A Robotic Vision

Christopher F. Thompson
Salt Lake Community College
Salt Lake City, Utah

Proposal

MISSION OBJECTIVE

Robotics Mission to Mars (RMM) has been designed to utilize an unmanned robotic rover, OSV-1, and four (4) companion Miniature Aerial Vehicles (MAV) to accomplish a series of goal oriented objectives. The outlined mission for OSV-1 and the MAV's will be to understand the processes and history of climate on Mars. OSV-1 and the MAV's will complete multiple tasks while on Mars; the following three (3) have been designated as top priority:

1 – Utilize onboard atmospheric utilities to perform in situ measurements of the lower atmosphere in order to establish climate and processes *[1 – page 22]*

2 – Utilize the MAV's while in stationary operations to perform in situ measurements of the upper atmosphere to establish climate and processes *[1 – page 22]*

3 – Utilize the Ensemble tool set in conjunction with OSV-1 and the MAV's to begin mapping and deciphering the planetary boundary layer *[1 – page 22]*

This RMM will begin to shape our understanding of Martian Meteorology by assisting NASA in the creation of detailed atmospheric models that can be used by future scientists.

MISSION TIMELINE

A May 2018 launch window has been chosen as the most appropriate date for RMM. RMM will launch from Kennedy Space Center on Wednesday May 23rd, 2018. RMM will be delivered into Low Earth Orbit (LEO) where it will remain for approximately 48 hours while in preparation for Tran-Mars Injection (TMI). With a successful TMI, RMM will be on route to Mars for an estimated nine (9) Earth month journey. RMM will arrive into Mars space in February 2019. Upon arrival to Mars space, RMM will then enter into geosynchronous orbit around Mars where RMM will remain for approximately 28 Sols. Once final preparations have been completed, RMM will enter the Martian Atmosphere as it makes its decent to the Martian surface. RMM is set to make surface contact on March 24th, 2019. Initial mission parameters have been set at 180 Sols. Depending on the level of success obtained during this initial 180 Sol mission, an extension may be granted based on requirements set forth by the NASA operations team.

MISSION BUDGET

In 2018 the National Budget will distribute, an estimated, $23.2 billion for NASA operations. From this 2018 National Budget, NASA will spend $5.33 billion on Space Operations. In order to project a 2018 National Budget for NASA, I calculated an estimated future budget allocation utilizing an annual 4.0% rate of inflation over 6 years. RMM will carry an estimated cost of $1.35 billion, which will be an estimated 25.3% of the Space Operations funding and 5.8% of the overall 2018 National Budget for NASA operations.

LANDING SITE

In order to meet and eventually exceed the three (3) top priority mission objectives, a location that offers consistency in elevation as well as a variety in elevation will be required. I have chosen a landing site that will offer RMM the best opportunity to achieve success. The location for the landing site can be quantified with the following Mars surface polar coordinates:

Northernmost Latitude:	36.48^{o}
Southernmost Latitude:	35.58^{o}
Easternmost Latitude:	265.6^{o}
Westernmost Latitude:	264.6^{o}

The landing site is specifically named Issedon Tholus *[2]*. Issedon Tholus is a Martian feature that appears to be flat and on par with rolling hills. The elevation within the general vicinity is very consistent and indicative of a location that will provide the best chance for complete mission success. To the north of this location, RMM will find the elevation drops gradually from 0 meters down to -3000 meters. Due south of this landing site RMM will find the elevation rises gradually from 0 meters up to +2000 meters. This landing location can be utilized to offer OSV-1 and the MAV's the widest range of elevations as they relate to lower atmosphere and planetary boundary layer measurements. I have included an elevation gradient of the approximate landing site, please see attached map.

ROVER SPECIFICATIONS

Propulsion

The OSV-1 robotic rover will be based on a crawler propulsion system. The traditional wheel based system of previous rover missions will be replaced with track technology. Similar in design to a tank or crawler crane track design, OSV-1 will utilize four (4) individual tracks that will contain an individual drive systems that can be operated independently or in unison. The track propulsion system will be monitored and operated in conjunction with the onboard Ensemble tool set. The tracks will be engineered and manufactured to be comparable to the 105M1-A2 model *[3]* offered by MATTRACKS.

The MAV's will have a dual rotary wing solution that will offer flexibility in mission design as well as an advantage in maneuverability. Some additional advantages offered by the dual rotary wing solution are the ability to maneuver in three dimensions, and the ability to hover.

Energy

The OSV-1 robotic rover will be powered by a Radioisotope Thermoelectric Generator (RTG). This RTG has been designed and implemented by NASA; more specifically known as a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG). This particular RTG technology has a proven track record by being the power source for multiple successful Mars Landers such as Viking 1 and Viking 2. More currently, the Mars Science Laboratory will house a MMRTG *[4]* that will be the model OSV-1 will utilize during RMM. This particular MMRTG has been designed to be compact and flexible in order to accommodate space saving requirements. This MMRTG will produce an approximate 125 watts of power upon initial start-up and will be capable of producing 100 watts of power for an additional 10 years *[4]*. During normal daily operations, the MMRTG will produce 2.5 kilowatts hours that will power the instrumentation, computer and more importantly the MAV's.

The MAV's will operate on rechargeable batteries that will be built directly into the sub frame. The exterior shell of the MAV's will contain a photovoltaic film capable of providing an operational charge of 8 hours. The MAV's will be capable of recharging their batteries by tapping the MMRTG while docked with OSV-1.

Communications

The OSV-1 will have a communications array capable of transmitting to the Mars Odyssey Orbiter as well as directly to the Deep Space Network (DSN) on Earth. Low-gain and High-gain antennas will be the transmitters of choice. OSV-1 will utilize the onboard Ensemble tool set to establish a real-time communication link with the MAV's that will be separate from the OSV-1 to Earth and Earth to OSV-1 communication loops. The Ensemble tool set will allow NASA to directly input mission directives on a daily basis for both OSV-1 and the MAV's while keeping data uploads and downloads separate from daily communications.

Guidance

The main computer systems responsible for guidance operations of OSV-1 and the MAV's will be a computer hardware system very similar to the MSL hardware package. The CPU will be designed by IBM with a minimum of 400 MHz of operational range. The hardware package will contain a minimum of 1024 MB of RAM and 1 TB of Flash Solid State Storage. The operating system will be the onboard Ensemble OS which is the core of the Ensemble tool set; a fully realized human / computer interface capable of real time operational assistance for OSV-1 and the companion MAV's. All real time navigation, driving, and directional imagery will be collected and directed to the Ensemble OS using four (4) low resolution, monochromatic navigation cameras.

INSTRUMENTS and EXPERIMENTS

Atmospheric Emitted Radiance Interferometer (AERI) *[5]*

This instrument will be responsible for calculating vertical atmospheric profiles of temperature and detection of trace gasses. With this instrument, we will be able to perform in situ measurements of the lower and upper atmospheres in order to establish climate and processes.

Surface Meteorological Instrumentation (MET) *[5]*

This instrument will be responsible for taking various forms of statistical information using in situ sensors. Primary measurements will be atmospheric pressure, atmospheric temperature, horizontal wind speed, long wave broadband down welling irradiance and short wave broadband total down welling irradiance. With this instrument, we will be able to perform in situ measurements of the lower atmosphere in order to establish climate and processes.

X-Band Scanning ARM Cloud Radar (XSACR) *[5]*

This instrument will be responsible for providing a radar model of local atmospheric phenomena. This instrument will be capable of recording and modeling current atmospheric energy levels in order to begin mapping and deciphering the planetary boundary layer.

Miniature Aerial Vehicle (MAV)

The MAV's will be utilized in order to provide radial wind velocities in the upper atmosphere. Pulses of energy will be transmitted into the atmosphere around the MAV's; the energy signal is then collected and measured. The MAV's will be capable of detecting trace gases in the mid and upper atmospheres. With this instrument, we will be able to perform in situ measurements of the mid and upper atmospheres in order to establish climate and processes as well as to begin mapping and deciphering the planetary boundary layer.

References

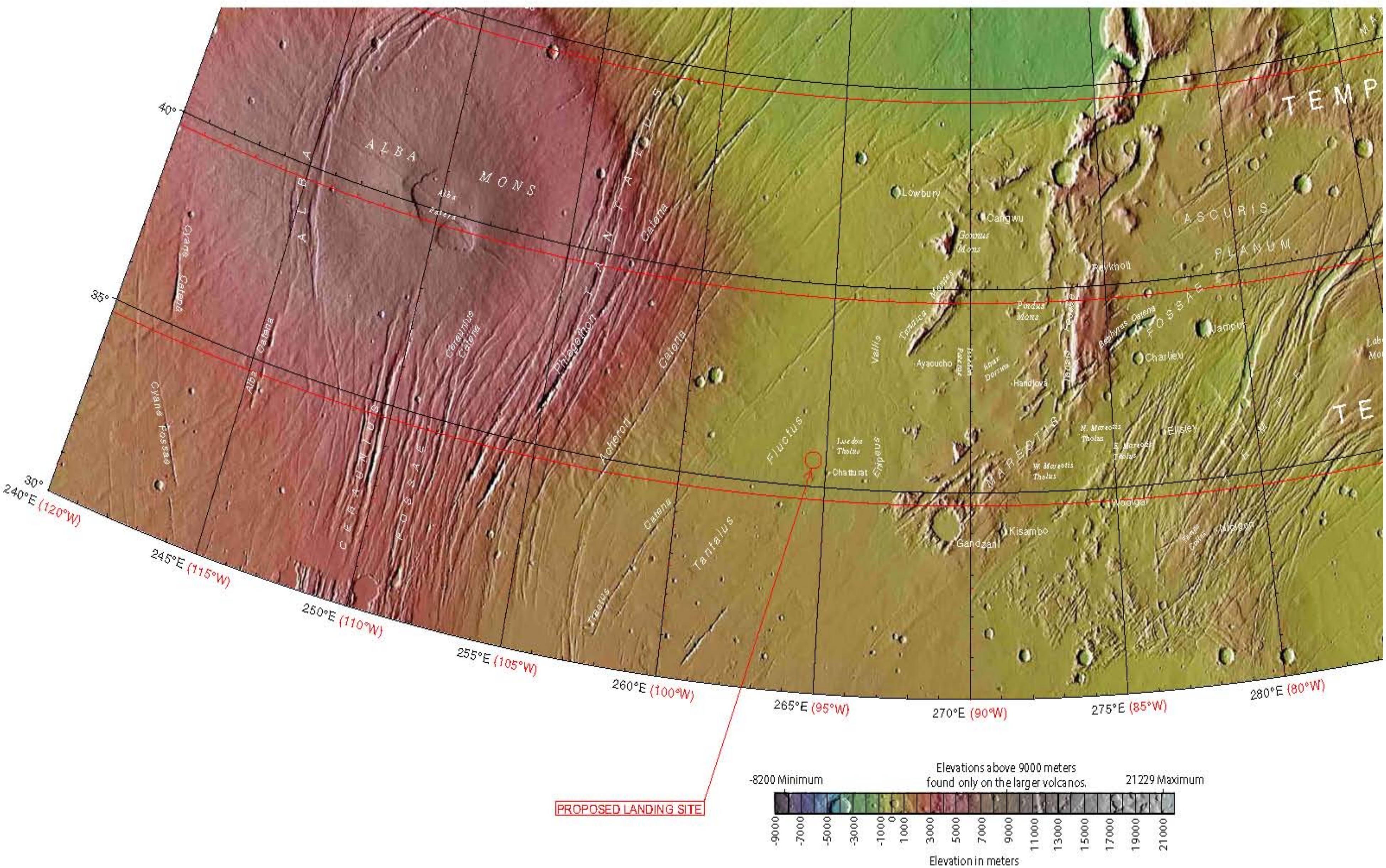
[1] – ***"Mars Science Goals, Objectives, Investigations, and Priorities: 2010"*** – September 24, 2010
MEPAG Goals Committee
http://mepag.jpl.nasa.gov/reports/MEPAG_Goals_Document_2010_v17.pdf

[2] – ***"Issedon Tholus"*** – Date: Unknown
International Astronomical Union (IAU) Working Group for Planetary System Nomenclature (WGPSN)
http://planetarynames.wr.usgs.gov/Feature/2746?__fsk=1869568487

[3] – ***"105 Model Series"*** – Date: Unknown
MATTRACK - Worldwide Track Technology
http://www.mattracks.com/html/model_105m1-a2.htm

[4] – ***"Mars Science Laboratory"*** – Date: Unknown
Wikipedia.com
http://en.wikipedia.org/wiki/Mars_Science_Laboratory

[5] – ***"ARM - Climate Research Facility"*** – Date: Unknown
ARM.gov
http://www.arm.gov/instruments



PROPOSED LANDING SITE
ALBA MONS
Alba Patera
ALBA
CERAUNIUS FOSSAE
Ceraunius Catena
TANTALUS
Phlegethon Catena
Acheron Catena
Tractus Catena
Tantalus Fluctus
Cyane Fossae
Cyane Catena
Alba Catena
Chatturat
Enipeus Vallis
Lowbury
Cangwu
Gonnus Mons
Tempe Mons
Ayacucho
Handlová
Reykholt
Charlieu
Jampur
Elsley
Woolgar
Kisambo
Gandzani
ASCURIS PLANUM
FOSSAE
MAREOTIS
TEMP
TE
30°
35°
40°
240°E (120°W)
245°E (115°W)
250°E (110°W)
255°E (105°W)
260°E (100°W)
265°E (95°W)
270°E (90°W)
275°E (85°W)
280°E (80°W)
Elevations above 9000 meters found only on the larger volcanos.
-8200 Minimum
21229 Maximum
-9000
-7000
-5000
-3000
-1000
0
1000
3000
5000
7000
9000
11000
13000
15000
17000
19000
21000
Elevation in meters