Creating Sustainable Work-environments

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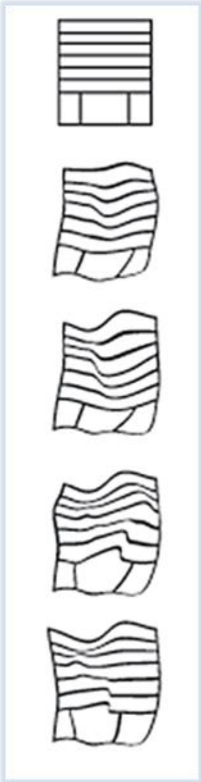

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SUSTAINABLE QUALITY: FROM SPACE STATIONS TO EVERYDAY CONTEXTS ON EARTH

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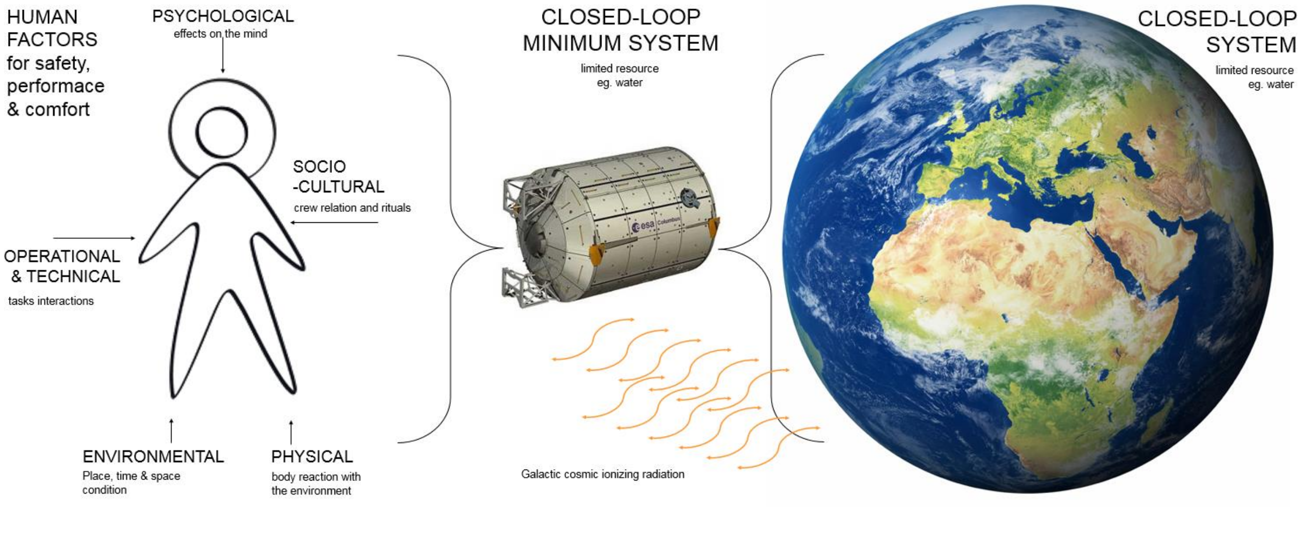
Abstract

Space stations are working places operating in extreme and isolated environments. In isolation, having no access to resources, these places need to be self-sufficient and sustainable and be able to reuse their resources. The transfer from extreme to domestic environments of the sustainable logic and technologies applied in these contexts has enormous potential for the quality of our everyday lives. This "sustainable quality" can be applied, for example, to address overpopulation and the increasing need for resources and can also be used for applications in megacities (Schlacht et al., 2015, 2014). In order to achieve "sustainability quality", two main elements will be explained in this paper: a holistic methodology and a slow approach.

To transfer the system logic from Space to Earth, we need to apply a holistic methodology. This can help us to understand each element of the system and their interrelations in the present as well as in the future considering the entire life-cycle. However, to implement quality of life, we also need to apply a slow approach. This slow approach outlines a new production and consumption model that is at the same time both subversive and feasible and focuses on the quality of the experience.

Schema:. Relations between human system & Closed loop artificial & Natural Systems. (Composition © Schlacht 2015; Image Columbus ©ESA Earth © NASA)



In summary, the concept presented here is "sustainable quality". The aim is to establish the basis for implementing quality of life on Earth by transferring sustainable technologies and know-how from Space to Earth using a holistic design methodology and a slow approach (Schlacht et al., 2009).

1. Sustainability vs. extreme environments

The Oxford Dictionary defines "sustainable" as "able to be upheld". Sustainable is something that is self-sufficient, autonomous, and able to regenerate itself in a sort of perfect equilibrium. This concept is applied in different contexts, for example in the closed-loop system of an aquarium. The Earth itself can also be considered a sustainable system, as can a Space station, which is isolated in an extreme environment and needs to regenerate its own resources.

Space stations are situated in an environment to "which humans are not naturally suited, and which demands complex processes of physiological and psychological adaptation" (Kanas and Manzey, 2008, p. 15). Of the various extreme environments that human beings have been able to reach, Space is the most extreme. For these reasons, a complex, self-sustainable system is needed to support human life in it. Extreme environments include: submarine vessels, underground, high mountains, underwater laboratories, dwelling stations in desert and Antarctic areas, radioactive areas, offshore drilling rigs and, of course, Space environments. All these environments are supported by closed-loop and sustainable technologies such as the recycling of water. Isolated working places in extreme environments need to apply high-tech in order to be self-sufficient and sustainable because they do not have access to local resources. These places are thus self-sufficient systems, based on the closed or semi-closed use of resources, with very limited impact on the external environment. Extreme environments are characterized by adverse environmental conditions that are particularly unfriendly to humans, such as extreme temperatures and pressure, lack of oxygen, and the presence of radiation. In Space, we have all these environmental conditions plus other factors, such as a wholly different level of gravitational force, meteorites, vacuum, as well as other effects, such as the very sharp contrasts between light and dark or severe temperature changes. For these reasons, it is Space where we can find the application of the best technologies and know-how regarding sustainability and closed-loop systems.

2. Closed loop: aquarium = Space station

A Space habitat is meant to be a sustainable system to the greatest extent possible, a closed-loop system with autonomy from Earth. To support human life in such a habitat, each specific element of this complicated system is designed and built artificially by considering the relationships among humans and environments.

To easily understand the concept of artificial closed systems, we can imagine an aquarium where each single element has a direct influence on the equilibrium of the overall system. In the aquarium, the equilibrium between fish, plants, and water is fundamental. Too many fish will eat all the plants, resulting in insufficient oxygen, resulting in water contamination, which will eventually result in extinction of the fish in that aquarium. Just as in an aquarium, in a Space ship, on Earth, or in a closed system, the relationship of a part to the whole is extremely intensified. In this sense, the user's well-being is strictly related to the equilibrium existing within the system (Schlacht, 2012). Fostering optimal relations among all the elements that constitute the living system becomes crucial for maintaining a perspective that is as global as possible when considering each phase of the system's lifecycle (Quantius et al., 2014)

A concrete example is the NASA project EcoSphere, whose goal was to develop technologies for obtaining the perfect closed loop for a Space station. The EcoSphere is a micro-aquarium with a completely enclosed ecosystem. Its biological cycle represents a simple version of Earth's own ecosystem. While beautiful to look at, it shows the delicate balance of an ecosystem just like our own. It contains shrimp, algae, and bacteria. The EcoSphere works by gathering energy from the light and converting it biochemically. Light, together with the carbon dioxide in the water, enables the algae to produce oxygen by photosynthesis. The shrimp breathe the oxygen in the water and graze on the algae and the bacteria. The waste from the shrimp is broken down by the bacteria into nutrients, which in turn feed the algae. The shrimp and the bacteria also give off carbon dioxide and the cycle is renewed when the algae use this once again to produce oxygen. (AAVV, 2007; NASA, 2015)

Image 1: Living in a Self-Sustaining Ecosphere (free © Wicker Paradise in flickr.com).

3. What: holistic sustainability vs. the quality of the life-cycle

On a Space station and on Earth, water is a limited resource to preserve. On Space stations, the logic of the closed loop tries to mimic the Earth's water system, recycling water from urine, waste, and sweat. The technology, the know-how, and the procedures used to create and maintain the artificial closed loop on a Space station could conceivably be applied in any environment with similar needs. In the closed loop logic, we need to preserve the entire system, holistically approaching all the elements and their interactions, such as the capacity to regenerate water while preserving its quality and the capacity to support the user's quality of life, including safety, performance, and his or her psycho-physiological well-being (Karga & Schlacht, 2012).

To preserve a system's sustainability, not only technological factors but also the psycho-physiological well-being of the user are important to support the holistic approach. A human who is not reliable psychologically may make mistakes and disrupt the small and fragile closed-loop system of a Space station (Schlacht et al., 2015b). But thinking holistically about a system does not only mean considering psychological and technical elements, but also the life-cycle perspective at all levels. This will guarantee results that are sustainable in the long term. In this approach, every action is considered in terms of its impact on its surroundings and beyond and its consequences for the well-being of people, land, air, water, plants, animals, and future generations, and their interactions. Moreover, this concept can be applied on different scales: micro (product, service, and process), meso (sector, supply chain, region, and system) and macro (economy-wide) (Iannaccone, 2014 p. 14).

In other words, the design should be holistic and consider all the elements and their interactions in the present and also in the future in order to guarantee optimal quality conditions for the user in relation to the system.

4. How: slow approach to distributed economy and sustainable sensoriality

We know now that for a Space station as well as for our applications on Earth we need to holistically consider all the elements and their life-cycle. We also know that the design approach that supports the user's quality of life is strictly related to the equilibrium of the system (Ceppi, 2012). However, we do not know which design approach we need to use to achieve "sustainable quality".

The slow approach is aimed at guaranteeing the quality of the design approach. For this reason, this approach is the one that is able to support sustainability and the overall equilibrium of the system, applying quality both on Space stations and on Earth. However, what does it imply?

"Above all, the slow approach means the simple, but in current times revolutionary, affirmation that it is not possible to produce and appreciate quality if we do not allow ourselves the time to do so, in other words, if we do not activate some kind of slowdown. However, slow does not only mean this. It also means a concrete way of actually putting this idea into practice. It means cultivating quality: linking products and their producers to their places of production and to their end-users who, by taking part in the production chain in different ways, become themselves coproducers" (Capatti, et.al. 2006 p.4). In a Moon village, this may easily be the case; indeed, in a small system, the relationships among the elements are much more direct and immediate. So, in a small settlement that needs to be autonomous, each astronaut may get in contact with "sustainable quality" to a much greater extent.

"So, the slow approach outlines a new production and consumption model that is at the same time both subversive and feasible. While clashing head on with the ideas and practices of today's prevailing globalisation, it can be enacted locally both immediately and, as Slow Food has proved, successfully.

In our opinion, the great potential of the Slow Food experience needs to be understood better, both in terms of its nature as a strategic project for the development of new food networks and, as is of greater interest to us here, in its more general potential as a contribution to the definition of new ideas on quality, well-being and development models" (Capatti, et.al. 2006 p.4)

5. Future application of sustainable quality to human factors

The holistic and slow concept can be applied to guarantee "sustainable quality" in all sectors related to human interaction. In particular, five Human Factors projects related to Space and Earth applications aimed at achieving sustainable quality are currently in development at Politecnico di Milano under the guidance of Dr. Schlacht and Prof. Ceppi. Below, the topic of each project related to Human Factors is described briefly:

- Psychological & socio-cultural factors: Integrating creative and artistic applications as part of the need for cultural development in the closed loop (project: Creative activity as psycho-social support in isolation).
- Environmental factors: The design is based on direct experience of the minimum closed-loop condition with simulation of place, time and space (project: Empathetic design).
- Operational factors: Collecting the collective lessons learned from previous experiences to design the elements of human interaction in extreme contexts (project: Collective habitability debriefing)
- Physical factors: Investigating body reaction, adaptation and exaptation with different variables, such as the changing of gravity and isolation (project: Movement interaction in microgravity).

In these works, an effort is made to consider Human Factors constructs in order to design sustainable systems using a slow approach and a holistic methodology to achieve sustainable quality (Ceppi, 2006; Schlacht 2015).

6. Conclusion

Future innovations should be developed to meet the requirements originating from the concept of “sustainability quality”. This concept aims to establish the basis for implementing quality of life on Earth by transferring sustainable technologies and know-how from Space to Earth using a holistic design methodology and a slow approach. It can have a wide variety of different applications, ranging from food production via eco-building to business practices. Case studies in this context predominantly include recent projects or experiences to improve understanding and encourage implementation.

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