

Evolving BLiSS Architectures for Surface Habitats

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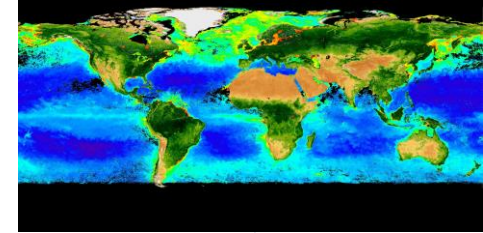
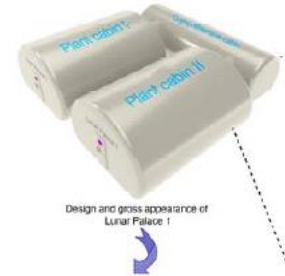
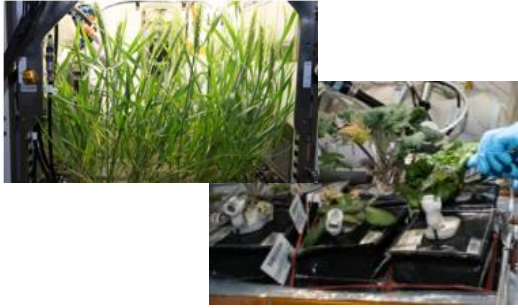
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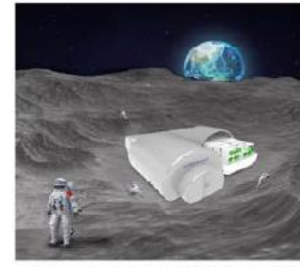
Scales of Bioregenerative Life Support Systems (BLiSS)



APH / Veggie
Bioreactor



Biomass Production
Chamber



Lunar
Palace



Biosphere 2

physiology

technology

demonstration

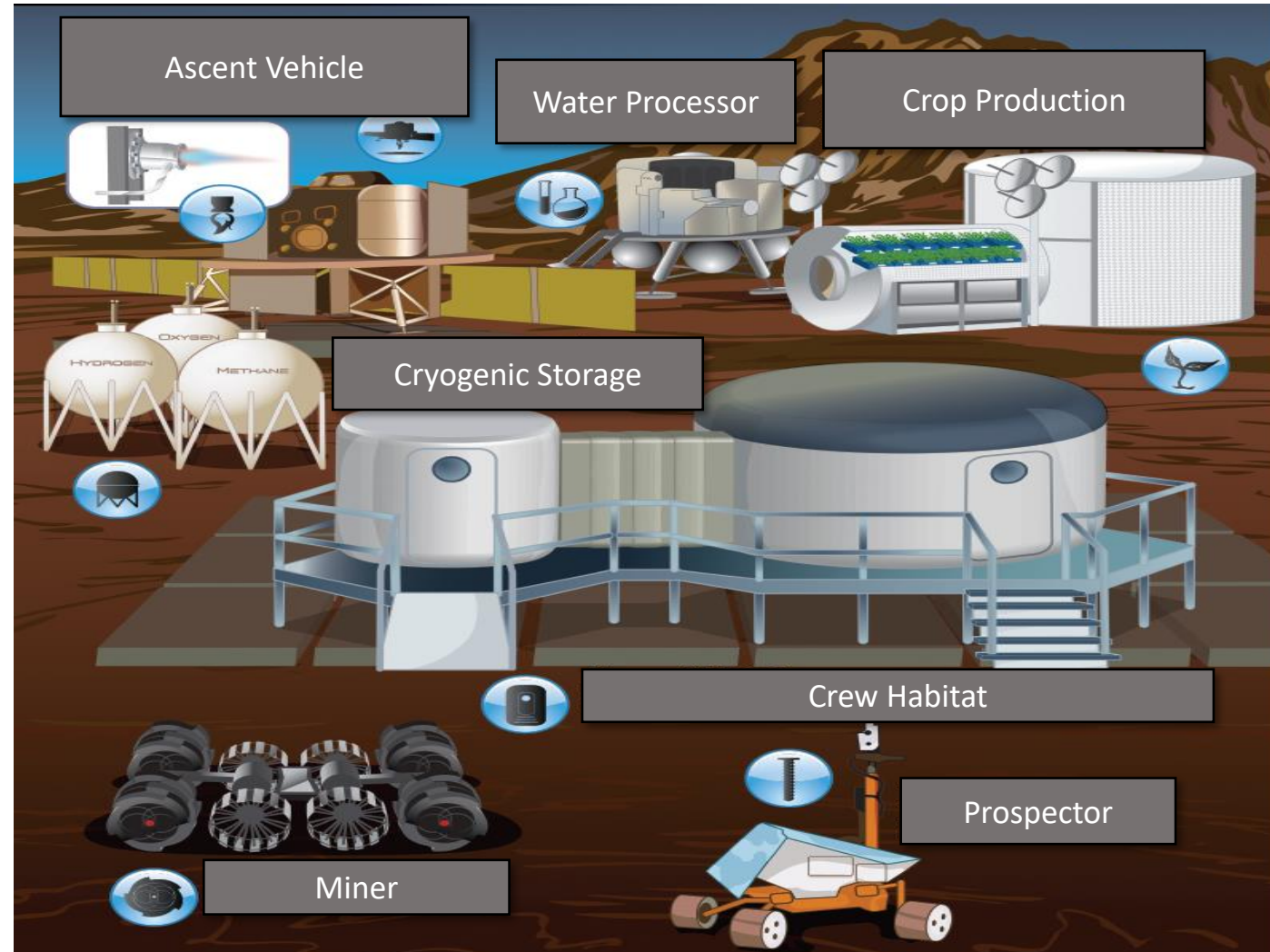
integration

implementation

ecology

Integrating Water Processing Technologies into Bioregenerative Life Support Systems (BLiSS)

- Bioregenerative Life Support System (BLiSS) Architecture can be integrated into Artemis Missions and future campaigns for Moon to Mars (M2M).
- BLiSS enables sustained human presence in extraterrestrial habitats where resupply to PC System is not practical.
- The KSC Water Science Work Area (WSWA) is developing and testing biological water processors for Exploration Surface Systems.
- NASA programs have been sponsoring the development of Water Processor technologies since early 90's.



Mars Surface Systems



Examples of NASA-Sponsored Biological Water Processor technology Development



1997

Verostko, C., M. Edeen, N. Packham, 1992. "A Hybrid Regenerative Water Recovery System for Lunar/Mars Life Support Applications," SAE Technical Paper 921276

Pickering, K. and Edeen, M., 1998. "Lunar-Mars Life Support Test Project Phase III Water Recovery System Operation and Results," SAE Technical Paper 981707



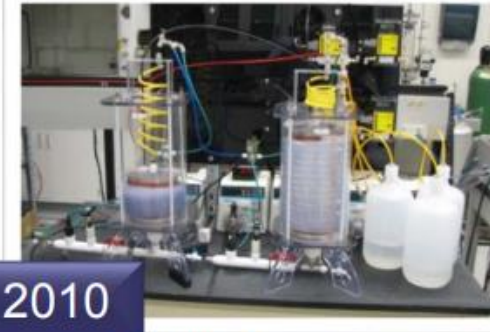
2006

Pickering, K., G. Pariani, B. Finger, M. Campbell; J. Gandhi, C. Carrier and L. Vega. 2001. Testing of a Microgravity-Compatible Biological Water Processor System. 31st International Conference on Environmental Systems, Orlando, FL

M. Campbell, B. Finger, C. Verostko, K. Wines, G. Pariani, K. Pickering. 2003. Integrated Water Recovery System Test. SAE Paper 2003-01-2577.



2002



2010

Bellows Bioreactors

Rector, T., J. Garland, K. Reid-Black, R.F. Strayer, M. Hummerick, M. Roberts, and L. Levine. 2006. Treatment of an early planetary base waste stream in a rotating hollow fiber membrane reactor. Earth and Space. 188:45-51.



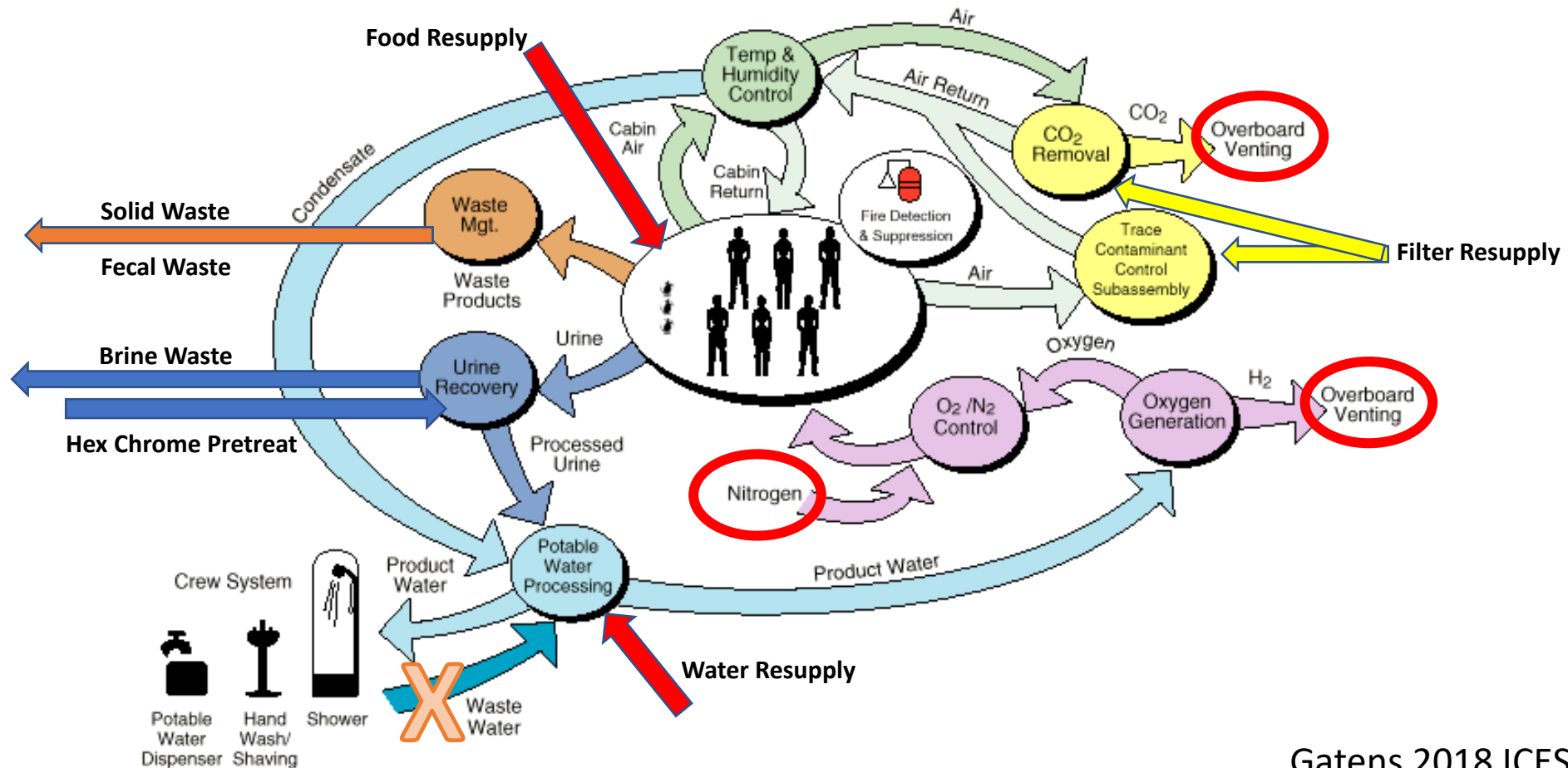
2011

Jackson, W.A., D. Christenson, K. Kubista, A. Morse, S. Morse, T. Vercellino, D. Wilson, and J.L. Garland. 2011. Performance of a TRL 5 bioreactor for pretreatment of an extended habitation waste stream. Amer. Inst. Aeronautics Astronautics, AIAA-2011-5132, 41st ICES, Portland, Oregon.

NASA's Current ECLSS Baseline – Resupply / Storage / Venting

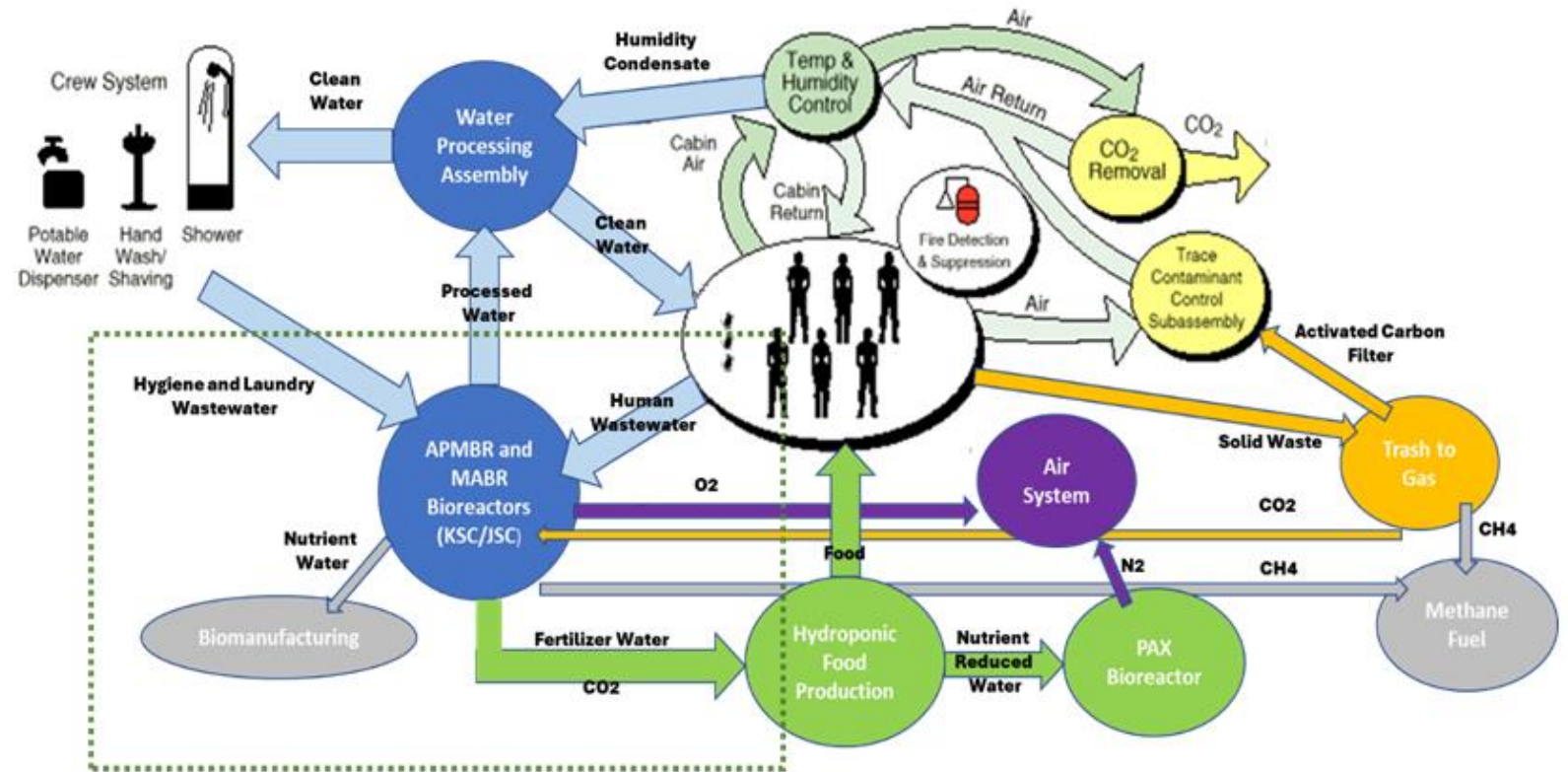


Space Station Regenerative ECLSS Flow Diagram (Current Baseline)



BLiSS Activity – M2M Architecture

- MCO BLiSS Activity is part of the M2M Surface Systems Domain Architecture.
- Components that take in human wastewater to produce usable water or products for biomanufacturing (see Green Dotted Box)



FY25-26 BLiSS Activity

Proposed M2M ECLSS Architecture

Key	
	Air Revitalization
	Air Reconstitution
	Crops
	Solid Waste Management
	Fuel or Other Resource
	Water

Stages for Habitat Evolution – Surface System Constraints

Assumptions:

1. Partial Gravity Habitat will build up over years
2. Durations of dormancy will occur requiring system stability
3. Crew of 4 humans
4. Vehicles and Habitats will have different systems for different cycles
5. Resupply must be minimized and eventually eliminated for Mars
 1. Food must be grown rather than brought
 2. Waste must be recycled rather than collected/stored

Outcomes:

1. Initial stages will focus on **survivability**; later stages on **sustainability**
2. Trade study findings show after 120-day BLISS outperforms current physical/chemical systems (Myers ESM)

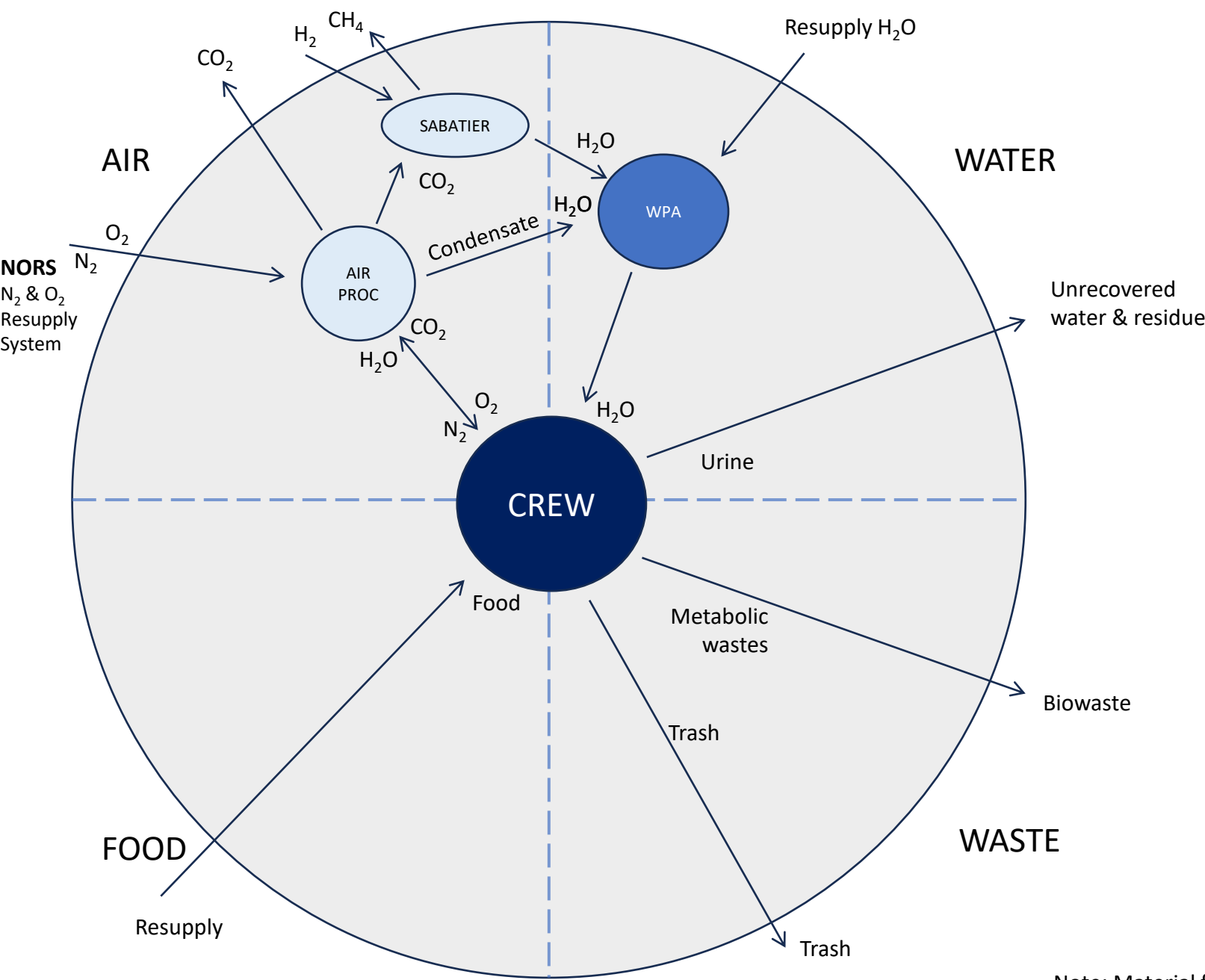
Proposed Stages:

1. Survival Stage – Air and Water focus
2. **Intermediate Stage** – Air, Water, and Metabolic waste
3. **Sustainable Stage** – Air, Water, Waste, Food
4. Mature Stage – Economy drives Food and Biomanufacturing in Space

Life Support System (LSS) for Surface Habitats – Architecture based on Current Physicochemical Capabilities

Short Duration

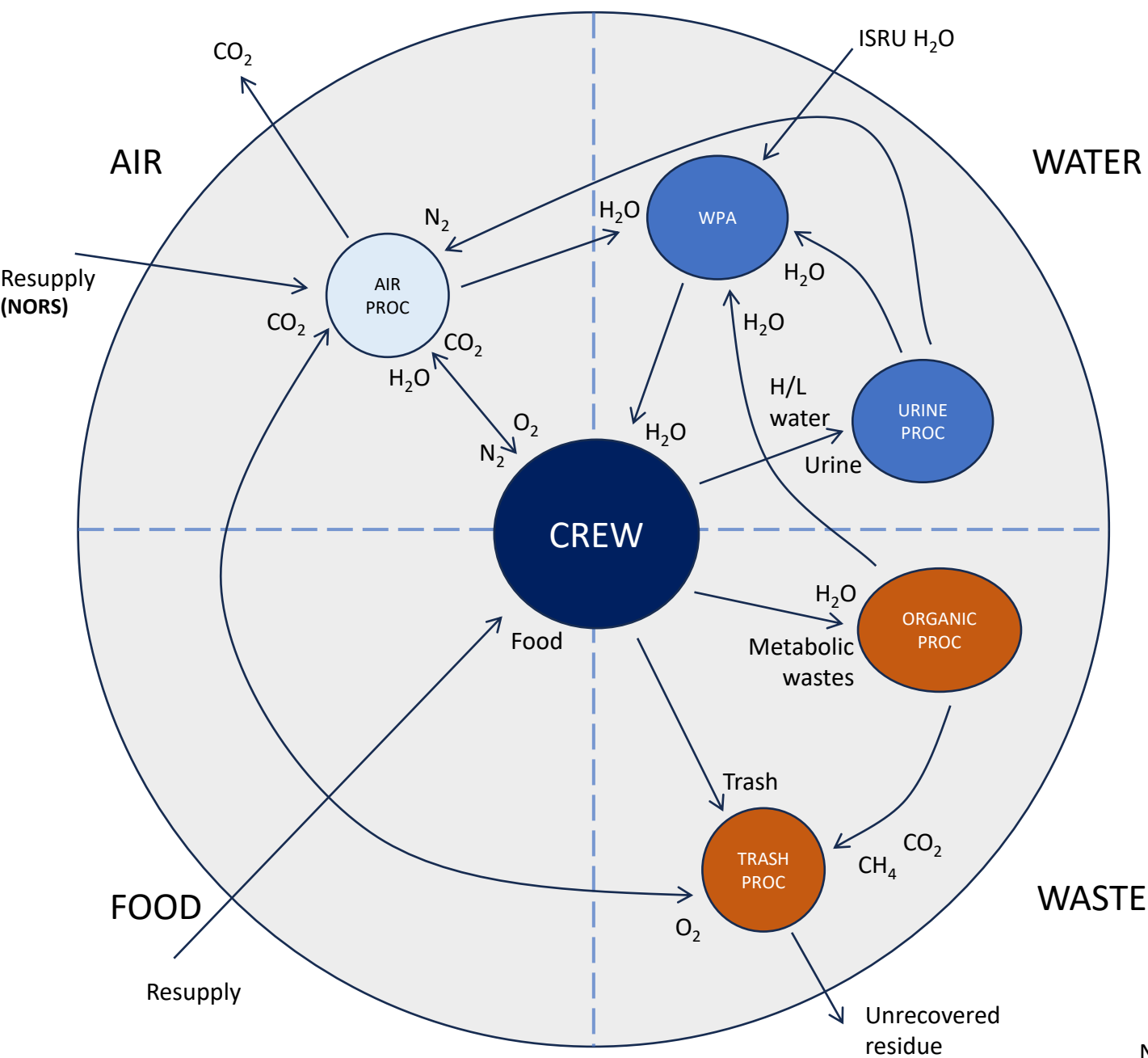
1. Survival Stage
(regenerative – P/C)



Bioregenerative Life Support System (BLSS) for Surface Habitats – KSC/USF Proposed Integrated Architecture

Intermediate Duration

2. Intermediate Stage
(bioregenerative to Reduce Resupply)

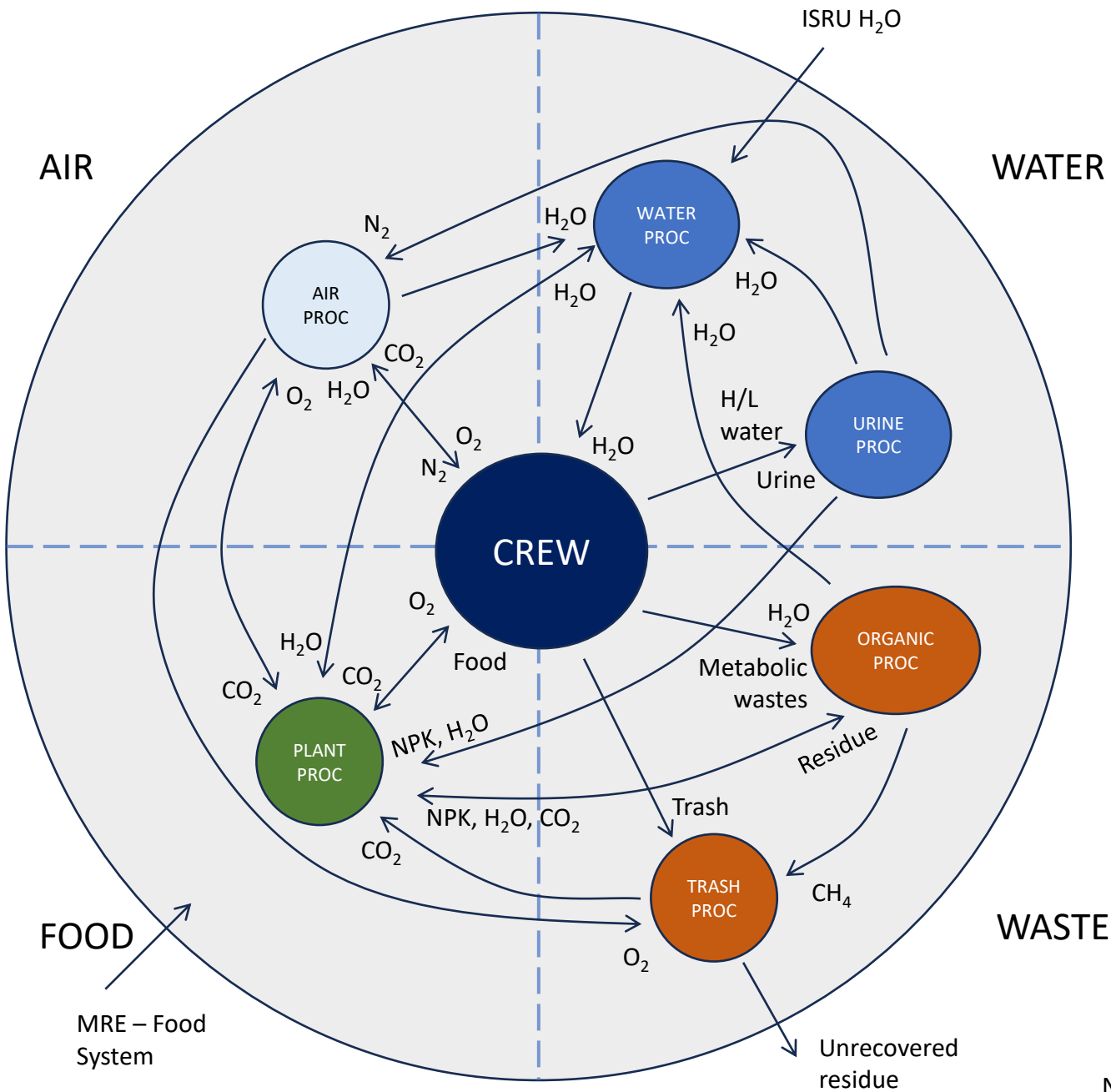


Unit	Function	Hardware
Air Processor	- Provide clean air for crew - Recover condensate - Provide CO2 for plants	Air revitalization system, CDRA, trace contaminant system
Water Processor	- Provide clean water for crew - Provide clean water for plants	Water processor assembly
Urine Processor	- Mitigate urine & hygiene/laundry water - Recover resources (water/fertilizer/N2)	- SAMBR (Suspended Aerobic Membrane Bioreactor) - Texas Tech MABR (Membrane Aerated Bioreactor)
Organic Processor	- Mitigate metabolic waste slurries (feces, food waste, vomit, etc), - Recover resources (water, fertilizer, CH₄/CO₂)	APMBR (Anaerobic & Phototrophic Membrane Bioreactor)
Trash Processor	- Mitigate trash and reduce volume of residue - Recover CO₂	- Heat Melt Compactor - OSCAR (Orbital Syngas/Commodity Augmentation Reactor)

Note: Material flow indicated by direction of adjacent arrowhead

Bioregenerative Life Support System (BLSS) for Surface Habitats – KSC/USF Proposed Integrated Architecture

Long Duration



3. Sustainable Stage
(with Food Production)

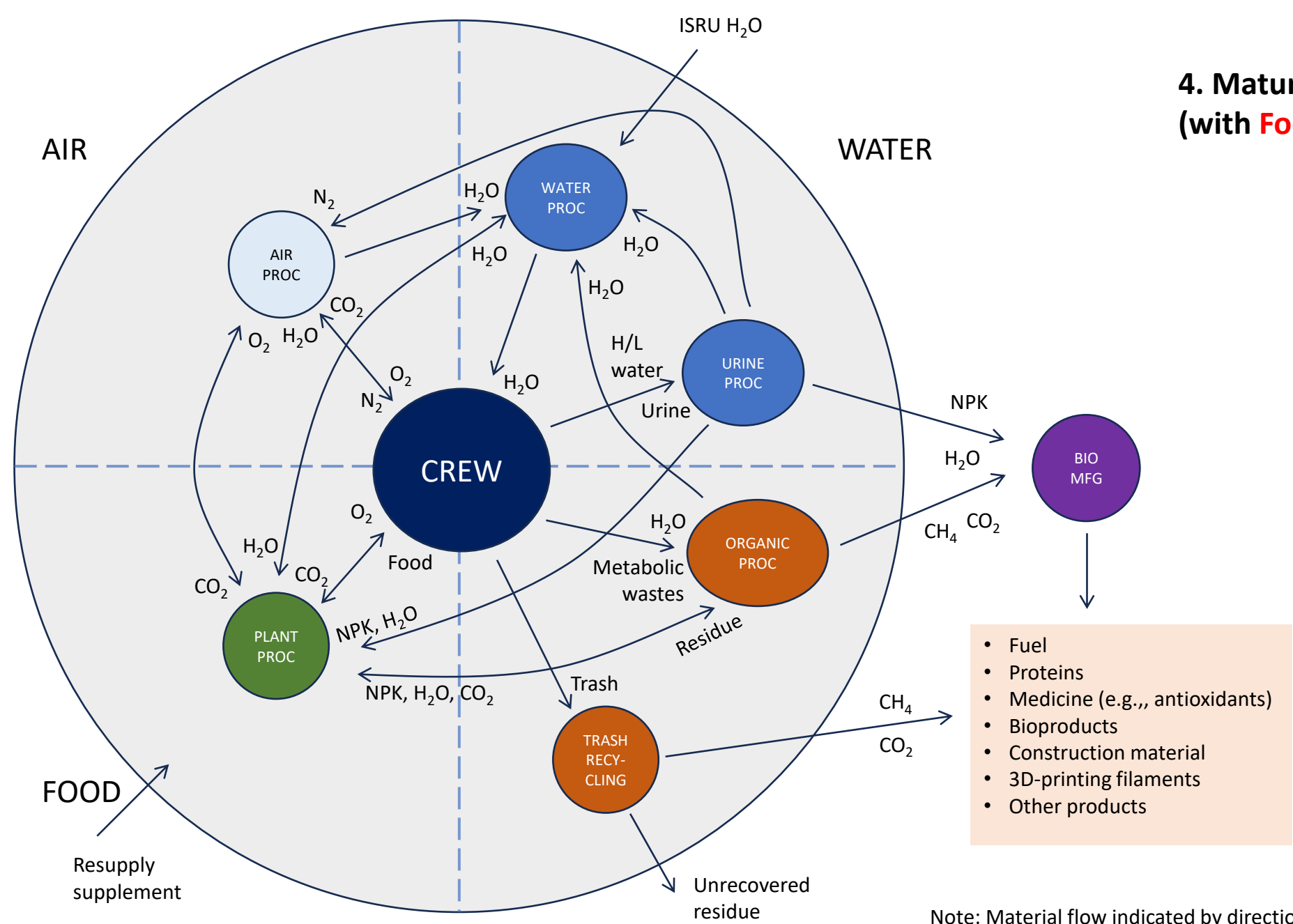
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Organic Processor	- Mitigate metabolic waste slurries (feces, food waste, vomit, etc), - Recover resources (water, fertilizer, CH4/CO2)	APMBR
Trash Processor	- Mitigate trash and reduce volume of residue - Recover CO2	OSCAR
Plant Production	- Produce food for crew - Revitalize air (O2) - Further purify water	Plant production systems

Note: Material flow indicated by direction of adjacent arrowhead

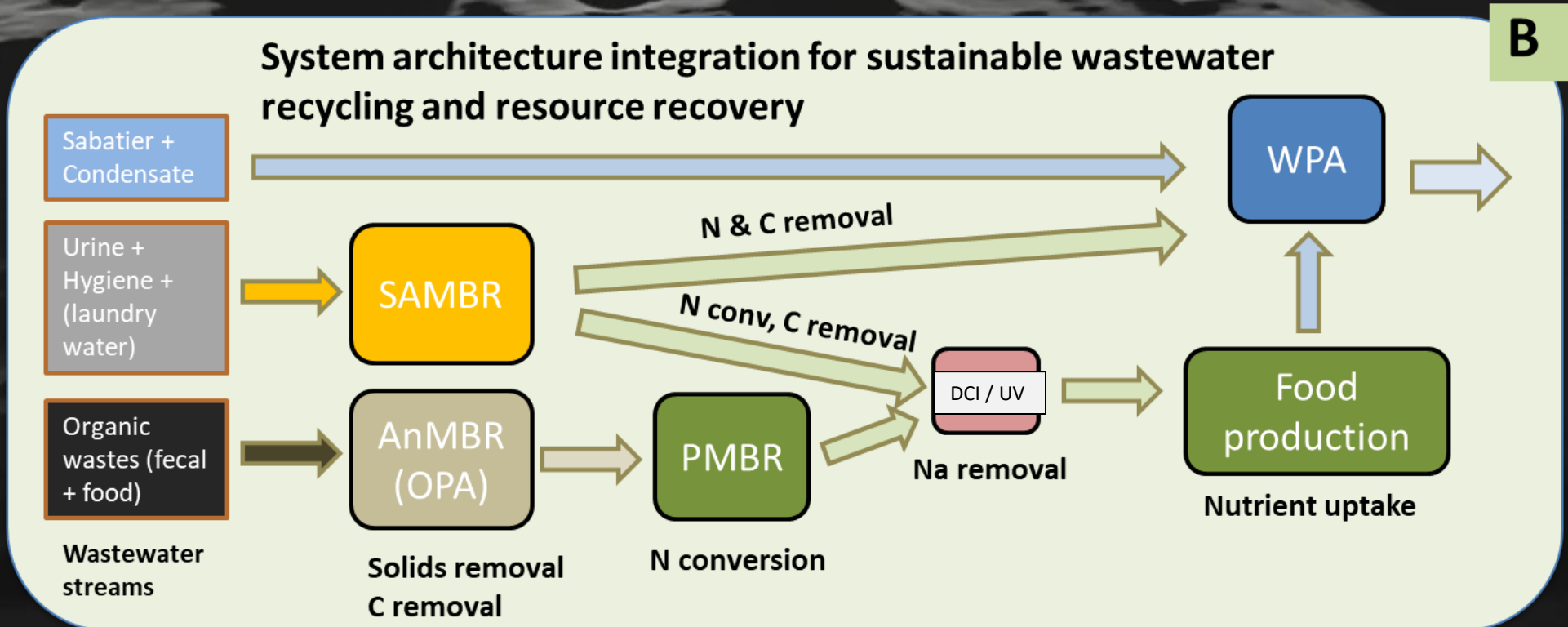
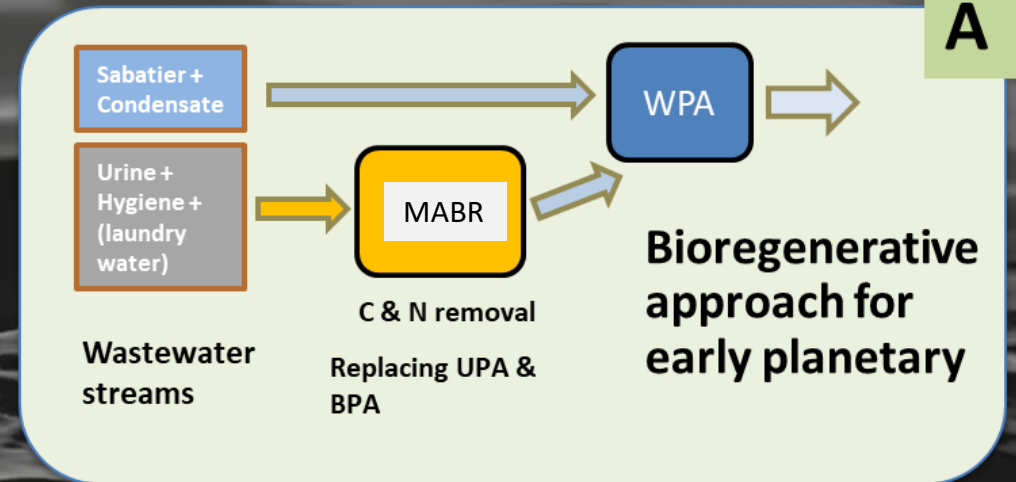
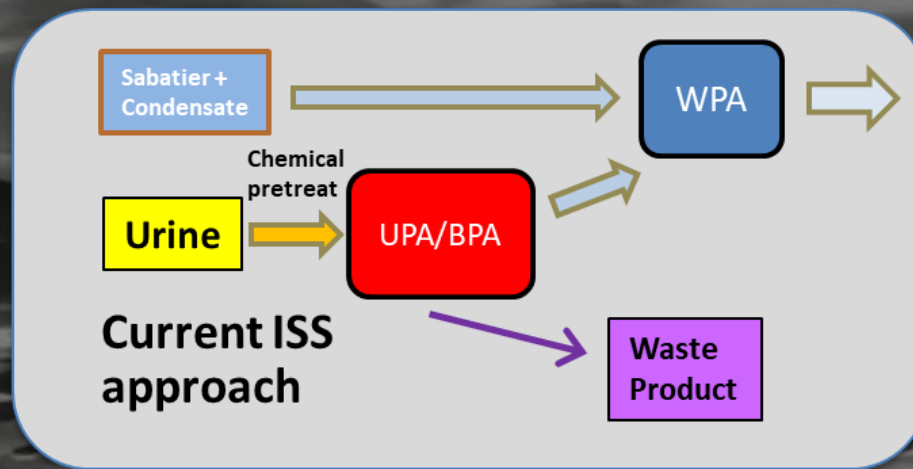
Bioregenerative Life Support System (BLSS) for Surface Habitats – KSC/USF Proposed Integrated Architecture

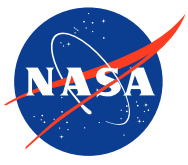
Permanent Duration

4. Mature Stage
(with Food + Biomanufacturing)



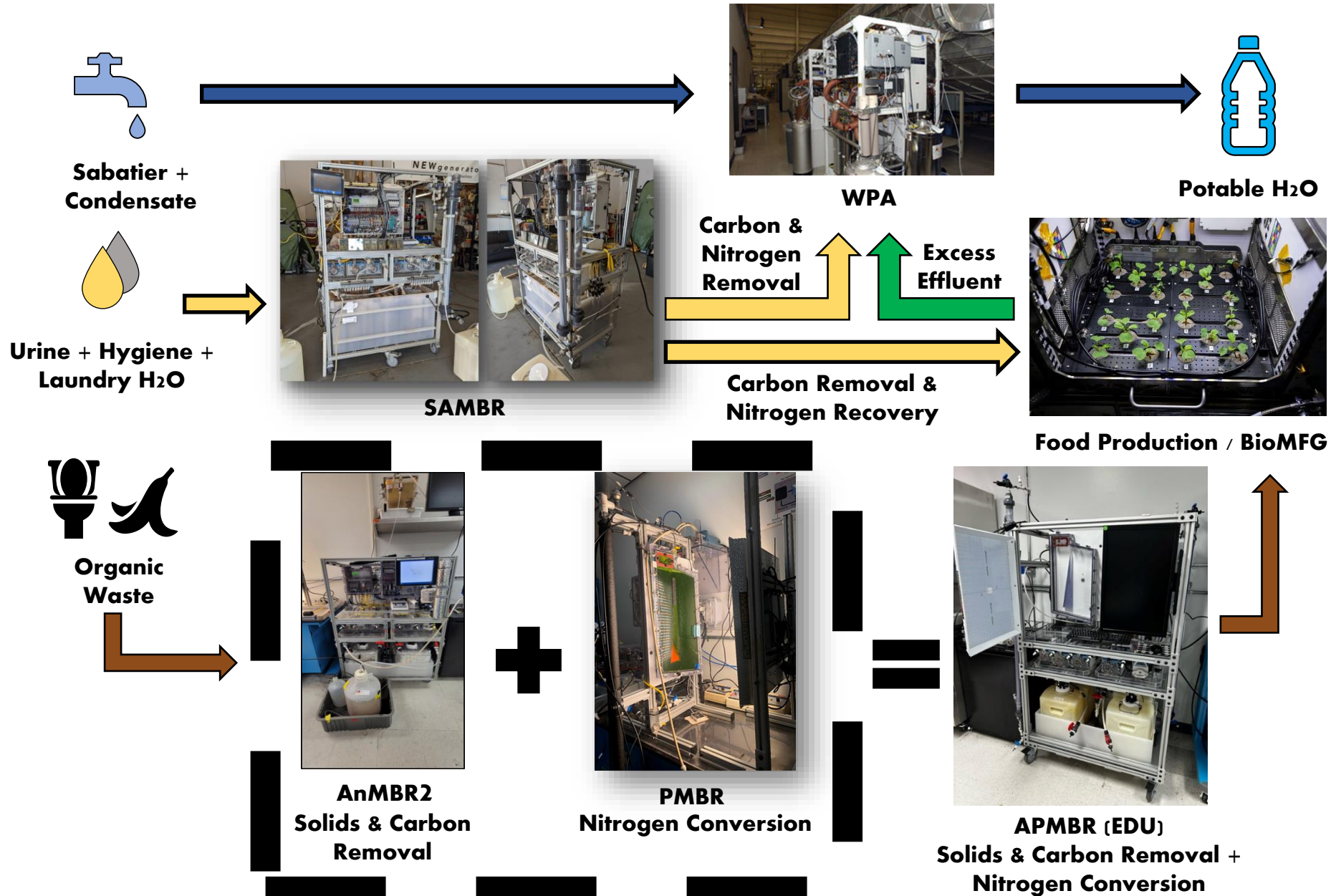
System Architecture Approach for EPB





Water Science Work Area

Bioregenerative Water and Resource Recovery



Questions?

Acknowledgments

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