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The Joy of Sets presents Capricorn Two: A Mars Mission Simulation

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Abstract

The Joy of Sets is an educational workshop series based on the activity of set-building. Primarily working in schools of art and design, it presents students with a chance to explore a rapid prototyping approach to realising ideas hands-on at 1:1 scale. The Joy of Sets champions making as not only a production process but a creative one, where thinking-through-making becomes a way of exploring scenarios and experimenting with ideas in dynamic and playful working atmospheres.

This paper discusses approaches and outcomes of a special edition of the The Joy of Sets entitled “Capricorn Two”: a collaboration between Joseph Popper, artist and workshop leader; Dr. Barbara Imhof, space architect and co-founder of LIQUIFER Systems Group, and students of the University of the Underground, Sandberg Institute in Amsterdam.

With guidance from Popper and Imhof, the students produced detailed, immersive environments out of cardboard and other simple materials, designed as stages for dedicated Mars mission simulations. The sets stood for locations on Earth and the surface of Mars, from where the students performed the different roles of the various crew members involved in the missions. The simulations were based upon Project MOONWALK analogue experiments where Imhof’s team was one of the project partners. An essential part of project MOONWALK were two complex mission simulations in Rio Tinto and subsea Marseille. The different sets of Capricorn Two were connected by video-call and a 30-second communications delay between Earth and Mars was imposed part of a strict mission protocol.

For the students, Capricorn Two was an opportunity to experience a dedicated mission in outer space based entirely on their own handmade objects and sets that they built in the studio. They were able to synthesise physical making with the enactment of an as yet unprecedented experience of human space exploration. Imhof scripted unexpected emergencies for the students to respond to and improvise upon - provided exercises in teamwork under stress and strict protocol, how to communicate clearly across the solar system.

Bringing set building together with space mission protocols demonstrates an exciting potential of hands-on making as a form of dedicated space research. By combining mission scenarios with invention, imagination and fabrication, handmade space simulations can be an engaging and valuable form of informed investigation by speculative methods of experience design.

Keywords: Simulation, Set-building, Mars, Experience Design, Education, Workshop

“Simulation does not imitate; it generates.”
(Lisa Messeri)

1. Introduction

This paper discusses the processes and outcomes of a workshop entitled “The Joy of Sets Presents Capricorn Two”: a collaboration between artist Joseph Popper, space architect Dr Barbara Imhof, and the students of the University of the Underground, Sandberg Institute. With guidance from Popper and Imhof, the students produced detailed stage sets at 1:1 scale and used them for practicing space mission simulations. In a short time-frame, the students were able to both create built environments in high resolution and also produce immersive and immediate experiences of conducting missions on Mars. "Capricorn Two" was an interdisciplinary meeting of different kinds of practice and areas of expertise. Popper builds scenographic art installations and leads educational workshops in set-building that focus on the rapid prototyping of ideas, Imhof is the co-founder of LIQUIFER Systems Group and designs analogue experiments for simulating complex space missions, and the designing of aesthetic experiences underpins many of the projects of the University of the Underground students. Through the workshop these complementary approaches came together in interesting and exciting ways. This interdisciplinary approach is reflected in the multidimensional learning outcomes of the workshop, relating to aesthetic practice and space research. The common thread connecting experience design, artistic research and space architecture is a shared interest in how creating experiences can be meaningful - for giving imaginative and tangible form to ideas and generating ways of knowing.

2. Background

Imhof and Popper were invited by Dr. Nelly Ben Hayoun, leader of the University of the Underground MA programme, to collaborate together on a workshop with the students. The University of the Underground is an international creative educational platform currently providing an MA in Design of Experiences in collaboration with the Sandberg Institute, Amsterdam. The mission of the University is to support unconventional research and practices investigating issues around the formulation of culture and the manufacture of knowledge. Students learn how to engineer situations and design experiences to interact with institutions and governments, as a means of democratising public access to them and instigating social change.

Both Imhof and Popper have extensive teaching experience in higher education. Through various projects they also share a history in bringing space culture to others, engaging with different aspects of outer space from multiple perspectives.

Fig. 01: The Joy of Sets x The Stanley Kubrick Archive London Design Festival 2016
Credit: Scene Everything


Fig. 02: The Joy of Sets at the Royal College of Art
Credit: Scene Everything, 2013

"The Joy of Sets" is an educational workshop series based on the activity of set-building, co-founded by Joseph Popper with Nicholas Mortimer. With "The Joy of Sets", Popper and Mortimer led art and design students to imagine speculative scenarios of outer space through building extra-terrestrial habitats at 1:1 scale. Previous iterations of the workshop held greater reference to science fiction and the cultural imagination of outer space, where students responded to science fiction films as primary source material to go about imagining and rapidly prototyping their own fictions. "The Joy of Sets" also collaborated with the Stanley Kubrick Archive and University of the Arts London students in an exhibition project for London Design Festival 2016. Here, the students responded to material from the Kubrick Archive to build a section from the iconic centrifuge set from "2001: A Space Odyssey", activating the archive through making and reimagining a speculative vision of spaceflight at full scale.

Figs. 03, 04: (above) Project MOONWALK Simulation
Credit: B. Stubenrauch, 2016

Fig. 05: B. Imhof in Project MOONWALK Simulation
Credit: Comex, 2016

Imhof taught, as part of a teaching team, a simulation workshop for the International Space University (ISU) Summer Session Programme (SSP) in Graz, Austria in 2010. The programme is directed towards master level and PhD students from all over the world with different backgrounds, mostly in space science and space engineering. The one-day-workshop included a simple half dome cardboard habitat, some goggles and gloves to simulate sample taking on a Martian surface. Further teaching experience include 8-years in space architecture design studios at the Vienna University of Technology Architecture Faculty, at the ETH in Zurich, PhD supervisor for simulation related PhDs at Chalmers University of Technology in Gothenburg and lecturer and teacher of one-day workshops at ISU since 2013. On a daily basis Imhof is with Waltraut Hoheneder the managing director of LIQUIFER Systems Group, a Vienna-based company comprising of architects, designers, space engineers and scientists. LIQUIFER have been working on human space exploration concepts and prototypes since 2003. In recent years, the team was involved in analogue research and space simulation activities such as project MOONWALK, funded by the European Commission and led by the German Center for Artificial Intelligence in Bremen. The team develops simulation hardware and interfaces, as well as conceiving mission scenarios. Barbara Imhof led the project MOONWALK for LIQUIFER, and also had the opportunity to serve as simulation astronaut in the simulation which was conducted in Rio Tinto, Andalusia. Additionally, Imhof has participated in the MOONWALK subsea lunar simulations off-shore Marseilles and has visited simulations by the Austrian Space Forum.

3. Simulation as a tool

Not many people have been to space, only about 550 astronauts and cosmonauts compared to over 7 billion people living on Earth. With such limited actual experience among us and the unparalleled difficulty and cost of leaving Earth, designing for space arguably becomes "speculative by default." (Peldszus & Dalke, 2010). Imagination is required to both understand the cosmos and also to "place" ourselves within it (Messeri, 2016).

Exploring far away worlds with humans is a highly complex and expensive venture. Space also presents an incredibly challenging and complex environment. Its harsh constraints mean complex procedures and systems are mandatory for human survival and also to achieve mission goals. Therefore, extensive preparations are needed and training under certain conditions - faithful to the real terrains - is essential to the success of a mission. Simulations present an excellent tool to model, mimic and enact specific conditions of investigative interest. With relatively little organisation, material and financial effort in respect to an actual mission the learning curve of simulations for real situations can be steep and valuable lessons can be learnt.

In the last 50 years many different kinds of simulations on a variety of fidelity levels were conducted in anticipation of real space missions or just to investigate specific research questions in the fields of physics, geology, sociology, psychology and many more. For example, in the Apollo mission preparations, astronauts pursued different kind of simulations to prepare themselves for the unknowns of the lunar environment and surface. Fig. 06 shows Apollo 12 astronauts Charles Conrad (left) and Alan Bean in their mockup spacesuits inside NASA facilities practicing every aspect of their missions in timeline run-throughs, here depicted, documenting lunar rock samples at Kennedy Space Center in 1969. Simulating a space mission enables the training of multiple skills, including the setting up of complex scenarios; understanding operations and comprehending places within the mission in relation to other crew members. To enact a space mission in an enclosed space is a matter of following procedures, acting out these guidelines and through this, testing setups, finding solutions to problems and generating new knowledge. By practicing simulations, astronauts learn not only what to do during their mission by heart but also what being in outer space would be like - enacting the activities as if they would already be at their mission destination. This familiarising of the strange helps them to feel more comfortable when being in the actual harsh environment, where errors can have deadly consequences.

There are three main components of a human space simulation, as identified by Susmita Mohanty (2009):

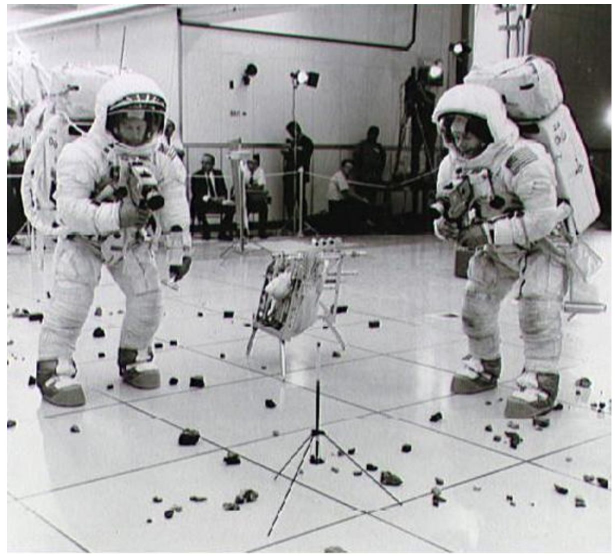

Fig. 06: Apollo mission simulations (Credit: NASA)

Simulator:
"A simulator is a system that can mimic planetary missions, both in terms of design and operations. The system comprises an isolation habitat at the very least, and might include, among others, a greenhouse, rovers, spacesuits, simulation support structures, and a simulated (or real) terrain resembling that of the destination planet. The system is either located in a non-extreme environment such as a building on a space agency site, or in an extreme environment such as the Arctic."
(Mohanty, Mount and Nyström, 2006)

Simonaut:
"A simonaut is a crewmember participating in a simulation."
(Mohanty, Mount and Nyström, 2006)

Simulation:
"Planetary simulations are simplified and abstracted representations of a more intricate real-life mission. They vary in complexity and degree of reality being represented. The role of space mission simulation design is to create facsimiles that are consistent with the proposed planetary mission, even if they are of a more simplified nature." (Mohanty, 2009)

Our Capricorn Two workshop integrated these three elements into its design. Set in an underground space, our simulations would follow precedents of other indoor experiments - such as the Mars 500 study, where 6 simonauts practiced an international 520-day Mars mission simulation at the Russian Institute for Biomedical Problems in Moscow from June 2010 - November 2011.(Ref. 2).

Fig. 07: Diego Urbina, Mars 500 crew member in the simulator, 2010 (Credit: ESA)

There are other examples of educational workshops based on space simulations. Researchers and students at the Space Systems Laboratory (SSL) at MIT conduct simulation workshops regarding human-robot collaboration and mapping the environment. Diego Urbina, space engineer and former Mars 500 simonaut, is also leading simulation workshops at the International Space University (ISU), Strasbourg. The ISU workshops focus on communications and the 3-minute communication delay between Earth and Mars. What differentiates the ISU workshop from ours is its use of readily available software, interfaces and props – including an actual S.H.E.E. (Self-Deployable Habitat for Extreme Environments) as a simulator. The workshops also run for a maximum of two days on average compared to our three-day timeframe.

4. Premise

The premise of simulating missions on Mars presented an opportunity for Imhof and Popper to design a workshop together, where combining their research interests and expertise helped create a particular methodology for both education and research. On one hand, the methods shared by "The Joy of Sets" champion the practice of research-in-the-making, they embrace generating and experimenting with ideas in physical form: this interest extends from the forms of handmade sets and objects as standalone artefacts to their diegetic potential for imagining and enacting narratives. On the other, the practice of space mission simulations is motivated by the effort to generate or gain knowledge of outer space and human space exploration. Imagined, dedicated scenarios are means for scientific testing of spaceflight architecture and knowing the realities of exploring outer space. With the "Capricorn Two" workshop, Imhof and Popper were able to both introduce creative methods for the rapid prototyping of ideas and also employ these methods to generate high resolution space mission simulations, generating experiences for the students of being on Mars. The workshop was a unique opportunity to synthesise physical making with a dedicated imagining of an as yet unknown, unprecedented experience of outer space - a chance to learn about making, and how making itself can be a way of knowing.

5. Problem Statement

In her article "Resonant Worlds: Cultivating proximal encounters in planetary science" (2017), anthropologist Lisa Messeri introduces the idea of "resonance" to describe a feeling that enables planetary scientists to experience the distant as a way of knowing. Messeri describes a moment of resonance during analogue fieldwork on a Mars Desert Research Station in Utah, where scientists encounter geological formations similar to those found on Mars, also described as "Martian blueberries". The rocks were found by the scientists to be so similar, so resonant with their Martian counterparts they "provoked a cognitive shift", generating an experience beyond studying Mars: creating an intimate sense of being there. Through resonance, the remote distance of Mars from Earth is collapsed as the similar "is transformed into the same" and *here* is substituted for *there*.

For Messeri, resonance is achieved through "combin[ing] reasoning with affect, imagination and embodiment". It is a kind of "attunement" where connections between distant worlds are sensed, detected and amplified to generate an intimate experience of remote, alien terrains. Through the imaginary encountering of Mars on Earth, Messeri conveys these scientists are able "to make the strange familiar and thus knowable". Resonance is most interesting because it describes a kind of imagining that achieves a kind of "impossible immediacy" in the context of a scientific process, overcoming the physical distances of the solar system to generate a "way to know, even experience another world" without leaving planet Earth. Here, we see a form of imagining working towards producing knowledge.

Messeri describes the "common challenge" of contemporary sciences "of knowing that which is removed from the human experience". This challenge is further complicated by the kinds of scalar, spatial and temporal divides that planetary scientists negotiate in order to study and know outer space. For Messeri, resonance is a way of knowing what is beyond the human experience *through* generating experiences, where the scientists' imaginations interact with knowledge to facilitate "deeper" understandings of Mars through alien encounters.

The ideas introduced by Messeri around resonance help set the scene for the questions we approached in "Capricorn Two": How can we understand "something that might not actually be present"? How can we overcome interplanetary distances? How can we generate "impossible immediacies", and experience being on Mars from a basement in Amsterdam? Conducting our space mission simulations offers a chance to combine expertise, knowledge and imagination in a process of "attunement", testing how cardboard can provoke cognitive shifts. Through building environments and performing mission scenarios, making and enactment were our tools for overcoming distances to know and experience another world.

Fig. 08: Earth Mission Control (Credit: Joseph Popper)


Fig. 09: Simonauts conducting EVAs on Mars surface Credit: Joseph Popper

6. The Workshop

In January 2018, Imhof and Popper met the students at the University of the Underground studios, a large basement underneath a bar in Amsterdam. The workshop was held in an intensive three-day timeframe. Following introductions by Imhof and Popper, the workshop brief was delivered to the students. They were divided into groups and tasked with designing and building three sets for the purposes of performing Mars mission simulations. The first two days of the workshop focused on set-building processes. Upon completion of the sets, the mission simulations ran on the third day as the concluding part of the workshop.

The first set of our scenario, Mission Control, was based on Earth. The second and third, the S.H.E.E. and a manned Mars Rover, were both set on the surface of Mars. A miniature scale model Martian terrain completed the array of environments – this was navigated by a remote-control rover fitted with a camera, providing a further layer of interaction for our simonauts. Each group was designated a set and provided with an envelope of references to respond to. These contained basic outline drawings, required object lists and imagery from existing space simulations and science fiction film. The groups began by constructing timber skeleton frames to inform the shape of the sets. Over the three days - working primarily with cardboard - they developed the resolution from basic structures and general shapes to high detail environments, with individual characteristics and aesthetic qualities to each station.


Fig. 10: Cockpit of Mars Rover on Mars surface
Credit: Joseph Popper


Fig. 11: Simonauts after completing EVA simulation
Credit: Joseph Popper

In parallel with the set-building, Imhof composed three scripts for the simulations to run. The scripts replicated aspects of the project Moonwalk analogue experiments conducted by MOONWALK partners in Rio Tinto and Marseille, testing new space exploration techniques and technologies. For the simulations the students changed roles from set-builders to actors - playing the different dedicated roles in the mission scenarios. Earth Mission Control, the S.H.E.E and the Rover each housed key roles in the mission, corresponding to key activities. For example, the S.H.E.E. was inhabited by two astronauts and a local CapCom along with a space tourist - their main actions were to perform E.V.A.s (Extravehicular Activities) for collecting samples of the Martian surface, relaying their progress with the other stations. The three sets, and each student had a role to play in every simulation in a process of constant communication and interaction under strict mission protocol, directed by Imhof. The three sets were connected via an online platform with an imposed 30-second time delay to mimic communicating over vast, interplanetary distances. Imhof also scripted unexpected emergencies for the students to respond to and improvise upon. These surprise emergencies were an opportunity for the students to improvise within the structure of the missions, and also were an exercise for the students to practice teamwork in urgent conditions.


Fig. 12: Miniature model scale rover on Mars terrain
Credit: Joseph Popper

7. Methodology

By combining and adhering to the three basic elements of a simulation (outlined by Mohanty above) we were able to shape our particular methodology for Capricorn Two. The methods and learning outcomes were informed by the different stages of the making process.


Fig. 13: Mars Rover set under construction (J. Popper)

<u>Stage 01: Building the Simulators:</u>
The students designed the different station interiors responding given source material. The aim of providing the reference material at first was to encourage the students to begin sketching and making from the start, an opportunity to move away from the computer and get

hands-on from the get-go. The next steps were to construct timber skeletons of the sets, and then render the environments out of cardboard and other simple materials. Cardboard was the main material of choice for its pliability and also its 'non-precious' quality, thereby encouraging students to try things and enjoy making mistakes: important aspects of a rapid-prototyping process. Each group was given a list of specific elements to include in their given sets: such as a mission control console, a rover cockpit or communications system. The building of multidimensional sets presented an opportunity for making at different scales, a process of zooming-in from larger, sculptural shapes to high detail components, while transforming simple materials in to tangible objects.

Stage 02: The Simulation

The simulations scripted by Imhof were simplified from existing models such as project MOONWALK. Reducing the Earth-Mars communications delay to 30-seconds enabled the students to run three versions of the simulation, and to act out a number of mission roles: such as the CapCom, scientist or Flight Director. The Earth and Mars sets were separated into different rooms in the studio, so that the Earth and Mars teams could not hear or see each other directly. This meant they had to rely on online communication to co-ordinate the mission, increasing a sense of imaginary distance between the stations. The simulations were also an opportunity to learn specific terminology and language protocols – further contributing to a sense of realism to the scenario.

Stage 03: Becoming Simonauts

With the sets and props ready, and the teams selected and briefed, it was left for the students to become simonauts and bring the mission narratives to life. While the general mission plans were known to all, we also introduced certain elements which could go 'wrong' to create unexpected events and unknown situations. Specific roles were given secret actions to play out as a way to upset mission procedures. By encountering unexpected circumstances, the simonauts were required to exercise individual and collective coordination and decision making in stressful scenarios, while also negotiating with the communication time-delay from Earth to Mars. These mission upsets encouraged the students to improvise and work together by increasing the sense of immediacy to the simulation experience. For example, a simonaut on Mars who injured herself on an E.V.A. would need to wait at least for 1 minute to receive medical advice from the doctor stationed on Earth.

Fig. 14: Spacesuit designs in progress
Credit: Joseph Popper

In short summary, the building of the different stations is an exercise in rapid prototyping methods at 1:1 scale, and the mission plans introduce to the students established space mission plans, protocols and terminology. The station sets and props together with the mission plans then become the tools for the designing of experiences, through developing and performing space mission narratives. Through animating their handmade environments and becoming simonauts, the students are able to generate a sense of immediacy akin to Messeri's "resonance", bringing them closer to Mars from a basement in Amsterdam, creating ways of knowing what it means to *be there*.

Fig. 15: Mars rover cockpit detail
Credit: Joseph Popper

8. The Set-up

The following diagrams illustrate how the different aspects of the workshop and simulation were organised:

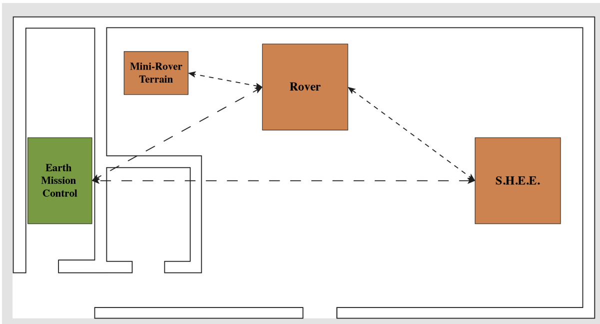

Fig. 16: Map illustrating the arrangement of four simulator sets in the University of the Underground studios; dashed lines represent lines of communication between the different stations during the simulations.

Fig. 17: Table of Simulation Roles *

Earth Mission Ctrl	S.H.E.E.	Mars Rover
1. Flight Dir. 2. Cap Com 3. Med Doctor 4. Scientist 5. Journalist	6. Cap Com 7. Astronaut 01 8. Astronaut 02 9. Space Tourist	10. Rover Crew 11. Rover Crew

* Plus x3 other students formed a film crew to document the simulations

9. Results & Potential

The students achieved a number of diverse learning outcomes - reflecting the interdisciplinary nature of the workshop. They practiced working with cardboard and paper at 1:1 scale, transforming simple materials into narrative spaces and objects. They accomplished a range of macro and micro building tasks and demonstrated their ability to problem solve with materials in order to realise their design ideas. The results were ambitious spaces rendered by hand in high resolution. By adopting a hands-on approach, they were able to put down the computer - breaking from usual studio routines and explore a different form of testing and project research. Upon their completion, the sets became the tools to perform imaginary and experimental narratives through enacting missions on Mars. The simulation scripts also focused on aspects of team play and communication, responding to the unexpected under the particular conditions of interplanetary exploration.

The groups were able to produce and realise so much in a short space of time. Given more time, there is further potential to produce and edit short films as artefacts for consolidating the performances and different simulation narratives. Films offer a chance to share the outcomes of the workshop with a wider audience. Another opportunity for dissemination is the format of a live video broadcast of the mission simulation.

Bringing set building together with space mission simulations demonstrated a potential of making to be a form of research in a dedicated way. The students imagined and realised environments as tools for venturing into the unknown – experiencing and testing as yet unexperienced future human-in-space scenarios. "The Joy of Sets: Capricorn Two" workshop demonstrates the potential of handmade simulations for producing knowledge through research in the making.

10. Conclusion

"The Joy of Sets presents Capricorn Two" was an opportunity to combine different educational approaches into a singular, unique workshop. It was a coming together of attitudes, where artistic practice met professional space design. This combination of art and engineering backgrounds provided a platform to approach with the human exploration of Mars along multiple levels of inquiry and concern. Through making and performing our simulations, the students were able to engage with the complex subject matter of human spaceflight in a dynamic and creative atmosphere.

We are perhaps most inspired by how the students were able to experience and and know about the 'realities' of being on Mars by making them in the studio. They demonstrated real ambition in the making, rendering their environments and props in high resolution with character and imagination. The resulting simulations were truly multidimensional and addressed different aspects of a Mars mission experience: from team play and protocols, communication delays between Earth and Mars, the weight of the E.V.A. suits to dealing with the unexpected.

In "Capricorn Two" the students were able to learn a diverse range of valuable skills and gain knowledge in a short space of time. They learnt about set-building and the potential of prototyping their ideas at 1:1 scale. They learnt how to compose and perform space mission scenarios true to actual models and protocols. Furthermore, they were able to apply these tools to create their own narratives of outer space, and in doing so learn about what it means to be on Mars. By combining mission scenarios with creative imagination and fabrication, handmade space simulations can be an engaging and valuable form of generating meaningful resonances of outer space through the design of experiences.

11. Acknowledgements

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References

1. Placing Outer Space: An Earthly Ethnography of Other Worlds; Messeri, Lisa; Duke University Press, 2016
2. Messeri, L., Resonant worlds: Cultivating proximal encounters in planetary science,; American Ethnologist, Volume 44, Issue 1, February 2017, Pages 131-142, https://doi.org/10.1111/amet.12431
3. MARS-500, https://en.wikipedia.org/wiki/MARS-500, as viewed 13.7.2018
4. Mohanty, Susmita; Mount, Frances; Nyström, Maria; Fidelity Evaluation Model for Planetary Mission Simulators: Part-I: Simonaut Survey, 2nd International Space Architecture Symposium [SAS], AIAA SPACE 2006, San Jose, 19-22 September 2006.
5. Mohanty, Susmita; Integrated High-fidelity Planetary Mission Simulators: A Toolkit for Fidelity Evaluation, Department of Architecture, Chalmers University of Technology Göteborg, Sweden 2009
6. Peldszus, R.; Dalle, H.; Spaceflight Settings as Laboratory for Critical Design, Swiss Design Network Conference 2010

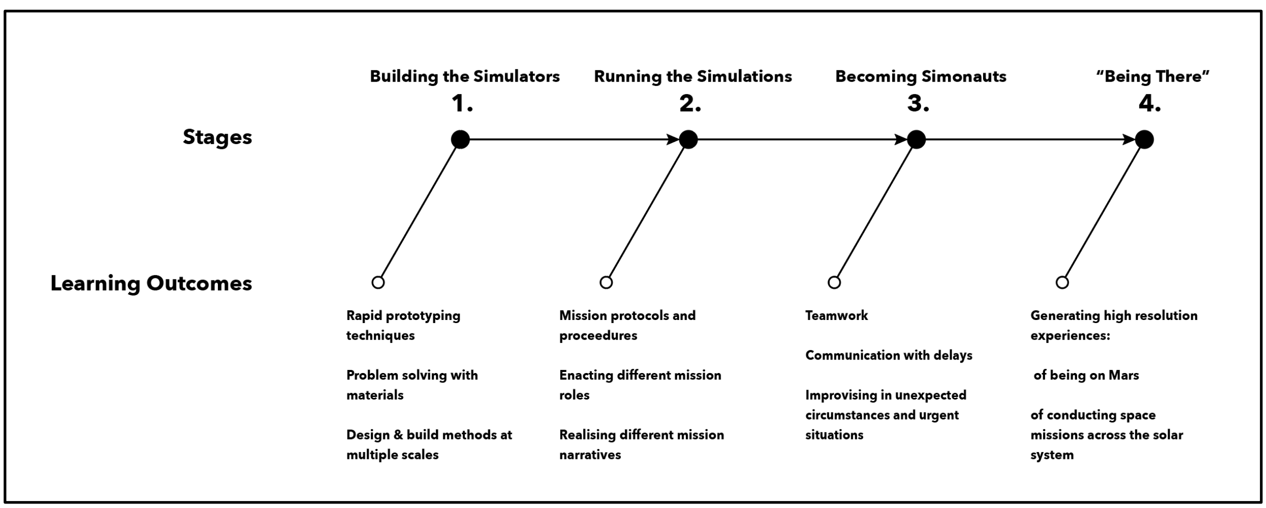

Fig. 18: The Joy of Sets presents Capricorn Two Methodology diagram