**CHRISTOPHER F. THOMPSON**
**ENGL 2100**
**PROJECT 3**
**SPRING 2012**

Christopher F. Thompson
Po Box 1288
West Jordan, UT 84084
April 01, 2012

Human Recourses
Structural Engineering and Design
Tetra Tech
2483 South 3850 West
West Valley City, UT 84120

Dear Mr. Winters,

Allow me to take a moment of your time. I am quite interested in becoming your next Structural Designer.

In the resume I forwarded to you previously, you will be able to determine that I am currently a Civil Engineering student who also has six solid years of engineering design work. I take pride in the fact that I have thus far maintained an overall 3.98 GPA during my college career. Over the past six years I have successfully mixed real life engineering design experience with theoretical engineering concepts and ideas.

I have a wide array of technical abilities that relate to the requirements of your Structural Designer position. I am capable of designing in 2D and 3D environments utilizing current Autodesk products such as AutoCAD 2012 and Revit Structure 2012. I hold current memberships with the American Institute of Steel Construction (AISC) and the American Society of Civil Engineers (ASCE) which will allow me to keep a working knowledge of current and future trends in the structural design industry.

I look forward to proving to you that I am the Structural Designer you are looking for. Thank you for your time.

Sincerely,

Christopher F. Thompson

TABLE OF CONTENTS

## Failure

In any form of engineering one word will most assuredly cause instant concern and in some cases fear; failure. To be more specific I will discuss Structural Failure as it relates to the profession of Civil Engineering. Structural Failure can occur in any type of constructed structure from concrete sidewalks to steel skyscrapers. In order to simplify the definition of Structural Failure, allow me to provide a few simple and relatable examples.

The Internet offers a few unique and a few confusing definition on what failure should be. Dictionary.com *[1]* defines failure as the following:

***Failure: an act or instance of failing or proving unsuccessful; lack of success.*** *[1]*

To be honest, when I see the actual word being defined used in the definition, I feel I need to dig a little further. Next I visited www.thefreedictionary.com *[2]* and found the following definition that is closer to what I would expect:

***Failure: the condition or fact of not achieving the desired end or ends.*** *[2]*

Great! This definition of failure is starting to reach the level that I wish to express to you. The same website *[2]* offered the following continuation of the failure definition that will lead to my final outcome of expressing Structural Failure to you:

***Failure: a decline in strength or effectiveness.*** *[2]*

The best and non-technical definition of structural failure I found comes from Wikipedia.com *[3]*:

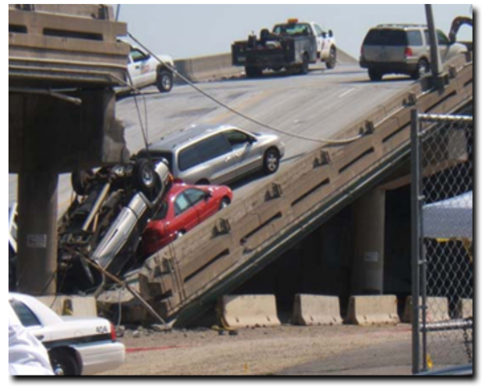
***Structural Failure: refers to loss of the load-carrying capacity of a component or member within a structure or of the structure itself. Structural failure is initiated when the material is stressed to its strength limit, thus causing fracture or excessive deformations.*** *[3]*

We can easily conclude that structural failure is a decline in strength or effectiveness of a specific structural object such as a concrete slab or steel bridge.

My first example of what structural failure appears like is this inserted image *[4]* of a fractured and excessively deformed piece of concrete. The best part of this image is that as we move through our day this particular form of structural failure is something we may all have experienced at one point or will experience in the future.

This following image *[5]* is an example of structural failure in the most extreme case. The failure of a structural bridge or building is truly a rare occurrence. Bridges and building have been designed to last for 20 years or more. In most recent examples, the failures of structures have been caused by natural disasters such as Hurricane Katrina or major earthquakes that have been felt in California.

In conclusion the word failure as it applies to engineering, more specifically structural engineering, can be utilized to explain what happens when objects such as a sidewalk or highway bridge will inexplicably fall apart or appear as if going through a deformity. Failure in the world of engineering is not a friendly word and will always be taken seriously in every way.




Resources:

[1] – Dictionary.com
dictionary.reference.com/browse/failure

[2] – TheFreeDictionary.com
www.thefreedictionary.com/failure

[3] – Wikipedia.com
en.wikipedia.org/wiki/Structural_failure

[4] – Roklin Systems blog:
roklinsystems.wordpress.com/2009/10/08/warehouse-concrete-repair-failure-story-part-1/

[5] – Forensic Engineering Services
www.esiomaha.com/forensic_engineering.htm

# A Robotic Vision

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**Abstract**

Within this paper you will find my vision for a future ***Robotics Mission to Mars***. The near decade of success achieved by NASA through the 2003 Mars Exploration Rover (MER) mission has proven that robotic rovers will be an integral part of the human exploration of Mars. With the physical and technological limitations placed on the frail human body, robots will be our right hand as we discover the unraveling mysteries of Mars.

The Mars Exploration Program Analysis Group (MEPAG) identified four goals for the scientific examination of Mars. The four exciting and fundamental goals set forth by MEPAG can be researched in further detail by locating the document: *[1]* ***'Mars Science Goals, Objectives, Investigations, and Priorities: 2010.'*** For this particular abstract, I will focus on the implementation of GOAL II which states the following:

> **GOAL II**: Understanding the Processes and History of Climate on Mars *[1]*

To be even more specific, GOAL II is divided into three objectives. Objective A will be the main driving force of this future robotic mission. Objective A states the following:

> **Objective A**: Characterize Mars' Atmosphere, Present Climate, and Climate Processes Under Current Orbital Configuration *[1 - page 21 thru 24 ]*

Currently NASA is in the process of selecting their next Space Launch System (SLS). The SLS that is most suitable for an unmanned payload delivery to Mars will come from designs based on a 'clean sheet' approach. According to a ***May 2011 SLS / MPCV Status Briefing*** *[2]*, a Large RP configuration (LOX/RP) will offer the greatest long term solution for this particular mission. The LOX/RP will contain an advanced liquid fuel engine capable of delivering between a 100 mT and 172 mT payload into Low Earth Orbit (LEO). From LEO the LOX/RP will separate and produce a module that will then continue beyond Earth orbit (BEO). The development of the LOX/RP will produce advancements in propulsion technology as well as create top-end performance for any future NASA endeavor *[2]*.

Rover technology has proven itself as a viable medium for the exploration of Mars. The robotics utilized for this mission will be very similar in architecture and functionality to the MER-A and MER-B rovers of the MER mission. The robotic rover, OSV-1, will be accompanied by four (4) fully autonomous Miniature Aerial Vehicles (MAV). OSV-1 will have a dual functionality. First, OSV-1 will behave and function as a mobile science laboratory; second, OSV-1 will act as a stationary forward operations base when the MAV's have been activated for service. In order to assure a fruitful mission, OSV-1 will employ a fully realized and integrated set of operational tools known as Ensemble *[3]*. This particular set of Ensemble tools have been optimized to provide a cutting edge human / computer interface capable of real time operational assistance for OSV-1 and the partner MAV's.

OSV-1 and the MAV's will perform multiple objectives once the main operational systems are on-line and functional; for this abstract I will discuss the top three (3).

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]*

In conclusion this abstract has only scratched the surface of my vision for a Robotics Mission to Mars.

**References**

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

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# A Robotic Vision

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**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 system 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
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[2] – ***"Issedon Tholus"*** – Date: Unknown
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MATTRACK - Worldwide Track Technology
http://www.mattracks.com/html/model_105m1-a2.htm

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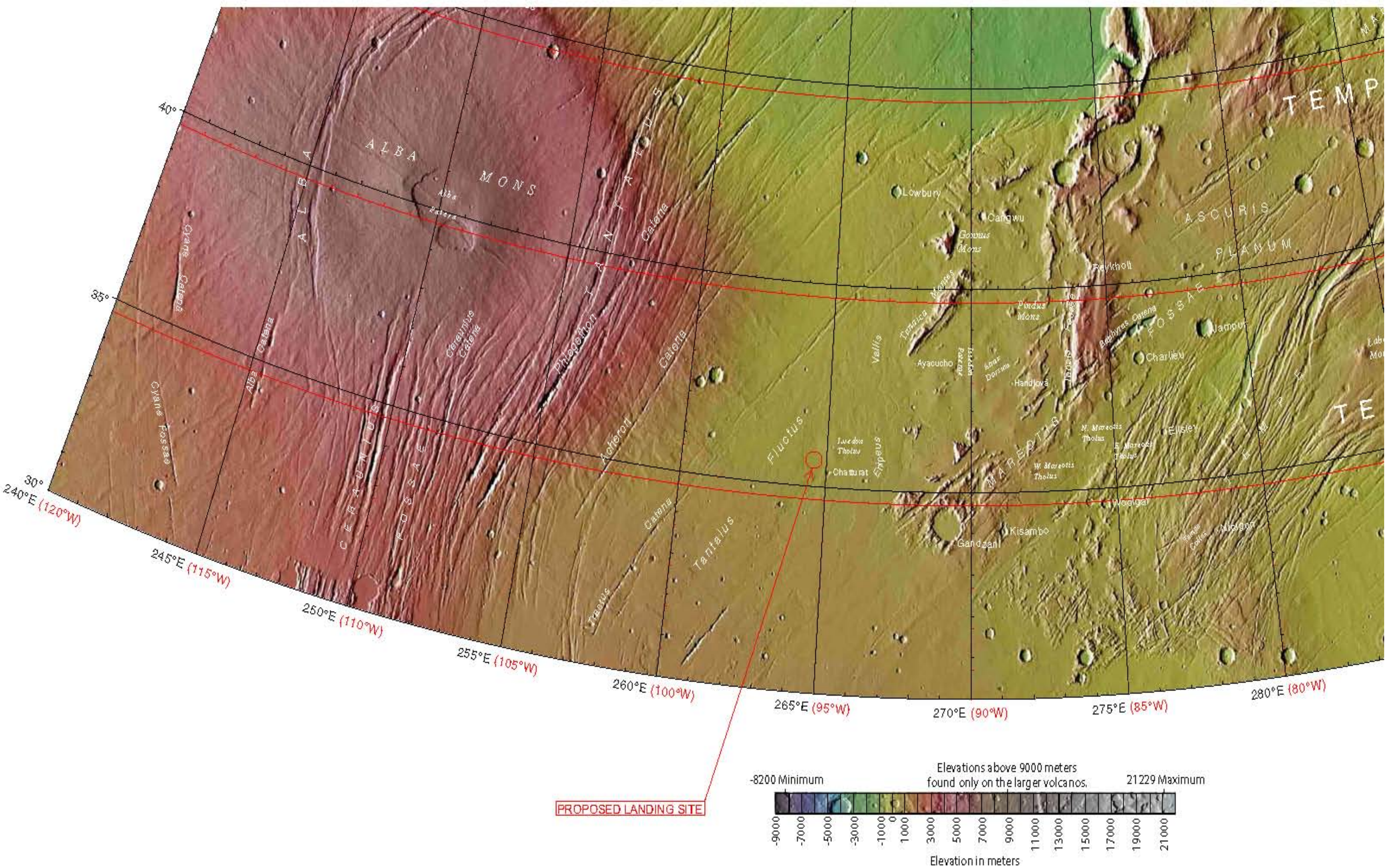
http://en.wikipedia.org/wiki/Mars_Science_Laboratory

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



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30°
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)
ALBA MONS
ALBA
Alba Patera
Cyane Catena
Cyane Fossae
Alba Catena
CERAUNIUS FOSSAE
Ceraunius Catena
Phlegethon Catena
TANTALUS
Acheron Catena
Tractus Catena
Tantalus Fluctus
Vallis
Enipeus
Lowbury
Cangwu
Gonnus Mons
Tanaica Montes
Ayacucho
Pindus Mons
Reykholt
Charlieu
Handlova
Chatturat
Kisambo
Gandzani
Ellsley
MAREOTIS
FOSSAE
ASCURIS PLANUM
TEMP
TE
PROPOSED LANDING SITE
-8200 Minimum
Elevations above 9000 meters found only on the larger volcanos.
21229 Maximum
-9000
-7000
-5000
-3000
-1000
0
1000
3000
5000
7000
9000
11000
13000
15000
17000
19000
21000
Elevation in meters

# A Robotic Vision

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**Timeline / Budget**

**TIMELINE**

In order to achieve a successful trip to Mars, a few factors must be considered. This timeline will discuss the following three topics:

**Launch Date:**

I have chosen May 2018 as the most appropriate launch window for my ***Robotics Mission to Mars*** (RMM). Having a launch date several years in the future will hold multiple benefits. For example, the machinery required to launch this mission's payload into Low Earth Orbit (LEO) and then Beyond Earth Orbit (BEO) is not, at this point, a viable technology. The extended time frame will provide NASA an appropriate cycle for development and implementation of the Space Launch System (SLS) necessary for RMM. The engineering and manufacturing of OSV-1 and the companion autonomous Miniature Aerial Vehicles (MAV) will require a significantly less development window; but will require precision coordination and appropriate field testing between OSV-1, the MAV's, and the Ensemble tool set.

RMM will launch from Kennedy Space Center on Wednesday, May 23rd, 2018. The SLS will be launched at an appropriate time that will be determined when the actual launch window date becomes closer. Once the SLS has placed the RMM spacecraft into LEO, the RMM spacecraft will remain in LEO for approximately 48 hours while in preparation for Trans-Mars Injection (TMI) *[1]*. Upon entering TMI, the spacecraft will travel to Mars on a Hohmann Transfer Orbit *[2]* that will take approximately nine (9) Earth months to complete.

**Landing Date:**

After a brief nine (9) Earth month sojourn through space, the RMM spacecraft will arrive at the prescribed destination; Mars. The approximate travel time will place the RMM spacecraft into Mars orbit sometime in February 2019. Upon arrival the RMM spacecraft will maneuver into geosynchronous orbit around Mars in order to prepare for descent to the Martian planetary surface.

The RMM spacecraft will spend approximately 28 Sols in geosynchronous orbit while calibrations are performed on OSV-1, the MAV's, and Ensemble; these calibrations will be required in order to accommodate the real time functionality between OSV-1, the MAV's and Ensemble. Once parameters set forth by the NASA operations team have been satisfied, descent to the Martian surface will then take place. The RMM spacecraft will release the RMM rover module into the Martian atmosphere with a trajectory that will take it into the Northern Martian Hemisphere. The RMM rover module is set to make surface contact on March 24th, 2019.

**Overall Mars Duration:**

Once the RMM rover module has made surface contact, the core RMM mission will begin. The initial mission parameters have been set at 180 Sols. The core mission has been designed in such a way that all operations coincide with the Martian seasonal cycle. The core RMM mission will commence as the Martian Spring begins and will continue through completion of the seasonal cycle. Depending on the level of success obtained during the initial 180 sol mission, an extension may be granted based on requirements set forth by the NASA operations team.

**Return Launch Date / Return Date**

This RMM mission will not have a return launch date or return date. OSV-1 and the MAV's have been designed to collect data points that can be recorded and measured while *in situ*. All data will be composed and stored in a computer mainframe that can be accessed by the NASA operations team while the RMM mission is in full operation. This RMM mission has not been designed to collect samples for return study and will therefore not require a return launch date or return date.

## BUDGET

The Budget presented for my ***Robotics Mission to Mars***, will address the following three questions:

**How will the mission be funded?**

In 2012, the National Budget will distribute $18.7 billion for NASA operations *[3 - page 151]*. The U.S. Government has estimated that NASA will spend $4.3 billion on Space Operations in 2012 *[3 - page 151]*. 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.

My 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. All costs can be offset in a number of different ways. For example, NASA may opt to include private sector and / or international partners to help with the funding of the RMM mission; an investment cap of 30%, or $405 million, will be place on funding received from external sources. The remainder of the funding for this RMM mission will then come from the 2018 National Budget.

**What is the breakdown of mission funds?**

This simplified breakdown of the mission cost will include all items necessary to complete the RMM mission. The following table will include initial Production Cost of each mission item, an estimated Launch Cost where applicable, and the percentage of the estimated $1.35 billion mission budget. All costs listed will be given in millions of U.S. Dollars.

| Launch Item | Production Cost | Launch Cost | % of Budget |
|---|---|---|---|
| **Space Launch System** | $350 | | 25.93% |
| **Fuel Module** | $50 | | 3.7% |
| **OSV-1 / MAV** | $150 | $300 | 33.34% |
| **RMM Spacecraft** | $100 | $300 | 29.63% |
| **RMM Rover Module** | $100 | | 7.4% |
| | | | |
| **TOTAL COST** | $750 | $600 | 100% |

**What is the justification for spending these funds?**

The justification for this NASA expenditure is quite simple; we need to go to Mars! This mission, and all future Mars missions, is necessary to keep the United States as the global leader in space exploration. Countries such as China and India are knocking on the back door and are poised to take our place. We need to continue to push our technological limitations. Going to Mars is just the thing to provide this much needed motivation.

## References


[1] – ***"Getting There"*** – Date: Unknown
Deborah Hutchings, Aerospace Scholars, NCAS and CAS Program Manager
Research materials provided to NCAS members

[2] – ***"Basics of Space Flight"*** – Section 1, Chapter 4: Interplanetary Trajectories – Date: Unknown
Jet Propulsion Laboratory – California Institute of Technology
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[3] – ***"Fiscal Year 2012 Budget of The U.S. Government"*** – February 14, 2011
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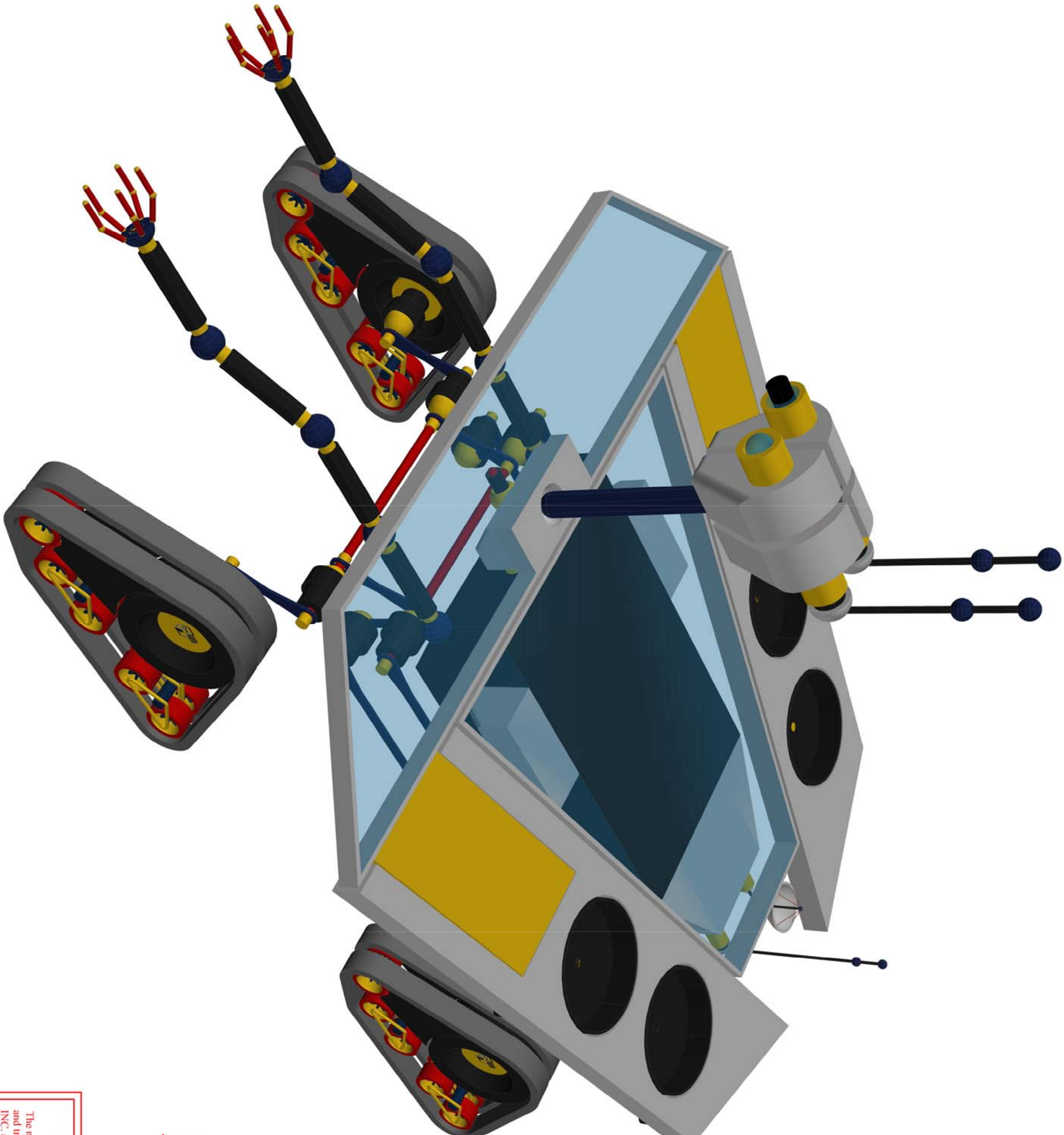
COVER SHEET

SHEET

G-0.1







P-0.1

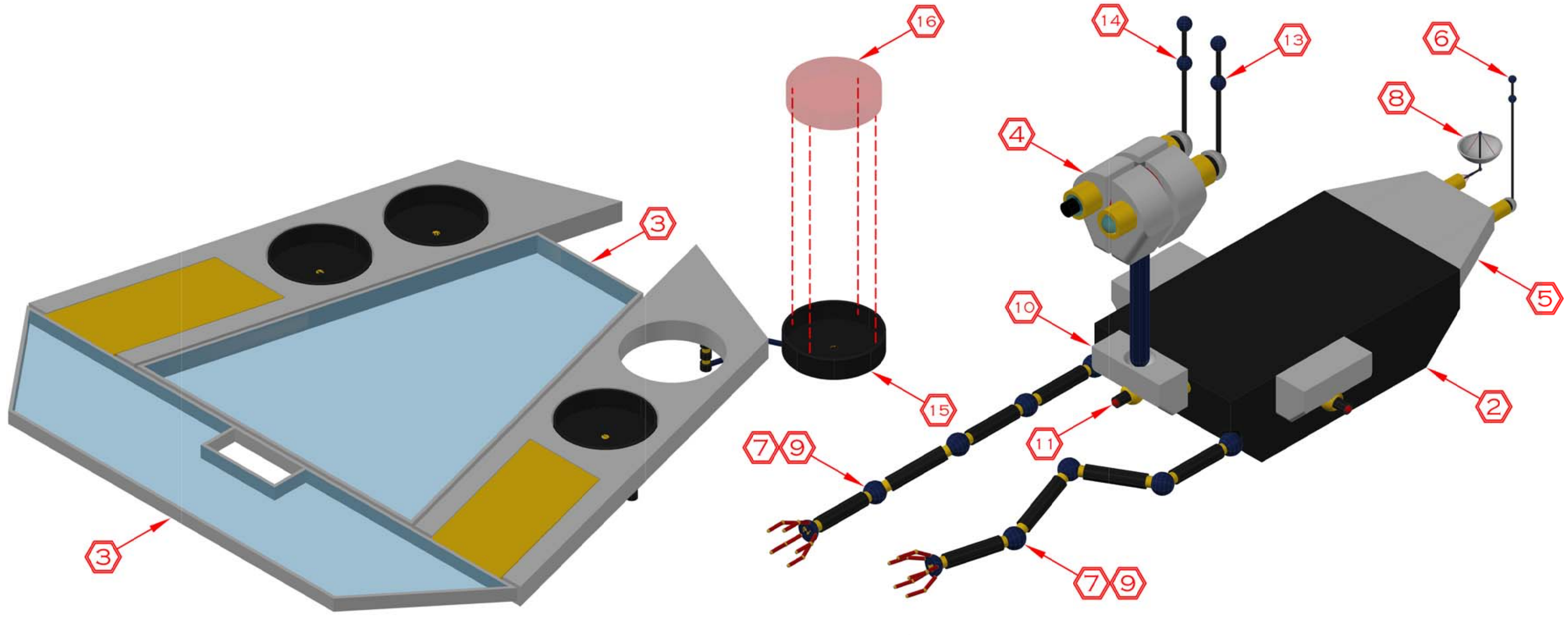
SHEET

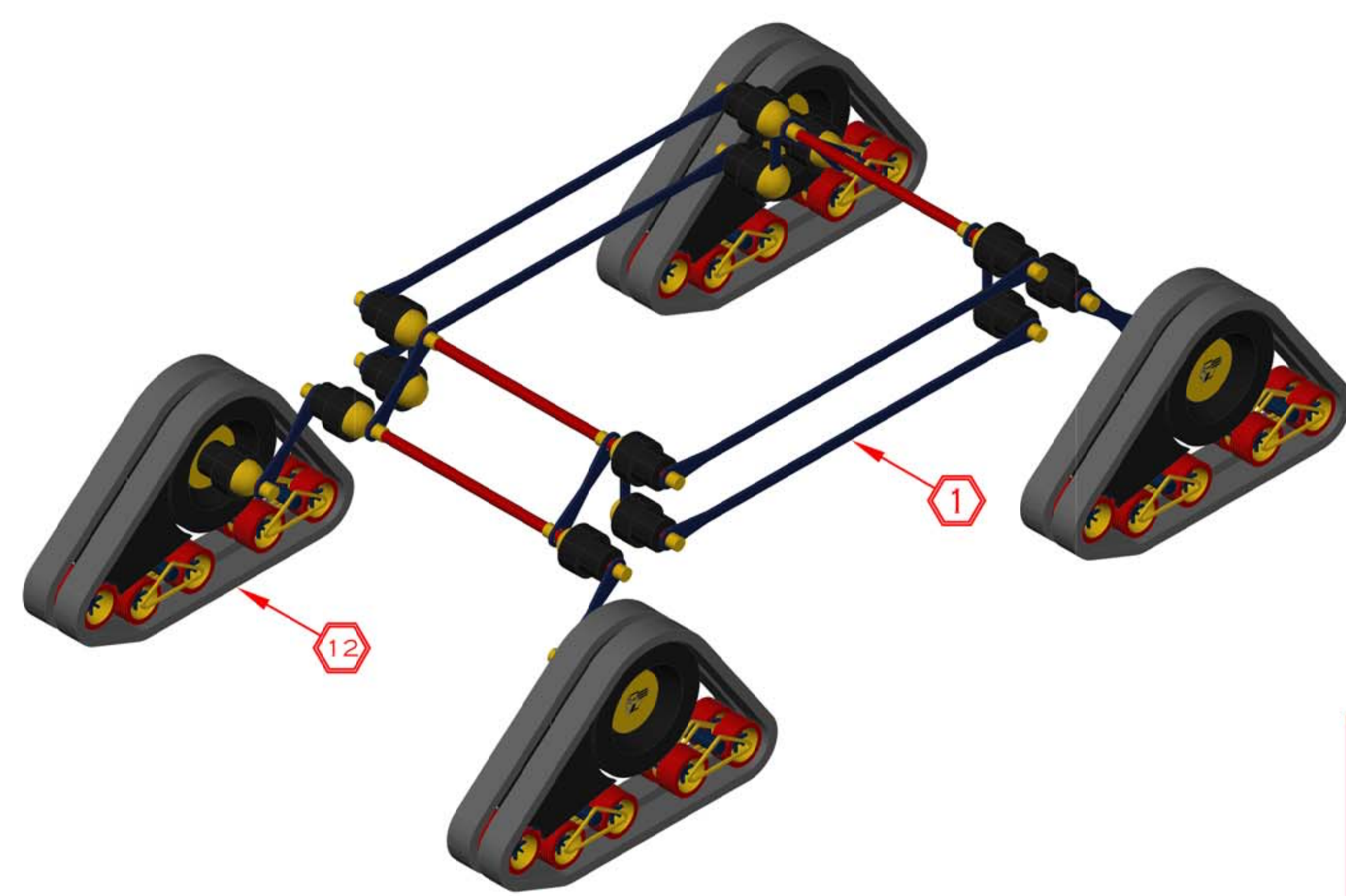
OS.V™ 1

PATENT PENDING

OVERALL 3D IMAGE

evobee




## ROVER INFORMATION

1. CHASSIS
2. POWER SOURCE - MMRTG
3. POWER SOURCE - SOLAR ARRAY
4. INSTRUMENT PACKAGE - ENSEMBLE OS
5. INSTRUMENT PACKAGE - CONTROL UNIT
6. INSTRUMENT PACKAGE - AERI
7. INSTRUMENT PACKAGE - MET
8. INSTRUMENT PACKAGE - XSCAR
9. ROBOTIC - MECHANICAL ARM
10. COMPUTER HARDWARE - ENSEMBLE CPU
11. NAVIGATION PACKAGE - CAMERA - TYPICAL OF 4
12. PROPULSION - TRACK SYSTEM - TYPICAL OF 4
13. COMMUNICATIONS - LOW-GAIN ANTENNA
14. COMMUNICATIONS - HIGH-GAIN ANTENNA
15. MAV DOCKING STATION
16. MAV - PROVIDED BY USAF



EVOBEE

# OS.V™ I

PATENT PENDING

EXPLODED 3D ISOMETRIC

SHEET

P-0.2