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Fidelity Evaluation Model for Planetary Mission Simulators: Part-I: Simonaut Survey

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Abstract

Space agencies are planning the next generation simulators in preparation for future human missions to Moon and Mars. Simulators serve as tools to test new technologies, habitat design, procedures, protocols, physiological requirements and psychological countermeasures. This paper focuses on simulator fidelity. Simulator fidelity, as defined by the research team, is: The degree to which a simulator system accurately reproduces the habitat (and/or transit vehicle) conditions, the Planetary Body of Interest (PBI) environment, procedures, protocols and operations of a real mission. Simulator fidelity is critical because the data collected and lessons learnt from simulations are intended for application towards the design of real space missions in the future. If simulator fidelity is compromised, then the simulation data generated might lead to erroneous conclusions. If such data is then used in the design of real missions, it has the potential to adversely affect the crew and in the worst case, even jeopardize the mission.

The paper begins with the definition and overview of simulators. This is followed by a discussion about fidelity standards outlined in a recent study by the European Space Agency and recommendations emerging from a workshop in Colorado focusing on improving the quality of future simulators. These recommendations reinforce the need for a 'Fidelity Evaluation Model' to measure, compare and improve fidelity of future simulators. As a first step towards the development of a Fidelity Evaluation Model, the authors gather data associated with simulator fidelity via a questionnaire-based survey of simulator crew members, referred to as *simonauts*. The authors debrief *simonauts* from the NASA Lunar Mars Test Project and the Mars Society simulations. The paper concludes with a summary of the survey outcome and a brief discussion of what the authors envision as the next steps in the development of the Fidelity Evaluation Model.

I. Introduction

NASA, the European Space Agency [ESA] and the Russian Space Agency are all planning the next generation of Planetary Mission Simulators in preparation for future human missions to Moon and Mars. In the past 20 years NASA has been using simulators to develop their closed-loop life support systems, as well as to confirm food and other crew support systems. At the present time, they are focusing on NASA's new Exploration Enterprise with fast-track horizontal and vertical mock-ups rather than simulators. The ESA simulator is called FIPES or Facility for Integrated Planetary Exploration Simulation. The name of the Russian simulation is not known. But as per a recent article in a German publication[1], the Russians are looking for six volunteers, who will be completely isolated from the outside world for 500 days, to participate in a simulated mission to Mars. The simulation is scheduled to begin in 2007 and will be conducted by the Institute for Biomedical Problems (IBMP) in Moscow. In addition to government space organizations, non-governmental entities such as the Mars Society run Mars analog stations: (a) Flashline Mars Arctic Research Station (FMARS)[2] on Devon Island in the Canadian Artic and (b) Mars Desert Research Station (MDRS)[2] in the Utah Desert. Mars Society is planning to install two more stations, one in Iceland and the other in Australia.

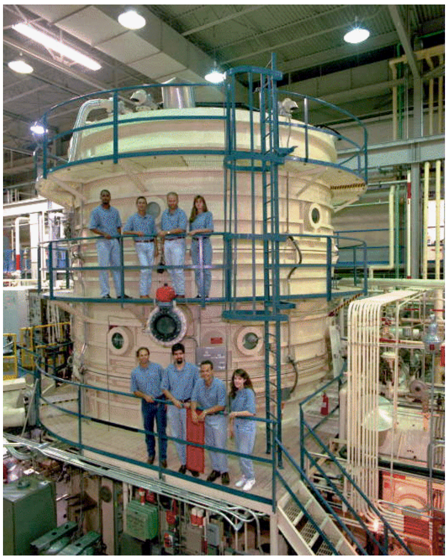

Image 1. Crew posing in front of the 20 foot LMLSTP test chamber [Credit: NASA]
Image 2. Mars Desert Research Station [MDRS] in Utah [Credit: Mars Society]

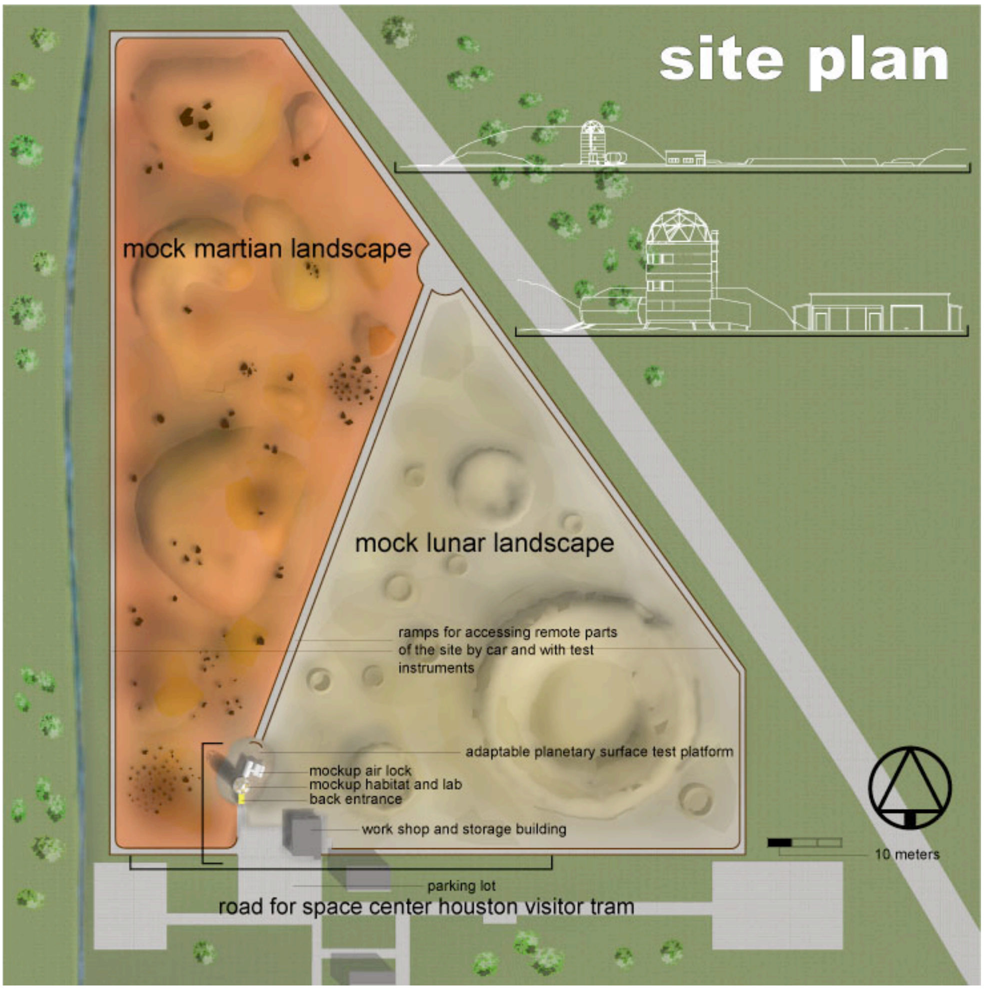

Image 3. Conceptual site plan for a future simulator at NASA Johnson Space Centre
[Source Credit: STAR Design student from Lund Institute of Technology, Sweden]

The terms *simulator* and *analog* are often used interchangeably in the aerospace industry. The word refers to 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 a *greenhouse, rovers, spacesuits, simulation support structures*, and a *simulated (or real) terrain* resembling that of the destination planet (Moon or Mars, in the present context).

The system is either located in a non-extreme environment such as a building in a secure site, such as a space agency site, or located in an extreme environment such as the Artic. For example the future NASA simulator is meant to be located in-situ at the Johnson Space Centre (JSC) in Houston. The Mars Society analog FMARS is located in the Arctic. The strategy in the former case is to allow easy and quick access by onsite personnel, which works well when the primary objective of the simulation is technology demonstration (e.g. test life-support systems). The latter is a good idea from a psychological perspective because it helps simulate a 'mental model' for the crew that they are (a) in an extreme environment and cannot have access to people or facilities nearby to help them in case of emergency, and (b) on a planetary terrain similar to Moon or Mars that allows for Extra Habitat Activity (EHA) simulations. It is important to point out, in the context of this research paper, that a *simulator* typically has a well-planned research agenda at the onset that treats a simulator mission as a controlled experiment based on a scientific methodology. Simulators serve as tools to test, among others, new technologies (e.g. life support systems, medical tools), habitat design (to ensure crew well-being over long duration missions), physiological requirements and psychological countermeasures.

Broadly speaking, simulator design broadly involves two major design components: (a) design of the simulator infrastructure (simulator habitat or transit vehicle and supporting elements such as the greenhouse and planetary terrain) and (b) the design of the simulation itself (operational aspects of the mission).

SIMULATOR DESIGN = INFRASTRUCTURE DESIGN + OPERATIONS DESIGN

II. Simulator Fidelity

A. Simulator Overview

There have been several simulations of space missions over the past decades. It is beyond the scope of this paper to list them all. Below is a short list of past, present and future simulators.

Table 1. Past, Present and Planned Simulators

EARLY SIMULATORS	• Regenerative Life Support Study by NASA Langley Research Centre • Apollo Ground-based Tests • Skylab Medical Experiments Altitude Test (SMEAT) • Skylab Mobile Laboratory (SML) • Ben Franklin Underwater Research Laboratory • Tektite I and II Underwater Research Laboratories
RECENT SIMULATORS	• BIO-Plex (Bioregenerative Planetary Life Support Systems Test Complex) • BIOS-3 (Institute of Biophysics-Siberia, Russia) • Biosphere-2 • Lunar Mars Life Support Test Project (LMLSTP) • Closed Ecology Experiment Facilities (CEEF)
CURRENT SIMULATORS	• NASA Extreme Environment Mission Operations (NEEMO) • Mars Desert Research Station (MDRS) • Flashline Mars Arctic Research Station (FMARS) • Concordia • NASA Fast Track Horizontal and Vertical Mock-Ups for lunar habitation
PLANNED SIMULATORS	• Facility for Integrated Planetary Exploration Simulation (FIPES) • EnviHab (Environmental Habitat) • European Mars Analog Research Station (EuroMARS) • Australian Mars Research Station (MARS-Oz)

It is important to highlight that there is no international standard in place that can be used to ascertain the *fidelity* of these simulations. Simulator fidelity as defined by the research team, is: *The degree to which a simulator* *system accurately reproduces the habitat (and/or transit vehicle) conditions, the Planetary Body of Interest (PBI) environment, procedures, protocols and operations of a real mission.*

NASA conducted a series of simulations in a closed chamber simulator located in Johnson Space Centre from 1995-1997. The project was called the Lunar Mars Life Support Test Project (LMLSTP)[3]. The project was carried out in four phases. The primary goal of this project was to test an integrated, closed-loop life-support system that employed biological and physicochemical techniques for water recyling, waste processing and air revitalization for human habitation with four crew members in a closed chamber up to a maximum duration of 91 days. Despite, a fair amount of research conducted during the simulations, covering diverse topics such as habitability, life sciences, psychological countermeasures, acoustics, sociokinetic analysis, among others, there were certain drawbacks in the level of fidelity associated with the simulations. For example, during one of the rotations when there were technical problems with the life support system, tools were supplied to the crew members from the outside to fix the system. Such a thing would never be allowed if the simulations are meant to be conducted in a high-fidelity mode. Another example of fidelity breach during LMLSTP were the transfers, that took place via airlock, that were unscheduled and unnecessary. Also, there was no provision for simulating Extra Habitat Activity (EHA) as will be undertaken on future planetary missions.

Another simulator called the NASA Extreme Environment Mission Operations (NEEMO)[4] began operating as an analog project in late 2001. Aquarius, the underwater habitat used for NEEMO missions was reconditioned and redeployed to the Florida Keys in 1997. The inset photo in the image below shows the laboratory on the dock before it was towed out to sea and placed in its current position at Conch Reef.

Image 4. An external shot of the Aquarius underwater habitat and a crew photo from a NEEMO mission

NEEMO is an excellent analog for exterior environment, confined crowded interior, Extra Vehicular Activity (EVA), supply and consumable management and use as a research platform. What it is not an appropriate analog for is maintenance and housekeeping. There are facility managers (habitat technicians) present at all times. Therefore, unexpected maintenance is not part of schedule changes and the resulting problems for the regular crew and maintanence, and the associated headaches is not a time event for the crew. Thus, some aspects of simulation fidelity are compromised.

While it is true that all simulators cannot replicate everything, it is important for simulator designers, operators and the crew to try and aim for the highest standards possible. Simulator fidelity is critical because the data collected and lessons learned from simulations are intended for application in the design of real future space missions. If simulator fidelity is compromised, then the simulation data that is generated does not meet the highest standards possible. If such data is then used in the design of real missions, it could adversely affect the crew and even jeopardize the mission.

A 2002 study called REGLISSE (Review of European Ground Laboratories and Infrastructures for Science and Support of Exploration)[5] conducted by the European Space Agency (ESA) has briefly outlined the level of fidelity required and the importance of making simulations as mission realistic as possible. The following section summarizes the REGLISSE recommendations for simulator fidelity.

B. Fidelity requirements proposed by ESA's REGLISSE study [2002]

The REGLISSE study[5] proposes that the ground-test facility should be physically as similar as possible to the structure scenario outlined in the NASA Mars Reference Mission[6].

1. PHYSICAL (ARCHITECTURAL) SIMIARITY
In this scenario it is assumed that the crew habitat will consist of a structural cylinder 7.5 meters in diameter and 4.6 meters long with two elliptical end caps (overall length 7.5 meters). The internal volume will be divided into two levels oriented so that each floor will be a cylinder 7.5 meters in diameter and approximately 3 meters in height. The habitat would provide 265 cubic meters of pressurized gross volume for the assumed crew of 6 astronauts including space for stowage. Yet, on the surface of Mars it is assumed that this volume will be considerably increased by the use of a second habitat sent by a separate cargo flight, or the attachment of an inflatable 'TransHab' structure[7].

The study goes on to emphasize that just the *physical similarity* will not suffice for being analogous in a *psychological* sense. Much more important is that the experiences and feelings of humans, living and working in the earth-based simulator are similar to those during an exploratory mission.[8] In order to simulate the psychological conditions of living and working in a confined space habitat, the REGLISSE study outlines two requirements: (1) *functional* similarity and (2) *organisational* similarity.

The study divides functional similarity requirements into two categories: functional *possibilities* and *constraints*. These are outlined below. These assume that the earth-based simulator will support an autonomous life for a crew of 6 in a sealed environment over a prolonged period of time.

2. FUNCTIONAL SIMILARITY
Functional Possibilities:

- An environmental control and life-support system
- Hygiene facilities
- Facilities for autonomous food production (including sufficient stowage capacity for food)
- Waste management system
- Health care facility
- Private crew quarters
- Opportunities/facilities for crew meetings
- Opportunities/facilities for meaningful work
- Opportunities/facilities for recreational activities
- Opportunities/facilities for physical exercise
- Support by an outside control team

Functional Constraints:

- Permanent dependence on a life-support system
- Restrictions of interpersonal face-to-face contacts to at most five other crew members
- Restrictions of personal space and privacy
- Restrictions of communication to the outside
- Restrictions of environmental cues
- Restrictions of hygienic facilities
- Restrictions of variety of food and no possibility of re-supply of fresh food during the mission

Appropriate structural and functional design features of an earth-based facility and its placement within an appropriate environment can meet most aspects of functional similarity. However, there are certain limitations to achieving full functional similarity. Ethical standards will prohibit the implementation of any functional constraints that are in conflict with the Helsinki Declaration[9] and with the principle of human rights, even though such constraints will characterize life and work on an interplanetary space mission and will determine the psychological burden of such a mission to a considerable degree. For example:

- There will be no possibility of returning to Earth during a Mars mission other than the scheduled return. This translates into the elimination of evacuation possibilities (in cases of emergency) for earth-based simulations. Such a feature can never be implemented due to the Helsinki Declaration[9].
- In addition, ethical as well as practical considerations prohibit the confinement and isolation of crews for as long as 1000-days which would be required for a complete simulation of a Mars mission scenario.

3. ORGANISATIONAL SIMILARITY
From a psychological view, the most relevant organisational features include:
- Provision of meaningful work for the crew
- Promotion of a mission mentality
- Provision of psychological countermeasures, i.e. selection, training, and support.

4. ENVIRONMENTAL SIMILARITY
The study also suggests the placement of the earth-based simulator in an appropriate environment. As an example it cites the FMARS station installed by the Mars Society in the Canadian high Arctic.

C. Simulator Workshop Recommendations [2003]

A "Workshop on Analog (Simulator) Sites and Facilities for Human Exploration of Moon and Mars" was held in 2003 at the Colorado School of Mines. Professionals from NASA, industry, and private analog projects such as the Mars Society gathered to discuss the shortcomings of past and present analog projects, and provide recommendations to improve analog research. The recommendations emerging from this workshop include:

(1) Devise a taxonomy for analogs (using whatever taxonomies might already exist)
(2) Devise metrics for analogs
(3) Define analogs; define what is being modelled and what the intended outcomes are
(4) Demonstrate the feasibility of long-term closed-loop life-support systems
(5) Address issues of communication and information flow
(6) Address issues of hazards and safety
(7) Address maintenance issues
(8) Address issue of integration of humans with hardware and software
(9) Address issues of crew health
(10) Address issues of determining accurate volumetrics
(11) Use analog sites to address habitability and other human support issues
(12) Capture in a data archive research data from analogs and space missions worldwide (data regarding habitability, physiology, psychology, contingency planning, design etc.)

Recommendations #(2) and #(12) above are of direct relevance to this paper. It recognizes the need for systematic means for comparing, analyzing and determining the credibility of planetary mission simulators. The authors believe that this could be achieved via a Fidelity Evaluation Model that can serve as a tool to:
- Define high-fidelity simulator system requirements
- Measure simulator fidelity
- Identify fidelity breaches
- Fine-tune simulator fidelity

As demonstrated in the above sections, planetary mission simulators need to be of the highest quality possible and one way of ensuring that is by way of a fidelity evaluation model. This paper is the first of a series of papers that will document the development of a Fidelity Evaluation Model for Planetary Mission Simulators. The authors believe that this model can serve as a useful tool while developing future simulators. The next section documents a survey conducted to gather data from *simonauts* with the ultimate objective of creating a Fidelity Evaluation Model.

III. Simonaut Survey

A. Survey Methodology

The authors conducted a questionnaire survey of *simonauts* (*simonaut* = simulator crew member) from the LMLSTP, FMARS and MDRS projects via a questionnaire. The questionnaire was delivered to the *simonauts* via email. The responses were also received via email. This method of delivery and response was chosen because of the following reasons:

(1) Computer literate and email savvy *simonaut* sample,
(2) Worldwide geographic distribution of *simonaut* sample, and
(3) Speedy delivery and response via an electronic medium.

The LMLSTP, MDRS and FMARS simulators were chosen for the survey because one of the authors served as a human factors specialist on the LMLSTP project, while another author had served as a crew member on one of the MDRS rotations in the Utah desert. This facilitated access to the subjects of the survey. It also ensured familiarity with the architecture and operations of the two simulations. The MDRS and FMARS missions were not chosen in any particular order. The emphasis was on selecting missions where the authors of the paper knew at least one *simonaut* in the mission; the rationale behind this was to ensure an efficient and effective response system. Three of the *simonauts* had been on both FMARS and MDRS missions and were able to compare and contrast the experiences from both. There was one crew member that had been on three crew rotations. The names of the *simonauts* who participated in the survey will be kept confidential. However, here is a brief overview of the demographics of the chosen sample from MDRS and FMARS.

B. Simonaut Demographics

LMLSTP: There were a total of twelve *simonauts* in the LMLSTP project. Two (2) subjects have left the JSC area and could not be contacted. Of the remaining ten (10), two replied to the request for information for this study. The replies came from one scientist and one engineer; one male and one female, Americans.

MDRS and FMARS: A total of thirty-three crew members (instead of thirty-six because three of the *simonauts* had been on two missions; each mission had six crew members) from six different missions were sent the questionnaire. The MDRS missions lasted 2 weeks, while the FMARS missions lasted 4 weeks. These missions were conducted in years 2002, 2003, 2004, 2005, and 2006. Fifteen (15) of the *simonauts* responded of which there were thirteen male and two female respondents. The *simonauts* education and work backgrounds were diverse: software enterpreneur, software engineer, teacher, attorney, scientist, aerospace engineer, student, researcher, biomedical scientist, helicopter pilot, technology consultant, project manager, structural engineer, aerospace architect, and astrobiologist. The *simonauts* who responded were from: USA, UK, India, Australia, Germany, Austria, Wales, and Bulgaria.

C. Questionnaire

The questionnaire was designed to be 'simple, short, and electronic'. Long and/or complex questionnaires usually tend to discourage respondents from reading and responding in a timely manner, or from responding at all. The authors, in scripting the questions (using words/phrases such as 'as many as possible' and 'procedure/protocols/etc.'), and providing keywords (see below) chose to be 'suggestive' rather than 'prescriptive'. The idea was to facilitate free and fluid thinking, rather than constrain it with framed boundaries or fixed definitions. The questionnaire is reproduced below.

Dear *Simonauts*,
We would like to request your input for an ongoing research involving the development of a 'fidelity evaluation model' for planetary mission simulators. Simulator Fidelity [as defined by the research team]: *The degree to which a simulator system accurately reproduces the habitat (and/or transit vehicle) conditions, Planetary Body of Interest (PBI) environment, procedures, protocols and operations of a 'real' mission.*

<u>Note</u>:
The researchers would like to protect the privacy of the respondents.
The names of the respondents will not be disclosed in any form or format.

Question 1:
Gender:
Age [optional]:

Occupation:
Nationality:
Simulation/Simulator Name:
Duration:
Year:

Question 2:
List and briefly describe procedures/protocols/etc [as many as possible] from your simulation experience that you think were highly mission realistic.

Question 3:
List and briefly describe procedures/protocols/etc. [as many as possible] from your simulation experience that you think compromised the fidelity of the simulations [i.e. Were not mission realistic].

Question 4:
List your suggestions to improve the fidelity of future planetary mission simulations/simulators.

Question 5:
If you have any technical papers that you wrote concerning your simulation experience, please forward an electronic copy of the same for reference purposes.

KEYWORDS to help you recall your simulation experience and provide your input.
Operations & Logistics, Physiology, Psychology, Engineering, Human Factors, Habitability, Crew Relationships, Food & Nutrition, Environmental Control & Life Support, Hygiene, Trash Management, Housekeeping, Maintenance, Research Activities, Exobiology, EVA / EHA, Bio-hazards, Emergencies, Communication, Documentation

IV. Simonaut Responses

This section attempts to capture a top-level summary of the *simonaut* responses. It is important to note that the responses were fairly detailed and amount to nearly 17 pages. The objective of the summary is not so much to analyse the responses, but to create an overview for this paper. Further, more detailed analyses will be covered in the following work by the author(s).

A. LMLSTP Simonaut Responses: Summary

1. Experiences that were mission realistic included:

1. tracking consumables such as food and water
    - tracking water use by logging hand washes, urinal flushes, etc.
2. exercise protocols were established
    - required to place a metabolic load on the life support systems
    - on an actual mission it would be required for crew health
3. participating as test subject for various evaluations
    - medical and psychological similar to an actual flight
    - monitored by 'mission control' 24 hours per day
4. participated in team building prior to test
    - as is done in actual flight

2. Experiences that were not mission realistic included:

1. no time lag on communications
2. reinforcement of ties to world outside chamber with daily pass-throughs
3. proximity of the outside world
    - created communication unrealistic in actual mission
    - real world was just outside the wall
        - reinforced ideal of low-risk environment

chamber not acoustically isolated
could hear people

3. Suggestions to improve the fidelity for future mission simulations/simulators

1. communication time lag
2. limited communication with the 'outside' world
3. eliminate unplanned pass-throughs
4. create higher fidelity isolation with respect to the following aspects -
   - no outside visual cues representing proximity of human contact
   - sound proof
   - create periodic communication blackouts and delays
   - limit communications with outside world
   - limit creature comforts
   - provide ambient visual cues consistent with a mission
     - day / night cycles, etc.
   - select crew based on specific predefined roles for habitat life

B. MDRS and FMARS Simonaut Responses: Summary

1. Experiences that were mission realistic included:

1. communications
   - limited
   - time delay
2. enforced isolation
   - necessity to bring all supplies with crew
   - unfamiliar climate and terrain
3. EVA
   - suit use
   - airlock time
   - EVA transportation
   - check list
4. housekeeping and maintenance
   - mechanical and electrical breakdowns
   - improvision with ductape to solve problems
5. medical arrangements
   - medically trained crew member
   - back-up mission support flight surgeon
6. research activities
7. dust impact
8. water use
   - monitoring
   - recycle

2. Experiences that were not mission realistic included:

1. safety requirements for refueling of generator and ATV 'out of simulation'
2. limited exercise regime
3. safety requirements for armed, unsuited person for protection from bears
4. outside contacts with press and locals (MDRS)
5. many repair tasks required breaking sim
6. food system
   - regular groceries
   - fresh goods
7. freedom of choice for participation in experiments
8. no documentation process
9. no team building prior to mission (some missions)

10. no strict exercise regime
11. crew could select 'level of sim' to participate in
12. unrealistic logistics
    local resupply
13. large areas of personal space
14. all ECLSS systems 'open'
15. EVA suits and equipment not realistic

3. Suggestions to improve the fidelity for future mission simulations/simulators

1. communications - type, length, and delays should simulate actual mission conditions
2. realistic food supplies to reflect an actual mission
3. maintenance is realistic, but repairs and logistics should not be 'out-of-sim'
4. more definitive chain of command
5. create and adhere to a realistic mission schedule
6. state purpose / goal of simulation and plan details of that purpose / goal to match

V. Next Steps

Step 1:
In addition to the data collected from the *simonauts* of the LMLSTP, MDRS and FMARS, attempt should be made to collect more data from the currently operational NASA simulator called NEEMO (NASA Extreme Environment Mission Operations). NEEMO missions are conducted in the Aquarius Underwater Laboratory off the coast of Key Largo, Florida. Recent NEEMO[10] missions have been used to practice long-duration space habitation, build undersea structures, practice tele-medicine procedures, simulate space station assembly spacewalk activities, and other skills. If restrictions (e.g. export control, crew privacy) come in the way of collecting data via the questionnaire, consider alternative data sources such as the diaries or logs of NEEMO *aquanauts* that are in the public domain and readily accessible via the Internet.[11]

Step 2:
Further analyse, simplify and better define the 'similarity classification' of the ESA REGLISSE study. This would be an important next step towards the development of the Fidelity Evaluation Model. Feedback from the peer review process has suggested simplifying and clarifying the four similarity classifications into three:
Configuration – what the simulator looks like, how big it is, and what it is made of
Operation – where it is located, how it works, and what support it needs
Psychology – how the people feel and behave who live in it, how they interact with the outside world

Step3:
Analyze, in more detail, the data collected from the *simonaut* survey to determine Fidelity Evaluation Model parameters

Step 4:
Develop a Fidelity Evaluation Model

Additional references for model development can include, but not be limited to:

- ESA HUMEX Study[12, 13]
- Human Spaceflight: Mission Analysis and Design[14]
- European Mars Mission Architecture Study[15]
- NASA 'Guidelines and Capabilities for Designing Human Missions[16]
- Soviet Space Stations as Analogs [17]
- Isolation: NASA Experiments in Closed-Environment Living [18]
- Human Exploration of Mars: the Reference Mission of the NASA Mars Exploration Study Team[6, 7]
- From Antarctica to Outer Space: Life in Isolation and Confinement[19]
- Pioneering the Space Frontier[20]
- Space Station Habitability Recommendations Based on a Systematic Comparative Analysis of Analogous Conditions[21]

Acknowledgments

The authors would like to sincerely thank the LMLSTP, MDRS, and FMARS *simonauts* who responded to the survey. Without their feedback and cooperation, this paper would not have been possible.

Abbreviations

BIO-Plex	Bioregenerative Planetary Life Support Systems Test Complex
CEEF	Closed Ecology Experiment Facilities
EHA	Extra Habitat Activity
EVA	Extra Vehicular Activity
EnviHab	Environmental Habitat
ESA	European Space Agency
EuroMARS	European Mars Analog Research Station
EVA	Extra Vehicular Activity
FIPES	Facility for Integrated Planetary Exploration Simulation
FMARS	Flashline Mars Arctic Research Station
IBMP	Institute for Biomedical Problems
INTEGRITY	Integrated Human Exploration Mission Simulation Facility
JSC	Johnson Space Centre
MARS-Oz	Australian Mars Research Station
MDRS	Mars Desert Research Station
NASA	National Aeronautics and Space Administration
NEEMO	NASA Extreme Environment Mission Operations
REGLISSE	Review of European Ground Laboratories and Infrastructures for Science and Support of Exploration
SMEAT	Skylab Medical Experiments Altitude Test
SML	Skylab Mobile Laboratory

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