Use of ISS for Validation of Advanced Power Systems for Exploration

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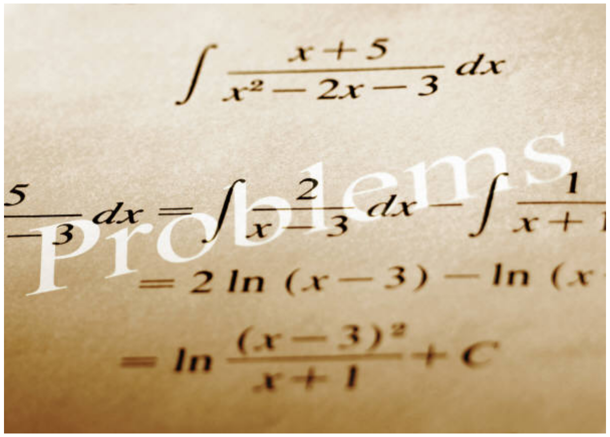
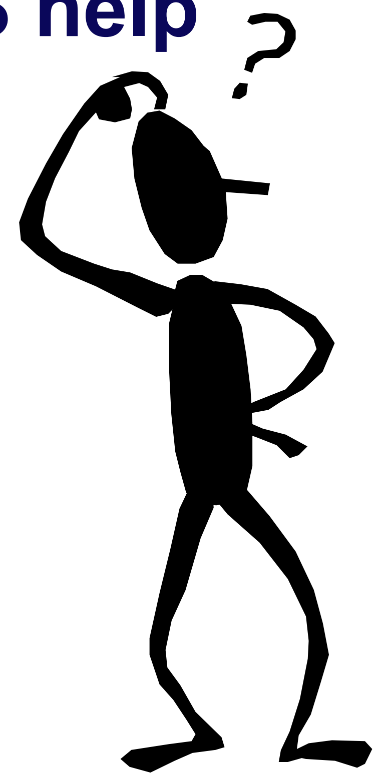
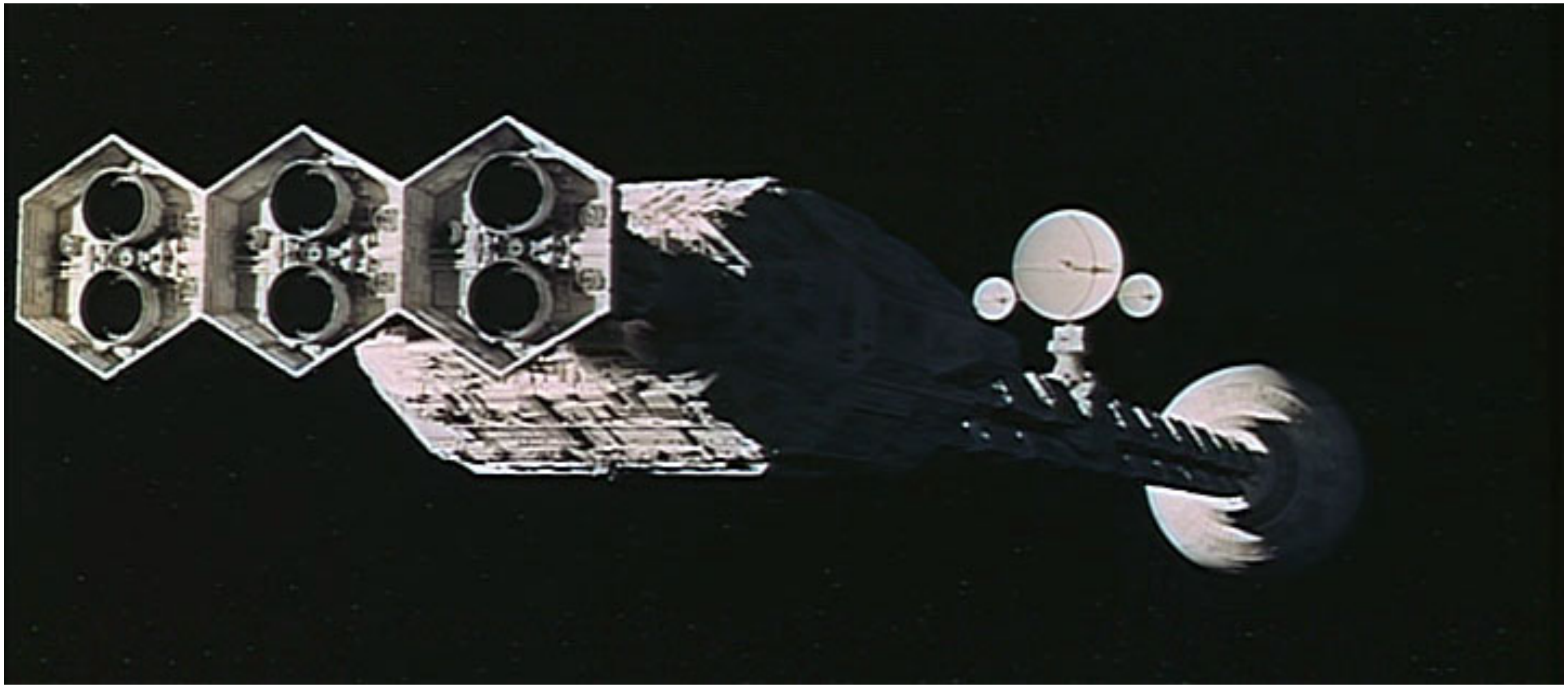


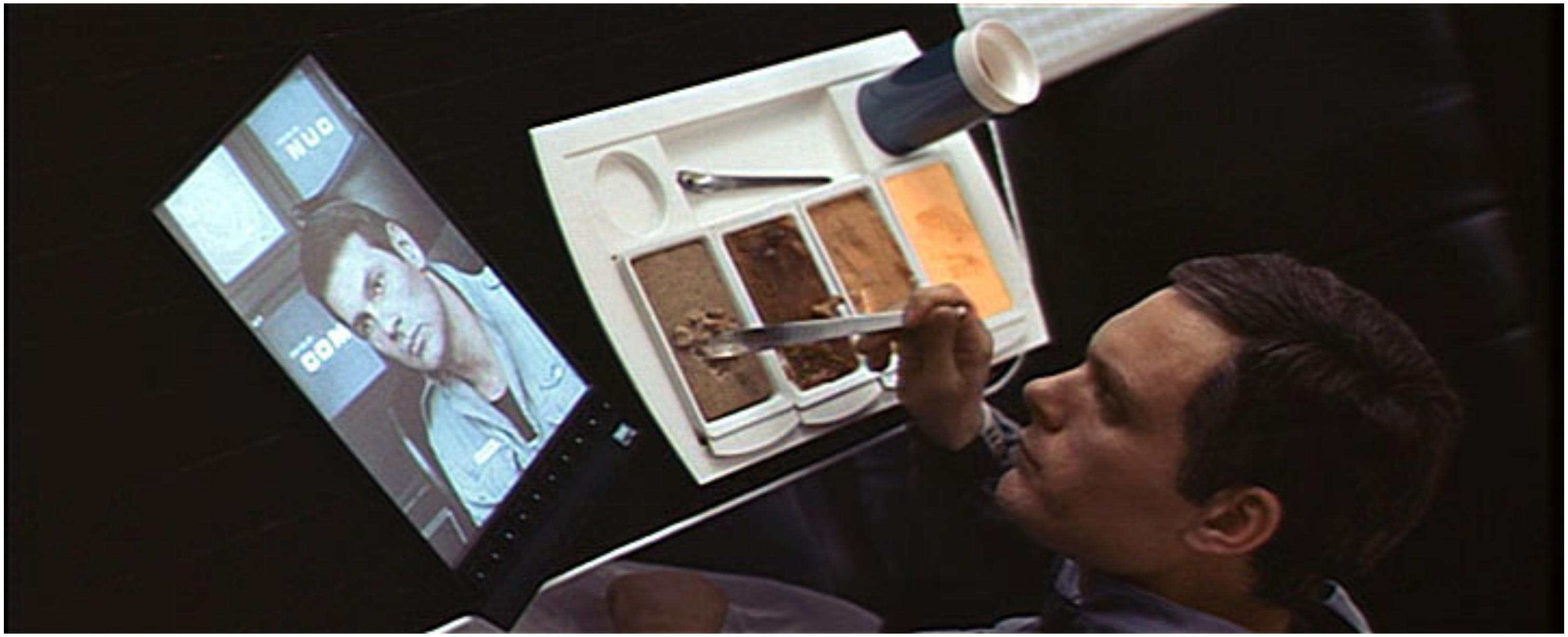
So what are the power issues in deep space exploration and how can the ISS help



Let's travel back and see how popular Sci-Fi looked at deep space exploration

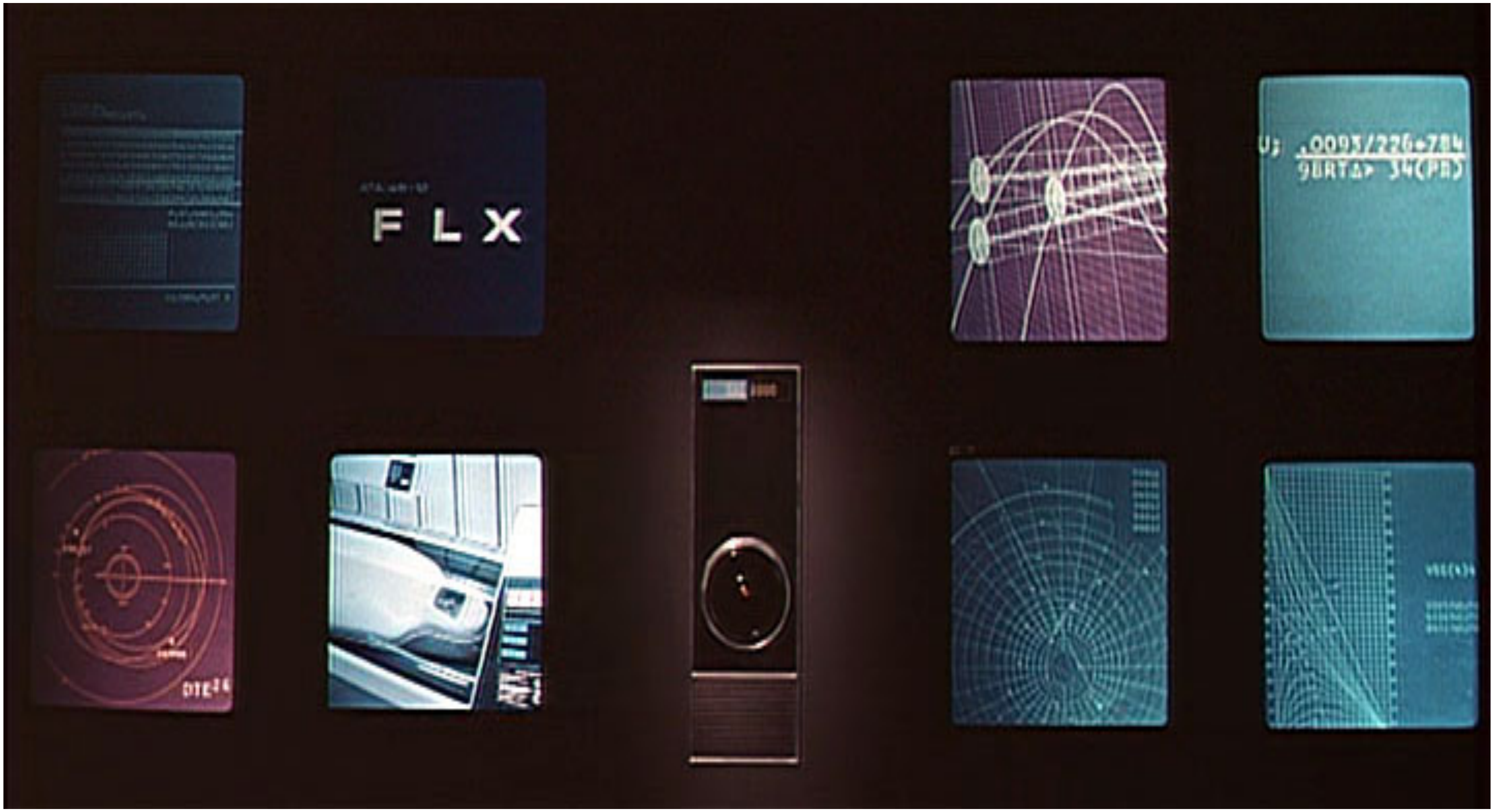


Today we are looking at deep space exploration similar to the mission to Jupiter in the movie 2001 by Spaceship "?"

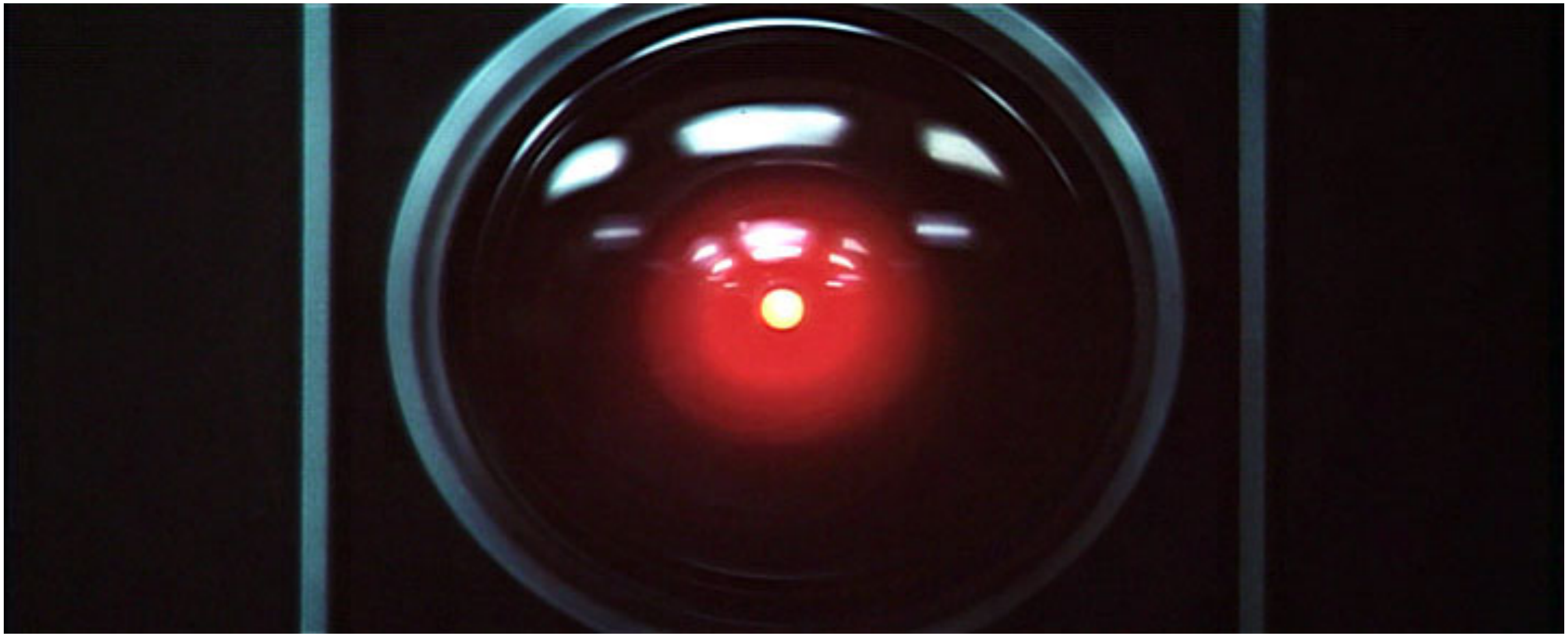


Communication and hence control from Earth was done with long time delays

The operation of the spacecraft was routine and mundane for the astronauts – autonomous operation of core systems

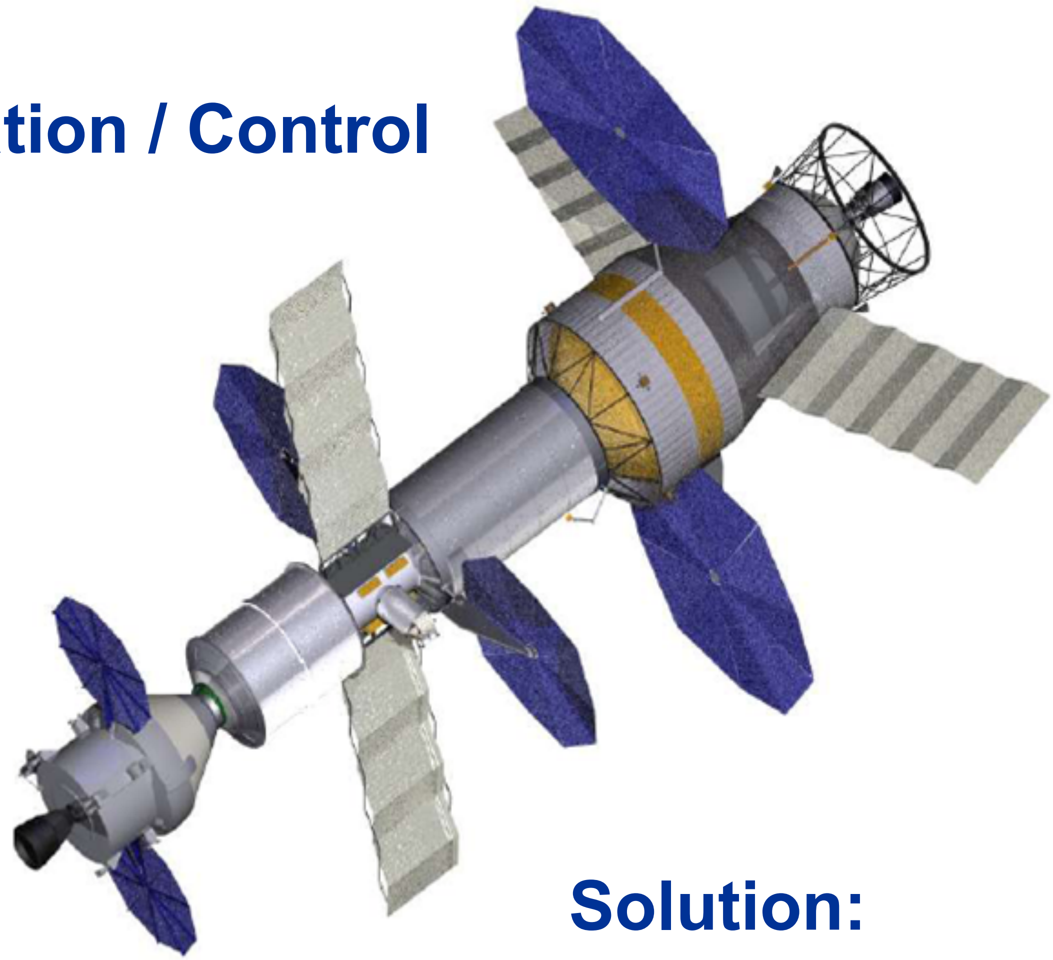


To accomplish this the ship was totally automated



But we want the systems to be helpful and respond to Cntrl-Alt-Delete

Problem:
Communication / Control delay



Solution:
Autonomous Control

NASA's ambition for deep space exploration requires the capabilities recognized long ago

Utilizing ISS as an engineering test platform can facilitate the vision for an automated future for selected core systems

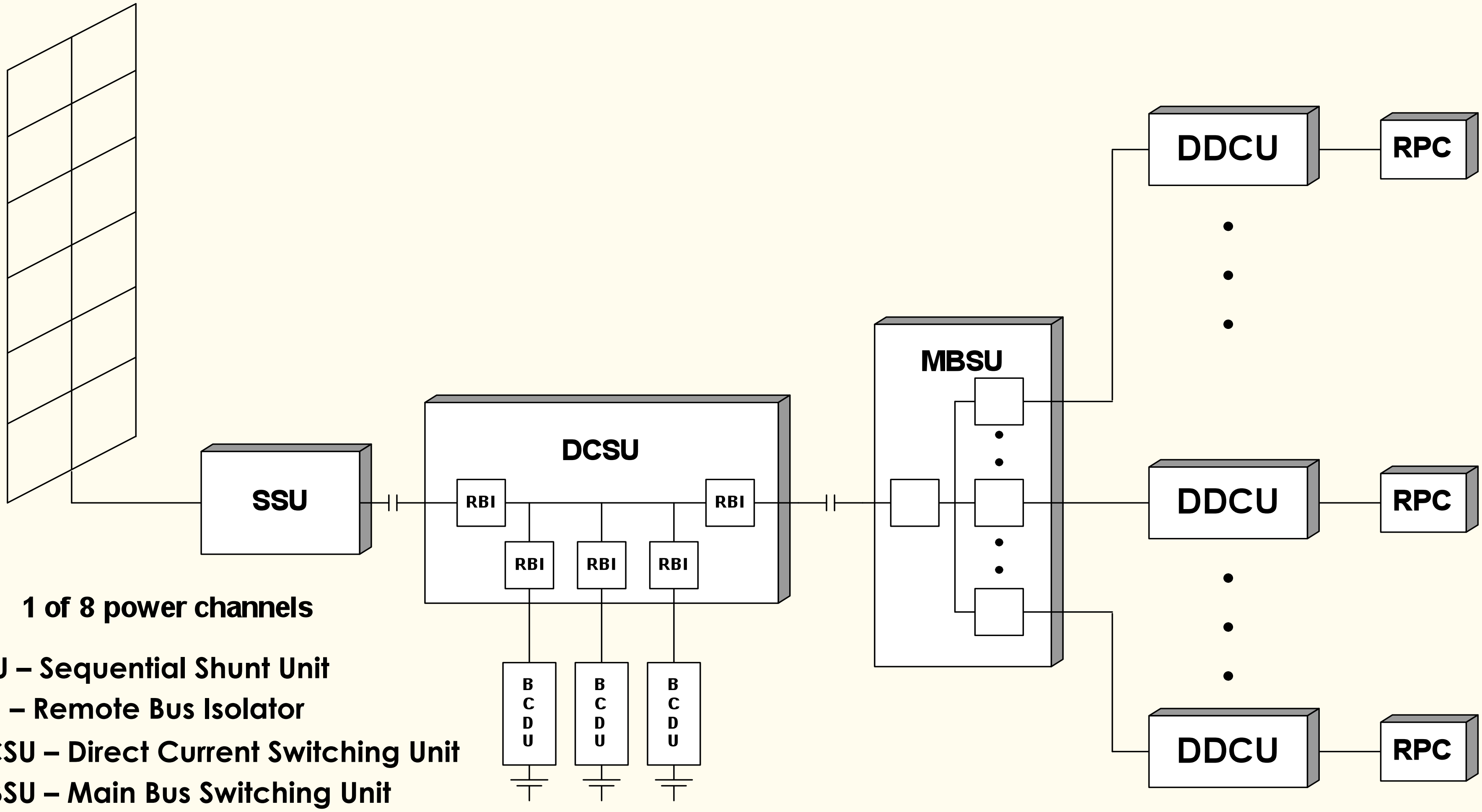
A Little Review of ISS Power

ISS Power System Characteristics

- Power 75 kW average
- Eight independent power channels -- 9.75 kW
- Solar array power
  - 200+ kW silicon arrays
- NiH battery storage
  - 1900 amp*hrs
- Distribution
  - 116 – 170 V primary
  - 120 V secondary

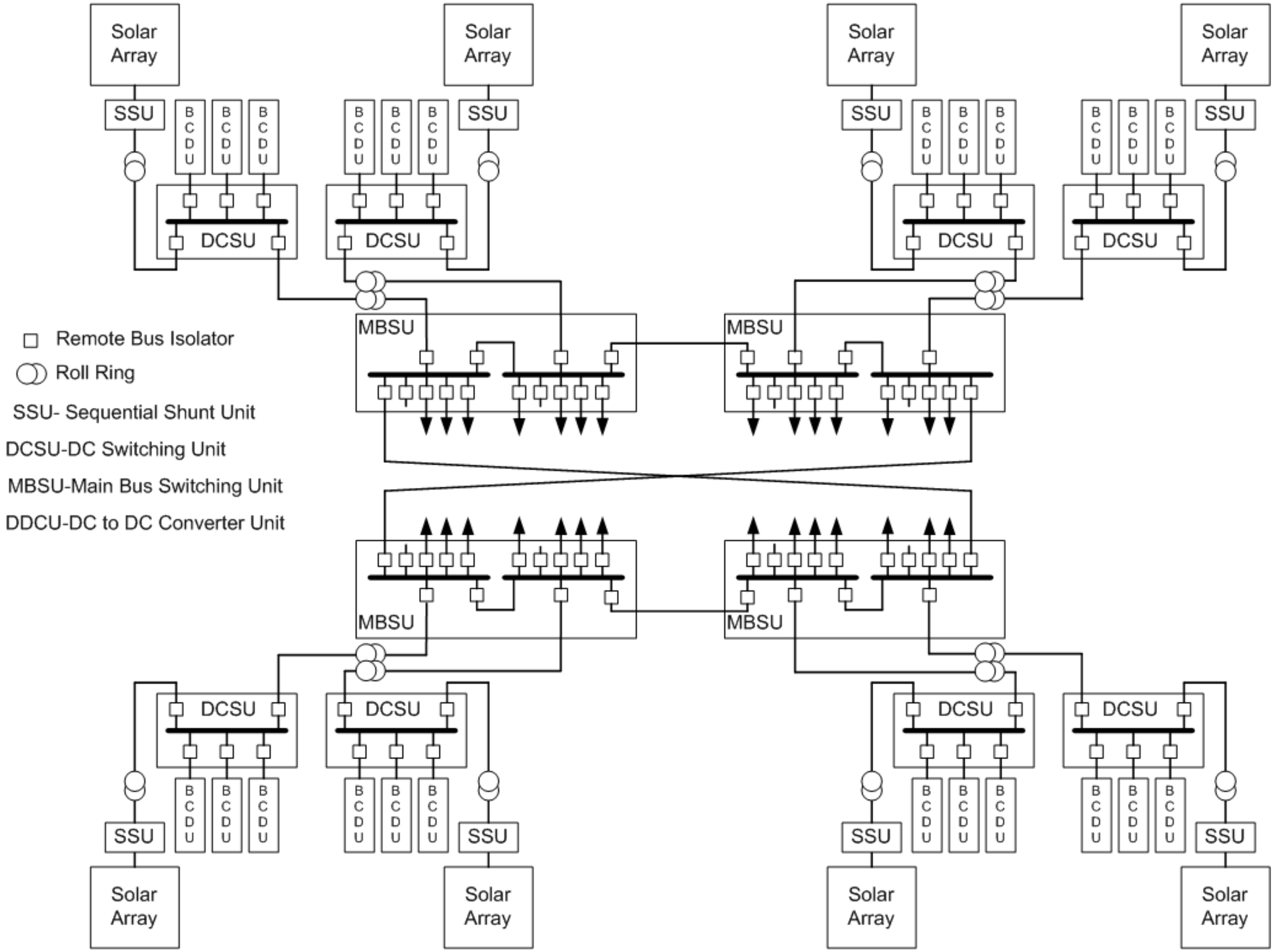
ISS is the largest power system that currently flies in space

ISS Power Architecture

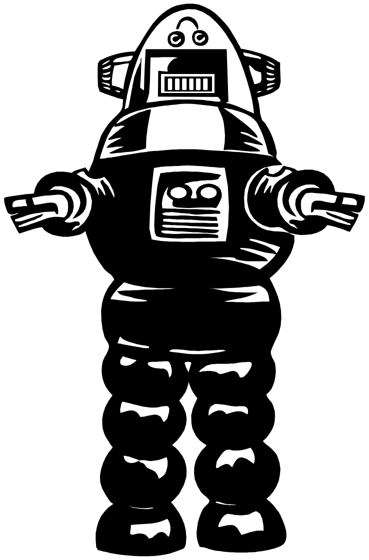


1 of 8 power channels

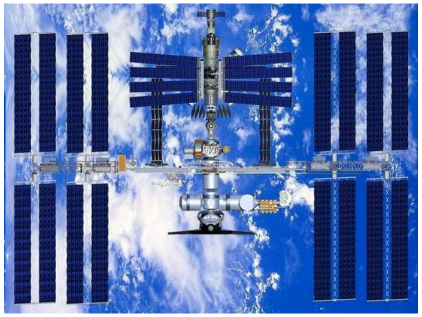
SSU – Sequential Shunt Unit
RBI – Remote Bus Isolator
DCSU – Direct Current Switching Unit
MBSU – Main Bus Switching Unit
DDCU – dc to dc Converter
RPC – Remote Power Controller



The ISS power system is a power grid

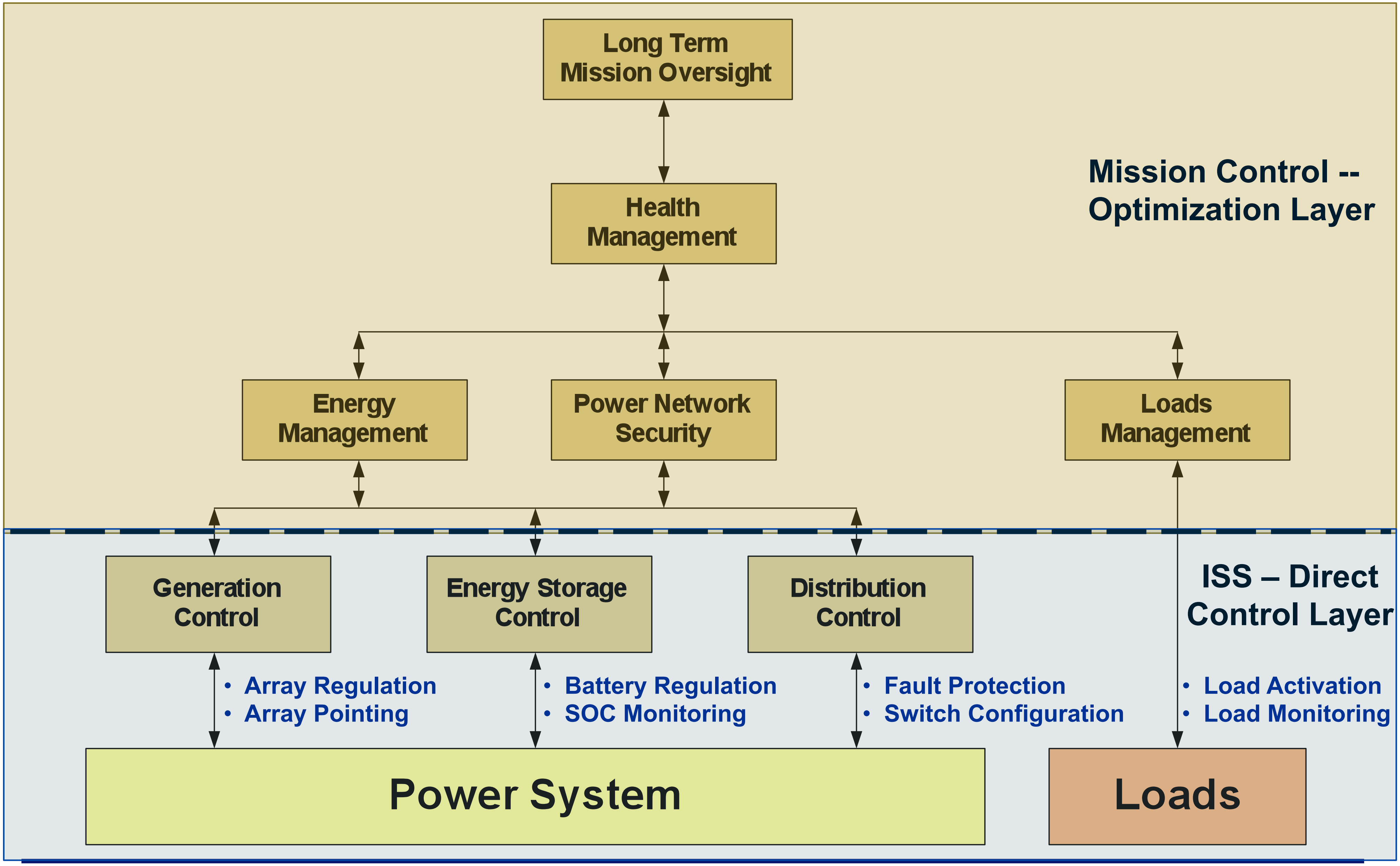


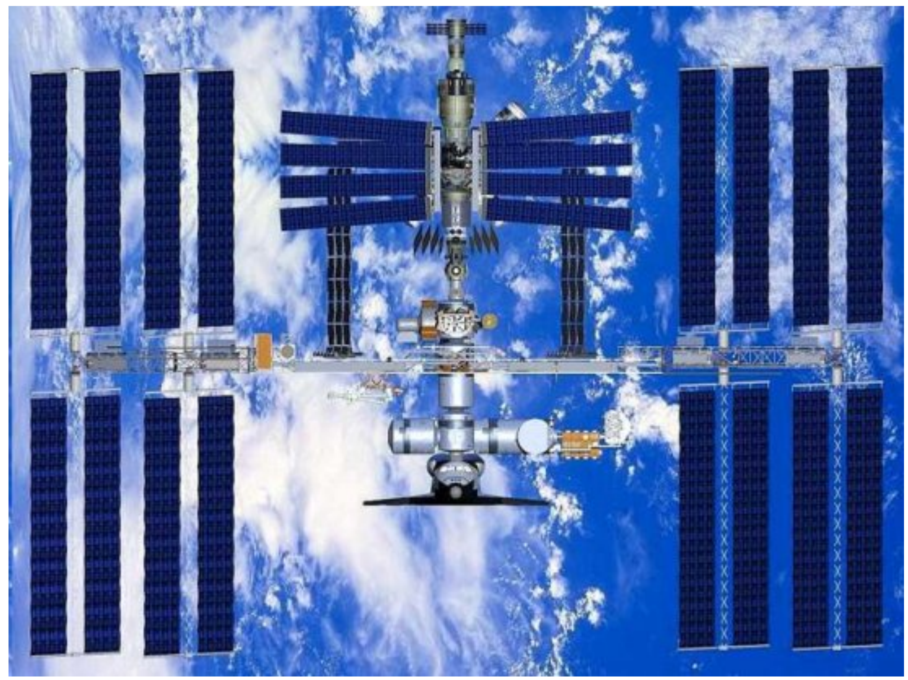
Autonomous Future



ISS relies on continuous real-time support of mission control

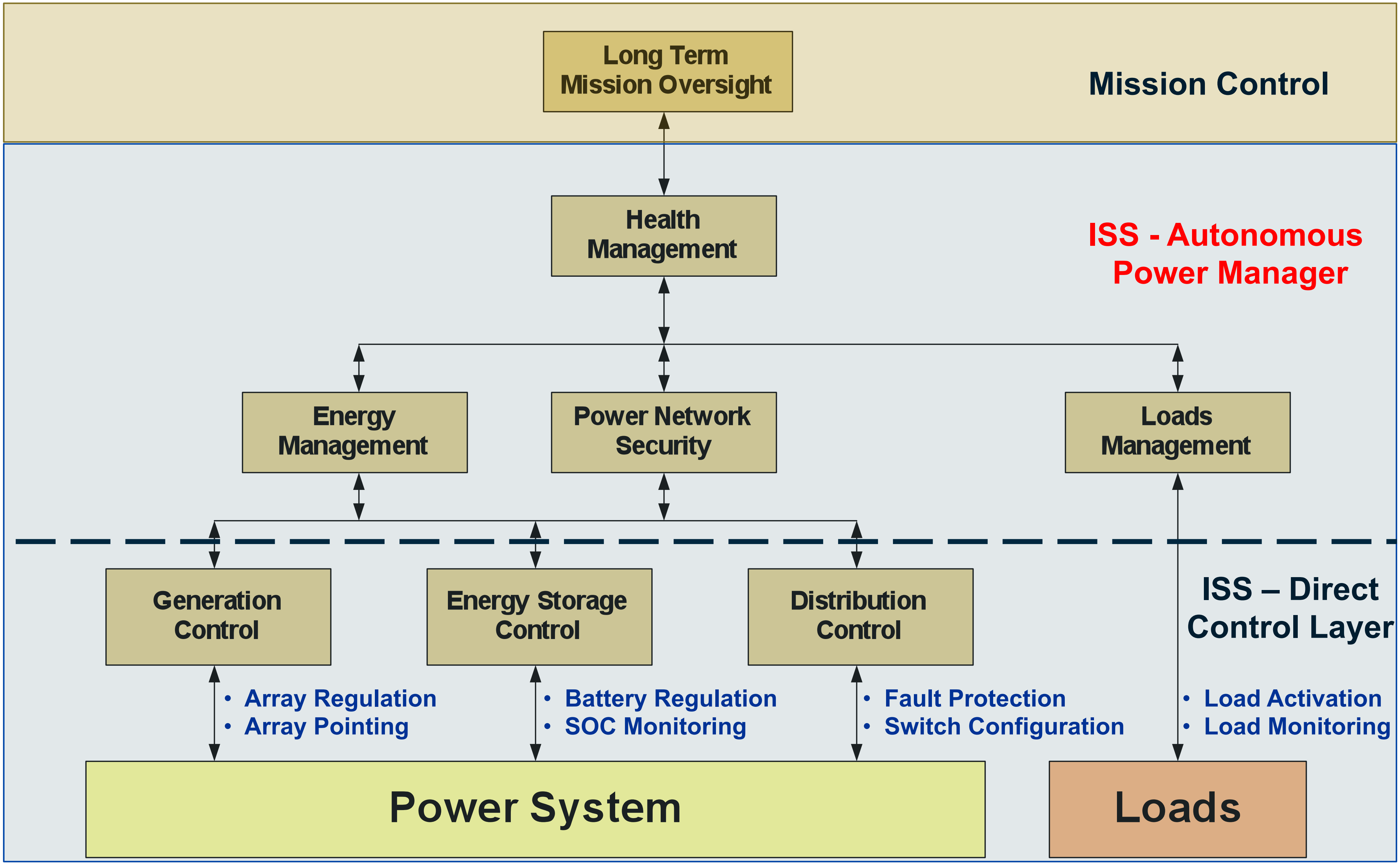
Current ISS Power System Control Functionality





Future space needs to have less dependence on the ground and more on internal intelligence. The ISS can be a pathfinder

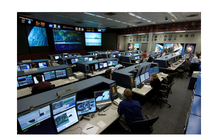
Future ISS Power with Autonomous Power Manager



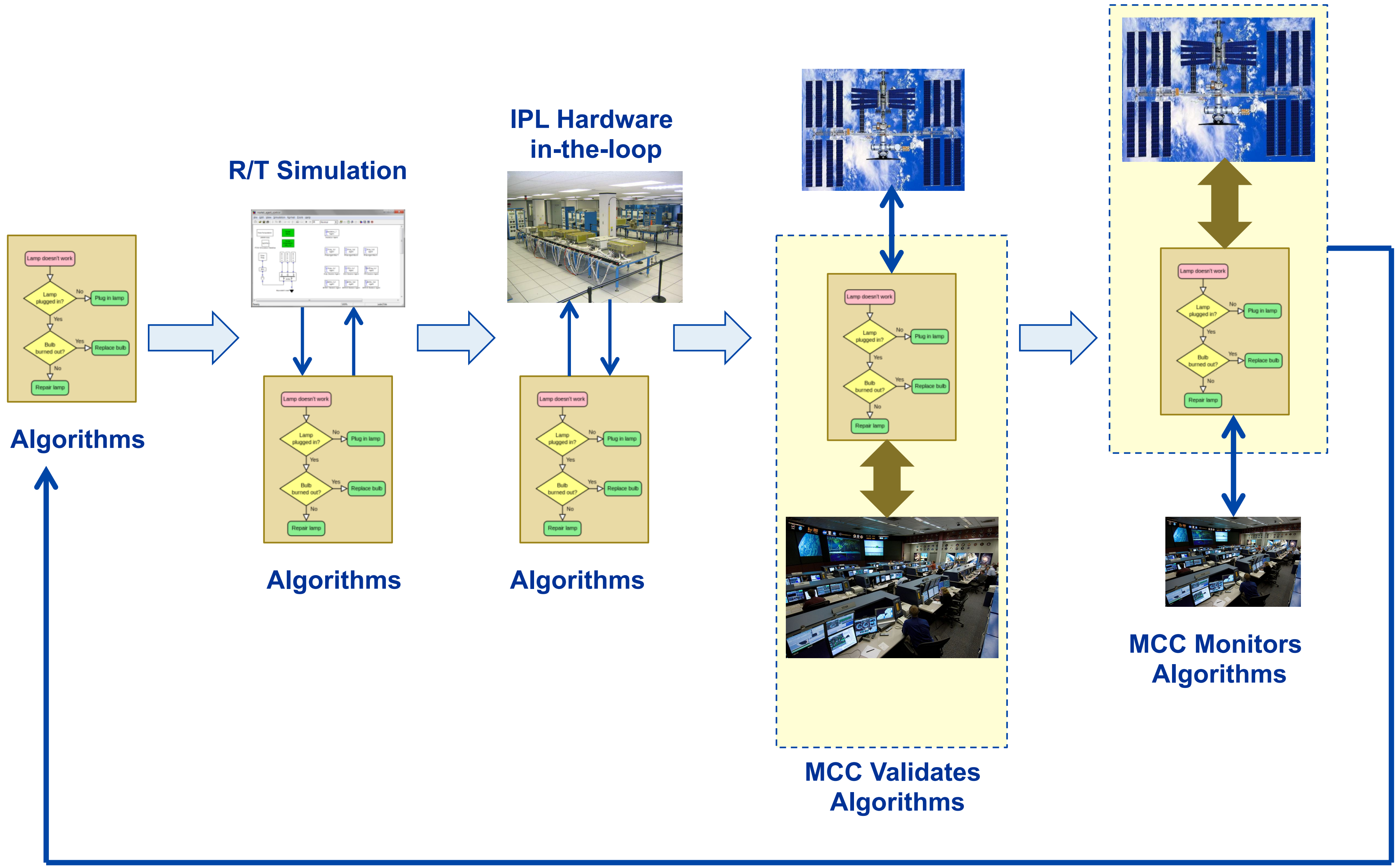
So How Do We Proceed?

National Aeronautics and Space Administration

Incremental Development & Demonstration Approach

Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Direct Control	Direct Control	Direct Control	Direct Control	Direct Control
	Energy Mgmt.	Energy Mgmt.	Energy Mgmt.	Energy Mgmt.
		Load Mgmt.	Load Mgmt.	Load Mgmt.
			Pwr. Net. Sec.	Pwr. Net. Sec.
				Health Mgmt.
				

Development Approach



Can we Apply Leverage to Achieve our Objectives?

National Aeronautics and Space Administration

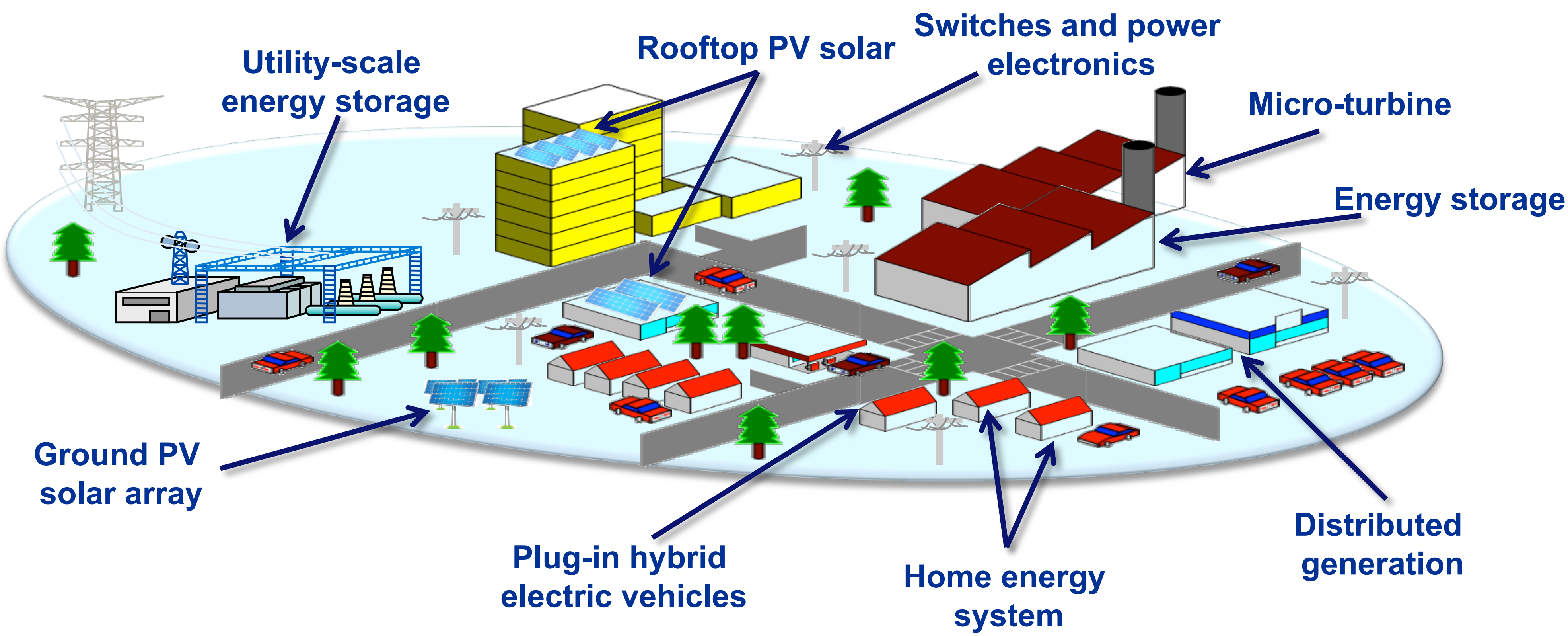
Commonality with Future Terrestrial Grids

Exploration Power vs Terrestrial Power

Exploration Power | **Terrestrial Power**

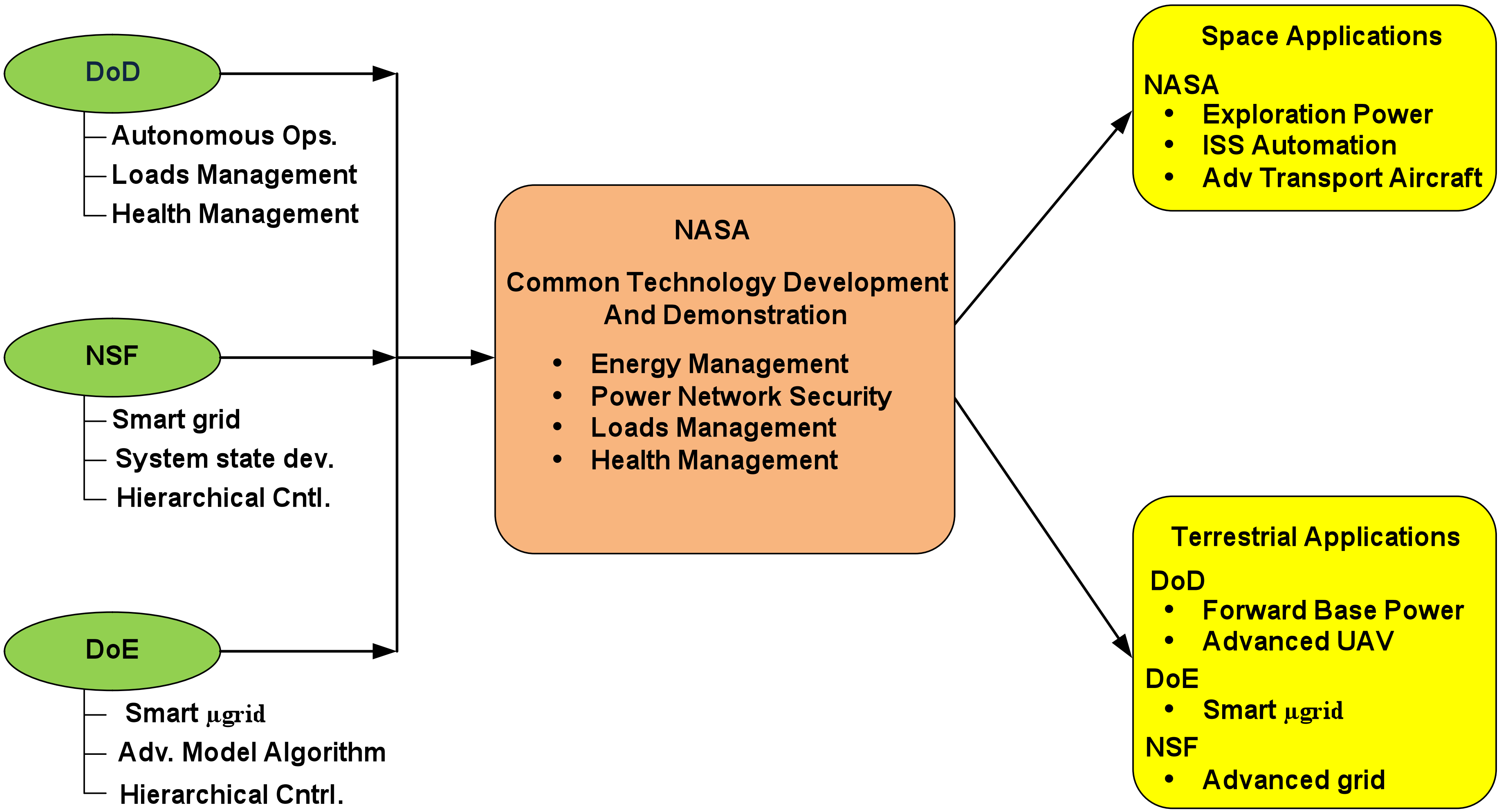
x	Automated control for operations management, fault detection and system reconfiguration	x
x	Increased power demands	x
x	Incorporation of large amounts of distributed energy storage	x
x	Seamless accommodation of Variable / Peak load demand	x
x	Failure diagnostics and prognostics for power components	x
x	Utilization of diverse power sources (renewables)	x
	[illegible]	

What We Learn on ISS Can be Applied on Earth



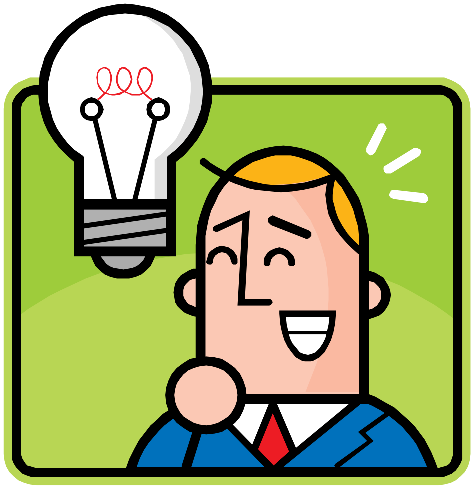
The distributed control of micro-grids proposed for modernization of the US Power Grid has automation issues similar to the ISS

Partnership Approach



Wrap-up

- We need automated systems for long term operation far from earth
- We can use the ISS to incrementally develop and demonstrate capability
- We can leverage other expertise and funding (Smart Grid etc.) to achieve our goals



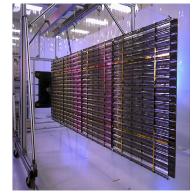
References

- **2001: A Space Odyssey Internet Resource Archive**

http://www.palantir.net/2001/gallery/mission.html

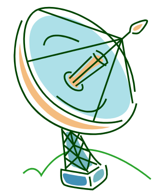
Back-up Slides

Energy Management



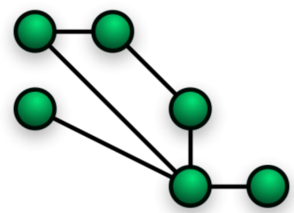
Control power generation and storage

Load Management



Schedule housekeeping, experiments, etc.

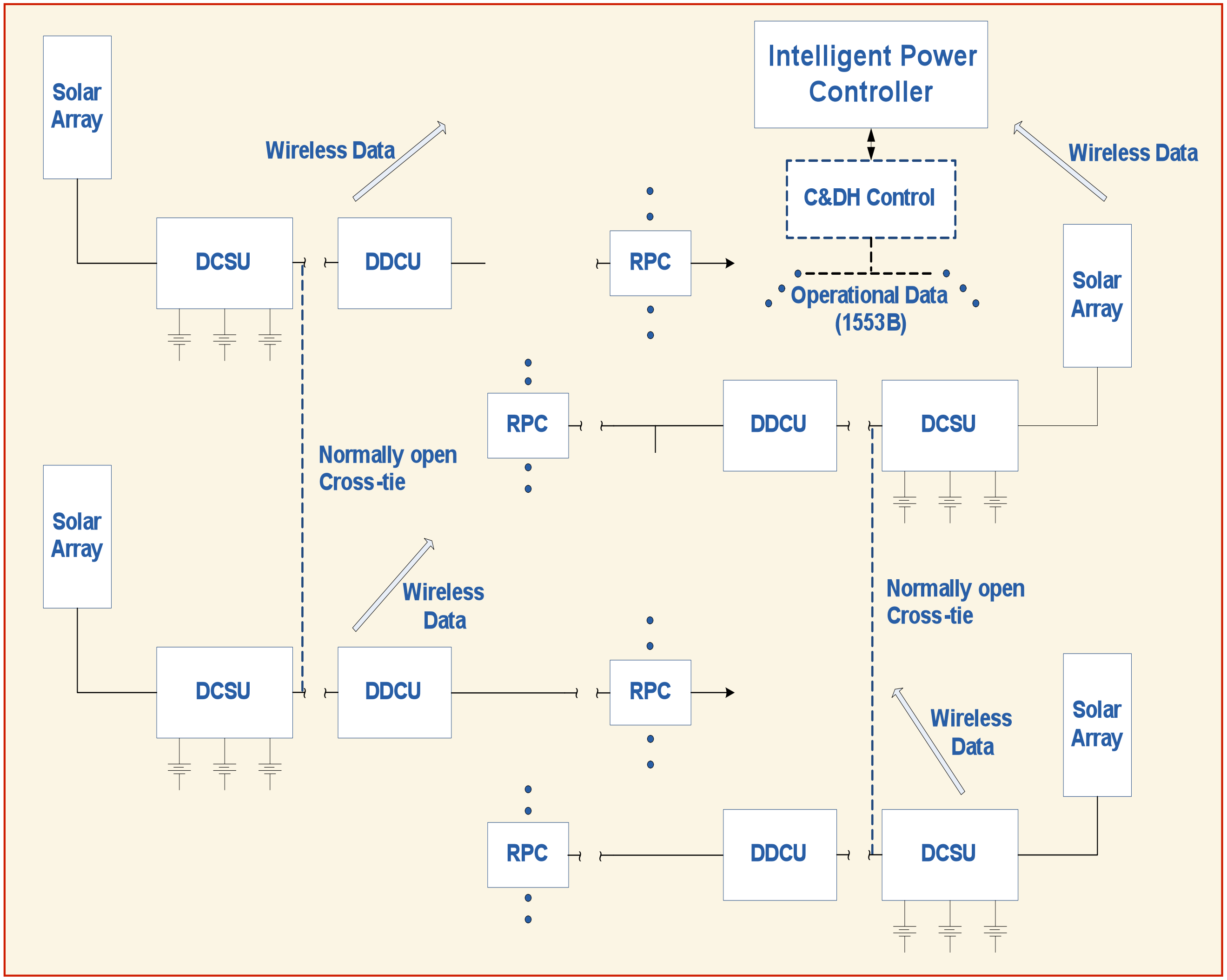
Network Security



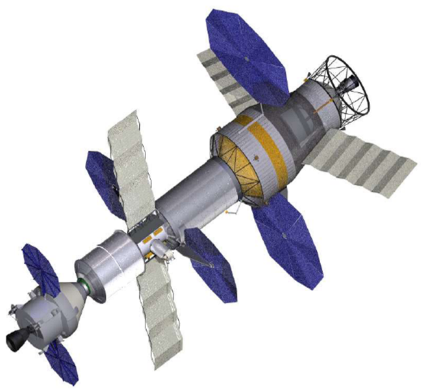
Optimize and control the configuration of the distribution network

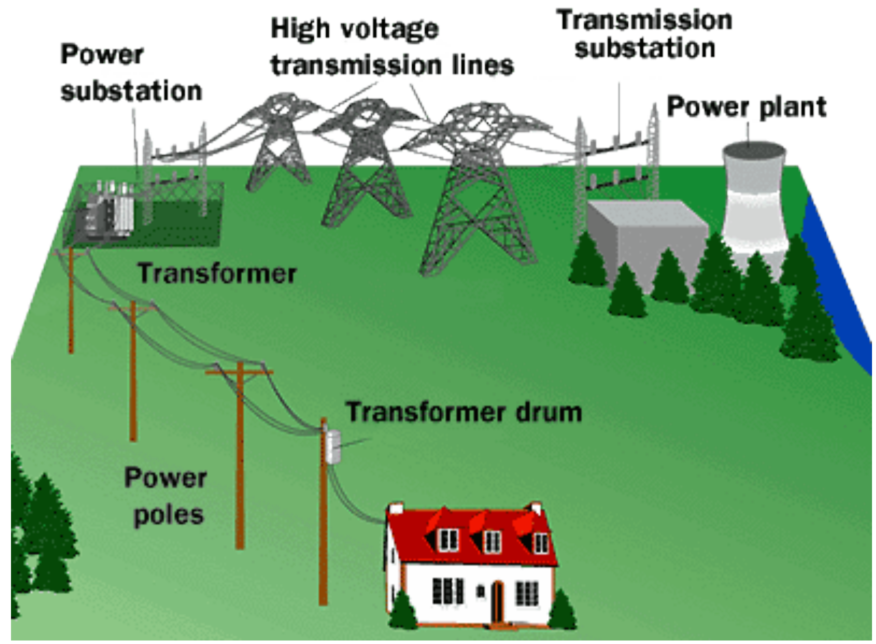
Health Management

Diagnose the state-of-health of ORUs



To implement on ISS, the current C&DH system is unchanged and wireless sensors plus an Intelligent Power Controller is added





Terrestrial

Exploration

The power system development issues for Exploration are common with that Terrestrial "Smart Grid"