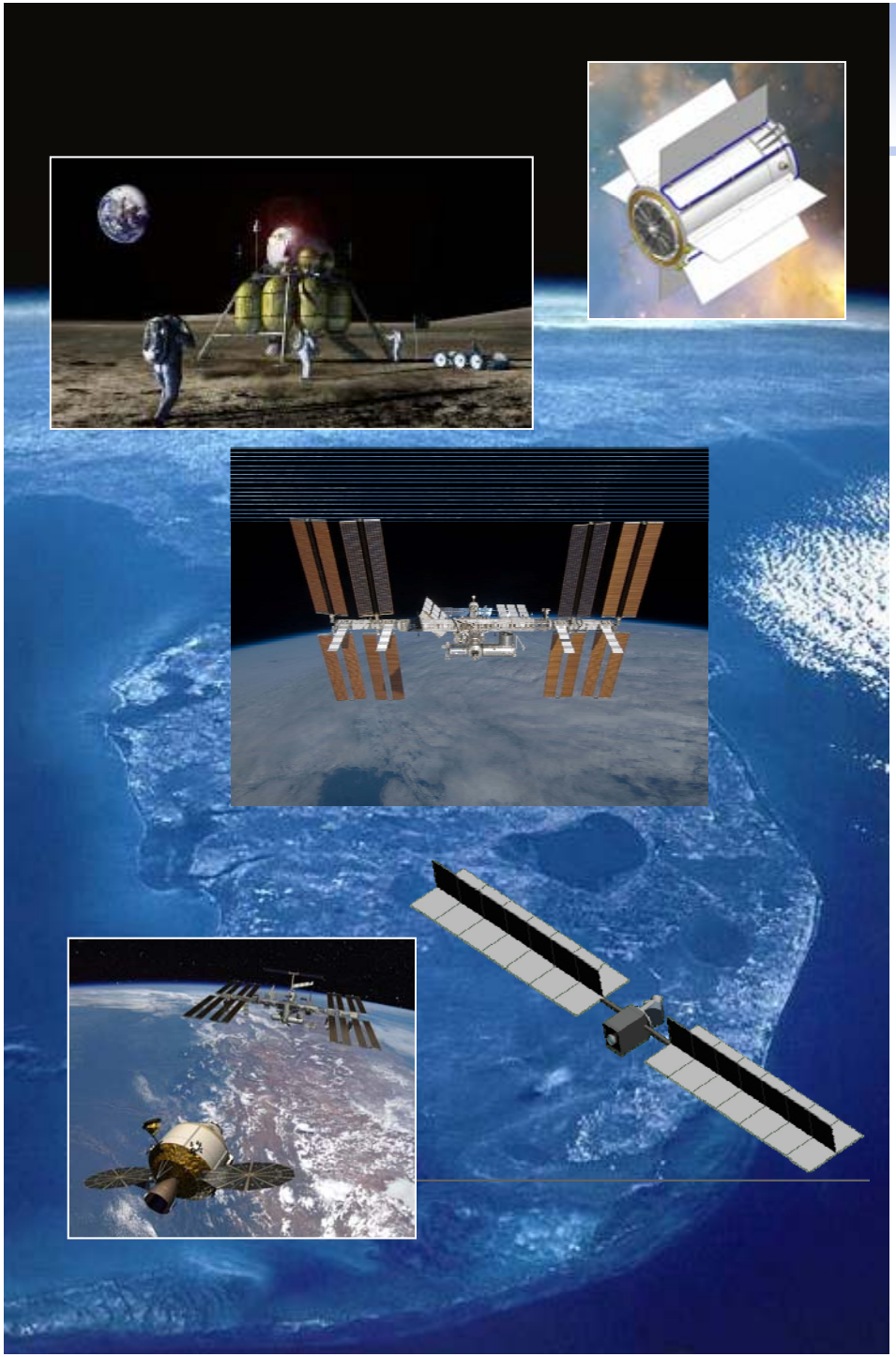

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Hamilton Sundstrand Space Systems & Defense Rocketdyne

ISS Testbed Capabilities

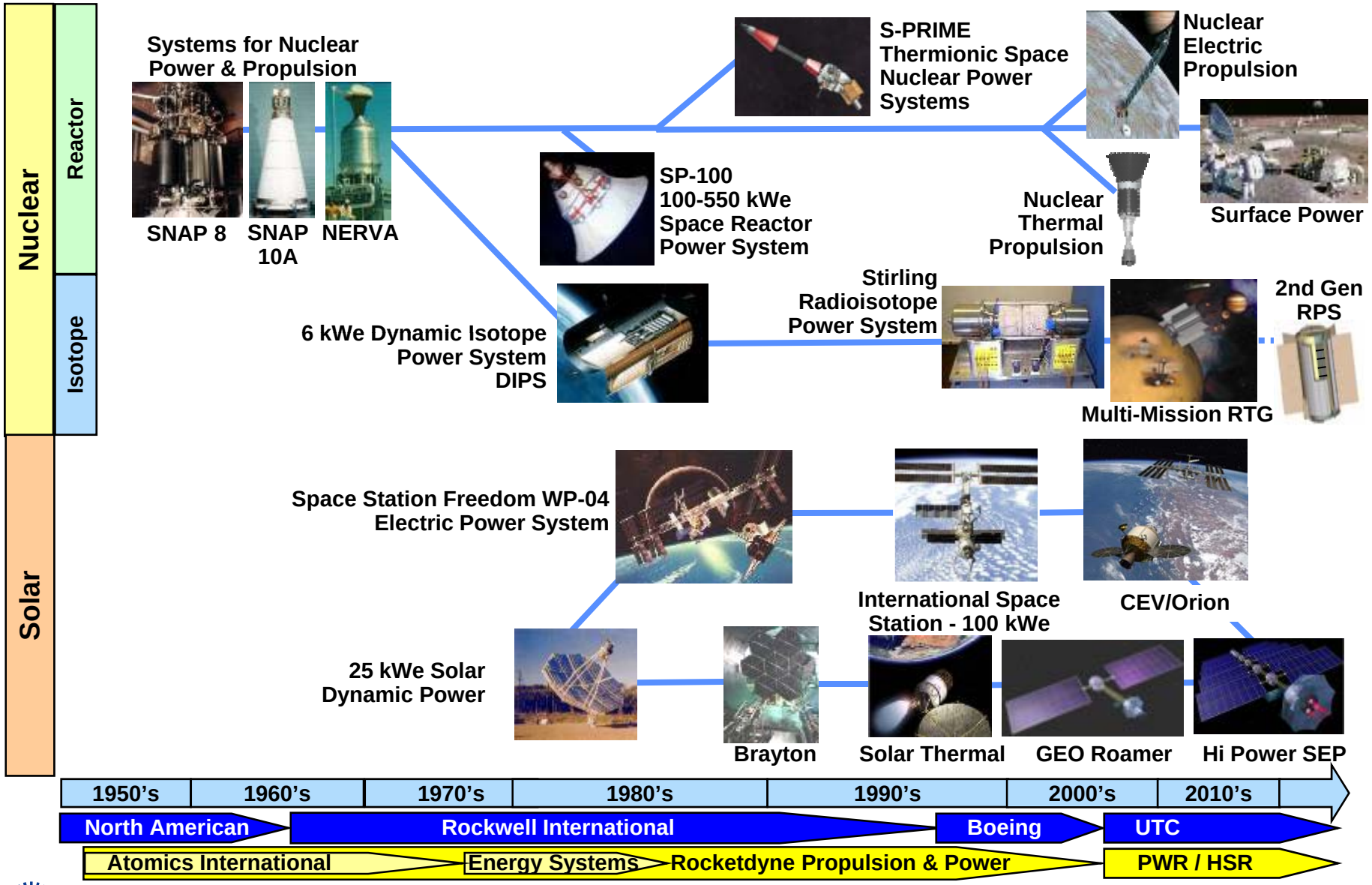
NASA ISS Research Academy & Pre-Application Meeting

4 August, 2010

Dr. Cheng-Yi Lu

Rocketdyne Space Power Heritage

End-to-end Space Power Technology Developed for 50 Years



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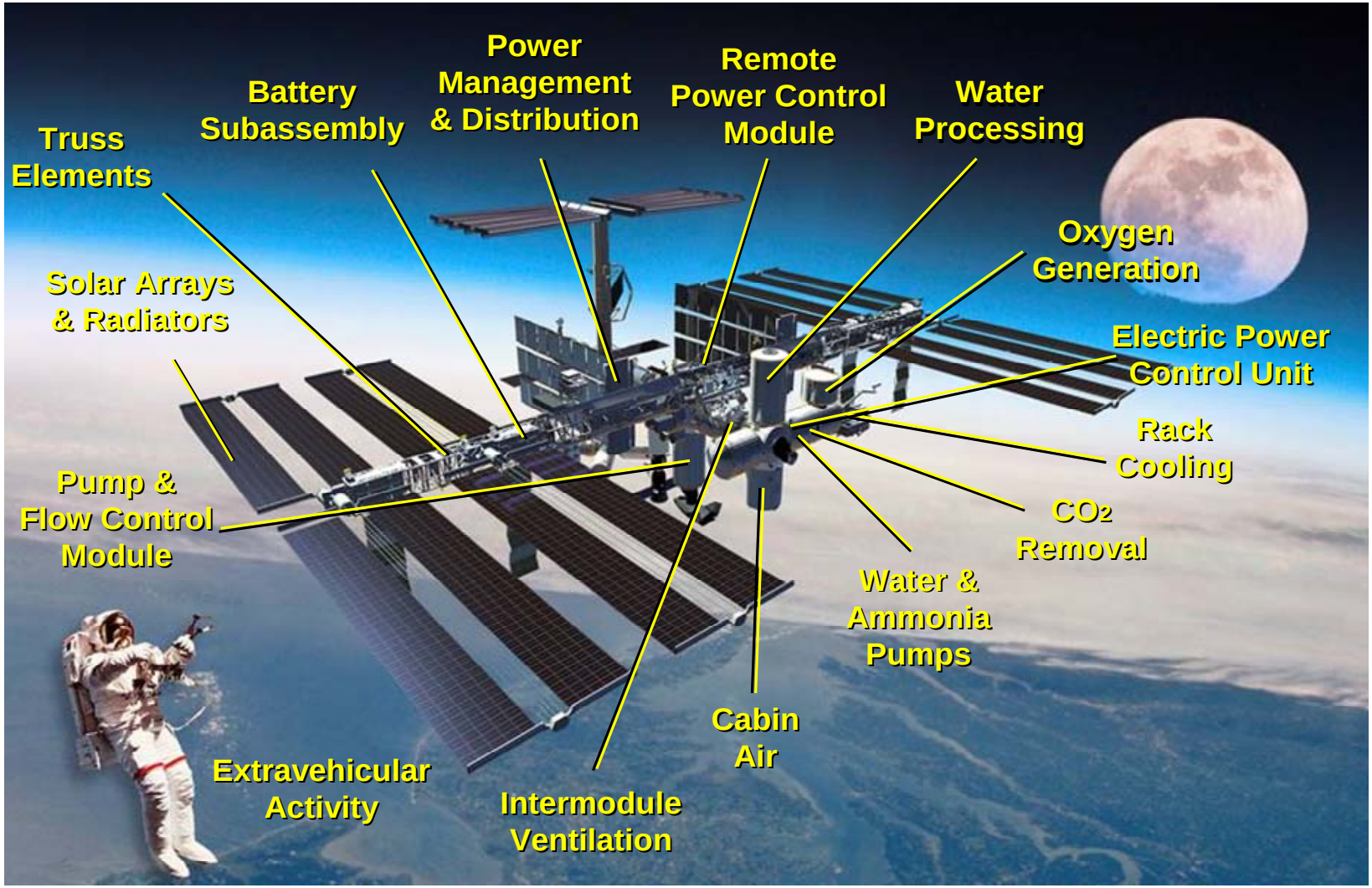
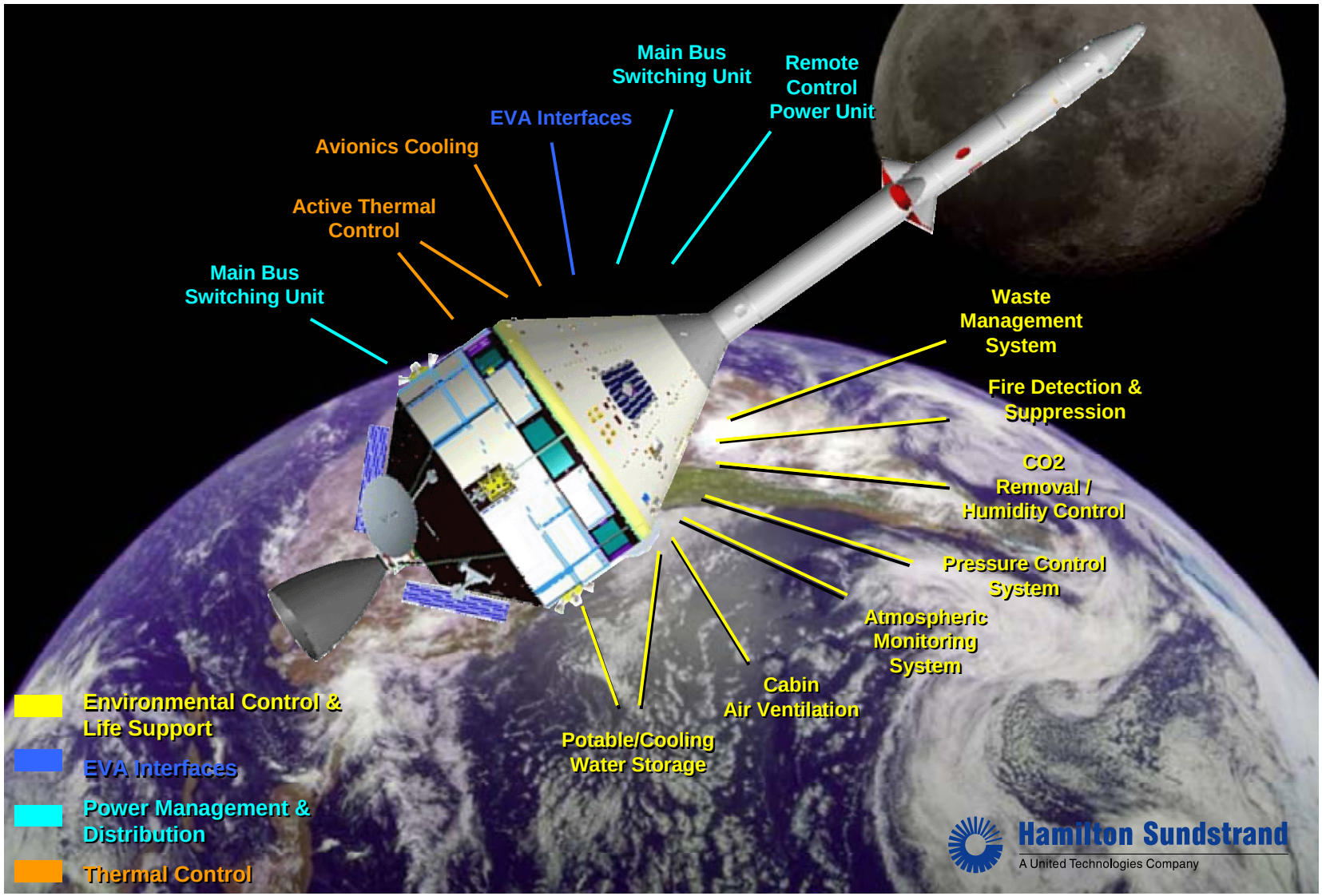
International Space Station Content

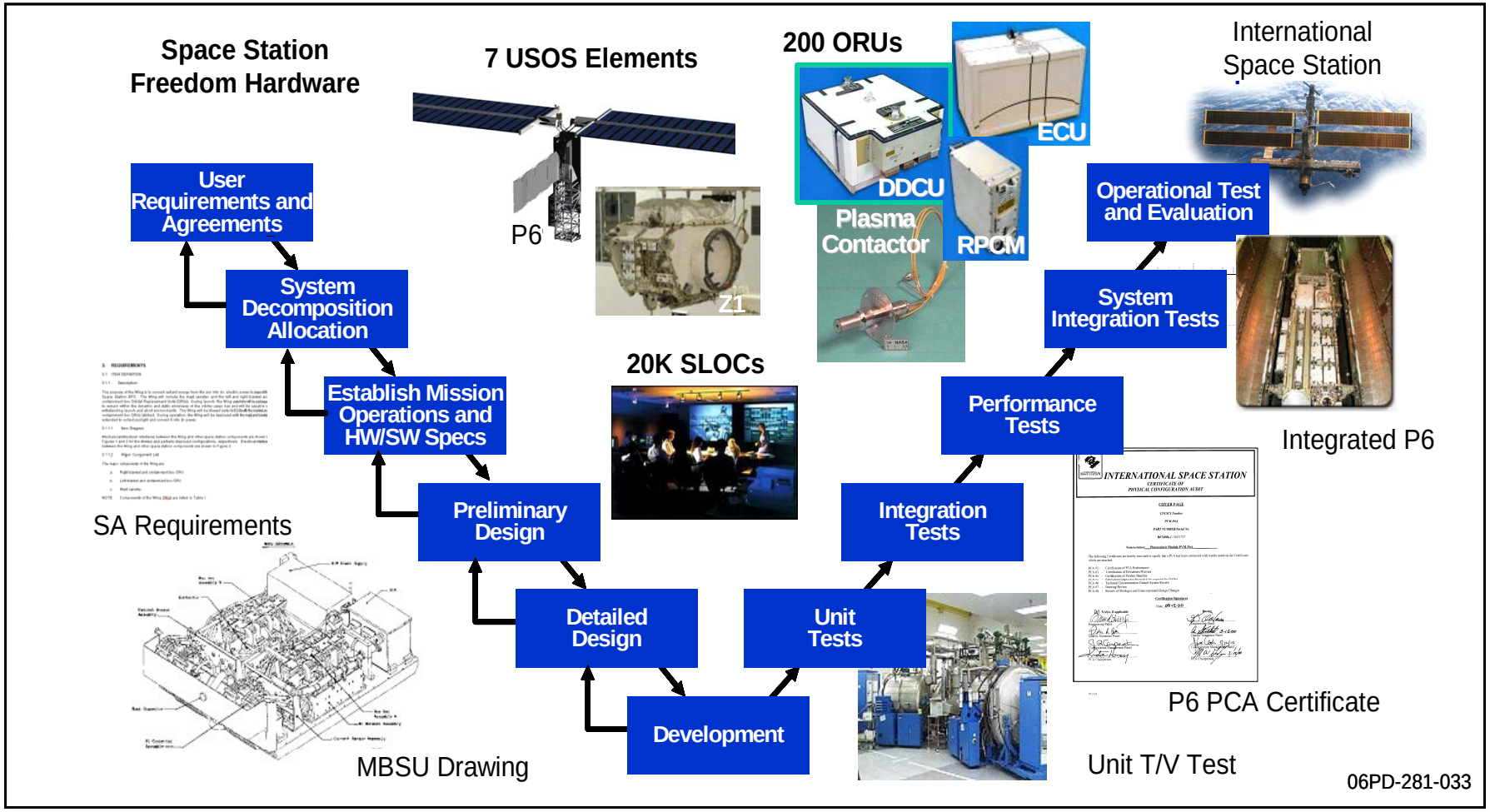


Hamilton Sundstrand
Orion Content



End-to-End System Engineering Process

- **Rocketdyne SE worked together with NASA, Prime, 6 major subcontractors and 15 foreign space agencies and their contractor teams in a concurrent design environment.**



End-to-End Space Power Technologies

Power System Integration

Energy Source

- Solar
- Chemical
- Nuclear
  - Fission
  - Radioisotope
- Magnetosphere Plasma

Power Generation

- Photovoltaic
- Reflector/CPV
- Fuel Cells
- Primary Battery
- Dynamic
  - Brayton
  - Stirling
  - Rankine
- Thermoelectric
- AMTEC
- MHD
- Thermionic
- Thermo PV
- Turbine or Cryogenic Engine
- Tether

Energy Storage

- Secondary Battery
  - Li-Ion/Polymer
  - NiH2
- Reg. Fuel Cell
- Flywheel
- Capacitor
- Superconducting ES
- Thermal Storage (MC)

PMAD

- Power Regulation
  - Series (PPT)
  - Shunt
- Architecture/ Topologies
- Li-Ion C/D Unit
- Electronics*
- Fault Protection
- PMAD S/W
- PMAD Facility

•SiC, GaN high power, high or low temperature, high efficiency and rad-hard

Thermal Management

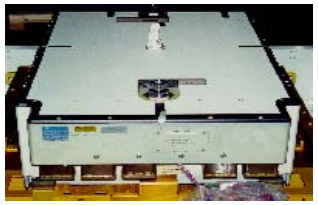
- Loop HP Radiator
- Pump Loop Radiator
  - Tube/Fin Radiator
  - HP Radiator
- Low T Coolant
- High T Coolant (LM)
  - EM Pump
  - Mechanical Pump
- Gas Coolant (CBC)
- Non-Conventional HP (SSHP)
- MMOD Protection

Power System Model

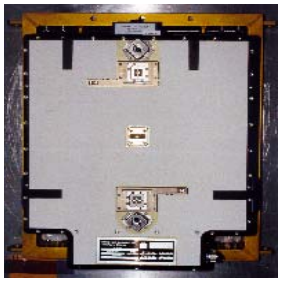
International Space Station Electric Power System

Battery Subassembly ORU

Main Bus Switching Unit

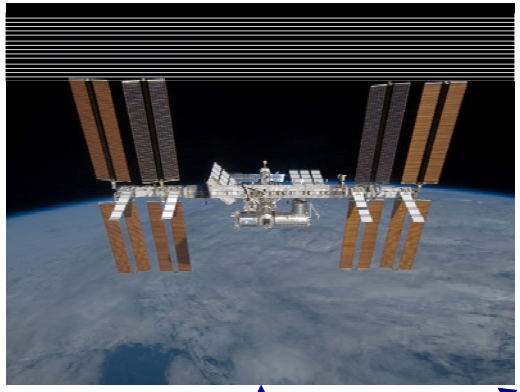


DC Switching Unit



DC-DC Converter Unit

Battery Charge-Discharge Unit



Sequential Shunt Unit

Remote Power Controller Module

Solar Array & Radiators

Plasma Contactor

Pump & Flow Control

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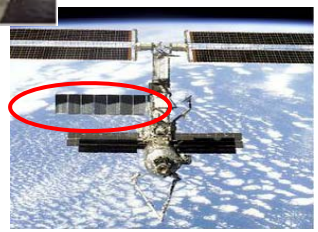
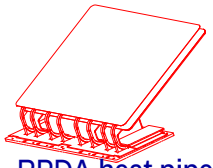
ISS Thermal Management Designs

Pump & Flow Control

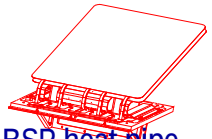
Pumped loop radiator



Dc Dc Converter - Heat Pipe

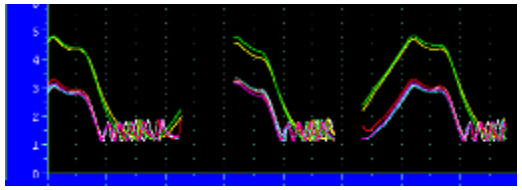


RPDA heat pipe



BSP heat pipe

Thermal blanket wrapped Z1 Truss



On orbit battery temperature measurement – TMS maintains battery temperature between 0 to 10 ^{o}C

- **Pumped loop, deployable radiator, NH_3 coolant**
  - **Each radiator has seven 3.4m x 2.1 m panels**
- **Direct NH_3 heat pipe (HP) radiators**
  - **HPs embedded in Al honeycomb**
  - **DDCU-HP radiator: 0.7 m^2**
  - **Remote Power Distribution Assembly radiator: 0.6 m^2**
  - **Baseband Signal Processor radiator: 0.3 m^2**
- **Passive**
  - **Thermal blanket, MLI, heaters, optical coating**
- **4 HP radiators and 4 pumped loops TMS have been in continuous operation**
  - **HP radiators and the first pumped loop TMS have operated since Dec. 2000**

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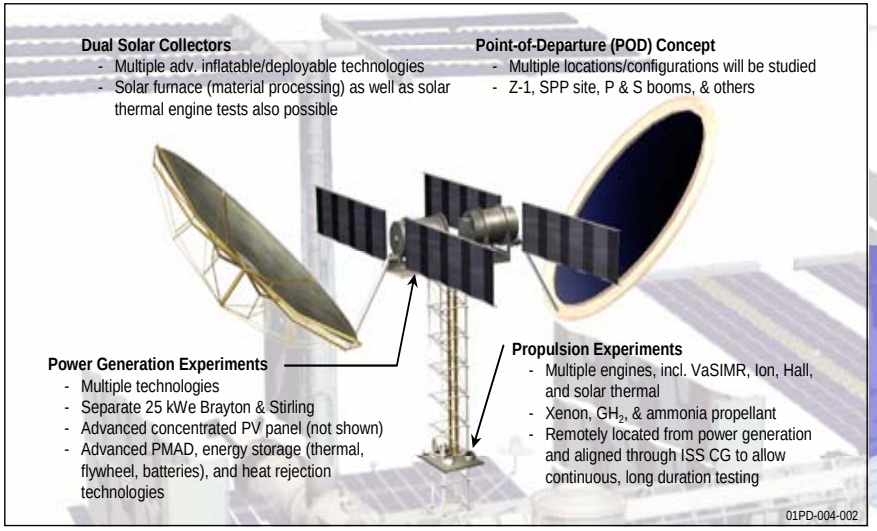
External ISS Testbed Platform for Technology Demonstration

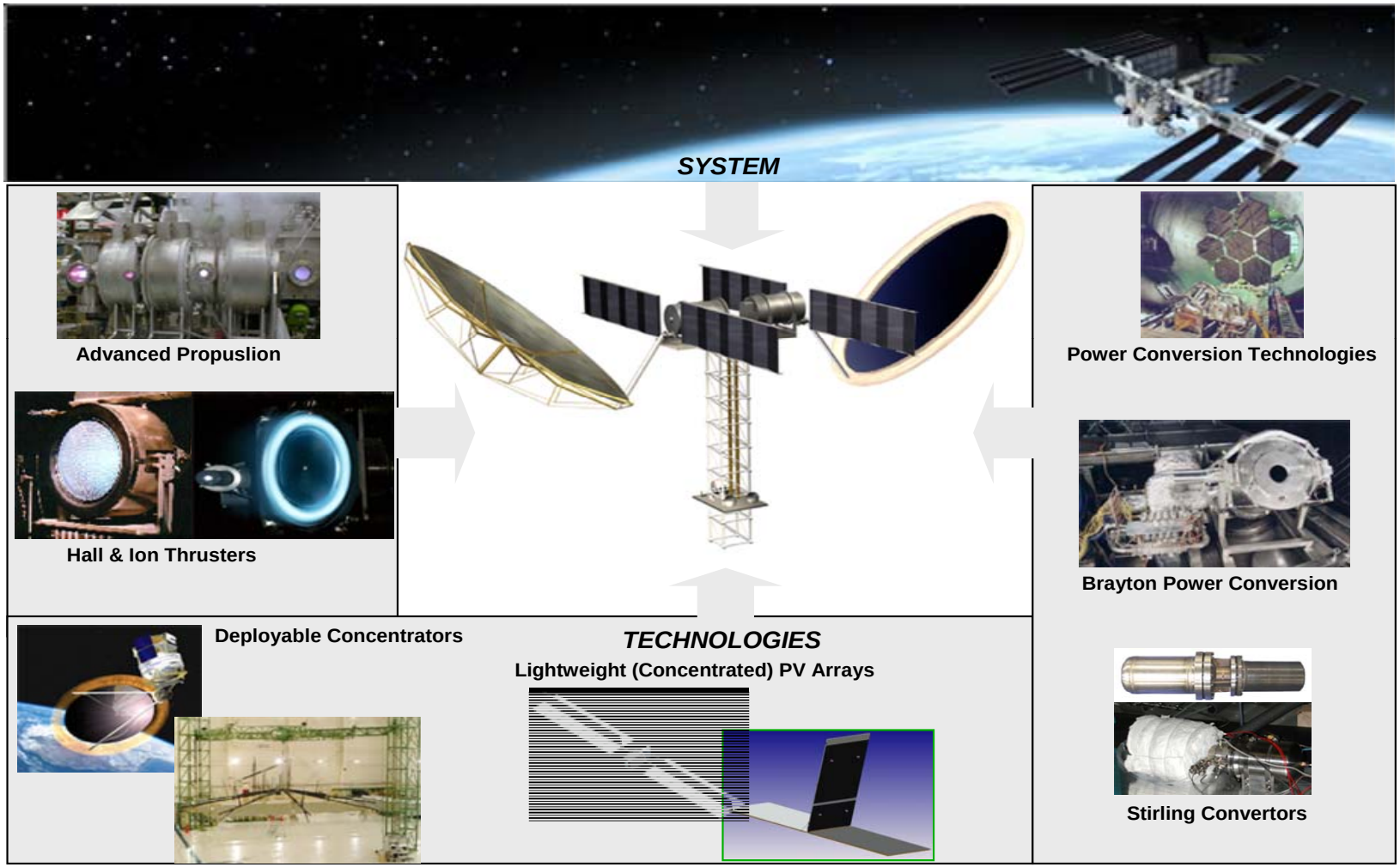
- **Use ISS to test propulsion, power, thermal & deployment technologies**
  - An external testbed platform with power, data link and thermal ready
- **Rocketdyne previous winning proposals**
  - Z1 Experiment Module (ZEM) proposal ('97 to '99)
  - Advanced Propulsion and Power Testbed (APPT) proposal ('00 to '01)
    - tests payloads in space environment
      - electric thrusters: Li-MPD, VASIMR, Hall Effect and XIPS
      - power and beaming: CPV, Stirling, microwave and laser beaming
      - deployable concentrator, radiator and antenna structure
    - provides services to co-orbiting space vehicles



APPT

ZEM

ISS Advanced Propulsion and Power Testbed



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Why and How Can Rocketdyne Be Your Team Member for ISS Testbed?

- **Demonstrated end-to-end ISS electric power system heritages**
  - Power conversion, energy storage, PMAD, thermal, user loads I/F and structure
  - Complete cycle of power systems development, test through operation
- **Recent and relevant human-rated space power system DDT&E experience**
  - International Space Station, Shuttle/ISS Power Transfer Unit and Orion PMAD
  - Skills, facilities and engineering tools in-place for immediate start
- **Previous ISS commercialization and testbed development experience**
  - Previously led ZEM (Z1 Experiment Module) work (7/1997 to 1/1999)
  - Previous APPT proposal for HTCI (2001)
- **Mature software & system design/fab/test processes – CMMI 3 Certified**
  - SE&I, Software, IPPD, Supply Chain certification
  - Provides process and mission assurance rigor for human-rated systems
- **Provide test platform system integration**
  - Testbed design and development designs
  - ISS electric power, thermal management, structure, data, software and environment interfaces