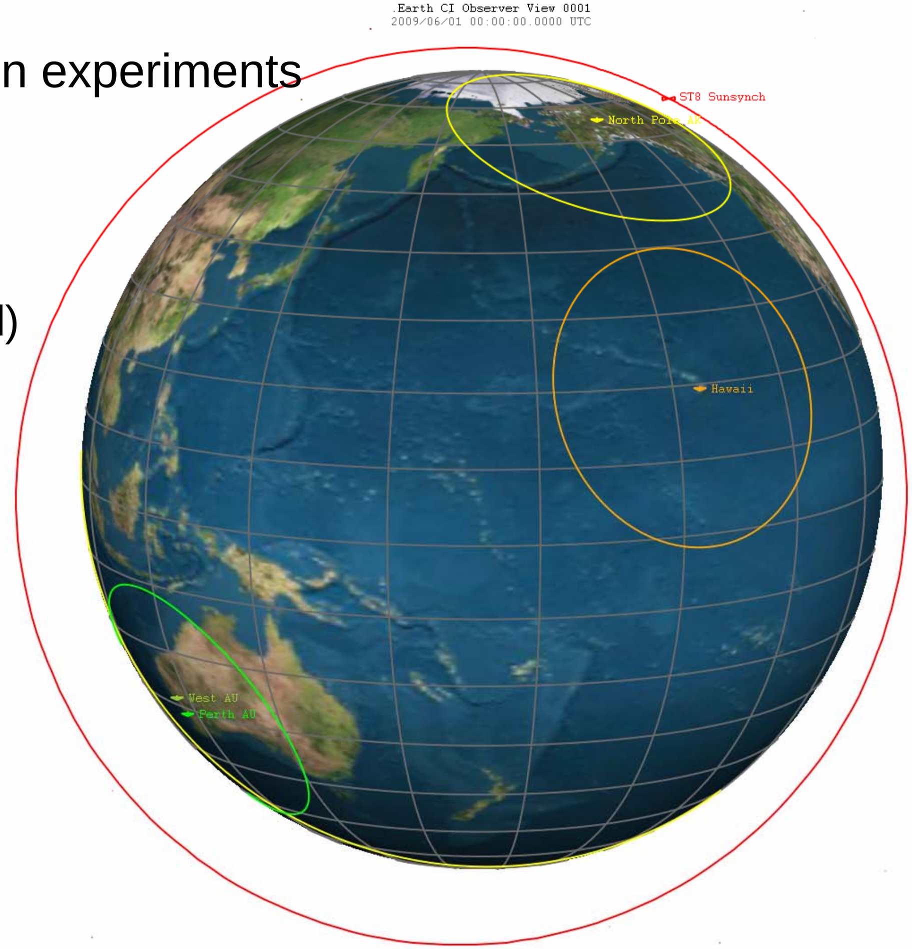
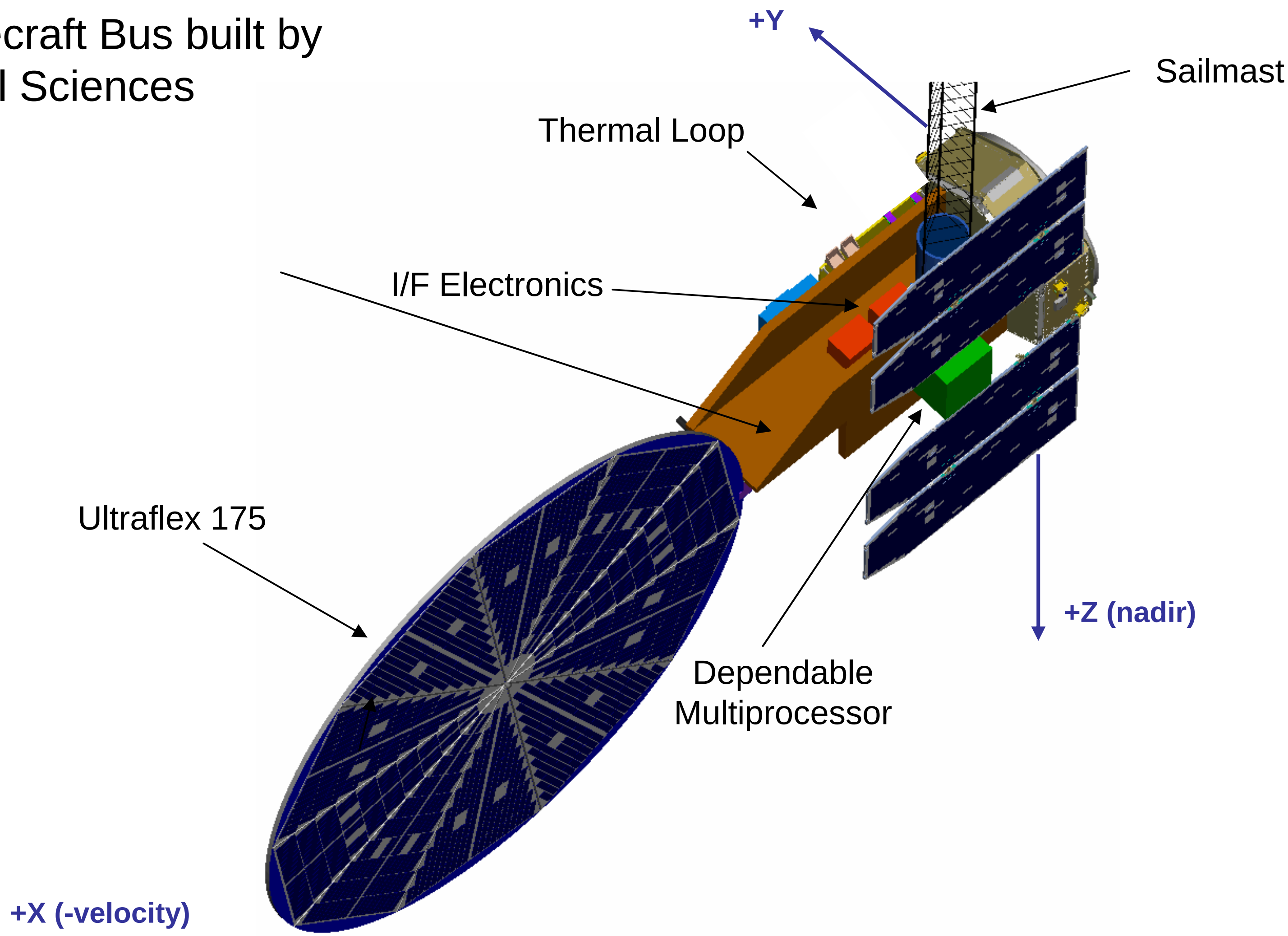
Agenda

- Mission Overview
- Experiments:
  - SAILMAST
  - Ultraflex 175
  - Thermal Loop
  - Dependable Multiprocessor
- Summary

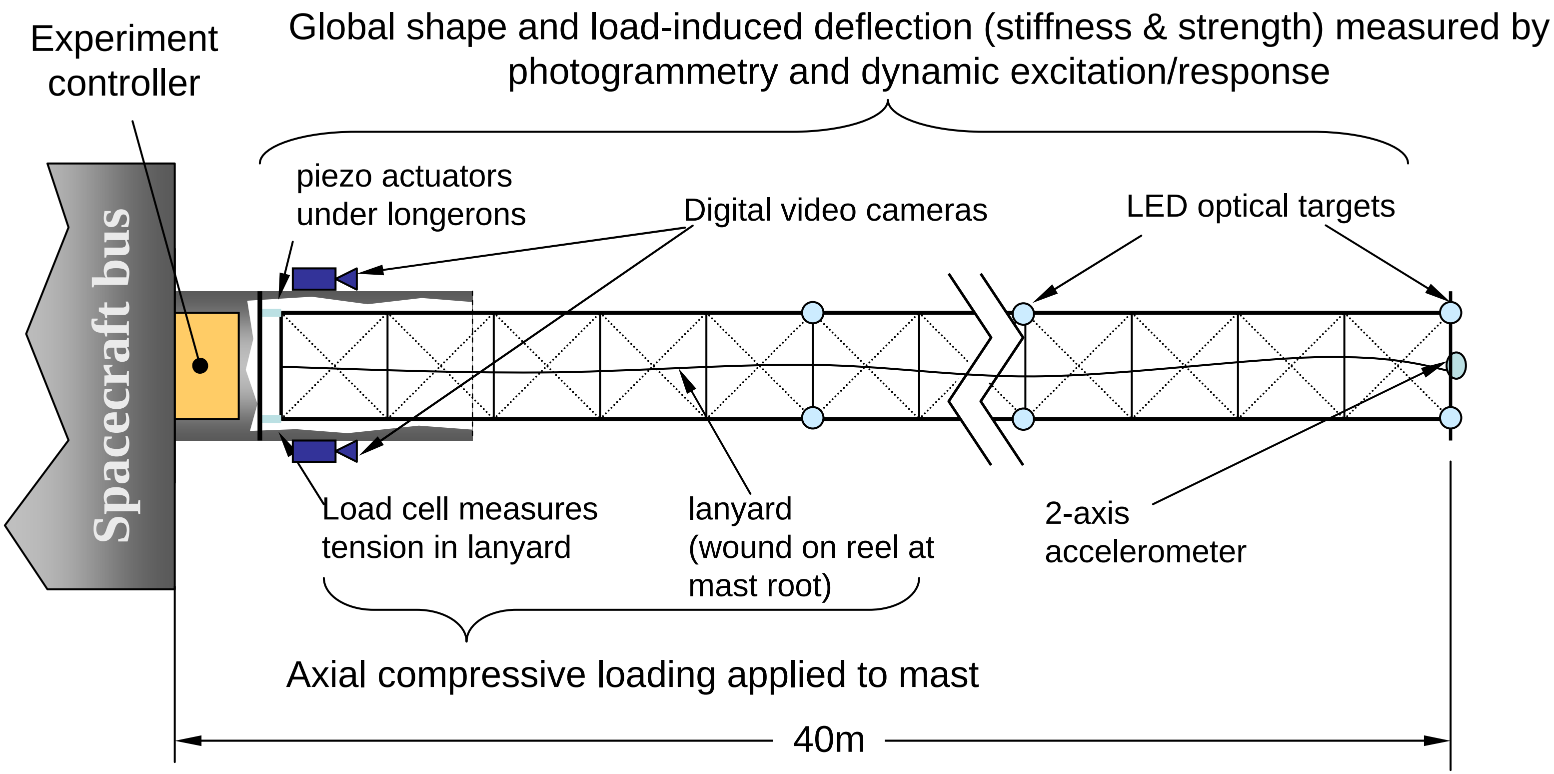
- ST8 carries 4 technology demonstration experiments
  - SAILMAST (ATK Space Systems)
  - Ultraflex 175 (ATK Space Systems)
  - Thermal Loop (GSFC)
  - Dependable Multiprocessor (Honeywell)
- Spacecraft bus (Orbital Sciences)
- Pegasus LV
- Launch in February 2009
- Low Elliptical (1300km X 320km), sun-synchronous orbit
- 7 month mission



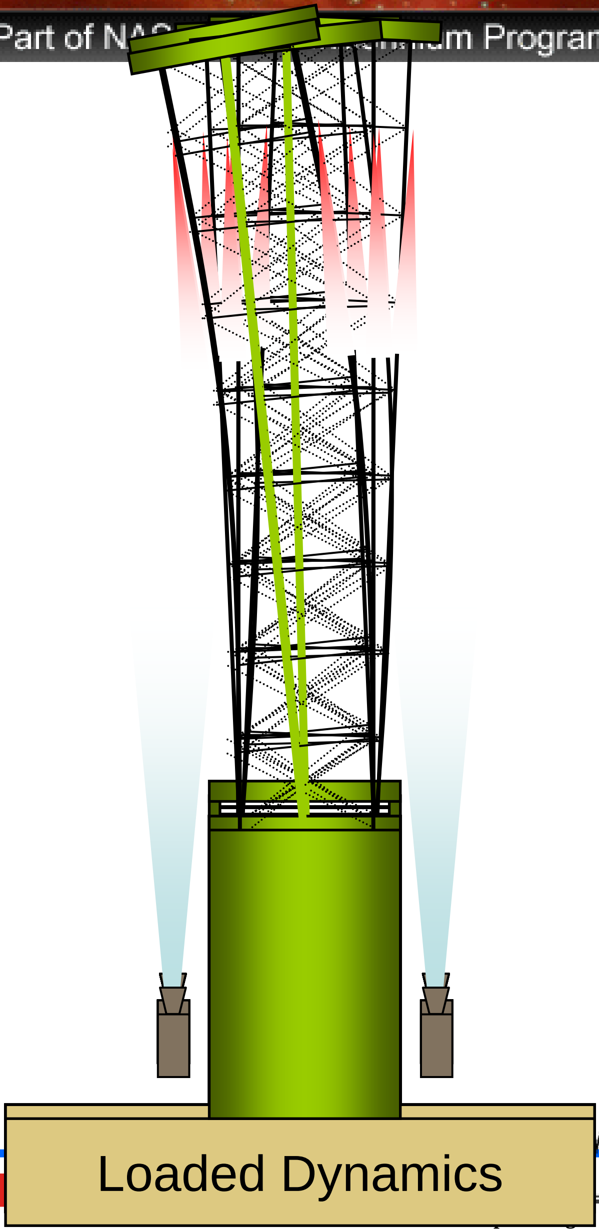
Spacecraft Bus built by Orbital Sciences



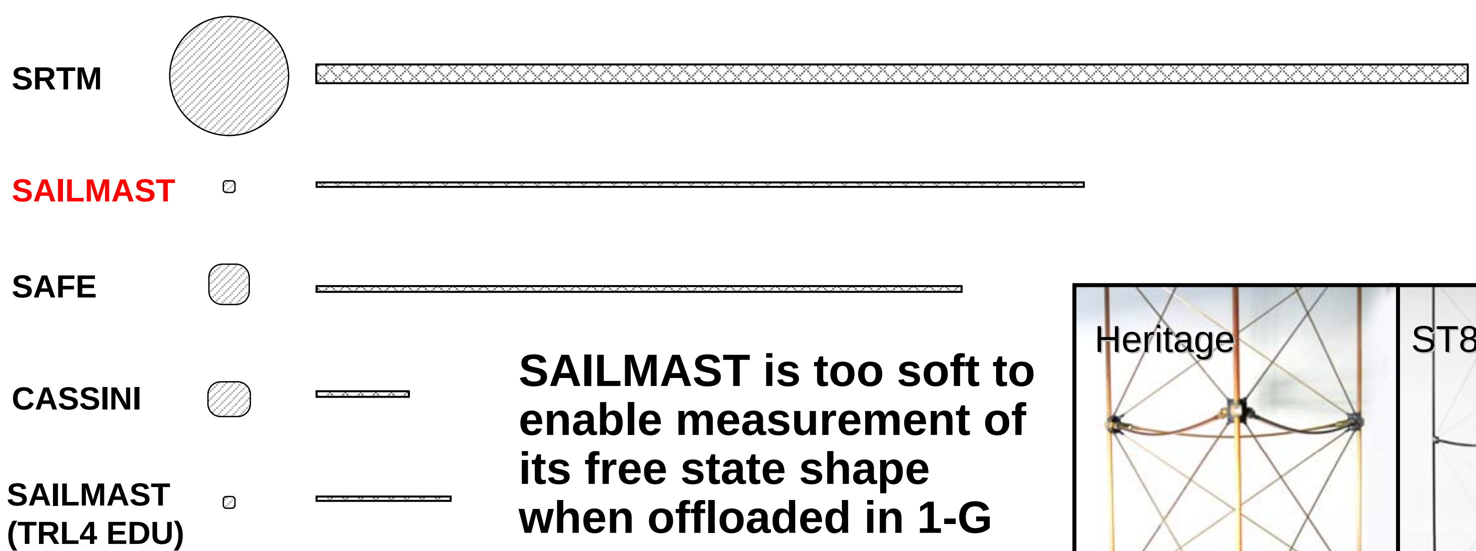
M. McEachen, PI (ATK Space Systems)



- Release
- Deploy
- Measure shape
- Measure bending frequency
- Apply axial (lanyard) load
- Measure deflection
- Measure bending frequency
- Repeat, increasing load



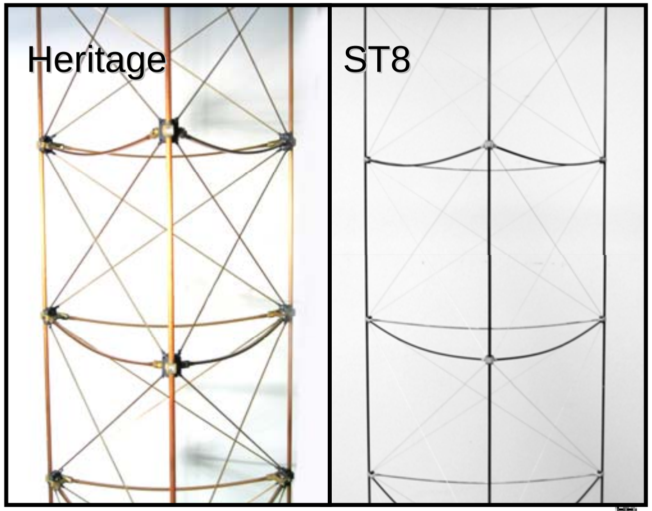
SAILMAST is nearly 2X more slender than previous deployable booms



Program	L/D	Length (m)	Loading
CASSINI	15	5	bending
SRTM	60	60	bending
SAFE	92	34	axial
SAILMAST	171	40	axial

SAILMAST is too soft to enable measurement of its free state shape when offloaded in 1-G

1-G behavior easily overwhelms the effects being modeled, making high-fidelity model correlation impossible



$Ø_M$ = 25.5 cm
r_L = 240 g/m

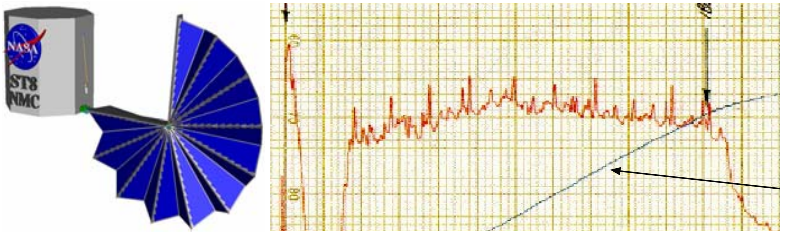
$Ø_M$ = 24.0 cm
r_L = 31 g/m

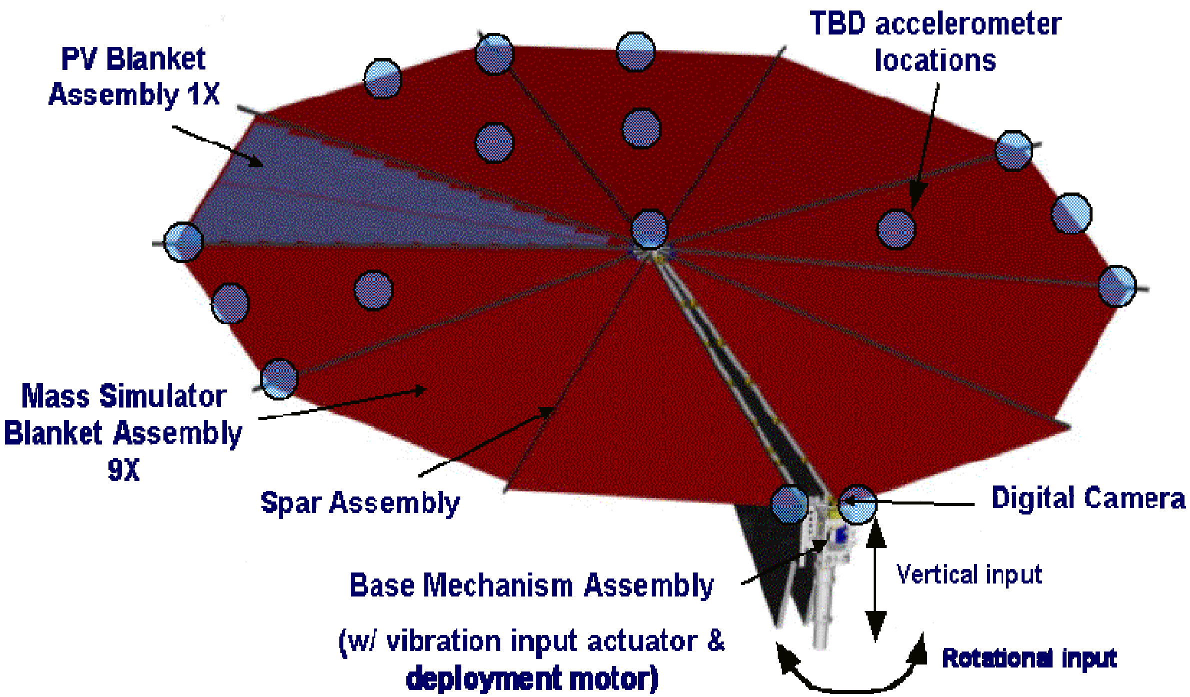
Ultraflex 175

UltraFlex-175 Experiments

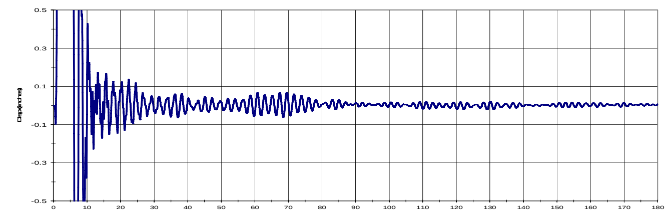
- Experiment #1: Deployment Kinematics
- Experiment #2: Deployed Dynamics
- Experiment #3: Power Production

Deployment kinematics

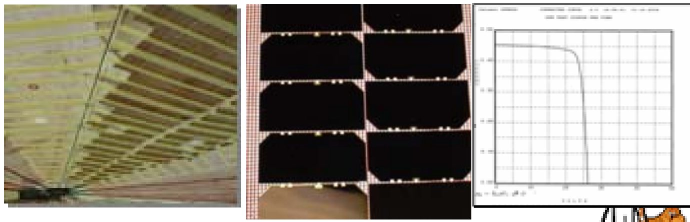




Deployed dynamics



MJ power production / survivability



S. White, PI (ATK Space Systems)

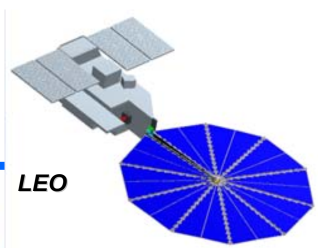
Ultraflex 175

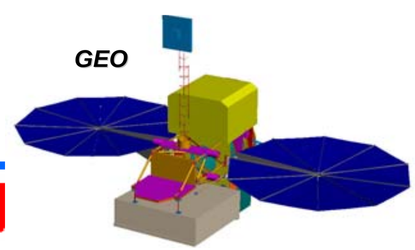
Performance Parameter	*7 kW UltraFlex-175*	*State-of-Art Rigid Array*
BOL Specific Power	**175-220 W/kg** (depending on PV / circuit technology)	60-70 W/kg
Stowed Packaging Efficiency	**> 40 kW/m^3**	7-10 kW/m^3
Deployed First Mode Frequency	**> 0.2 Hz**	0.1 Hz
Operational Limitations	**None**	None
Reliability	**High**	High
Normalized Cost	**Low** (post-technology development)	Low

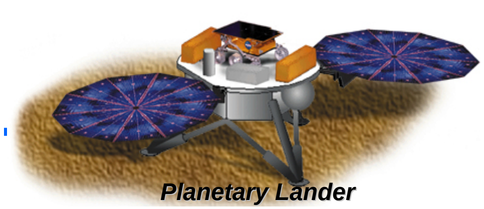
- **Ideal for mass and stowage volume-critical applications**
- **Allows mission planners to maximize payload, reduce launch costs, or simply enable a mission because of exceptional performance metrics**

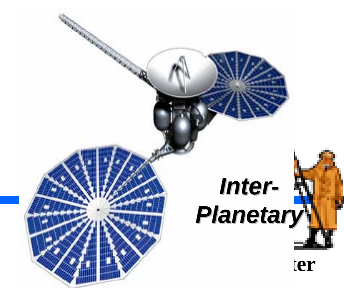
UltraFlex-175 is easily interchangeable with rigid array technology and usable in all normal S/C operational modes

Applications:



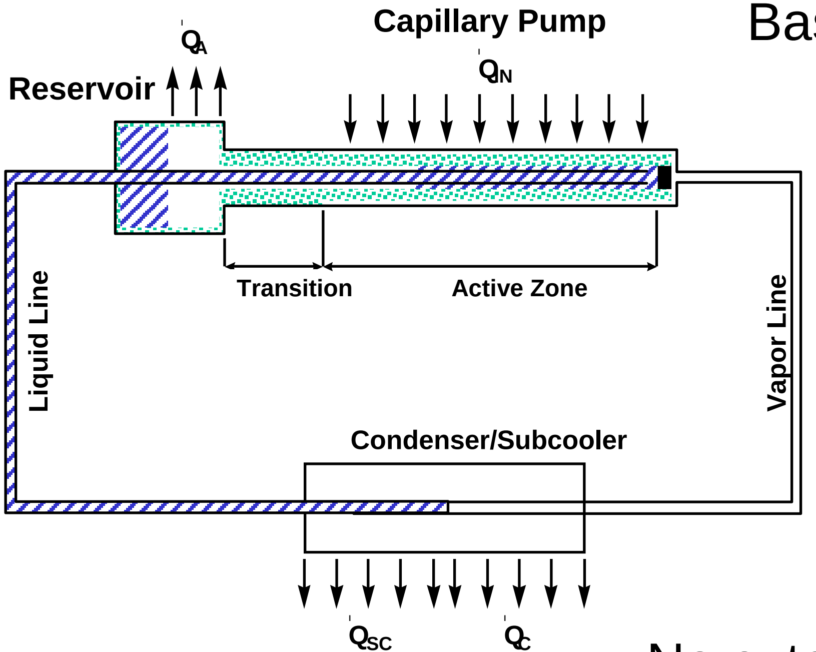


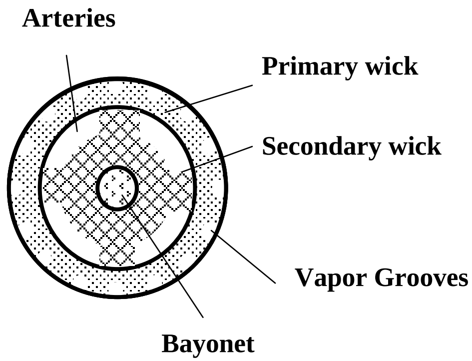




Basics

J. Ku, PI (GSFC)



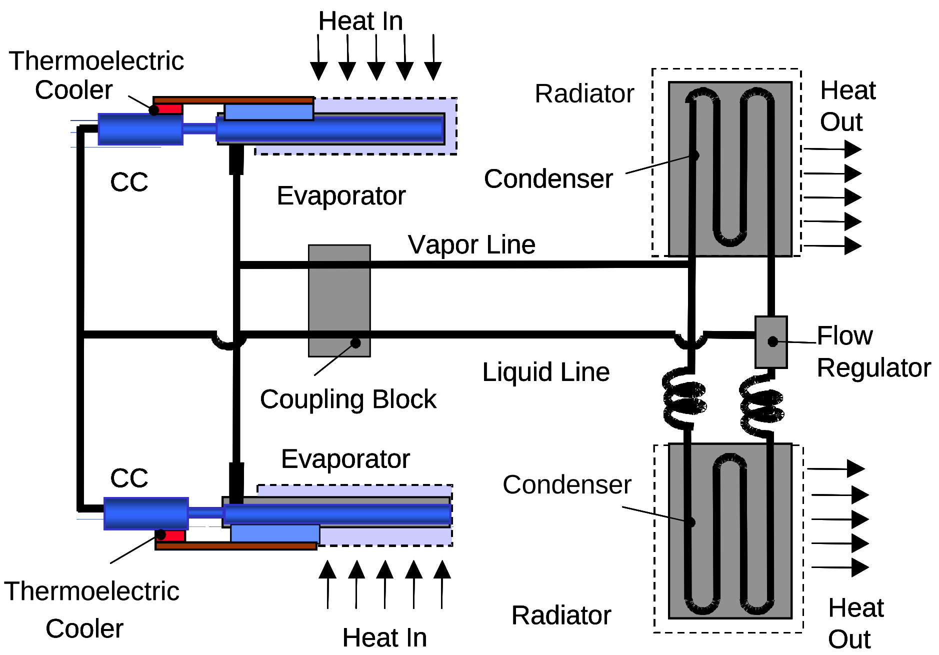


Cross Sectional View of Evaporator Core

- No external pumping power
- No moving parts
- Passive
- Self-regulating
- State of the Art
  - Single evaporator with 25mm OD

Concept

- Loop heat pipe containing two parallel evaporators and two parallel condensers
  - Passive and self regulating
  - Heat load sharing between evaporators
- Thermal Electric Coolers (TECs)
  - Maintain Condensation Chamber (CC) saturation temperature by providing heating and cooling
  - Assure reliable start-up and shutdown
  - Variable set point control for operation over a wide range of temperatures
- Coupling Blocks
  - Reduces control heater power requirements by transferring heat from vapor to return liquid
- Working Fluid
  - Anhydrous ammonia

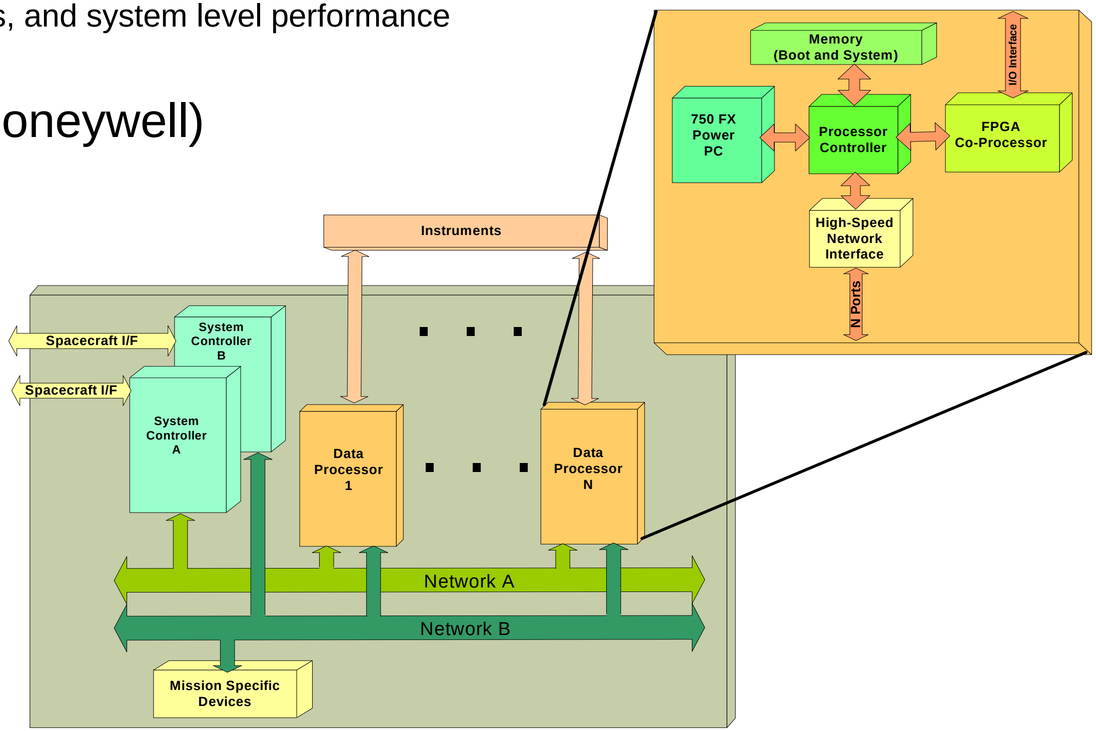


Technology Advances

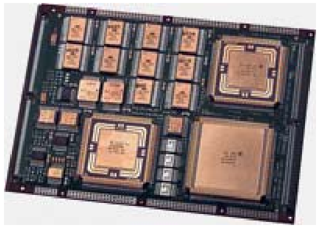
Technology Item	*State-of-the-Art*	*ST8 Technical Advance*
Integrated Thermal Subsystem – Miniature Loop Heat Pipe with TECs on CCs	**Louvers, Heat Pipes, LHPs, Heaters, Thermostats**	**Flexible Location of Heat Dissipating Components, Heat Load Sharing, TEC for temperature control and Start-up Enhancement**
Loop Heat Pipe Configuration	**Single Evaporator**	**Multiple Evaporators**
Loop Heat Pipe Evaporator Diameter	**25mm O.D.**	**13mm O.D.** **Reduced volume and mass**
Modeling of LHP	**Top-Level Transient Model for Single Evaporator** **No Scaling Rules**	**Detailed Transient Model for LHPs with Multiple Evaporators** **Scaling Rules are established**

- An architecture which enables COTS-based, high performance, scalable, multi-computer systems to be used in a space environment, incorporating reconfigurable co-processors
- An application software development and runtime environment that is familiar to science application developers
- An autonomous and adaptive controller for fault tolerance configuration, responsive to environment, application criticality, and system mode
- Allow the prediction of the system's behavior in the space environment, including: availability, dependability, fault rates/types, and system level performance

J. Samson, PI (Honeywell)

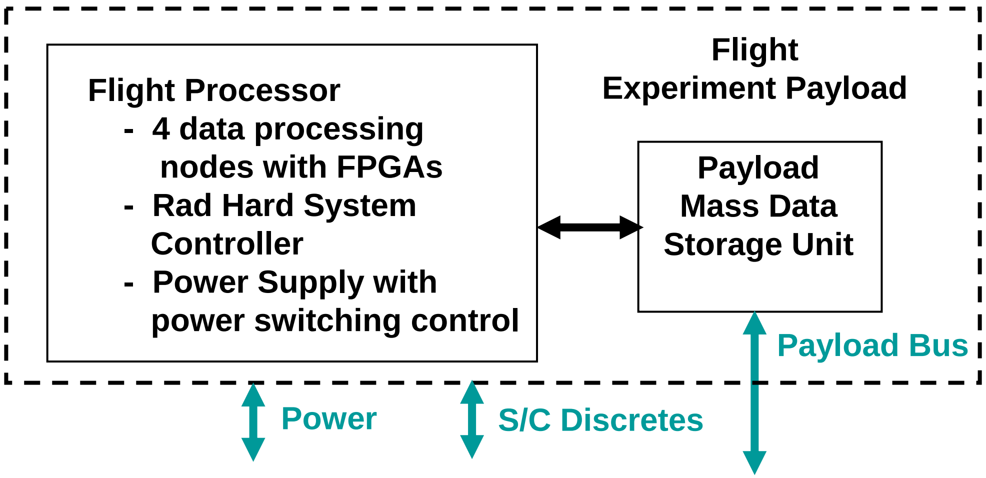


Indian Ocean Meteorological Instrument (NRL) vs. Geosynchronous Imaging Fourier Transform Spectrometer Example (NMP EO3) vs. Dependable Multiprocessor

Radiation Tolerant 750 PPC SBC		133 MHz ~ 266 MOPS ~ 1.2 kg ~ 20 watts	Rad tolerant design
Radiation Hardened Vector Processor		DSP24 @ 50 MHz ~ 1000 MOPS ~ 1.0 kg ~ 22 watts	Rad hard design
Dependable Multiprocessor 750FX PPC SBC only		1 GHz ~ 1500 MOPS ~ 1.2 kg ~ 20 watts	Radiation tolerance, high Reliability, and high Availability

- Objectives of the experiment:
- 1) to characterize the radiation environment,
  2) to correlate the radiation performance of the COTS components with the environment,
  3) validate the predictive Reliability, Availability, and Performance models for this and for future NASA missions

- Measure component and system parameters that can only be validated in a real space environment
  - component error rates dues to radiation
  - accuracy of predictive fault/error model



- ST8 is a low-cost mission that will demonstrate 4 technology experiments which will enable future missions.

Back-up Slides

Rationale for Flight Experiment

- LHP operation involves complex physical processes.
  - Fluid dynamics, heat transfer, and thermodynamics
  - Gravitational, inertial, viscous and capillary forces
- Gravity causes liquid to stratify in one-G, affecting LHP operation.
  - Void fraction in evaporator core is critical in LHP operation.
- LHPs with a 13-mm O.D. wick have never been space flight tested.
- LHPs with multiple evaporators have never been space flight tested.
  - Strong interactions among components in one-G tests
  - Heat load sharing in zero-G
- LHP model predictions must be validated with flight data.
  - Zero-G operation cannot be completely simulated in one-G.
  - Long duration zero-G tests are required.
- LHP Operation with TECs on the CCs must be validated in zero-G.

Why Fly in Space?

- First adopters of the technology are less likely to take on the risk of a technology with no flight heritage
- Our technology advance is centered around the validation of predictive model parameters. To accurately validate our model parameters it is necessary to conduct experiments in the relevant environment
- The space environment cannot be replicated on Earth
  - validating DM technology on the ground is limited;
  - radiation beam tests can simulate the space environment to a limited extent;
  - beam tests can simulate the effects of single particles, but cannot cost-effectively emulate the different types of particles, the range of particle energies, and directions from which the particles can impinge on the system;
  - the only way to cross the final barrier is to demonstrate and validate DM technology in the real space environment