The Space Farming Project

Space colonization, techno-agriculture and the future of extraterrestrial biopolitics

Vermeulen, Angelo C.J.; van Gansbeke, Ramona; Pannecoucque, Nick; Degrande, Rufin; Leenknecht, Bart; de Jaeger, Christophe; Brazier, Frances

Publication date
2019

Document Version
Final published version

Published in
Proceedings of the International Astronautical Congress, IAC

Citation (APA)
Vermeulen, A. C. J., van Gansbeke, R., Pannecoucque, N., Degrande, R., Leenknecht, B., de Jaeger, C., & Brazier, F. (2019). The Space Farming Project: Space colonization, techno-agriculture and the future of extraterrestrial biopolitics. *Proceedings of the International Astronautical Congress, IAC*, *2019-October*, Article IAC-19_E5_3_3_x52527.

IAC-19-E5.3.3

The Space Farming Project: Space Colonization, Techno-Agriculture and the Future of Extraterrestrial Biopolitics

Angelo C.J. Vermeulen[a,b]*, Ramona Van Gansbeke[c], Nick Pannecoucque[d], Rufin Degrande[d], Bart Leenknecht[e], Christophe De Jaeger[c], Frances Brazier[a]

[a] *Systems Engineering and Simulation, Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, 2628 BX Delft, the Netherlands,* a.c.j.vermeulen@tudelft.nl, f.m.brazier@tudelft.nl
[b] *SEADS (Space Ecologies Art and Design), www.seads.network*
[c] *Gluon, Brussel, Slachthuisstraat 4, 1000 Brussels, Belgium,* ramona@gluon.be, christophe@gluon.be
[d] *Provincial Technical Institute (PTI) Kortrijk, Graaf Karel de Goedelaan 7, 8500 Kortrijk, Belgium,* nick.pannecoucque@pti.be, rufin.degrande@pti.be
[e] *Howest, Marksesteenweg 58, 8500 Kortrijk, Belgium,* bart.leenknegt@howest.be
* Corresponding Author

Abstract

In order to sustain human life for extended periods of time in deep space one cannot solely rely on support from Earth. It'll be essential to become self-sustaining through a combination of in situ resource utilization, waste recycling, and space farming. The latter can provide astronauts and colonists with locally grown food and biogenic oxygen, and will be an indispensable component of any future outpost in deep space. The type of agriculture that will develop itself in outer space will be extremely technologically mediated because of limited resources and the hostile conditions in which crops have to be cultivated. From a biopolitics perspective, this will cause a significant shift in power relations. Because of the extreme dependence on technology, the lack of open reservoirs (e.g., no atmosphere), and an atomized commodification of life-supporting resources (every molecule is valuable), space colonists will live in a world in which they are potentially vulnerable to inequalities, power concentrations, and even coercion. Historically, colonization and agriculture have always worked with each other. But in the unparalleled conditions of space, this dialectic relationship is bound to take on new contours, with its own unique set of ideologies and ethical ramifications. The 'Space Farming Project' is an art project that specifically addresses these issues. It was initiated by the international SEAD collective, developed in collaboration with Gluon and Howest, and supported by the Flemish Government. Together with a diverse community of volunteering technologists, agricultural researchers, teachers, and students, different space biology prototypes have been developed: a centrifuge for plant cultivation in space, a microgravity simulator, and experiments with spirulina algae and edible callus tissue. These are the central components of a larger art installation that also features visual and discursive references to the history and future of colonization, and its entwinement with agriculture. In this paper, the conceptual background of the 'Space Farming Project' is described, together with its development process and the resulting prototypes. The future of the project, with potential experiments on board the ISS, is also discussed.
Keywords: Space colonization; Regenerative life support; Agriculture; Horticulture; Biopolitics; Installation art

1. Introduction

> *In extreme environments like outer space, the concept of environment cannot be bracketed out from life processes; as a result, investments of power and knowledge shift from life itself to the sites of interface among living things, technologies, and environments.*
> – Valerie A. Olson, 2010

> *In the unforgiving environment of outer space, technological apparatus itself becomes not only a fundamental means but also a central object of biopolitical governance.*
> – Katarina Damjanov and Damien Crouch, 2018

These quotes from Olson [1] and Damjanov and Crouch [2] encapsulate the significant shift that happens when the locus of human life shifts from the surface of the Earth towards deep space. Open and readily available reservoirs with life-supporting elements such as oxygen and water do not exist any longer. Each of those molecules needs to be fabricated, contained, stored, transported and delivered. The human body becomes completely dependent on a technological apparatus that provides it with every single molecule it needs. Herein lies a dramatic shift of power, and potential new seeds for friction and conflict in human civilization. Governing citizens and their body become a very direct affair, up to a molecular level. Ideally, the governance of life-supporting elements would be governed as a commons to maximize autonomy and guarantee freedom. But it is not unthinkable that our future in outer space would look very different, with commercial or political entities taking sole control of these essential resources and using that to control populations and accumulate power and wealth.

The production of life's essentials such as oxygen and water does not need to be strictly produced by machines. Currently, life support in space habitats such as the International Space Station is administered by a series of interconnected machines such as CO_2 scrubbers and water recycling equipment. But for truly long-term exploration and space colonization, it'll be essential to take along living organisms and make use of regenerative ecosystems that recycle human waste, produce crops, generate oxygen and purify water [3,4]. Such ecosystems will be managed and complemented by technology, creating a hybrid fusion of ecology and machines, a techno-agriculture creating the conditions for long-term human life in the hostile environment of space.

The word 'colonization' is deliberately used here as a provocative term, specifically because it conjures up problematic images from the past (a more neutral term would be 'settlement'). Historically, there's always been a strong entanglement between colonization and agriculture. These quotes from Knoblauch [5] illustrate this well:

> *The two words work together: colonization is about enforcing landownership through a new, agricultural occupation of lands once used differently.*
> *Colonization […] brings culture to a wilderness. Colonization is an agricultural act.*
> – Frieda Knobloch, 1996

However, agriculture is actually just a component of a larger biopolitical framework that is instrumental in colonization processes. Biopolitics is used here according to the definition of Foucault. It can be understood as a political rationality which takes the administration of life and populations as its subject "to ensure, sustain, and multiply life, to put this life in order." [6,7] France, for example, employed biopolitics in its colonization of Western Africa. Thanks to the germ theory of disease pioneered by Robert Koch and Louis Pasteur, the etiology of some of the deadliest diseases such as cholera and typhoid began to be understood in the 1890s. Attention then turned to the tropical climates. The bacillus of bubonic plague was isolated, and vectors of malaria and yellow fever were identified. Public health laws were passed to introduce up-to-date health standards. The goal was for African subjects to respond in exactly the same way as metropolitan citizens to market incentives and new technologies imposed by a progressive state. As such, public health was a political concern in the sense that the state assumed citizens would be more productive if they were healthier and lived longer. [8]

All of the above forces us to take a more critical look at current narratives about space colonization. The fact that, historically, colonization has always been enabled by shifting the locus of biopolitical power through agriculture and biological science gives us reason to pause and reflect. Especially in extreme contexts such as outer space where vacuum is the most dominant physical condition.

2. Space Farming Project

The Space Farming Project is a community art project that specifically explores these issues. It was initiated by the SEADS collective and Gluon, developed in collaboration with Howest and the Provincial Technical Institute (PTI) Kortrijk, and supported by the Flemish Ministry of Culture. Together with a diverse community of volunteering technologists, agricultural researchers, teachers, and students, different space biology prototypes have been developed: a microgravity simulator, a centrifuge for plant cultivation in space, and bioreactors for growing plant callus and microalgae. These prototypes represent an open source response to the question how we can create more direct ownership over the biopolitics that are inevitably being developed in outer space. They open up the possibility of reconceptualizing space colonization and reimagining life-supporting ecologies. The different prototypes form the core elements of a larger art installation that includes visual and discursive references to the history and future of colonization, and especially its entwinement with agriculture.

3. Project development

The first iteration of the project was developed over the course of several months, more specifically from December 2018 till the presentation of the project at BOZAR during the Tendencies '19 exhibition which ended on June 9, 2019. Several phases characterized the development of the prototypes. Firstly, the concept was presented to all interested partners and communities in the area of Kortrijk, Belgium. Subsequently considerable brainstorm sessions were held in order to conceptualize the shape of the project, after which exploratory experimentation and testing were initiated (Fig. 1). Over time, the group zoomed in on the use of undifferentiated parenchyma cells, applications with microalgae and artificial gravity.

These ideas crystalized into three specific prototypes that were developed by three different teams, in close collaboration with the first author. Weekly meetings were set up during which everyone updated the entire group on their progress. This involved different disciplines such as horticulture, biotechnology, mechanical engineering, 3D printing, critical design, art theory and more. This co-creation methodology had been employed before by the SEADS collective, in other community art projects such as Biomodd [9] and Seeker [10]. Before the final presentation at the Tendencies '19 exhibition, all prototypes were tested in order to assure a continuous development of the biological cells and plants during the exhibition.

Fig. 1. Space Farming project, project development at Howest and PTI Kortrijk. Photos by Angelo Vermeulen and Ramona Van Gansbeke.

4. Installation description

The first iteration of the project was an art installation exhibited at BOZAR in Brussels during the Tendencies '19 exhibition. An overview of the different installation elements is given below.

4.1 Prototype 1: Artificial Gravity Generator

Plants can develop and produce seeds in microgravity conditions, but it is still unclear how crop productivity is affected by the lack of gravity. When deployed in outer space, plants grown in this rotating device experience artificial gravity, due to centrifugal forces. Accordingly, this device allows for running comparative plant experiments and determine how to best grow food in space (Fig. 2 and 7). Much larger concepts of this approach have been envisioned in the 70s by Gerard K. O'Neill in his seminal work on rotating space colonies.

4.2 Prototype 2: Plant Morphogenerator

Plant callus is a growing mass of undifferentiated parenchyma cells. Using different plant hormones, these cells can be triggered to either develop edible cell mass, roots or leaves. Using this approach, plants can be 'shaped' according to different nutritional needs. As such, this seems a promising technology to deal with the inherent unpredictability of space colonization. One prototype is growing potato plants (Fig. 3), the other beetroot (Fig. 4). Potatoes are a classic staple providing essential calories and have already been grown in space. Beetroot contains a large diversity of minerals, vitamins and antioxidants, and could be an ideal supplementary crop in space colonies.

4.3 Prototype 3: Arthrospira Photobioreactor with Microgravity Simulator

Arthrospira is an edible microalga that has been used as protein source since millennia. It was harvested in South America in Inca times, and is still used as a staple ingredient in Chad. It is also a key organism in the MELiSSA regenerative ecosystem developed by the European Space Agency [11]. The three vertical photobioreactors contain cultures of three different strands of Arthrospira, each which a distinctive cell shape (Fig. 5). This shape has consequences for ease of cultivation and harvesting efficiency. The kinetic device is a random positioning machine (RPM), used to simulate microgravity conditions (Fig. 6). The RPM is used here to study the growth of Arthrospira in space-like conditions.

Fig. 2. Space Farming Project, Artificial Gravity Generator. Photo by Gluon.

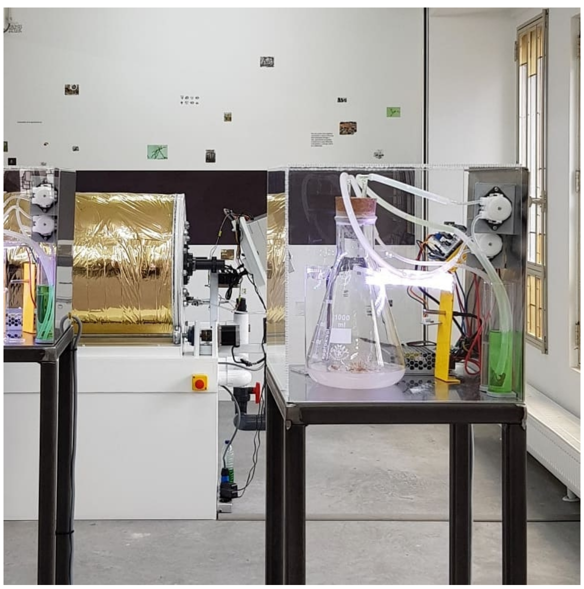

Fig. 3. Space Farming Project, Plant Morphogenerator. Photo by Gluon.

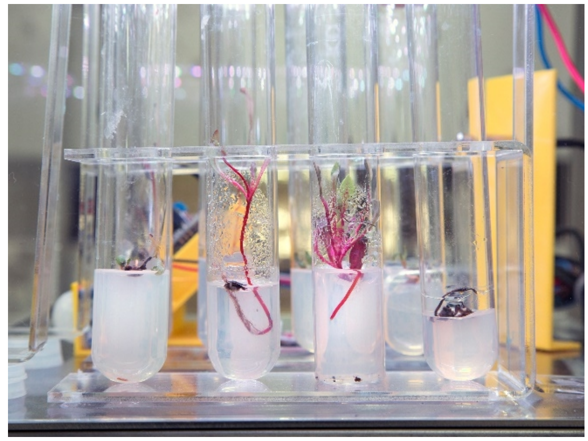

Fig. 4. Space Farming Project, Plant Morphogenerator. Photo by Angelo Vermeulen.

Fig. 5. Space Farming Project, Arthrospira Photobioreactor with Microgravity Simulator. Photo by Angelo Vermeulen.

Fig. 6. Space Farming Project, Arthrospira Photobioreactor with Microgravity Simulator (detail). Photo by Angelo Vermeulen.

Fig. 7. Space Farming Project, installation view, BOZAR, Brussels, 2019. Photo by Angelo Vermeulen.

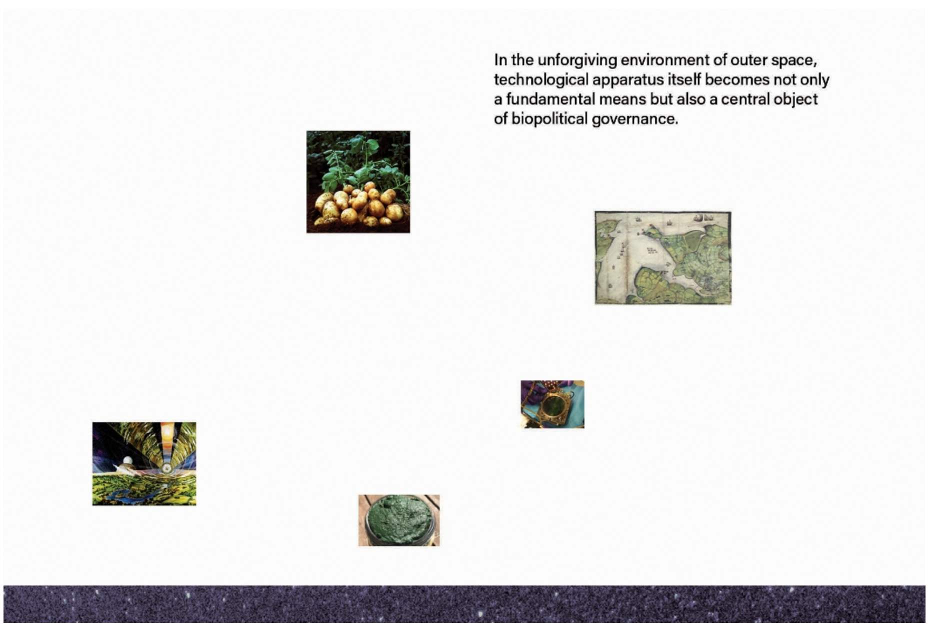

Fig. 8. Space Farming Project, detail of wall-mounted graphic design. Design by Victor Steemans.

4.4 Graphic design as recontextualizing framework

A large-scale graphic design composition was mounted against two adjacent walls of the exhibition space (Fig. 7). This composition contained both images and text (Fig. 8). The images ranged from historical images about colonization and agriculture to space biology research and futuristic visions of space ecosystems. The texts were selected quotes, some of which are also used in this paper (see Introduction). All these elements were organized in a non-linear, associative manner above and below a large horizontal image of a starfield exposing a part of the Earth's surface. The individual images and quotes were deliberately printed in a small format to avoid them becoming a mere visual background for the prototypes and engage the audience to come closer and engage with their meaning.

5. Conclusion

None of the participants who built the space biology prototypes was a space professional which is a key element in this first iteration of the Space Farming Project. By employing a DIY approach and operationalizing a hacking ethos in the development of the prototypes, a conceptual shift of power and knowledge occurs. The act of shaping the course of the future of humankind in outer space is opened up, disconnects itself from the exclusive domain of state agencies, large knowledge institutions and corporations – it becomes radically inclusive and participatory. Additionally, by presenting the prototypes within a visual and discursive context of colonizing narratives of biopolitical power, the artifacts get a new meaning and become invitations to rethink assumptions and question entrenched paradigms.

For the next step of the project, the goal is to turn one of the three prototypes into a small-scale space biology experiment that is launched to the International Space Station and brought back to Earth. Space Application Services is a potential partner for this project with their ICE Cubes framework that facilitates access to space. Bringing the project physically into space will undoubtedly further evolve it by bringing about a whole new range of questions and insights.

Acknowledgements

Space Farming project is an initiative of SEADS ivzw and Gluon vzw. The first iteration of the project was developed in collaboration with the Provincial Technical Institute (PTI) Kortrijk, Howest, Aquaterra, ArAqua and Algimun. Project participants: Hans Ameel, Vincent Benoit, Rufin Degrande, Germain Desmet, Jorden D'Hulster, Koen Fauconnier, Adriën Fauconnier, John Geldof, Bart Leenknegt, Dries Ongenae, Nick Pannecoucque, Rik Tanghe, Victor Steemans, Pieter Steyaert, Ramona Van Gansbeke, Angelo Vermeulen.

Flanders
State of the Art

References

[1] V.A. Olson, The Ecobiopolitics of Space Biomedicine, Medical Anthropology 29(2) (2010) 170-193.
[2] K. Damjanov, D. Crouch, Orbital Life on the International Space Station, Space and Culture 22(1) (2019) 77-89.
[3] B. Imhof, P. Weiss, A.C.J. Vermeulen, The world in one small habitat, in: R. Armstrong (Ed.), Star Ark, Springer, Switzerland, 2017, pp. 287-296.
[4] A.C.J. Vermeulen, M. Sirenko, A. Papic, J. Kiem, A. Theys, F. Brazier, Evolving Asteroid Starships: A Bio-Inspired Approach for Interstellar Space Systems, IAC-18-D1.1.2, 69th International Astronautical Congress, Bremen, Germany, 2018, 1-5 October 2018.
[5] F. Knobloch, The Culture of Wilderness: Agriculture as Colonization in the American West, The University of North Carolina Press, Chapel Hill, 1996.
[6] M. Foucault, The Will to Knowledge – The History of Sexuality Volume 1, Penguin Books, London, 1998.
[7] R. Adams, Michel Foucault: Biopolitics and Biopower, 10 May 2017, http://criticallegalthinking.com/2017/05/10/michel-foucault-biopolitics-biopower, (accessed 27.10.19),
[8] S. Stockwell, The Rise and Fall of Modern Empires – Volume III: Economies and Politics, Routledge, Oxon, 2016.
[9] D.S. Maranan, A.C.J. Vermeulen, When Ideas Migrate: Postcolonial Perspectives on Biomodd [LBA^2], 21st International Symposium on Electronic Art, Vancouver, Canada, 2015, 14-19 August.
[10] A.C.J. Vermeulen, C. Nevejan, F. Brazier, Seeker: Co-Creating Diversified Futures, in: J. Boelen, I. Huygens, H. Lehtinen (Eds.), Studio Time: Future Thinking in Art and Design, Black Dog Press, London, 2018.
[11] C. Lasseur, J. Brunet, H. de Weever, M. Dixon, G. Dussap, F. Godia, N. Leys, M. Mergeay, D. Van Der Straeten, MELiSSA: The European project of a closed life support system, Gravitational and Space Biology 23(2) (2010) 3-12.