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

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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
• 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
• 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

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

• Facilitating/supporting
  – CDR and crew share in decision making

• Delegating/empowering
  – CDR turns over responsibility for decisions to crew
  – Meant for crew who are willing and able to take the responsibility
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  – Political differences
  – Career background  – Gender differences
  – Multinational vs. single country  – Single vs. married
  – Primary Language differences

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

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

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

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

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