ECLSS Technology Development on ISS

Aeronautics and Space Engineering Board Meeting
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Agenda

- ECLSS Roadmap and Gap Analysis
  - Key Results
- Plans for utilizing ISS
  - Current
  - Proposed
- Challenges & Forward Work

ECLSS Roadmap & Gap Analysis

- "Highly reliable ECLSS" was identified as one of the top priorities in the OCT roadmaps
  - TA06 – Human Health, Life Support, and Habitation Systems)
- In order to pinpoint areas within ECLSS requiring further work, the ECLSS community performed a gap analysis
  - ECLSS broken into functional areas
  - State of the Art was measured against 3 representative missions which map to all candidate Exploration DRM's
    - 1- Short-duration microgravity or surface (< 1 month)
    - 2 - Long-duration microgravity (1 month – years)
    - 3 - Long-duration surface (1 month – years)
  - Gaps identified in 2 categories
    - "Enabling" – will not be able to perform mission without some improvement or additional capability
    - "Enhancing" – could perform mission with current SoA but improvement would be beneficial
  - Results recently reviewed and adopted by larger international partner ECLSS community
    - Currently determining which technologies would benefit from ISS demonstration and how IP countries can contribute, as part of IEWG efforts

Current ISS ECLSS – What's Worked & What Hasn't

- What's worked well:
  - Trace Contaminant Control System
  - O2/N2 storage & distribution system
  - Air circulation (intermodule ventilation fans/valves, cabin fans)
  - Emergency equipment (masks, fire extinguishers, smoke detectors)
  - Potable water distribution system
  - Vehicle pressure control

- What has had challenges:
  - Carbon Dioxide Removal Assembly – sorbent dusting, heater short, temp sensor failures
  - Major Constituent Analyzer – mass spec life issues, controller logic faults
  - Oxygen Generation Assembly – cell stack contamination and failure, overall complexity and reliability
  - Urine Processor Assembly – calcium sulfate precipitation and Distillation Assembly failure
  - Water Processor Assembly – effects from biomass formulation, contaminant breakthrough, catalytic reactor leakage
  - Filtration issues - dust bunnies at fans, mufflers not protected by HEPA filter
  - Condensate collection - CHX and water separator hydrophilic coating degradation

(Red items still in work)

Functional Capability Needs – Atmosphere Management - Enabling

Function	Need	Mission				ISS Demo Value
		ISS	1	2	3	
Fire Suppression	**Replacement for Halon & CO2 PFE (small volume, non-toxic)**	X	X	X	X	Medium
Atmosphere Recovery	**Smoke Eater**	X	X	X	X	Low
Personal Protective Equip	**PPE filtering mask (O2 mask replacement for small volume O2 safety)**	X	X	X	X	Low
Trace Contaminant Control	**Replace sorbents and catalysts which are becoming obsolete & performance improvement (enhancing)**		X	X	X	Medium
CO2 Removal	**Robust sorbent bed (improvement, solves SOA dusting)**	X		X	X	High
O2 Supply	**OGA reliability improvements**	X		X	X	High
O2 Supply	**Oxygen recharge for EVA**	X		X	X	High
Monitoring	**On-board trace contaminant monitor**	X		X	X	High
Filtration	**Surface dust pre-filter**				X	Low
Fire Suppression	**Partial-g material flammability testing data**				X	Low

Functional Capability Needs – Atmosphere Management - Enhancing

Function	Need	Mission				ISS Demo Value
		ISS	1	2	3	
Circulation	Quiet fan technology		X	X	X	Medium
CO2 Removal	Common bed core/commonality		X	X	X	High
Monitoring	Major Constituent Analyzer reliability improvements	X	X	X	X	High
Monitoring	Fire product sensor improvements	X	X	X	X	High
Monitoring	Prop & thermal fluid hazard sensor improvements	X	X	X	X	Medium
Resource Recovery	CO2 reduction beyond Sabatier (possibly enabling depending on trades)	X		X	X	High
Filtration	Longer life/regenerable particulate filters	X		X	X	Medium
CO2 Removal	Lower power	X		X	X	Medium
Resource Recovery	Lower power CO2 compressor	X		X	X	Medium
Resource Recovery	More efficient interim CO2 storage	X		X	X	Medium
Monitoring	Microbial monitor (air and water)	X		X	X	High
Fire Detection	Smoke detector improvements – false alarm, partial-g			X	X	Medium
Monitoring	Surface dust particulate monitor				X	Low

Functional Capability Needs – Water Management

Function	Need	Mission				ISS Demo Value
		ISS	1	2	3	
Urine processing	**Increased water recovery from urine (minimum 85%) (enhancing for missions <6 months) ***	X		X	X	High
Laundry	**Develop laundry capability (enhancing for missions <6 months) ***			?	X	High
Wastewater processing	**Reduce Expendables, extend life**	X		X	X	High
Microbial control	**Testing and potential mods to accommodate long periods of dormancy**			X	X	Medium
Microbial control	Replacement biocide (silver), method for introduction	X (RS)	X	X	X	Medium
Urine collection	Backup to spin separator (robust redundancy)		X	X		High
Urine pretreatment	Alternate pretreat (lower tox, no precip) – ties to increased water recovery	X		X	X	High
Urine processing	Improved reliability, tolerance to precip., calcium monitor	X		X	X	High
Water Chemistry Monitoring	Organic and inorganic species	X		X	X	High
Hygiene capability	Hygiene washing system improvements			X	X	High

Enabling **Enhancing**

Functional Capability Needs – Solid Waste Management

Function	Need	Mission				ISS Demo Value
		ISS	1	2	3	
Stabilization – trash and fecal	**Long term stabilization/planetary protection**			X	X	Medium
Wet trash disposition	Jettison capability (if dumped)			X		Medium
Wet trash – storage & resource recovery	Compaction & dewatering			X	X	Medium
Metabolic waste	Commode improvements	X	X	X	X	High
Metabolic waste - water recovery	If trades show needed			X	X	Low

Enabling **Enhancing**

Current NASA ISS ECLSS Improvement Efforts

Atmosphere Management

- CO_2 Removal (CDRA) reliability → -4 bed redesign (delivery Dec 2012)
- On-orbit trace contaminant monitor → DTO Air Quality Monitor (AQM) (on-orbit) and GFE AQM (launch on SpX-2)
- Water Mist PFE → funded through CDR (Mar 2013)
- PPE filtering mask → approved with flight units delivered Jan 2013
- OGA reliability → remediation kit installed (on-orbit), failed cell stack TT&E (complete), further operational enhancements (in testing and/or evaluation), membrane alternate vendor and material cert required (approved)
- Oxygen recharge for EVA → Nitrogen/Oxygen Recharge System (NORS) (delivery Oct 2013); ceramic oxygen separation from ambient air for Airlock O_2 HPGT recharge (proposal in work)
- MCA reliability/complexity → joint Orion Air Monitor development (approved through SRR)

Water Management

- Water Processor life/expendables improvements → Performance impacts from biomass (evaluation), elevated TOC concerns (MF bed redesign study approved with completion Summer 2013)
- UPA reliability & efficiency due to precipitation → testing and evaluation of calcium remediation via IX bed (approved through PDR in April 2013) and alternate pretreat options (approved)

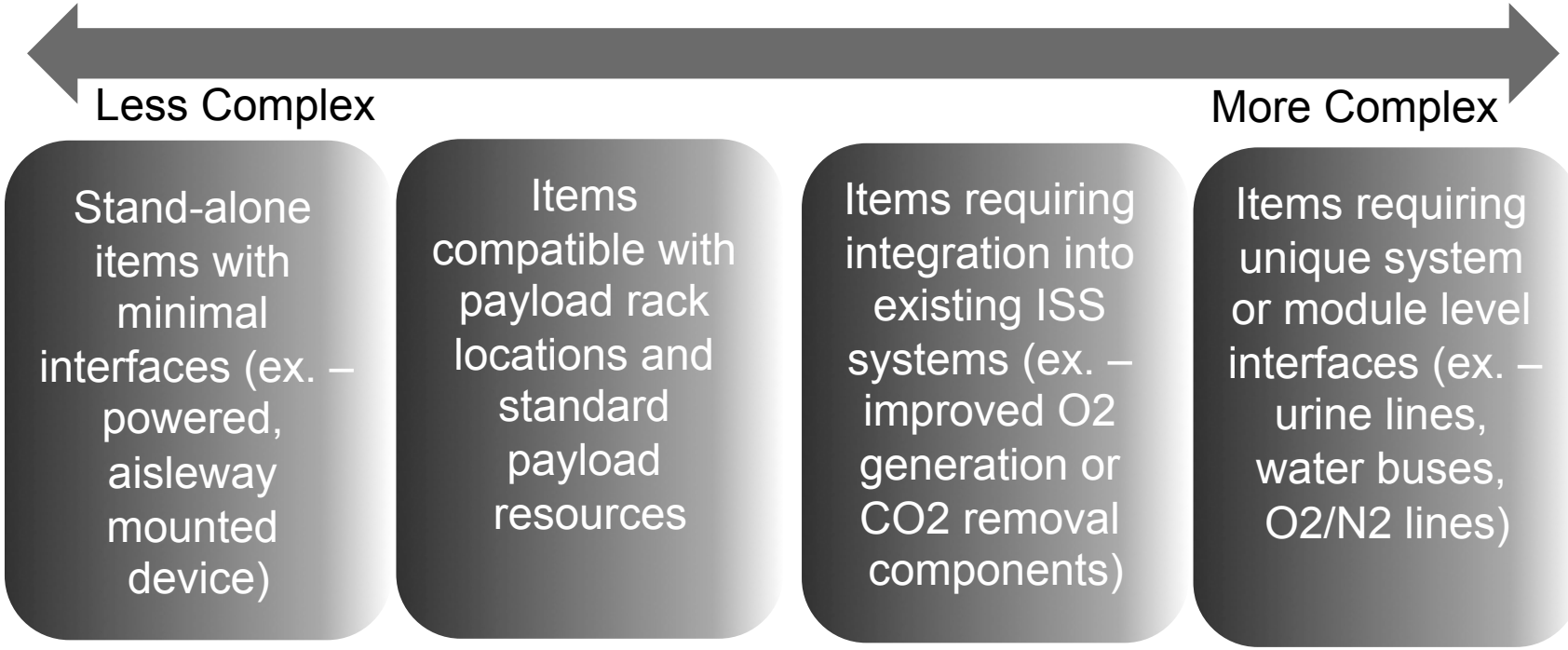
Proposed ISS ECLSS Efforts

- **In addition to current efforts, NASA and its International Partners are planning or have proposed the following:**
  - **Roscosmos**
    - Have made quiet fan improvements
    - Will fly new urine processor on MLM and make improvements to Elektron reliability in 2013
    - Plan to improve life of condensate processor and make urinal reliability improvements
    - Would like to make Vozduhk CO2 removal improvements and add a Sabatier CO2 reduction capability (not yet funded)
    - Working on method for silver biocide introduction
  - **ESA**
    - Plans to fly Advanced Closed-Loop System (ACLS) (O2 gen, CO2 removal, Sabatier) on Columbus in 2016
    - Propose to fly ANITA-2 air monitor and MIDASS microbial monitor in 2016 (pending approval)
  - **JAXA**
    - Plans to fly demonstrations of Sabatier CO2 reduction, Oxygen Generator electrolysis cell, wireless sensor array, and integrated water recovery system on JEM
  - **NASA**
    - Technology programs (AES, OCT) investing in many ECLSS gap areas, but additional flight demonstrations TBD pending funding

Implementation Challenges

- **ISS Demos will be affected by certain inherent ISS considerations**
  - **Finite amount of crew time to support all needed tasks**
  - **Limited available stowage volume and deployment locations**
  - **Lack of "plug-and-play" infrastructure for demos which require more involved integration with existing ISS systems**

- **Complexity of ISS integration will vary greatly across the different demos**



ECLSS Forward Plan

- **Continue to work with subteam under IEWG to evaluate and prioritize list of proposed flight demonstrations (Feb 2013)**
  - *Hope to eliminate some overlapping work in lieu of covering additional gaps*
- **Coordinate within ISS and between ISS and technology programs to lay out timelines and prioritize funding so that critical ECLSS gaps are addressed and validated on ISS before they are needed for Exploration missions.**