Flashline Mars Arctic Research Station (FMARS) 2009 Crew Perspectives

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Abstract

A crew of six 'astronauts' inhabited the Mars Society's Flashline Mars Arctic Research Station (FMARS) for the month of July 2009, conducting a simulated Mars exploration mission. In addition to the various technical achievements during the mission, the crew learned a vast amount about themselves and about human factors relevant to a future mission to Mars. Their experiences, detailed in their own words, show the passion of those with strong commitment to space exploration and detail the human experiences for space explorers including separation from loved ones, interpersonal conflict, dietary considerations, and the exhilaration of surmounting difficult challenges.

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I. Introduction

IN July 2009, six 'astronauts' embarked on a mission to test the bounds of human exploration of other planets here on Earth. These six formed the twelfth crew of the Mars Society's Flashline Mars Arctic Research Station (FMARS) on Devon Island in the Canadian Arctic. The one month mission included over one week of habitat preparation and modification for environmental auditing and over two weeks of simulated Mars exploration mission including Extra Vehicular Activity (EVA). EVAs included excursions to interesting sites in the vicinity to test the capabilities of astronauts in spacesuits conducting meaningful experiments including geological sample collection, seismic station deployment, and taking geophysical measurements on a planetary surface mission. The crew also tested the application and usability of scientific equipment such as an unmanned aerial vehicle (UAV), high power laser therapy (HPLT) medical device, and satellite communications in the simulated Martian mission environment. The technical accomplishments of this crew were vast and are discussed in partial detail where relevant in this presentation. However, the main focus of this document is to discuss crew *perspectives* on the mission, e.g. how did crewmembers perceive situations differently? What were the challenges experienced by the crewmembers as individuals and as a team? How were interpersonal relations affected by issues such as generation gap, diversity of background and training, and personalities? The following sections provide insight into these issues beginning with an overview of the continuing FMARS project and major objectives of FMARS 2009, followed by individual discussions by each crewmember on issues of their choice. To conclude, the FMARS crew provides their recommendations to improve human factors for future planetary missions and simulations.

II. FMARS Introduction

As part of a Mars Society initiative to promote human settlement of Mars using the Mars Direct architecture[1], FMARS was designed to simulate a habitat for astronauts on a Martian surface exploration mission. The tough external walls of the cylindrical "tuna can" module are made of corrugated fiberglass which provides exceptional insulation and protection against wind, snow, and water damage.

Fig. 1: The FMARS 2009 Crew immediately before leaving Devon Island at the conclusion of the mission. The twin otter plane can be seen in the background on final approach. From left to right: Stacy Cusack, W. Vernon Kramer, Christy Garvin, Brian Shiro, Kristine Ferrone, Joseph Palaia IV.

FMARS was constructed through considerable peril in July 2000[2] on Devon Island in the Canadian Arctic, the largest uninhabited island in the world. The habitat (or "Hab") is 8.81 m in diameter and 7.66 m tall at the top of its domed roof[3], containing enough living volume for 6-7 crewmembers on missions ranging from one to four months in duration. The Hab contains a science laboratory, engineering space, exercise equipment, hygiene facilities and two simulated airlocks on the first floor. The second floor is dedicated to crew accommodations including desk space, kitchen facilities, a dining table, and six small staterooms. A loft above the second floor provides storage for consumables and a possible seventh sleeping area.

Transportation around the terrain is by foot or via gasoline-powered all-terrain vehicles (ATVs) with attachable trailers for carrying cargo. The rented ATVs are very old; this caused considerable trouble during FMARS 2009 as will be discussed in a later section. Starting the ATVs and keeping them running during an extended mission from the Hab was a tenuous assumption, and often caused worry that crewmembers would be left stranded.

Fig. 2: Kristine Ferrone on a trip to Lowell Channel to collect water for the Hab via the primary mode of transportation: the ATV. The water jugs are pictured in the ATV trailer.

Fig. 3: Kristine Ferrone filling water jugs from Lowell Channel during potable water resupply trip. The ATV and trailer are in the background.

The potable water supply is taken from Lowell Channel, approximately one half mile away from the Hab. Five gallon plastic jugs are transported to the stream via ATV trailer (Fig. 2), filled manually by the crew (Fig. 3), and returned to the Hab. Water is treated with a weak bleach solution and stored in a reservoir in the loft. Gravity and a small pump provide the water pressure for sinks and the shower. Conservation of water was not only a simulation mission objective, but also an operational goal as collection of water required the investment of crew time and ATV resources that could be better spent on science objectives.

Crew selection is conducted by Mars Society officials, beginning with a call for volunteers posted on the Mars Society homepage[4]. Applicants are informed from the beginning that they will receive no pay and be responsible for their own transportation costs to and from Resolute Bay on nearby Cornwallis Island – upwards of $5,000 - $6,000 for round trip airfare. Applicants are evaluated on their academic and research experience as well as their ability to arrange for and conduct their own experiments at the Hab. Crew dynamics and diversity are also considered. Final crew selections for FMARS 2009 were made a few months before the mission, and the crew had the opportunity to meet for one weekend pre-mission training session on "Earth" to discuss mission objectives, communications with Mission Support staff, shop for arctic gear, and design the crew patch (Fig. 7).

Expenses, lodging, and food are provided by the Mars Society once the crew arrives in Resolute Bay via commercial airline. Small twin otter planes are chartered by the Mars Society to deliver the crew to and from Devon Island from the Resolute Bay outpost; flights are highly dependent on weather conditions and can be postponed for days at a time with little notice. At any point during the stay in Resolute Bay, even at midnight when the sun is shining brightly, a knock at the door can be the notification of an imminent takeoff of a twin otter. The crew must then scramble to gather all the equipment and supplies, hitch a ride to the Resolute Bay airport, and begin loading the plane with the assistance of the flight crew (Fig. 4). Crewmembers are strapped into fold-down seats in the rear of the twin otter cabin, often right next to barrels of fuel, all-terrain vehicles (ATVs), luggage, or boxes of food (Fig. 5). The flight to the Devon Island 'airstrip' lasts only about 30 minutes. Landing on the makeshift landing strip can be rough depending on arctic winds on the Island. A few flags mark the location of a relatively flat and rock free area of Devon Island next to Haughton Crater. Crew and supplies including ATVs, and full-size fuel barrels are off-loaded from the plane via a small ladder. ATV trailers serve as transportation for large cargo items, crew personal luggage, and fuel barrels. The drive from the airstrip to the FMARS Hab is relatively short but involves crossing Lowell Channel and forging a fairly steep slope which is ice- and snow-covered in early July and can be difficult to traverse. The FMARS 2009 crew spent long hours shoveling and scraping that pathway in order to deliver cargo and water supplies to the Hab.

The doors to the Hab are never locked as a sign of arctic courtesy. It is available as shelter for anyone stranded over the long, dark arctic winters. These front and rear exits to the Hab are designed as simulated airlocks; the crew will wait inside for a designated period of time before and after each Extravehicular Activity (EVA) to simulate atmosphere depress and repress. Immediately inside the front airlock is an EVA preparation room for keeping spacesuit components, potable water supplies, and cold weather gear. The majority of the Hab first floor houses laboratory space and engineering tools and equipment. A treadmill, exercise cycle, and dumbbells are also available for crew physical activity during the mission.

The remaining space on the first floor houses hygiene facilities including a small shower stall, sink, and inoperable Incinolet toilet. Since one of the objectives of simulated missions to FMARS is to model consumables usage, the crew will only be allotted one shower per week during their stay to conserve water. Toilet facilities include a small bucket for liquid waste which is emptied into a funnel leading to a 55 gallon drum under the Hab. The urine drums are flown back to Resolute Bay via return flights on the twin otter (sometimes seated next to the crewmembers). Solid waste is collected in plastic bags and burned in an incinerator outside the Hab.

Fig. 4: Loading the twin otter with supplies for FMARS – fuel barrels, personal items, and food.

The second floor of the FMARS Hab is designated for crew living space. A dining/working table sits in the center with folding chairs and desk space is distributed around the curvature of the walls. The kitchen is limited but adequate including a camp stove, miniature refrigerator, toaster oven, microwave, coffee maker, sink, and cabinet space. Along the back wall are six tiny crew staterooms with room enough only for a narrow sleeping plank piled with sleeping pads and blankets and a small shelving unit for storing clothing and personal items.

Food is selected by the crew and flown before the mission into Resolute Bay from the nearest grocery store in Yellowknife. In order to simulate long-duration spaceflight, food selections are limited to items that have a shelf life of one year or more. The groceries are delivered to the Hab with the crew in cartons and is organized and stowed in the cabinets for the duration of the mission (Fig. 9). Surplus items are stored in the loft above the crew staterooms (Fig. 10). Items such as canned meat, vegetables, and fruits, dried pasta and rice, jarred sauces, and popcorn and potato chips are commonly requested. Resources such as cooking oil or butter and any refrigerated or frozen items are scarce and highly valued treasures to the crewmembers.

Fig. 5: View from the crew seat on the twin otter flight. Boxes of food are in the background, an ATV is in the middle, and fuel barrel to the right.

Power is provided to the Hab by diesel generators located in a shed approximately 50 feet from the back exit and connected via long power cables. The noise from the generators is considerable, but stifled by the shed and distance from the Hab. The generators must be refueled every 8 hours to ensure a continuous power supply to Hab electronics and appliances. Power dips are common when the generator is running low on fuel, so a small, uninterruptible power supply was deployed during the FMARS 2009 mission to ensure continuous power to the satellite internet, wireless router, and hard drive archive.

The atmosphere inside the Hab was initially extremely humid, causing water to condense on the domed roof and begin dripping. Two dehumidifiers running continuously were required to maintain comfortable humidity levels. Temperature is generally stable due to the excellent insulation provided by the Hab’s thick walls. Yet the first floor would often become cold and require the use of space heaters for comfortable working conditions in the laboratory. During oven operations on the second floor, the living areas could become quite warm as well.

The day/night cycle on Devon Island does not mirror that of Mars; at such high latitude, during the summer FMARS experiences 24 hour daylight. This caused early FMARS explorers to construct window covers to deploy around 10pm each night to simulate darkness and encourage the crew to go to sleep. This method was fairly effective for most crewmembers to get into a normal sleep cycle. The major obstacle to adequate sleep for the crew was the activity of the other crewmembers late at night or early in the morning. A video tour of the Hab by the FMARS 2009 crew can be found on YouTube (http://www.youtube.com/watch?v=_eSTtZEQu68).

One additional consideration on Devon Island that is not present on Mars is the threat of polar bear encounter. The FMARS crews all receive a briefing on the likelihood of polar bear encounters and how to respond most effectively. Loud projectile flares called ‘bear bangers’ were carried with each crewmember on EVA as personal protection. One crewmember out-of-simulation (i.e. no spacesuit) followed each EVA team as safety watch and carried a shotgun for contingency protection. Neither of these personal protection methods were needed during FMARS 2009 as no polar bears were sighted at any time.

The fidelity of the simulation during the FMARS 2009 mission was limited by many external factors including environmental compliance issues as well as marginal or inoperable ATVs. The expected limitations of water collection and ‘polar bear watch’ were minimal in comparison. The Hab itself was quite effective in simulating Martian living conditions and provided the opportunity to collect valuable data on human factors issues that are discussed in the following sections.

III. FMARS 2009 Mission Objectives

The FMARS 2009 crewmembers and mission support team convened in Denver, CO in May 2009 to discuss overall mission objectives and planning. The following priorities were identified:

1. Maximize ‘in sim’ time, i.e. time spent in as full Martian simulation conditions as possible including wearing spacesuits outside the Hab for every exit, rationing water, consuming only food items with a shelf life of one year or more to, producing daily commander’s, science and engineering reports, and refraining from real-time communication with ‘Earth’ to simulate the communications time delay due to the large Earth-Mars distance.
2. Complete individual crew science objectives including deployment of and data collection from a seismic station, completing a time-domain electromagnetic survey of subterranean makeup, testing the effects of the HPLT device in treating crew muscle soreness and acute tissue injuries, testing Mission Planner software provided by the Massachusetts Institute of Technology in mapping pathways for exploration, researching new telemedicine protocols, locating and producing water from a gypsum deposit, performing geological studies on collected samples as necessary, deploying the Omega Envoy rover outside the Hab, and testing the UAV technology in simulation.
3. Complete crew outreach events with educators and students at Georgia Tech (via the NASA Distance Learning Network), students in April Andreas’ SMU Gifted and Talented Class, and interns at Kennedy Space Center from the FMARS Hab.
4. Complete Hab modifications for environmental compliance including digging a gray water sump, building spill containment platforms for fuel, and deploying an incinerator for burning solid waste.

Throughout the FMARS 2009 expedition, the crew monitored status of various mission objectives by displaying them on a prominent whiteboard in the crew living area of the Hab (Fig. 6). These objectives could be easily modified, assessed, or marked completed. This provided a daily reminder of goals and objectives to the crew and was discussed at each morning meeting.

A Commander’s Report was produced daily, with Science Reports and Engineering reports produced as required (approximately every three days). Journalist Reports were also produced throughout the mission to document crewmember perceptions of dynamic events such as EVAs and science experiments.

Mission objectives are also highlighted in the FMARS 2009 crew patch (Fig. 8) which displays a pictorial of the Hab and various icons symbolizing research conducted during the mission. The crew patch provided a common alignment for the crew and helped unify the six individuals into a cohesive team with common goals and objectives.

The daily schedule for FMARS 2009 was similar to the crew schedules commonly used in prior missions to FMARS and its sister station, the Mars Desert Research Station (MDRS) in Utah. The first crew rotation at MDRS described their schedule as follows:

> The schedule was to represent the simulation of an actual Mars mission. Upon waking, the crew was to eat breakfast and be ready for a 9 a.m. meeting. The goal of this meeting was to plan the EVA and other activities for the day. It was suggested that three to four people suit up for EVA each day, with more or less participating on certain days if needed. Those remaining at the Hab would serve as CapCom or perform maintenance or laboratory tasks. EVA was planned for 11 a.m. to 3 p.m. Crew members on EVA were to make sure their stomachs were full before leaving at 11 a.m. because no food was available on EVA. At 4 p.m., an EVA debriefing was scheduled to generate and send a journalistic voice report to Mission Support via email… After the debriefing, the evening meal would be prepared and eaten. After the meal, reports would be written on laptop computers and sent via email to Mission Support. If there was extra time in the evening, an organized social activity was encouraged. The crew planned to sleep around midnight.[5]

Fig. 6: Crew objectives and tasks whiteboard in the main living area

Fig. 7: FMARS XII 2009 crew patch

This generic schedule was very similar to the one chosen for FMARS 2009; Table 1 describes the generic daily schedule chosen, but this often varied significantly based on the day's events.

FMARS 2009 Daily Crew Schedule	
0800-0900	Crew wake. Time for crew to prepare and eat breakfast individually and to perform hygiene activities. Two crew members required to fuel the generator.
0900-1000	Commander's morning meeting. Time to plan the day's EVA and science activities and discuss overall objectives and status of tasks.
1000-1200	EVA Preparation. EVA crew dons spacesuits, radios, boots and gloves for EVA with the help of non-EVA crewmembers. Science equipment prepared for EVA if necessary.
1200-1600	EVA Operations for three to five crewmembers including one out of simulation 'gunner' to provide safety watch. Remaining crew to stay at the Hab and work on laboratory science or write reports and to act as CAPCOM for the EVA crew. Two non-EVA crewmembers to fuel the generator around midday.
1600-1700	EVA Ingress. EVA crew doffs spacesuits with help from the non-EVA crewmembers. Stowage of science equipment and start of data collection, reporting, debriefing.
1700-1800	Report writing including Commander's, Journal, Science, Engineering reports. One crewmember to start meal preparation.
1800-1900	Meal. Two crewmembers assigned daily to perform post-meal clean up.
1900-0000	Report writing, preparation for following day's activities, and social events.
0000	Crew sleep. Two crew to fuel the generator immediately prior.

Table 1: FMARS 2009 Daily Crew Schedule

Efforts to build and maintain a more formalized schedule for the FMARS crew included experimental usage of NASA Onboard Short Term Plan Viewer (OSTPV) software which is currently used to build and display the daily flight plan for the International Space Station (ISS) astronauts and flight controllers. However, prohibitive network sluggishness due to NASA VPN and internet connection made it infeasible to create a daily plan with this method. Yet the need for this type of electronic schedule with the ability to track resources, crew hours, and power became apparent throughout the remainder of the mission.

Despite a few planning issues, the FMARS 2009 crew was able to complete all mission objectives successfully. Outreach is ongoing, with recent presentations to middle school students, interviews on public radio as well as several feature articles published in newspapers and magazines.[6] Detailed information on daily accomplishments during the expedition and mission summary can be found on the crew's website (http://www.fmars2009.org/).

IV. Table for Six: Mars Cuisine and Nutrition

Kristine Ferrone

Astronauts on a mission to Mars will have to live with subpar cuisine as a fact of life. The unavailability of fresh produce, dairy, and meats severely limits the quality and variations of meals the crew can prepare. The limited space and electrical power available for cooking appliances further restricts the culinary options for Mars astronauts. In effort to maintain a high-fidelity simulation, the crew of FMARS 2009 suffered likewise by allowing only food items with a shelf life of one year or more to be delivered to the Hab and by cooking in the limited FMARS kitchen.

Cooking responsibilities were initially distributed evenly with all six crewmembers assigned equal turns in the kitchen, but one crewmember – me - quickly became the unofficial ‘chef’ because I actually enjoy cooking and was interested in experimenting as much as possible with the ingredients on hand. The act of preparing meals was very therapeutic for me, and I enjoyed preparing tasty meals for my crewmates to enjoy. I learned a lot about my own abilities to be creative in the kitchen - skills (and even a few recipes) which have transferred to my ‘Earth’ life as well.

Fig. 8: FMARS XII 2009 crew at the dining table enjoying a meal of pasta and vegetables

How did we end up in such a plight with nothing good to eat? The Mars Society tasked the FMARS 2009 crew to come up with a pre-mission grocery list with the rule that all items must have a shelf life of one year or more. Requests were fairly reasonable and most items were in stock at the nearest grocery store in Yellowknife, Canada and delivered as requested to Resolute Bay. The supplies were delivered to FMARS along with the crew packaged in cardboard boxes. During the first few days at FMARS, the crew organized and stowed all the supplies into cabinets and loft space for easy retrieval during meal preparation.

The kitchen facilities available at the FMARS Hab include a camp-style propane stove, microwave, toaster oven, small refrigerator, coffee maker, CrockPot®, and sink. Utensils, mixing bowls, cabinet space, pots and pans are limited but adequate with few exceptions. Bread makers have proven very popular with past crews, but unfortunately both of ours were inoperable. So I made the best of the resources available to produce the best tasting and most nutritious food as possible.

Staples in the FMARS 2009 kitchen were canned chicken, canned fruit and vegetables, dried pasta and rice, and canned soup. Baking supplies were also used quite often including flour, sugar, vanilla extract, Bisquick, powdered milk and eggs, and cooking oil. Boxed brownie and cake mixes were useful for quick desserts (when the oven was cooperating and not cooking unevenly). Fig. 9 is an image of the baking cabinet, which was used quite often.

Fig. 9: FMARS Baking cabinet. Highlights include Bisquick, powdered milk, cake mixes, sugars, various types of flour, vanilla and yeast.

Breakfast and lunch were “Fend for Yourself” as my grandmother would say; meaning each crewmember was responsible for preparing his/her own daytime meals. Usually breakfast was oatmeal, Pop-Tarts®, cookies or granola bars. Lunch often consisted of Chef Boyardee® pasta, canned soup, Cup-O-Noodles®, Kraft Macaroni and Cheese®, or leftovers from the previous night’s supper. Nutritionally, these items were fairly adequate as the crew required high levels of carbohydrates for energy during intense EVA activity. The addition of more dried or canned fruit to the daytime meals would help supply vitamins and minerals that may have been lacking in the diet.

Dinners were usually some combination of canned meats, canned beans, or rehydrated textured vegetable protein (TVP) for protein, pasta or rice for carbohydrates, and canned or rehydrated vegetables. The limited choices had the danger of becoming monotonous, so dried spices were critical to vary the taste of meals day to day. While I had fairly adequate spices to work with, I would have vastly increased my repertoire of recipes if I simply had more exotic spices such as curry powder, miso paste, fish sauce, chili sauce, or saffron. Bouillon cubes or canned broth would have been helpful as well for making homemade soup. The spices I used often were garlic and onion powders, black pepper, dried thyme, and dried basil.

Nutritionally, dinner meals were well-rounded for the crew and portion sizes were chosen carefully to provide for all crewmembers while minimizing waste from the limited food supplies. One outstanding dietary concern was the high intake of sodium for the crew. This was due to consuming excessive servings of canned meats, vegetables, and soups which contain high percentages of recommended daily allowance of sodium. This issue was fairly minimal over the one month mission to FMARS with no noticeable health effects, but it will need to be addressed in a future Mars mission of a year or more. Sustained elevated sodium intake is proven to have adverse effects on adults, including increased blood pressure[7] and increased risk of stroke mortality[8].

Fig. 10: Christy Garvin stowing food in the FMARS loft shortly after arriving at the Hab.

Snacks consisted of pretzels, crackers and chips often with peanut butter, Nutella®, or Cheez Whiz® spread on them. Seeing as our groceries came from Canada, we were never lacking adequate supply of Cheez Whiz®…

Beverages at FMARS were limited to water or water flavored with powdered drink mix, coffee, or tea. Luckily, many different flavors of Kool-Aid®, Hawaiian Punch®, Crystal Light®, Nestea®, and Countrytime® Lemonade were on hand to provide variety for beverages. The added challenge was the lack of ice for the drinks; the FMARS refrigerator was tiny with an even tinier freezer which was not capable of producing enough ice to chill drinks for the crew. The semi-cool water was the only option and was adequate but tiring over the duration of the mission.

Some favorite recipes at FMARS 2009 were BBQ Chicken, Spaghetti, and Chicken Pot Pie. Vernon's wife packed a folder of recipes for him to bring to FMARS, some of which were so tasty that I still make them at home including Turkey Patties, Fruit Cobbler, and Biscuits. I also brought along some family recipes including Peanut Butter Kiss Cookies (hands-down the crew favorite recipe), Pierogi, and Spinach Chicken Casserole. Details from selected FMARS recipes which could be prepared on a future mission to Mars can be found in Fig. 11 and 12. The comfort provided by familiar smells and tastes of favorite recipes can have a significant boost on crew morale. Therefore, it is imperative that future Mars exploration missions take this into account and provide adequate supplies and equipment for preparing wholesome, satisfying meals and not just Meals Ready to Eat (MREs) or other freeze-dried equivalents.

Fig. 11: Selected Crew Favorite Recipe: Peanut Butter Blossoms

Peanut Butter Blossoms

48 Hershey's® Kisses	2 T Milk
1/2 C Shortening	1 t Vanilla Extract
3/4 C Peanut Butter	1 1/2 C Flour
1/3 C Sugar	1 t Baking Soda
1/3 C Light Brown Sugar	1/2 t Salt
1 Egg	Granulated Sugar

1. Heat oven to 375º. Remove wrappers from Kisses.
2. In large bowl, beat shortening and peanut butter until well-blended. Add 1/3 C granulated sugar and brown sugar; beat until light and fluffy. Add egg, milk, and vanilla; beat well. Stir together flour, baking soda, and salt; gradually add to peanut butter mixture. Shape dough into 1-inch balls. Roll in granulated sugar; place on ungreased cookie sheet.
3. Bake 8-10 minutes for until lightly browned. Immediately place a Kiss on top of each cookie, pressing down so cookie cracks around edges. Remove from cookie sheet ato wire rack. Cool completely. About 4 dozen cookies.

Fig. 12: Selected Crew Favorite Recipe: Mrs. Kramer's Fruit Cobbler

Mrs. Kramer's Fruit Cobbler

1 C Bisquick®
1 C Milk
1 C Sugar
1/4 C Butter
1 can any fruit

1. Heat oven to 350º. Melt the butter in 8x8 baking pan.
2. Mix together Bisquick, milk, and sugar. Pour into pan.
3. Add can of fruit, do not drain. Stir slightly.
4. Bake about 1 hour, serves 6.

V. Is it OK To Be Almost 69 Years Old For A "Space" Mission?

Walter Vernon Kramer

You can be a "senior citizen" and still contribute significantly to a (simulated) Mars mission! This was tested with the Mars Society FMARS 2009 mission, where I was chosen to be Commander of the mission at age 68 (birthday September). You can take on any space mission as long as you remain healthy (mentally and physically) and are driven to make a mission successful.

Unknown to many, there is no set age restriction with the NASA astronaut recruiting program. The average age of NASA astronaut candidates at the time of selection is 34[9], but many fly well into their 50s.

What is the history of senior citizens in space? Alan Shepard was 47 when he went to the moon[10]. The oldest person in space record is held by John Glenn at age 77 (1999)[11]. Mike Melvill at 63 piloted SpaceFlightOne Flight 13P (2004)[12]. AstronautVance Brand made his last shuttle flight at age 59[13], and astronaut Karl Henize made his inaugural space flight at age 58[14]. So there are examples of seniors pushing the envelope in human spaceflight.

Fig. 13: The FMARS Habitat on Devon Island

Participating on a simulated Mars mission at my age should not be considered that unusual. One thing for sure, my age was not a major handicap to complete this mission. It was the numerous "glitches" with our habitat and the all-terrain vehicles (ATVs) used as simulated Mars rovers that provided "handicaps" and obstacles to completing a successful mission.

The personnel for the FMARS 2009 mission were knowledgeable, highly educated, and motivated; an exceptional crew who all brought their own set of knowledge and skills… And they were basically half my age. This meant that there were a certain set of social and cultural differences that we all had to overcome.

Internet social networking skills are an integral part of the present day generation and my crew were experts at this. I personally had not appreciated how important the application of these networks is to the audience of people who are interested in the space program. I should have known about this and should have been prepared for this since I teach at a community college. But my crew members eagerly provided information to the world in these formats – for which I was grateful. Internet social networking is a fact of life today.

Thankfully the crew and I were all knowledgeable about using Google and the internet in quickly solving problems. For example, we used the internet to find a method to clean shotguns, to clean ATV carburetors, to find certain menus and the list goes on.

My career as an engineer and my age allowed me to have a wide range of experiences. This came in handy for items like hooking up pumps and plumbing, building oil spillage platforms, changing oil filters with generators, hooking up butane tanks, etc. These are skills that only time provides you (although they can eventually be looked up on the internet).

The first "age cultural difference" was brought to the forefront was when the entire crew sat down to watch the "humorous" *Mars Attacks* DVD. One crew member commented "that I just wasted two hours of my life that I will never be able to recover." Most felt that showing this movie to POWs would allow information to be gathered without any other form of torture. This shows that movie preferences change with each generation.

A minor event was the discovery that my crewmates really weren't into country music. This was a major cultural shock to me that this highly-educated generation would not think Willy Nelson an icon. This is probably caused by their upbringing in states along the eastern seaboard. When I think about these musical encounters now, I have to laugh at our various comments about what makes the best type of music.

A personal problem that comes with age is the obsession that problems must be addressed immediately and solved before taking a day of rest. Seniors have a tendency to feel this way because we have learned that very soon another emergency will rear its ugly head. I had to back off several times and allow some recovery time (but probably not as often as I should have).

As I have become a senior, I have become accustomed to needing less sleep and awaking early in the mornings. This had both advantages and disadvantages at the FMARS habitat. The advantages included having quiet time to reflect on what transpired throughout the crew day and thinking about methods to resolve current crises. The disadvantage was trying to remain quiet while the younger generation crew were getting their needed rest and fulfill the natural desire to sleep until noon (which I wish I could train myself to do).

My senior physical well-being status was not a detriment to moving and lifting heavy objects (you learn to use leverage). Although I am still physically flexible, I saw that I was more deliberate and cautious in handling situations where a wrong step could lead to an injury. While I was successful in meeting the physical challenges in the simulated Mars mission environment here on Earth, it is important to note that astronauts on a real mission to Mars would have to face issues of bone and muscle atrophy due to microgravity exposure – effects which have more pronounced effects on senior citizens[15]. Hopefully, scientists can solve this physiological dilemma for the sake of all astronauts and to level the physiological playing field for senior citizen astronaut candidates.

Should age be considered for space programs? My experience with the FMARS 2009 mission demonstrates that age should not be a detriment to enter any field of endeavor, including the space program.

VI. My FMARS Odyssey and Beyond

Brian Shiro

When I first learned of my selection for FMARS, I was elated. Although I'd previously spent considerable time in the Arctic and Antarctic, it had been nearly six years since my last major field expedition. I needed to return to the wild to keep my field science skills nimble. However, almost as soon as I stopped jumping for joy at my selection, I paused. This would mean leaving my then 18-month-old son behind. He and I are very close, and I'd never been gone from him for more than a few days. Plus, I wasn't sure how my wife would take the news that I wanted to go play astronaut and leave her to care for him alone. I broke the news to her later that evening on our family walk together. To my relief, she supported me. Having just gone through a year's worth of the NASA astronaut selection process and then not making the cut, I think she realized I needed this. Sure, FMARS would be expensive in terms of both time and money, but I proudly emailed Robert Zubrin the next day and told him I would accept his offer.

The crew that Zubrin had himself personally selected for the twelfth FMARS mission had impressive resumes, and I was honored to be among them. We quickly got to know each other virtually over email, phone, and Facebook. Later, we all met in person for a whirlwind weekend in Denver to finalize our mission plans. Soliciting donors to help fund the expedition became almost a full time job, and we all had varying degrees of success finding money.

Living off the land on Devon Island was a soul-cleansing experience that I wish everyone could have. One must be keenly aware of the inputs and outputs required by living in an enclosed habitat. This includes collecting water, dealing with gray water, and properly disposing of waste products. I personally enjoyed that sense of closeness to the environment, although constantly having to get water, burn trash, carry drain water away, etc. did detract from the fidelity of our Mars mission simulation. Having a more automated life support system would be better. One thing we learned is that living on Mars is hard work. Most of us didn't carve out extra time specifically for exercise, but I tried to as much as I could. I think real astronauts will need to exercise daily to stay fit for the rigors of Mars.

Fig. 14: The EVA 8 crew of Brian Shiro, Christy Garvin, Kristine Ferrone and Stacy Cusack with Brian's EM survey equipment.

Throughout the mission, most of the crew were actively promoting our activities on the social media services. Prior to the mission, we had an interesting debate with Sheryl Bishop, a human factors researcher, about the pro's and con's of having a crew directly send updates like this. She pointed out that on a real mission, such communication would likely be filtered by mission control and that if we really want to have a simulated Mars mission we might consider doing that as well. Likewise, crews on a real mission won't have the live internet as a resource, and we considered archiving portions of it like wikipedia for use offline while at FMARS. However, in the interest of having direct public relations and information access, we opted to just use the internet much like we normally would subject to the simulation's required 20 minute communications delay.

As the crew's geophysicist, I brought two experiments of my own to the mission. One was to install and operate a seismic station to record earthquake activity, and the other was to conduct an electromagnetic survey to search for groundwater. Seven out of our mission's sixteen EVAs were devoted to these two projects, and I ended up logging nearly 29 hours of EVA time – the most of any crewmember. The seismic project unfortunately did not return any useful data, but the electromagnetic soundings have provided some useful constraints on the resistivity of the subsurface near the FMARS habitat and an upper bound of how deep the groundwater is there. One main lesson learned is that terrestrial geophysical equipment will need modification for use by astronauts given their limited dexterity and visibility within space suits.

Another unique contribution I made to the mission was coordinating the collection and presentation of geographic information for all EVAs. On each EVA, a crewmember wore my Garmin Forerunner GPS watch and heart rate monitor to gather concurrent GPS track and heart rate data (Fig. 15). Crewmembers also captured geotagged photos using a Nikon P6000 GPS-enabled camera. After each EVA, I combined this information within Google Earth to produce graphics for display on the FMARS website. This allowed anyone to follow not only our tracks but also see what we saw with the geo-referenced photos.

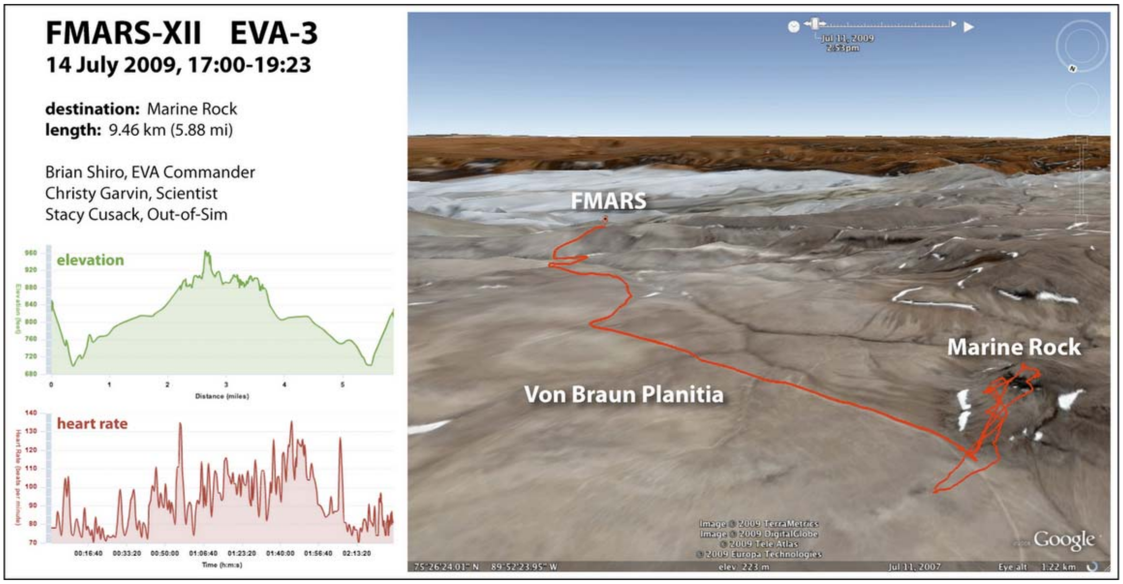

Fig. 15: Brian's graphic for EVA 3 to Marine Rock displaying the GPS path, elevation, and heart rate data from the Garmin Forerunner GPS watch.

Absence makes the heart grow fonder. That's one of the lessons I learned during the FMARS expedition. It was difficult being away from my wife and son for so long. However, every few days my wife would post photos and videos of their activities, so I never felt too far removed from what they were doing. I think having a connection back to normal life on Earth is important. Having to write emails to one another probably brought us closer together since in our daily lives we don't communicate in that way. I've noticed this phenomenon on more than one extended trip away from home.

In summary, I think we had a good crew and despite having a shorter formal simulation than we had planned, we successfully met all of our mission goals. This is a testament to our effectiveness as a crew. However, I think if the mission had gone on much longer, we may have had some interpersonal issues. By the end of the mission, I noticed some problems with motivation for some crewmembers. This manifested itself as increased complaining or an unwillingness to write daily reports. To some degree, pre-mission screening and training ahead of time could mitigate this. The interpersonal issues experienced during our mission mirror those commonly observed in polar missions suggesting that personal compatibility, long-term unit training, a clear command structure, and drawing crews from a common cultural background are necessities for crew development for long-duration missions[16].

My FMARS experience opened doors for me that I would not have otherwise had. For example, I was featured no less than ten times in the news media, and I gained some modicum of notoriety for it. My contacts in the social media spheres roughly doubled too. About three months after returning from FMARS, the Mars Society selected me to command the 89th mission to the Mars Desert Research Station (MDRS) in Utah, the sister facility to FMARS. As I write this, I have just returned from my second Mars mission and hope this experience helps me to one day leave my own boot prints on the real Mars.

VII. ATVs, EVAs, UAVs and Tough Fun in the High Arctic

Joseph E. Palaia, IV

From my perspective, FMARS 2009 was a lot of hard work, but it was also a fun and very rewarding experience. I have been a passionate supporter of manned Mars exploration for a long time, and when I was selected for FMARS, I knew that this would be a great opportunity to learn more about what it would really take to send a group of explorers to live on the Red Planet. I was honored to be selected, and even more honored to have the opportunity to work with such an incredible group of fellow crew members. We had our good days and our bad, but we endured the trials of an arctic summer together, and I am glad to have shared the experience with them.

Fig. 16: Joe working on his laptop in the FMARS airlock, looking for online manuals for the Honda ATVs. A partially disassembled ATV appears in the background.

I found myself wearing a number of different hats leading up to and through the course of the expedition. Initially, I considered myself an instigator, as I convinced Vernon Kramer, my colleague from 4Frontiers, to also submit an application for the crew. He was selected as the expedition's Commander and I as his Executive Officer. Vernon and I share a zeal for adventure, and a work ethic which demands getting things done, and doing them right. Sharing these beliefs, I feel, made us good working companions.

I felt that it was my job, as Executive Officer, to support Vernon in the decisions that he made for the crew. He and I would on occasion break off from the rest of the group for some private discussion to debate the direction the mission was going and discuss appropriate paths forward. I always tried to have these conversations in private with him, so that it did not appear that I was challenging his authority in front of the rest of the crew. I hope that he found comfort in my counsel as the mission progressed, as I did in his, and I appreciate his thoughtfulness, sound judgment, and witty sense of humor.

After being selected for the Crew, but before we actually departed for the Arctic, I found myself working as a fundraiser. I took it upon myself, along with the help of my fellow crew members, to work at obtaining financial donations to offset the costs of the mission and equipment for use in scientific investigations in the Arctic. This was a natural role for me, as I am currently the co-founder and Vice President of an entrepreneurial space startup company. My past experience has taught me that you will be amazed at what you can get if you only have the courage to ask. That experience served me well as we were able to raise sufficient funds to cover my airfare to and from the Arctic as well as obtain an Unmanned Aerial Vehicle which we used for surveys of Devon Island, a prototype lunar rover, and a software package to help plan EVAs.

This leads to another role that I assumed, that of UAV operator. Prior to the mission, I was able to convince an innovative and forward looking company, Prioria Robotics of Gainesville, FL, to loan me an incredible piece of technology - the Maveric UAV. Over the course of two days, I was trained in its operation and gained experience flying it. Then on Devon Island, I became the first person in history to launch and operate a UAV while wearing a simulated space suit. I conducted a series of flights, with the help of my fellow crew members, gathering imagery and operational experience that proved the utility of using UAVs during manned surface exploration. I hope to continue this line of research in the future..

Fig. 17: Joe and Kristine preparing to launch the UAV from Maveric Flats. The control laptop sits on a platform Joe built as a power converter from the ATV battery to the laptop.

Another role that I assumed for the mission was Chief Engineer. I consider myself a jack-of-all-trades, and as such I felt comfortable assuming this role. I learned very quickly that an engineer can be a good thing to have in a remote environment! If possible, bring two or three! I always found myself with something to fix or something to build. Many of these tasks were caused, with little doubt, by the age and condition of the equipment that we were forced to rely on. This being said, I believe that any mission to Mars will likely see a similar number of maintenance and repair tasks to be performed. The truth is that harsh and remote environments like the Arctic act in often unpredictable ways on technology and hardware. What you need in these situations is an inventive mind, a drive to succeed and the perseverance to overcome the challenges that face you.

My biggest challenge by far involved our All Terrain Vehicles (ATVs). These borrowed vehicles were our only means of transportation around the island (other than by walking) and as such it was critical that they perform reliability. Unfortunately, as vehicles tend to get as they age, these were highly unreliable. They would cough, they would sputter, they would die without warning. At times you would crank them until their batteries died, and at others, they would start at the first push of the button, only to die a few feet down the road. When the first ATV died halfway between the airstrip and the habitat, I suspected we might be facing a challenge. Several days later when four of the five were out of commission, I knew something had to be done that would most likely require a considerable investment of crew time. This was not surprising seeing as equipment troubleshooting and maintenance has eaten up crew time in Mars Society missions since the start. As reported by the first crew of FMARS sister station MDRS, "Significant contributing factors to the lack of a strict schedule at MDRS were operations and engineering-related factors. Not unlike current space missions, significant man-hours were devoted to maintenance, repair, and improvement of Hab systems."[17] I had similar experience, as I spent significant time at FMARS troubleshooting these machines. It is important to note that until a few days prior to this, I had never even ridden one before, let alone troubleshot its systems! So what was to be done? Initially we tried everything we could think of. We blew out the air filters. We cleaned and reseated the spark plugs. We tried replacing the plugs and re-gapping them. We blew out the fuel filter caps and tried running with them loose. Nothing seemed to work.

For the first time since I had arrived in the Arctic, I got out my credit card. Using the Hab's satellite internet link, I was able to use Google to search for and purchase the ATV's service manual, which I downloaded as a PDF. At the same time, I conversed with family in New Jersey (brother and father who have both rebuilt car engines) and mission support in Denver, CO. With their help, we were able to arrive at a likely diagnosis, as well as develop a strategy to fix the problem. The following days' activities included removing the carburetors from each of the ATVs, completely disassembling them, boiling them in soapy water, and drying them in the Hab's laboratory oven (carburetor stew, anyone?). Amazingly, the reassembled and reinstalled carburetors seemed to solve the majority of our problems! The vehicles were much more reliable for the remainder of the mission.

I consider my efforts to fix the ATVs a personal triumph, and I am proud to have gotten the vehicles in working, reliable condition in time for the crew to appropriately celebrate the 40th anniversary of the Apollo moon landing. On this day, July 20th, the crew conducted the longest and most challenging EVA of our entire mission. We traversed 36.44 km to an extensive deposit of breccias, a region known as Gemini Hills. There is something be said for traveling in beautiful places. The traverse to and view from Gemini Hills was truly a breathtaking experience. We captured some of the essence of the experience through high definition video and stills, but until you work alongside a team of scientists and engineers, feeling the crunch of gravel beneath your boots and standing upon the precipice with only the wind on your helmet and whirl of air from your suit, you will never know what it means to explore a new world. For one short month, that was my honor. Perhaps someday, I will repeat the experience only this time, the sky will not be blue.

Fig. 18: Joe taking in the scenery after summiting a peak near Gemini Hills during EVA 9

VIII. Health and Safety Officer Observations

Christy Garvin

As mankind decides to explore farther and farther from our home planet, there will be numerous challenges regarding both physical and psychological health. Crew members will face many new stressors and dangers that will have to be addressed, and when it is not feasible to return to Earth for medical care, a different mindset and level of both training and equipment will be necessary to ensure crew well being. As the Health and Safety Officer for the 2009 FMARS field season, I made many observations concerning the healthcare of crew members.

The first observation concerns the psychological makeup of the 2009 FMARS crew with regards to personal safety and risk. As is the case with most explorers and adventurers,[18] the members of the 2009 FMARS crew tended to be individuals who were very comfortable with a certain degree of risk. The potential for danger was quite evident on Devon Island; quicksand type mud, polar bear encounters, extreme weather conditions, riding all terrain Vehicles (ATVs) on steep rocky terrain, and atypical travel conditions were all possible situations crew members might encounter. These dangers were understood and accepted by all crew members, but this ability to accept risk seemed to translate into a willingness to take some unnecessary risks. There were times when crew members chose to ride ATVs on hazardous terrain (Fig. 19) without helmets, went to get water without a spotter to help watch for polar bears, climbed the satellite tower without a harness, or rode on the back of an ATV, which was expressly prohibited by a safety placard. Although our crew discussed safety and set up various protocols, these protocols were quickly abandoned when following them would prove to be inconvenient or time consuming. This occurred despite the fact that we had communicated with the FMARS 2007 crew and learned the following about their mission:

Fig. 19: An example of the treacherous driving conditions on Devon Island. Brian Shiro, Vernon Kramer, and Joe Palaia are shown riding the ATVs.

> They [2007 crew] received polar bear training and always had a polar bear spotter with a gun. While they didn’t encounter any bears, they did see footprints. A big safety issue was in driving the ATVs. Every crewmember ended up flipping them at least once due to the rocky terrain, and one person hit her head pretty severely but was okay thanks to her helmet. For safety reasons, they wore motorcycle helmets since they offer more substantial protection than the simulated spacesuit helmets.[19]

Although many of the breaches in safety protocol would not be cause for alarm on Earth, the consequences could have been much more serious in the Arctic or for future explorers on Mars. Given the limited medical resources available at FMARS and the length of time required for transport, an injury which could be quickly stabilized and treated in most communities could prove quite serious in an extreme environment. This fact should encourage a paradigm shift in the way risk is viewed by crew members; any risk which is not absolutely necessary should be mitigated or entirely eliminated if possible. This seems to be a difficult mindset for individuals who are by nature explorers and risk takers; however, in a situation where definitive medical care is not immediately available, it is a state of mind which might well save the life of a crew member.

A second observation concerns workload and fatigue as related to crew health. The habitat, where the crew lived and worked, had no insulation between the living/working areas and sleeping quarters. Some crew members would arise early and others retired late, which in effect, meant that the habitat had a significant amount of noise for approximately 20 out of every 24 hours. The crew found that earplugs were of little helping in alleviating clamor, and this issue of noise is one that currently plagues astronauts on the International Space Station.[20] In addition to the noise issue, the crew work day was typically fifteen hours long and only one and a half days were allocated as “light duty days” during the FMARS 2009 field season. Crew members rarely had time to socialize with one another, watch movies, or play games in the evening, and this resulted in a crew that spent a great deal of time together, but never really got to know each other.

This lack of rest and relationship gave rise to a crew that tended to be fatigued and less able to handle the stressors of the harsh environment. This was readily seen in an inability to communicate well, annoyance over minor issues, frustration with daily tasks, less tolerance and patience than was necessary, and a greater susceptibility to illness and injury.[21] One crew member in particular struggled with an upper respiratory infection, headaches, and a general feeling of malaise for the majority of the field season. Because of the noise in the habitat this individual was unable to get the rest that was desperately needed, and was incapable of participating in the majority of simulation activities. At times arguments broke out and disagreements occurred over minor issues, which could probably have been avoided if crew members were well rested and refreshed.

From these observations, it is evident that on any type of long duration mission, crew members must receive adequate rest and time for relaxation and enjoyment. Habitats and living quarters must be constructed in such a way that work activities are not taking place near sleeping quarters and good insulation is a must. Maintaining a healthy sleep schedule is imperative as is adequate personal time and an opportunity to build and maintain strong interpersonal relationships within the crew. As individuals become tired and fatigued they are less able to work efficiently, interpersonal relationships suffer, and there is a greater likelihood for injury and illness; obviously, these are all detrimental factors regarding the success of a long duration mission.

The third and final observation concerns level of training, type of equipment, and outside support necessary for a mission where return to Earth for medical care is not practical. As an intermediate level Emergency Medical Technician (EMT), I was the crew member with greatest amount of medical training and thus was named the Health and Safety Officer. EMT's are allowed to conduct certain medical procedures under the "standing orders" of a physician, but must contact their medical director before administering care that would fall outside of those basic guidelines. For the 2009 season, Tam Czarnik, David Little, and Dan Bunker served as medical directors, and a telemed system was put in place providing almost immediate contact twenty-four hours a day. This system was tested several times during the season to make sure it would work in the case of a true emergency, and it was consistently reliable. Weekly medical reports were sent to the medical directors along with bimonthly safety reports that included examining smoke and carbon monoxide detectors, fire extinguishers, and other safety equipment located in the habitat.

Basic medical supplies such as Band-Aids, ointments, rubbing alcohol, thermometers, and medications for colds and gastrointestinal issues were readily available to all crew members. In addition, a medical bag containing a cervical collar, bag valve mask, Sam splints, and other miscellaneous medical supplies was also available for emergency situations. Should a crew member need antibiotics, pain medications, steroids, or an EpiPen, these items were kept in a locked box which could be opened upon receiving orders from one of the medical directors.

Although we did not have any serious emergencies during the 2009 FMARS field season, a great deal of thought was given to whether or not our supplies and/or medical training were adequate. Given the fact that transport to a definitive care facility could take sixty hours or more, it was my conclusion that additional equipment was needed, as there is little an EMT or doctor can do without the proper tools. The Mars Society is a volunteer organization, and as such, the cost of some of the desired medical equipment was prohibitive. However, recommendations were made to provide the following equipment should finances allow: stethoscope, blood pressure cuff, IV set up, fluids, oxygen, a Combitube, manual suction device, traction splint, backboard, and an Automated External Defibrillator.(AED).

As far as the level of training is concerned, it is my belief that all crew members should undergo a basic wilderness first aid course and at least one crew member should have the minimum of an intermediate level EMT license; obviously, having a paramedic or medical doctor would be preferable. EMT's and paramedics train to stabilize patients, but are unable to provide definitive medical care. Although this might not be a major problem for arctic missions or even missions to the moon, it would most certainly pose a much greater threat for missions to Mars or the far reaches of the solar system. Telemedicine is a very promising technology, and researchers and doctors such as Dr. Christian Otto have successfully used the technique to provide medical expertise to explores on Everest and in the High Arctic.[22] Although this system provides many benefits and will most likely be used for distant missions, it should not take the place of having a highly qualified medical professional as part of the crew. Although I am by no means an expert in this area, the time I spent on Devon Island convinced me that having a surgeon onboard for a long duration/long distance mission would be a very wise choice with regards to level of medical training.

Altogether, the time on Devon Island provided some excellent insights into the psychological and physical health of crew members. Helping explorers develop a more conservative view on taking unnecessary risks, ensuring there is adequate rest and time for relaxation, and providing the highest quality of medical training and equipment possible are all important aspects to maintaining crew health as we seek to extend human presence throughout our solar system.

IX. Observations of an Spaceflight Trainer

Stacy L. Cusack

This was my second tour as a crewmember for a Mars analog simulation. In November 2002, I was a member of the Mars Desert Research Station (MDRS) Crew 7. I spent two weeks at MDRS with an international crew from Belgium, France, Britain, and the United States. As a result, I had a decent idea of what to expect at FMARS, but I knew from my MDRS experience that you always learn new things almost every day during these simulations.

I volunteered to take part in these two missions to learn everything possible about preparing spaceflight teams and crewmembers for future Moon and Mars surface exploration missions. My goal during both tours was to bring back to Johnson Space Center (JSC) as many lessons learned as possible. I currently work at JSC as a Space Station Training Lead where I prepare astronauts and ground flight control teams for spaceflight missions. Prior to becoming a Training Lead, I supported real-time spacecraft operations in Houston's Mission Control Center where I managed the operations of the life support systems on the International Space Station (ISS). I also worked as a Spaceflight Instructor training crewmembers in the operations of the ISS life support systems and Space Station emergency response. I wanted to add the crew perspective to my repertoire to better understand how to prepare and train crewmembers and ground teams.

I quickly observed during both of my simulations that crewmembers on long duration Mars missions will face new and unique challenges compared to those in close communications proximity to Mission Control centers. Crews on Mars will need to become more autonomous and responsible for their day-to-day planning. They will need to make frequent real time decisions without the assistance of large ground support teams. The ground-centric control paradigm of today will no longer be an option due to the communications delays. In addition, the lack of regular resupply and a quick way home will require the crew to be very skilled in troubleshooting and creative repair techniques.

Fig. 20: A screenshot of an EVA traverse using Mission Planner

I also discovered that surface exploration EVAs are very different from EVAs performed in microgravity. ISS EVAs are performed by running through step-by-step procedures practiced extensively on Earth with well known conditions. Surface exploration EVAs will require crews to modify their plans regularly based on surface conditions, weather, and field observations. Crews will no longer be able to rely on the ground team for real-time troubleshooting assistance or consumables monitoring (oxygen usage, battery time, etc.). At FMARS, I tested a new software tool that may be used in the future for surface EVAs called Mission Planner. This tool is being developed by the Man Vehicle Lab at the Massachusetts Institute of Technology. The Mission Planner software can be used to pre-plan an EVA traverse to find the most efficient, and safest, route between the habitat and a desired site for exploration. This is just one example of the types of new tools that will need to be developed for surface EVAs. I also found that performing meaningful science in an EVA suit can be a challenge. The simplest tasks become complicated: picking up an interesting rock is difficult with bulky gloves, reading data off equipment LCD screens through a helmet visor is tricky, kneeling down to study surface features is challenging with a heavy back pack, and getting back up to a standing position can be even harder. Adding sturdy knee pads to the suit is a must and providing the crew with some type of hiking pole that also serves as a folding shovel/pick may be very beneficial. Supplying the crew with a good set of geologist's tools such as rock hammers, chisels, hand lenses, and samples bags is also necessary. Even more critical is a highly reliable radio communication system and rover for exploration. In order for a crew to maximize their discoveries on Mars, they will need to be able to travel long distances from the habitat to explore sites of interest. If a rover breaks down on Mars, there is no auto club to come by and save the crew - they will need to be able to repair the rover themselves, likely without much assistance from ground teams.

Fig. 21: Stacy with a rock hammer and sample bag examining a rock

Another key to mission success is maintaining the crew's health – both physical and psychological. An ISS crewmember's day is carefully planned out for them down to the minute. This daily plan is built to ensure that the crew always has sufficient sleep time, post sleep time for hygiene, off duty time, and meal time. The crewmembers also have regularly scheduled private medical and family conferences. In addition, the ISS is well stocked with medical supplies for all contingencies - minor through severe. In contrast, a crew on Mars may be planning more of their own day, medical supplies may be more limited simply due to the cost of launching equipment to Mars, and communications delays may reduce the effectiveness of private conferences. If a crewmember becomes incapacitated on ISS, there is always the option to have them return to Earth and be replaced by a new crewmember. This will not be the case on Mars. The Mission Commander and Crew Medical Officer are going to have a greater responsibility to ensure that the crew has sufficient off duty time and personal time to prevent burnout and maintain good morale. In addition, the entire crew will need to be cross trained to a sufficient extent for the mission to continue even if a crewmember needs to be taken off active duty due to an illness or injury. Keeping the crew healthy will be critical to a successful mission.

Out of all the many things I learned, the biggest surprise to me was just how critical the Commander's leadership style and crew dynamics were on mission success, efficiency, and morale. Going into the simulations, I had guessed that crew selections based on things such as technical skills, career background, multinational vs. single country, gender, marital status, etc. would be crucial to mission success. Instead, I found that these areas had almost no impact on the mission. Of course, the crew will need to be well trained in all technical aspects of the mission, but they will also need to develop the interpersonal skills needed to adapt to such a challenging environment of isolation and the unknown. Even more important is the selection of a Mission Commander who can lead a team of highly skilled individuals with strong and varied opinions in a way that promotes crew consensus, maintains fairness, balances conflicting science objectives, and prevents unnecessary crew fatigue.

X. Conclusion

The crew of FMARS 2009 faced difficult challenges, similar to those on a future mission to Mars will face. Issues such as generation differences, consumption of exclusively nonperishable food, inoperable ATVs, separation from family and friends, communication delay with Mission Support, interpersonal friction, lack of immediate medical care, fatigue, and excessive risk taking are well-documented effects of long duration spaceflight, both real and simulated. However, these issues described in the crew's own words, help to provide new insight into the different perspectives of six crewmembers on the same one month expedition. Understanding individual differences in perspectives leads to a core understanding of value systems and life experience which is vital for future crew selection and mitigation of the issues faced by the FMARS 2009 crew.

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