ARES Mars Desert Research Station Mission Plan

Food Production for Human Exploration, Dust Mitigation, UAV Surveying, Mineralogy, Biometrics, Astrobiology, and Astronomy

ARES MDRS Crew Scientific Research and Engineering Testing

Astrobiological Research and Education Society (ARES)
Charter Chapter at the Florida Institute of Technology
150 W. University Ave.
Melbourne, FL 32901

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Introduction:

The Astrobiological Research and Education Society (ARES) at the Florida Institute of Technology is the charter chapter of the organization and has been in existence since the fall of 2016. Three ARES members were on Crew 205 to MDRS in February of 2019 as part of the International Emerging Space Leaders Crew where they studied leadership in austere, extraterrestrial environments so they could in turn lead a crew in the 2019-2020 season. Many of our research proposals below were designed to be follow up studies to Crew 205's research. We are now returning on Crew 219 with a whole Florida Tech crew. One recently developed element of ARES operations is the Future Astronaut Corps (AFAC). AFAC is group of individuals devoted to training for and supporting human exploration simulations as mission plans are developed, to develop the skills and knowledge-base necessary for a successful habitation experiment, and to facilitate annual participation with crews and support as we continue our relationship with the Mars Society. This will provide for a mentored educational pipeline for undergraduate and graduate students from participating ARES Chapters, infusing the industry with qualified professionals with simulation experience.

ARES is based upon the fundamental vision of providing tangible research opportunities to undergraduate and graduate students, facilitating interdisciplinary cooperation among STEM disciplines, as well as educating the general public about the wider field of astrobiology. We are striving to eliminate discrimination in the sciences by incorporating a variety of academic fields and cultural backgrounds into our organization. Much of the research conducted by ARES is based on space exploration, and thus having an entire crew of ARES members to the Mars Desert Research Station is an ideal environment to test many of our scientific and engineering projects. The FIT ARES chapter wants to send a crew to MDRS every year in the hopes of providing research experiences for its members and to contribute tangible science to the common goal of putting humans on Mars.

<u>Primary Crew Member Names and Roles:</u>
Commander: David Masaitis
Executive Officer: Nathan Hadland
Lead Science Officer: Hannah Blackburn
Health and Safety Officer: Keith Crisman

GreenHab Officer: Cynthia Montanez
Crew Astronomer: Robinson Raphael
Crew Geologist: Abdul Elnajdi
Crew Engineer: Alejandro Perez

Alternate Crew Member Names and Roles:
Crew Engineer: Nathaniel Bouchie
Natural Science Officer: Alessandro Boniuto

Note: The Journalist duties for this crew will be shared between all crew members.

Acknowledgments and Partners:

The ARES at Florida Tech Crew is supported by several partners around the world including the Florida Institute of Technology, Ball State University, Compass Equipment LLC, and Anker. Moreover, outreach programs are going on using the following networks: Pi Lambda Phi fraternity (USA), Astrobiological Research and Education Society (USA), and the Student Astronomical Society. We also would like to thank several people that made this mission possible. Thank you to Dr. Andrew Palmer without whom none of us would be where we are today. We would also like to thank our outreach coordinator David Merced. Additionally, we would to thank Dr. Daniel Batcheldor, Dr. Sam Durrance, Dr. Saida Caballero, David Handy, and MDRS Crew 205 (IESL) for their support.

Crew Bios and Headshots:

Dave Masaitis -- Commander

Dave was born in 1983 and spent most of his childhood growing up along the Outer Banks of North Carolina. He was an avid outdoorsman and naturalist, constantly looking out to sea, and upwards towards the sky. He attended Space Camp three times between 1995 and 1997, and that lasting impression would resurface later in life. He graduated from Oakton High School in Northern Virginia in 2001.

Dave served in the US Army from 2002 to 2013, carrying out duties over a decade in Air Defense, Army Aviation, and later the Cavalry. He served in support of NATO operations in

Afghanistan on two occasions; first in 2007 as a UH-60 Maintenance Section Leader and Downed Aircraft Recovery Team (DART) Leader, and again in 2010-2011 as a Scout Section Leader. His military education includes the Airborne School, Sniper School, Primary Leadership Development Course, Advanced Leadership Course, Army Combatives Instructor Course, Javelin Missile Instructor Course, among others.

After leaving the Army in 2013, Dave spent a couple years as a certified gunsmith, before enrolling in Daytona State College in 2015, to study Marine Biology. While there he researched novel approaches to capturing dolphin vocalizations, before transferring to the Florida Institute of Technology in 2016. Upon arrival he declared a double-major in Astrobiology, and served as the Founding President of the Astrobiological Research and Education Society (ARES) until the Spring of 2018.

After stepping down from the board, he assumed leadership of the ARES Agricultural Robotics Team, where he presently remains. He is otherwise leading research in Recirculating Integrated Multi-Trophic Aquaculture (RIMTA) systems, intending to create a self-contained sustainable solution for food production on long-duration space exploration expeditions.

In February of 2019, Dave joined seven other young professionals as the Executive Officer of Crew 205 - The International Emerging Space Leaders crew.

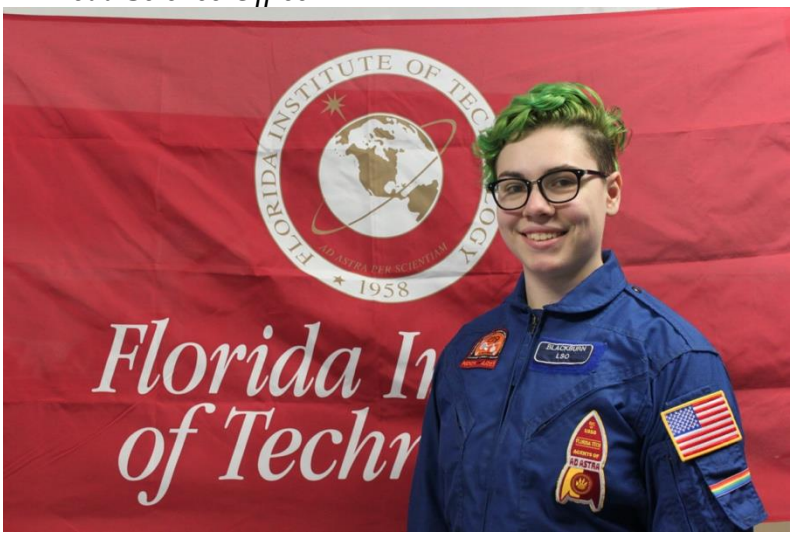
Dave is a member of the Astrobiological Research and Education Society, Pi Lambda Phi Fraternity, the Planetary Society, The Mars Generation, the 82nd Airborne Division Association, the Army Sniper Association, and the Veterans of Foreign Wars.

Nathan Hadland -- Executive Officer

Nathan Hadland is a student at Florida Institute of Technology pursuing a Bachelor of Science degree in Astrobiology with a minor in Physics. Nathan is an MDRS verteran-- in February of 2019, Nathan joined seven other young professionals as the GreenHab Officer of Crew 205 as part of the International Emerging Space Leaders crew. He began scientific research in his freshman year in a planetary science lab, conducting atmospheric simulations of Neptune's Great Dark Spot. Since then, he has been a co-author on several different conference abstracts and will be the first author on an upcoming publication. The following semester, he added Research to Advance the Development of Interstellar Horticulture (RADISH) to his research portfolio, which investigates sustainable, in situ, food productions systems by growing plants in Martian regolith simulant. The research also involves developing agricultural robotics

to cut astronaut crew time spent on food production, a project that is done in conjunction with the Kennedy Space Center. The publicity for this research largely comes from the Astrobiological Research and Education Society's charter chapter at Florida Tech, which Nathan serves as president of. Additionally, Nathan spent the summer of 2017 at the University of Tennessee for an NSF REU program in microbial ecology, which focused on the growth kinetics of heterotrophic bacteria over long periods while in co-culture with the toxic cyanobacteria, Microcystis. In the summer of 2018, Nathan worked at the Johnson Space Center with the Astromaterials Research and Exploration Science laboratory and the Lunar and Planetary Institute (LPI) where he used experimental petrology to constrain fluid:rock chemistry on Mars through acidic, hydrothermal dissolution of phosphate-rich and phosphate-poor basalts with implications for the Stimson Formation in Gale Crater. In the summer of 2019, Nathan worked at NOAA's Earth Systems Laboratory in Boulder, Colorado where he worked on unmanned aerial systems in the Arctic through the NOAA Hollings program which provides tuition assistance and an internship.In the near future, Nathan hopes to go to graduate school to pursue his PhD with the hopes of working in research at NASA, a non-profit, or another governmental agency in the realm of planetary science and an ultimate goal of becoming an astronaut.

Hannah Blackburn -- Lead Science Officer



Hannah Blackburn was raised in the Research Triangle region of North Carolina. Hannah studies astrobiology at the Florida Institute of Technology, the first and only American university to offer an astrobiology undergraduate degree program. Hannah's research is focused on in situ resource utilization (ISRU), the use of local materials by spacecraft and for human space exploration. Martian regolith is one such resource, and its potential as a growth substrate for agricultural use is being explored by the Research to Advance Interstellar Horticulture (RADISH) project at the Aldrin Space Institute. Hannah also studies the effects of microgravity on plant-microorganism interactions such as genetic transformation of the model plant Arabidopsis thaliana through the plant-pathogenic bacteria Agrobacterium tumefaciens. Hannah has prior experience at the Mars Desert Research Station from the International Emerging Space Leaders Crew 205. Through the Florida Institute of Technology chapter of the Astrobiological Research and Education Society (ARES), Hannah engages in public science outreach. As a member of Florida Tech's Student Astronomical Society, Students for the Exploration and Development of Space, and Society of Physics Students, Hannah mentors underclassmen.

Hannah is proud to represent LGBTQ+ scientists by flying a rainbow flag at the Mars Desert Research Station.

Keith Crisman -- Health and Safety Officer

Keith Crisman is a PhD Candidate in the Florida Institute of Technology's (FIT) Human Centered Design program with an emphasis on rescue and safety systems in human spaceflight. He is currently supporting FITs Human Spaceflight Laboratory as the Safety Officer and Research Assistant. Keith performed thorough risk analysis and developed Adaptive Spaceship Cockpit Simulator and Intravehicular Spacesuit operational procedures supporting successful IRB application for Humans-in- the-Loop Simulations. Further, he has collaborated on FAA Commercial Space Transportation research related to analytics of the normative Human Spaceflight environment as well as collaborations with Embry Riddle University during research on IVA Spacesuit Ergonomics for Spacesuit Cabin Integration Human Factors. He has an immense educational background starting with automotive technology certification from Pike-Lincoln Technical Center, an AAT from Ozarks Technical Community College, a BS in psychology/biology from the University of North Dakota, and Human Factors of Aeronautics with an MS from the Florida Institute of Technology. His dissertation focuses on emergency medical systems for human spaceflight with microgravity and scenario driven design. Current titles include NASA Student Ambassador, NASA Aerospace Scholar, as well as Safety Officer and Research Assistant for HCD's Human Spaceflight Lab. His certifications include DAN DFA-PRO provider, PADI Rescue Diver, and AAUS Scientific Diver along with various related certifications. His work throughout this path has resulted in a Contained Environment Airlock Pass-Through (CEB) and Geologic Sample Return Container (SMR) for a Pressurized, Manned Rover, Collaboration between NASA Marshall Space Flight Center and the University of North Dakota Space Studies Department, completed in 2012 and a patent for a Ferrohydrodynamic Thermal Management System and Method, US20160116223 A1, Fourier Electric LLC, Orlando, FL, USA, patent filed 2014. Keith's current design is an emergency containment system for single person use in a microgravity environment. Along with all of this, Keith is slowly instilling his love for space, the cold, and hockey with his 5-year-old daughter. His primary goal is to become an Astronaut for NASA. Semper Exploro.

Alejandro Perez -- Engineer

Born in 1997 near the heart Connecticut Alejandro was encouraged as a child to explore and learn the places around him. From an early age he was obsessed with learning about the way life worked not only in the nature around him, but the machines and systems that were commonly used.

Before leaving highschool Alejandro was involved with a multitude of science and engineering camps ranging from basic circuitry for electric cars to constructing large structures like catapults. He also participated in tissue engineering research at the University of Connecticut shortly before graduation. While he was in highschool Alejandro was a large advocate for education and learning for all. Here he found his love for science in biology and engineering.

After highschool Alejandro would be accepted at the Florida Institute of Technology to study Biomedical Engineering. The goal being to design space suits for future deep space exploration. During this time he was selected to be the Risk Manager of Delta Tau Delta Fraternity. Simultaneously being the project lead for many studies involving the human bodies response to stress. Once the taste of research was had Alejandro would later be invited to join the Astrobiological Research and Education Society to help participate in Martian Regolith experimentation revolving around plant response. He will then become motivated to take on the Treasures position of this organization as a step into the administrative world of research and development. After switching degrees to Genomics and Molecular Genetics he currently studies plant pathogenic research involving genetic engineering of bacteria to reform plant DNA for CASIS division at NASA. He is also involved with the Agricultural Robotics Team (ART) for mars exploration with Farmbot at the Kennedy Space Center Visitor Complex. His newest conquest is working for the Education department of NASA teaching the public and children about space sciences and space history at the Kennedy Space Center.

Cynthia Montanez -- GreenHab Officer

For as long as she can remember, Cynthia has always been passionate about plants. From a young age, she had spent her first 5 years in upstate New York enjoying the activity of apple picking. She would go every autumn season to pick the ripest apples and the freshest pears. Moving at the age of 6 to Orlando, Florida, she quickly became accustomed to the southern life and its forestry's. From going orange picking, to playing in state parks, Cynthia has always loved being amongst the land surrounded by flowers and crops.

With her passion in botany, she started her Astrobiology journey by having her first job as a groundskeeper within her community. While assisting her neighbors with their lawn needs, she also educated them on basic plant science. As years passed, she also got a job in Lowes as the Outside Lawn and Garden Associate whom of which took care of the plants and educated the customers of basic horticulture.

Currently, she is enrolled at the Florida Institute of Technology, majoring in Astrobiology. She plans on using her knowledge and skills to grow plants on Mars. While being within the Astrobiological Research and Education Society (ARES), she was able to start using her skills by assisting in a vermicompost study within Mars regolith, and designed a regolith remediation project to transform the nonviable nature of said substrate into something viable. These two separate projects are to further express the notion that Mars itself is inhospitable unless conditioned with the right nutrients. Once able to provide evidence that such nutrients assist in the regolith's viability, and that the experiment achieves the desired goal, Cynthia would like to see if she could one day work as a scientist within the botanical division of NASA's Kennedy Space Center working to further perfect her experiment.

Robinson Raphael -- Astronomer

Robinson Raphael was born in Hewlett, New York. When he was younger his parents taught him basic skills that he eventually grew to do on his own. Such skills include cooking, cleaning, gardening etc. Being drawn to space at such a young age, Robinson would find ways to learn more about the cosmos. Whether it was looking at videos or looking at images, these small things fueled what he is passionately striving towards today. In high school, Robinson would try to take classes that revolved around his interest in majoring towards Astrophysics/Astronomy. From freshman to senior year, he has taken a multitude of science classes that range from astronomy to physics to chemistry. When it came time to graduate high school, he worked on a senior project with his astronomy professor. The project consisted of wavelength color application, with regards to X-ray imaging of various celestial bodies. Currently in college, Robinson is working under Dr. Caballero, who is the head director of the Olin Observatory here at Florida Institute of Technology. His initial research project involved mosaic imaging of a multitude of chosen celestial bodies that would be observed with the Ortega Telescope. As of now, his current project involves dust mitigation with regards to optical mirrors through the use of electrodes. With his time on campus, Robinson has gotten an understanding of the Ortega Telescope here on campus and its various key components. Not only that but also how to troubleshoot problems that may interfere with observations. Additionally in the research group he is apart of, him and his colleagues have also developed an updated manual of how to use the telescope as well as its various attachments. As time persisted, Robinson has also gotten the chance to learn a multitude of universal programs that are geared towards astronomical observations. Such programs include Simbad, Aladin, Isaac Newton Group of Telescopes and AstroImageJ. Even now with the upcoming semester, Robinson seeks out to find new opportunities to further his knowledge and experience in hopes of becoming an observational astronomer.

Abdul Elnajdi -- Geologist

Born and raised in Libya. He graduated from Omar Al Mukhtar University and he worked as assistant research for 4 years. He had a passion for space and planets science since he was 5 years old. In 2009 He was the first Libyan student to space camp in Alabama where he learned many things about space technology. After college he got first camera and telescope and used it to photographing the sky and observing the planets. In 2013 he founded the first Libyan scientific society for astronomy and space technology. He used his organization to hold seminars and scientific activities to simplify space science for public. In 2014 he became Libya's delegate to The Arab Maghreb Union for Astronomy and Space Technology.

In 2016 he got a scholarship from his university in Libya to come to the united states to finish his master dgree. Abdul has accepted at the Florida Institute of Technology to study Biochemistry with minor in Geochemistry. During his time in Florida Tech, Abdul is involved with many students' organizations such as Alpha Phi Omega, Florida Tech Video Production, Rockets Society. Abdul later be invited to join the Astrobiological Research and Education Society to help participate in Martian Regolith where his thesis was about Mars simulant "MGS-1 Mars Global Simulant". The thesis title was: Impacts of Sieving and Cultivation on Martian Regolith Simulant; The effect of different size particle fractions of JSC-MARS1A on chemical and mineralogical data was examined in this study. Also, because of his studies on Martian Regolith, He was able to study other types of regolith: KMS-1, MMS to increase his knowledge about the simulate.

Abdul graduated from Florida Tech 2018 and now he is a Ph.D. candidate at Ball State University pursuing a Ph.D. of Environmental Science degree in Geochemistry. In the near future, Abdul hopes to finish his PhD with the hopes of working in research at UAE space agency, and develop the knowledge about space science in his country, Libya.

Overview of Research Projects and Methodologies

Crew Training and Preparation for Extended Performance in Austere Environments
By: David Masaitis

Most people in first-world countries view work performance as something that occurs during standard business hours, with ample rest and relaxation time allotted per work week. For those holding such occupations, stress, exhaustion, and sleep deprivation are kept to minimums in order to optimize performance on the job. General physical fitness is not a requirement and is left to the discretion of employees as a recreational consideration. Other occupations have mission-dictated requirements that not only demand a higher degree of physical fitness, but also ask a person to work in a hostile and austere environment, often with less sleep than normal and devoid of typical stress-relief outlets.

The United States armed forces play host to many such occupational requirements, and as such, the Department of Defense has spent decades developing methods to help service members remain fit and functional even under the most harrowing conditions. As a veteran and former Master Fitness NCO for my element, I had to play an instrumental role in designing both physical fitness and field training that would better prepare service members to perform high-risk tasks with great precision under adverse conditions. For this crew, I have monitored the pre-mission physical training of selected crew members that opted to receive additional physical training and will have the opportunity to bias their performance against those who did not.

While on mission, I will be evaluating the success of this preparation methodology and will correspondingly improve the fundamental doctrine published by previous crews, including the International Emerging Space Leaders crew, Crew 205. A thorough review of training documents and standard operating procedures will not only improve the workflow of our crew but will give future crews a solid doctrinal foundation to prepare for their missions. This sort of doctrinal foundation is critical to the safe and productive operation of any team working in hazardous and austere environments and will help serve as a fundamental blueprint for other organizations in the industry seeking to engage in the human exploration of other planetary bodies.

Biometrics and Neurobehavioral Research Pertaining to Cardiovascular Health during Extra Vehicular Activity on Exploration Class Missions
By: Keith Crisman

This research is inline with the ***Risk of Injury and Compromised Performance due to EVA Operations*** as noted by NASAs Human Research Program (HRP) as part of their Human Health Countermeasures (HHC) element. Along with this risk are various tasks and gaps between two of HRPs elements; HHC and Human Factors and Behavioral Performance (HFBP) in which cardiovascular health is of concern considering both physical and neurological stressors to crew members in isolated, confined, and extreme (ICE) environments. This research may address elements of the following identified Gaps:

§ ***Cbs-Bmed3: We Need to Identify and Quantify the Key Threats to and Promoters of Mission Relevant Behavioral Health and Performance During Autonomous, Long Duration and/or Long Distance Exploration Missions***

§ ***Cbs-Bmed2: We Need to Identify and Validate Measures to Monitor Behavioral Health and Performance During Exploration Class Missions to Determine Acceptable Thresholds for These Measures***

As they pertain to the following Identified Tasks:

§ ***Effects of Emotional Stress on the Cardiovascular System (*HHC*)***

§ ***Standardized Behavioral Measures for Detecting Behavioral Health Risks During Exploration Missions (*HFBP*)***

The goal of this research is to ascertain any correlation between EVA and cardiovascular health, particularly to the decrement of cardiovascular health during high stress (physical and neurological) and long duration EVAs.

To best achieve this, a two-series data collection will be implemented concurrently; Series I will focus on collection of biological metrics and Series II will focus on collection of neurobehavioral metrics on varying schedules. Metrics within each series and frequency of data collection are outlined below.

MDRS CREW 219				BIOMETRICS & NEUROBEHAVIORAL RESEARCH
EVA DATA COLLECTION SERIES I + II				
IDENTIFIER	SYSTEM	METRIC	RATIONALE	TOOLS / FREQUENCY
B1	CVS-S/S	UPPER EXTREMITY	Edema is an indicator of cardivascular stress as decreased circulation in limb extremities: showing in the hands / mid-antebrachium on the upper extremities and ankle / mid-cnemis on the lower extremities.	TOOL(S): TAPE MEASURE (cm), POSITIONING TOOL (ALLOWS FOR CONSISTANT MEASUREMENT)
B1.1	CVS-S/S	HAND		
B1.1.1	CVS-S/S	HAND LENGTH		
B1.1.2	CVS-S/S	PALM WIDTH		
B1.1.3	CVS-S/S	PALM CIRCUMFERENCE		ON THE FOLLOWING SCHEDULE: PRE / POST MISSION + PRE / POST EVA
B1.1.4	CVS-S/S	CARPUS CIRCUMFERENCE		
B1.2	CVS-S/S	ANTEBRACHIUM		
B1.2.1	CVS-S/S	MID-ANTEBRACHIAL CIRCUMFERENCE		
B2	CVS-S/S	LOWER EXTREMITY		
B2.1	CVS-S/S	FOOT		
B2.1.1	CVS-S/S	ANKLE CIRCUMFERENCE		
B2.2	CVS-S/S	CNEMIS		
B2.2.1	CVS-S/S	MID-CNEMIS CIRCUMFERENCE		
B3	CVS-S/S	CARDIOVASCULAR	Biometric measurements of cardivascular functional state	TOOL(S): PULSEOX / SPHYGMOMETER / VISUAL AND TIMED ASSESSMENTS
B3.1	CVS-S/S	BLOOD PRESSURE		
B3.2	CVS-S/S	PULSE OXIMETRY		ON THE FOLLOWING SCHEDULE: PRE / POST MISSION + PRE / POST EVA
B3.3	CVS-S/S	HEART RATE		
B4	CVS-S/S	RESPERATORY		
B4.1	CVS-S/S	RESPERATORY RATE		
N1	PSYCH	EVA PRE SURVEY	Ascertain environmental and workload factors for recorded metrics	ON THE FOLLOWING SCHEDULE: PRE / POST EVA
N2	PSYCH	EVA POST SURVEY		
N3	PSYCH	Modified DAN OSNE	These provide neurobehavioral state / trait metrics	ON THE FOLLOWING SCHEDULE: PRE / POST MISSION + PRE / POST EVA
N4	PSYCH	SLEEP LOG		QD (once daily)

Series II Tools include the following:

§ EVA OCQ Open Commentary Questionnaire [N1/N2]

§ Modified DAN OSNE On-Site Neurological Examination [N3]

§ HAB SLOT Sleep and Off-Time Log [N4]

These tools will be used in conjunction with observed behavior to create a master log for each crewmember. As an order of privacy, each crewmember will be assigned a random moniker in which their log information will be stored and analyzed to create the assessment profile.

UAV Transport and Deployment
By: Alejandro Perez

The objective of this experiment is to determine the viability of drone deployment while on EVA. Drones can be a useful tool in the field by providing observations of local terrain that would otherwise be inaccessible. While performing EVA's to new locations, preliminary reconnaissance may be necessary to identify hazardous features, possible points of scientific interest, and routes. The UAV can provide field researchers with the capability to search larger areas with greater efficiency. Drones can also be equipped with additional observational instruments such as radar or infrared for further topographical observations. The purpose of this project is to investigate the utility of deploying a UAV system to assist in scientific research on the surface of Mars.

MDRS Crew 219 has independently designed and assembled an unmanned aerial system. The UAV includes a flight controller, 18-inch arms with rotors, and a battery unit. A GoPro style camera will be placed on the drone to capture photos and videos. When crewmembers are on EVA, the mounted GoPro will give crewmembers a bird eye view of their location. Additionally, the photos and videos taken can provide additional image analysis post-EVA. With the GoPro system, live video feedback is now possible to achieve in real time. Outreach media such as photos of the EVA can also be obtained using the UAV.

The following is the checklist used during UAV system checks both prior to and during the mission:

Plan for transportation:

- Arms (positioning and secure)
- Rotors (placement and disassembly)
- Battery packs (detachment and performance test)
- Tools and accessory items (i.e. Go-Pro, lights, etc.)

Assembly of the drone on site:

- Unpacking UAV
- Arms (positioning and secure)
- Rotor and arm assembly and positioning
- Power cycle and battery test (testing rotor, controller, and camera functions)
- Controller power cycle
- Test controller response before attempted take-off

Location for flight:

- Open field with no visible obstructions within 10 meters of takeoff/landing zones
- Vertical and horizontal clearance

Goals during flight:

- Test vertical and horizontal movement and range
- Test flight time and battery life
- Test controller capabilities

Record results:

- Flight time
- Performance
- Recovery

The goal of this project is to develop the Standard Operating Procedure (SOP) for transportation and deployment of the drone and assess the utility of using a UAV in EVA operations. Future work will use images taken by our UAV system in a fractal analysis software (see the "Protocols for the Discovery of Life on Mars" section below). Additions to our UAV system in the future may include remote sensing instruments which could provide a new avenue of explorational capacity beyond human capabilities.

Dust Mitigation for Optical Mirrors

By: Robinson Raphael, Maria Galvez Gonzalez, and Ryan Crouch

When it comes to observational astronomy, the presence of dust leads to obscured and distorted images. Depending on the environment, the amount of dust as well as other debris on an optical mirror can vary. The process of having to remove it carefully without scratching or damaging the mirror is tedious and time consuming. On the surface of Mars, astronomical observations may be taken frequently and consequently, dust and other particulates will be a major problem. In this project, we will be testing various known cleaning methods for optical mirrors in a Mars-like environment.

MDRS Crew 219 brought a 135 mm diameter mirror and an optical mount. This mirror will be set up outside between the Musk Solar Observatory and the Robotic Observatory with stakes marking its location. Photographs will be taken every day on EVA or during the Engineering EVA in order to observe the rate of natural dust collection. In the second week of the mission, contingent on sufficient data collection, we will simulate a dust storm by applying sieved regolith to the surface of the mirror. The cleaning methods to be tested include:

1.) Non-contact method: Hand pump (air-blower)
2.) Contact method (non-alcoholic): Lens tissue with optical screen cleaner (altura®)
3.) Contact method (alcoholic): Cotton swabs and balls with rubbing alcohol
4.) Contact method (no cleaning solution): Optical brushes and cotton fiber swab

A before and after image will be taken, showcasing the effects of each cleaning method on the optical mirrors. Multiple trials for each cleaning method will be taken to accommodate for various parameters of the mirrors being changed (angle, orientation, position, etc.) if time permits. Future work will employ the use of electrodes to harness electromagnetic properties to expel dust.

Astrophotography of Celestial Bodies

By: Robinson Raphael, Maria Galvez Gonzalez, and Ryan Crouch

The primary purpose of this experiment is to observe the effects of various filters on the observation of celestial bodies. Some of the objects selected are in collaboration with the Student

Astronomical Society at the Florida Institute of Technology. The following steps will be taken to perform these analyses:

1.) Take images using the Johnson-Cousins set and a set of generic filters.
2.) Generate a fits file for the chosen celestial body, which will range from binary stars to nebulae to galaxies.
3.) Calibrate and stack each filter's respective fits file.
4.) Stack each calibrated filter stack in order to generate a fully colored image.

The observational portion of this project will use the MDRS-14 telescope. The calibration and stacking will use AstroImageJ. Taking into account weather and atmospheric distortion, certain procedures will be implemented to ensure optimal results. These methods include choosing the best fits file for each filter prior to calibrating and stacking as well as repeating observations for various celestial bodies.

The second astronomy project at MDRS is Discovery, which aims to survey an isolated part of the night sky. The Minor-Planet-Center website generates a digital plot of telescopes that are looking at specific areas of the night sky. The goal is to initially get isolated coordinates to use with the MDRS-14 telescope. A total of 9 surveys will be taken, with each survey representing one image under the V filter. A max exposure time for each celestial body will be taken to ensure optimal clarity. From there, we will use AstroImageJ to stich the 9 surveys together in order to generate a 3x3 final image. Ultimately, the purpose is to discover an object previously unknown to the astronomical community.

Remediation of Mars Regolith

By: Cynthia Montanez

Cyanobacterial inoculations of regolith samples will be investigated to examine possible mineralogical changes within the sample to accelerate primary and auto-succession. Fundamentally, the purpose of this work is to take biologically inert surface materials (regolith) and making it suitable for plant growth. The characteristics of interest are clumping, wettability, and chemical and texture change. Previous experiments of this nature were performed by the Graduate School of Life and Environmental Sciences in the University of Tsukuba, the Institute of Space and Astronautical Science, and the Faculty of Science and Engineering at Chuo University. They utilized the cyanobacteria *Nostoc commune* and a regolith simulant made of basaltic sand from Miyake Island and ferric oxide powder. These studies found that *N. commune* inoculations increased concentration of nitrogen, potassium, and phosphorus, which are necessary for plant growth. For this study, 4 samples of regolith will be collected from the MDRS region during EVA missions. The cyanobacteria used in this study is *Anabaena cylindrica*, which is similar to *N. commune.*

Microorganisms adapt to their environment by chemically changing the composition of their immediate surroundings. These chemical changes provide their environment with necessary vitamins and minerals. Once adapting to the new surroundings, colonization takes place through asexual reproduction. Therefore, they are an excellent tool for in-situ resource utilization, as more microbes can be made as needed and the chemical changes they make are beneficial to a variety of organisms.

Cyanobacteria is utilized in this study is because it effectively remediates nonviable sediments. Its structure is a matrix of extracellular polymeric substances (EPS) that form a border between its cells and its immediate environment. This border contains capsular polysaccharides (CPS), which have multiple functions for the organism. One of these functions

is to protect its external structure, allowing for the cyanobacteria to survive in extreme environments. In addition, cyanobacteria produce many biologically active substances such as phosphate solubilization promoters, antitumor and antifugal compounds, insecticides, antibodies, repellents, and algaecides, which promote plant growth. Because of this, cyanobacteria are an important part of primary and auto-succession of nonviable soils.

Presently, microbiological experimentations are being performed at Florida Tech's Plant Biochemistry lab to determine if life can be sustained in Mars Mojave simulant (MMS). At MDRS, the cyanobacteria *Anabaena cylindrica* will be inoculated into regolith samples and population growth and decay will be observed daily to determine if the organism is capable of surviving in the regolith samples and starting primary and auto succession. The recorded growth rate will determine the rate at which the algae adapts to the regolith and begins changing its composition.

The goal of this experiment is to induce primary and auto succession in MDRS regolith samples with *A. cylindrica*. Cellular density will be measured by manually counting the cells within thirty filaments and taking the average of the recorded values. The recorded value will determine the populations rate of growth and decay. Follow up work will be done once the Mars analog mission is completed by investigating the mineralogical changes on the regolith and the changes in biochemical markers of the cyanobacteria. Assessments of mineralogical changes will be done using X-ray diffraction, and the biochemical markers will be determined by using an IR spectrometer. The presence of mineralogical and biochemical changes to the regolith will indicate succession occurred due to *Anabaena cylindrica* inoculation.

Chemical and Mineralogical Composition of the MDRS Site

By: Abdul Elnajdi

Missions that have landed on Mars have provided preliminary information about the nature of the Martian regolith. Currently, many scientists around the world are using Martian regolith simulants that are made from soil and regolith collected on Earth and are similar to actual Martian regolith. Data from ground-based landers/ rovers and orbital spacecraft revealed that the Martian surface is dominated by basaltic regolith composed primarily of pyroxene, plagioclase feldspar, and olivine as well as minor amounts of Fe and Ti oxides. On Earth, Palagonite is typically composed of an amalgamation of all or some of the following materials: residual basaltic glass, zeolites, carbonates, phosphates, hematite, Fe-hydroxides, poorly crystalline aluminosilicate mineraloids, and smectite clays. Several places on Earth and Mars exhibited a history of volcanism. The nearly continuous eruption history of the Mars desert research area provides an opportunity for the real time study of formation and alteration of basaltic minerals. Previous studies have reported on the geologic history and morphology of the MDRS site. In this study, we will investigate the chemical and mineralogical composition of local region with the ultimate intent of using GIS to map the site based off of these analyses.

1.) Goals:

The goals of the proposed research are to collect samples from various locations and determine the chemical and mineralogical composition by using XRD and XRF analysis.

Set up:

1- Collect samples with GPS points

2- Divided the samples into different fraction sizes

3- Desiccate and grind the samples

4- Run XRD and XRF analysis (This step will take place in geochemistry lab at Florida Tech or Ball State University).

2.) Procedures For Geochemical Sampling and Analysis:

Geochemical exploration for mineral deposits is based on the systematic measurement of one or more chemical properties of a naturally occurring material. These properties include the trace-element analysis and mineralogy of rocks, soils, and stream sediments (Rose and et al. 1979).

Generally, sampling locations are on a rectangular grid with 400 m spacings. Each location will have multiple samples collected spaced approximately 10 m apart. If the composition of the sampling location is approximately known, then the depth and number of samples collected can be reduced. However, if the composition is unknown, samples will be collected down to 10 cm with a greater sampling frequency.

The optimum spacing between sampling lines and sample sites will depend on the purpose of the survey and the expected size of the dispersion halo to be detected. Generally, the aim is to obtain at least 2 samples from the anomaly on a sampling line. Common sample spacings for reconnaissance soil sampling are 400m by 400m or 200m by 400m. For detailed anomaly detection samples are commonly collected at 100m intervals on 200m spaced lines with infill sampling down to 50m on 100m spaced lines. Shallow samples are conveniently collected using a pelican pick (or similar). A planting shovel (with narrow straight blade) may be more efficient in hard soils. Deeper samples can be collected with a hand auger (e.g. standard 20 cm diameter soil auger). The following steps will be taken on each EVA where samples are collected:

- Locate sample sites with GPS receiver and enter into data base or GIS platform.
- Record the regolith landform setting.
- Estimate the range in clast size.
- Estimate the proportion of transported and in situ lag.
- Desiccate the sample in an oven at 100^{o}C for about 6 hours or overnight.
- Sieve out the coarse pebbles, sticks etc (greater than 1 or 2 cm) on to a plastic sheet and quickly pick out any obvious organic material. An alternate approach is to float off any light organic material by washing the lag in water prior to sample preparation.

3.) Results:

These analyses will be useful for testing procedures that aim to interpret conditions of regolith formation and future use on Mars. The results of this study will help to understand the geological history of the red planet. In addition, there is a possibility of obtaining regolith that is very similar to that Martian soil for scientific propose that related to the development of scientific research tools. The XRD and XRF results that will be obtained after the mission will be useful in understanding the mineralogical composition of the MDRS site. We will use this data to create a GIS map of the chemical makeup of the local region for future crews to use and update.

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Protocols for the Discovery of Life on Mars

By: Nathan Hadland, David Masaitis, Hannah Blackburn

Manned expeditions to Mars will need effective methods to identify and characterize extraterrestrial biology. Considering the persistence of water on Mars, both historically and presently, it is possible that extremophilic life has existed or currently exists on the surface. This research will work to define standards for the collection of the following categories of samples collected at MDRS:

1.) Known sources of microbial life (i.e. standing water, lichen, mosses, etc.) as the control group
2.) Random samples as the experimental group.
3.) Fossilized invertebrates (i.e. *gryphea*) as a proxy for extinct lifeforms.

The samples will be photographed and collected for further study. As these samples are collected, Crew 219 will develop the Standard Operating Procedures (SOPs) for proper sample collection methods and characterization in the laboratory. These SOPs will be designed in order to prevent contamination of the samples and identify which tests are most useful to characterize the samples.

One possible method in the identification of extraterrestrial life is using fractal analysis. Using FrAn, a Python program, we will analyze the photographs for their fractal dimension or "D" value (Azua-Bustos and Vega-Martinez 2013). Previous work has demonstrated that fractals are an indicator of life, both on a microscopic and macroscopic scale. By searching for fractal patterns, we may be able to identify non-standard biology on other planets. We will take images of the three different types of samples listed above using a microscope. This data will then be uploaded into the analysis software and if the D value exceeds a threshold, we can hypothesize that biology may exist in the sample. Future work will use images taken by our UAV system in this fractal analysis software (see corresponding section above).

As these samples are imaged and tested in the laboratory, standardized testing procedures such as the fractal analysis will be developed. These procedures can be then followed to test for biology in any sample collected on the surface of Mars.

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