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# A Spacecraft Backbone Plug ‘n’ Play Concepts for a Deep Space Habitat

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December 16th, 2015

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# Deep Space Habitat

- Human Exploration and Operations Mission Directorate (HEOMD) multi-phased development approach
- Includes missions in cislunar space to demonstrate and validate hardware/operational techniques in a “proving ground”
- Each mission is a build up from previous missions
- Decreasing reliance on Earth, developing systems necessary for pioneering space and the journey to Mars

- **Resilient architecture featuring multi-use, evolvable space infrastructure**, minimizing unique major developments, with each mission

# HUMAN EXPLORATION

*NASA's Path to Mars*

## EARTH RELIANT

MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

Mastering fundamentals aboard the International Space Station

U.S. companies provide access to low-Earth orbit

## PROVING GROUND

MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit

The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

## MARS READY

MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

Developing planetary independence by exploring Mars, its moons and other deep space destinations

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# Strategic Principles

- Application of high **Technology Readiness Level (TRL)** technologies for near-term missions, while focusing sustained investments on **technologies and capabilities** to address challenges of future missions
- Exploration beyond low-Earth orbit will involve the coordination, cooperation and support of other countries
- Continue and expand international partnerships to achieve a greater set of exploration objectives, earlier and more effectively

# Objectives

- Affordability initially and for 20 years (or more) into the future
  - Specifically, low initial and future integration costs
- Non-proprietary systems and interfaces that allows all vendors (in competition with one another) to create add-on products that increase a system's flexibility, functionality, interoperability, potential use, and useful life
  - Ex: want to replace a part of your air conditioning unit at low cost without replacing the whole thing, including air ducts

- Uses official and/or popular (international) standards that have strong support in industry.
  - That is, standard & common power, electrical, and data interfaces

- Allows use of open source (free/low cost) software and hardware
- Allows users to customize and extend a system's capabilities to suit requirements as they change and evolve over time

***A Spacecraft Backbone has promise to address these needs***

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# Approach

- Utilize ISS and Habitat designs to define & analyze system interfaces

- Focus on where standards are used, or should be used
  "Open standards at system level more important than subsystem level"

- Identify key questions to answer, such as…
  - What elements are part of the "spacecraft backbone"?
    - **Network**
    - **Software and common protocol layer**
    - **Data system**
    - **Power**
    - Water
    - $CO_2$ reduction
    - Fans
    - Filters (Water and Air)
    - etc.
  - Where should standards be applied?
  - Where should standardized hardware and software be used?
  - What requirements will enable open sustainable architecture?
  - Are "self recognizing" plug 'n' play interfaces feasible, where and to what degree?

# Approach

**ConOps**

**ISS Designs, Standards, Interfaces**

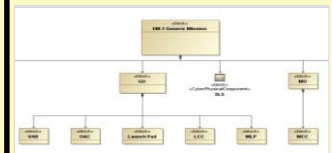
**Habitat Designs**

**Mission Objectives**
Open & Evolvable Architecture

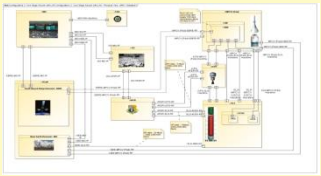
## Utilizes Model Based Systems Engineering Approach

Perform Analysis Activities

Components



Interfaces

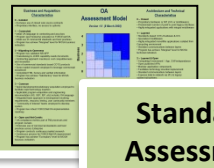


OA & Standards Used

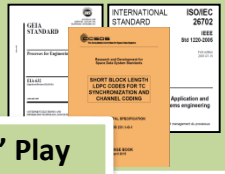

Questions

**Plug 'n' Play Habitat Requirements**

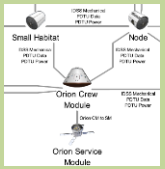
**Plug 'n' Play Assessment**



**Standards Assessment**




**Plug 'n' Play Architecture**



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# Future Needs

- Greatest need in avionics is high performance computing systems, which include processor, memory and INTERCONNECT – in the interconnect area, need a high speed (order 10Gb/s or greater), highly reliable, real time capable, low power, general purpose interconnect that is and capable of operation over copper, fiber optic and wireless media - *R. Some Program Technologist*

- Figures of Merit
  - Security/Threats
  - Reliability/Vulnerability
  - Data Rate
  - Fault Protection/Fault Tolerance
  - Radiation Hardened
  - Real-time (deterministic)
  - Common architectural approach
    - May be used in variety of configurations
  - Storage
  - Mass

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# Spacecraft Bus Trade Study

| Bus Name | Bandwidth | Fault Tolerance | Radiation Hardness | Point to Point Connection | Network connection | Real Time (Deterministic) | Common Architecture | Reliability/ Vulnerability | Security |
|---|---|---|---|---|---|---|---|---|---|
| MIL-STD-1553 | 1 Mbps | | Y | | X | X | X | X | X |
| Time Triggered Ethernet (TTE) | 1Gbps | | Y | | X | X | X | X | X |
| Wireless (802.11x) | 50Mbps | | N | | | ? | | | |
| SpaceWire | 100Mps | | Y | X | | X | X | X | X |
| SpaceFibre | 200Mps | | ? | | | X | X | X | X |
| Serial Peripheral Interface (SPI) | <1Mps | | Y | M/S | | X (latency) | X | X | X |
| Inter-Integrated Circuit ($I^2C$) | <1MPs | | Y | X | | | X | X | X |
| Controller Area Network (CAN) | <1MPs | | N | | X | | X | X | X |