National Aeronautics and Space Administration

Human Health and Surface Exploration Panel Workshop
ECLSS & Habitation Systems






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Outline:

- An Operational Perspective
- Technology Development and Systems Engineering
- Interdependencies
- Key factors
- Closing

An Operational Perspective

- Flight Programs have been a critical mechanism for technology development & maturation
  - Baseline Shuttle Environmental Control & Life Support System (ECLSS) was a substantial technological advancement
    - Supported by significant system-level integrated testing
  - The need to extend Shuttle Orbiter mission duration drove further ECLS technology development via upgrades
    - EDO waste collection system
    - Regenerable CO2 Removal System (RCRS)
    - Shuttle Urine Pretreat Assembly (SUPA)

An Operational Perspective

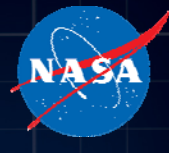
- This approach can be unnecessarily burdened by numerous constraints
  - Configuration management requirements
  - Integration within existing system's requirements
  - Safety impacts
  - Operational constraints
  - Logistics-related manifest limitations

- The result: Difficult ***and*** Expensive

Technology Development & Systems Engineering

- We tend to think of “technologies” as components that are used to assemble a System
  - LiOH cans
  - Carbon Dioxide Removal Assembly (CDRA)
  - Amine swingbed
- But ECLS “technologies” are ***processes*** that are integrated to assemble a larger process
  - Atmosphere revitalization
  - Water management
  - Waste management
  - Pressure control
- The ECLS ***Process*** does not end
  - Constant operations
  - Closely monitored
  - Frequent operational changes

Technology Development & Systems Engineering



- Systems Engineering expects us to pursue an integrated approach from cradle to grave
  - Typically mission-driven
  - Mindful of life cycle costs
  - Requirements based
- We can apply SE principles to develop capabilities and technologies, independent of specific mission requirements
  - Function-driven
  - Satisfy basic requirement set and understand flexibilities & limitations
  - Always strive for minimum mass, volume, power
- For TA06 ECLS roadmap the key drivers (sect. 2.1.1, p.8) are:
  - High reliability processes & integrated systems
  - Increased self-sufficiency
  - Minimized logistics supply

Interdependencies

- ECLSS processes are interdependent, and that interdependency increases with the need to recover resources
  - "Air loop" and "water loop" are linked
  - Waste collection, management & "repurposing" are linked to air & water
- Disruption of a sub-process can initiate a "ripple effect" through the larger ECLSS process
  - Example: alcohol from wipes collects in condensate and "poisons" water processor and/or oxygen generator, driving hardware repair or replacement
- Integrated performance is a critical component of any ECLSS technology or process development effort
  - Neglecting to do so prior to on-orbit implementation is a guaranteed cost and risk multiplier

Key Factors

- Environment
  - Gravitational effects & fluid dynamics
  - Thermal
  - Pressure & Oxygen
- Operational
  - On/off cycling
  - Contamination
  - Degradation
  - Maintenance
  - Emergency response
- Architectural
  - Transportation vs. Habitat
  - “Plug & play”
  - Upgradability

Vulnerabilities and Gaps

- Current
  - Oxygen generation (electrolysis)
  - Urine processing/water recovery
  - Water chemistry control
  - Onboard air & water quality monitoring and verification
  - Regenerative CO2 removal
  - Gas/Liquid separation
- Future / Ongoing
  - Contamination control/filtration
  - Materials
  - Interfaces (fluid & electrical connectors, human interfaces)
  - Instrumentation & control systems
  - Mass, volume, power reductions

Closing

- The key to long-term manned space operations is a stable, reliable ECLS that enables increasing self-sufficiency
- ECLS is a ***PROCESS*** made up of several interdependent sub-processes
- Technology/process development must consider and quantify effects on the greater integrated process
- Regenerative ECLS is game-changing for long-duration spaceflight
- Further development of the ISS regenerative ECLS shows the greatest promise for a point of departure for exploration beyond LEO