January 2013

Crew Training Requirements For Long Duration Missions

Ann Wargetz

CREW TRAINING REQUIREMENTS FOR LONG DURATION MISSIONS

by

Ann Marie Wargetz

Bachelor of Arts, University of Houston, 2003

A Thesis

Submitted to the Graduate Faculty

of the

University of North Dakota

In partial fulfillments of the requirements for the degree of

Master of Science

Grand Forks, North Dakota
August
2013

This thesis, submitted by Ann Wargetz in partial fulfillment of the requirements for the Degree of Master of Science in Space Studies from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done, and is hereby approved.

____
Dr. Vadim Rygalov

____
Dr. David Whalen

____
Dr. Mike Gaffey

____
Dr. Richard Ferraro

This thesis is being submitted by the appointed advisory committee as having met all of the requirements of the Graduate School at the University of North Dakota and is hereby approved.

____
Dr. Wayne Swisher
Dean of the Graduate School

____
Enter the Date

Title Crew Training Requirements for Long Duration Missions

Department Space Studies

Degree Master of Science

In presenting this thesis in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the library of this University shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my thesis work or, in his absence, by the Chairperson of the department or the dean of the Graduate School. It is understood that any copying or publication or other use of this thesis or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my thesis.

Ann Marie Wargetz
March 25, 2013

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE

LIST OF TABLES

TABLE

LIST OF EQUATIONS

EQUATION

Effective Date: July 30, 2013

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to the members of my advisory committee, Pablo de Leòn, and the members of the Department of Space Studies for their guidance and support during my time in the master's program at the University of North Dakota.

To my parents who taught me I could accomplish anything

ABSTRACT

After reviewing the journals of astronauts, cosmonauts, and others who lived and worked in confinement, a new pre-mission training approach for missions in confinement was developed. This new training approach is founded on the idea that conflicts in confinement often arise due to humanity's propensity to focus on how others behave rather than our own behavior. After reviewing the stresses experienced during spaceflight and astronaut training and selection methods, a survey was written and distributed to researchers with experience living and working in confined environments. The questions sought to discover whether conflicts arise for these reasons based on the participant's experiences and how effective they think this new approach to pre-mission training would be. Survey participants agreed conflicts were a result of this behavior and supported the hypothesis that pre-mission training including codependency rehabilitation techniques would be effective. This thesis recommends implementing these techniques in future astronaut training.

I. INTRODUCTION

Humans must explore; it is in our best interest and is the only way for our species to advance and survive. Since we now occupy all of the land masses on Earth, we must begin to explore beyond LEO and seriously consider settling other planetary bodies such as the Moon and Mars. This will help ensure the survival of our species and help to advance our technologies.

This is not an easy endeavor, though. Conducting human spaceflight is a perilous task because to be in space, we must live and work within the confines of a spacecraft which protects us from the unforgiving environment of space. In space, we will encounter radiation, micro-meteoroids, microgravity, and our bodies will deteriorate. We will encounter psychological stresses as well from the isolation and confinement we must endure during these travels.

Since traveling through space causes us to encounter multitudes of physiological and psychological stresses, astronauts must be selected who exhibit the physical, mental, and emotional strengths to tolerate these stresses. These astronauts cannot travel alone, so in addition to all of the stresses, they must also be able to live and work in cramped quarters with others whom are chosen to travel with them. As a result, conflicts are inevitable and some of these conflicts inherently come about because we let what others are doing affect us. After reviewing the journals of those who have lived and worked for extended periods in the confinement and isolation of space, it was found that conflicts do occur and can pose a significant problem.

To help mitigate such conflicts, techniques used to rehabilitate those diagnosed with codependency can be implemented into the astronaut training regimen to assist astronauts with coping mechanisms and help them remain focused on their own actions and behaviors.

A survey of individuals with experience in living and working in confined and isolated environments on Earth showed that the participants in the survey agreed that conflicts they witnessed were a result of this behavior of focusing on the actions and behaviors of others. Those participants agreed that implementing techniques to help those in confinement remain focused on their own deeds would be effective in mitigating such conflicts. Perhaps additional screening can also be implemented to test for codependent tendencies, and then used to select out those individuals or apply additional training.

Conflicts will happen so we must work now to determine how we will deal with this problem. The anecdotal data collected through this thesis's survey supports the data collected from astronaut journals that conflicts will occur and that pre-mission training will be effective.

The Difficulties of Spaceflight

Spaceflight is a difficult endeavor for two main reasons: the transition from Earth's surface to outer space is a difficult and dangerous journey and space is a hostile environment which affords humans no life support. Spaceflight is a journey into an "isolated, confined, and hazardous environment" which stresses both the individual person, the entire crew, and the relations between the crew and mission control and their families (Clément, 2011).

To begin with, every journey into space which claimed lives did so during the launch or re-entry phase. The *Soyuz* 1, *Soyuz* 11, and *Columbia* STS-107 tragedies occurred during re-entry, while the *Challenger* STS-51-L disaster took place during launch. Getting into space is a perilous journey because one must overcome gravity, which requires the use of dangerous and explosive propellants. Also, to achieve orbit, you must punch through Earth's atmosphere and deal with the drag it creates. During re-entry, you must be able to withstand the tremendous temperatures of the friction-generated heat. So leaving from and returning to the Earth's surface provides such a challenge that it has taken numerous lives.

The Space Environment

Once in orbit, the danger does not cease, but rather increases. There is a significant increase in the amount of radiation the astronauts absorb and there is a lack of gravity which causes havoc on our bodies. In space, there is no atmosphere so we must live inside pressurized spacecraft to overcome the vacuum. Finally, there are magnetic fields surrounding the Earth which trap charged particles, making the environment more dangerous. Let us examine each of these in more detail. We will cover the effects these hazards have on our bodies in the section on physiological stresses in space.

Space Radiation

The first and most severe hazard of living in space is the radiation to which astronauts are exposed. There are various types of radiation to which they are exposed, each type presenting its own challenges. The first type to discuss is the electromagnetic radiation that comes from our Sun. At the Earth, we receive 1390 W/m^2 of the Sun's radiation, which is essential for life on the planet. However, as with most forms of radiation, receiving too much can be harmful to humans (Eckart, 1996). However, as we travel further away from the Sun, the intensity of the radiation emitted from the Sun decreases, although it still must be considered dangerous.

Planet	Solar Intensity Relative to Earth's Value
Mercury	6.68
Venus	1.91
Earth	1
Mars	0.43
Jupiter	0.04
Saturn	0.01
Uranus	0.003
Neptune	0.001
Pluto	0.0006
Earth's Moon	1
Mars' Moons	0.43
Asteroids	0.28

Table III.1: Solar Intensity on Planets of the Solar System [17]

Figure 1 The Sun's Intensity at Other Planets (Eckart, 1996)

The Sun is not the only source of ionizing radiation. There are also particles that come from outside the solar system, such as high energy protons, α particles, and heavy nuclei (such as from Li and Ni). These particles combined are called Galactic Cosmic Radiation (GCR) and they originate at distant stars and other galaxies, impacting the Earth from all directions (Eckart, 1996). When we are orbiting the Earth, approximately 5%-10% of all radiation received is from GCR.

While humans can use materials like aluminum or water to shield ourselves in space from electromagnetic radiation, GCR is of such high energy that the only shielding available in space is regolith on the surfaces of other planetary bodies (Letaw, 1997). While we are traversing between planetary bodies, we are unprotected from GCR and therefore must limit our time spent in these exposed situations.

There is another source of radiation exposure to humans and charged particles in the Earth's magnetic fields, or magnetosphere. When particles arrive at the Earth, they encounter the Earth's magnetic fields and some are trapped within the fields. One of these radiation zones is referred to as the Van Allen Belts. While the particles are trapped, humans in orbit about the Earth encounter them and they are absorbed.

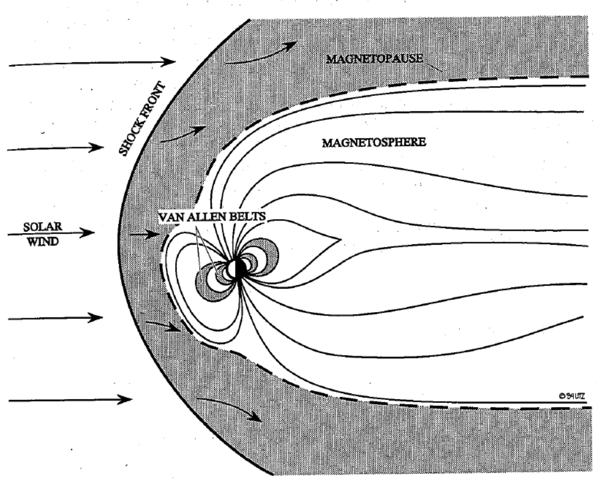


Figure 2 Earth's Magnetosphere (Eckart, 1996)

So the magnetosphere protects humans on the surface of the Earth but in space, it provides yet another source of radiation. However, due to the nature of how solar radiation interacts with the magnetosphere, when solar radiation is at its maximum, its ability to shield us from GCR increases, so while we receive more radiation from the Sun, we receive less radiation from GCR. The converse is also true: when in the lowest intensity of solar radiation, we receive more GCR since the magnetosphere is reduced in size (Eckart, 1996).

As humans travel into space, we will have to protect ourselves from radiation using shielding and limiting the time we are exposed since we cannot see or feel when we are being exposed. There is another hazard which we can perceive: microgravity.

Microgravity

Humans evolved in a 1-g environment so our bodies and all processes that occur within it are adapted to the gravity on Earth. When we transit into space, we experience microgravity, or such a low level of gravity that it is not perceived. Some scientists even believe that microgravity is the "most dramatic environmental characteristic of spaceflight" which "results in extensive physical, physiological, and psychological effects", most of which will be discussed in further details in later sections (Eckart, 1996).

Astronauts experience "weightlessness" in space due to the fact that their spacecraft is in a constant state of "free fall". The spacecraft is being pulled towards the Earth at such a rate that in order to stay in orbit, the spacecraft is moving forward at a certain velocity. This causes the "free fall" condition and thus, the astronauts experience a microgravity environment (Fazio, 1997).

Space Vacuum

Finally, the last example of why space is a hostile environment is because there is a vacuum. The Earth's atmosphere is made up of a gas mixture which contains 78% nitrogen, 21% oxygen, 1% argon, 0.03% carbon dioxide, and water vapor, along with various other trace gases. The atmosphere at sea level is at a pressure of 101.1 kPa. As you increase in altitude, the pressure decreases such that the density decreases, and when you reach an altitude of 3 km, you begin to be affected by the reduction in atmosphere (Fazio, 1997).

If you continue on to the altitude of 9 km, which is the approximate height of Mount Everest's summit, the pressure of carbon dioxide and water vapor is such that there is less oxygen so climbers on Mount Everest must use supplemental oxygen. Above 22 km, the atmosphere is only 4% as dense as at sea level and once you reach 45 km, there is not enough oxygen for combustion (for propulsion, for example) to occur. The next milestone happens at 60 km where there are no longer enough gas molecules for sound or shock waves to occur (Fazio, 1997). To put this into perspective, the orbit International Space Station (ISS) is kept between 320 and 400 km above the Earth's surface.

Since there is no atmosphere that can be used to support a crew, all spacecraft must be pressurized with an atmosphere suited for humans. In fact, the vacuum of space is so dangerous that if there were to be a sudden, explosive depressurization of the spacecraft (depending upon the pressurized volume), the astronauts might only be able to survive for up to 15 seconds (Eckart, 1996).

Justifications for Sending Humans into Space

So if the environment we encounter in space is so unfriendly, why would we still choose to send humans, intentionally placing them in this unforgiving setting? The set of challenges the space environment exhibits would make one wonder: why not send robots instead? The following paragraphs seek to answer these questions.

It is true that in order to survive the bleakness of space, humans require extensive physiological and psychological support. They must be protected against the vacuum of space using air tight and pressurized spacecraft and spacesuits. Humans must be able to hydrate themselves, requiring water which is the heaviest commodity needed to sustain a human life, and they must eat food to stay well nourished. Humans require protection against the various forms of radiation. On top of this, they require psychological support in order to withstand the stresses of life in such an isolated and confined environment (Clément, 2011). Humans are prone to feeling homesickness and are not always predictable. All of these requirements are not needed to support robotic life.

There are advantages to sending non-human explorers into the harsh environment of space. Robots require no primary life support: they need no air, water, or food. Robots only require propellant, or a way to get to their primary scientific objective, and a source of energy once they arrive. Most often the source of energy is either solar power used to charge batteries or a nuclear power generating device. Robots do not need to have crew mates, nor do they sense isolation. They do not have feelings or need to be motivated. Robots are able to perform repetitive tasks and are adept at collecting large amounts of data. They are able to perform simple analysis and are highly predictable (Clément, 2011).

What then are the disadvantages of robots? The answer to this is simple: robotic life cannot adapt to situations for which it was not intended. When robots fail, they are incapable of coming up with a solution on the fly. For example, if a robot were designed to drive around on another planetary surface, it would need to be designed to handle certain kinds of terrains. If it were to encounter terrains it was not designed to handle, the mission would end. The robot could not think on its own, engineer a solution, and fix itself. The thing that sets humans apart is our ability to adapt. This is quite possibly the most important reason why we should still send humans. Humans would be able to collaborate, find a solution, engineer and implement it. Humans are not restricted to just one type of analysis, like scientific instruments are. If a human were to encounter data they were not originally assigned to collect, they would still be able to collect this data and would possibly be able to interpret it (Clément, 2011).

Astronaut Characterization

Human spaceflight began April 12, 1961 with the flight of Yuri Gagarin. His *Vostok* 1 mission took him on a trip into space in which he orbited the Earth once on a trip that lasted about 108 minutes. Since then, more than 520 astronauts, cosmonauts, and taïkonauts have flown into space; 12 of which actually walked on the Moon's surface during the Apollo program. If you were to combine all of the time these people have spent in space, it would total more than 100 years. Only four of these people have spent more than a year in orbit (Clément, 2011).

The following figure shows the frequency of how many humans have been in space based on the duration of the mission. As you can see, most human mission durations center on the 10 day duration.

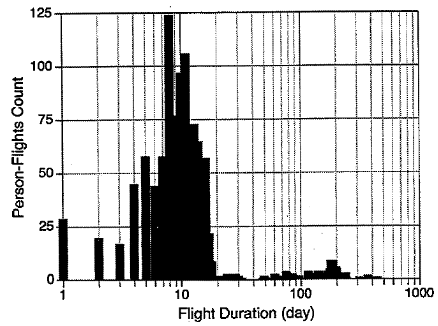


Figure 1.5. Number of Human Spaceflights as a Function of Flight Duration from 1961 to 2010. Note the Logarithmic Scale for Flight Duration. Most Human Flights Were of Short Duration (8–14 days) on Board Soyuz or the Space Shuttle.

Figure 3 Number of Human Spaceflights as a Function of Flight Duration from 1961 to 2010 (Clément, 2011)

This figure shows that we do not have much experience in long duration spaceflight, where long duration is any mission which lasts more than six months. In fact, as shown in the figure, there have been very few humans who stay in space longer than six months.

The following figure represents the same data but as a count of single flight duration.

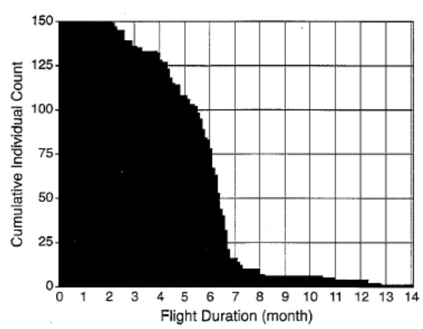


Figure 1.6. Cumulative Histogram Showing the Astronaut and Cosmonaut Count as a Function of (Single) Flight Duration.

Figure 4 Cumulative Histogram Showing the Astronaut and Cosmonaut Count as a Function of Single Flight Duration (Clément, 2011)

Again, you can see that there have been very few humans who have spent long durations in space. In current scenarios which represent missions to Mars, none of them are shorter than two years. There have been no humans who spent more than 14 months consecutively in space. There are many reasons why this fact exists.

II. PHYSIOLOGICAL AND PSYCHOLOGICAL STRESSES OF SPACEFLIGHT

Now that we have discussed the facts about the space environment and why we need to send humans rather than robots, it is important to take a look at what happens to a human before, during, and after a flight into space. The focus will be on the affects that space has on the body and the mind. As mission durations increase, so does our need to focus on the psycho-sociological issues, especially as spaceflight crews increase in size and heterogeneity (Clément, 2011).

Physiological Stresses of Spaceflight

Due to the nature of the space environment, the human body experiences many stresses that affect how the body performs and how quickly it deteriorates. These stresses begin as soon as a person has begun the screening process for becoming an astronaut and continue even after that person has returned from a spaceflight.

Pre-flight Physiological Selection and Support

Once a person applies to become an astronaut, the physiological stresses begin and some may argue they have already begun since to be considered for the astronaut corps, you must be physically fit. All astronaut applicants must be able to pass some form of physical test and must fit certain height requirements. In the beginning of the astronaut program, these requirements were much stricter. For example, when NASA began looking for astronauts for the Mercury program, they asked the military for recommendations of members who met their requirements which included having a stature conducive to fitting inside of the small Mercury capsule. The applicants were required to be less than 40 years old and less than 5 feet 11 inches and in "excellent physical condition" (NASA, 1981). These requirements have changed over the years as the missions have evolved, but one thing that has not changed is the fact that there are different selection criteria for the pilots versus the mission specialists and regular crew (Clément, 2011).

As soon as someone is selected to the astronaut corps, their pre-flight health maintenance begins. Each member of the astronaut corps is required to complete annual medical evaluations where they are screened for medical conditions. The reason for this is to detect any conditions that are developing so they can be treated, keeping the astronaut healthy and ready for flight. If an issue is detected, once they are finished with treatment, they must re-certify for flight. Each astronaut corps member also meets one-on-one with nutritionists and flight surgeons to receive a personalized fitness and nutrition regimen to keep them at their optimal health (Clément, 2011).

All health and nutrition standards applied to members of the astronaut corps were developed here in a 1-g environment. Those standards are continually re-evaluated for validity since more is learned each year about how to maintain a human body in space (Clément, 2011).

After being assigned to a mission, astronauts go through even more health screening and preventative measures to help ensure they are the healthiest they can be prior to flight. Medical care that is administered is done so in a way to prevent illness so the astronauts remain healthy once they arrive in space. An example of measures taken to help ensure optimum health during their mission is that one week prior to flights, Shuttle astronauts would be quarantined so as to reduce their exposure to infectious illnesses (Clément, 2011). The astronauts were also not allowed to go into crowded areas like movie theaters and were only allowed to be in contact with designated people named primary contacts, or PCs (Logan, 1997). Even the PCs were restricted from coming within six feet of the astronauts.

In-flight Health Monitoring

Before astronauts fly into space, the medical care they receive is geared towards preventative measures which aim to keep the astronaut as healthy as possible so that when they arrive in space, they are at their optimum health level. Once the astronauts arrive in space, the medical care switches to monitoring their health condition and treating issues as they arise.

In flight medical care is designed to "ensure crew safety and health maintenance during routine operations, prevent excess mortality (death) and morbidity (illness/disease), prevent early mission termination due to medical contingency, prevent an unnecessary rescue, and increase the probability of success of a necessary rescue" (Logan, 1997). These countermeasures are required due to the physical stresses space flight inflicts on the human body.

The first stresses encountered during flight are brought on by the microgravity environment experienced. Approximately 80% of all astronauts experience Space Motion Sickness (SMS), which results from conflicts in the signals received from different senses (Lathan & Clément, 1997), on their first flight into space and the symptoms are loss of appetite, nausea, and vomiting. There were no reported cases of SMS on the Mercury or Gemini missions, but there have been cases of SMS on every mission since (Lathan & Clément, 1997). They also experience disorientation and orthostatic hypotension; all while being exposed to accelerations, vibrations, noises (especially during launch), toxic substances and pressure changes (Clément, 2011). There are countermeasures which have been used in astronaut training to help mitigate the effects of SMS, such as anti-motion sickness drugs, acupuncture, and bio-feedback training (Lathan & Clément, 1997).

While living in microgravity, the astronauts experience bone density loss and redistribution, muscle atrophy, especially in the cardiac muscle. The greatest time of muscle atrophy is in the first month, and afterwards is stabilized by exercise regimens (Eckart, 1996). Because the heart does not need to pump against the Earth's gravity, it begins to atrophy as well causing the heart and blood vessels to encounter dysrhythmias (Clément, 2011). The heart's chamber size decreases by as much as 10% due to the atrophy, which leads to an increased heart rate throughout the mission (Eckart, 1996).

Since the load bearing bones do not have to work against gravity, they decalcify and weaken. The bones also redistribute their densities to non-load bearing areas during spaceflight (Clément, 2011). Bone decalcification starts out slowly then increases and does not reach a plateau, that is to say it keeps increasing. The decalcification increases at a rate of 0.05% of bone loss per month and current research states that exercising does not mitigate this problem (Eckart, 1996). Some bones have been reported as losing 3-5% of their density in a month. At this rate, a human could only survive a mission that is less than two years in duration.

Living in microgravity also has an effect on our back's support system. Since gravity is not pulling on our spines and supportive muscles, they elongate and stretch out. Very often this elongation causes lower back pain for the astronauts.

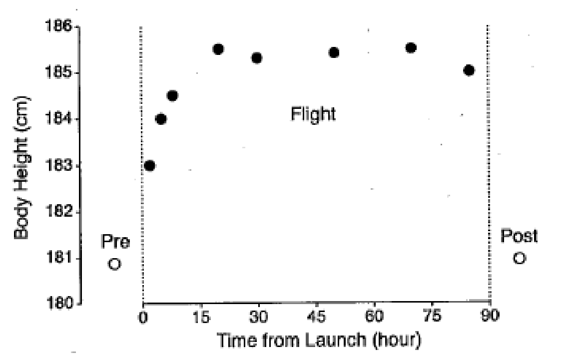


Figure 1.16. Diagram Showing the Increase in the Height of an Astronaut During the Firs Hours of a Space-Flight. (Adapted from Thornton and Moore [1987]).

Figure 5 Astronaut Height Before, During, and After Spaceflight (Clément, 2011)

In addition to these changes, the body's internal fluids shift upward, referred to as the cephalad fluid shift, since gravity is no longer pulling them down into the lower extremities. As a result, the legs lose girth and up to 2 liters of fluids can be lost in the legs alone, especially in the thighs (Churchill & Bungo, 1997). This also causes the astronauts to have a sense of being "stuffy", or having nasal congestion, and the faces of astronauts often appear puffy.

Dr. Oleg Atkov wrote in his journal about how his face's puffiness made him unrecognizable, even to himself. When he stood in front of the mirror to shave, he saw "not the usual European face but instead a Mongolian stranger peering back at him" (Churchill & Bungo, 1997).

The main problem with the cephalad fluid shift is one of the ways the body interprets this shift. There are sensors in the body, called baroreceptors, which are designed to measure and sense the blood pressure. These baroreceptors, located on the blood vessel walls, exist in the brain and heart, the two most vital organs. When the fluid shift occurs, they register that the blood pressure in the body is too high. The body reacts immediately by reducing the heartbeat strength and adjusts the heart rate to compensate and thus decreases the pressure placed on the blood vessels (and thus the pressure placed on the baroreceptors) (Churchill & Bungo, 1997). The following table shows how drastically the heart rate can be affected by the cephalad fluid shift.

Table 1 Resting Heart Rates Following Short-duration U.S. Flights (Churchill & Bungo, 1997)

Program	Flight	Sample Size	Flight Duration	Δ H.R.	Ref. No.
Mercury	MA-8	1	9 hrs	+22%	[13, 26]
	MA-9	1	1.4 days	+15%	[8]
Gemini	GT 3–12	20	1–14 days	+18% Δ +62%	[11]
Apollo	7–17	24	6–13 days	+15%	[45]
U.S. Space Shuttle	STS 1–4	8	2.3–8 days	+17%	[21]
	STS 5–8†	17	5–6 days	+31%	[19]
	STS 8–51G†	15	6–8 days	+29%	[77]
	STS 26–34†	24	4–5 days	+23%	[78]

† Crews used oral saline loading as countermeasure for postflight orthostatic intolerance.

The second way the body interprets the fluid shift is that there is too much fluid in the body, so it increases urine output since changing the strength and rate of the heartbeat did not fix the problem. Astronauts see the increase in urination frequency as a hassle and so they decrease their fluid intake, which is exacerbated by a decrease in thirst. As a result of this fluid dump, there is a reduction in intravascular space and the astronauts become dehydrated. This also constitutes a portion of the weight loss seen by astronauts in space, so their weight loss is not just from losing fat (Churchill & Bungo, 1997). The dehydration coupled with the decalcification of the bones often leads to kidney stones while in orbit (Eckart, 1996). The kidneys are the main organs used to accomplish the fluid reduction. The kidneys remove plasma from the blood, not just the red blood cells, and in the process, the body loses sodium which is crucial for nerve and muscle activity (Churchill & Bungo, 1997).

Most of the previous affects are mitigated by the body by achieving a new homeostasis, or steady state, while in space. However, there is one area in which homeostasis is not achieved which could cause a disaster on an interplanetary mission. Microgravity inflicts immunosuppression on the astronauts in orbit. Our bone marrow and immune system atrophy, causing a reduction in red blood cells which results in 'space anemia' and an immune system which is less able to fight off illness and disease (Eckart, 1996). Clément also agrees with this conclusion in that the immune system is the only system in our bodies which appears unable to reach a new homeostasis in microgravity (Clément, 2011).

The immune system cannot fight off simple infections that would not cause any sickness here on Earth. This is due to several compounding reasons. First of all, bacteria are able to proliferate faster in space. For example, one strain of bacteria was able to get to a certain quantity in 9 hours in space versus 17 hours in a 1-g environment. One theory used to explain this fact is that instead of expending energy on mobility, the bacteria can spend all energy on proliferation. In space, convection of air is forced by fans and moisture and dust particle float around rather than settle as they do here on

Earth, providing the bacteria with ample resources for proliferation. Also, bacteria are more resistant to antibacterial mechanisms. The reasons behind this are not yet clearly understood (Lewis & Hughes-Fulford, 1997).

On top of the bacteria being more efficient in space and more resistant, the immune system is not able to fight off infection. In the example of lymphocytes, which protect the body against "harmful organisms including bacteria and viruses", are 90% less active in space. This fact alone proves that the immune system shuts down in space (Lewis & Hughes-Fulford, 1997).

Post-flight Recovery

Upon return to Earth, the arduous task of helping to rehabilitate the astronaut's bodies begins. Due to the fluid shift while in space and the changes in the blood composition, astronauts faint (also called "syncope") quite often because the mechanisms used to make sure our fluids are distributed against the gravity vector have been weakened during spaceflight, so there is not enough fluid in the head. This phenomenon is referred to as "post-flight orthostatic intolerance" (Clément, 2011). One of the countermeasures for mitigating orthostatic intolerance (OI) is to drink large quantities of water and ingest salt tablets. The purpose of this countermeasure is to increase the overall fluid volume in the cardio-vascular system. This countermeasure is often efficient for mitigating OI after shorter duration missions (4-7 days) but is not as effective for longer duration missions. This fact points to the idea that the entire cardio-vascular system has altered during spaceflight (Churchill & Bungo, 1997). After the short duration missions, recovery was also short, taking about 4-10 days. But the

Soviets recorded recovery times of 4 weeks to return to pre-flight cardiovascular conditions after spaceflight missions of up to 10 months (Churchill & Bungo, 1997).

Also, after returning to Earth, the astronauts meet with flight surgeons to discuss the medical changes experienced on board and post-flight. These debriefings occur the same day as landing and then also three days later (Clément, 2011).

The astronauts return to a regular exercise regimen to counter the atrophy that occurred in their muscles while in space and to attempt to regain bone density. Their fluids redistribute themselves and the heart readapts to the hydrostatic load of living in a 1-g environment again.

There is an increased risk of developing cancer due to the exposure to radiation but there is nothing that can be done except for regular cancer screenings, just as is done with the regular population.

Psychological Stresses of Spaceflight

Despite how easy the astronauts living and working on the ISS make it look, being in space takes a mental toll on astronauts. They live and work in a potentially deadly environment, confined and isolated away from their loved ones where not even simple tasks like eating are done the same way they are done on Earth. To cope with living in space, Santy recommends that crews receive training in some areas such as "communication and cooperation, stress management, coping with operational demands, and group problem solving" (Santy, 1997). This laundry list of training needs speaks volumes about the stresses encountered in space.

The following figure outlines some of the areas which will be discussed in further details in the subsequent paragraphs. As shown in the graphic, there are numerous methods used to support the crew of the ISS psychologically, both from the ground and on board the space craft.

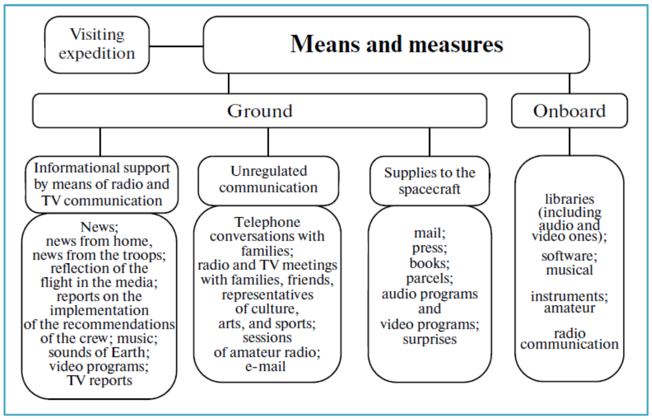


Figure 6 Schematic of Psychological Support Methodologies Currently used on ISS (Kozerenko & Ponomareva, 2010)

Just as space is harsh to the human body, it is harsh to our minds. Spaceflight is dangerous and this fact weighs on the minds of the humans on board spacecraft orbiting the Earth.

Pre-flight Selection and Support

One aspect of supporting a crew psychologically begins with the design of the crew itself, namely the selection process. There are two methods used in the astronaut selection process specifically designed to eliminate from the candidate pool those people who would not adjust well to living and working in space. These two methodologies are the “select out” and “select in” criteria. These criteria were developed over the course of the manned spaceflight program. They were not initially used. The following table depicts some of the selection procedures used in previous manned spaceflight missions.

Table 6.5. **Summaries of Psychiatric and Psychological Selection Procedures in the U.S. Space Program (1959–1985).** Adapted from Santy et al. [1991].

Procedure	Mercury	Gemini/Apollo	Shuttle
Number of hours for the psychiatric evaluation	30	10	3
Screening method	2 psych interviews 25 psych tests 5 stress tests	2 psych interviews 10 psych tests 1 stress test	2 psych interviews
"Select-in" criteria used by psychiatrists	1. Intelligence 2. Drive and creativity 3. Independence 4. Adaptive motivation 5. Flexible 6. Motivation 7. Lack of impulsivity	1. General emotional stability 2. High motivation 3. Adequate "self" concept 4. Quality of interpersonal relationships	None documented
Validation of criteria	Data not available	Not done	Not done

Figure 7 Psychiatric and Psychological Selection Processes in the US Space Program (Clément, 2011)

As the manned spaceflight program has evolved, so too have the fields of psychology and psychiatry. In use today are refined methods to identify and eliminate those who exhibit unpredictable behaviors that might indicate that person's inability to later adapt to life in microgravity.

First we will discuss the "select out" criteria. These criteria are described as "medical criteria specifying those psychiatric disorders which would be disqualifying" where "disqualifying" means to eliminate those "at risk for a psychiatric disorder during a space mission" (Clément, 2011). NASA currently uses two of the most widely accepted self-reporting questionnaires: the Minnesota Multiphasic Personality Inventory (MMPI) and the Million Clinical Multi-axial Inventory (MCMI). The "select out" criteria are specifically designed to find out if the person being considered for the astronaut corps would possibly have a psychotic episode in space. If a person is deemed to be at risk for this, they are eliminated from the process since it would put their lives, the lives of their fellow crew members, and the entire mission in jeopardy.

The next set of criteria is referred to as the “select in” criteria. The “select in” criteria are defined as being used to “identify and select candidates with characteristics that predict for optimum performance in the isolated, confined, and hostile environment of space” (Clément, 2011). These criteria are often likened to figuring out if they are perfect for the job based on their skills and personality. The “select in” criteria are designed to help find individuals who would be able and willing to get the job done regardless of their own personal feelings or motivations once they are in space.

So while “select out” criteria eliminates those who could potentially not be able to handle the rigors of spaceflight, “select in” criteria looks for those attributes which would make a person a good fit on a crew and who have the necessary skills to perform the tasks that would be required of them. These two methodologies combined help to mitigate many psychologically induced problems that might have occurred otherwise on board the ISS during a mission.

The next issue that must be discussed is the training regimen for the crew. Training acts as part of the psychological support for the crew since it provides the crew with countermeasures for supporting each other during the mission. In addition to training the crew on the mission objectives and emergency procedures, the crew needs to be trained in such areas as “culture and language differences”, conflict mitigation and resolution, “privacy and interpersonal relationships”, and how “to prevent the occurrence of severe adjustment problems” (Clément, 2011). Clément also recommends that the crew be trained on team building exercises that can be completed during the mission. The ground crew should go through this training program as well, since throughout the history of manned spaceflight, there are consistent examples of the crew in space and the ground crew not acting cohesively.

Despite the fact that a crew preparing for a mission on the ISS spends years in training and must absorb copious amounts of information prior to their mission, it is crucial that they be trained on these recommended topics so they are prepared for inevitable difficulties. In space, especially on a long duration mission, it is not a question of whether there will be inter-personal conflicts; it is a question of when and how those problems will manifest themselves. More importantly, it will also be a question of whether the conflicts will be detrimental to the mission itself (Santy, 1997).

In-flight Psychological Stresses

During spaceflight, there are numerous issues that can affect the psychological health of the astronauts. There are numerous human related issues such as astronaut physical health, group behavior and cohesion, and the psychology of the group. Stresses also come from the spacecraft and habitat in which the astronauts live, including the design of the spacecraft or habitat and how well it lends itself to living and working. The physical environment in which the astronauts live and work can also take a toll on them psychologically, with stressors including the amount of gravity, dust, and weather concerns. Finally, stress can come from mission operations, such as the timeline of the mission and what the objectives and goals are (Santy, 1997).

One of the major effects of spaceflight missions is that the crew is removed from their natural environment where they have a chance to interact with many people who serve many social roles. When in space, the astronauts are sent up with people with whom they were “forced” to engender friendships. In regular life, we experience the birth of friendships when we voluntarily engage in creating a new friendship. We essentially choose who we want to spend our time with. The astronauts do not typically have a say in who their crew mates will be, so they have no choice other than to get along with them. Even with extensive training, there are changes in crew dynamics that come to fruition in space under the stress of the mission. The crew may spend years “knowing, working, and traveling with each other”, but in space, as Lichtenberg states, there is “nowhere to go to find some privacy” and you cannot simply “go out for a walk” when tensions mount (Lichtenberg, 1997).

The crew is considered a micro-society from which major roles, like teacher, wife/husband, and friend, have been removed. These roles force us to exercise different skills and abilities that we have, such as being someone’s confidant or partner. On Earth, we live with our family and friends and each of us plays various roles and provides feedback to each other within those roles. We look to certain people within our lives to provide “reassurance, affection, and respect”. These forms of feedback may be missing which causes a form of social sensory deprivation (Connors, Harrison, & Akins, 1985).

Current ISS astronauts do have support during their stays on the ISS. During their expeditions, ISS crews have access to flight surgeons and the Psychological Services Group which provide psychological support. The Psychological Services Group (PSG) is comprised of “behavioral scientists and psychologists who learned significantly from the analog environments” here on Earth which simulate the isolation and confinement that ISS crews encounter (Clément, 2011). The PSG also regularly lobbies for improvements to the ISS environment by making recommendations on how to improve the “habitability and stowage, acoustics and vibration, food variety and storage, and crew quarters” as well as consulting on issues such as the “work and rest schedules, language training, and culture training” the ISS crews go through (Clément, 2011).

The crew has daily communications with the flight surgeons to go over their current health conditions and regular communications with the PSG. During these communications, the PSG is watching for possible interpersonal problems as well as psychological difficulties a particular crew member might be facing.

In addition to the already-mentioned responsibilities, the flight surgeons and PSG are also responsible for the “psychological reconstruction of environmental conditions for the prevention of monotony” and are constantly monitoring interpersonal communications between the crew and the ground services to watch for building tensions (Kozerenko & Ponomareva, 2010). The PSG also is charged with helping the astronauts to “[maintain] motivation” throughout the mission (Clément, 2011). This is an important support mechanism as motivation and productivity fluctuates throughout the mission. In the beginning of the mission, the astronauts are in a state of wonder from being in space. They start the mission learning to adapt to life in space but soon, they get into a rhythm of working. It is not long however, before this rhythm turns into a monotonous routine, bringing a sense of guardedness and a decline in motivation and productivity (Lichtenberg, 1997).

The flight surgeons and PSG help the astronauts by monitoring their behaviors by reviewing their voice patterns for stress and anxiety as well as watch their facial expressions and body language during the video conferencing (Clément, 2011). They are monitoring the astronauts constantly during the mission and can intervene with recommendations for countermeasures such as medication, self-hypnosis, and relaxation strategies.

While in space, crews are expected to deal with a very compact schedule with much to accomplish. Astronauts comment regularly on the “stress of [the mission] timeline” and having to work for long hours constantly just to not fall behind on their tasks (Lichtenberg, 1997). On top of their already busy schedule, astronauts must work against the clock also in the sense that most everything takes longer to accomplish in space than it does here on Earth.

The astronauts are living in a hostile environment that can claim their lives at any moment. As former astronaut Byron Lichtenberg states, “Although we are not really afraid, there is a part of the mind that knows you are in a potentially dangerous environment” (Lichtenberg, 1997). He also mentions that while this adds “exhilaration”, it also contributes to the overall stress of the mission. Astronauts, to date, were either in Low Earth Orbit and so were within hours of return to Earth, or were within a few days return if on a Lunar mission. However, this underlying stress might be increased for crews as they venture further and further from the safety of the planet.

A crew on a voyage to Mars might encounter shock due to not being able to look out the spacecraft window and see Earth. In a study of ISS astronaut journals, “Photography” and “Earth Viewing” were the first and third most popular “Recreation/Leisure” activities, respectively (Stuster, 2010). These two items accounted for nearly 40% of all entries in the “Recreation/Leisure” activities category. We have already seen what the Earth would look like from Mars and Earth is barely distinguishable from stars.

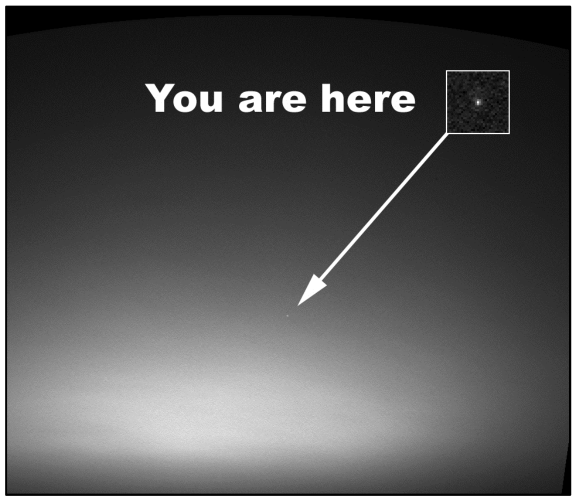


Figure 8 Earth from the Surface of Mars as seen by the Spirit rover in 2004 (NASA, 2004)

From the surface of Mars, you would not be able to see the oceans or make out the different countries. As Lichtenberg points out, “from a humanistic standpoint to look back at the Earth from Mars, and realize it’s just one more point of light in the heavens…this extreme sociological shock needs to be addressed before those first pioneers reach out across the solar system” (Lichtenberg, 1997). This issue could be likened to when the first sea explorers lost sight of the shore of their home land.

Another stress which is felt by both the space and ground crews is whether to inform the other of bad news. Space crews might disagree over whether to notify the ground of bad news, such as malfunctions which are not dangerous or mistakes that were made. While some astronauts might feel that full disclosure is crucial, others may feel that it would be best to wait until they are back on Earth to inform the ground crew of what has happened (Santy, 1997).

From the other standpoint, the ground crews may find themselves with the dilemma over whether to tell space crews bad news. There are various forms of bad news, from national tragedies such as 9/11 to personal losses. An example of this is the instance of when a crew member's family member has died. In one circumstance, a cosmonaut's father had died while he was in space. The cosmonaut was not informed until he returned to Earth much later. There was resentment from the cosmonaut who felt he had the right to know. On the other side of the spectrum, European astronaut Paolo Nespoli was on a 6 month mission on board the ISS when his mother passed away. He was given only a few days to grieve during which he was relieved of as many responsibilities as possible, including public appearances. After those few days, he was returned to duty (Santy, 1997).

Both sides of the argument have pros and cons, but perhaps this decision should be left to each individual. Each astronaut could be given the opportunity pre-flight to inform the ground crew whether they would want to be informed of bad news.

Post-flight Re-acclimatization to Life on Earth

The PSG and flight surgeons are an integral part of providing crucial support to astronauts. They interact with and train the crews prior to launch and are with them during their missions as well. In recent years, they have also begun conducting "behavioral health assessments" after each mission is completed, as a result of the Lisa Nowak case (Clément, 2011). They also help the astronauts readapt to life on the ground with their families and friends as well as help relieve leftover stresses that might exist between them and their fellow crewmates or mission control. So, the psychological support does not end when the mission does, and perhaps even takes on a more crucial role after the mission ends to help the astronauts return to their "regular" life back on Earth. This will perhaps be even more important when helping a crew that has been gone from Earth for years reacclimatize to "normal" life.

III. A BRIEF HISTORY OF ASTRONAUT TRAINING

Astronaut selection and training has evolved tremendously over the more than 50 years of human spaceflight that have elapsed in the United States. Originally, astronaut selection was a program where NASA asked the military for its best and brightest. It has now become, for some, a life-long endeavor of training, education, and submitting application after application with the hopes of being selected to the astronaut corps.

The Mercury, Gemini, and Apollo Years

In 1959, the newly formed NASA agency asked the United States military services to provide them with a list of their best for the new “manned space flight program”. NASA provided the military with a list of specifications that individuals must meet to be considered for the new training program. The applicants were to be selected and trained as “pilots” for the new spaceflight program, so NASA put an emphasis on those who had experience in “jet aircraft flight” and “engineering training”. The physical characteristics of the individuals must be within certain parameters so they could fit inside of the Mercury capsule which was already being designed (NASA, 1981).

The following is a brief overview of the characteristics requested of the military by NASA:

> Less than 40 years of age; less than 5 ft. 11 inches tall; excellent physical condition; bachelor's degree or equivalent in engineering; qualified jet pilot; graduate of test pilot school, and at least 1500 hours of flying time (NASA, 1981)

After the military reviewed their rosters, they provided NASA with a list of more than 500 individuals. Those individuals were then placed through a series of physicals and psychological evaluations. At the end of the process, there were 7 who emerged as NASA's first astronaut corps. Those selected were Alan Shepard, Gus Grissom, John Glenn, Scott Carpenter, Wally Schirra, Gordon Cooper, and Deke Slayton (NASA, 1981).

Three years later, NASA began another recruitment cycle to find the Gemini and Apollo astronauts. There were a few adjustments made to the selection criteria, including decreasing the age limit to 35 and increasing the height limit to 6 feet. This recruitment cycle, however, would be open to civilians. More than 200 applications were received and sorted through, leading to a group of 32 who would go through further screening, which then resulted in 9 new astronauts added to the corps in September 1962 (NASA, 1981).

In order to narrow the 32 candidates down to the new 9, NASA would put the men through rigorous physical tests which included finding out how much heat and noise the men could tolerate, how many balloons they could inflate before they would pass out, how long they could keep their feet submerged in icy water, and how long they could exercise on a treadmill. They were also put through multitudes of psychological tests which included such questions as "Write 20 different answers to the question: 'Who am I?'" (Sherrod, 1975).

So, to characterize the astronauts from the Mercury to the Apollo programs, the selected astronauts have been described as "brighter; better integrated; more independent; and had a 'good balance between sensitivity/creativity and conventionality'…[and] relatively few showed any evidence of psychopathology" (Santy, 1997).

In the case of the Apollo program, the training program relied heavily upon training in the simulators. The astronauts ran through the simulators with the simulator commanders throwing every imaginable error, malfunction, and problem at the crew to see how they reacted and to train them to handle the equipment. The simulators were exact replicas of the spacecraft the crews would actually be using on the missions. The Apollo 11 crew was selected in January of 1969 and flew in July. Between their selection and flight they would spend more than 2000 hours in the simulators, tirelessly running through scenario after scenario (Sherrod, 1975).

In regards to the behavioral training for the astronauts, there was a strong emphasis on the topic leading up to and during the Mercury program. It was necessary to prove on the ground that the astronauts were going to be able to withstand the rigors of spaceflight. However, once this was proven, behavioral training was put aside. Behavioral science was viewed almost with a stigma since the Gemini and Apollo astronauts were chosen to have the "right stuff" and were encouraged by the program managers that "personal hang-ups should be put aside in favor of the mission" (NASA, 2011). Behavioral health training issues were not revisited until after astronauts spent time on Skylab and Mir, when they discovered that it was insufficient to simply brief the astronauts on what stresses they might encounter and how others had handled those stresses (Hysong, Galarza, & Holland, 2007).

Training During the Shuttle Years

Space Shuttle crews were comprised of two pilots, mission specialists, and payload specialists. The training required for each was different, but there was much overlap in the more crucial aspects of training, such as learning about the Shuttle spacecraft itself. To learn the Shuttle's spacecraft systems took between 40-45 weeks and even the non-pilot astronauts would train in aircraft to learn communication, navigation, and flight planning. Basic training for all astronauts took approximately 18 months to two years and then once they are assigned to a mission, they undergo more training specific to their mission (Association for Career and Technical Education (ACTE), 2008).

For pilots and mission specialists, they received much training as self-study, classroom training, and hands on training, as was the case with flying in aircraft designed to mimic the Shuttle. They were then trained on the Shuttle itself so they could perform maneuvers such as rendezvous and EVA. Pilots and mission specialists were typically selected 12 to 18 months prior to the mission (Lichtenberg, 1997).

Training and selection was different for payload specialists, whose training was more focused on the scientific objectives of the mission. Payload specialists, selected about two years prior to their mission, were still trained on the Shuttle but it was not as intensive as the training pilots received. Payload specialists were trained on subjects such as "thermal control, guidance, navigation and control, propulsion, communications and tracking, electrical, life support, and habitability" and the training focused on nominal operations, then focus would shift to "off-nominal", or malfunctioning, scenarios (Lichtenberg, 1997).

There were several training techniques used in the Shuttle training program, but overall, the training was centered on the following model: "information, demonstration, and practice (IDP)". This instructional model was directed by the different learning techniques, in order to make sure all learning methods were covered so all astronauts would learn. Those learning techniques were "information input" ("abstract conception versus concrete experience") and "information processing" ("reflective observation versus active experimentation") (Hysong, Galarza, & Holland, 2007). The Shuttle training program included a wide variety of exercises which helped the astronauts cope with the amount of information they were required to learn and were tested on before being allowed into orbit.

The instructional methods for the IDP system utilized variations within each portion of the training program to also keep the training interesting and interactive, thus increasing retention of knowledge. For the information based methods, the information was typically delivered in a lecture or conference type format. For demonstrations, the presentations utilized audio and visual techniques to present information. For the practice-based methods, the astronauts would engage in behavior modeling, games centered on business, conduct role playing activities, and practice simulations, including field experiential training simulations. The final method is referred to as CAI, or Computer Aided Instruction, where the astronauts would go through self-paced courses individually on computers (Hysong, Galarza, & Holland, 2007). Each different technique offered a variety of ways in which to keep the astronauts knowledge retention high and at a fast, efficient pace in order to complete the training in a timely fashion.

It has been repeatedly noted that NASA does not focus on psychological training for their astronauts. In fact, an astronaut during a six month expedition on the ISS wrote in their journal: “I like the incremental approach the Russians use for preparing for this sort of event; the Americans would assume that you’ll do all your mental preparation in your spare time” (Stuster, 2010). In fact, the selection process is geared towards using selection to “select out” those who would not be suitable for spaceflight and afterwards, training is focused on the mission architecture. Currently, the astronaut selection process utilizes computer examinations to screen candidates for their psychological health and is followed up by psychiatric screenings and interviews to determine a candidate’s emotional and mental suitability (Hysong, Galarza, & Holland, 2007).

Training Differences Based on Mission Durations

For Shuttle missions which lasted anywhere from around 11 days to 17 days, the main concerns for the crew were physiological concerns and meeting the operational goals of the mission timeline. As we move towards longer missions that venture further away from earth, the focus will shift to maintaining the psychological health of the crew.

For shorter duration missions, the crew is trained using repetition so they are able to remember everything. The crew practices everything repetitively with an emphasis on efficiency since the mission is a short duration mission. Time is of the essence, so the schedule for the mission is not as flexible. An illustration of this is that the crews on shorter duration missions are trained to repair equipment, but it is not emphasized since the mission schedule does not allow much time for fixing equipment. Time spent on repairs takes away time from other experiments or operations (Lichtenberg, 1997).

In contrast to that, crews who will be on longer missions are trained to maintain and repair equipment since it is critical, and to work as a team with their crewmates. For any spacecraft used on a long duration mission, such as the ISS currently, everything must be reparable. However, it is nearly impossible to train everyone on everything (Lichtenberg, 1997).

Currently, Astronauts are trained in skills that will prove crucial in maintaining their emotional and mental support. The astronauts will need training in these areas, but for long duration spaceflight missions, such as the 6 month and 1 year stays on the ISS, focus will need to shift to include support for the psychological issues the crews will experience. As one ISS astronaut wrote: “My only other experiences have been short duration flights, where the pace just doesn’t allow the seeds of conflict to germinate” (Stuster, 2010).

A list of critical factors was generated and compared as to what will be the most important factors on Long Duration Missions (LDM) versus Short Duration Missions (SDM). As the table below illustrates, the primary concern will involve keeping the crew stable mentally and emotionally (Hysong, Galarza, & Holland, 2007).

Table 2 Critical factors and sample skills required for long- and short-duration space missions (Hysong, Galarza, & Holland, 2007)

LDM Critical Factors (listed in order of criticality for LDM)	SDM Critical Factors (listed in order of criticality for SDM)
Factor 1: Mental/Emotional Stability	Factor 2: Performance under stressful conditions
Factor 2: Performance under stressful conditions	Factor 1: Mental/Emotional Stability
Factor 3: Group living skills	Factor 7: Judgment/Decision-making
Factor 4: Teamwork skills	Factor 4: Teamwork skills
Factor 5: Family Issues	Factor 8: Conscientiousness
Factor 6: Motivation	Factor 5: Family Issues
Factor 7: Judgment/Decision-making	Factor 3: Group living skills
Factor 8: Conscientiousness	Factor 6: Motivation
Factor 9: Communication skills	Factor 9: Communication skills
Factor 10: Leadership capability	Factor 10: Leadership capability

These 10 factors can be categorized in three ways: self-care and management, teamwork, and leadership. While the current astronaut training methods involve some aspects of these themes, more will need to be incorporated as we move forward into missions of longer lengths. For example, the leadership themes will become more important since the leadership of the crew on a long duration mission will have to act more autonomously since communication delays will increase as the crew goes further away from Earth. If the crew is near Mars where there can be a time delay of 40 minutes and if a problem occurs, there may not be enough time to consult with mission control on a solution, so the leadership on board will be forced to act independently. Also, they must be able to work with reduced resources since they will have to develop a solution that uses the equipment they brought on the mission (Connors, Harrison, & Akins, 1985).

IV. CREW COMPOSITION CONSIDERATIONS

The composition of the crew could play a vital role in the inter-personal dynamics of the crew as well as determine how the crew reacts to the long duration confinement of the mission. Over time, there is a decline in "health, morale, and performance of groups" living and working in any confined environment and the crew's composition is crucial to dealing with these declines (Santy, 1997). Also, as crew heterogeneity increases, it becomes more important that the crew agrees on some of the more major themes in life because this can serve to mitigate some conflicts that could arise (Connors, Harrison, & Akins, 1985). Crew composition is a difficult area to address because each aspect of crew composition includes both benefits and drawbacks, as will be discussed in the following paragraphs.

Gender

The differences between genders have existed since we began as a species. These differences serve to both bind us in areas where the differences are complimentary and to separate us in areas where they clash.

Spaceflight has been a male-dominated journey. Referencing statistics collected up through April of 2011, females have only accounted for 11% of the 520 people who had been to space between April 1961 and April 2011 and only 11% of all flights in that same time span included females (129 flights). Finally, out of the more than 100 years of accumulated time spent by humans in space, only 8 of those years were accumulated by females (Clément, 2011).

In terms of having both genders represented in a crew, the inclusion of both genders serves to add diversity and allows each member to act in roles that might not otherwise be exercised. This diversity adds to social stimulation (Connors, Harrison, & Akins, 1985).

However, if both genders are to be included in a crew that will serve in isolation, it is imperative that none of the crew sees either gender as being more capable or adept at handling the objectives of the mission. Every crew member must be unbiased about the genders and see them as equals. The problem of bias is well documented in the military and has served to compromise mission objectives (Connors, Harrison, & Akins, 1985).

Another aspect of having mixed gender crews which could cause problems on long duration missions is whether either gender takes advantage of gender to accomplish personal goals in such a way that endangers the mission. For example, you would not want males to engage in activities that have higher risk in order to impress a female. Likewise, you would not want a female to feign weakness in order to have males on board complete her tasks so she dodges having to complete her duties (Connors, Harrison, & Akins, 1985).

Another obvious problem that could arise is the development of an intimate relationship during the mission. One might believe that an intimate relationship would help the couple cope with the isolation and confinement. However, this could cause problems amongst the rest of the crew. For one reason, jealousy and/or resentment could arise within the other crew members who are not in an intimate relationship and long for this particular kind of affection. If one of the other crew members has concealed romantic feelings for one of the members of the couple, they would become jealous as well which could cause conflict.

The other crew members could become uncomfortable if the couple chose to display signs of affection towards each other in the presence of the rest of the crew. The outward signs of affection could be seen as unprofessional or even offensive, depending on the cultural backgrounds of the other crew members (Connors, Harrison, & Akins, 1985).

The situation might be different if the couple is chosen for the mission and all crew members understand that the couple is committed. However, this does not preclude the opportunity for problems during the mission if there is infidelity or if another crew member develops romantic feelings for one of the members of the couple. If the relationship dissolves of its own volition during the mission, this could also cause tensions between the two members of the relationship.

Age

Age is another factor which must be considered when reflecting on crew composition. There are biological concerns which could inhibit the selection of certain crew members. For example, you would not want to expose an individual who is still developing physiologically to the radiation of space, nor would you want a more elderly individual exposed to the radiation either. Also, those who are older typically have decreased bone density, which could cause additional problems since in microgravity, the bones decalcify. However, it has been scientifically shown that those over 40 adapt better to Space Motion Sickness (SMS) (Connors, Harrison, & Akins, 1985).

Another benefit of including older individuals is the idea that they have had more life experiences and could be perceived as being wiser than others. This aspect might prove helpful in being able to "let go" of potential conflicts and see the "bigger picture", that is the success of the mission.

Crew Size and Compatibility

As the size of the crew increases, you are adding social interaction and stimulation buffers to the crew since there are more people to interact with. You are also allowing a larger number of intra-crew groups to form. If there are more people in the group, there is more social variety and more societal roles which can be filled.

One problem you create however is that as the size of the group increases, you increase the chances of factions forming. There is a numerical way of estimating this and it is expressed in the following equation:

$$\frac{n^2 - n}{2}$$

Equation 1 Number of Possible Cliques within a Crew (Connors, Harrison, & Akins, 1985)

In this equation, n represents the number of crew members, so as n increases, so do the possible number of cliques that can form. This relationship does not mean to imply that the cliques *will* form, but rather how many of them can possibly form. If the number of cliques that do form is small, there will not be a lot of mixing between the groups, as was seen in the Biosphere 2 project. Crews are more productive where there are more people, as evidenced by the productivity measurements of those stationed on military bases in more heavily populated areas versus their counterparts who are stationed in less densely populated areas. Those stationed on bases in more remote locations with less people to interact with were less compatible during periods of confinement and isolation (Connors, Harrison, & Akins, 1985).

Cultural Differences

As a crew's heterogeneity increases, so does the chance of introducing cultural differences. While the differences themselves are not a problem, potential prejudices arising from these differences could prove to be a problem. Cultural differences could serve a role in adding diversity and social stimulation, but underlying prejudices among the crew members could cause tensions. These prejudices may stem from "an assumption that people from other ethnic groups maintain attitudes [that differ] from one's own" and can cause crew members to misinterpret the intentions of their crewmates (Connors, Harrison, & Akins, 1985). There are cultural differences that give words different meanings as well as different ways of communicating that also contribute to these misinterpretations (Lichtenberg, 1997). These misinterpretations sometimes appear in the journals of ISS astronauts when the astronauts comment on how their crew mates from other countries follow protocols differently or perform procedures in different ways from their own (Stuster, 2010).

Other prejudices may stem from the assumption that the crew mates from other cultures are of a lower social status. It should be reinforced during training that all astronauts on the mission are just as qualified as themselves. This training could help mitigate this type of prejudice (Connors, Harrison, & Akins, 1985).

Since the crews will be interacting during training, there will be time for the crew to become familiar with each other's cultures, at least partially. With enough training and interaction prior to the mission, there should not be any cultural surprises once the crew begins the mission. Familiarity with each other's cultures would increase as the training duration increases (Connors, Harrison, & Akins, 1985).

The training should assist crew members understand each other's cultures and languages, to reduce the language barriers between each crew member. The training should include training on such topics as cultural taboos, traditions, dietary preferences, preferred leisure activities, mannerisms, and as many other aspects of culture as time allows. It is also important that the training be tailored to the crew specifically, because not all cross-cultural training is effective in every training situation (Hysong, Galarza, & Holland, 2007).

In summary, it will be crucial to study all of the factors which can lead to problems based on cultural differences and institute as much training as possible (Santy, 1997).

Personal attractiveness

One thing that could interfere with group cohesion is how attractive the crew members view each other. While it appears to be a shallow concern, it is nevertheless a valid concern. Very few individuals would want to be confined with another person who we deem to be overly annoying or distasteful. On the opposite of this, no one would want to be confined with someone who finds many of our own attributes aversive. We would not want to be with someone overly judgmental or finicky since they have the potential to make the experience unpleasant (Connors, Harrison, & Akins, 1985).

Other Miscellaneous Crew Composition Factors

There are a few other factors that can affect the composition, and thus the intra-group dynamic. One of these factors is the emotional stability of the crew members. It could prove difficult to journey on a long duration planetary mission with a crew mate who is overly emotional or emotionally unstable, in general (Connors, Harrison, & Akins, 1985). With the various stresses the crew will encounter on the mission, emotional instability could prove to be an annoyance, for example if one of the crew members becomes overly anxious or overtly sad or joyous. Some of the ways to test for this in crew candidates is by looking for such traits as "stability, self-control, self-confidence, and freedom from mental disorder" (Hysong, Galarza, & Holland, 2007). These are not necessarily traits that you can train an individual to have, so using selection techniques for this particular aspect would be required.

One item which must be considered is whether to have veteran astronauts or astronauts who have never flown. It has been documented that the first time a person goes in to space; it is a highly emotional experience. Also, the effects of SMS are generally much worse, and veteran astronauts comment regularly that their symptoms on their second and subsequent flights were diminished compared with their first flight. As Lichtenberg states, "even though it had been almost 9 years between my two spaceflights, my seemed to have a much easier time of adapting both to the 0 g environment and to return to Earth" (Lichtenberg, 1997). However, with veteran astronauts, you must monitor their career radiation accumulation more closely.

The perceived competence of the crew members amongst each other is important (Connors, Harrison, & Akins, 1985). If the other crew members perceive one of the crew to be incompetent, they could form an opinion that the "incompetent" crew member is incapable of handling certain emergencies, which could result in putting the entire crew in jeopardy. It is important that the crew views each member as being competent and able to complete the mission at hand.

Each member of the crew must be cooperative, that is to say that they must be willing to let go of their own ego and cooperate for the better good of the crew (Connors, Harrison, & Akins, 1985). A crew member who does not cooperate or who is overly defensive could prove detrimental to the crew dynamic, as the others might begin to resent or even dislike the uncooperative crew member. In all aspects, a crew member must be willing to put the entire mission and the lives of their crew mates above their own pride and ego.

One other characteristic that would be beneficial to consider regarding crew composition is that the people in the crew should be socially versatile (Connors, Harrison, & Akins, 1985). Since there will be a loss of social roles due to the nature of this micro-society, it will be immensely valuable to select and train crew members who can adapt and fill in roles not naturally included in the crew. For example, the crew members should be able to adapt to the different personalities on board and support each other. This is referred to as androgyny. Androgynous people are stereotypically viewed as being more self-confident and able to develop many meaningful relationships often with very different types of personalities (Connors, Harrison, & Akins, 1985). An androgynous person would be an asset to the crew since they can essentially play the roles of several people.

In conclusion, the composition of the crew will be a critical factor to consider during the crew selection and training procedures because it is a proven fact that during times of isolation and confinement, especially in high stress situations when the environment is hostile, social irritability and social tensions increase dramatically since the isolation and confinement interferes with people's ability to get along with each other (Connors, Harrison, & Akins, 1985). Isolation and confinement reduces human's tolerance for one another, so the stronger and more adaptable the crew is, the better they will be able to handle the stresses in the long term.

V. CONFLICTS IN CONFINEMENT

Everything discussed up to this point, including the stresses of living and working in space, the confinement and isolation the crews experience, crew composition, and the selection, training process, can and do contribute to the development of conflicts in space. As crew size and mission duration increase, it is not a question of if conflict will occur, but rather when. The conflicts will certainly occur between crew members and between the crew and the ground crews as it has in the past. This section demonstrates that conflicts occur and illustrates the natures of those conflicts.

As discussed, the environment of working in a spacecraft can contribute to conflicts. Space stations are noisy environments since fans must be used to circulate air. Also, the ISS is almost as large as a football field, which means there may be great distances between crew members if they are not working directly next to each other on a project. So the noise and distances between the crew members can interfere with communication, which can add to misunderstandings and misinterpretations of what is being said (Santy, 1997). With an international crew in which language barriers exist, the chances for misunderstandings will also increase.

Conflict Examples from ISS Astronaut Journals

The International Space Station (ISS) has served as a platform for allowing humans to continually stay in space for longer durations than was previously possible.

Since November 2, 2000, the ISS has been continually occupied by humans, with most expedition astronauts remaining on the station for an average of six months (Kauderer, 2012). During those six months, astronauts experience health issues, operational stresses, and swings in their motivation levels. To live and work under a tight schedule with the same people for six months without being able to get away from those people or take a walk brings stresses on the crew they might not have anticipated. In these confined and isolated situations, humans can be irritated by the smallest of annoyances which in a normal situation would not bother them in the slightest. The table on the following page lists several examples in which the behaviors of others bring about conflicts and feelings of contempt for their crewmates.

Table 3 ISS Astronaut Journal Entries (Stuster, 2010)

Journal Entries
"X rubbed me the wrong way again. In general, he sounds patronizing and condescending on the radio, and always must have the last word. When I ask a question, he has a tendency to talk down to me as if I don't know what I am doing."
"Interesting, how you can be on top of the world one moment (literally) and then be completely demoralized the next, because of what is said on the ground."
"W carries on his twice-daily arguments with his mission control center as usual, but I've learned that what appears to an American to be a dispute is actually just their normal mode of conversation. To me, it's interesting to hear the difference in the US and Russian interactions."
"I was really surprised this morning to find that X had completely failed to perform a task yesterday, one required in order for me to perform a task this morning. I was quite angry and later apologized and accepted responsibility for not "monitoring" more closely. I'm still disappointed that X never took responsibility for the mistake."
"Had a 5 minute break. Went to grab some coffee. Y has now decided not to have the water heater on continuously, so had no hot water. Again amazed by how inconsiderate Y is."
"We did have a run-in one night. I was really livid after Z snapped at me quite viciously about something that wasn't my fault. I let Z have it, like I can't remember ever before in a professional relationship, and stormed off."
"We moved some racks together today, in the morning and throughout that entire process U was barking at me constantly."
"I'm finding myself losing tolerance for T. I can't explain exactly what it is that bothers me."
"I feel like I am complaining in these journals, and maybe that is what they are for. But regardless, I am lucky I have this opportunity and it will be gone before I know it, so I am enjoying it to the maximum I can - even with the ________ I have to stay here with."

The previous journal entries describe feelings of resentment and conflicts in which astronauts become involved in what their crewmates do and how they behave. This is not a phenomenon restricted to just astronauts, but has also been seen in the journals of cosmonauts, sea farers and undoubtedly is sure to appear in the journals of anyone who lives and works in confined situations, such as submarines.

Here are two such examples from the journal entries of Valentin Lebedev, who spent 211 days on the Salyut 7 space station from May 13 to December 10 in 1982. He and Anatoli Berezovoy spent the time together in the space station and were visited by others during their stay (Lebedev, 1988). There were a few instances however where the two had minor conflicts involving being occupied with what each other was doing.

Table 4 Lebedev Journal Entries (Lebedev, 1988)

Journal Entries
"Today Tolia complained to me: 'Valentin, how long will I have to keep catching your stuff?' (The sextant, still camera, and movie camera are my stuff.) 'Tolia,' I told him, 'if we start counting what's yours and what's mine just one week after the beginning of our mission, it won't be any good.' I could see that he was irritated."
"We feel we are under constant observation by our guests. This interrupts our regular lifestyle somewhat."

As shown by the nature of these journals, conflicts can arise regardless of our genders, cultures, or language. This would indicate that these conflicts will continue to occur unless new training methods are introduced, which is what this paper presents.

VI. CODEPENDENCY

After reading through the journals of astronauts, cosmonauts and others who live and work in confined and isolated environments, one might notice a trend that some of the conflicts arise because the crews are focused heavily on what the others are doing and how they are behaving. This sounds similar to something called codependency.

Clinical definition

There are many varied definitions of codependency, but this paper will use the definition offered by Fuller and Warner (2000) as it does not depend on clinical psychology terminology: “a dysfunctional pattern of relating to others with an extreme focus outside of oneself, lack of expression of feelings, and personal meaning derived from relationships with others” (Fuller & Warner, 2000). The portion of this definition which is most important is the phrase “relating to others with an extreme focus outside of oneself”. This thesis does not intend to imply that all astronauts exhibit codependency, but rather when we become focused on others acts, we can sometimes lose sight of our own acts and behaviors. The discrepancy comes when we try to control other’s actions because this is when conflicts can arise. If we are preoccupied with how someone else is following scientific protocol, unless we are supervising them, we might begin to scrutinize and become aggravated at how they are accomplishing their tasks.

For those struggling with codependency, it is often a coping mechanism. It is easier for the person to focus on another's actions and behaviors than to deal with pains or issues they do not want to process. An example of this is a codependent who is in a relationship with a drug abuser. It might be easier for the person with codependent tendencies to focus on trying to keep the person from going on a drug binge than it is for that person to deal with the pain of watching a loved one throw away their life.

Rehabilitation techniques

There are a multitude of rehabilitation techniques for unlearning codependent tendencies. One of these therapies is cognitive behavioral therapy. The person who is struggling with codependency can visit with a clinical psychologist and learn methods to re-focus their attention on to themselves and realize that they deserve to be taken care of as well (Fuller & Warner, 2000).

One such technique is through working with a diagram that shows a street with a sidewalk on both sides. There are a series of questions and statements which "cross the road" and help the person to realize that when they are on the other person's side of the street, they are not on their own side and are neglecting themselves. This technique helps the person to "stay on their side of the street" and not worry about what is happening on the other side since they are not in control of it anyways.

The following sheet is a demonstration of this concept and was developed by Jim Murphy, a licensed counselor (J. Murphy (personal communication, September, 2012)).

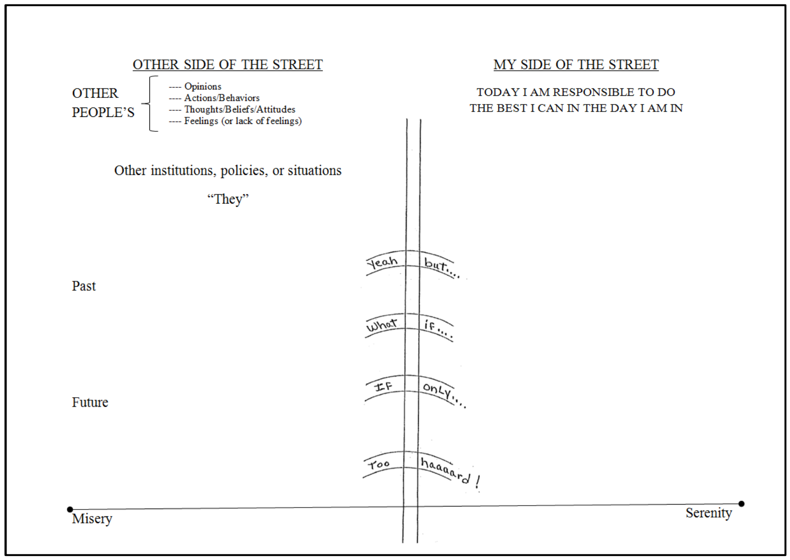


Figure 9 Jim Murphy's Sheet for Codependency

There are a multitude of support groups for those coping with rehabilitating themselves away from codependent predispositions. One of these groups is Codependents Anonymous (CoA) who uses the same twelve step program as Alcoholics Anonymous (AA) but has adapted them to make them relevant for those with codependency, rather than alcohol abuse (Fuller & Warner, 2000). The twelve steps are a program the person works with the rest of their lives to stay clear of those inclinations to take care of others concerns rather than their own.

Finally, the most recognized author who writes books about codependency is Melody Beattie. She is a recovering codependent and has written books such as Codependents' Guide to the Twelve Steps and Codependent No More. She offers a personal account of her own journey and offers workshops and workbooks to help codependents work through the programs on their own.

How does Codependency relate to the conflicts described?

While those engaged in spaceflight are not directly exhibiting codependent behavior, it is still possible for them to become fixated on the behaviors of others which can lead to conflict. When living and working together with people in a confined and isolated environment becomes a tedious task, it may become easier to nit-pick the actions of others than to deal with the pains the person is going through due to the stresses of spaceflight. The rehabilitation techniques that codependency rehabilitation offers could potentially help the astronauts deal with these issues and not engender conflicts for such petty items as not leaving the water heater on or becoming aggravated at where a person stores their camera.

VII. STATEMENT OF HYPOTHESIS

Taking into consideration the selection and training processes that have been used in the past, we have seen that there are still conflicts in space. Space is a hostile environment in which death can occur in mere seconds and this fact, along with the confinement and isolation experienced by crews can contribute to the friction that the crews feel towards one another. When the crews experience the pressure of spaceflight, it is easy to see why they can become annoyed with one another, to the point at which conflicts occur. So this brings up the question: if crews are confronted with the possibility of getting on each other's nerves, why not train the crew to re-focus their attention back on themselves in an attempt to mitigate these types of conflicts?

An analysis of the conflicts that have occurred in space and confined environments reveals that conflicts often result from crew members being absorbed in the actions and behaviors of their crew mates. This thesis seeks to prove that future pre-confinement training should include certain aspects of clinical rehabilitation techniques for codependency in order to reduce the occurrence of conflicts in confined environments. These techniques help re-focus one's attention on to their own thoughts, feelings, and behaviors so that the mind is occupied with actions and behaviors that can be controlled, rather than the actions and behaviors of others which cannot be controlled.

VIII. METHODOLOGY

Appropriateness of the Research Design

Since selecting a crew and having them embark on a long duration mission to the Moon, an asteroid, or Mars was not possible, this thesis seeks to prove the hypothesis using survey data collected from individuals who have spent time in confinement. The subject of my hypothesis was brought about by reading the journals of ISS astronauts, and so to test the theory, a survey was the best fit for collecting data about whether the theory was valid.

Research Design

The research for proving the hypothesis was designed around using an online anonymous survey of individuals who had spent time in confinement. The survey questions were written collaboratively by my thesis advisor, Dr. Rygalov and me. The questions were written to gather information about the subject's experiences in confinement, including questions about any conflicts encountered. The survey sought to ask about the nature of those conflicts and if the subjects thought the conflicts were related to crew members being fixated on how the other crewmembers were behaving. The questions also asked the subjects basic profile information, such as what age range they fit in and how much time they spent in confinement.

After the questions were solidified, the survey was created online on the University of North Dakota's Qualtrics website (https://und.qualtrics.com). Qualtrics was selected because of the analytical tools and ease of use, as well as ease of access to UND students.

The survey was set up so that all responses were anonymous, even to me.

Ethical Considerations and the IRB process

In order to conduct the survey, the "University of North Dakota Except Certification Form" was filled out and submitted, along with the appropriate materials, to the UND Institutional Review Board. The Human Subject Education course was completed successfully.

Since the survey asked questions regarding conflict during the subject's experiences in confinement, the email sent to the subject who had already agreed to take the survey, cautioned the subject that there might be some discomfort in dealing with those memories. The email also stressed that participation was voluntary and that not all questions must be answered. As stated in the previous section, the survey was set up so that I could not distinguish who gave a particular response. The survey participants were made aware of this fact.

The following is an image of the email template used to send subjects the information to take the survey once they had agreed to take the survey. This template was submitted to the IRB as part of the materials to receive IRB approval.

Email Template to be sent to participants once they have agreed via email/phone to take the survey

Mr./Ms. _________________,

As we discussed via email/telephone, I am conducting research by asking my colleagues who have had experience in living or working in confined and/or isolated situations. This research will contribute to the originality of my proposed ideas included in my thesis entitled "Crew Selection and Training Requirements for Long Duration Manned Planetary Missions", which I will be defending March 25 of this year.

To complete the survey, please use the link below and select the answers which best fit your response to the question being asked, or if the question requests a written answer, type your answer in the space provided. The survey will most likely take 10-15 minutes of your time to complete. A few of the questions ask about experiences involving conflict, which might facilitate memories of unpleasant experiences. If you do not feel comfortable answering these questions, you can skip past them.

Please keep the following pieces of information in mind:

- Your participation is completely voluntary.
- If at any time, you do not wish to continue, close your browser window. Incomplete surveys will be discarded when the survey closes.
- If there are questions you are not comfortable answering, skip them. Answers to questions are not required.
- Your answers are completely anonymous, even to me. There are no questions where you must identify yourself.
- In the answers in which you are requested to write a response, please do not use any identifying data about yourself or others, including names, ages, location, etc.

If at any time you have questions about this research or the survey, please contact me on my cell phone (832) 287-1031 or by email at adastra225@gmail.com.

Link to the survey: https://und.qualtrics.com/SE/?SID=SV_cBJGMeApMJucYYJ

Survey password: **confinement**

Best regards,

Annie Wargetz

Figure 10 Email Template for Survey Subjects

IRB approval was granted and survey subjects were contacted to take the survey.

Setting and Participants

The survey participants were contacted directly either through email or by phone to request that they take the survey. Once a participant agreed to take the survey, they were sent the text from Figure 10 Email Template for Survey Subjects. The surveys were completed by following the link in the email and entering the password to the survey.

The survey participants were personal contacts who were selected by my thesis advisor, Dr. Rygalov, and me. The subjects were selected for having experience in living and/or working in confined environments. Participants work in a variety of industries all across the United States and Russia. The only requirement of the subjects is that they had spent time in confinement.

Based on the results of the survey, the following is a summary of the participants:

Table 5 Summary of Survey Participants

Percentage of Participants	Characteristic
78%	Male
22%	Female
56%	Married/Partnered with children
44%	Married/Partnered without children
44%	Identified themselves as "very close to family"
56%	Identified themselves as "close to family"
56%	Identified themselves as "not religious at all"
33%	Identified themselves as "somewhat religious"
11%	Identified themselves as "religious"
56%	Currently hold "supervisory" roles at current job
11%	Currently hold "managerial" roles at current job
11%	Currently hold "executive" roles at current job
22%	None of the authority roles listed fit description of current occupation
33%	Lived/worked in confined environment for less than 1 month
33%	Lived/worked in confined environment for between 1 and 6 months
33%	Lived/worked in confined environment for between 6 months and 1 year

Of all the participants who responded, 44% had served as commanders of a mission in a confined environment.

Instrumentation

To conduct the survey, I used the UND Qualtrics website. Qualtrics identifies itself as an "online survey platform" with the ability to conduct "sophisticated" research (Qualtrics, 2013). The website offers a way to design and input your survey allowing various types of responses. Please refer to

APPENDIX A

SURVEY QUESTIONS to review screen shots of the survey to which participants responded.

The website also offers multiple reporting capabilities and provides the basic statistical data, such as mean and standard deviation, when you request to view your results.

Procedure

The procedure used to collect the survey data began with question formulation, which was a collaborative effort conducted by my thesis advisor and me. The questions were selected with collecting information about stressors in confined environments. Once we had the questions completely revised and were satisfied with their format and the mixture of questions, I entered the questions into the Qualtrics website.

The next step in the process was to gain IRB approval and complete the human subject education. Once this was granted, Dr. Rygalov and I began contacting the possible survey subjects. Answers began to accumulate almost immediately.

Three weeks prior to my thesis's first draft due date, I collected the data from the Qualtrics website and ran two reports to see the results.

Data Processing and Analysis

Data analysis was conducted by reviewing the reports generated by the Qualtrics website. The questions of main interest to my hypothesis were questions 16 and 17, so the responses to these two questions were reviewed first. I then extracted data from the questions dealing directly with the stressors experienced in confined situations to compile a list of the top five stressors the subjects had experienced, based on number of respondents who selected them as stressors and their perceived impact on mission success.

Summary

In summary, the survey design and execution process was conducted collaboratively between Dr. Rygalov and me. The Qualtrics website was used to conduct the reporting process during data analysis, with very few uses of Excel required. The graphs and charts referenced in the RESULTS AND DISCUSSION section come directly from the Qualtrics reports.

IX. RESULTS AND DISCUSSION

As discussed in the Methodology section, the survey participants were asked a series of questions about their experiences in confinement. This research is focused on the concept that conflicts in confinement stem from the behavior that crew members focus too heavily on the actions and behaviors of others and that pre-mission training to re-focus attention back onto ourselves would help to mitigate such conflicts. The results of the survey will now be presented in the following paragraphs.

Survey participants were asked the question "Many conflicts documented in confined environments appear to originate from crew members being fixated on what their crew mates are doing or how they are behaving. (Example: crew mate not collecting data correctly, not following protocol, breathing/eating too loudly) Would you characterize the conflicts you have witnessed in confinement to be related to this fixation?" The following chart shows the distribution of responses to this question.

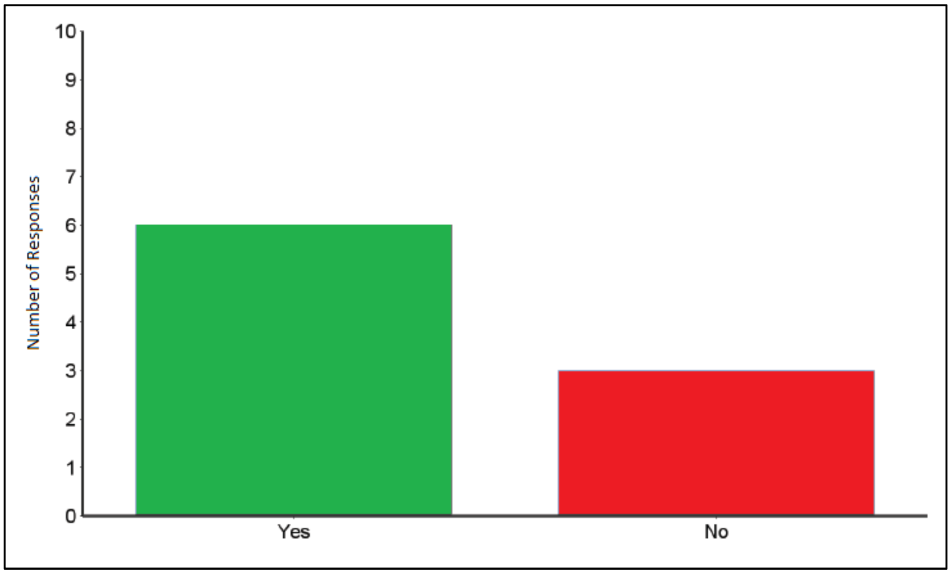


Figure 11 Results from Question 16 of the Survey

With 67% of the survey participants indicating that the conflicts experienced during their time in confinement were related to crew members being focused on other's behaviors and actions, it can be concluded that the survey participant's responses support the concept that the conflicts stem from this problem.

The next question on the survey asked participants to rank the effectiveness of pre-mission training to help those in confinement re-focus their attention: "How effective do you think pre-confinement training would be that teaches crew mates how to re-focus their attention back on their own actions rather than focusing on the actions/behaviors of others? Please rate how effective you think this training would be on a scale of 1 to 10, where 1 means 'ineffective' and 10 means 'extensively effective'." The following chart displays the results from this question.

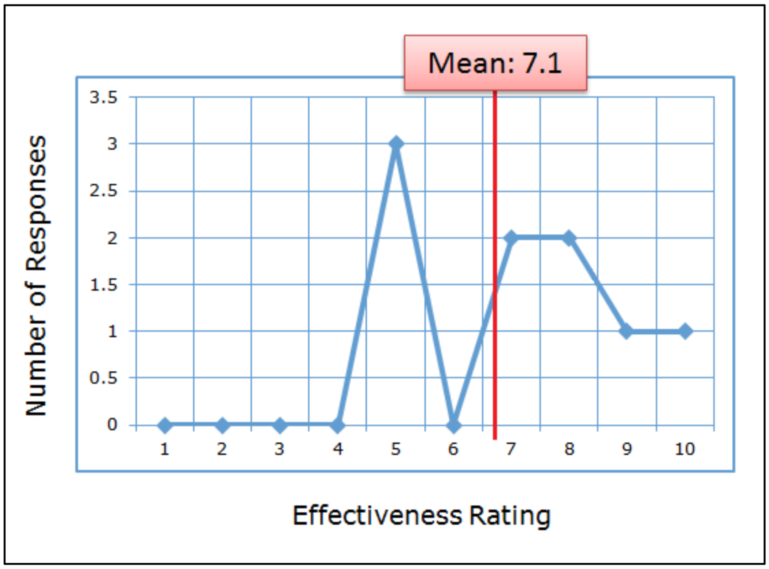


Figure 12 Results from Question 17 of the Survey

As seen from the results, 66% of the survey participants agree with the hypothesis that pre-mission training to re-focus crew member attention on their own actions and behaviors would be effective since it received an average effectiveness rating of 7.1. The average score for the effectiveness demonstrates that the survey participants feel the training would be very effective in mitigating these kinds of conflicts.

Based on this survey of people who spent time in confinement, it would be effective to train crews on how to retain focus on their own actions and behaviors rather than what their crew mates are doing and how they are behaving. While the study was limited to a small population, these findings are still significant since the average score received on the rating of effectiveness was so high. None of the other questions whose responses required a scale rating received as high an average as this particular question, indicating that the participants felt strongly about this particular response.

Since no other studies have been conducted on this particular aspect of conflicts in confinement, that the author could find, it would be crucial to continue this research with larger populations of individuals with experience living and working in confinement. In order to improve this research, it would be essential to ask astronauts who have spent six months or more in space these questions before making this particular method of training a permanent aspect of astronaut training. It would also prove interesting to ask submariners who have spent six months submerged and scientists who have wintered over in Antarctica.

What is significant is the fact that those who did take the survey recognized that concentrating on others was having a negative impact on them. To mitigate this negativity, it would be prudent to employ not only new training techniques but also new selection techniques. There are a number of assessments used which can measure a person's codependent characteristics. Entire assessments or portions of them could be used to indicate a person's codependent index which could then be compared to a pre-established threshold. If the person's measurement is above the threshold, they could then be "selected out" of the candidate pool.

Additional Results

The survey participants were asked how effective their own pre-mission training was on the same scale of 1 to 10 and the mean for that question was 5.6. This is significantly lower than the score the participants gave for the effectiveness of the re-focusing training. When asked to name the most effective part of their pre-mission training, 50% of the responses mentioned some aspect of working with their future crew mates to learn who they are and how to understand each other prior to the confinement. The next question asked the survey participants to name the least effective aspect of their pre-confinement training and 50% stated that they did not have enough time before the mission to get to know their crew mates and work out any personal issues prior to starting the mission. The survey participants offered their advice for improving pre-mission training and all but one of the responses included either selecting people based on their personalities or spending more time together pre-mission to learn to work as a team.

The results from these four questions support the proposed concept that pre-mission training should include time to get to know each other and learn each other's personalities before the mission begins. This aspect of pre-mission training would also help each crew member to learn about the dispositions of their crew mates so that they can better understand what potential incompatibilities might arise during the mission and, if possible, work those out prior to the mission.

One characteristic of the survey participant population that needs to be kept in mind, that was mentioned earlier, is that despite the similarity in some of the responses, the durations of their confinement missions varied equally among the participants. That is to say that the population was divided into thirds on how long they had spent in confinement:

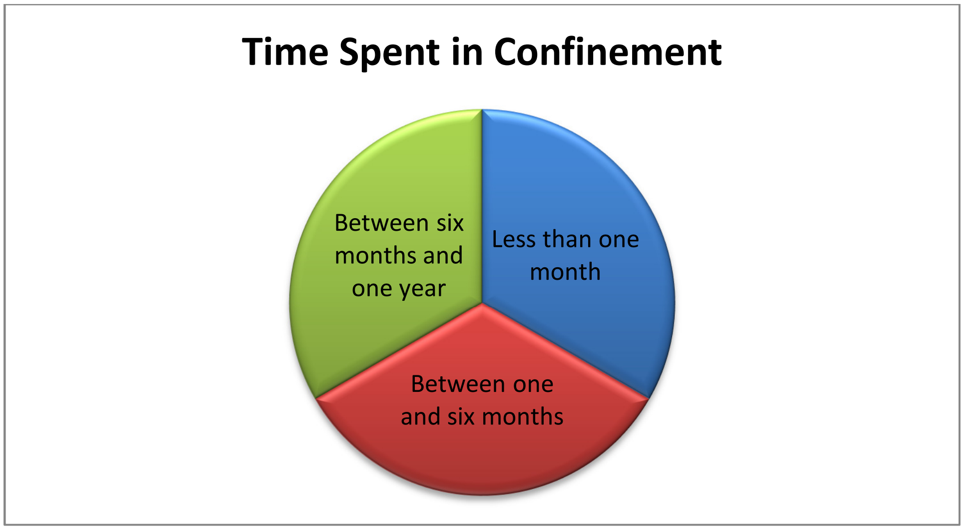


Figure 13 Time Spent in Confinement by Survey Participants

This is an interesting characteristic of the survey population given that a majority of their responses, especially to the questions in which they wrote a response in their own words, sounded very similar and used similar wording.

To describe the experiences and feelings about conflicts that the survey participants experienced, the questions which asked about stressors and conflicts are listed in the table on the next page, along with the top five responses for each.

Table 6 Additional Survey Results Regarding Conflict

Question	Top Five Responses (number of responses in parenthesis)
There have been a number of items identified as possible stressors that arise in confined situations. Please state how often you have been stressed by these possible stressors in confined situations.	1. Workload (10) 2. Isolation from friends and family (9) 3. Sleep disturbances (8) 4. Changes in motivation (7) **4. Personal conflicts (7)**
Please tell me about the frequency of your experiences with the following types of personal conflicts during your time in confined situations.	**1. Personal conflicts within crew due to professional differences (7)** **1. Personal conflicts within crew due to rank/status (7)** **3. Personality conflicts (6)** **4. Personal conflicts within crew due to difficulties with "rookies" (5)** **4. Personal conflicts within crew due to difficulties with "veterans" (5)**
Which of the following stressors affected you most during your experience with confinement?	1. Unable to communicate with friends and family (3) **2. Personal Conflicts (2)** 3. Changes in motivation (1) 3. Fear of danger (1) 3. Workload (1) 3. Sleep disturbances (1)
Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following stressors on the success of a mission taking place in confinement.	**1. Personal conflicts (mean: 5.89)** 2. Workload (mean: 5.33) 3. Unable to communicate with friends and family (mean: 5.00) 4. Changes in motivation (mean: 4.78) 4. Sleep disturbances (mean: 4.78)
Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following personal conflict stressors on the success of a mission taking place in confinement.	**1. Personality conflicts (mean: 5.89)** **2. Personal conflicts due to rank/status (mean: 5.00)** **3. Personal conflicts within crew due to difficulties with "veterans" (mean: 4.33)** **4. Personal conflicts with authority figures (mean: 4.22)** **4. Personal conflicts within crew due to difficulties with "rookies" (mean: 4.22)**

As seen with these results, personal conflicts were in the top five stressors that occur in confinement and were listed as the number two most frequently experienced stressor for the survey participants. This demonstrates that conflict is a major portion of the stressors that are experienced in confinement, in the opinion of the survey participants.

The most significant finding is that the mean score for personal conflicts was 5.89 on a scale of 1 to 10, placing it at the top of the list of stressors ranked by which could cause mission failure. While the correlation of this average is not high enough to indicate the survey participants strongly believe personal conflict could end a mission, it is significant that the mean was above 5 and that it received the highest average. This fact supports the concept that implementing pre-mission training to end conflicts would be a wise investment of the crew's time before a mission.

Finally, the survey participants were asked to rate how close they are to their families and all participants selected either "close to family" (56% selected) or "very close to family" (44% selected). It would be interesting to have asked what the answer to this question was before they had spent any time in confinement to see if their confinement experiences drew them closer to their families.

Recommendations for the Inflatable Lunar Habitat crew

As a part of the Department of Space Studies at UND, the Human Spaceflight Laboratory (HSL) is currently developing and constructing an analog planetary base, complete with an Inflatable Lunar Habitat (ILH) for habitation and scientific experimentation, a Pressurized Electric Rover (PER) crews can use to drive to sites for conducting EVAs, and two NDX-2AT space suits connected to the PER via a suit port for conducting EVAs during which rocks and soils are collected.

Based on the responses of the survey participants, the following items are recommended for the crew who is to inhabit the Inflatable Lunar Habitat (ILH) once it is deployed on an analog mission.

The first recommendation for the crew is pre-mission training on how to retain focus on what their own actions and behaviors are, utilizing either of the rehabilitation techniques discussed earlier in this thesis. This serves as a potential conflict mitigation technique since the members of the crew will be contained in such a small volume for up to a month. It is also recommended that the pre-mission training include team building activities, such as team problem solving activities which can be creative in nature. An example would be an egg drop contest where an egg is dropped from a certain height and the team must construct a vessel to protect the egg so it does not break on impact with the ground.

The crew of the ILH should also undergo pre-mission training in which they review and are tested on team decision making processes. If there will be a chain of command during the mission on board the ILH, then the chain of command should be established prior to this activity so that decision making processes will closely mimic what will be experienced on board. Out of the five responses received on this question in the survey, all five responses indicated discrepancies in how decisions were made, proving this is a crucial problem for which boundaries should be set and training implemented prior to the mission.

It is recommended that the crew spend time together and isolated prior to the mission in the ILH, so that the crew can figure out for itself what intra-crew dynamics exist and to experience each other's personalities. An example of this type of activity would be to send the crew on a one-day hike or road trip where they are isolated and together, and must rely on each other. The crew could be expected to navigate using only maps and a compass, as might be expected during the ILH mission EVAs. It is recommended, if pre-mission training time allows, that these types of meetings occur more than just once, as one survey participant explained "one meeting was helpful, but not enough".

Finally, two survey participants recommended using selection techniques which screen for personalities that might work well together. It is not known at this time whether this will be possible for the ILH crew selection process, but if possible, it should be implemented. NASA uses this also during astronaut selection processes and refers to this as their "select in" process. It would be important to have individuals in the ILH mission who have complementing personalities, promoting cooperation among the crew members.

X. CONCLUSION

This thesis covered astronaut selection and training for short- to mid-duration missions on which we have already traveled and shown that despite our best efforts, conflicts still arise. If we are to send humans beyond LEO or the Earth-Moon region, we must implement new training methodologies, such as training on maintaining focus on our own behaviors utilizing current techniques for overcoming codependency. This research was conducted through a literature review of the stressors experienced in spaceflight, astronaut training methods, codependency rehabilitation, and an interview of individuals with experience in living in confinement. Those surveyed supported this thesis's hypothesis that conflicts occur because we are focused on other's behavior and that pre-mission training on re-directing our focus onto our own behavior would be effective. Current astronaut training agendas do not include significant behavior training and this must change if we are to succeed at long duration missions beyond LEO.

Recommendations for the Inflatable Lunar Habitat crew

The crew selected for the 30 day missions on board the ILH will encounter psychological challenges from living in confinement with people who might be strangers until meeting as a crew for the first time. The selection process will prove crucial in selecting people with the right skills as well as the right demeanor. After crew selection is complete, it will be necessary to train the crew, not only on how to conduct the mission, but also on how to conduct themselves in the confinement of the ILH. It is likely that this will be the first confinement for all of the crew members, so equipping them with the right skills to complete the mission physically and mentally will be a requirement.

During the one month mission, some of the obvious stresses that the crew may encounter include motivation changes, sleep disturbances, time distortion issues, dealing with mechanical failures or adjustments in protocol, compatibility issues, as well as many others. After the crew settles in and finds a rhythm to their day-to-day procedures, keeping them emotionally and mentally balanced will be important. The application of special meals and celebrations can also be used to keep life on board the ILH interesting and fresh while the crew accomplishes the scientific goals of the mission.

Much thought should be given to the crew selection and training aspects of the one month mission.

Future Research Directions

As a result of the limited access to a research population, only those who the author and her advisor could contact directly were invited to take the survey. In the future, it would be prudent to repeat the survey with a larger participant population. It would be interesting to run the survey on specific subjects such as submariners, researchers who have wintered over in Antarctica, and those who have spent significant time on oceanic research vessels without going to port for long periods of time. The survey should also be circulated through a population of astronauts and/or cosmonauts who have served on six month tours on the ISS as part of an expedition crew.

The psychology of long duration spaceflight with highly heterogeneous crews is an under-researched area, and much needs to be learned before we send our first astronauts, cosmonauts, or taîkonauts beyond the Earth-Moon system. If we send them before doing much research, we are placing that mission in jeopardy of failure.

Future Research Directions for the ILH Crews

As mentioned previously, a clear plan of selecting the crew must be developed before crew selection should begin. This should mimic the procedures used by the Shuttle program, incorporating a system of “select out” and “select in” criteria as possible that accommodates the applicant population and that complies with the IRB regulations. Also, a clear strategy to conduct pre-mission training should also be developed which incorporates both mission objectives and self-management skills.

The crew could be surveyed both before the mission and after to ask questions similar to those included in this thesis’s survey, such as how close the participants are to their family. The survey would also pinpoint what the participants saw as the most and least effective aspects of their pre-mission training. The results of such a survey could be used to adjust the trainings and selection criteria for subsequent missions.

APPENDICES

APPENDIX A

SURVEY QUESTIONS

The following pages contain screen shots of the survey that subjects took.

THE UNIVERSITY OF NORTH DAKOTA

There have been a number of items identified as possible stressors that arise in confined situations. Please state how often you have been stressed by these possible stressors in confined situations.

	Extensively Experienced	Experienced	Somewhat Experienced	Not at all Experienced
Changes in motivation				
Feelings of confinement				
Isolation from friends and family				
Transcendental experiences				
Fear of danger				
Workload (too little, too much, etc.)				
Sleep disturbances				
Time sense disturbances				
Personal conflicts (either within the crew and/or between the crew and authority)				
Development of unforeseen psychiatric disorders/deviations (diseases)				

Please tell me about the frequency of your experiences with the following types of personal conflicts during your time in confined situations.

	Extensively Experienced	Experienced	Somewhat Experienced	Not at all Experienced
Personal conflicts with authority figures				
Conflicts within the crew relating to professional differences				
Personality conflicts (example: inability to make a decision)				
Personal conflicts regarding difficulties with "rookies"				
Personal conflicts regarding difficulties with "veterans"				
Personal conflicts regarding difficulties due to rank/status among the crew				
Personal conflicts regarding difficulties with aggression				
Personal conflicts regarding cultural differences				

0% 100%

>>

Figure 14 Questions 1-2 of Survey

THE UNIVERSITY OF NORTH DAKOTA

Which of the following stressors affected you the most during your experience with confinement?

- ○ Changes in motivation
- ○ Feelings of confinement
- ○ Being unable to communicate with friends and family
- ○ Transcendental experiences
- ○ Fear of danger
- ○ Workload (too much, too little, etc.)
- ○ Sleep disturbances
- ○ Time sense disturbances
- ○ Personal conflicts (either within the crew or between the crew and authorities)
- ○ Development of unforeseen psychiatric diseases

If you selected "Personal conflicts" in the previous question, which type of personal conflict affected you the most? If you did *not* select "Personal conflicts", please select "Not applicable".

- ○ Personal conflicts with authority figures
- ○ Conflicts within the crew due to professional differences
- ○ Personality conflicts
- ○ Personal conflicts regarding difficulties with "rookies"
- ○ Personal conflicts regarding difficulties with "veterans"
- ○ Personal conflicts regarding difficulties due to rank/status among the crew
- ○ Personal conflicts regarding difficulties with aggression
- ○ Personal conflicts regarding cultural differences
- ○ Not applicable

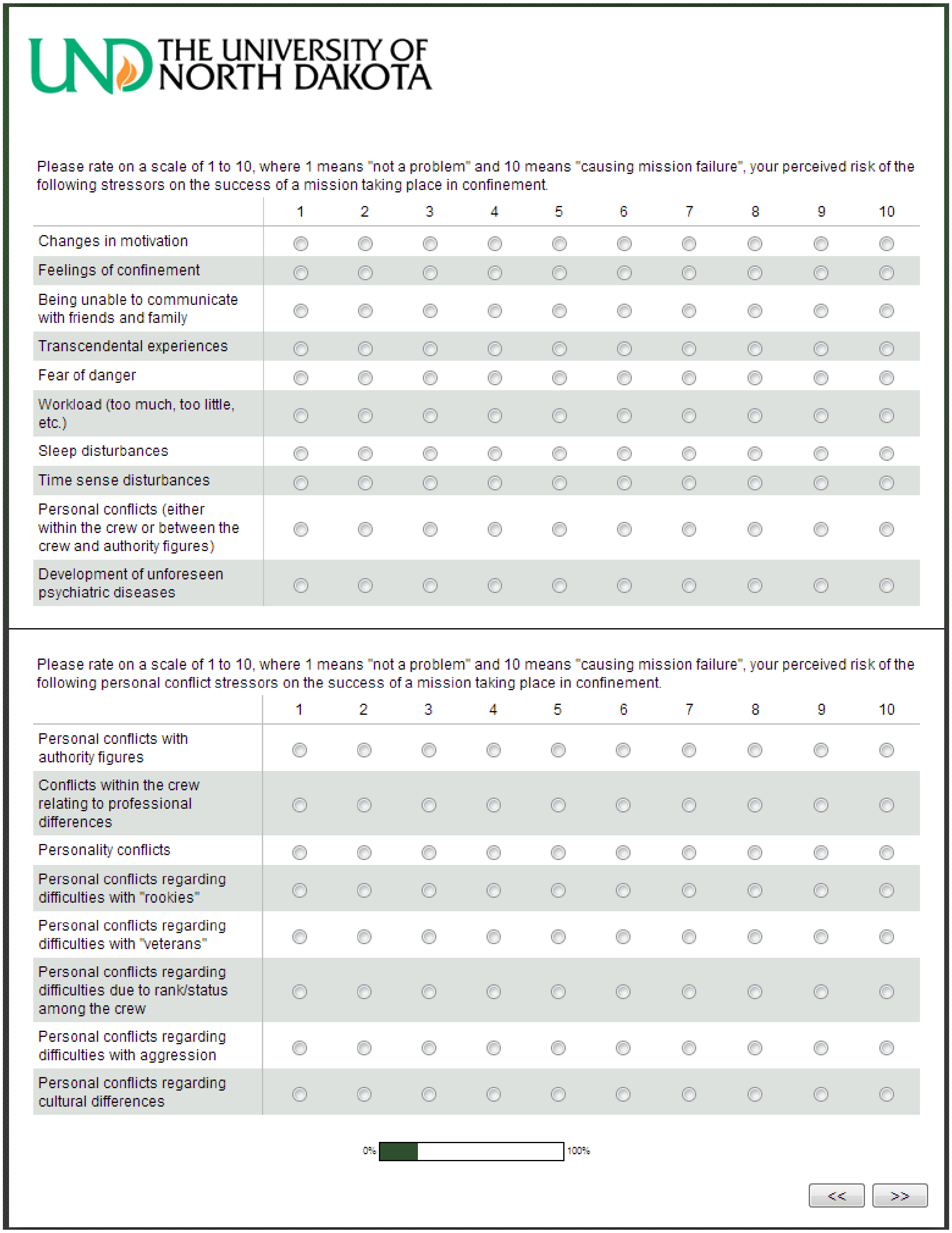
If you have experienced personal conflicts, please explain what was/were the cause(s) of these conflicts.

What steps were taken to reduce the stress or end the conflict? Was this successful in ending the conflict? Why or why not?

0% 100%

<< >>

Figure 15 Questions 3-6 of Survey



THE UNIVERSITY OF NORTH DAKOTA

Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following stressors on the success of a mission taking place in confinement.

	1	2	3	4	5	6	7	8	9	10
Changes in motivation										
Feelings of confinement										
Being unable to communicate with friends and family										
Transcendental experiences										
Fear of danger										
Workload (too much, too little, etc.)										
Sleep disturbances										
Time sense disturbances										
Personal conflicts (either within the crew or between the crew and authority figures)										
Development of unforeseen psychiatric diseases										

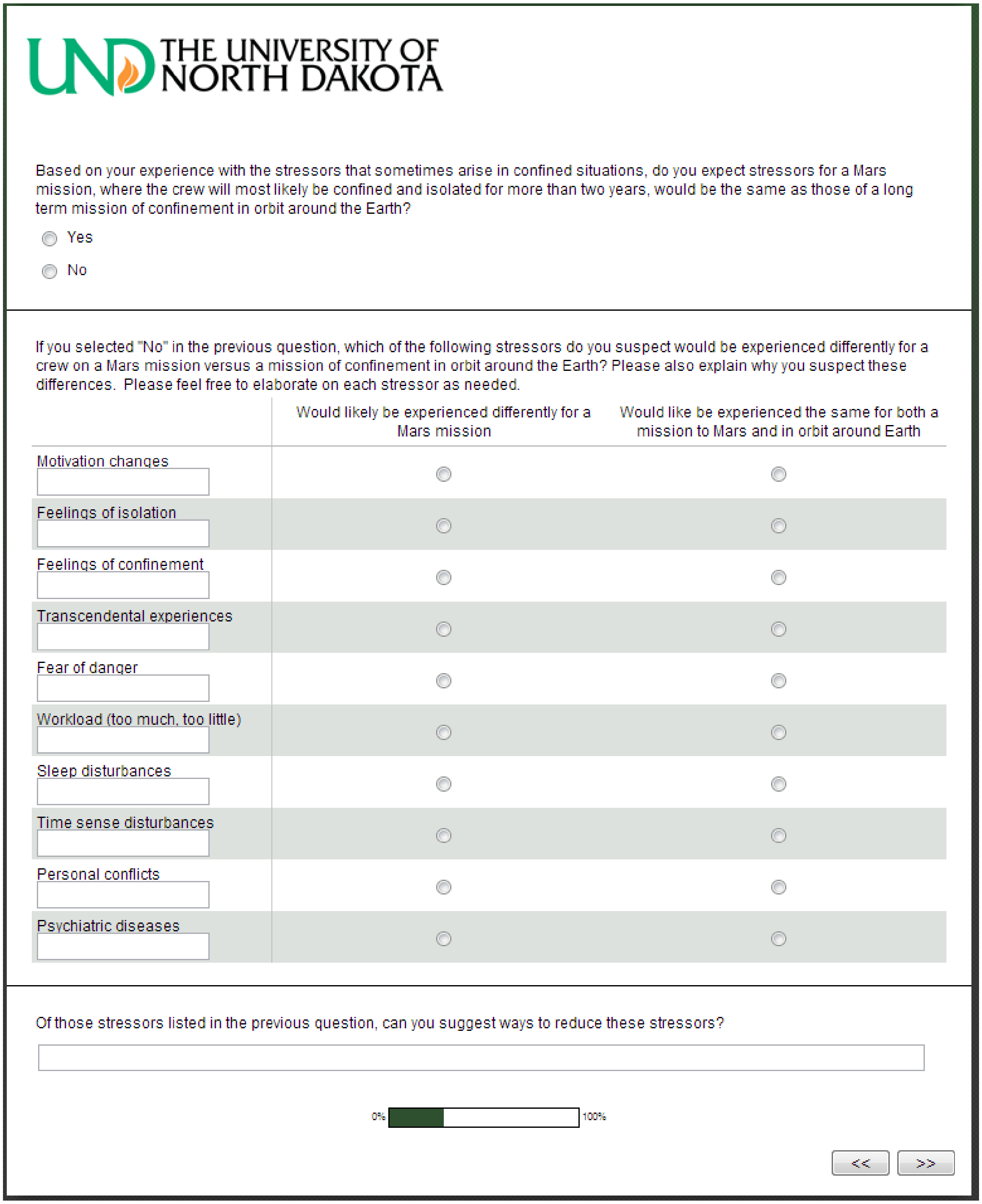
Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following personal conflict stressors on the success of a mission taking place in confinement.

	1	2	3	4	5	6	7	8	9	10
Personal conflicts with authority figures										
Conflicts within the crew relating to professional differences										
Personality conflicts										
Personal conflicts regarding difficulties with "rookies"										
Personal conflicts regarding difficulties with "veterans"										
Personal conflicts regarding difficulties due to rank/status among the crew										
Personal conflicts regarding difficulties with aggression										
Personal conflicts regarding cultural differences										

0% 100%

<< >>

Figure 16 Questions 7-8 of Survey



THE UNIVERSITY OF NORTH DAKOTA

Based on your experience with the stressors that sometimes arise in confined situations, do you expect stressors for a Mars mission, where the crew will most likely be confined and isolated for more than two years, would be the same as those of a long term mission of confinement in orbit around the Earth?

- Yes
- No

If you selected "No" in the previous question, which of the following stressors do you suspect would be experienced differently for a crew on a Mars mission versus a mission of confinement in orbit around the Earth? Please also explain why you suspect these differences. Please feel free to elaborate on each stressor as needed.

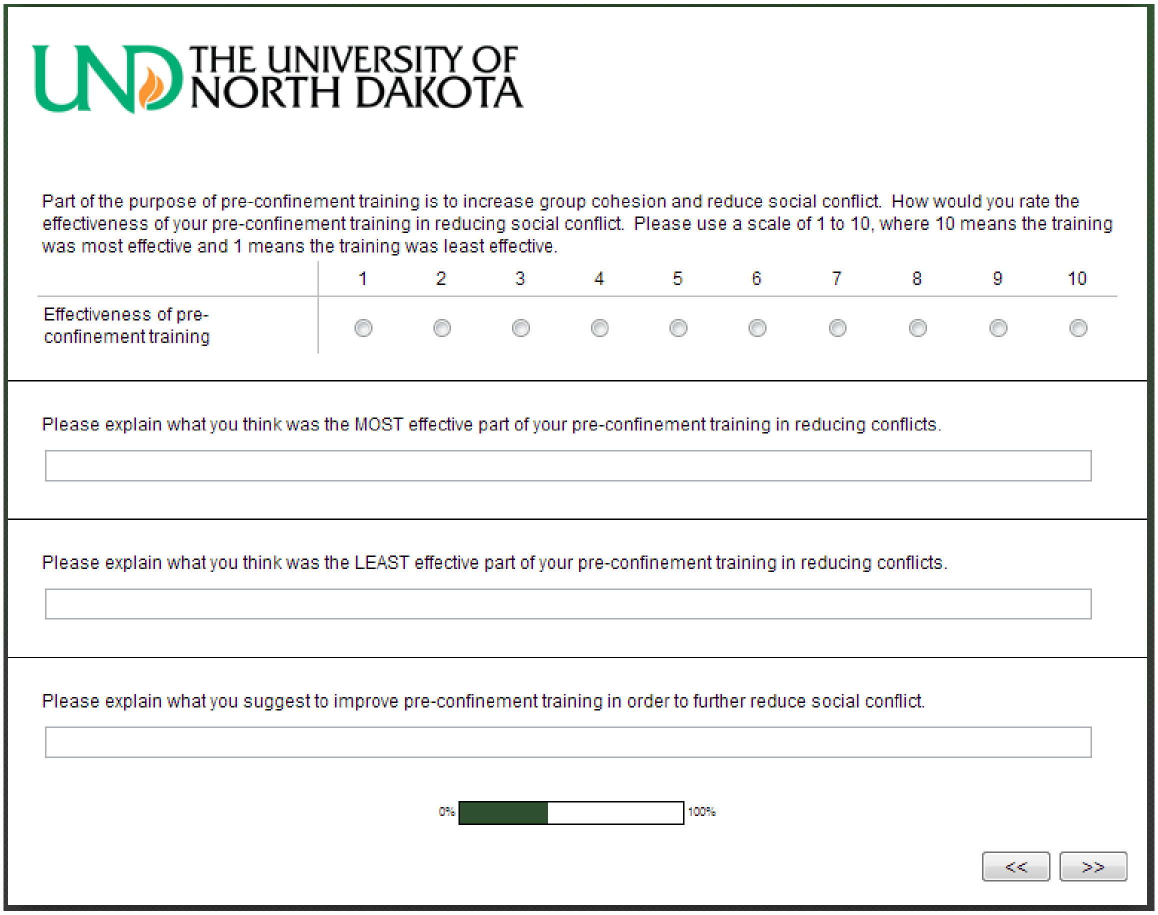
	Would likely be experienced differently for a Mars mission	Would like be experienced the same for both a mission to Mars and in orbit around Earth
Motivation changes	○	○
Feelings of isolation	○	○
Feelings of confinement	○	○
Transcendental experiences	○	○
Fear of danger	○	○
Workload (too much, too little)	○	○
Sleep disturbances	○	○
Time sense disturbances	○	○
Personal conflicts	○	○
Psychiatric diseases	○	○

Of those stressors listed in the previous question, can you suggest ways to reduce these stressors?

0% 100%

<< >>

Figure 17 Questions 9-11 of Survey


THE UNIVERSITY OF NORTH DAKOTA

Part of the purpose of pre-confinement training is to increase group cohesion and reduce social conflict. How would you rate the effectiveness of your pre-confinement training in reducing social conflict. Please use a scale of 1 to 10, where 10 means the training was most effective and 1 means the training was least effective.

	1	2	3	4	5	6	7	8	9	10
Effectiveness of pre-confinement training										

Please explain what you think was the MOST effective part of your pre-confinement training in reducing conflicts.

Please explain what you think was the LEAST effective part of your pre-confinement training in reducing conflicts.

Please explain what you suggest to improve pre-confinement training in order to further reduce social conflict.

0% 100%

<< >>

Figure 18 Questions 12-15 of Survey

THE UNIVERSITY OF NORTH DAKOTA

Many conflicts documented in confined environments appear to originate from crew members being fixated on what their crew mates are doing or how they are behaving. (examples: crew mate not collecting data correctly, not following protocol, breathing/eating too loudly) Would you characterize the conflicts you have witnessed in confinement to be related to this fixation?

- Yes
- No

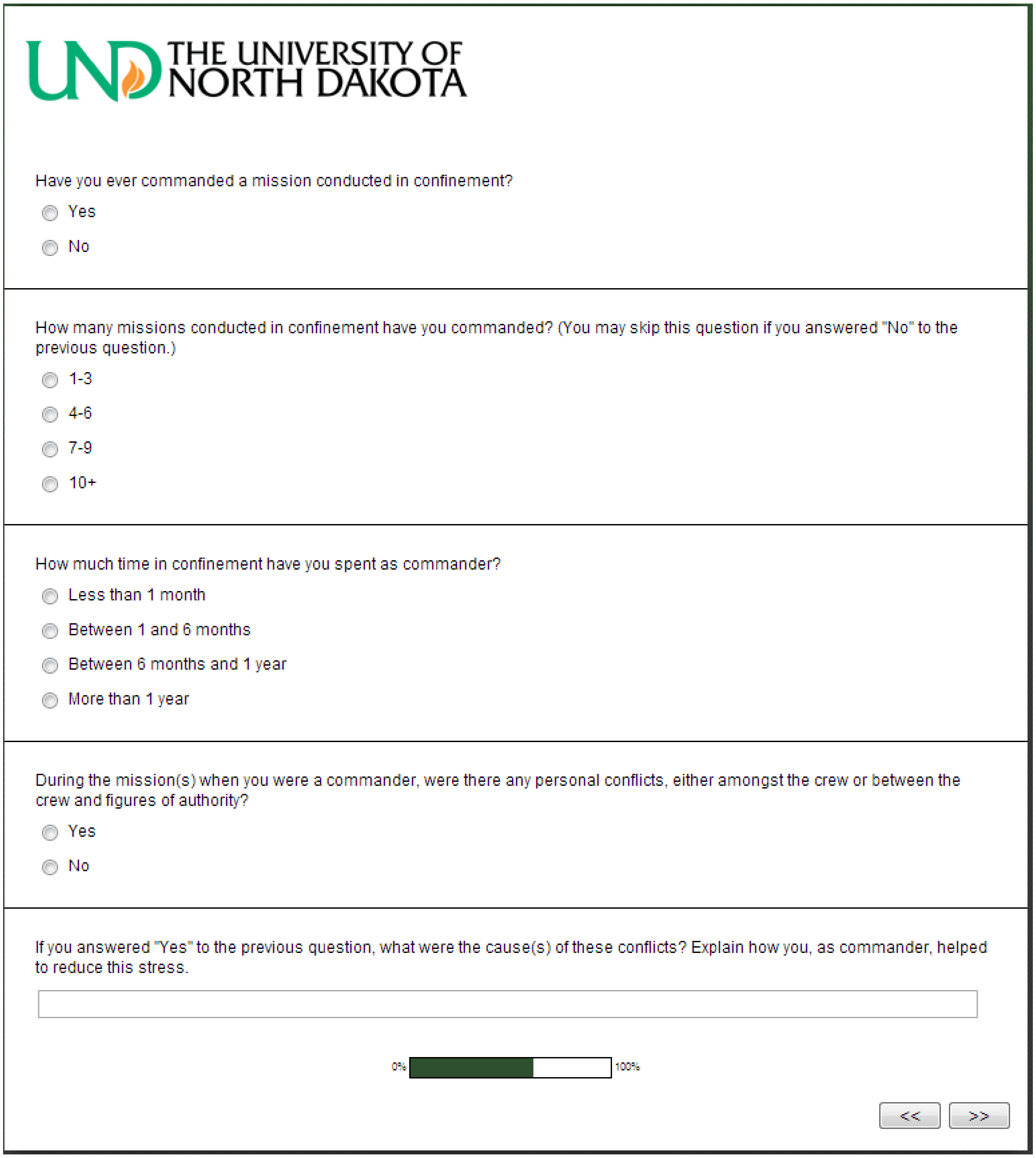
How effective do you think pre-confinement training would be that teaches crew mates how re-focus their attention back on to their own actions rather than focusing on the actions/behaviors of others? Please rate how effective you think this training would be on a scale of 1 to 10, where 1 means "ineffective" and 10 means "extensively effective".

	1	2	3	4	5	6	7	8	9	10
Effectiveness of pre-confinement training to focus on one's own actions and behaviors rather than those of others	○	○	○	○	○	○	○	○	○	○

0% 100%

<< >>

Figure 19 Questions 16-17 of Survey



THE UNIVERSITY OF NORTH DAKOTA

Have you ever commanded a mission conducted in confinement?

- Yes
- No

How many missions conducted in confinement have you commanded? (You may skip this question if you answered "No" to the previous question.)

- 1-3
- 4-6
- 7-9
- 10+

How much time in confinement have you spent as commander?

- Less than 1 month
- Between 1 and 6 months
- Between 6 months and 1 year
- More than 1 year

During the mission(s) when you were a commander, were there any personal conflicts, either amongst the crew or between the crew and figures of authority?

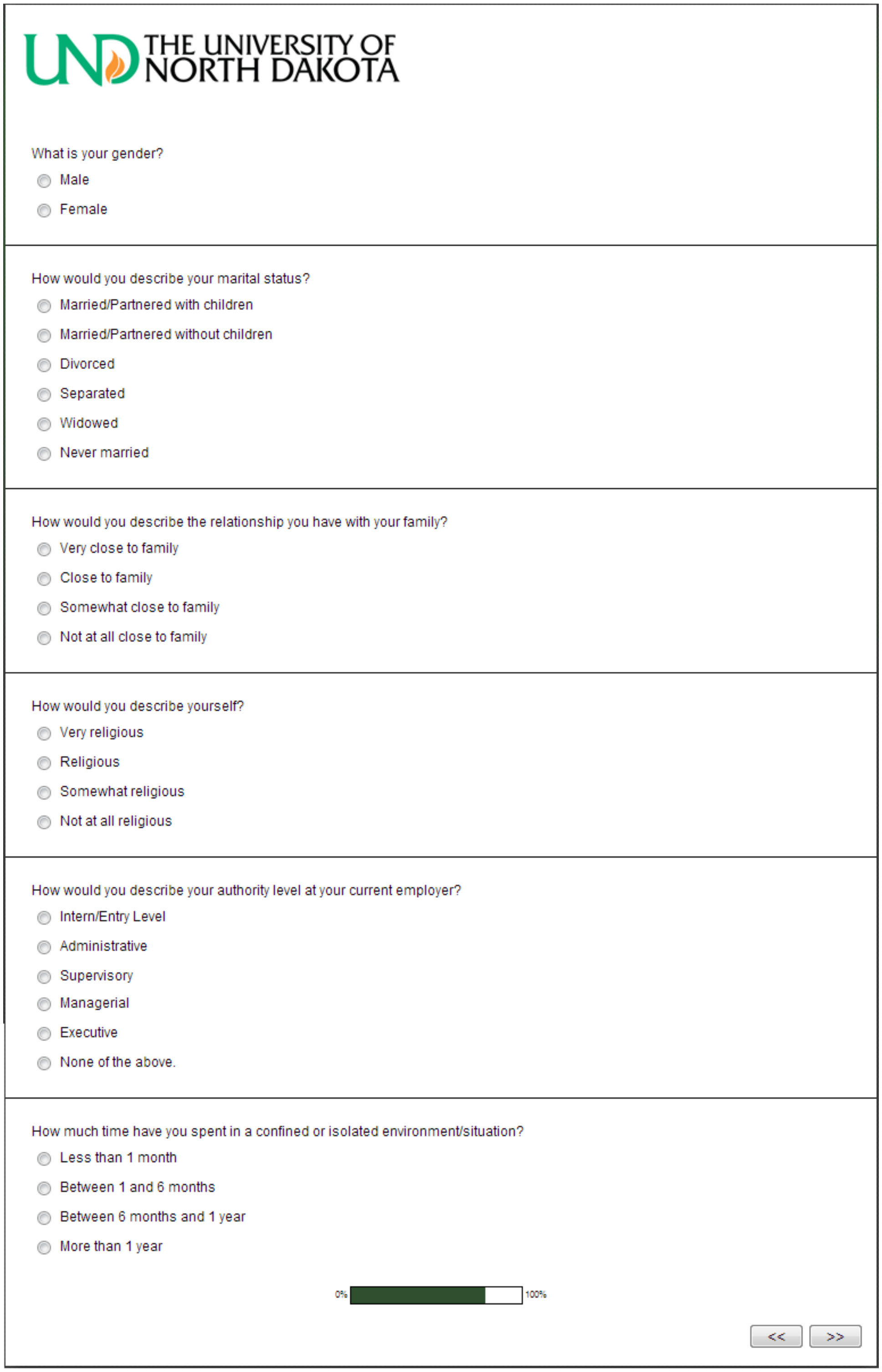
- Yes
- No

If you answered "Yes" to the previous question, what were the cause(s) of these conflicts? Explain how you, as commander, helped to reduce this stress.

0% 100%

<< >>

Figure 20 Questions 18-22 of Survey



THE UNIVERSITY OF NORTH DAKOTA

What is your gender?

- Male
- Female

How would you describe your marital status?

- Married/Partnered with children
- Married/Partnered without children
- Divorced
- Separated
- Widowed
- Never married

How would you describe the relationship you have with your family?

- Very close to family
- Close to family
- Somewhat close to family
- Not at all close to family

How would you describe yourself?

- Very religious
- Religious
- Somewhat religious
- Not at all religious

How would you describe your authority level at your current employer?

- Intern/Entry Level
- Administrative
- Supervisory
- Managerial
- Executive
- None of the above.

How much time have you spent in a confined or isolated environment/situation?

- Less than 1 month
- Between 1 and 6 months
- Between 6 months and 1 year
- More than 1 year

0% 100%

<< >>

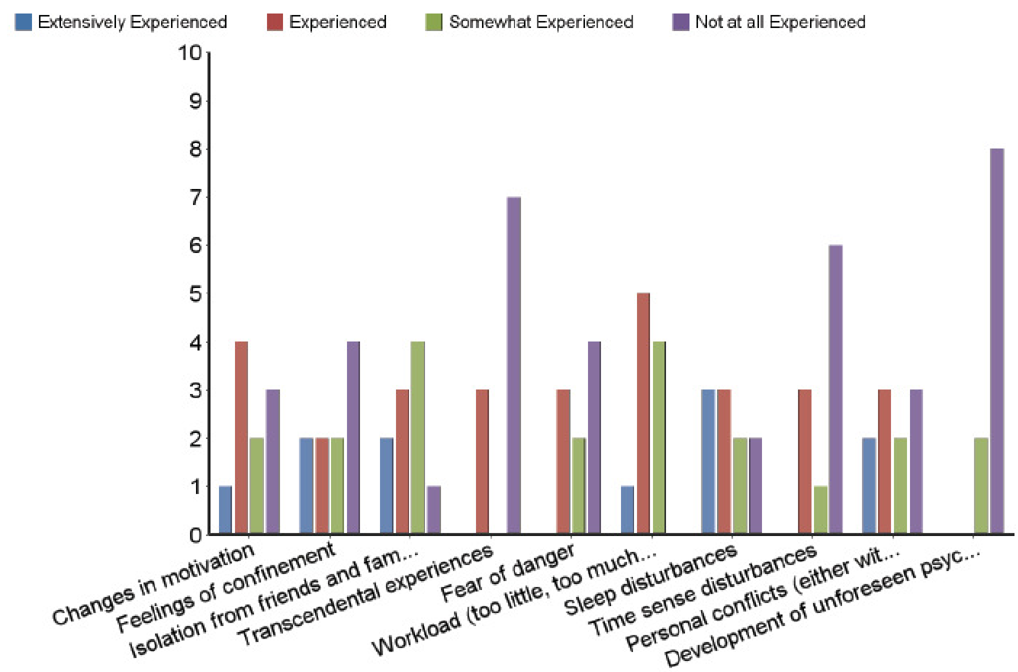
Figure 21 Questions 23-29 of Survey

APPENDIX B

SURVEY RESULTS

The following pages contain screen shots of the survey results from the Qualtrics report.

There have been a number of items identified as possible stressors that arise in confined situations. Please state how often you have been stressed by these possible stressors in confined situations.



#	Question	Extensively Experienced	Experienced	Somewhat Experienced	Not at all Experienced	Responses	Mean
1	Changes in motivation	1	4	2	3	10	2.70
2	Feelings of confinement	2	2	2	4	10	2.80
3	Isolation from friends and family	2	3	4	1	10	2.40
4	Transcendental experiences	-	3	-	7	10	3.40
5	Fear of danger	-	3	2	4	9	3.11
6	Workload (too little, too much, etc.)	1	5	4	-	10	2.30
7	Sleep disturbances	3	3	2	2	10	2.30
8	Time sense disturbances	-	3	1	6	10	3.30

Figure 22 Question 1 results

9	Personal conflicts (either within the crew and/or between the crew and authority)	2	3	2	3	10	2.60
10	Development of unforeseen psychiatric disorders/deviations (diseases)	-	-	2	8	10	3.80

Statistic	Changes in motivation	Feelings of confinement	Isolation from friends and family	Transcendental experiences	Fear of danger	Workload (too little, too much, etc.)	Sleep disturbances	Time sense disturbances
Min Value	1	1	1	2	2	1	1	2
Max Value	4	4	4	4	4	3	4	4
Mean	2.7	2.8	2.4	3.4	3.11	2.3	2.3	3.3
Variance	1.12	1.51	0.93	0.93	0.86	0.46	1.34	0.9
Standard Deviation	1.06	1.23	0.97	0.97	0.93	0.67	1.16	0.95
Total Responses	10	10	10	10	9	10	10	10
Total Respondents	10	10	10	10	9	10	10	10

Figure 23 Question 1 results – continued

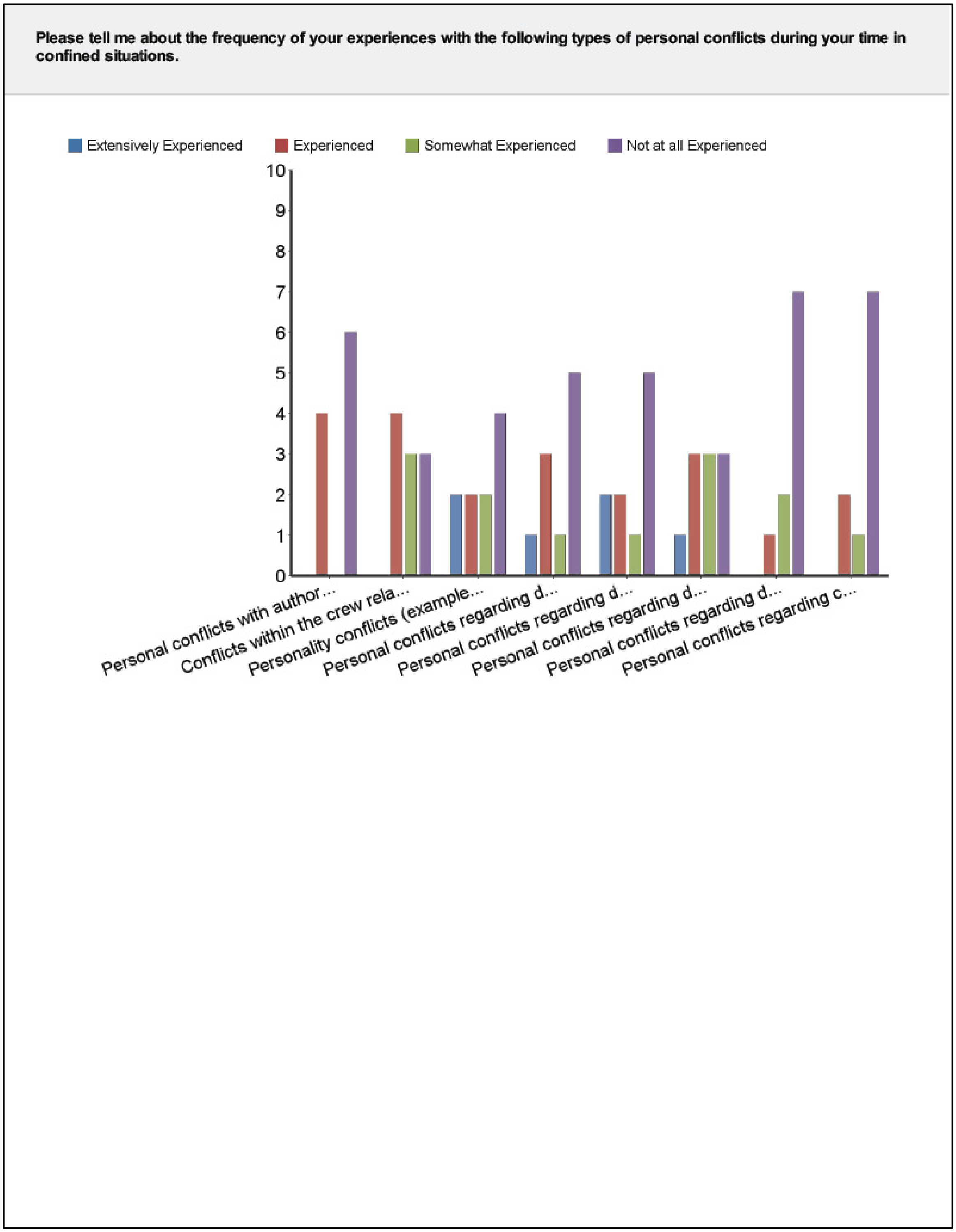


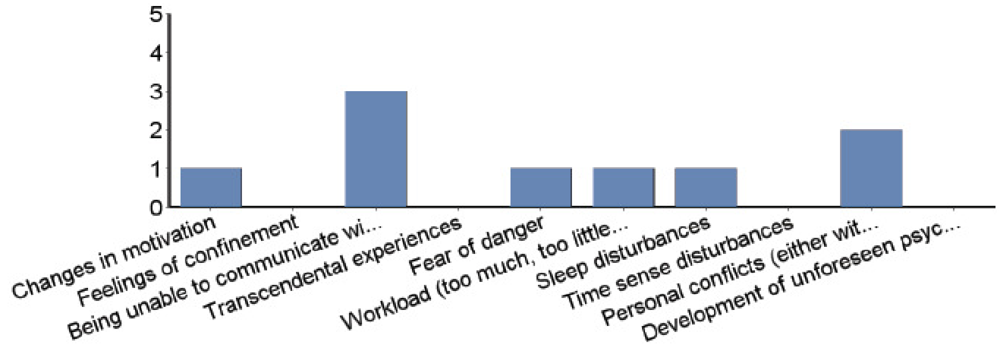
Figure 24 Question 2 results

#	Question	Extensively Experienced	Experienced	Somewhat Experienced	Not at all Experienced	Responses	Mean
1	Personal conflicts with authority figures	-	4	-	6	10	3.20
2	Conflicts within the crew relating to professional differences	-	4	3	3	10	2.90
3	Personality conflicts (example: inability to make a decision)	2	2	2	4	10	2.80
4	Personal conflicts regarding difficulties with "rookies"	1	3	1	5	10	3.00
5	Personal conflicts regarding difficulties with "veterans"	2	2	1	5	10	2.90
6	Personal conflicts regarding difficulties due to rank/status among the crew	1	3	3	3	10	2.80
7	Personal conflicts regarding difficulties with aggression	-	1	2	7	10	3.60
8	Personal conflicts regarding cultural differences	-	2	1	7	10	3.50

Statistic	Personal conflicts with authority figures	Conflicts within the crew relating to professional differences	Personality conflicts (example: inability to make a decision)	Personal conflicts regarding difficulties with "rookies"	Personal conflicts regarding difficulties with "veterans"	Personal conflicts regarding difficulties due to rank/status among the crew	Personal conflicts regarding difficulties with aggression	Personal conflicts regarding cultural differences
Min Value	2	2	1	1	1	1	2	2
Max Value	4	4	4	4	4	4	4	4
Mean	3.2	2.9	2.8	3	2.9	2.8	3.6	3.5
Variance	1.07	0.77	1.51	1.33	1.66	1.07	0.49	0.72
Standard Deviation	1.03	0.88	1.23	1.15	1.29	1.03	0.7	0.85
Total Responses	10	10	10	10	10	10	10	10
Total Respondents	10	10	10	10	10	10	10	10

Figure 25 Question 2 results – continued

Which of the following stressors affected you the most during your experience with confinement?

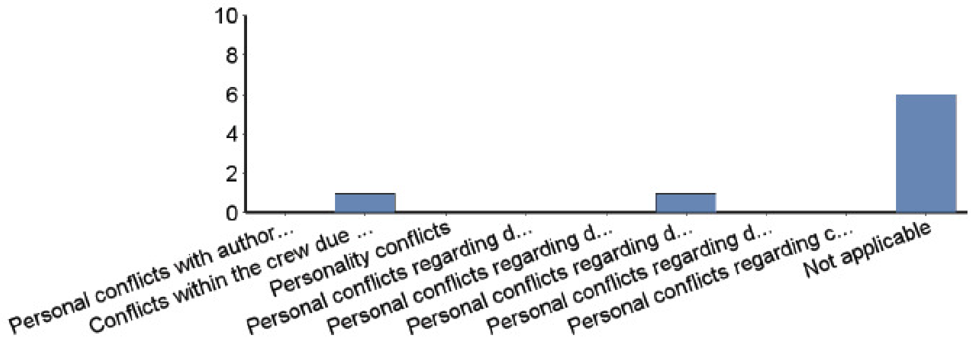


#	Answer	Bar	Responses	%
1	Changes in motivation		1	11.11%
2	Feelings of confinement		0	0.00%
3	Being unable to communicate with friends and family		3	33.33%
4	Transcendental experiences		0	0.00%
5	Fear of danger		1	11.11%
6	Workload (too much, too little, etc.)		1	11.11%
7	Sleep disturbances		1	11.11%
8	Time sense disturbances		0	0.00%
9	Personal conflicts (either within the crew or between the crew and authorities)		2	22.22%
10	Development of unforeseen psychiatric diseases		0	0.00%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	9	5.11	8.11	2.85	9	9

Figure 26 Question 3 results

If you selected "Personal conflicts" in the previous question, which type of personal conflict affected you the most? If you did *not* select "Personal conflicts", please select "Not applicable".

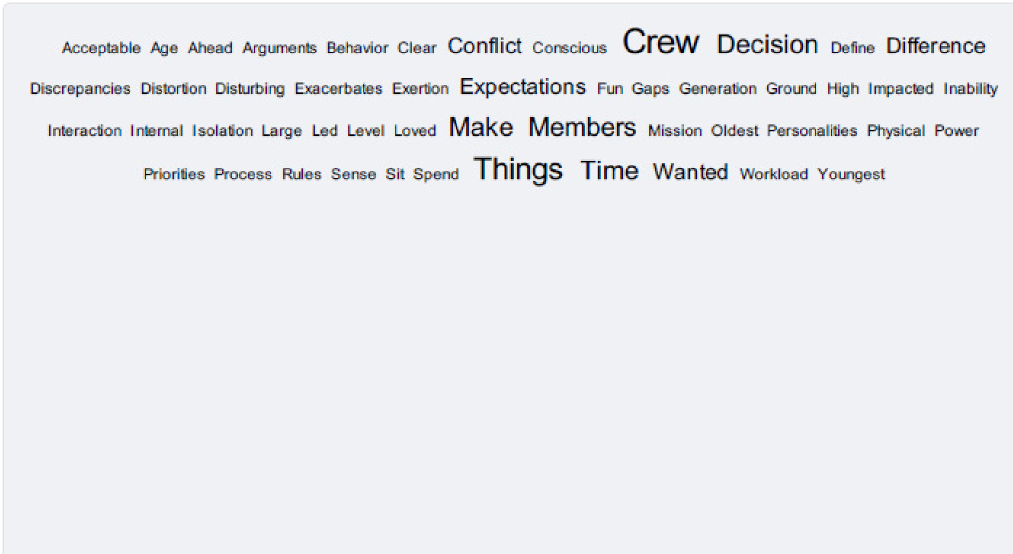


#	Answer	Bar	Responses	%
1	Personal conflicts with authority figures		0	0.00%
2	Conflicts within the crew due to professional differences		1	12.50%
3	Personality conflicts		0	0.00%
4	Personal conflicts regarding difficulties with "rookies"		0	0.00%
5	Personal conflicts regarding difficulties with "veterans"		0	0.00%
6	Personal conflicts regarding difficulties due to rank/status among the crew		1	12.50%
7	Personal conflicts regarding difficulties with aggression		0	0.00%
8	Personal conflicts regarding cultural differences		0	0.00%
9	Not applicable		6	75.00%
	Total		8	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
2	9	7.75	6.50	2.55	8	8

Figure 27 Question 4 results

If you have experienced personal conflicts, please explain what was/were the cause(s) of these conflicts.



Text Entry
Our crew did not sit down ahead of time and clearly define the ground rules and expectations for our interaction with each other and our decision making process. This led to conflict, especially as different crew members had very different personalities and different expectations of acceptable behavior.
Inability to make a clear conscious decision, it was most disturbing 'internal' conflict
Differing priorities among the crew and arguments over which decisions to make or how to spend time. The high workload, physical exertion level, time sense distortion, and isolation from loved ones exacerbates these things.
We had a large age difference among the crew and the generation gaps really impacted the mission. The oldest member of the crew wanted everyone to do things exactly the way they liked to do things, the youngest members only wanted to do the things that were fun.
power discrepancies

Statistic	Value
Respondents	5

Figure 28 Question 5 results

What steps were taken to reduce the stress or end the conflict? Was this successful in ending the conflict? Why or why not?

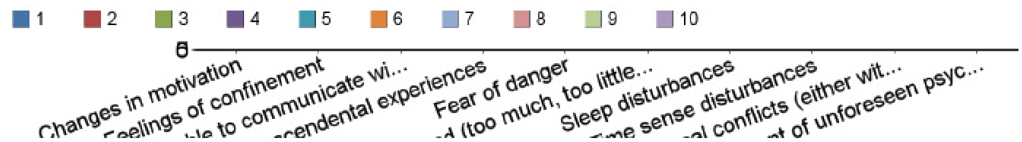
Activities Addressed Began Bonding Cdr Chain Command Communal Conflict Crew Decision Degree Democratic Effort Ended Environment Exercise Fairly Final Games Giving Group Hazardous Including Inequities Internal Isolating Major Meals Members Mission Movies Part People Playing Preparation Problem Real Remote Resolved Space Steps Successful Switch Task Time Watching

Text Entry
We had a chain of command and we followed it. Being in a remote, hazardous environment, the decision of our commander was final... although we tried to be fairly democratic about it if we could.
switch to to the different task or problem was most successful in ending 'internal' conflict
Group bonding activities are a must, including communal preparation of meals, watching movies or playing games, and group exercise. One way we resolved conflict was also by giving people space and time alone.
No real steps were taken as the CDR was a major part of the conflict. Most crew members just began isolating themselves. The conflict only ended when the mission ended.
Addressed the inequities. Successful to a degree after much effort.

Statistic	Value
Respondents	5

Figure 29 Question 6 results

Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following stressors on the success of a mission taking place in confinement.

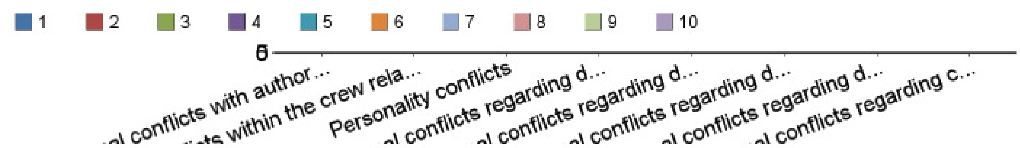


#	Question	1	2	3	4	5	6	7	8	9	10	Responses	Mean
1	Changes in motivation	1	1	2	2	-	-	-	2	-	1	9	4.78
2	Feelings of confinement	1	3	3	-	-	-	1	-	-	1	9	3.67
3	Being unable to communicate with friends and family	-	2	1	1	1	1	2	-	1	-	9	5.00
4	Transcendental experiences	3	3	1	-	1	1	-	-	-	-	9	2.56
5	Fear of danger	2	2	1	1	1	1	-	-	-	1	9	3.78
6	Workload (too much, too little, etc.)	1	1	-	-	3	-	3	-	1	-	9	5.33
7	Sleep disturbances	1	-	2	1	1	2	1	1	-	-	9	4.78
8	Time sense disturbances	3	1	1	1	-	2	-	1	-	-	9	3.56
9	Personal conflicts (either within the crew or between the crew and authority figures)	-	2	1	-	1	1	-	2	1	1	9	5.89
10	Development of unforeseen psychiatric diseases	3	-	2	1	-	-	-	-	1	1	8	4.00

Statistic	Changes in motivation	Feelings of confinement	Being unable to communicate with friends and family	Transcendental experiences	Fear of danger	Workload (too much, too little, etc.)	Sleep disturbances	Time sen disturbanc
Min Value	1	1	2	1	1	1	1	
Max Value	10	10	9	6	10	9	8	
Mean	4.78	3.67	5	2.56	3.78	5.33	4.78	3.
Variance	9.69	8.5	6	3.28	8.44	6.5	4.94	6.
Standard Deviation	3.11	2.92	2.45	1.81	2.91	2.55	2.22	[illegible]
Total Responses	9	9	9	9	9	9	9	
Total Respondents	9	9	9	9	9	9	9	

Figure 30 Question 7 results

Please rate on a scale of 1 to 10, where 1 means "not a problem" and 10 means "causing mission failure", your perceived risk of the following personal conflict stressors on the success of a mission taking place in confinement.

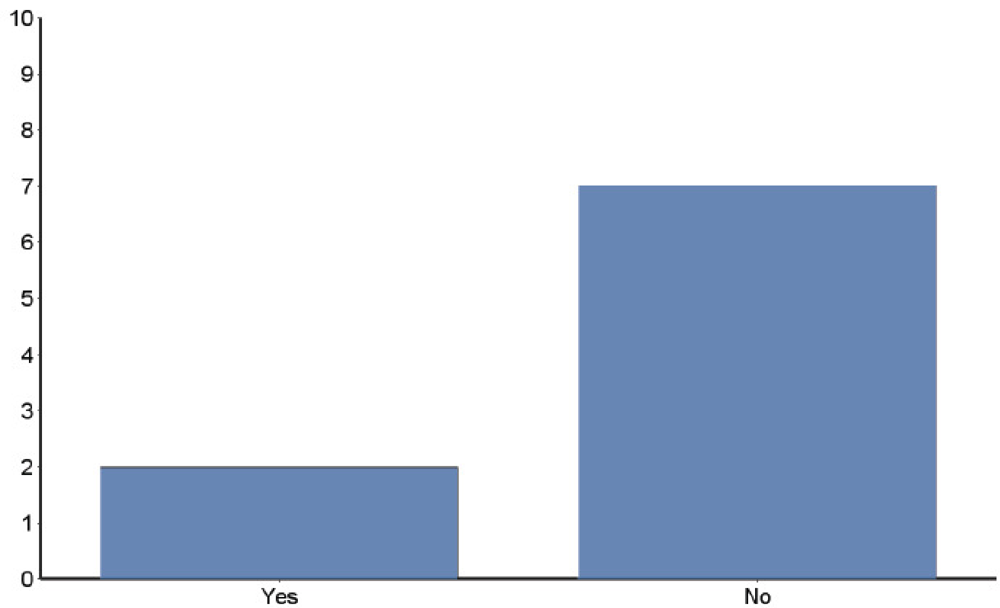


#	Question	1	2	3	4	5	6	7	8	9	10	Responses	Mean
1	Personal conflicts with authority figures	2	-	2	2	-	1	1	-	1	-	9	4.22
2	Conflicts within the crew relating to professional differences	1	2	2	-	2	-	1	-	1	-	9	4.11
3	Personality conflicts	-	2	-	1	1	1	-	2	2	-	9	5.89
4	Personal conflicts regarding difficulties with "rookies"	2	1	2	-	-	2	1	-	1	-	9	4.22
5	Personal conflicts regarding difficulties with "veterans"	2	1	2	-	-	1	2	-	1	-	9	4.33
6	Personal conflicts regarding difficulties due to rank/status among the crew	1	1	2	1	-	-	2	-	2	-	9	5.00
7	Personal conflicts regarding difficulties with aggression	2	2	2	1	-	1	-	-	-	1	9	3.56
8	Personal conflicts regarding cultural differences	3	1	1	1	1	1	-	1	-	-	9	3.44

Statistic	Personal conflicts with authority figures	Conflicts within the crew relating to professional differences	Personality conflicts	Personal conflicts regarding difficulties with "rookies"	Personal conflicts regarding difficulties with "veterans"	Personal conflicts regarding difficulties due to rank/status among the crew	Personal conflicts regarding difficulties with aggression	Personal conflicts regarding cultural differences
Min Value	1	1	2	1	1	1	1	1
Max Value	9	9	9	9	9	9	10	8
Mean	4.22	4.11	5.89	4.22	4.33	5	3.56	3.44
Variance	7.19	6.86	7.86	8.19	8.75	9.25	8.28	6.28
Standard Deviation	2.68	2.62	2.8	2.86	2.96	3.04	2.88	2.51
Total Responses	9	9	9	9	9	9	9	9
Total Respondents	9	9	9	9	9	9	9	9

Figure 31 Question 8 results

Based on your experience with the stressors that sometimes arise in confined situations, do you expect stressors for a Mars mission, where the crew will most likely be confined and isolated for more than two years, would be the same as those of a long term mission of confinement in orbit around the Earth?

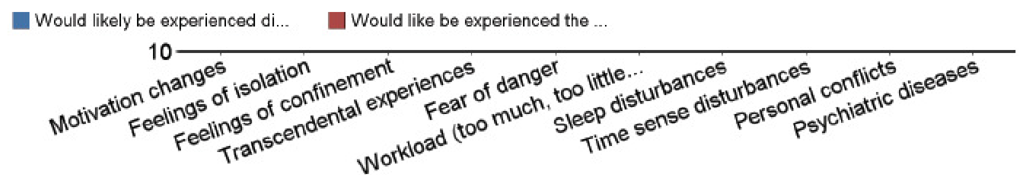


#	Answer	Bar	Responses	%
1	Yes		2	22.22%
2	No		7	77.78%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.78	0.19	0.44	9	9

Figure 32 Question 9 results

If you selected "No" in the previous question, which of the following stressors do you suspect would be experienced differently for a crew on a Mars mission versus a mission of confinement in orbit around the Earth? Please also explain why you suspect these differences. Please feel free to elaborate on each stressor as needed.



#	Question	Would likely be experienced differently for a Mars mission	Would like be experienced the same for both a mission to Mars and in orbit around Earth	Responses	Mean
1	Motivation changes	5	2	7	1.29
2	Feelings of isolation	6	1	7	1.14
3	Feelings of confinement	6	1	7	1.14
4	Transcendental experiences	3	4	7	1.57
5	Fear of danger	7	-	7	1.00
6	Workload (too much, too little)	4	3	7	1.43
7	Sleep disturbances	3	4	7	1.57
8	Time sense disturbances	3	4	7	1.57
9	Personal conflicts	4	3	7	1.43
10	Psychiatric diseases	4	3	7	1.43

Statistic	Motivation changes	Feelings of isolation	Feelings of confinement	Transcendental experiences	Fear of danger	Workload (too much, too little)	Sleep disturbances	Time sense disturbances
Min Value	1	1	1	1	1	1	1	1
Max Value	2	2	2	2	1	2	2	2
Mean	1.29	1.14	1.14	1.57	1	1.43	1.57	1.57
Variance	0.24	0.14	0.14	0.29	0	0.29	0.29	0.29
Standard Deviation	0.49	0.38	0.38	0.53	0	0.53	0.53	0.53
Total Responses	7	7	7	7	7	7	7	7
Total Respondents	7	7	7	7	7	7	7	7

Figure 33 Question 10 results

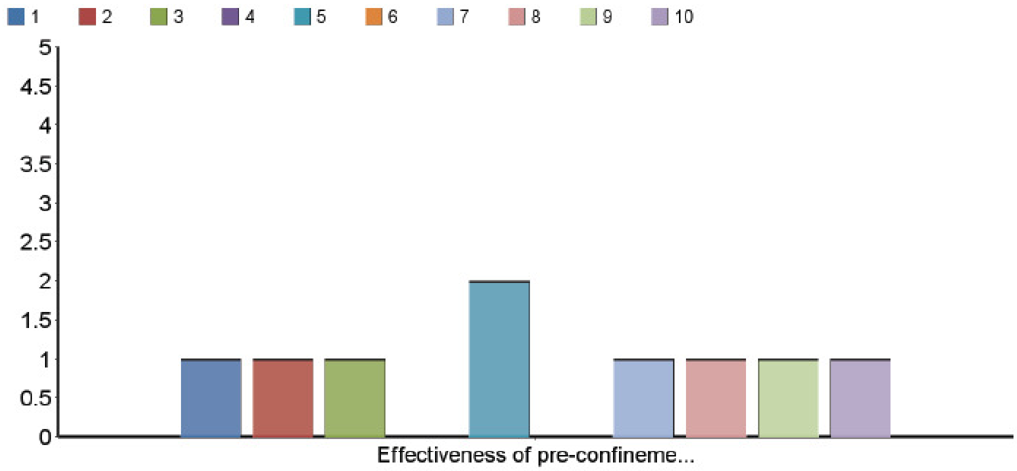
Of those stressors listed in the previous question, can you suggest ways to reduce these stressors?

Text Entry
Don't test the Mars crew in Earth orbit. Test them in a Mars analog site.
extensive pre-mission training in simulated isolation environments like Mars 500 tests
Find something that provides an anchor of safety to the crew to make them feel less isolated.
Test the Mars crew in advance using current analogs to ensure the correct crew dynamic, ensure that workload is well balanced with plenty of time off for the crew, do everything possible to ensure lots of comm with the crew and their family
Sorry. I cannot.
pre-fligth training

Statistic	Value
Respondents	6

Figure 34 Question 11 results

Part of the purpose of pre-confinement training is to increase group cohesion and reduce social conflict. How would you rate the effectiveness of your pre-confinement training in reducing social conflict. Please use a scale of 1 to 10, where 10 means the training was most effective and 1 means the training was least effective.



#	Question	1	2	3	4	5	6	7	8	9	10	Responses	Mean
1	Effectiveness of pre-confinement training	1	1	1	-	2	-	1	1	1	1	9	5.56

Statistic	Effectiveness of pre-confinement training
Min Value	1
Max Value	10
Mean	5.56
Variance	10.03
Standard Deviation	3.17
Total Responses	9
Total Respondents	9

Figure 35 Question 12 results

Please explain what you think was the MOST effective part of your pre-confinement training in reducing conflicts.

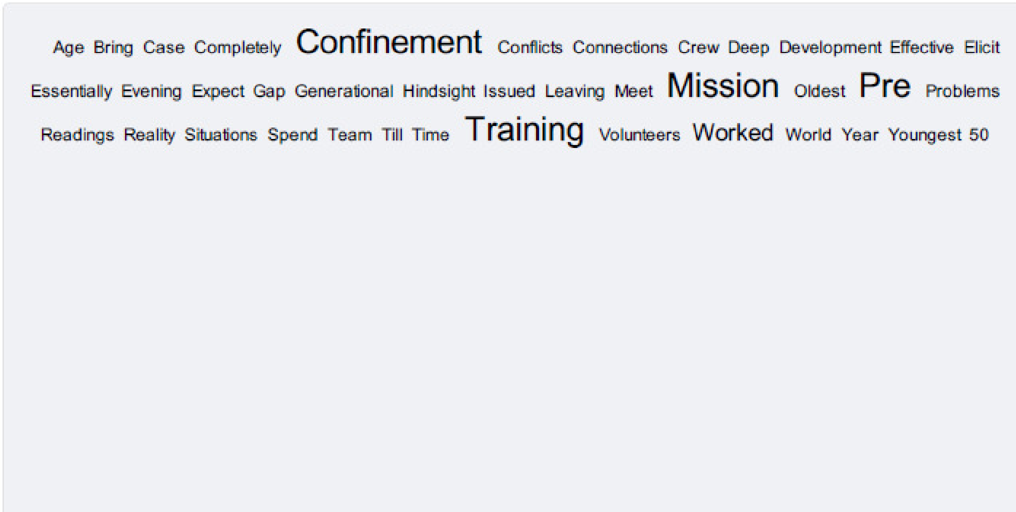
Anticipation Began Behave Confined Conflicts Crew Dangerous Day Deal Desires Expected Great Heading Helpful Increases Individual Initial Interpersonal Mates Meeting Met Mission Negatives Occur Personality Pre Problems Reduce Spaces Team Temperaments Training Undersanding Understanding Wilderness Work

Text Entry
I was alone on the mission, so there were no conflict except conflicts within personality
Did not have any pre-confinement training.
pre-mission training to understand each others desires better
Understanding the team, their individual temperaments, and what was expected of each of us helped a great deal.
increases undersanding on how you behave in confined spaces and how you can behave to reduce interpersonal conflicts
You get to know your crew mates and can work out any initial problems before heading out into the dangerous wilderness.
We only met each other once for a day before our mission began, that one meeting was helpful, but not enough
Anticipation of negatives that are likely to occur

Statistic	Value
Respondents	8

Figure 36 Question 13 results

Please explain what you think was the LEAST effective part of your pre-confinement training in reducing conflicts.

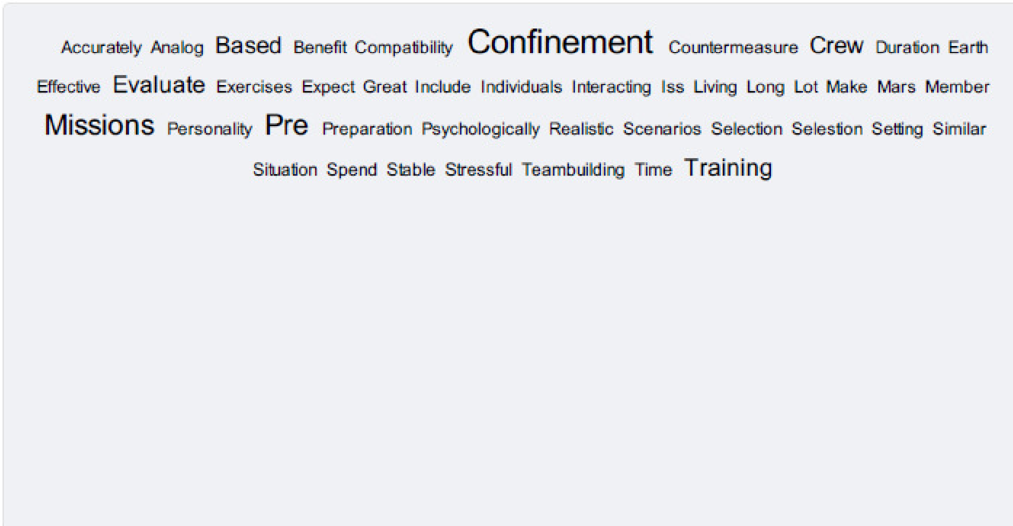


Text Entry
We didn't spend enough time working together as a team and really getting to know each other before the mission.
Least effective in pre-confinement training probably will be any development of deep connections to the world what you are leaving, though in my case there were no any pre-mission training
Crew did not meet till evening before.
One could always use more pre-confinement training to help bring up situations that might elicit conflicts. We didn't expect so many generational problems on one of my missions (50-year age gap from oldest to youngest), but in hindsight we would have liked to have worked through those issued before the mission.
We had essentially no pre-confinement training as we were all just volunteers
readings about confinement, in reality it was almost completely different, more serious

Statistic	Value
Respondents	6

Figure 37 Question 14 results

Please explain what you suggest to improve pre-confinement training in order to further reduce social conflict.

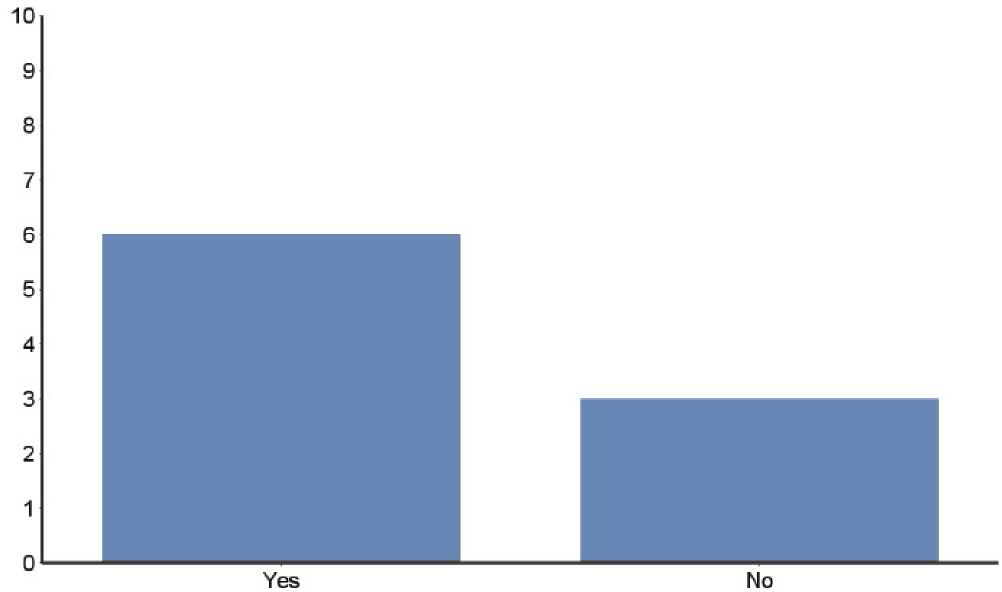


Text Entry
Spend a lot of time together as a crew, living together and interacting in various setting and scenarios... stressful and not... to accurately evaluate crew member compatibility.
Selection for psychologically stable individuals would be a most effective countermeasure
I expect for long duration mission pre-confinement teambuilding exercises would have a great benefit
See above. Try to make the pre-confinement training as realistic and similar to the confinement situation as possible.
For Mars missions, pre-confinement training should include the use of the Earth-based or ISS analog missions for preparation
selestion based on personality evaluation

Statistic	Value
Respondents	6

Figure 38 Question 15 results

Many conflicts documented in confined environments appear to originate from crew members being fixated on what their crew mates are doing or how they are behaving. (examples: crew mate not collecting data correctly, not following protocol, breathing/eating too loudly) Would you characterize the conflicts you have witnessed in confinement to be related to this fixation?

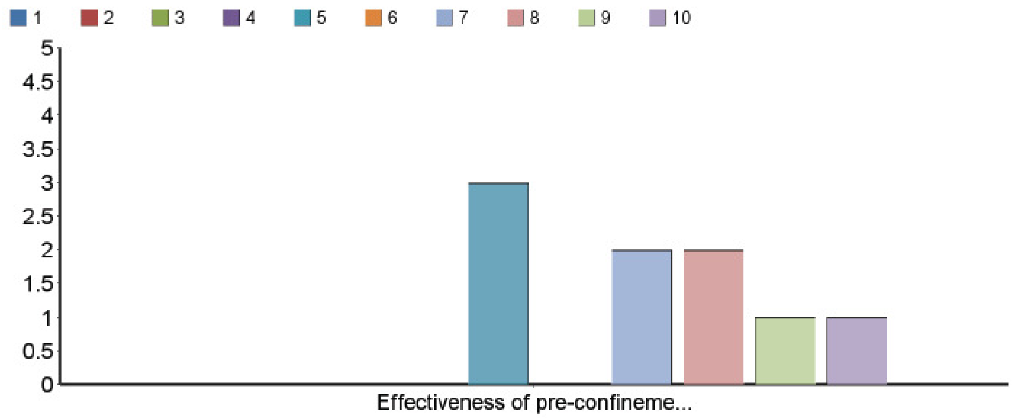


#	Answer	Bar	Responses	%
1	Yes		6	66.67%
2	No		3	33.33%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.33	0.25	0.50	9	9

Figure 39 Question 16 results

How effective do you think pre-confinement training would be that teaches crew mates how re-focus their attention back on to their own actions rather than focusing on the actions/behaviors of others? Please rate how effective you think this training would be on a scale of 1 to 10, where 1 means "ineffective" and 10 means "extensively effective".

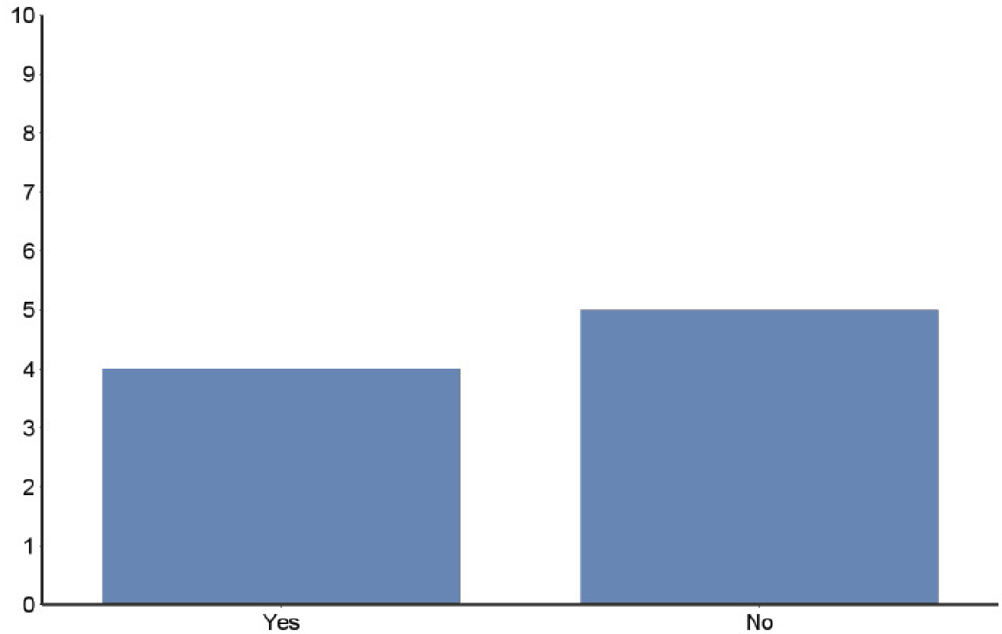


#	Question	1	2	3	4	5	6	7	8	9	10	Responses	Mean
1	Effectiveness of pre-confinement training to focus on one's own actions and behaviors rather than those of others	-	-	-	-	3	-	2	2	1	1	9	8.44

Statistic	Effectiveness of pre-confinement training to focus on one's own actions and behaviors rather than those of others
Min Value	5
Max Value	13
Mean	8.44
Variance	10.78
Standard Deviation	3.28
Total Responses	9
Total Respondents	9

Figure 40 Question 17 results

Have you ever commanded a mission conducted in confinement?

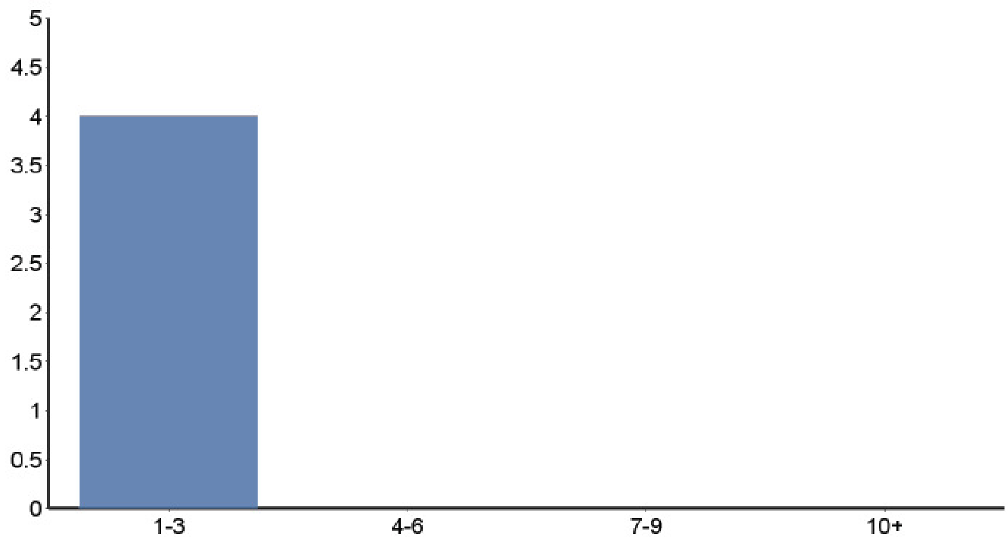


#	Answer	Bar	Responses	%
1	Yes		4	44.44%
2	No		5	55.56%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.56	0.28	0.53	9	9

Figure 41 Question 18 results

How many missions conducted in confinement have you commanded? (You may skip this question if you answered "No" to the previous question.)

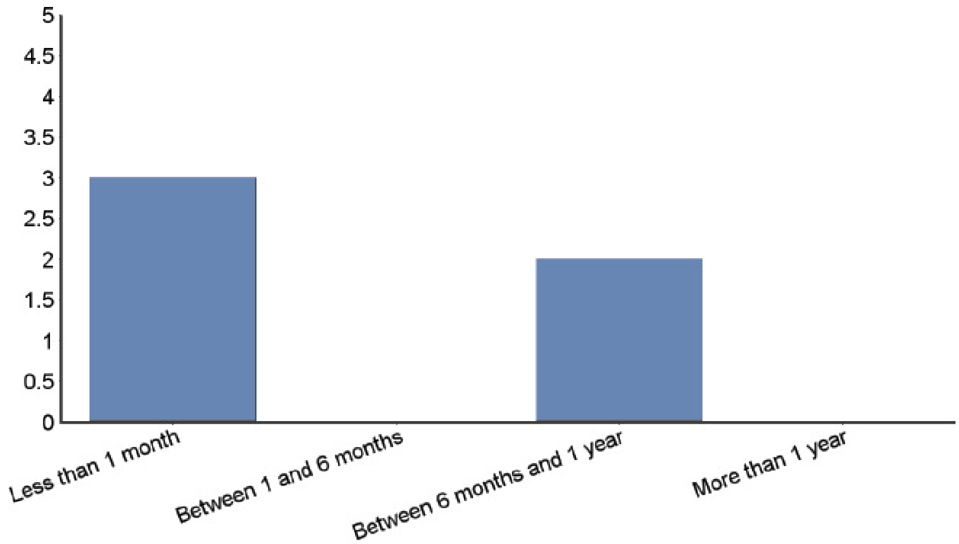


#	Answer	Bar	Responses	%
1	1-3		4	100.00%
2	4-6		0	0.00%
3	7-9		0	0.00%
4	10+		0	0.00%
	Total		4	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	1	1.00	0.00	0.00	4	4

Figure 42 Question 19 results

How much time in confinement have you spent as commander?

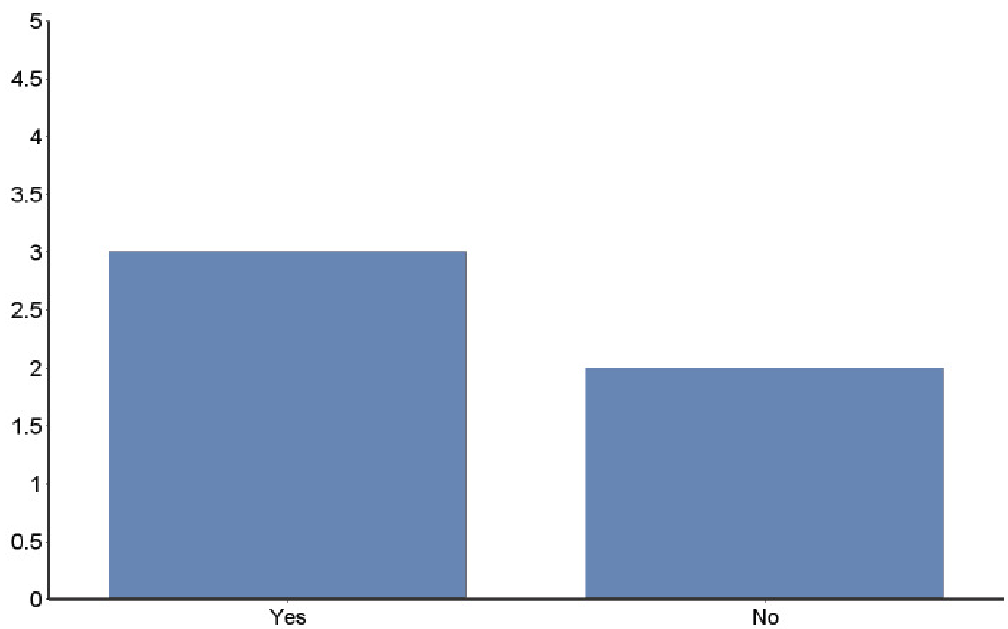


#	Answer	Bar	Responses	%
1	Less than 1 month		3	60.00%
2	Between 1 and 6 months		0	0.00%
3	Between 6 months and 1 year		2	40.00%
4	More than 1 year		0	0.00%
	Total		5	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	3	1.80	1.20	1.10	5	5

Figure 43 Question 20 results

During the mission(s) when you were a commander, were there any personal conflicts, either amongst the crew or between the crew and figures of authority?



#	Answer	Bar	Responses	%
1	Yes		3	60.00%
2	No		2	40.00%
	Total		5	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.40	0.30	0.55	5	5

Figure 44 Question 21 results

If you answered "Yes" to the previous question, what were the cause(s) of these conflicts? Explain how you, as commander, helped to reduce this stress.

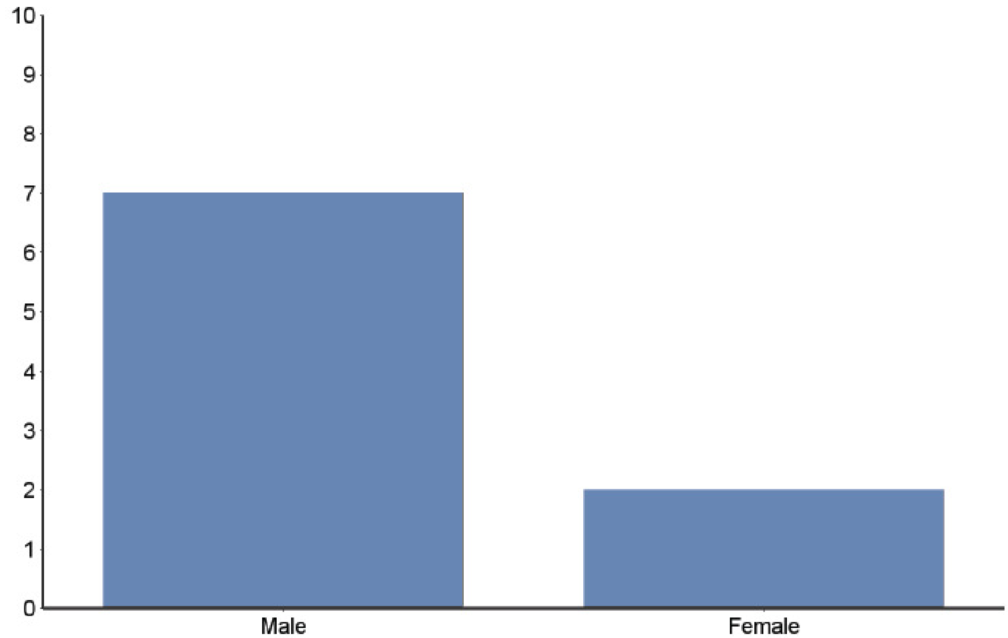
Activity Authority Commander Conflict Control Countermeasure Crew Criticism Decision Eva Figures Foster Great Greater High Intra Level Made Mission Participate Personal Resolve Resources Rookies Shielded Site Subordinatory Support Team Unity Veterans

Text Entry
Our crew got along great, but we had a conflict with our mission support team / authority figures over a decision I had made as commander regarding the use of on-site resources for an EVA activity. I shielded my crew from most of the criticism but used it also to help foster greater crew unity ("us" against "them").
I was alone on the mission and all conflict were intra-personal, high level of self-control is the only countermeasure to resolve conflicts on mission where you participate alone
veterans -rookies, subordinatory conflicts

Statistic	Value
Respondents	3

Figure 45 Question 22 results

What is your gender?

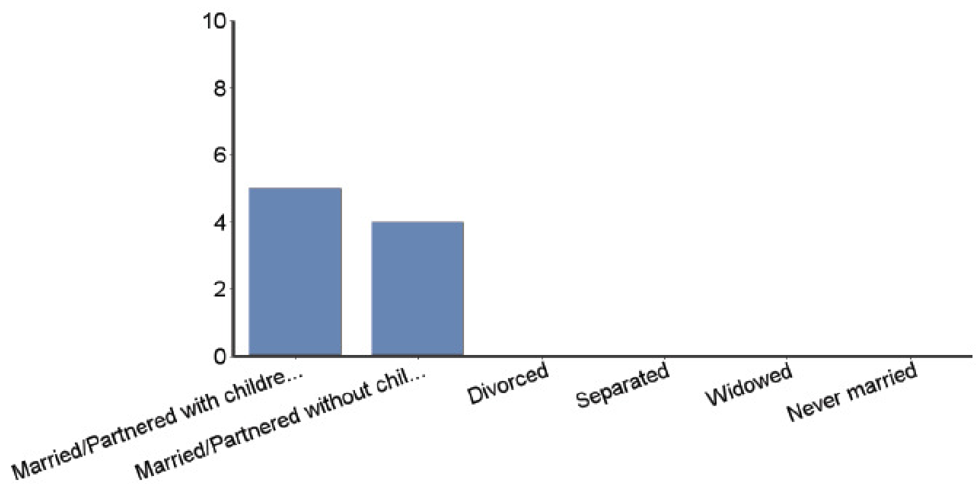


#	Answer	Bar	Responses	%
1	Male		7	77.78%
2	Female		2	22.22%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.22	0.19	0.44	9	9

Figure 46 Question 23 results

How would you describe your marital status?

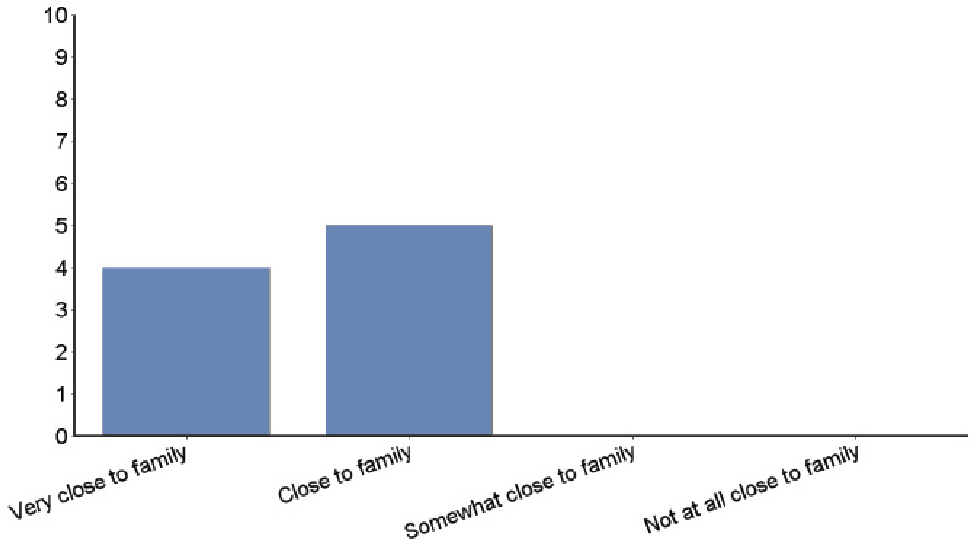


#	Answer	Bar	Responses	%
1	Married/Partnered with children		5	55.56%
2	Married/Partnered without children		4	44.44%
3	Divorced		0	0.00%
4	Separated		0	0.00%
5	Widowed		0	0.00%
6	Never married		0	0.00%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.44	0.28	0.53	9	9

Figure 47 Question 24 results

How would you describe the relationship you have with your family?

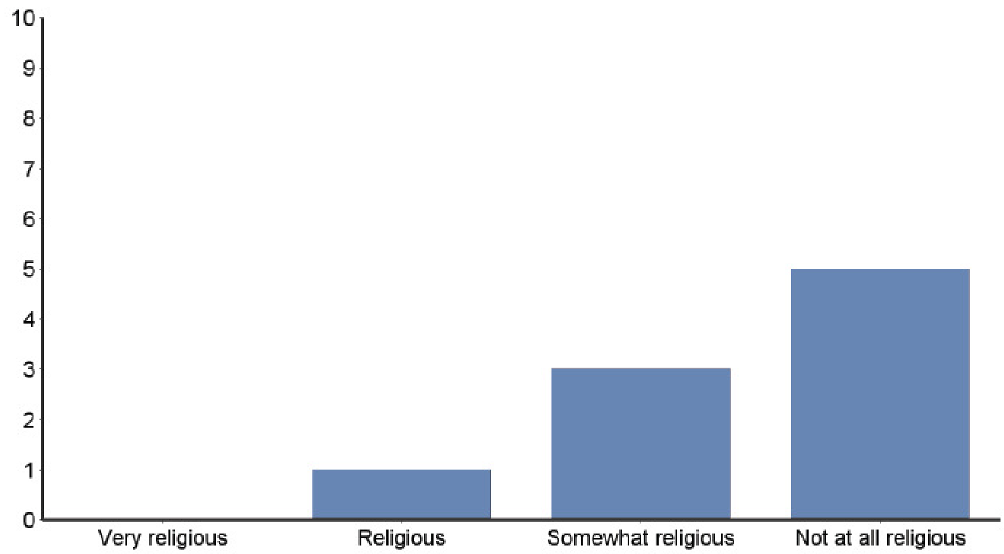


#	Answer	Bar	Responses	%
1	Very close to family		4	44.44%
2	Close to family		5	55.56%
3	Somewhat close to family		0	0.00%
4	Not at all close to family		0	0.00%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	2	1.56	0.28	0.53	9	9

Figure 48 Question 25 results

How would you describe yourself?

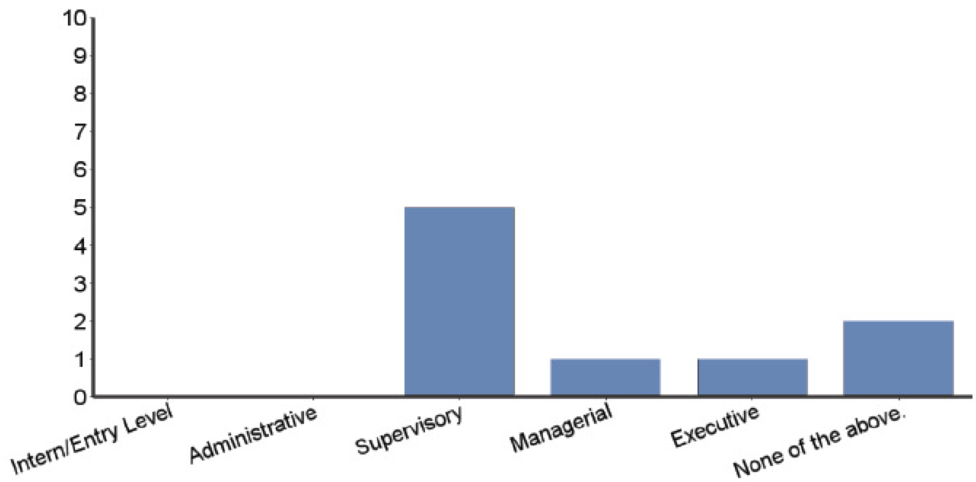


#	Answer	Bar	Responses	%
1	Very religious		0	0.00%
2	Religious		1	11.11%
3	Somewhat religious		3	33.33%
4	Not at all religious		5	55.56%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
2	4	3.44	0.53	0.73	9	9

Figure 49 Question 26 results

How would you describe your authority level at your current employer?

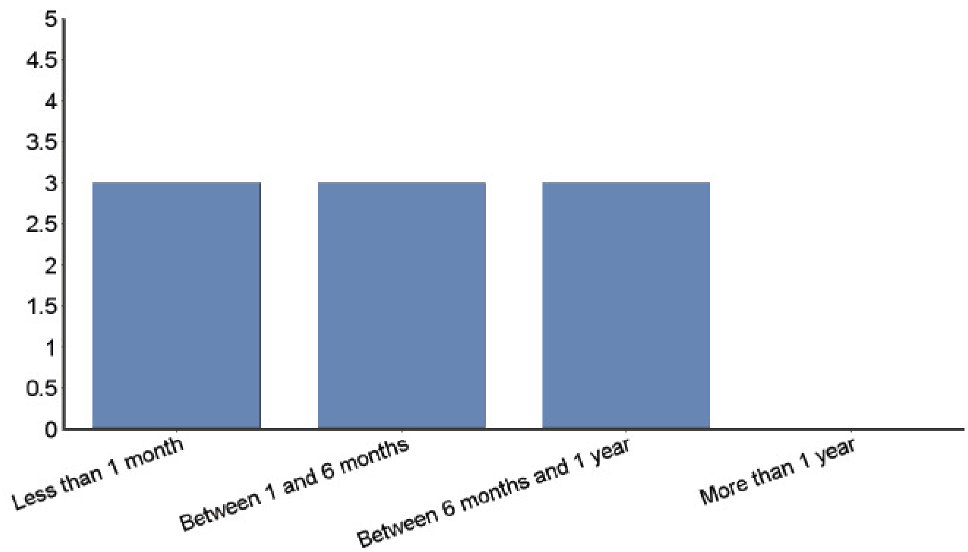


#	Answer	Bar	Responses	%
1	Intern/Entry Level		0	0.00%
2	Administrative		0	0.00%
3	Supervisory		5	55.56%
4	Managerial		1	11.11%
5	Executive		1	11.11%
6	None of the above.		2	22.22%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
3	6	4.00	1.75	1.32	9	9

Figure 50 Question 27 results

How much time have you spent in a confined or isolated environment/situation?



#	Answer	Bar	Responses	%
1	Less than 1 month		3	33.33%
2	Between 1 and 6 months		3	33.33%
3	Between 6 months and 1 year		3	33.33%
4	More than 1 year		0	0.00%
	Total		9	100.00%

Min Value	Max Value	Mean	Variance	Standard Deviation	Total Responses	Total Respondents
1	3	2.00	0.75	0.87	9	9

Figure 51 Question 28 results

REFERENCES

Association for Career and Technical Education (ACTE). (2008, January). NASA Discusses Its Selection and Training of Future Astronauts. *Techniques*, pp. 15-16.

Boyd, J. E., Kanas, N., Gushin, V. I., & Saylor, S. (2007). Cultural differences in patterns of mood states on board the International Space Station. *Acta Astronautica, 61*, 668-671.

Catanzariti, J. (2012, December 10). *Flight training for Apollo: An interview with astronaut Harrison Schmitt.* Retrieved from The Space Review: http://www.thespacereview.com/article/2199/1

CBR News Team. (2012, May 31). *Marvel's "The Avengers" to Screen for Crew of International Space Station.* Retrieved from Comic Book Resources: http://www.comicbookresources.com/?page=article&id=38942

Chong, C., Tsunaka, M., Tsang, H., Chan, E., & Cheung, W. (2011, Jan/Feb). Effects of Yoga on Stress Management in Healthy Adults: A Systematic Review. *Alternative Therapies, 17*(1), 32-38.

Churchill, S. E., & Bungo, M. W. (1997). Response of the Cardiovascular System to Spaceflight. In S. E. Churchill, *Fundamentals of Space Life Sciences* (pp. 41-63). Malabar: Krieger Publishing Company.

Clément, G. (2011). *Fundamentals of Space Medicine.* El Segundo: Microcosm Press.

Connolly, J., Fitts, D., Russo, D., & Kloeris, V. (2011). Habitability and Environmental Health: Habitability. In W. Hale, *Wings In Orbit: Scientific and Engineering Legacies of the Space Shuttle* (pp. 393-394). Houston: NASA Johnson Space Center.

Connors, M. M., Harrison, A. A., & Akins, F. R. (1985). *Living Aloft: Human Requirements for Extended Spaceflight.* Washington, D.C.: NASA Scientific and Technical Information Branch.

Eckart, P. (1996). *Spaceflight Life Support and Biospherics.* Torrance: Microcosm Press.

Fazio, G. G. (1997). Vacuum, Temperature, and Microgravity. In S. E. Churchill, *Fundamentals of Space Life Sciences* (Vol. 1, pp. 3-6). Malabar: Krieger Publishing Company.

Fuller, J. A., & Warner, R. M. (2000). Family Stressors as Predictors of Codependency. *Genetic, Social, and General Psychology Monographs, 1*(126), 5-22.

Holland, A. (2011). Psychological Support - Lessions from Shuttle-Mir to International Space Station. In W. Hale, *Wings In Orbit: Scientific and Engineering Legacies of the Space Shuttle* (p. 152). Houston: NASA Johnson Space Center.

Hysong, S. J., Galarza, L., & Holland, A. W. (2007). *A Review of Training Methods and Instructional Techniques: Implications for Behavioral Skills Training in U.S. Astronauts.* Houston: NASA.

Johnson, P. (2010). The roles of NASA, U.S. astronauts and their families in long-duration missions. *Acta Astronautica, 67*, 561-571.

Kauderer, A. (2012, November 2). *Facts and Figures*. Retrieved from International Space Station: http://www.nasa.gov/mission_pages/station/main/onthestation/facts_and_figures.html

Kozerenko, O., & Ponomareva, I. (2010). Psychophysiological Issues of Manned Space Flights. *Human Physiology, 36*(7), 788-794.

Kumar, A. (2012, October 29). Preparing an Ideal Astronaut. *The New York Times*.

Lathan, C. E., & Clément, G. (1997). Response of the Neurovestibular System to Spaceflight. In S. E. Churchill, *Fundamentals of Space Life Sciences* (Vol. 1, pp. 65-82). Malabar: Krieger Publishing Company.

Lebedev, V. (1988). *Diary of A Cosmonaut: 211 Days in Space.* (L. Diangar, Trans.) College Station: Phytoresource Research, Inc.

Letaw, J. R. (1997). Radiation Biology. In S. E. Churchill, *Funamentals of Space Life Sciences* (pp. 11-18). Malabar: Krieger Publishing Company.

Lewis, M. L., & Hughes-Fulford, M. (1997). Cellular Responses to Spaceflight. In S. E. Churchill, *Fundamentals of Space Life Sciences* (pp. 21-39). Malabar: Krieger Publishing Company.

Lichtenberg, B. (1997). The Experience of Spaceflight: Personal Insights. In S. E. Churchill, *Fundamentals of Space Life Sciences* (Vol. 2, pp. 179-185). Malabar: Krieger Publishing Company.

Logan, J. S. (1997). Operational Medicine and Health Care Delivery. In S. E. Churchill, *Fundamentals of Space Life Sciences* (Vol. 1, pp. 149-157). Malabar: Krieger Publishing Company.

NASA. (1981). *Astronaut Selection and Training.* Houston: NASA. Retrieved from NASA Technical Reports.

NASA. (2002, October 21). *How Astronauts Get Along.* Retrieved from NASA Science News: http://science.nasa.gov/science-news/science-at-nasa/2002/21oct_getalong/

NASA. (2004, March 8). Earth from Mars. *Image*. Pasadena, CA, United States of America: NASA. Retrieved from http://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=1483

NASA. (2011). Behavioral Health. In NASA, & D. A. Vakoch (Ed.), *Psychology of Space Exploration* (pp. 17-45). Washington, D.C.: NASA.

NASA. (2012, July 23). *Ham Radio.* Retrieved from International Space Station Reference: http://spaceflight1.nasa.gov/station/reference/radio/

New Scientist Staff. (2007). Astronauts and Cosmonauts React Differently to Stress. *New Scientist, 195*, 19.

Qualtrics. (2013, February 23). *Qualtrics*. Retrieved from Qualtrics: https://www.qualtrics.com/

Rygalov, V. (2012, December 6). Life Support Areas. (A. Wargetz, Interviewer)

Santy, P. A. (1997). Behavior and Performance in the Space Environment. In S. E. Churchill, *Fundamentals of Space Life Sciences* (pp. 187-201). Malabar: Krieger Publishing Company.

Sengupta, P. (2012, July). Health Impacts of Yoga and Pranayama: A State-of-the-Art Review. *International Journal of Preventative Medicine, 3*(7), 444-458.

Sherrod, R. (1975). Men for the Moon. In E. M. Cortright, *Apollo: Expeditions to the Moon* (pp. 143-166). Washington, D.C: NASA.

Stepaniak, P. (2011). Astronaut Health Care. In W. Hale, *Wings In Orbit: Scientific and Engineering Legacies of the Space Shuttle* (pp. 403-407). Houston: NASA Johnson Space Center.

Stuster, J. (2010). *Behavioral Issues Associated with Long-Duration Space Expeditions: Review and Analysis of Astronaut Journals.* Houston: NASA.