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Diversifying the concept of analogue missions to explore and evaluate new concepts for future space missions

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A range of analogue space missions has been successful in exploring the psychological impact of confinement, analysing team dynamics during long-term isolation, performing biomedical research, developing food strategies, testing space suit simulators, and investigating human-robot interactions. In this presentation, we compare three different environments that use sustainability and/or artistic practices that provide possibilities to expand and diversify the concept of analogue missions. This presentation uses a literature review and observations to identify possibilities for reciprocal learning and collaboration between currently run analogue space missions and the following three projects, in which the author team has been involved in as a participant or as a researcher: a) ecovillages, b) virtual futuristic space mission workshops called CTIM, c) a community developed art installation called Seeker. The relevance of this comparative exercise comes from the fact that all these scenarios inquire into how to create conditions for the sustenance of human and non-human life in adverse environments: disrupted terrestrial ecosystems and the life-threatening conditions of outer space. The scenarios explored by ecovillages, Seeker, and CTIM can provide complimentary perspectives and inform discussions on how to prepare for different aspects of short term or long-term future space missions.

### I. INTRODUCTION

A range of analogue missions has been designed and used to explore and evaluate different aspects of future space mission e.g. HI-SEAS, HERA, NEEMO, Mars500Biosphere 2. They have been successful in exploring aspects of team work, nutrition, testing space suits, the psychological impact of confinement, restriction and loneliness. In this presentation, we introduce, discuss and compare three different environments that use sustainability, artistic practices, or a combination of both, that provide possibilities to expand and diversify the concept of an analogue mission. This presentation uses a literature review and observations to identify possibilities for reciprocal learning and collaboration between currently run analogue space missions and the following projects, in which the author team has been involved in as a participant or as a researcher:

- a) Ecovillages;
- b) Virtual futuristic space mission workshops called CTIM (Clinical Trials in interplanetary missions);
- c) A community developed art installation called Seeker.

The relevance of this comparative exercise comes from the fact that all these scenarios inquire into how to

create conditions for the sustenance of human and non-human life in adverse environments, such as disrupted terrestrial ecosystems and the life-threatening conditions of outer space. These extreme contexts force us to rethink accepted relationships between living organisms, humans and their environment, and to come up with new configurations thereof.

### II. THREE COMPARISON MODELS

We first introduce each model before discussing the comparison between them.

#### II.I. Ecovillages

Long-term space missions and human settlements require transdisciplinary efforts that aim to design and implement socio-biological structures that can support human life in extreme conditions despite life-threatening events, uncertainties and resource scarcity. The latter requires that we re-think the current relationship between humans and their environment and other living organisms in the environment. It also requires a new approach to human interactions that can translate into regenerative communities. Ecovillages are a good example of such structures. (Danesh, 2006, Guattari, 2000, Alcaide, 2019, Manzini, 2019).

Ecovillages can be defined as whole systems human settlements that redefine the synergy between humans and nature and provide an environment for testing, developing and promoting collaborative practices and technologies to minimize the ecological footprint of human activity (Ergas and Clement, 2016). They redefine supply chains according to perceived natural patterns of (re)integration, symbiosis and cyclical flow (Lockyer and Veteto, 2013). Despite all the extensive work around ecovillages, none of them yet have achieved full self-sustainability and autonomy from wider natural or social systems (Lockyer and Veteto, 2013). Still, they have explored practices that can be useful to inform future settlements in space. These include ways to develop modular life-support systems that maximize self-sufficiency and circularity, promoting equitable access along with supporting individual mental health and collaborative and participatory group dynamics.

## II.II. Clinical Trials in Interplanetary Mission (CTIM)

As part of a series of systematic reviews (Fiebig et al., 2019, Fogtman et al., 2020, Fogtman et al., 2021, Kim et al., 2021, Konda et al., 2019, Richter et al., 2017, Winnard et al., 2017) that we conducted, we identified several limitations in the current space medicine literature. One of them was that most of the clinical research conducted on astronauts or in analogue missions were at high risk of bias. The challenges involved in conducting space medicine research make it difficult to identify strategies how to reduce risk of bias. In 2018, we decided to explore and discuss it further through an immersive, simulation model of a future space missions called CTIM, which stands for Clinical Trials in Interplanetary Mission (Nasser et al., 2020) The project has since then evolved into a series of virtual simulation missions to inform discussions on how to design clinical research for future space missions.

All of the workshops except one used a futuristic scenario of a space mission on Mars, in which the mission doctor has received increasing number of reports of unexplained eye problems among the crew. The symptoms are difficult to understand and differentiate, and it is unclear whether they are caused by a contagious disease or by environmental or other factors. The participants need to design not only a strategy to respond to these health issues but also a research project that can collect reliable data for future space missions that might face a similar problem. In one workshop, we used an interstellar mission that the individuals are on an asteroid rather than a planet. Some of the workshops were done face-to-face, others done virtually, and still others done using a hybrid format.

Initially, we used a case-based immersive workshop; since then, we have used science fiction narratives, interactive gameplay, role-playing and a game-driven website that aims to increase the ability of individuals to immerse in the scenario.

## II.III. Seeker

Seeker is a series of community architecture projects, each of which culminates in a starship sculpture. This habitable sculpture is then used as a platform in which individuals –who serve as its crew – experiment with social, ecological and technological systems to rethink the future of human habitation, sustainability and exploration. The project uses a co-creation methodology to engage with local individuals from a range of different backgrounds. The project teams are characteristically multidisciplinary and their members vary in age, ranging from teenagers to retirees. The architecture of the starship sculpture is emergent and no predesigned blueprints are being used. The design process is rather process-oriented and allows each individual to contribute with new ideas at any given moment. Physical experimentation is being encouraged and the design process is semi-decentralized. A Seeker project is typically created using waste materials such as used wood, cardboard, plastic sheeting, and in some cases even re-purposed caravans. Each sculpture is unique as it involves a different group of people and builds on their interests, skills, and previous knowledge and experience. The ultimate goal of the project is to become a space for dialogue, performance and experimentation. As of this writing, six Seeker projects have been carried out by different communities in Belgium, the Netherlands and Slovenia. (Vermeulen et al, 2018)

## III. COMPARATIVE EVALUATION

We now examine five aspects of these three models to elaborate on how they can inform the design of analogue missions:

### III.I. Physical aspect

Compared to more standard analogue missions like HI-SEAS, our three environments lack the same level of fidelity and precision to a space environment. However, they have other unique characteristics.

Ecovillages have an open environment that connects with outside world that is different from space environment; however, it is more enclosed and self-sustaining than most other types of human settlements and it provides a unique opportunity to look at the

relations between humans and other species over a longer time period.

In CTIM and Seeker, the participants have a lot more control in designing and owning the environment and, if needed, “tear down the walls”. That creates a unique relationship between the crew and the environment. In HI-SEAS missions, the borders between “inside” and “outside” is quite clear. These kinds of borders could be replicated in a Seeker crew mission; in contrast, the borders are much more porous in CTIM and ecovillages.

### III.II. Social and psychological aspect

Similar to HI-SEAS, a crew can be limited to a small space during a Seeker mission with the difference that the latter is quite short-term and limited. As part of the CTIM project, we can immerse individuals in high-risk scenarios such as an unexplained epidemic that we could not have implemented in a more standard analogue mission. In ecovillages, there is a unique opportunity to test social technologies to see how people contact with each other in a group and remotely with the rest of community.

### III.III Speed/feasibility/cost of running a simulation

CTIM is probably the cheapest alternative for an analogue mission. While it has limited fidelity, it is low-cost, can be done within a shorter timeframe, and is easy to organise and run. In contrast, missions like HI-SEAS are quite complex and costly. Seeker is more resource-intensive but still relatively low-cost and feasible as long as some initial support is available. Ecovillages are more resource intensive and experience, however, ecovillages provide essential functions (such as shelter and employment) to its participants. Therefore, the costs are more acceptable and easier for people to accept and cover. Ecovillages are the only one that make truly long-term evaluation possible.

### III.IV. Autonomy versus control

Currently, space missions are quite controlled and managed by the ground crew. However, the same level of control and management would not be implementable in long term missions to Mars. Hi-SEAS mission reflect a standard relation between the ground crew and analogue astronauts (albeit using delayed communications). CTIM, Seeker and Ecovillages provide an environment that different level and balance of autonomy versus control can be explored and the impact on the performance of individuals and their social dynamics studied.

### III.V. Level of self-sustainability

Although self-sustainability has been extensively studied in analogue missions like Biosphere 2, two of our models—Seeker and ecovillages—provide unique opportunities to explore self-sustainability. In Seeker, individuals can co-create their environment to fit their self-sustainability goals. In Ecovillages, individuals can test and pilot self-sustainability practices and technologies over a long period of time and see how it affects the social dynamics.

### III.VI Dependency and interconnection

In discussing dependency and interconnection, we refer to both the interconnection between humans but also synergies with other species. CTIM provides a space that individuals can explore innovative, out-of-the-box or unusual strategies as the workshop happens in a tough experiment. Ecovillages actively encourage and support an interspecies approach to build a community. This is in contrast with simulations like HI-SEAS that individuals might run experiment on another organisms (e.g., plant species) but do not necessarily build an interconnected community with them. (It is worth noting that only in ecovillages is it possible to have intimate interpersonal relationships involving regular sexual activity.). Seeker actively encourages its participants to explore and experiment with creating relations between social, biological, and technological systems in the environment, or what Maranan and Vermeulen (2015) have described as “critical connectedness”. During the missions, conversations are set up to discuss ideas relevant to the project. Living organisms such as insects, fish, ornamental plants and edible crops are often part of these missions.

## IV. CONCLUSION

Ecovillages, CTIM, and Seeker represent three models in which extreme contexts force us to rethink accepted relationships between living organisms, humans and their environment, and to propose new configurations. Ecovillages provide a unique environment in which to explore long term human interactions in re-generating or recreating ecosystems, through the promotion of circular feedback systems including biological and mineral entities. They help to explore how families and communities develop in these scenarios in timeframes and with organizational frameworks that are not possible in standard analogue missions. Seeker is an artistic installation in which members of the participating community build their own starship prototype and then run isolation missions in them. It gives opportunities for individuals to experiment and shape their own ideas about life in space and push the

boundaries of experimentation. Because of its co-creation methodology it provides a sense of ownership that affects how individuals interact with the environment and others during the missions. Finally, CTIM involves a futuristic space mission workshop that uses role playing and immersion to get people to imagine events in future space missions and response to them. It provides an opportunity to push discussions on how to innovate system building and methodological innovation with an interdisciplinary group. These three scenarios can provide complimentary perspectives and inform discussions on how to prepare for different aspects of short-term or long-term future space missions. We have specifically highlighted considerations around long-term versus short-term evaluation of social processes and technologies or evaluating the social dynamics or response towards risky or unsafe events.

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