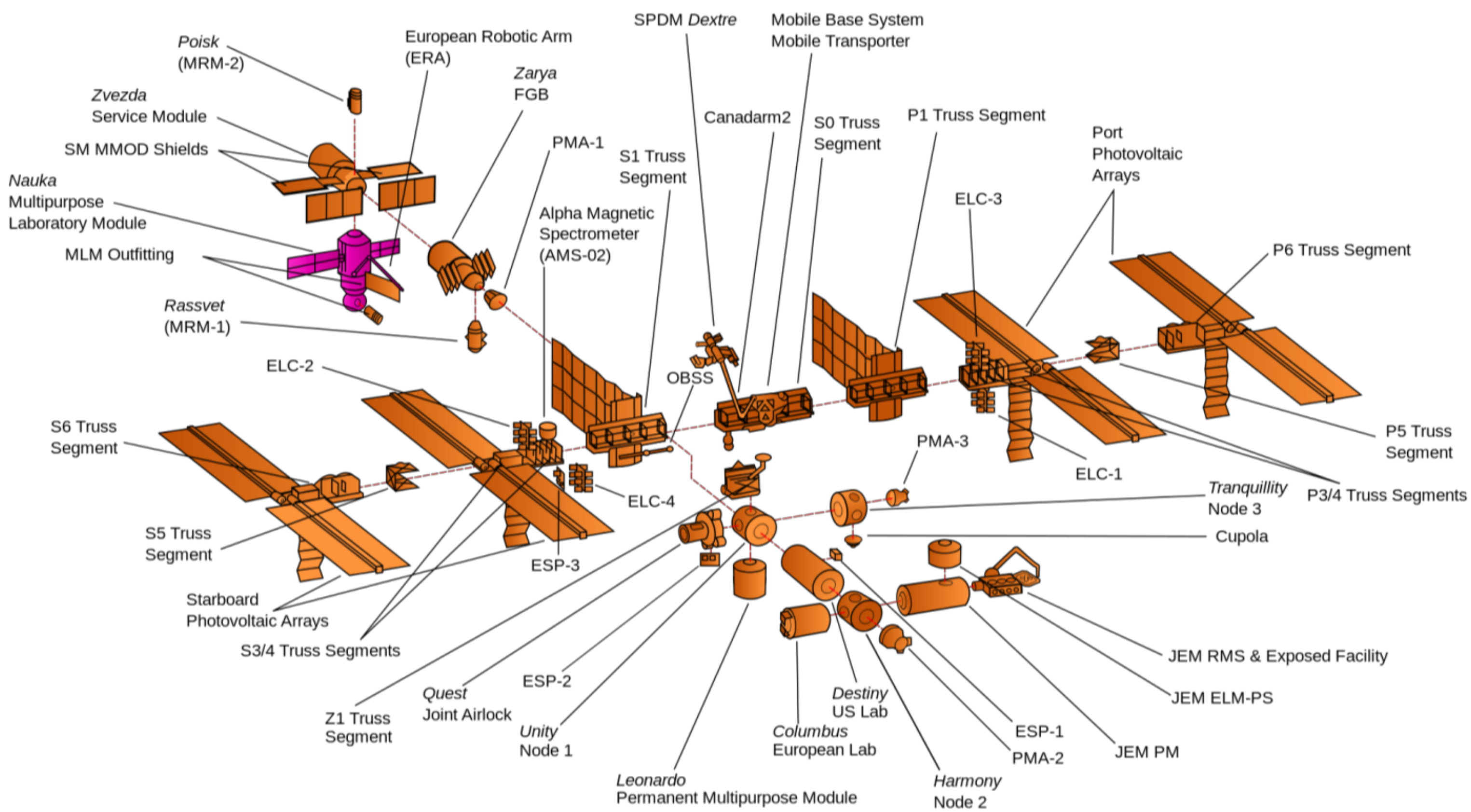
ISS Lessons Learned

Matthew Duggan

ISS Background

- International Partnership - ESA/JAXA/CSA since 1988, Russia since 1993
- A key part of ISS success was the successful integration of hardware and needs into requirements and specifications



ISS Systems Engineering

- ISS systems engineering challenges:
  - Extended Development
  - Test and Verification
  - Program Scale
- Each stage had to operate as a standalone vehicle, requiring multiple baselines.
- ISS required integration of multiple partners with different hardware and different approaches to engineering, safety and risk management.
- Developed innovative methods to test and verify interfaces.
- Fused diverse system engineering approaches to develop a complete set of requirements and verify that the design met those requirements.

ISS Restructuring

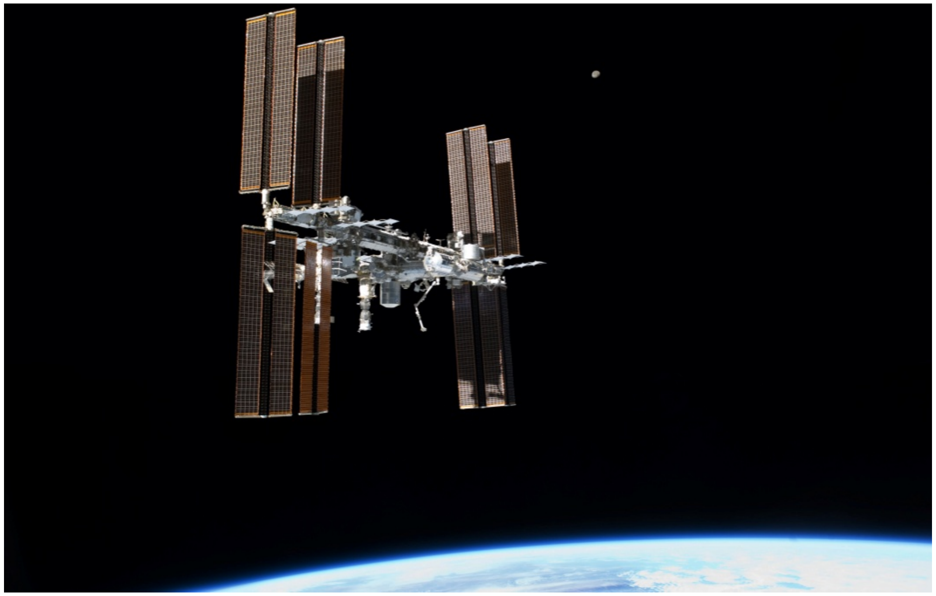
- Restructured from Freedom to Alpha
  - Significant integration challenges due to geographic spread and the decoupled financial oversight
  - Responsibility for systems engineering was not linked to work package definition authority
  - Boeing became prime contractor and prime systems engineering integrator - MIL-STD-490
- Restructured from Alpha to ISS to partner with Russia
  - Merged of Alpha (NASA/ESA/NASDA/CSA) with Mir (Russia) to form ISS
  - Significant integration challenges due to geographic spread and pre-existing hardware
  - Required integration of numerous existing elements into a coherent set of requirements and specifications

ISS Lessons Learned

- Keep systems engineering in mind from the start – integrated planning, interfaces and teams.
- Keep interfaces as simple as possible.
- Don't let hardware development outpace program planning.
- Evolutionary design can have advantages over revolutionary designs.
- Multi-element integrated testing, with flight hardware or high fidelity simulators, is vital and should be planned from the start.

Leveraging ISS

- Future Exploration programs are likely to face similar challenges to ISS – financial, political and engineering.
- Use ISS as a testbed for Exploration technologies.
- Use ISS partnership agreements as a basis for Exploration.



Interoperability

Industry Perspective

Interoperability

- Interoperability is the interconnection of disparate systems for a common goal
- Standardized parts and processes can reduce sparing, improve readiness, and increase integration.
  - Lower costs with more reliability
- Highly focused, special purpose designs produce complex systems that are not interoperable and are unable to evolve.
- Interoperability aids systems engineering by mitigating the difficulties of integrating several partners
  - Decouples design efforts and allows the creation of independent, complementary systems with common interfaces.

Approaches

- Interoperability requires a clear understanding of system objectives and goals at the policy level.
- However, user needs and technological environments must also be considered to ensure that best practices are captured.
- Apply common standards and tools for developing interfaces
- Use existing robust interface designs whenever possible
- Minimize external interfaces for end-to-end systems

Areas for Interoperability

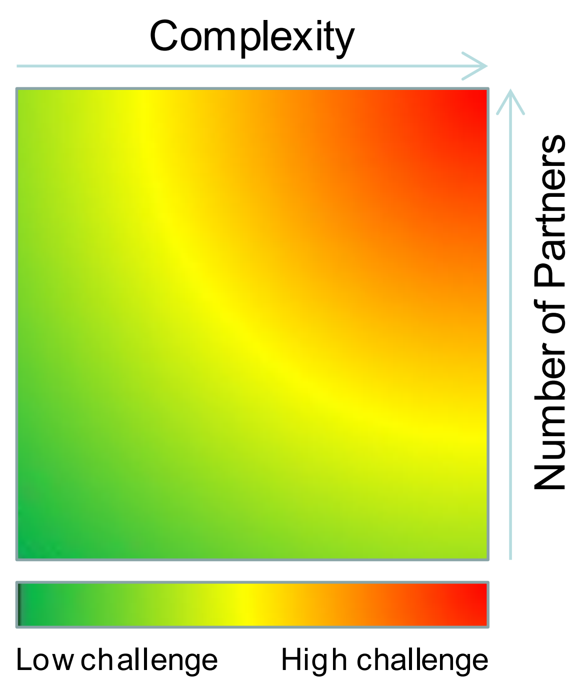
- Life Support
  - Joint atmosphere and water
- Power
  - Voltage and quality
- Structures
  - Docking systems
- Data Handling/Communication/Software
  - Telemetry, audio/video and command passing
- Navigation
  - Attitude determination and control
- Common
  - Spares and consumables
- Ground
  - Control centers, planning, procedures, training, safety
- Program Management Structure

Challenges

- Different industry and safety standards
- Different life cycle development philosophies
- Different engineering and management practices
- Export control
- Different national priorities

Risks

- Greater complexity increases risk.
- Dissimilar redundancy contributes to system redundancy (fault tolerance) by avoiding common failure modes.
- Functional versus fault tolerant risk assessment can also reduce complexity
- Must balance risk of extended logistics chain



Path to Interoperability

- Apply a systems engineering approach from the beginning.
- Set interoperability as a goal.
- Determine elements to be interoperable.
  - Systems, payloads, ground, etc.
- Define joint processes to define and control interfaces.
  - Establish boards and panels, WGs, TIMs, etc.
  - Define a selection process and set comparison criteria to evaluate competing options
- Drive the process and implement the decisions.
  - Overall design architecture, interoperability standards, common vendors, COTS, etc.

Recommendations

- Interoperability planning for Exploration should start now.
- ISS is a valuable starting point for interoperability.
- Create a global Exploration interoperability advisory structure
  - Promote the communication and integration necessary for interoperability.
  - Create a body of commonality/ interoperability standards
  - Pursue interoperability from the top down but build it from the bottom up.