Update on NASA Life Support Technology Research and Development

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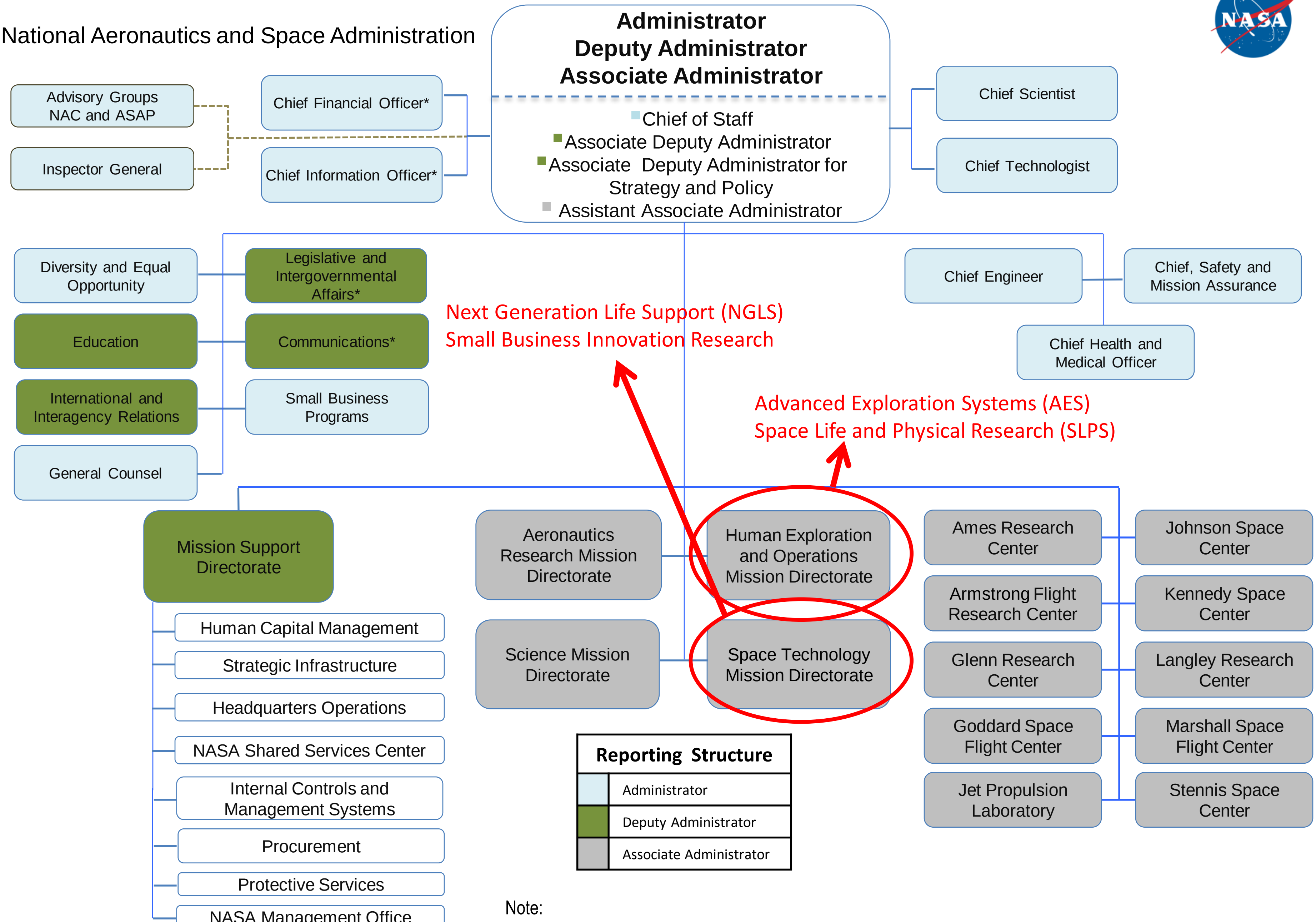

Note:
* Center functional office directors report to Agency functional AA. Deputy and below report to Center leadership.

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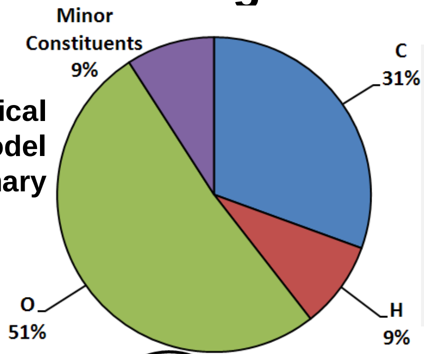
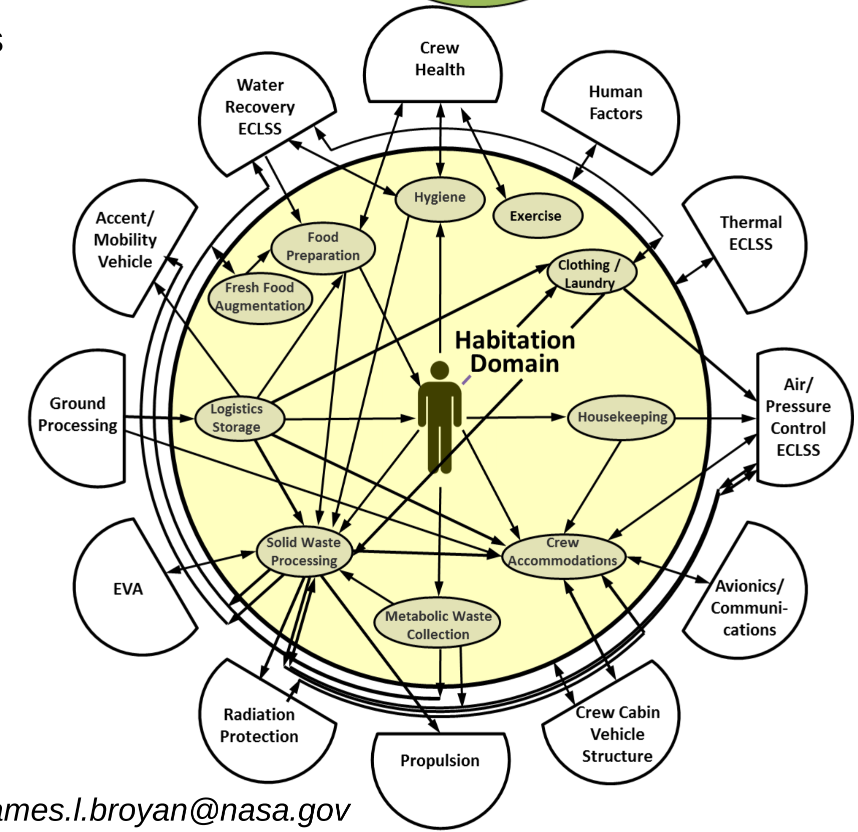
AES Logistics Reduction and Repurposing (LRR)

- **Logistics Reduction and Repurposing (LRR) utilizes a cradle-to-grave approach to reduce total logistic mass**
  - Waste should be considered a resource!!!
- **Six technologies being developed**
  - Direct reduction of logistical mass
    - Advanced Clothing Systems (ACS)
    - Universal Waste Management System (UWMS)
  - Direct reusing and repurposing of logistical items avoids flying separate items to meet both functions
    - Logistics to Living (L2L)
  - Reduce crew time on logistics tasks
    - Autonomous Logistics Management (ALM)
  - Reprocessing of logistical items to provide a secondary function, increase habitable volume, and enhance life support closure
    - Heat Melt Compactor (HMC)
  - Deconstruction of logistical wastes and reconstruction to primary gases or vented to reduce waste volume
    - Trash to Gas (TtG)

LRR Waste Chemical Constituent Model Summary



Minor Constituents	
Element	%
Al	2.4
F	1.8
N	1.5
Cl	1.1
Na	0.80
Zn	0.41
Fe	0.36
S	0.35
K	0.26
Si	0.14
Mn	0.02



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AES Water Recovery Testing

- **Cascade Distiller System (CDS)**

  Objective: Advance the technology readiness level (TRL) of the CDS by testing its performance with flight-like waste streams and define a flight compatible design for the CDS.

- **Brine Water Recovery**

  Objective: Evaluate in-house (ARC and JSC) developed and SBIR Phase II brine dewatering technologies for applicability to an exploration mission architecture. Explore mitigation of common roadblocks associated with brine dewatering in a microgravity environment, including reliable operations and safe handling and disposal of the remaining brine solids.

- **GreenTreat Formula Optimization**

  Objective: Identify and evaluate low-toxicity wastewater stabilization (LTS) alternatives while maintaining the stabilization functions of preventing urea hydrolysis and microbial growth.

- **Silver Biocide**

  Objective: Identify methods for adding silver biocide to water on-orbit during both operational use and dormancy, as well as methods to maintain silver concentration in stored water.

- **Water Recovery Systems Analysis:**
  - Long-term dormancy assessment, Exploration Water Recovery System architecture study, Advanced Controls

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AES Atmosphere Resource Recovery & Environmental Monitoring (ARREM)

The ARREM Project is supported by 6 NASA Centers (ARC, GRC, JPL, JSC, KSC and MSFC)

KSC - Sorbent characterization & Ammonia Reduction
MSFC - Redesign of the TCCS

JPL
JSC
MSFC
ARC

ARC- Reduction of desiccant bed size

MSFC – SOA OGA Improvements & SBIR High Pressure Electrolysis
JSC – Oxygen Compression

Trace Contaminant Control*

Environmental Monitoring*

H_2O

Gas Drying*

CO_2 Removal*

ARC - Two stage CO_2 compressor
KSC - Sorbent Characterization
MSFC - CDRA Improvements & Sorbent Characterization

O_2

O_2 Generation

H_2O

H_2O

Resource Recovery

CO2 Compressor

HyPA

$C_2H_2 + H_2$

CH_4

GRC - Design and testing of cabin filters

JSC - Gas Compression & Storage (CO2 & Oxygen)
MSFC - PPA, HyPA & Alternative Technologies

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Next Generation Life Support Project
Top Level Overview

Project Participants

- **Lead Center:** JSC; **Supporting Centers:** ARC, KSC, MSFC, WSTF (JSC)
- **External Partners:** United Technologies – Aerospace Systems, Cobham Life Support, Texas Tech Univ., Iowa State Univ., Univ. of California – Santa Cruz, Univ. of Puerto Rico

Current Tasks

Extra Vehicular Activity

- **Rapid Cycle Amine Swing-bed**
  - Dual function: removes both CO_2 and humidity from the atmosphere within pressurized space suits.
  - Because it regenerates in real time, it will not limit the duration of extra-vehicular activity.
  - Reduces mass and complexity of the suit by eliminating condensing heat exchangers and separators.
- **Variable Oxygen Regular**
  - Continuous control of suit pressure provides increased safety, operational flexibility & mission flexibility.
  - Robust and tolerant of contamination. Designed to withstand combustion events.
- **High Performance EVA Glove**
  - Generate quantitative standards for glove performance for exploration class missions
  - Develop high performance EVA gloves addressing fatigue/injury, mobility, fit, and durability

Cabin Environmental Control and Life Support Systems

- **Alternative Water Processor**
  - A “green” choice for spacecraft water recycling, treats a wider range of wastewater types and exploits natural biodegradation to mineralize organic and nitrogen compounds in wastewater.
  - The system is capable of treating a complex wastewater stream that includes urine, condensate, hygiene water (including hand wash and shower), and laundry.
- **Bosch Carbon Dioxide Reduction**
  - Further closure of atmosphere revitalization – development of Series Bosch Test Stand


RCA


VOR


HPEG


AWP


Bosch

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Next Generation Life Support
FY14 Technical Accomplishment Highlights

Rapid Cycle Amine (RCA)
- RCA Pre-Integration Acceptance Testing as part of PLSS 2.0 Integrated Test
- Initiated Fabrication of RCA 3.0 Test Article
- RCA Oxygen Hazard Compatibility Assessment
- RCA Ball Valve Life Testing
- Completed Build-Up of the Suited Manikin Test Apparatus
- Held Test Readiness Review (TRR) to Initiate RCA Unit Functional Testing

Variable Oxygen Regulator (VOR)
- VOR Pre-Integration Acceptance Testing as part of PLSS 2.0 Integrated Test
- Oxygen Compatibility Testing
- Initiated Design of VOR 3.0 Test Article

High Performance EVA Gloves (HPEG)
- Glove Mobility Testing to Support Development of Standards to Assess Glove Designs

Alternative Water Processor (AWP)
- Completed AWP Integrated Test
- Conducted Delta TRR for Reactor Loading and Rapid Start-up Testing
- Modified Membrane Aerated Biological Reactor Fibers for Rapid Start-up Testing
- Conducted Supporting Research and Development
- Conducted Brine Water Recovery Technical Interchange Meeting (January 14, 2014)

Advanced Oxygen Recovery (AOR)
- Build-Up of Series Bosch Test Stand
- Held Test Readiness Review (TRR) for Reverse Water Gas Shift (RWGS) Reactor Testing

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Veggie Vegetable Production Unit

LED Light Cap

Teflon Bellows

Reservoir

Pillow Rooting Concept

- Wicking surface
  - Allows passive wicking from reservoir
- Media inside
- Fertilizer
  - Time release
- Single use - fills with roots

VEG-01
Hardware Verification Test - Goals

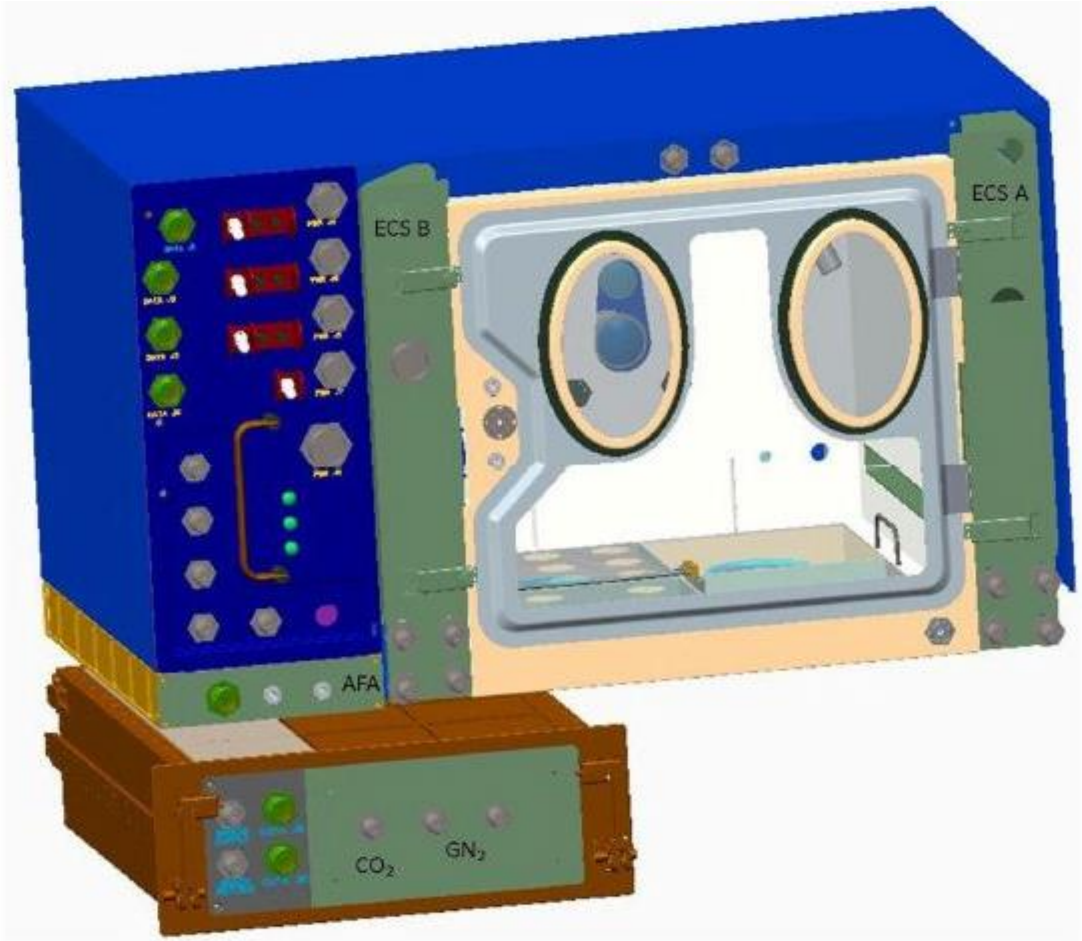
- Demonstrate hardware function on ISS
- Test procedures for Veggie operation
- Demonstrate plant pillow concept
- Compare two rooting media
- Look at microbial growth on plants, in pillows, and on surfaces
  - Food safety
- Assess plant productivity and health
- <u>Generate data for future Veggie researchers</u>

Veggie Facts

- Small Vegetable Production System – 0.15 m^2 growing area
- Compact stowage, low launch mass
- Low energy usage –lights and fans
- Minimal crew time
- Separate components allow for reuse or replacement
- Flying to ISS on SpaceX-3

VEGGIE is designed and built by Orbital Technologies Corporation (ORBITEC), Madison, WI, USA

Advanced Plant Habitat – APH



Chamber slides out 10" from
The main unit for viewing
Through the top window.

Advanced Plant Habitat Specifications

- **Growth Light : Assembly** — **0-1000 µmol m^{-2} s^{-1} PAR in increments of 50**
  Red (630-660 nm); Blue (450±10 nm); Green (525±10 nm); White (LED); Far Red (730 nm)
- **Uniformity** — **±15% (15 cm below GLA, 5 cm in from wall)**
- **Temperature:** — **18 - 30° C (± 1° C)**
- **RH** — **Controlled / monitored: 50 - 90% (±5%)**
- **CO_2:** — **Controlled / monitored: 400 ppm-5000 ppm (± 50 ppm or 3%)**