Advanced Life Support Systems Proposal By Kermitt Davis

1. Introduction

Space is the final frontier its vast expanse offers humanity a chance for endless expansion, invention, and exploration. However, the greatest impediment to settling this frontier is space itself which prevents our most basic biological processes from functioning leading to unconsciousness in seconds and death in minutes.[1]

To endure space humanity has constructed Life Support Systems (LSS) the most relevant found within spacesuits, spacecraft, and space stations. These LSS, that make sustained human exploration possible, must account for tasks such as water recycling, oxygen synthesis, and waste treatment to name a few.

Throughout this proposal I will examine what type of future Advanced Life Support Systems (ALSS) must be created for the human exploration and colonization of our solar system.

2. Vision

A new series of ALSS, that are able to be utilized for future expeditions to areas such as the Moon, Lagrangian Points, Mars, and beyond, must be created.

Though critical today, with future expeditions taking place far beyond Earth, the import of ALSS will only increase. For early explorers and colonists, the failure or inadaptability of these systems will mean a probable death with little chance of terrestrial rescue.

As a result key and necessary areas identified for future ALSS advancement include:

- Enhanced Capabilities
- Size Reduction
- Modularity

Within these broader categories concepts such as in situ utilization of resources and ALSS portability will also be addressed.

3. Approach

3.1 Current capabilities

ALSS must be more efficient than they are today. As it stands one ISS payload rack, that houses the LSS aboard the ISS, is 2 meters high, 1.05 meters wide, and .86 meters deep.

With this size of LSS several astronauts aboard the ISS can be kept alive in a habitat that is 8.5 meters long with a diameter of 4.27 meters while each consumes approximately 2.42 kg of water (for drinking and eating) and .84 kg of oxygen daily.[2] [3] [4] It must be noted that 93% percent of this water is recyclable and 2.3 - 9kg of oxygen is synthesized daily.[5] Water is the keystone substance in this process as it is also required to synthesize oxygen.

In spite of this high rate of recyclability and synthesization approximately 35% of the water used aboard the ISS must be shuttled in from Earth. This is both a timely and costly endeavor. In short, the water and oxygen utilization to recyclability ratio must be improved in order to create self-sustaining ALSS that will not rely on resupply from Earth.[5]

3.2 Enhanced capabilities

As the LSS components inside an ISS payload rack were selected and designed in the late 1980s, (though periodic upgrades continue) improvements in hardware that have been made in recent years can now be utilized for future ALSS.[6]

Components identified for utilization in future ALSS include:

- Forward Osmosis Bag
- Mars Oxygen ISRU Experiment (MOXIE)
- Heat Melt Compactor

The Forward Osmosis System is a compact osmosis system that is able to successfully recycle larger quantities of contaminated water more rapidly and efficiently than the reverse osmosis systems currently utilized on the ISS.[7] Astronauts will be able to have an effectively infinite supply of drinkable water while exploring the solar system.

MOXIE is a self-contained system, to be tested for the first time during the Mars 2020 rover expedition, that will synthesize oxygen from carbon dioxide found on Mars.[8] If MOXIE is successful and improved upon astronauts will be able to synthesize a perpetual supply of oxygen. This will be a necessity for long term solar system exploration and colonization.

The Heat Melt Compactor has the ability to melt waste created during the course of a space expedition and turn it into a solid piece of tiling.[9] Though admittedly the most speculative of the hardware components I selected the Heat Melt Compactor has the potential to turn generated waste into tools such as radiation shields and even shelter. This will allow astronauts to adapt and rapidly react to unforeseen circumstances during exploration of our solar system.

3.3 Size Reduction

The size of the ISS payload racks are too large for future manned missions which will in all likelihood utilize spacecraft with small dimensions and little interior room (at least initially). The dimensions of hardware components selected for the ALSS are as followed:

- Forward Osmosis Bag 10.16 x 15.24 cm,
- MOXIE 23.876 x 23.876 x 30.988 cm
- Heat Melt Compactor by 48.26 x 58.42 x 83.82 cm [10]

Due to their small form factors these hardware components will fit inside a self-contained ALSS payload rack of .5 x .6 x .9 meters; significantly smaller than ISS payload racks. The small size of this ALSS will have three primary effects. One, more ALSS can be packed into a spacecraft or settlement increasing redundancies. Two, the ALSS will be relatively portable allowing astronauts to escape seemingly habitable areas that prove unsuitable for human habitation. Three, increased efficiency and reduction in size will allow for both a larger quantity of and more powerful ALSS to be taken on missions.

3.4 Modularity

A modular ALSS, or one that is least partially modular, will be necessary for the manned space missions of the future. These long term and open ended missions will take humans far beyond Earth. Routine mission planning and procedure, as seen in environments such as the ISS, will be all but impossible.

The small form factor of both the selected hardware components as well as the ALSS rack will allow astronauts to customize the interior of their ALSS as circumstances change. Though the ISS payload racks are modular themselves hopefully this ALSS design will allow for a more rapid and complete modularity.

Conclusion

Space is the final frontier and I wish to do my part to help settle it. Though not a design that runs the gamut of all systems required to keep people alive in the course of space exploration I hope this initial proposal demonstrates how I think about the creation of next generation ALSS. If you want to give feedback and/or have questions feel free to email dkermitt@gmail.com .

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