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Space Itineraries

Scientific, psychological and cultural aspects of human missions in extra-terrestrial Space

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Abstract

The following article provides a general overview of the current technological, psychological, and cultural aspects on manned extra-terrestrial space missions.

Since the beginning of space exploration, crew selections have mainly been performed on military professionals to cover mission targets for limited amounts of time. Now, Space Agencies (e.g., ESA) are currently evaluating a new generation of capable astronauts, expanding the pool of potential candidates with no military background by involving heterogeneous fields of knowledge.

Within this context, extra-terrestrial manned missions have been proven to be one of the best methods to perform cutting-edge technology experiments, since they offer an unbiased and unique environment whose conditions are hardly reproducible on Earth. Also, it should be noted that one of the most challenging space-related risks is represented by the astronauts' safety in a radiation-exposed environment as well as the long-term exposure to micro-g conditions that can affect their psycho-physical health. Structural and health damages could be persistent, even after the supposed successful outcome of the mission. For this reason, it is compulsory to design both the physical and social settings accurately. In addition, analysts are bounded to predict almost every aspect of space missions, to anticipate undesired events such as basic instinct reactions to Space-like environments, performances decline, and psychological changes.

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1 Introduction

The space race started during the second half of the Twentieth Century and brought innumerable technological advances (e.g., broadcast and navigation systems, synthetic materials) that made a remarkable impact both on the economic system and the overall quality of life, emerging as an indispensable medium of strategic importance in different sectors, following [1]. It is indispensable to address the topics related to the scientific, psychological, and cultural sectors, for the main goal is to extend the capacity of human beings to live and work in a sustainable environment beyond Earth.

2 Scientific Aspects

Space missions represent a great opportunity to conduct experiments in orbit. Researchers develop technologies and procedures to enhance space travel safety to keep humans healthy in low-gravity environments. Specifically, the actual ISS serves as a laboratory to explore unanswered questions in different disciplines and as a platform from which to observe the Earth. The following areas are currently widely addressed:

- Biomedical Research.
- Support Technology.
- Materials Science.
- Earth Science.
- Biology.
- Physics.

These fields involve long-term benefits. As an example, low-gravity environments can be useful to study materials' properties, which can be exploited to better understand semiconductors, metals, polymers, etc. manufacturing processes or to study gravitational effects on plants and animals whose research results can be of aid to medical, agricultural, etc. industries.

2.1 Mission design and transport

Space missions are tailored to specific features and can be varied, but they all respond to the following criteria: functional, operational, and constraint requirements. The design requirements involve many disciplines. Design iterations are inevitable since the process depends on analyses, simulations, experimentation, and compromise. Space missions observe the following design path, as remarked by [2]:

- Concept exploration (i.e., initial study phase).
- Detailed development (i.e., detailed definition of the system components).
- Production and deployment (i.e., hardware and software construction).
- Operations and support (i.e., system maintenance and dismissal or recovery at the end).

Figure 9 outlines the typical mission flow and the technical aspects involved.

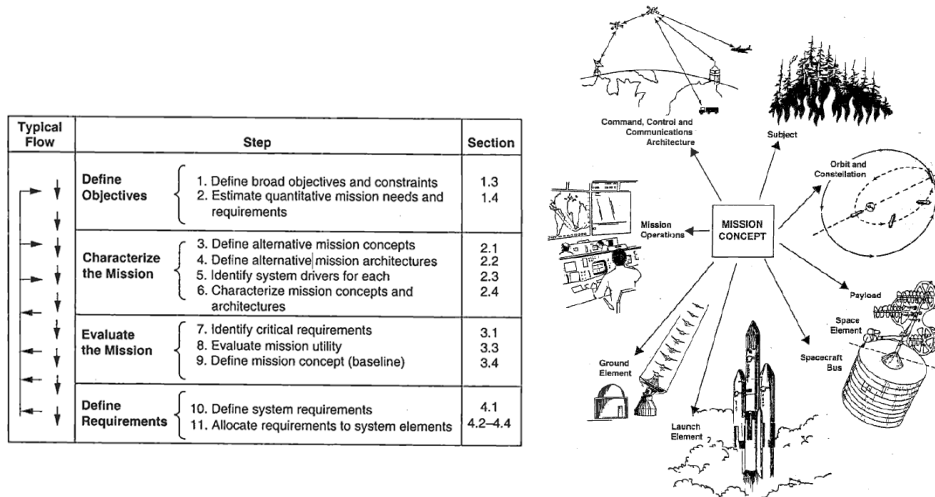


Figure 1: Space mission design process (a) Concept (b). [2]

In this framework, transportation systems are essential to reach outer space by defying Earth's gravity as well as its atmosphere and ensuring a safe re-entry. The entire system size depends available the state-of-the-art technology, capabilities, and cost issues. Design iterations are compulsory to understand the interaction among subsystems and performances. The major subsystems in a launch vehicle are the vehicle structure, propulsion, aerodynamics, etc. Since space missions are expensive, each subsystem's role can only be handled by an engineering approach right from the concept stage. Without that, non-optimal designs may occur.

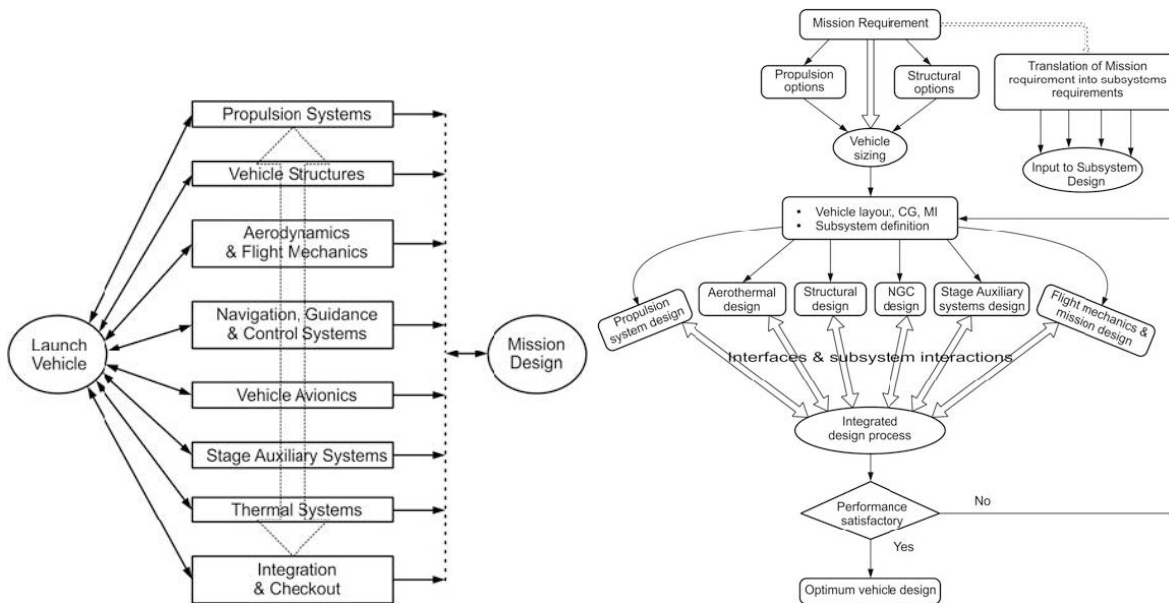


Figure 2: (a) Mission design subsystems (b) Overall design process. [1]

Once the general vehicle process parameters and constraints are settled (e.g., structural, thermal, aerodynamic, control, and trajectory studies), it is possible to consider other auxiliary aspects (e.g., stage and propellant mass). Generally, most of the vehicle analysis activities are performed in parallel and tested accordingly to take care of uncertainties. Failure to comply with this method may lead to vehicle redesign issues, affecting the overall schedule and costs. **Figure 3** highlights the various interaction phases.

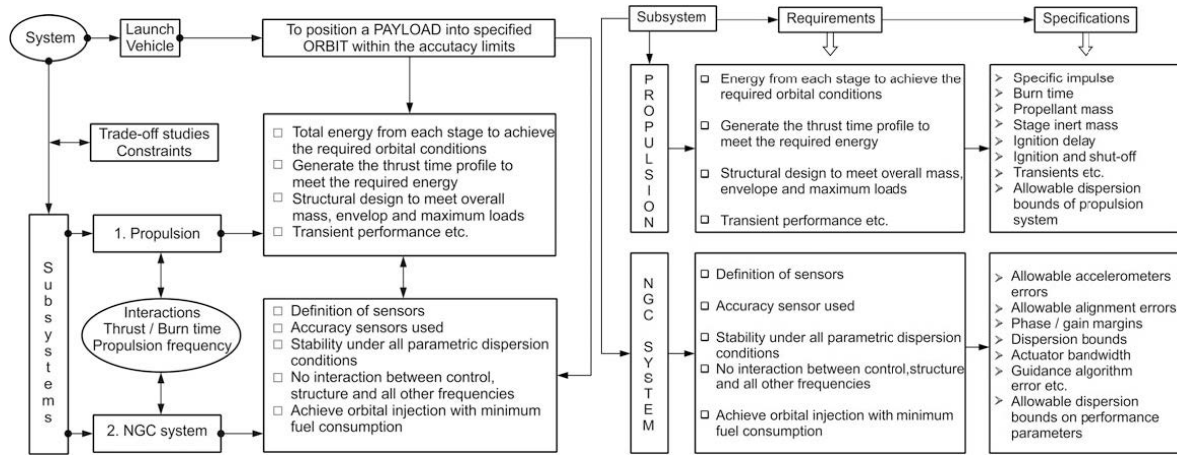


Figure 3: (a) System requirements (b) Specifications. [1]

The subsystems' interactions tend to be conflicting. It is required a detailed analysis to understand their mutual compatibility. In this circumstance, the integrated design approach monitors the vehicle design continuously. As the main system is optimally designed, there are sufficient margins to operate in a hostile flight environment. [1].

Mission experts and engineers must consider realistic requirements, for they might have a negative influence on the costs, schedule, and risks.

2.2 Risk management process

Risk defines the damage probability within a given framework. Depending on the design robustness, it becomes essential to carry out a detailed risk analysis for each subsystem. The process is an integral part of the design phase, and it is strictly related to the positive outcome of the scientific goals of a mission. It can be qualitative, semi-quantitative, and quantitative. Generally, the process is divided into three macro-areas (i.e., hazard identification, risk assessment, and risk control), inside which the analysts consider:

- The hazard nature and failure likelihood.
- The consequence evaluation.
- The coupling between risk level acceptance and feedback.

Well-known procedures and tools (i.e., HAZOP, FMEA, FTA analyses) must be used to define the risks involved and the consequences on the system to minimise failure occurrence. To facilitate this process, more intuitive tools have been developed (e.g., risk matrices) to enhance safety requirements. The rigid application of standards does not guarantee the achievement of adequate space safety levels over time.

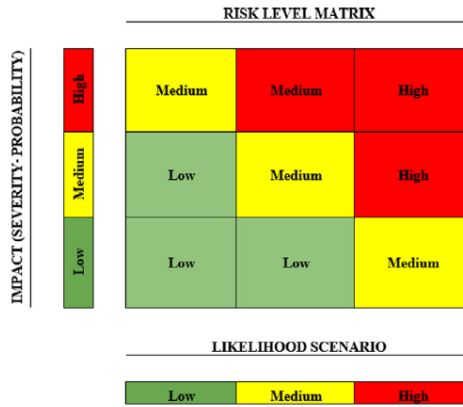


Figure 4: 3x3 Risk matrix (OHSAS 18001 Model). [3]

Suitable design modifications must be implemented to improve the robustness against such failures without violating system constraints and requirements. Typical examples involve rotating elements, high-pressure valves, propellant feed lines, injectors and thrust chambers. Even the failure of a single element can propagate downstream and may affect elements severely, resulting in mission failure.

Risk Assessment Form for 3D model

Department	Task Description
Risk Assessment Ref	Area / Zone Assessed
Work Description	
Hazard Description	
Hazard Category	Risk Groups
Initial Event Probability	V. Low Low Medium High
Precautions taken to reduce the probability of the event occurring	
Residual Event Probability	V. Low Low Medium High

Use the same Residual Event Probability in each of the Cube Layers below

		Consequence Layers			
		Plant / Prod. Loss >\$1M Environmental damage >\$1M Fatality / Perm. Disab.	Plant / Prod. Loss \$250K - \$1M Environmental damage \$250K - \$1M Major Injury	Plant / Prod. Loss \$5K - \$249K Environmental damage \$5K - \$249K Minor Injury	Plant / Prod. Loss <\$5K Environmental damage <\$5K First Aid
Probability of Consequence	H				
	M				
	L				
	VL				
		VL	L	M	H
		Probability of Event			

Precautions taken to reduce the probability of a catastrophic incident	Precautions taken to reduce the probability of a major incident occurring	Precautions taken to reduce the probability of a minor incident occurring	Precautions taken to reduce the probability of a first aid or <\$5K Plant or Env. Loss incident occurring

Assessor's Name	Date
Job Title	Review Date
Signature	

Figure 5: 3D quality risk assessment example. [4]

Analysts should also assess the element failure impact at different stage phases by identifying the failure modes of the most critical ones first. The usual practice requires logic diagrams. If the consequences are severe, increasing design margins should be considered.

2.3 Life & Support Systems, radiation analysis, and monitoring

Spacecrafts are enclosed spaces containing complex machines as well as science experiments. Among the relevant equipment, Life support systems address human needs (i.e., air supply and temperature, pressure, water, and waste disposal) to allow astronauts to perform their tasks. An exceptional system interaction example of ECLSS¹ is represented by the ISS, as already considered by [5] and [6]. The technologies include:

- Atmosphere management, which is critical for oxygen recovery and chemicals removal. It includes contamination management through both passive and active filtering methods.
- Water management, to support long-term human exploration in deep space. Scientists have developed water-treatment systems to recycle the crew's wastewater. the goal is to reduce the payload that needs to be launched from Earth and to avoid resupply missions.

Work is underway to increase the miniaturization, reliability, and performance of current technologies (i.e., to reduce mass, power, and volume). Future needs for long-term missions will be addressed by embracing modular integration, and employing highly efficient approaches. Manned space missions also entail medical issues that cannot always be predicted accurately. Analysts must address astronaut exposure to ionizing radiation, for large amounts of it would result in changes at the cellular level and health-related issues. The ISS is found within the Earth's magnetosphere and its astronauts approximately receive $\simeq 80$ milliSieverts (mSv) for 6 months, whereas people on Earth receive $\simeq 2 \frac{mSv}{year}$, as investigated by [7].

Recent developments have allowed the International Space Station controllers to actively monitor the crew's cumulative exposures and dose rates, assess the organ risk exposure, and collect data to reduce ambiguities and uncertainties, as presented in **Figure 6b**.

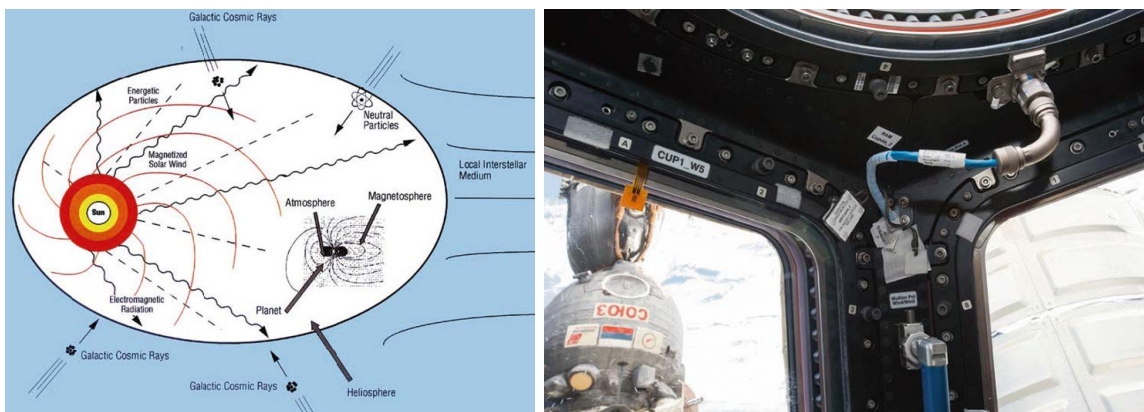


Figure 6: (a) Cosmic radiation (b) ISS passive dosimeters. The ISS Medical Operations Requirements Document states the radiation exposure limits. [7]

The biological consequences of radiation exposure mainly relate to altered neurogenesis (i.e., [8]), oxidative damage (i.e., [9]), and radiation-induced bone loss (i.e., [10]) Many factors determine the extent of direct and indirect damage to genetic material (e.g., type of radiation, age, gender). When all these factors are considered, a risk projection calculation can be made. Dose limits for non-cancer effects are presented in **Table 1**.

¹Environmental Control and Life Support System.

Table 1: Short-term and career non-cancer effects dose limits. [7]

Organ	30-day limit [mGy-Eq ¹]	1 year limit [mGy-Eq]	Career limit [mGy-Eq]
Lens	1000	2000	4000
Skin	1500	3000	6000
BFO ²	250	500	N/A
Heart	250	500	1000
CNS ³	500	1000	1500

¹ The Standard International (SI) unit of absorbed radiation dose.

² Blood-Forming Organs.

³ Central Nervous System.

Finally, different strategies that can be addressed to reduce radiation exposure involve water shielding (i.e., [7]), magnetic shielding (i.e., [11]), and electrical shielding. (i.e., [12]). Future developments must improve radiation shielding requirements and mitigation measures.

2.4 Mission modelling facilitation

A recent paper [13] presented a method to facilitate the design and decision process associated with the development of space systems since it is essential to reduce risks and costs. The study evaluated the in-space transportation portion of manned exploration missions through a MATLAB[®]-based model by focusing on principal mission parameters. The identified fundamental functions were the provision of life support systems, living spaces, and transportation. However, these are not the only aspects that drive the key metrics. They may be influenced by independent properties. The overall function representation can be seen in **Figure 7**.

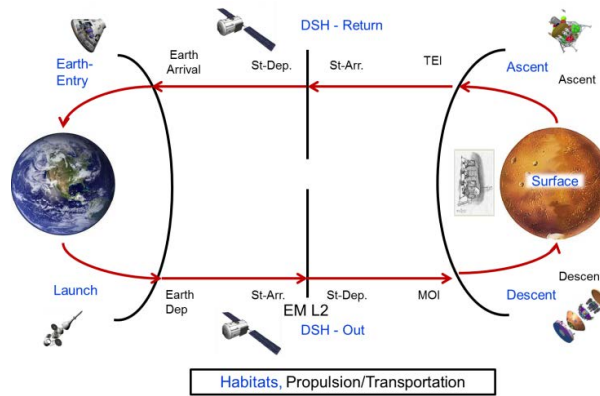


Figure 7: Habitat and transportation functions in a Mars mission context. [13]

2.5 Future prospects

space missions require to meet targets and constraints thoroughly. Major changes are expected to come to life because of the never-ending emphasis on low-cost missions. The need for space missions will lead to the implementation of smaller and more feasible systems. For this purpose, future activities are also expected to be more complex because of the increasing technological maturity and use of autonomous systems to run repetitive difficult commands.

3 Psychological Aspects

In preparation for extra-terrestrial missions, astronauts must prepare themselves to live in an isolated micro-society whose success is strictly dependent on the intense and frequent interaction of its members. To achieve that, it is important to rely on effective individuals when selecting the most feasible and cohesive astronaut crew. The optimal group performances may be highly influenced by the group heterogeneity and individual attitudes, mission tasks and duration. This could lead to a favourable mission outcome.

3.1 Crew capabilities & autonomy

To maximize astronaut performance and minimize the risks associated with fatigue, sleep disturbances, altered sleep-wake cycles and desynchronization of body rhythm, their activities should be varied or at least congruent with their interests, following [14]. At the same time, they should be left to operate autonomously within their daily routine, and the findings in [15] attest that crew members who are more satisfied with their need for autonomy experience greater self-endorsed motivation. Space agencies could train Mission Control members to actively implement autonomy-supportive measures in their interactions with the crew, to the benefit of the crew members and the success of the mission.

3.2 Negative reactions & threatening situations

A relevant study [16] suggests that withdrawal from normal society determines the loss of variety and identity in social relationships where compliance, influence, and independence play an important role in group dynamics. Within these settings, it has been observed that a person experiencing a severe psychological disturbance due to unforeseen settings shows impairment in at least one of the following:

- Thinking.
- Perception.
- Mood.
- Impulse.

Since they can represent a serious deficiency in carrying out the required activities and experiments, it is possible to lower the risk by training people to deal with challenging situations. If that turned out to be insufficient for a single individual, the other crew members should intervene by applying well-established treatment procedures. To achieve that, cognitive group strategies may be considered.

3.3 Positive reactions

Another study [17] outlines the positive psychological impact that space can have on the well-being of astronauts. All research participants (i.e., thirty-nine anonymous astronauts) reported positive effects while in space. The changes regarded, among others, their perception ability. The experiences were reported as so profound that led to behavioural attitudes changes. Successful predictive models were used to foretell these changes. The study found differences in two groups, which appear to be based on personality traits. The study's relevance is limited because of the small sample size, but future works may have implications for astronaut selection, training, and health monitoring.

So far, the professionalism shown by astronauts has not highlighted any major unsolved crisis² in space yet. In future space missions, it should not be excluded those threats posed by capable but untrained individuals might arise, leading to a disruptive outcome of the crew cohesiveness and mission targets.

3.4 Hosting structure issues

Another important aspect regarding the psychological sphere of human behaviour in space is represented by the space structure habitability and isolation. Within a confined space, both privacy and the allocation of available spaces become a major concern. Close contacts may involve group dynamics issues. People must be kept actively engaged to avoid passive behaviours and to maintain commitment. Analogue experiences in extreme environments (i.e., [18]) have shown that even in isolated settings the desire for social contact increased over time, whereas feelings of resignation did not. The study outcome underlines how talking about personal matters determines lower levels of psychological resignation, as opposed to social withdrawal.

At last, the following matters should be equally outlined:

- Hygiene.
- Food-related gatherings.
- Temperature and hygrometric conditions.
- Lighting and noise levels.
- Interior spaceship design.

Hygiene discomforts are frequent because of the current unripe technology costs as well as the impossibility to contain fluid and odorous particles within a confined environment. Recent studies [19] found that the overall stressors (i.e., confined spaces, usage time, odour, operation of devices) affected the astronaut experience preponderantly. Also, the visual perception of the hygiene area environment and cleaning devices play an important role in the definition of a sense of harmony, since they require a high level of cleanliness. **Figure 8** represents the typical space hygiene setting.

²It should be noted that some aspects are not considered in this paper (e.g., grief, homicide and suicide, complex "stressors").

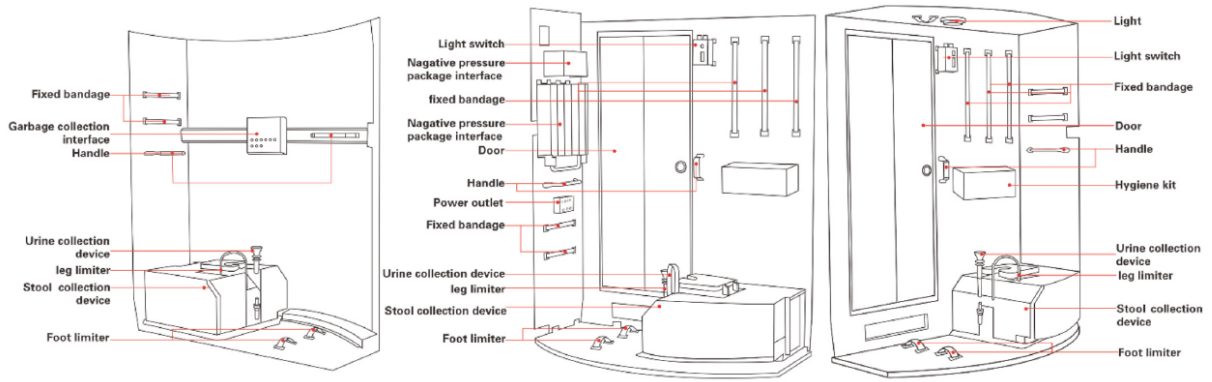


Figure 8: Space station hygiene area. [19]

Since it has been a long-term human evolution companion, food has also become an important factor in terms of alleviating tensions during social gatherings. For this reason, it can be seen both as mean towards health and a source of enjoyment. Moreover, food can be linked to the need to think beyond the functional purpose of food in the context of space exploration [20]. Future space missions will require long-life nutritious food as well as consider its weight and transport costs.

Temperature [21] and humidity [22] conditions should be kept in line with typical working conditions since they can affect human performances heavily. The former study analysed health self-reported symptoms, fatigue, thermal sensation, thermal comfort, thermal acceptability, and endurance. The results show that temperature steps have a significant impact on human subjective perception, therefore leading to asymmetry in human response to temperature steps of equal magnitude but diverse directions. Also, the psychological phenomenon occurs after both up-steps and down-steps, showing that thermal feelings vary much faster than skin temperature response. The latter study performed an analysis on the stress responses, physical activity and sleep quality of 231 white-collar workers, based on the relative humidity of a defined work environment. The correlation analysis of stress responses yielded evidence of an optimum range for the relationship between relative humidity and stress responses. The goal is to avoid both overly dry and humid conditions. Future interventions may also be able to investigate the effect that different types of cooling and heating systems have on stress and sleep, in a low-gravity setting.

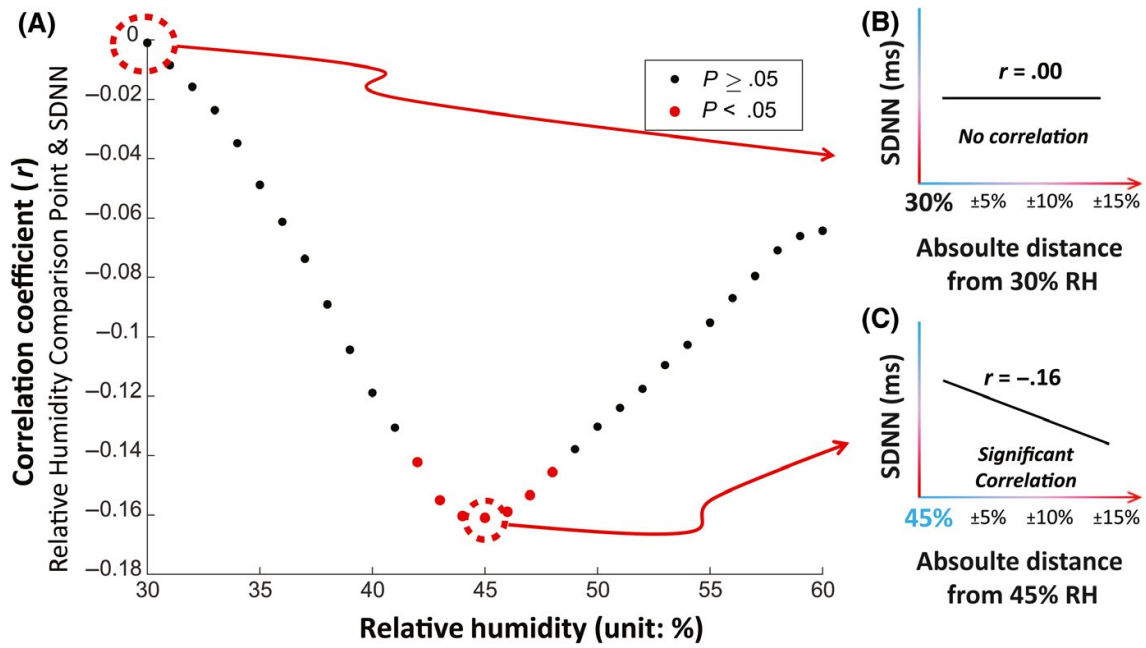


Figure 9: (A) Correlation between participants’ average normalized standard deviation (SDNN) and the corresponding absolute distance between participants’ average Relative Humidity (RH) exposure and each comparison point between 30% and 60% RH. (B), At RH=30% no correlation seems to exist. (C) At 45% RH, the highest correlation appears. This suggests an optimal range in the relationship between RH and stress response, where RH values on either side of 45 are associated with higher stress. [23]

Also, proper lighting and noise levels are important in confined spaces. the former is responsible for the astronaut’s day- and night-cycle well-being. The latter involves pain to his or her auditory apparatus. It is considered a psychological stressor and could lead to long-term damage. Both can trigger negative outcomes. The typical noise level should not exceed $\simeq 70\text{dB}$ [23], but for long-term missions, a safe maximum level is lowered to $\simeq 45\text{dB}$. [16]

Ultimately, the internal setting surroundings should soothe the human mind and can be related to the above-mentioned topics. The optimal setting design should consider low weight materials, textures, proper colours, and costs, and can be ultimately carried out by examining the discomforts humans generally experience on Earth.

4 Cultural Aspects

During the first Space Era, mankind tried to consolidate both its human and technological presence in space through manned and unmanned space missions, rovers, and satellites. The new Space Era is currently at its peak, and it influences the human way of thinking about culture both on Earth and in orbit. The discoveries have been astounding in every field of knowledge, from life-science research to behavioural and sociological sciences.

Concerning the global recent events, the main aspects currently affecting the development of a new space era and culture are related to:

- Companies' race for space and market share.
- Companies' research for the well-being of people in orbit.
- Countries' investments for asteroids natural resources retrieval.

The efforts provide an overview of how the culture of space is currently being shaped by the actions of both the private and public sectors. Upcoming missions present a whole set of important challenges that will contribute to the definition of an interplanetary species. The following sections try to assess the aspects involved.

4.1 Cultural identity and space culture

Culture is an evolving feature humans inherited from their ancestors, whose behaviour is heavily influenced by it. It generally tends to facilitate daily living and create a social environment from which other individuals can learn and spread these practices to other clusters or descendants in the form of social norms and lifestyles. Within this context, a human movement from the home planet to uncharted extra-terrestrial territories will reshape culture: the implications may be related to Earth perception and behaviour, as well as issues on safety. Aerospace industries need to address these implications in advance. [24]

Current research in evolution indicates that harsh environments often result in innovation among species. The pattern of the past reveals that creatures are better at inventing and surviving when challenged by extreme environments. Analogue experiences have been underway for the past twenty years to explore the several implications of multicultural environments in isolated settings (i.e., NASA's Human Research Program³).

Astronauts will pose the basis for a space culture to emerge, possibly quite distinct from their terrestrial analogues. The extra-terrestrial areas can become laboratories to promote peaceful and synergistic activities. It would be essential to promote cultural norms that support cooperation and mutual help instead of competition and excessive individualism.

Now, whether sponsored by private contractors or public space agencies, crews have become more multicultural and international. For future missions, it is essential to optimise differences in people, foster cooperation, and project the resources toward common goals. To accomplish that, future astronauts will require:

- A collaborative, regulated setting.
- Multicultural management, in accord with [25].
- Greater cross-cultural knowledge and competencies to deal with cultural differences.

³For more information, visit: <https://www.nasa.gov/hrp>

CHARACTERISTICS OF SPACE CULTURE

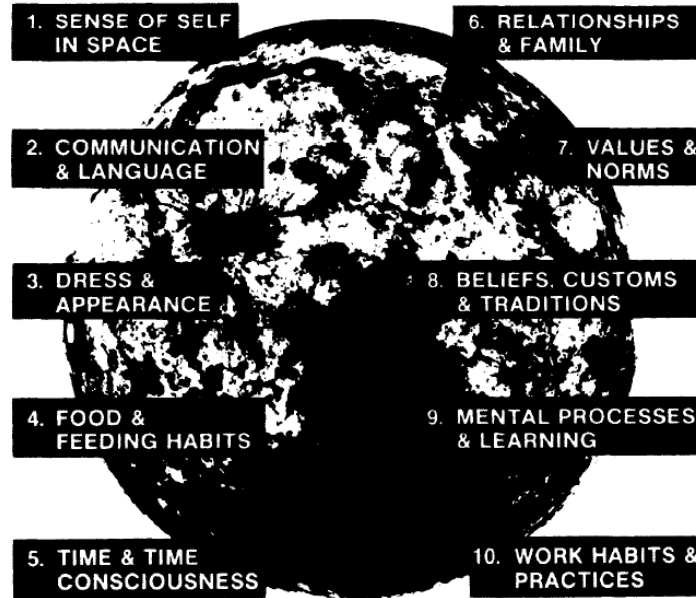


Figure 10: Culture implications. [24]

Regarding [24], the implications related to the formation of a space culture are:

- Identity. Culture contributes to one's identity and acceptance, providing a sense of comfort within a group. Space missions offer a nonpareil environment to enhance this feeling.
- Complicity. Culture groups develop verbal and non-verbal communication systems. Terminology will change because of environmental circumstances.
- Clothing. Astronauts use spacesuits with life-support systems for EVAs, but their design already emphasizes the use of materials that offer more flexibility and lower costs.
- Food. It is an important cultural trait; its variety, preparation, and eating procedures tend to define distinctive clusters of people. Space agencies have pioneered food technologies [26]; as a result, new food preparation techniques, diet, and eating manners have taken place.
- Time. Culture influences one's sense of time. Astronauts rely on the current orbiting environment, which affects circadian rhythm as well as work schedules and sleep patterns.
- Interpersonal relations. Support services facilitate communication with families and friends. Culture fixes human clusters by relationships, age, sex, status, etc. For now, since astronauts are sent into space mainly for technical duties and to perform experiments. Future missions (both on orbiting platforms and planets) may require human settlements to be established and relationships to be maintained.

- Beliefs and traditions. Culture manifests people’s attitudes and outlook on life. Current extra-terrestrial manned missions need to make sure no major cultural conflict arises. The emergence of a new space culture may cause humanity to focus more on technical aspects, which would result in different brain development and differentiating of cultural heritage. Future explores will be immersed in a wide range of sophisticated technology. Diverse educational system methods are underway⁴ and countries, as well as private institutes, already encourage cross-training in multiple disciplines with a heavy emphasis on numerical simulations and artificial intelligence.
- Habits. Values and norms are the basis of cultural identity. Work habits must be processed and established. One way to analyse cultures is to examine how functional their society is.

4.2 Cultural influence

In the beginning, the organizational culture of space travel and technology influenced goals to set and pursue, missions to design, people to train and send with no regard for international collaborations. Nowadays, most space enterprises are involved in the process of globalization, which ultimately relies on international cooperation. This results in organizational cultures in becoming more transnational, each influenced by their counterparts in other countries. [24].

The scheme previously outlined in **Figure 10** can also be applied to the analysis of organizational culture like those of national space agencies. Another approach can be found in **Figure 11**. Such organizational cultures determine objectives, missions, roles, expectations, obligations and boundaries which affect personnel morale and performance. These micro-cultures influence decisions, planning, operations, research, and development. The research [24] reported that excellent organizations have strong functional cultures, constantly subject to renewal.

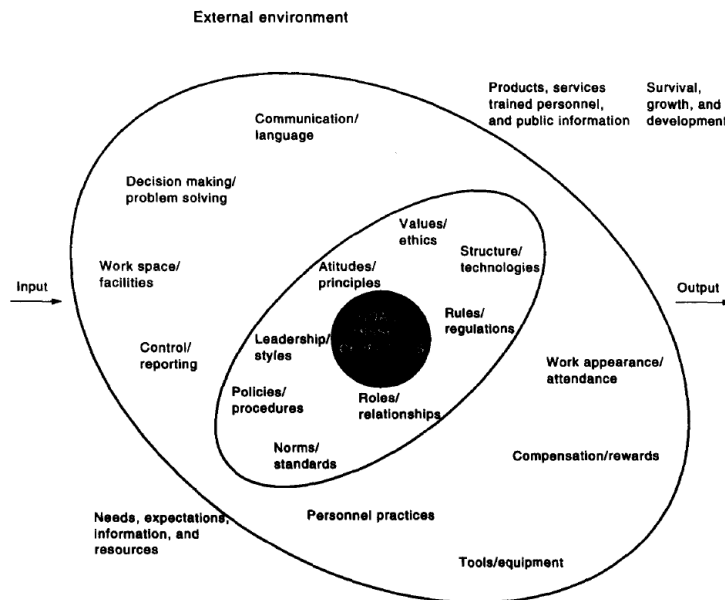


Figure 11: Organizational culture overview. [24]

⁴For more information, visit: <https://www.isunet.edu/>

4.3 Empirical evidence, results, and countermeasures

Historically, a consistent number of both interpersonal and cultural issues have risen during manned space missions: these include, but are not limited to, language and cultural factors.

Previous studies [27] explored these issues and examined some of them through a questionnaire that was returned from fifty-four astronauts and cosmonauts who flew into space. All the respondents believed that it was important for space crews to be fluent in a common language. Also, of several factors that were believed to possibly influence crew communication, four were rated as significantly helping (i.e., shared experience, space flight excitement, close quarters, and isolation from Earth); three were judged hindering (i.e., facial swelling, ambient Noise, and space sickness). They endorsed the value of contact with loved ones on Earth as having a positive influence on mission performance. The study outlined how crews should not be composed to include one person who is different from the others in a major demographic or cultural characteristic.

Also, cultural and language disparities may contribute to interpersonal tension and negatively influence crew cohesion. Language stresses relate to the technical and slang features of space communication. Long-term space missions have highlighted these issues, leading to inefficient communication problems. [28] Another NASA-funded study [29] found issues that can affect the performance of space crews and tried to address the findings related to social and cultural issues during Shuttle and Mir space missions. One of the main objectives was to determine how social and cultural issues influenced the crew and ground environments. The goal was to provide empirical information that would assist in the development of countermeasures for future multi-national space missions. A total of five American and four Russian space crews, and ground support personnel were studied. American subjects reported more dissatisfaction with their interpersonal environment than their Russian counterparts. Mission control personnel were more dysphoric than crew members. It is possible that the work role of the Americans was not well-defined and that language and cultural differences contributed to their perception of being poorly oriented to tasks. Alternatively, people in mission control might have been under special stressors that contributed to their dysphoria. Based on the above findings, several countermeasures that might help astronauts in future multi-national missions are suggested:

- For people who belong to a cultural and language group in the minority, more support should be provided.
- Crew members should have intensive and advanced pre-mission language training as well as briefings on cultural issues relevant to the make-up of the crew.
- Team-building exercises to strengthen cohesion within the group should always be performed. [29]

Current manned missions already include a pool of diversity and integration among the astronauts. Future missions will also involve more people coming from different backgrounds. The goal is to avoid conflicts based on personal beliefs and cultural habits since it is inherent in the human psyche to bear prejudices among other cultures. Thus, the crew size and background must be taken into consideration, even if the number of possible interactions increases proportionally to the number of the people as well as the possibility to exchange cultural information (e.g., traditions and recipes) and develop cross-cultural bonds. A relevant study [16] suggests groups should be heterogeneous (i.e., a person with the need to teach might establish a satisfying relationship with a person with a need to learn.). Nevertheless, the important thing is to have a compatible set of individuals that can carry out the mission goals.

Conclusions

All the aspects involved in manned space missions are a powerful concept, upon which relies the future of the World's space program as well as the humans as an interplanetary species. It is up to manned missions to provide consistent information and perform relevant experiments that can ensure the human race's technological and sustainable advancement. Those engaged in these fields would certainly benefit from the current research discoveries. Specifically, scientists can make contributions to the global space program by:

- Planning the preliminary space settlements.
- Assisting engineers to understand how to deploy operations safely.
- Consulting with agencies on practices renewal to facilitate space industrialization.

Due to the distances involved, deep space missions will not be able to waste any resources nor to resupply air, water, etc. Therefore, the efficiency and reliability of the current system must be improved. Within these premises, the catalysts for extra-terrestrial activities come from both public and private companies: both appreciate the return on investment that can be realized by the sustainable exploitation of space resources, since space represents the ideal place for synergy, international cooperation, and the development of long-term projects.

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