Observations of Crew Dynamics During Mars Analog Simulations

Lessons Learned

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Presenter Background

- Over 10 years at NASA's Johnson Space Center supporting International Space Station (ISS) Operations
- Space Station Training Lead
  - Trains astronauts and cosmonauts in the operations of the International Space Station
  - Leads simulations used to certify flight control teams who operate the systems on ISS
  - Develops training plans to prepare astronauts for future Moon missions
- Environmental Control & Life Support Systems (ECLSS) Officer
  - Managed the operations of the life support systems on the ISS
  - Supported 2000 hours of spacecraft operations in Houston's Mission Control Center
  - Worked eight Shuttle/ISS assembly missions and eight ISS Increments
- ECLSS Spaceflight Instructor
  - Trained crewmembers and ground support personnel in the operations of the ISS life support systems
  - Trained Space Station emergency response (fire, cabin depressurization, toxic atmosphere)
- Served on two Mars analog crews as a volunteer for the Mars Society

Mars Society Research Stations

- Background on The Mars Society
  - An international nonprofit volunteer organization
  - Purpose is to further the goal of the exploration and settlement of Mars
- The Mars Society conducts Habitat simulations at two locations – Utah and Devon Island
  - Habitat locations selected based on their similarities to Mars conditions
  - Research to understand technical and human factors that may be faced by Mars explorers – learning how to live and work on another planet
- Habitat description
  - Approximately 8 meters (26 feet) in diameter
  - Lower level contains two Airlocks, EVA (Extra Vehicular Activity) preparation area, “bathroom”, science lab, and engineering tools and equipment
  - Upper level contains sleep/crew quarters for 6 crewmembers, common area, computing area, and galley
  - Loft area above crew quarters for storage
- Activities outside of the Hab are conducted in mock spacesuits whenever feasible
  - For safety reasons generator fills, trash burning, waste removal, and ATV maintenance are not conducted in suits

Habitat Locations

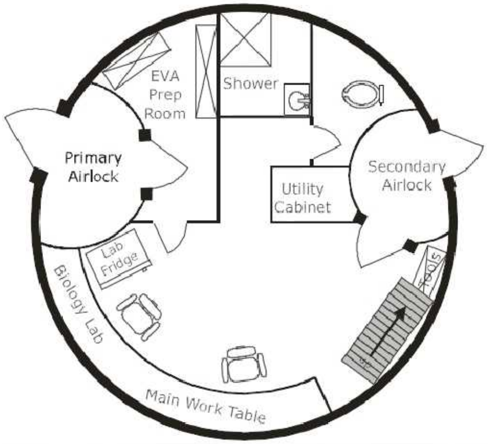
Flashline Mars Arctic Research Station (FMARS)

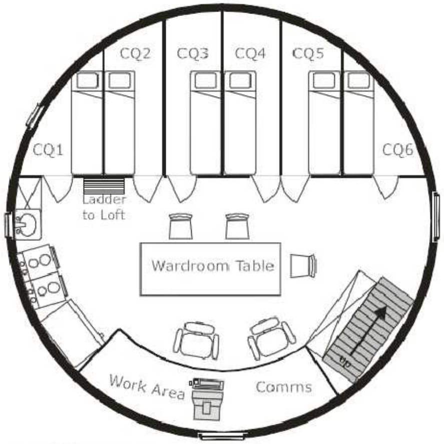
- Located on Devon Island at 75 deg North in the Canadian Arctic
- Island is completely uninhabited and unvegetated
- Habitat is located on the edge of an impact crater
- One month long simulations conducted during the month of July during the Arctic “summer”

Mars Desert Research Station (MDRS)

- Located near the southern Utah town of Hanksville
- Site is very isolated and has Mars-like appearance and terrain
- Two week long simulations conducted from November through May each year

Habitats and Mock Space Suits





Habitat Layout

First Floor – two Airlocks, exercise & work area (scientific equipment and repair/maintenance), EVA preparation and suit storage

Habitat Layout

Second Floor – computer work area, common area, galley, crew quarters

Habitat Layout

Crew Quarter (upper bunk),
Loft (potable water and food storage)

Exterior Activities

Generator shack, fuel storage,
ATVs, potable water source

MDRS Crew 7

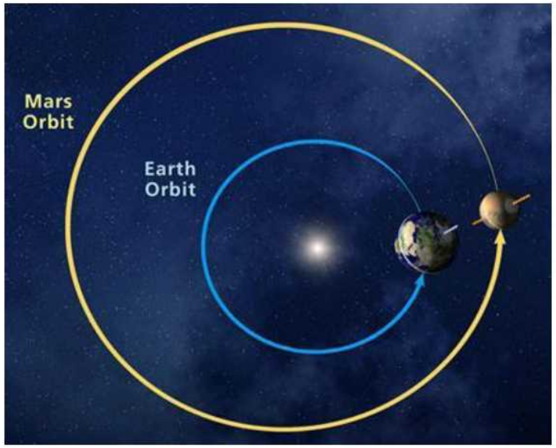
- Completed a two week tour at MDRS in November 2002
- Served as the Executive Officer, Habitat Capcom, and one of the geologists on the crew
- International crew was comprised of members from France, Belgium, United Kingdom, and the United States
- Crew Background – geologist/author, rocket propulsion system engineer, NASA flight controller, teacher, BBC news editor, and full time student
- Age range – 22 to 55 (difference of 33 years)
- Completed 24 EVAs

FMARS Crew 12

- Completed a 5 week mission at FMARS in July 2009
- Served as the EVA Lead, Capcom, and one of the geologists on the crew
- All American crew
- Crew Background – mining geologist, engineer, NASA training lead, elementary school teacher, NASA flight controller, NOAA geophysicist
- Age range – 26 to 69 (difference of 43 years)
- Completed 16 EVAs

Mars Analog Operations Philosophy

- Command structure consists of a Commander (CDR), Executive Officer (XO), and scientists/engineers/etc.
- All food and supplies are already at the Hab or are brought in with the crew
  - Generally, no resupply occurs during the mission
  - Crew has to make do with whatever is on hand for repairs
  - Very few spare parts are available due to limited storage space and limited funds
- Round trip communications time between Earth and Mars ranges from 6 to 40 minutes, averaging around 20 minutes
  - MDRS and FMARS missions typically simulate a 20 minute round trip time

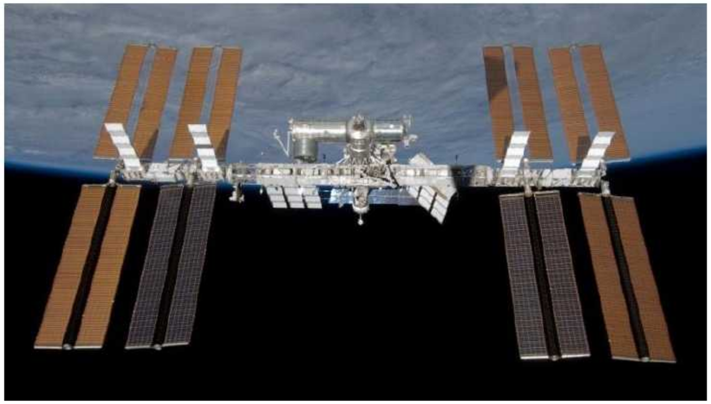


Mars Analog Operations Philosophy

- Crew responsibilities:
  - Crew is essentially autonomous due to the communications lag time
  - Required to perform troubleshooting and make decisions without the real-time assistance of ground support teams
  - Responsible for day-to-day and long term planning, as well as prioritizing mission and science objectives
  - Required to write daily reports summarizing mission activities and the status of all the Hab systems
- Mission Support team responsibilities:
  - Assists the crew with complex troubleshooting which does not require a quick turnaround
  - Provides telemedicine support
  - Provides news from home

ISS Operations Philosophy

- ISS command structure consists of a Commander (CDR) and Flight Engineers (FE)
- ISS is well stocked with food and supplies
  - Regular resupply is provided by the Space Shuttle; Russian, European, and Japanese cargo vehicles; and in the near future, Commercial cargo vehicles
  - Many systems have built-in redundancies or there are multiple systems which perform the same function
  - Numerous spare parts can be stored and are available onboard
- Communications time between Earth and ISS is essentially instantaneous
  - Communications gaps do exist due to numerous users sharing the Tracking and Data Relay Satellite (TDRS) system
  - However, in a spacecraft emergency, the gaps can be quickly closed by bumping all other users of the TDRS system and calling up additional ground stations as needed



ISS Operations Philosophy

- Crew responsibilities:
  - Crewmembers are the hands and eyes of the ground control team
  - Executes the daily plan as laid out by the Mission Control team
  - Maintains real-time situational awareness of onboard systems and environment to assist the ground team
  - Responds to spacecraft emergencies and failures which require action in 5 minutes
- Mission Control team responsibilities:
  - Performs all troubleshooting that does not require an immediate response
  - Assists the crew during emergencies and failures requiring a rapid response
  - Responsible for day-to-day and long term planning, as well as prioritizing mission and science objectives
  - Creates all of the step-by-step procedures used by the crew to execute the daily plan
  - Required to keep daily logs summarizing mission activities
  - Provides the crew with a daily status of all ISS systems
  - Provides telemedicine and psychological support

EVA Operations Shift

- EVAs will be completely different from those of today
  - Today's EVAs are performed by running through step-by-step procedures practiced extensively on Earth with known conditions
  - Surface exploration EVAs will require crews to modify their plans regularly based on surface conditions, weather, and field observations
  - Crews will not be able to rely on the ground for real-time troubleshooting assistance or consumables monitoring (oxygen usage, battery time, etc.)

Operations Philosophy Shift

- Crews of long duration, surface exploration Mars missions may require a different set of skills compared to those required of today's astronauts and cosmonauts
  - Ground-centric control will no longer be an option due to communications delays
  - Frequent real-time decisions will need to be made without the assistance of large ground support teams
  - Crews will be more autonomous and responsible for their day-to-day planning
  - The lack of regular resupply and a quick way home will require the crew to be very skilled in troubleshooting and creative repair techniques
- Decision making will largely fall on the crew rather than the ground team
  - Selections of the crew will need to account for both individual skill sets and overall team interactions and adaptability
  - Crew dynamics may make the difference between mission success and mission failure
  - Selecting a Mission Commander with the right leadership style will be critical

Decision Making Styles

- Decide Alone (autocratic)
  - CDR makes decisions on their own without crew input
  - Works if crew feels the CDR is competent and perceives that the CDR understands their views and interests
- Consult Others
  - CDR consults crew for solutions, but makes final decision
  - Works if crew believes their information is used to make the decision
- Seek Consensus
  - CDR acts as a partner with crew to make decisions
  - Works if crew has a common goal and conflicts can be resolved among themselves
- Delegate (democratic)
  - CDR empowers crew to make decisions and solve problems on their own
  - Works if crew can resolve issues themselves, have a common goal, and feel that all voices are equal

Leadership Styles

- Directing/telling
  - CDR tells crew what, when, and how to do various tasks
  - Meant for crew who are insecure or inexperienced, but committed to the mission


Gen. Patton

- Coaching/selling
  - CDR is still directing, but works to get crew buy-in


Prof. Xavier

- Facilitating/supporting
  - CDR and crew share in decision making


Gen. Eisenhower

- Delegating/empowering
  - CDR turns over responsibility for decisions to crew
  - Meant for crew who are willing and able to take the responsibility


Fantastic Four

Observations of Contrasting Leadership Styles

- FMARS Leadership Style
  - CDR primarily lead by Directing/Telling and made decisions without crew input
  - Decision style was not well suited to a group of highly motivated, highly skilled crewmembers
- MDRS Leadership Style
  - CDR primarily lead by consensus and delegation
  - Always worked with the crew as a team
  - Used all four leadership styles based on the circumstances and needs at the time
- Crew productivity was directly impacted by the leadership style
  - MDRS crew completed 24 EVAs in only 2 weeks
  - FMARS crew completed only 16 EVAs in 5 weeks

Observations of Contrasting Leadership Styles

- Crew harmony and cohesion were greatly impacted by the Commander’s leadership style.
- FMARS crew had numerous conflicts over a range of areas:
  - Task assignments, EVA and science priorities, meeting times, water usage, crew wake/sleep times, workload, etc.
  - Discussions often degraded into yelling matches
  - Crewmembers often “escaped” to their crew quarters for hours at a time avoiding all interaction with fellow crewmates
  - Crew was only allowed one day off during the entire 5 week period

Observations of Contrasting Leadership Styles

- MDRS crew had virtually no conflicts
  - EVA and science objectives were thoroughly discussed, prioritized, and planned
  - Housekeeping chores and maintenance tasks were assigned based on crew preferences whenever possible
  - “Dirty” jobs were balanced between the entire crew
  - Squabbles were handled quickly and fairly
  - Many of the crewmembers are still in frequent contact after 7 years and thousands of miles of separation

Generational Differences

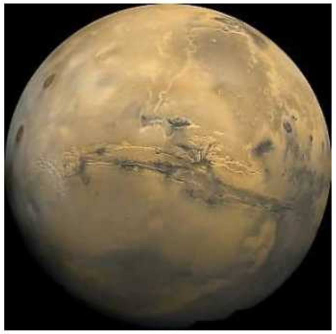
- Were some of the crew dynamics challenges generational?
  - 1980-2000 - Generation Y
  - 1965-1979 - Generation X
  - 1946-1964 - Baby Boom
  - 1925-1945 - Silent Generation
- Generation X and Baby Boomers seemed to work well together and formed a cohesive unit
- Silent Generation and Generation Y did not seem to bond with the rest of the crew

Crew Age Considerations

- Crewmembers born in the 1980's (Gen Y) were not well integrated into the crew (by choice)
  - Preferred to work solo
  - Preferred to work tasks that they picked and enjoyed
    - Selected tasks which were rewarding to them (EVAs, high profile science experiments, public outreach, etc.)
    - Did not perform "menial" or "dirty" jobs (trash & solid waste burning, waste water dumping, generator fueling, construction work, etc.)
  - Seemed to operate as "what's best for me" not "what's best for the crew/mission"
- Crewmembers from the Silent Generation had similar problems integrating with the rest of the crew
  - Daily routine was rigid and not adapted to the rest of the crew
  - Had difficulty "understanding" younger crewmembers
- NASA astronaut average selection age is 34, selection age range is 26 through 46, average age at first mission is 42

Crew Selection Considerations

- Leadership styles and interpersonal skills had more affect on mission success and crew dynamics than:
  - Technical skills
  - Career background
  - Multinational vs. single country
  - Primary Language differences
  - Political differences
  - Gender differences
  - Single vs. married
- A Mission Commander of long duration space missions will need to be able to:
  - Lead a team of highly skilled individuals with strong and varied opinions
  - Promote crew consensus without dictating
  - Maintain fairness across the crew
  - Balance conflicting science objectives
  - Prevent unnecessary crew fatigue
  - Quickly adapt and use all styles of leadership as necessary



For More Information

The Mars Society Website:

http://www.marssociety.org/

FMARS Crew 12 Website:

http://www.fmars2009.org/

MDRS Crew 7 Website:

http://desert.marssociety.org/fs02/crew07/

Facebook:

http://www.facebook.com/martian1113

Twitter:

http://twitter.com/martian1113

References

All Mars analog photos taken by MDRS 7 and FMARS 12 Crewmembers:

Stacy Cusack, Hilary Bowden, Kristine Ferrone, Charles Frankel, Christy Garvin, Vernon Kramer, Joseph Palaia, Pierre-Emmanuel Paulis, Derek Shannon, Brian Shiro, and Alain Souchier

Habitat locations map modified from: http://www.marsonearth.org/about/devon.html

Habitat floor plan from: https://shop.sae.org/technical/papers/2004-01-2369

Earth to Mars time delay, orbital diagram, and Mars photo from: http://www.jpl.nasa.gov/

Decision Making Styles from:

NASA Leadership Training – Crossroads, Sterling Institute, Jerry Bory
Decision Making model developed by Victor Vroom and Phillip Yetton

Leadership Styles from:

NASA Leadership Training – Situational Leadership, North American Training and Development, Inc., Dianne Bobko
Situational Leadership model developed by Paul Hersey and Ken Blanchard

General George S. Patton photo from: http://www.totalnavy.com/

General Dwight D. Eisenhower photo from: http://www.afrikakorps.org/

Professor Xavier with X-Men from: http://movies.yahoo.com/

Fantastic Four photo from: http://www.fanpop.com/

Generation definitions from: http://en.wikipedia.org/wiki/Generation

ISS, FCR-1, EMU photos, and Astronaut ages: http://www.nasa.gov/