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INTEGRATION OF BIOLOGY AND TECHNOLOGY FOR EVOLVABLE AND ADAPTABLE LIFE SUPPORT SYSTEMS

Abstract

In the past decades, we have successfully developed intricate life support systems for human activities in space, including ISS. We are now entering the era where private companies such as SpaceX or Mars One started having the visions of building cities on Mars. Although realizing such plans still takes time, other ideas such as manned space missions for a longer period of time, space travel and hotels, building bases or manufacturing plants on planetary/ lunar bodies, are realistically discussed. As we move toward that direction, designing even more advanced (complex) life support systems will be required sooner or later.

The fundamental problem we will face in the near future is that the current design of life support system is enabled by controlling everything on a chemical level. Everything from air control to urine purification is monitored and regulated by human-engineered systems. Although such engineered systems can be quite robust, they are not adaptable, flexible, or evolvable systems. Unlike biological organisms (which are also systems that control the flows of energy and resources), technological machines cannot respond to unexpected environmental changes or perturbations by adapting to new situations flexibly. Another demerit is that the entire system is heavily dependent on the premise that machines keep working, and quickly collapses once they malfunction.

Because of these characteristics of engineered systems, we need to start questioning what the best balance between biological control and technological control is. We propose this new concept of integrated life support systems. The system can be potentially more robust if we do not control everything precisely by technological machines but control some parts by what biological organisms can provide. One practical short-term question is how we should integrate space farming or plant growth technologies into the existing system, and what ratio is appropriate with respect to the size of the entire system. Starting to discuss these questions at this point will allow us to be better prepared for the coming decades of interplanetary exploration.