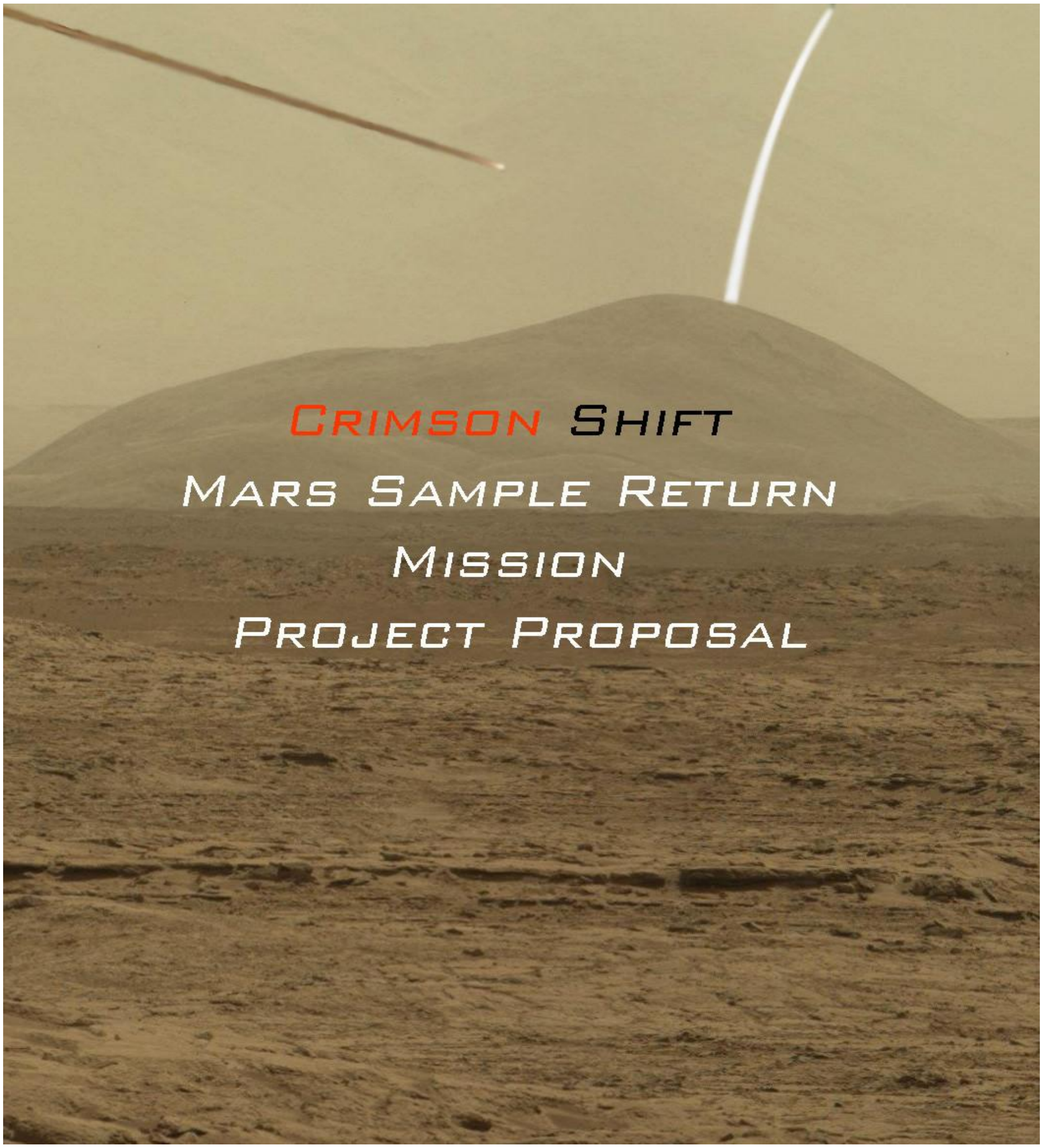
2014



[MARS SAMPLE RETURN: CRIMSON SHIFT]

The Mission NASA needs to accelerate Mars Exploration both technologically and scientifically.

The Team

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Foreword

“Mars is out there, waiting for us.” – Edwin “Buzz” Aldrin

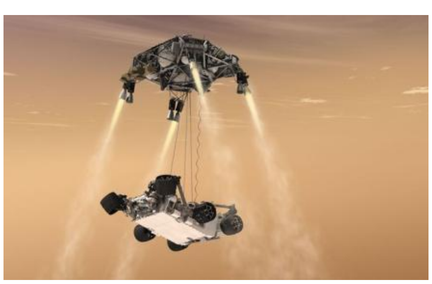
As the 21st Century progresses, the curtains of manned space exploration are drawn out once again for Humanity to make leaps and bounds onto a cosmic stage that we had left behind. With the progression and success of robotic space exploration, we have allowed ourselves unparalleled preparation for the next big leap in exploration; manned missions to Mars. Not just for exploring and discovering scientific agendas, but eventual colonization. Something Humanity has not done, in hundreds of years. Mars is a mystery, an ongoing 20th to 21st century grade challenge that only the smartest and innovative dare undertake. Each robotic Mars mission to date is just as technologically advanced as the previous. We push for the development of new systems and deriving current designs to improve on them. The aim and imperative to increase and prove our accessibility to Mars is crucial to manned spaceflight capabilities and robotic exploration.

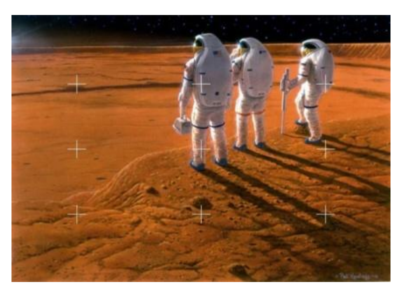
Need

Since the late 20th Century, NASA and its successive number of missions to Mars had developed the drive for newer technology and or repeating proven missions with new hardware to enhance the exploration of the Red Planet. The Martian Surface, as over time observed and studied, has a chemical composition and molecular similarity extremely similar to Earth's. It contains many elements such as potassium, chlorine, carbon and other important minerals that are essential to plants on Earth. The initiative for conducting ISRU (In-Situ-Resource Utilization) on Mars is now set in stone in conjunction with a manned mission. It is important more as ever to closely study the soils of Mars and find out with facilities and hardware that cannot be brought to the Martian surface. One example of returning many samples from Mars is to allow scientists the opportunity to experiment and genetically modify current plant life to live on Mars to the soil compositions and replicating the chemistry to a usable level.

Because of this, the idea of a Mars Sample Return mission has been an idea on the drawing board for decades. As scientific discoveries on Mars progressed, the required need for new spacecraft with complex scientific instruments could be developed and fitted onto a Lander. In conjunction with new missions, NASA has been a proponent for pushing new technologies to land heavier payloads with accurate landing hardware onto the Martian Surface, to prove the technology can be achieved and applied for an eventual manned mission to Mars. There are many opportunities with a Mars Sample Return mission to improve current technology and upcoming technology as the amount of intellectual and scientific data gained in return is worth the investment and time available for appropriate technology maturation leading up to the planned 2024 or earlier launch date.

There is the demand to know if there is, was or is able to support life on Mars. The importance to finding out if there ever was live on Mars is to get a broader perspective to how life began, and possibly, how it can end. Knowing if there is life on Mars in an unambiguous manner can shed light on what is necessary for a planet to sustain life. Lastly there is a necessity to find out if humans can not only survive on Martian soil but prosper on it. Therefore the need of this project is to know what the resources at the surface of Mars are.





Goals

To get a better grasp on the sustainability of life on Mars, resources must be accounted for. Satellite imaging has its limits and the instruments on the current rovers might get vague results on the composition of some minerals on the surface of Mars. At the absence of scientists to directly analyze Martian soil calls for the need of various samples that need to be studied. The ability to let an upcoming rover successor to the Mars Science Laboratory (MSL) with newer or improved instruments is able to determine what is of scientific interest to bring back to Earth for further study. It is still imperative that this MSR is capable of the primary goal: Bringing samples back to Earth.

Previous proposals and MSR layouts have only allowed for a finite payload of samples to be launched back to Earth. This is due to the constraints of the use of proven *Viking* mission architecture. These limitations such as weight and volume constraints hamper on the ability to bring back a diverse sample payload. The MSR architecture shown below circumvents these issues and is designed to bring back a large, diverse payload from Mars for equal distribution to research for Laboratories and Universities across the World. In conjunction with the primary mission of returning a sample from Mars to earth, the goal of *Crimson Shift* Mission is to also set the standard for future mission designs. Immediate examples of the innovations involved will prove the capability to land heavier Landers on the surface at various altitudes, demonstrate new EDL methods, and proximity landing to assets already on the ground.

The goals of *Crimson Shift* are outlined as follows:

1) Develop mission architecture through means of developing new technology and improving current systems for a robust, long term mission contingency.

2) Utilize and prove new mission systems are effective for the MSR mission and able application for future missions both manned and unmanned.

3) Conduct mission operations to land on Mars within range performance of Rover already on the ground by means of new EDL and proximity landing.

4) Acquire already scientifically interested samples from Rover Asset to return to Earth.

5) Confirm hazards or assurance that Martian Samples are dangerous or safe for handling by human interaction onboard the ISS or rendezvous vehicle.

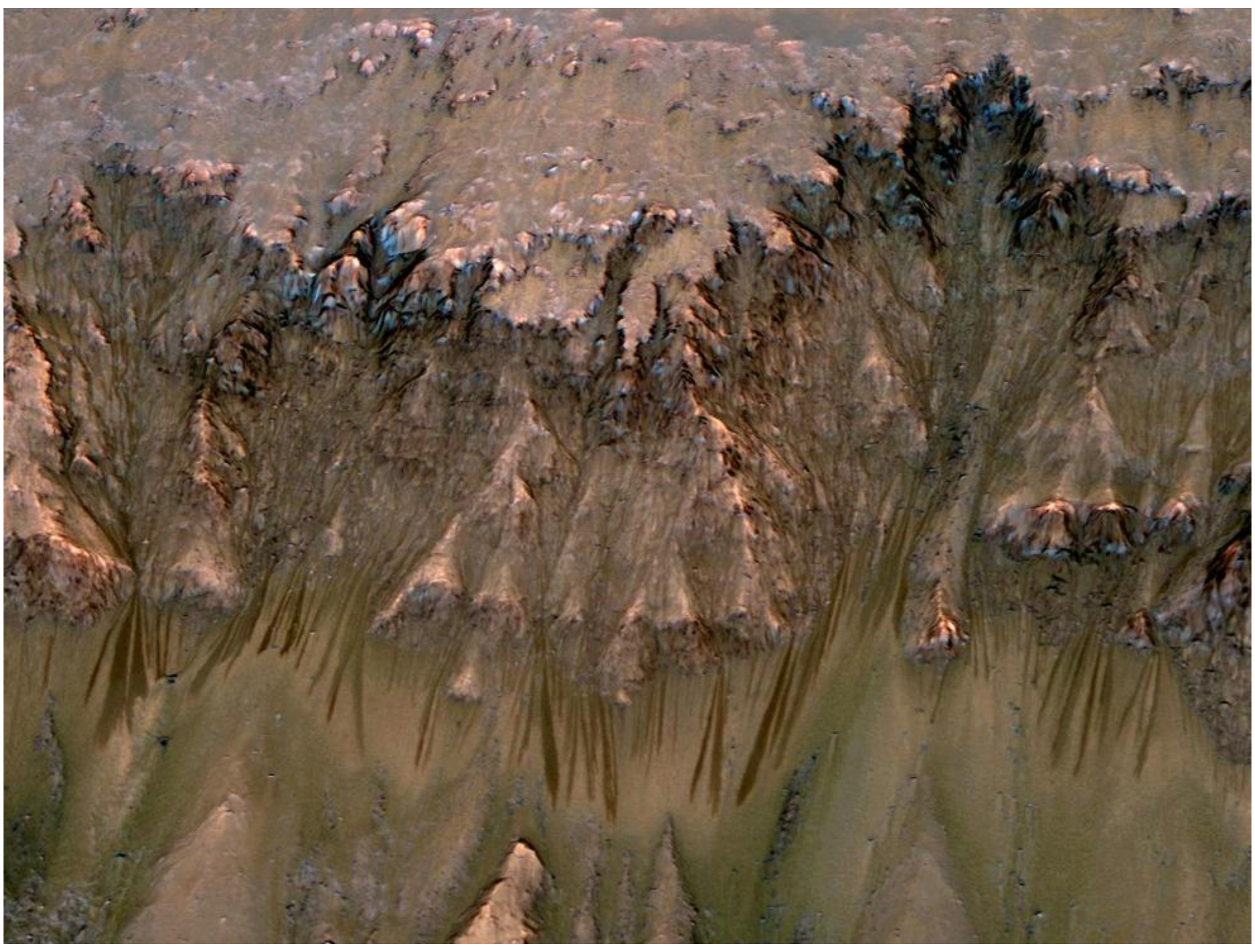
6) Distribute to Labs and Universities to conduct experiments on samples.

Objectives

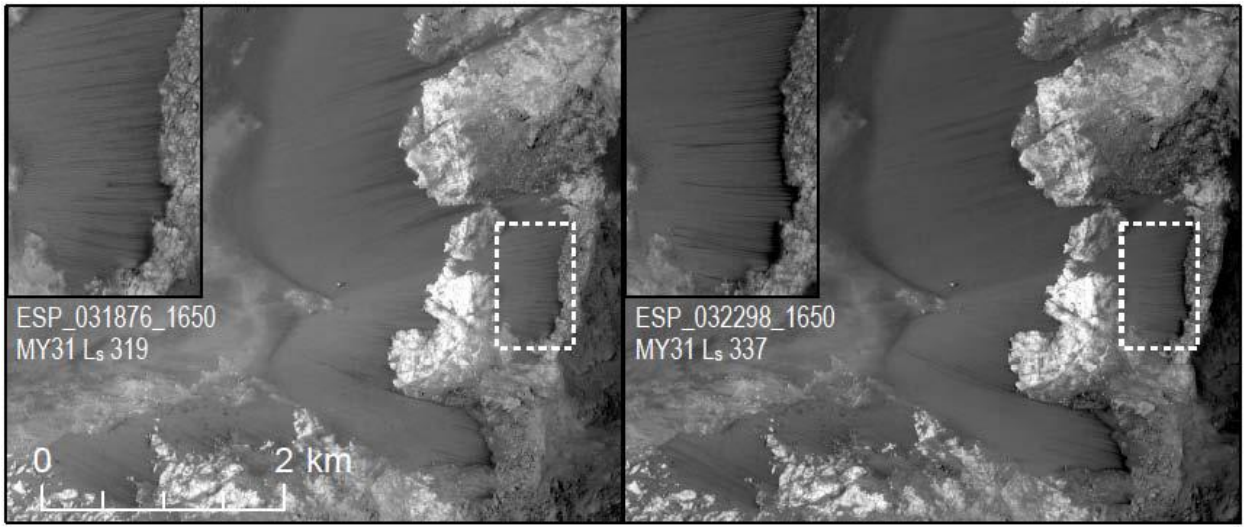
Therefore, to get a better assessment and advance instrumentation maturation, a new remote control Lander with the most advanced or improved instruments derived from current technology must be developed. The Lander design will be applying this new technology with an EDL method designed to land in an area within reach of the other asset on the ground. A second option is to land ahead of the rover's path in an area where some of the samples might deem conclusive or scientifically interesting. To rendezvous where a rover already is on the ground and has samples onboard is essential. In context, to designing a Lander to rendezvous with a mission asset already on the ground, we will be designing mission specific elements for the first time that parallel NASAs agenda of advancements to prepare for an actual Human mission to Mars.

Geology Objectives and Potential Mission Sites

There are locations of potential high scientific interest that reflect NASA's agenda to landing in terrain previously inaccessible. It is the responsibility of the *Crimson Shift* mission to adapt and land in the same terrain or within driving distance outside the terrain with the MAV ready to pick up the samples from the Mars 2020 rover. Examples of previously inaccessible terrain include locations that exhibit one of the most exciting mysteries of Mars: the Recurring Slope Lineae (RSL). Examples of locations that we have considered for this mission and investigation are the Coprates Chasma, located in the Valles Marineris, and Newton Crater.



RSL in the Newton Crater



RSL activity in the Coprates Chasma.
Credit for photos goes to NASA/JPL/ University of Arizona/ Caltech/ HiRISE/MRO

The Mars Reconnaissance Orbiter has captured photos of what has been speculated to be liquid salt water flowing on the surface of Mars. These "dark streaks" have been labeled as Recurring Slope Lineae and occur at numerous locations on Mars, namely along the walls of craters or canyons.

RSL tend to appear during the Martian summer and recede or fade away during the winter. They are a few meters across and can extend to over one thousand meters long. It is hypothesized that frozen water at the walls of the crater form during the winter and melt during the summer, flowing downhill and forming the RSL. They appear in many locations near the Martian equator including in the Valles Marineris, at Coprates Chasma, as well as at Newton Crater, Horowitz Crater, Palikir Crater, and Raga Crater.

In our sample return mission, the Mars 2020 rover and our sample recovery lander would land at the Coprates Chasma in the Valles Marineris on Mars. The Coprates Chasma was identified by the Mars 2020 Science Definition Team, in their July 2013 report, as a possible landing location for the Mars 2020 Rover and for possible future Mars missions. According to the report, the Coprates Chasma makes an ideal landing location because it is located only two kilometers north of a landing ellipse deemed suitable for a rover to land.

For our mission, the Mars 2020 Rover would take samples of the RSL during both the winter and summer months. The sample cache will then be recovered and return to Earth for analysis. These samples could then be examined side-by-side, determining differences in chemical composition, and help us solve the mystery of the Recurring Slope Lineae. It has been suggested that the RSL are composed of liquid salt water, and possibly contains iron-bearing minerals. Aside from the RSL, the Science Definition Team noted that the Coprates Chasma is also enriched in Low Calcium Pyroxenes and possibly phyllosilicates Image. This mission is scientifically interesting in examining the geology of Mars and is a critical step in the pursuit of searching for signs of life, past or present, on Mars.

Technological Objectives

The Mars Sample Return mission, Crimson Shift, is aimed at accomplishing the Sample Return objective by undergoing a necessary new phase in Mars Lander architecture. Current mission designs are reliant on The Viking Mission architecture.

It is a design which, while proven, can only be developed and used within certain parameters. As of 2012, Viking Mission Architecture has worked successfully to land .99 tons safely by new EDL methods. A Mars Sample Return Mission will require a rocket that can meet the demands of a heavy payload and guaranteed shot to orbit. In simple terms, the MSR Architecture will require to work beyond the bounds of a capsule. The capsule shell, a 70 degree cone shell, can only be used a limited amount to land mission designs within its weight and volume limits that are constraining. When developing a multi-step Sample Return Mission. The limited volume space of a cone shell prohibits the ability to take a heavy payload up containing surface and atmospheric samples within a MAV. Crimson Shift shall circumvents these constraints by designing a multi-functional Lander and re-entry vehicle that is capable landing within proximity of a Mars Rover Asset already on the ground, The Mars 2020 Rover.

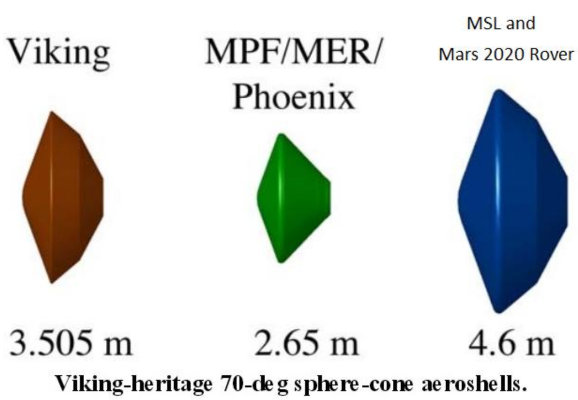


FIGURE 1- Viking Architecture

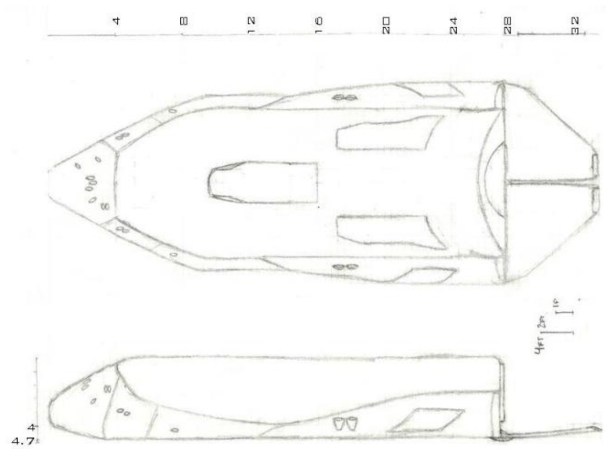
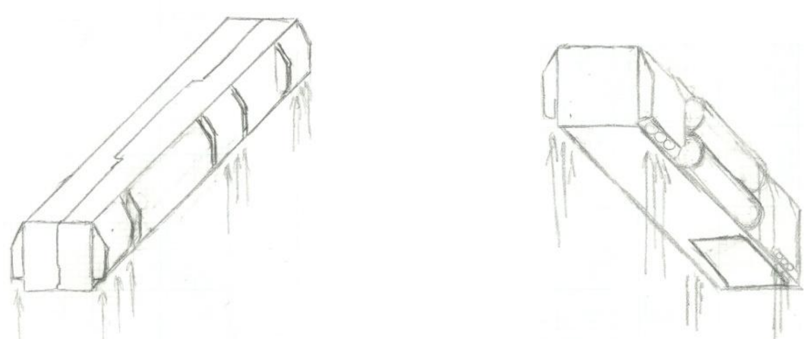


FIGURE 2- Lifting Body Aeroshell Concept

The use of new and actively tested (up to the launch date) EDL Methods will allow for a safer re-entry and landing of a heavier payload due to room for more powerful computer hardware and rugged systems that can function quickly and adapt by means of flight. The lifting body Aeroshell has an ability to glide rather than parachute deceleration. With an Aeroshell, the MSR is able to follow a flight path of descent leading up to the final target point before separating to deploy the SILO Lander.



FIGURES 3 AND 4- Beginning Concepts of SILO MSR Lander

Mission

Mars 2020 Rover Summary

Current plans of the Mars 2020 Rover Mission Architecture is independently laid out and operationally underway. Once on the ground and all systems are checked, the rover will proceed to its own mission timeline of acquiring samples and analyzing them for scientific interest and on the spot experimentation. Further samples on the surface or sub-surface that are deemed of high interest will be placed in a sample container on board the Rover. After a mission time of 2 years, the rover may or may not have a filled up sample cache for future retrieval. Most importantly, the sample cache will be containing samples and will be ready by 2024 to drop off the sample container with the Mars Sample Return Mission.

Mars Sample Return Mission

The Surface mission of *Crimson Shift* is to land in proximity to the Mars 2020 Rover. The proximity landing maneuver shall be within driving range of the Mars 2020 Rover. As proximity landing is being done for the first time, The Crimson Shift mission has deemed that the landing zone is within a 3km diameter distance of the Rover Asset as a safe contingency should the conditions during the landing phase not go as planned to land within approximately 250 meters of the target. It is imperative to avoid landing too close to the Mars 2020 Rover that we might damage instruments due to immense dust kicking during landing or develop atmospheric discrepancies with all the airborne dust and sand. After landing and systems check, the SILO Lander can conduct its own scientific experiments (through piggybacked independent sub-systems and instruments that lie within weight and dimension parameters) while waiting to retrieve the Martian soil sample from the Mars 2020 Rover.

Authority

Scientific Institutions
(SWRI, Academic Universities, National Academy of Science, etc)
National and international academies and firms have an opportunity to contribute input for the Mars Sample Return Mission: *Crimson Shift.* Institutions shall have two options available.

The first option is to submit proposals for mission related instruments that are capable to meet weight and dimension requirements within the SILO Lander.

The second option is submitting Science based criteria for preferred soil samples to obtain for the Mars Ascent Vehicle and the hypotheses behind what there is to be discovered.

National Aeronautics and Space Administration (NASA)
NASA is responsible for the majority of in-house development and testing for the Mars Sample Return mission. The testing of mission architecture ranges from facilities usage regarding aerodynamics, propulsion, structural integrity.

Contracted Companies (Boeing, XCOR, Lockheed, Rocketdyne, etc)
Various Aerospace Industries shall be contracted awards to submit, where qualified and authorized, specific optimal mission or mission capable components that are backed by years of Aerospace or completed contract experience for Aerospace or Space based mission architectures.

Contracted companies will also have the opportunity to launch or test completed mission architecture that lies within a company's capabilities. An example of this is utilizing sub-orbital space companies such as XCOR Aerospace for launching components for space worthy testing or whole mission architecture such as the Sample Extraction Ascent System and or the Earth Return Stage capture and payload storage unit for integral and function testing.

Space Exploration Technologies (SpaceX)
SpaceX is responsible for launch system assembly, payload fairing assembly cooperative integration of the MSR payload with a Falcon Heavy launch system. Mission Jurisdiction prior to launch shall be handed to SpaceX during the movements of the MSR Payload into the Falcon Heavy payload fairing and eventual integration with the Rocket System leading up to the launch window. Mission Authority is handed over concurrently with mission preparation leading up to launch day for the MSR. Full authority falls with SpaceX through out the launch sequence leading up to payload separation for the Trans-Mars Injection.

Assumptions and Projections as of 2014 to 2024

NASA is obtaining ongoing funding of at least ~17 Billion USD per year for the next 15 years.
Many of the technologies being developed will require consistent, but not excessive funding for technology maturation of the MSR Mission. Certain items that can be better developed outside of NASA will be contracted out to firms and agencies in a joint-effort capable of creating mission specific items in fields such as propulsion, aerodynamic bodies and composite materials.

NASAs Space Launch System (SLS) program is canceled.
The shifting politics and budget constraints behind the Space Launch System has deemed this heavy lift launch system controversial to whether it will be operational by the 2024 launch date. This proposal runs under the notion that the SLS will not be around in 2024 or a successor SHLV (Super Heavy Launch Vehicle) project will already be in development, but not ready in time for the Mars Sample Return mission.

Space Exploration Technologies (SpaceX) develops a fully tested Falcon Heavy Rocket by 2017 and is priced as announced.
The ongoing success of SpaceX and their Falcon series of rockets have brought the attention of their upcoming capabilities to launch their super heavy launch vehicle, the Falcon Heavy. This particular launch system meets the MSRs needs of a launch vehicle capable of sending a payload upwards of 29,000 lbs on a Mars trajectory under its own power. This is extremely appealing to sending a multi-component MSR payload all in one launch within payload limitations. As of 2014, the company is in a busy time period under the constraints of meeting launch manifests of the Falcon 9 series and the ability to land and reuse whole launch vehicles. The current costs of a Falcon Heavy launch vehicle, reusable or not, is exponentially cost effective against other launch systems.

The Mars 2020 Rover is developed on schedule and on budget with a 15% increase of the first estimate. It successfully launches on time from Earth and lands on Mars in a region of scientific interest.
The mission architecture for the MSR shall assess the Mars 2020 Rovers exact location of the Lander and finalize an EDL flight plan that lands the MSR near or to close proximity the Mars 2020 Rover.

The International Space Station is still operational beyond 2024. A MSR in context to the ISS that this mission architecture being shown may be last final scientific mission of the Space Station before decommissioning. Should the ISS be decommissioned in 2024, Mission architecture can adjust for alternate retrieval by remote or manned spacecraft once in Earth Orbit. The International Space Station is not being designated the role of a lab to do science, but to simply be the decontamination barrier to prove and confirm that the Mars samples are not deadly to the human body and safe for physical handling. A commercial or government based spacecraft capable of re-entering Earth's atmosphere adds a layer of guaranteed protection of the samples for a safe descent back to Earth.

Constraints

A mission to space or another planet will come with constraints. The Mars Sample Return mission is no different. Analysis of current constraint factors that would pose immediate risk to the mission are both predictable and various.

Launch System Constraints

One constraint would be that the MSR Mission, *Crimson Shift,* is relying on one launch system. And within limits of what it's capable of. There are other launch options available and more immediately ready such as the delta IV heavy and the Arianne 5 and 6, but would require drastic weight changes and limitations as they cannot lift the same payload in lbs. under their own power on a mars trajectory. Only the Falcon heavy is confirmed projected to execute this feat. Launch related constraints on the pad are relative to possible software or sub-system glitches that may hamper on a rockets ability to reach orbit successfully. Adequate time must be considered for possible mishaps.

Awarded Contracted Components and Reliance on Private Enterprise.

The reliance on rewarding mission components to be assembled by other companies and firms with accrued expertise in that particular field sets the MSR mission on the accountability factor of those companies completing those mission specific pieces on time and within budget. The factors that lie with contracting components is that the MSR Mission may be dependent on mission critical pieces that may or may not be completed on time or within budget parameters. There will be contingency plans behind the scenario that one of more mission components contracted to companies to develop do not be met on schedule.

Time Constraints

The launch for a vehicle to Mars is limited to a certain window of time. Ideally, the launch must occur when the Earth and Mars are closest in their orbit. This happens once every 26 months approximately. The Earth will be closest to Mars in January 2025 so the launch for our MDL should take place in late 2024. It is important that all phases of the development of this mission are on schedule to meet this deadline.

Budget Constraints

The operations of this mission must be managed within a fixed budget. NASA's budget is subject to what is granted by the federal government; its budget must be approved by both Congress and the President. Problems with staying within budget could possibly lead to time management problems consequently.

Facility Constraints

For this mission we will be using the facilities of contractors such as SpaceX, Boeing, and Lockheed Martin. Because these companies will be working on other ongoing projects, we will likely have a limited amount of time and space to work with at these facilities.

MSR Mission Schedule
An Immediate Projected Overview to 2024

<u>2014- Onward</u>

MSR Approved. Begin MSR Life Cycle Operations

-6 years development time for New MSR Technology
-Technical Reviews over 6 year span confirm or adjust mission architecture and or systems to remain within mission parameters
-Contracted awards to companies of specific expertise
-Science Laboratories and Universities authorized to develop additional science instruments for mission to be within specific weight, dimension requirements.

<u>2020</u>

Mars 2020 Rover successfully assembled on schedule and launched.

-Life Cycle Parameters and Reviews met
-Sample Container Unit component approved to mission goal and onboard Rover
-Consistent Funding of Mars 2020 Rover leading up to launch with funding for operations.
-The Mars 2020 Rover lands on Mars next year and begins science experiments.

<u>2021</u>

All Technology Maturation requirements met and Contractor Components Integrated and Tested to Proper review date by end of year.

-All contracted components and mission specific hardware functioning optimally or to mission standards.
-Specific hardware integrated with mission control systems.
-Additional scientific instruments submitted by labs and universities.

<u>2022.</u>

MSR Assembly Approved. Finalized Mission components construction under way. Launch System negotiated for purchase and under Construction earlier last year.

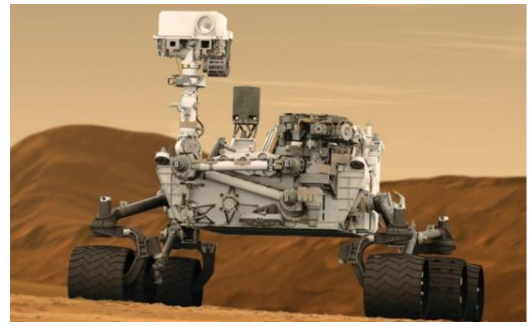
-Falcon Heavy Purchased. A reusable or expandable version will be determined the day of or during technical review.
-All MSR Hardware and Structure begins for final assembly and construction.

<u>2024</u>

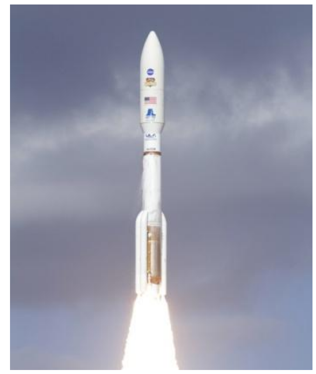
SpaceX is given jurisdiction of handling payload after completion and integration onto Falcon Heavy Rocket from Assembly Completion. MSR *Crimson Shift* Launched and set on trajectory to Mars.

-MSR Payload Integrated with Falcon Heavy Flight Systems
-Payload inserted into Custom Falcon Heavy Fairing
-Final Checks and Discrepancies noted and or fixed prior to launch. Adequate time allotted in case of Contamination.

Budget



Our budget shall account for all aspects of the Mars Sample Return Mission, Crimson Shift. It also includes that of the expected budget of the Mars 2020 Rover. The costs of the MSR will be higher due to the mission architecture of developing new technology that shall be applicable for future robotic missions and an eventual manned mission to Mars as well. *Crimson Shift* shall allocate appropriate funding for the development of new necessary systems to execute the mission. The development of the new design architecture can be justified as a long term investment as these new systems and designs will pave the way for future missions and not just immediate mission needs. The projected budget is as follows.



Total budget: $6.25 Billion

Mars 2020 Rover costs:
$1.5 Billion for Mars 2020 Rover, including support and launch costs.

Projected costs for Crimson Shift mission:

$2.5 Billion for Mars Sample Return technology maturation, development and applications of improving existing systems.
These allocated costs shall be used but not limited to:

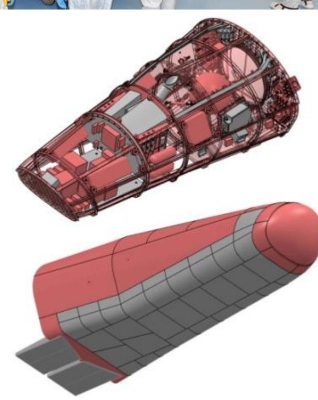
1) The Launch Vehicle- A SpaceX Falcon Heavy Series Rocket (Reusable or Expandable model)

2) Development of new mission systems for the MSR and for application of future missions (Aeroshell, Lander)

3) Testing of new mission systems on the ground, and the conducting of mission simulations.

4) Active Testing (Launching components or mock missions into orbit by means of Suborbital Spacecraft to test instruments for performance, accuracy and rendezvous capabilities.

5) Testing and possible application of new materials and techniques that enhance or improve mission sustainability.



$1.75 Billion on support of the Operations, which includes staff, use of facilitates and other expenses of operations.

$**500 Million allocated toward contracted awards and additional mission architecture where appropriate.**

MSR Mission Architecture

Mars 2020 Rover

Our Sample Return Mission will utilize the capabilities of the Mars 2020 rover, currently under development at NASA. One of its missions is to collect soil samples from the surface and sub-surface of Mars for future retrieval. The rover in regard to the MSR, Crimson Shift, will store the samples in a Sample Cache until the SILO arrives on Mars to retrieve it. Complimenting an existing Mars Mission on the Surface removes the need to create a fetch rover to acquire samples. It also allows the MSR mission, as previously stated, to focus on newer technology and proving new applicable systems for future missions.

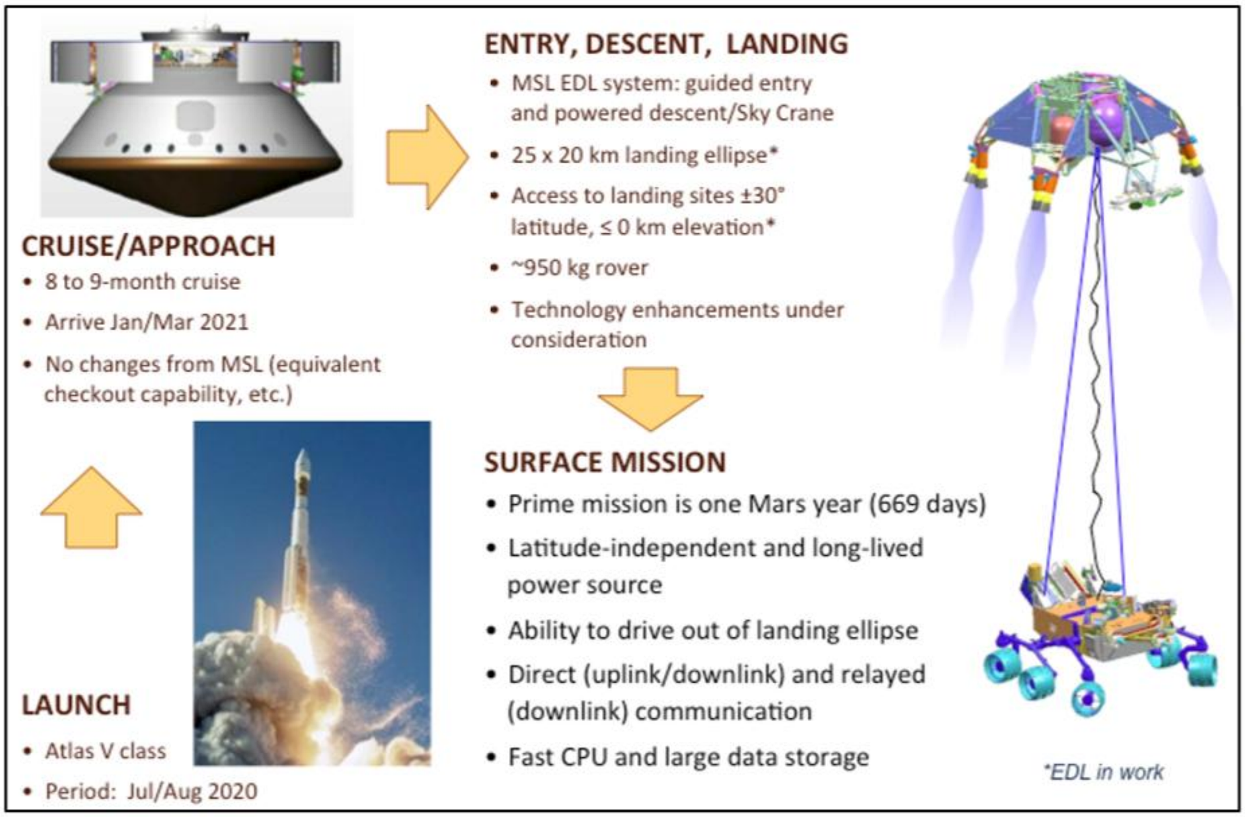
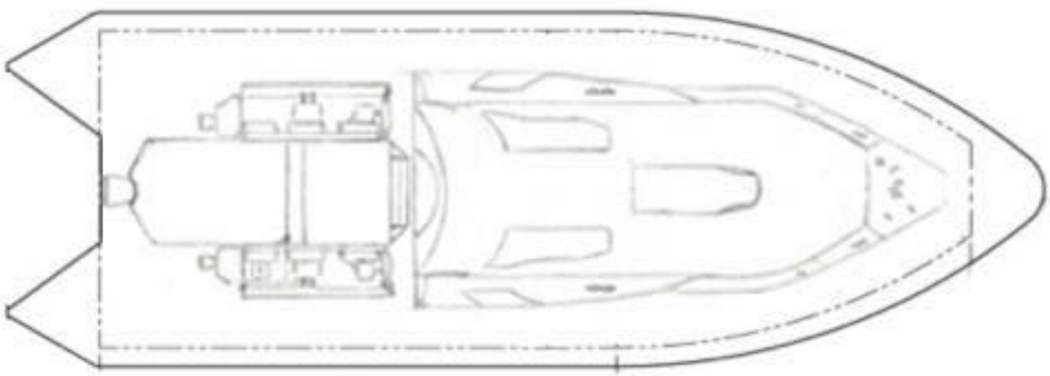
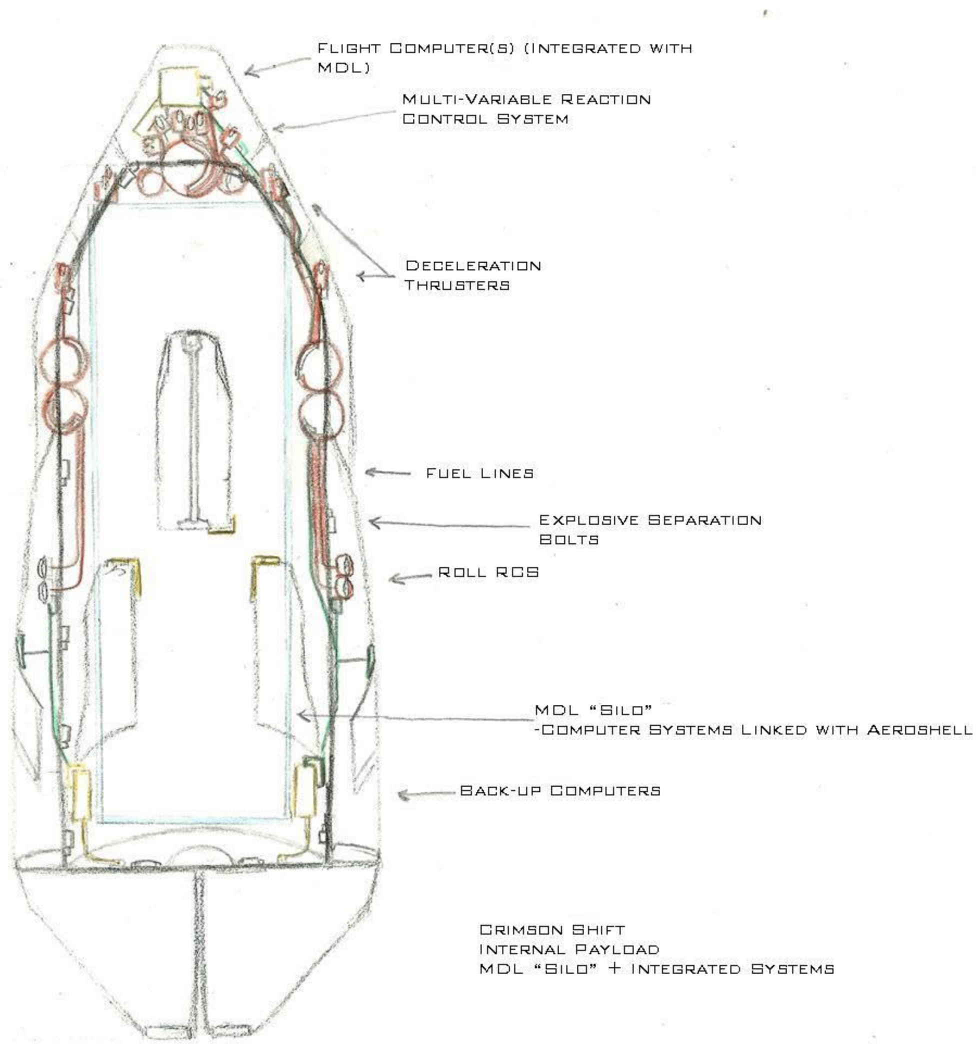


FIGURE 5- Mars 2020 Rover Mission Architecture and Timeline.

Falcon Heavy Launch Vehicle

SpaceX's Falcon Heavy vehicle shall launch the entire MSR Payload on a trajectory to Mars. The Falcon Heavy has a payload capacity is 29,000 lbs that is capable of launching this weight under its own power on a Trans-Mars Injection.





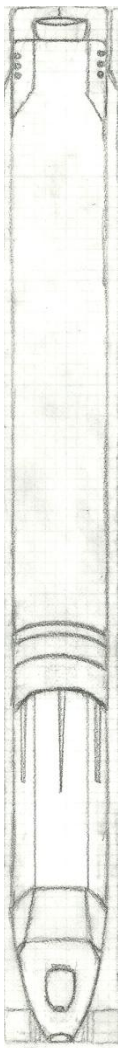
Mars Descent Vehicle: SILO and Aeroshell

The SILO lander will be launched from Earth, travel to Mars, and land on Mars near the Mars 2020 rover. The Lander is in a lifting body Aeroshell vehicle and shall rapidly slow down over the surface of Mars using deceleration thrusters and flight maneuvers due to its design containing flight surfaces to follow a descending flight path. The materials used on the spacecraft are aluminum for the body, titanium where applicable to increase integrity and rated thermal tiles to move the ionized particles and heat off and around the spacecraft. The Aeroshell shall separate in two to deploy the SILO for final descent to the surface. The 2020 rover will transfer the soil samples to the SILO and prepare for the trip back to Earth. The SILO shall also contain up to 1 additional sample cache for the 2020 Rover to swap and use to increase mission duration after transferring the primary Sample Cache it came with to the Mars Ascent Vehicle.

Mars Ascent Vehicle (MAV) and Sample Extraction Ascent System (SEAS)

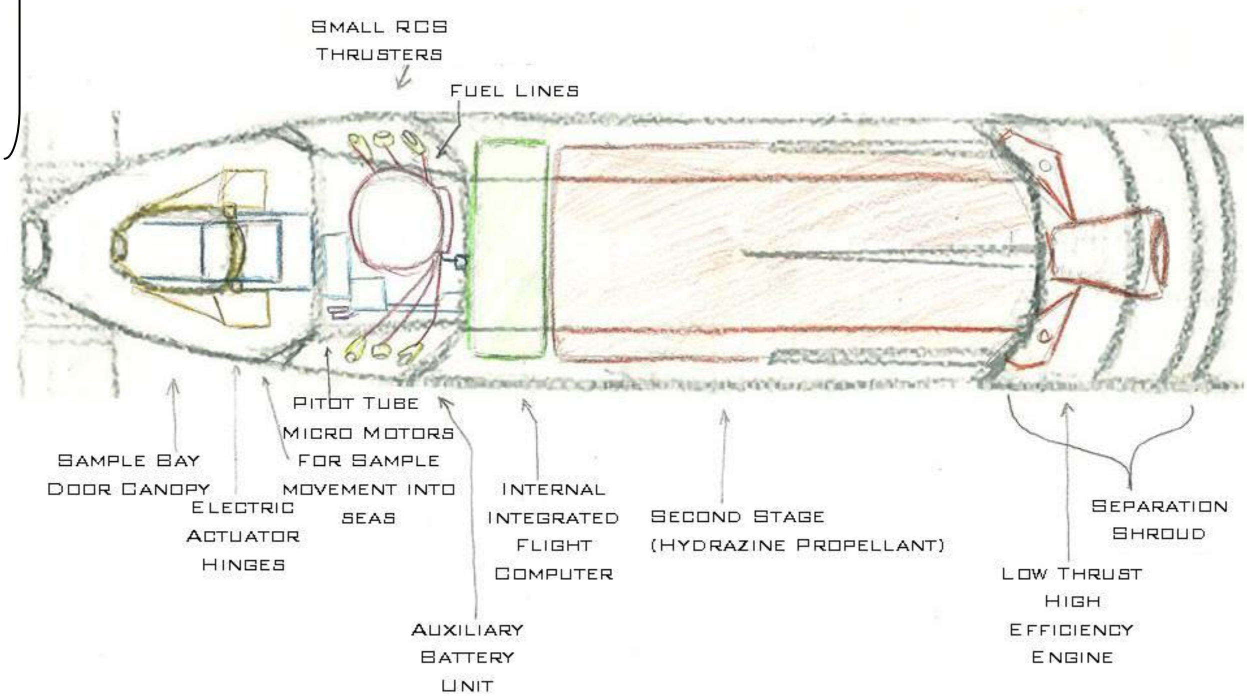
The Mars Ascent Vehicle (MAV), which contains the Sample Extraction Ascent System (SEAS), is the part of the SILO that will return the Martian soil sample to Earth orbit. The MAV will be launched on a rocket from the SILO into an orbit around Mars. It will dock with the ERS in orbit and rendezvous with the ISS for biohazard testing of the Martian soil samples.

The SEAS is the upper stage component to the Mars Ascent Vehicle. It is comprised of a liquid propellant second stage designed to establish itself into an orbit once the first stage has the SEAS away on a flight path that puts it out of the Martian Atmosphere. The SEAS contains a 31 Sample Cache, the one exclusively used on the Mars 2020 Rover.



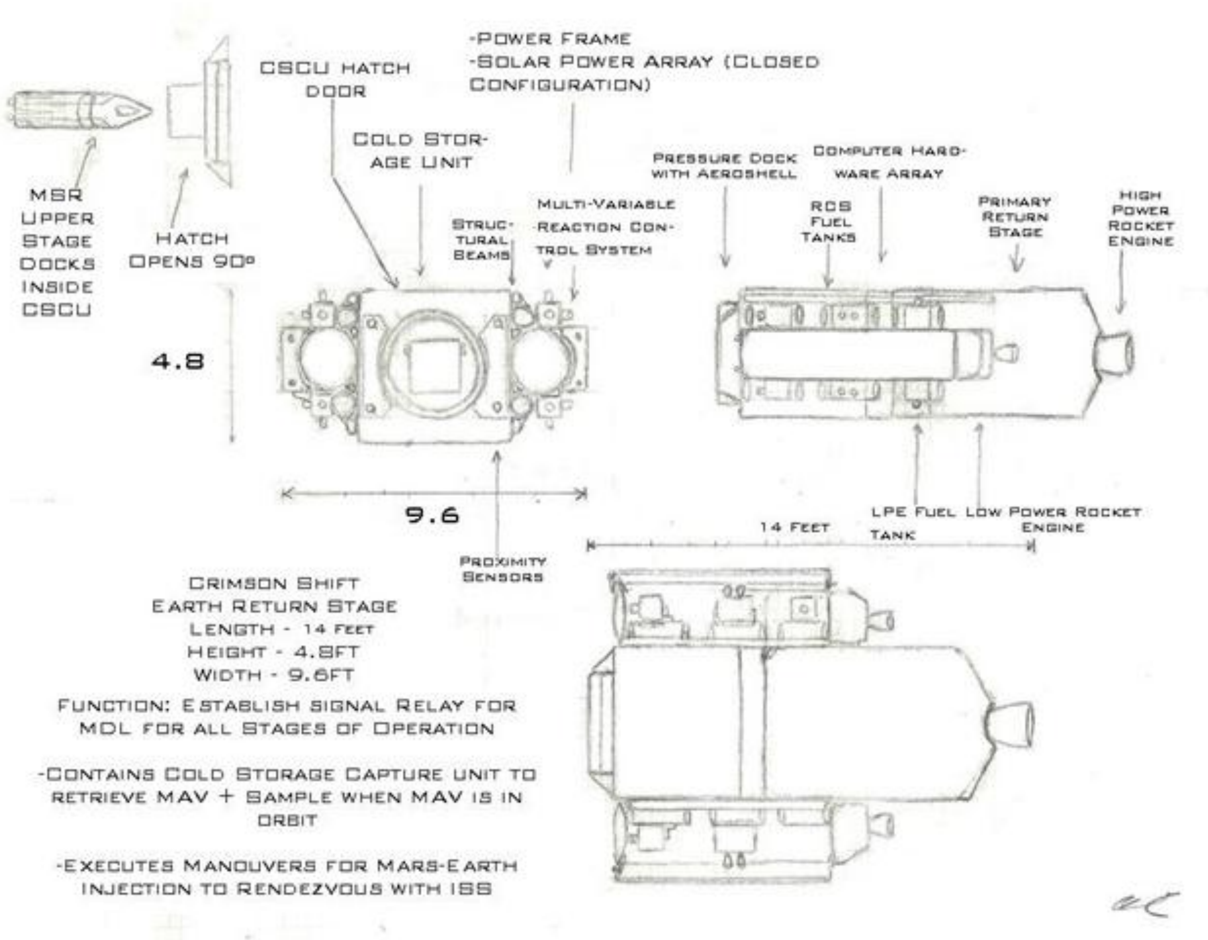
SEPARATION THRUSTERS

FIRST STAGE (SOLID ROCKET PROPULSION)



Earth Return Stage and Cold Storage Containment Unit (ERS/CSCU)

When the Upper Stage (SEAS) achieves orbit, it will adjust for a trajectory to rendezvous with the Earth Return Stage (ERS). The ERS contains a Cold Storage Containment Unit that will freeze the samples to Mars like temperatures for the trip back to Earth. The CSCU is lined with aerogel insulation to retain a reduced absence of heat to remain below freezing for the duration of the trip. The Adapter Shroud that connects with the Aeroshell is designed to be compatible with ISS and Modern Spacecraft soft docking bays. This allows for adaptability for the transfer of the samples either between a spacecraft or the ISS (whichever is readily available of still in service).

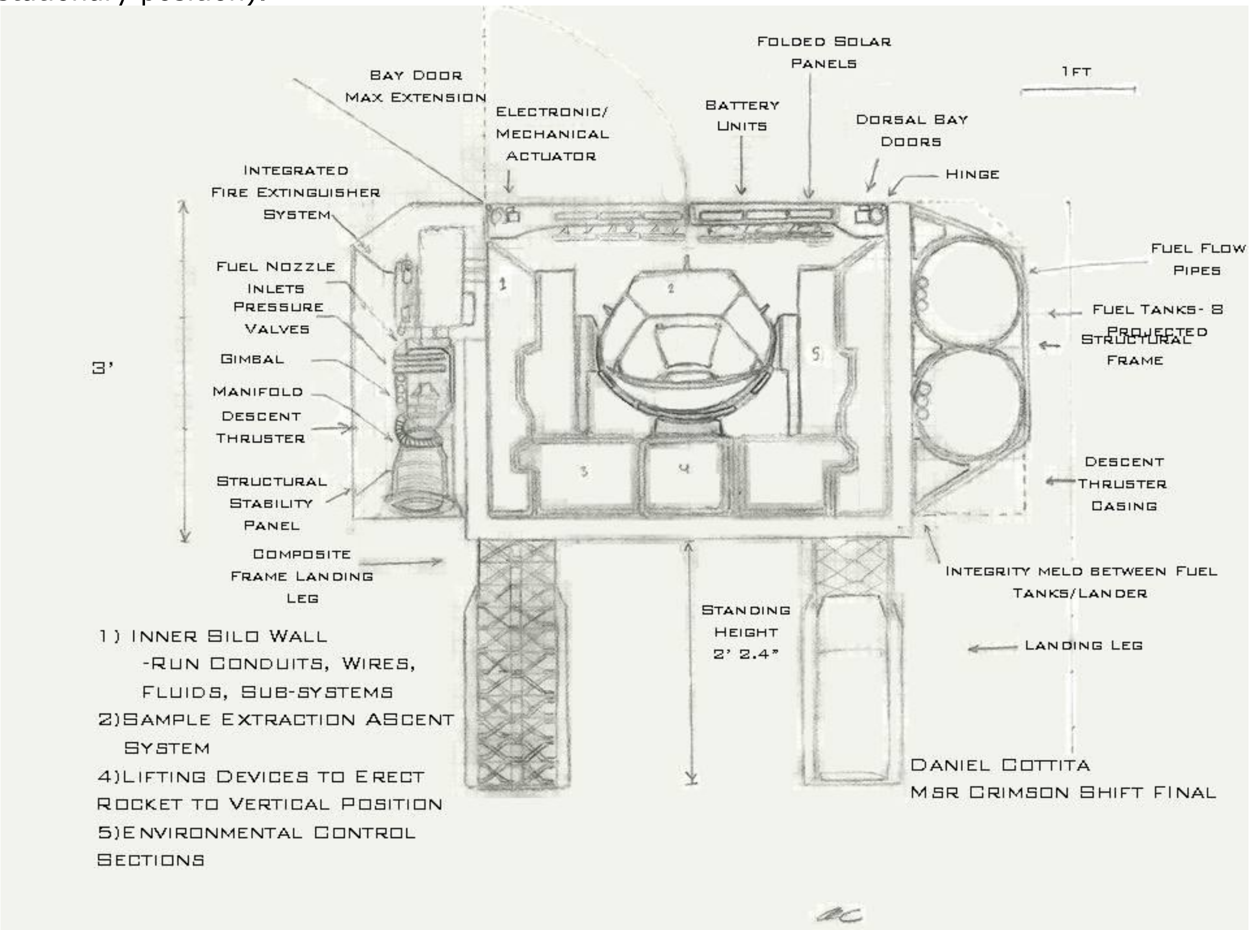


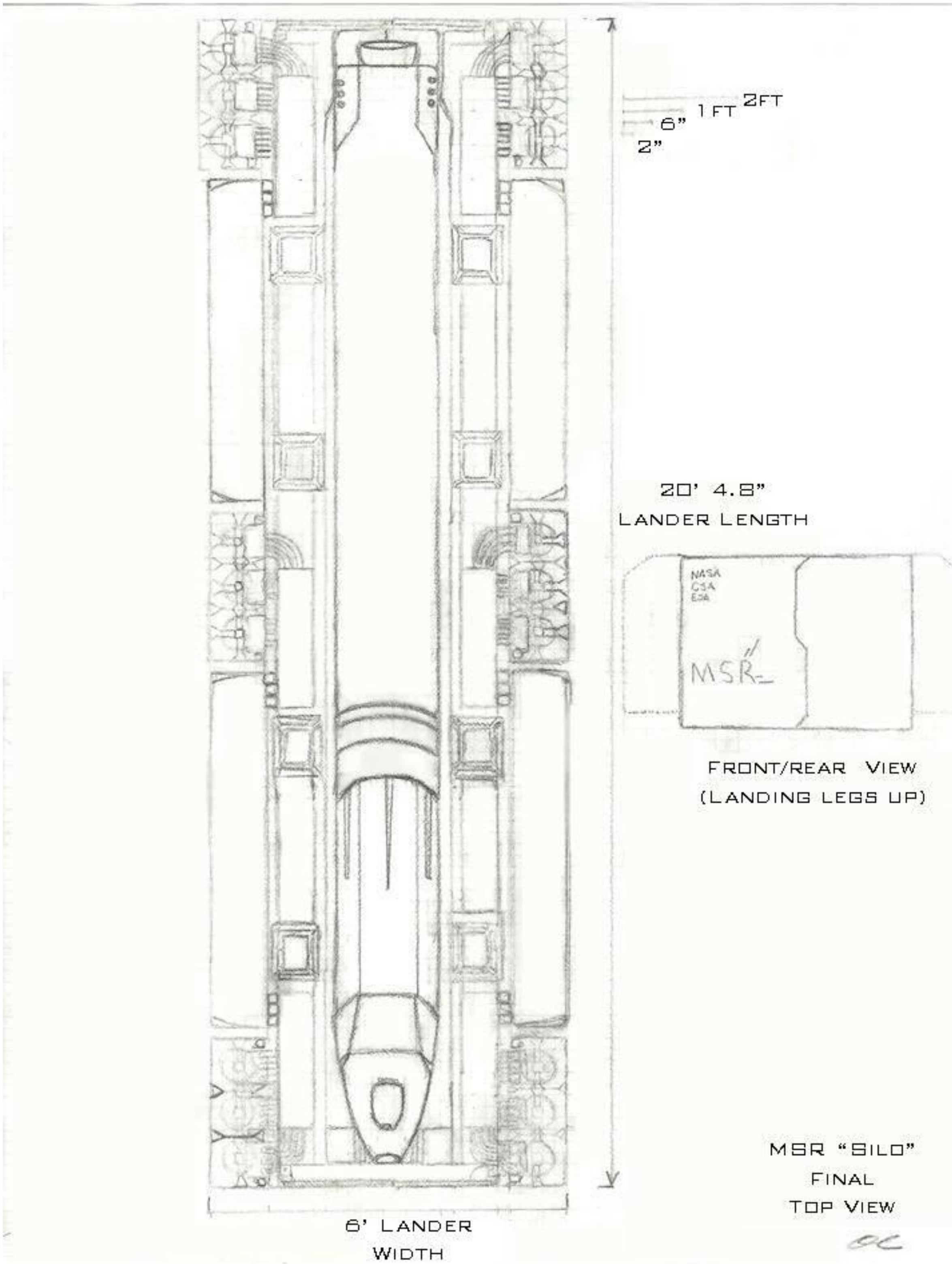
DETAILED ELEMENT: Mars Descent Lander (SILO)

The Designs below are of the Mars Descent Lander, also known as the SILO. Its design was derived from two basic military applications. The first innovation is from how vertical launch missile systems used on naval military ships offer ease of portability and compatibility with all the contents inside a compact, but spacious volume availability.

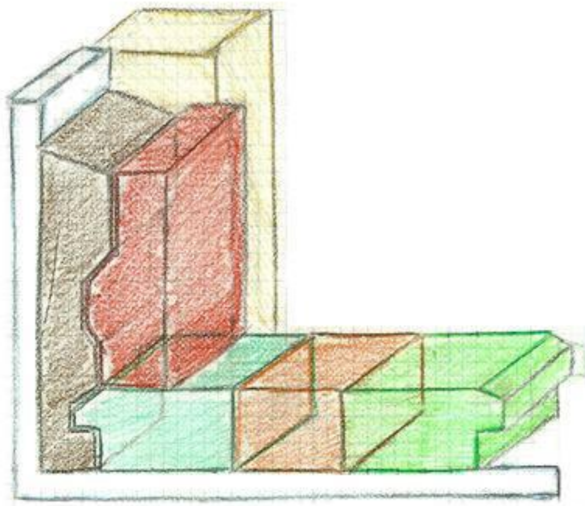
The second innovation comes from Russian military missile trucks that erect their missile systems by a mechanical lift system that allows the missile to be fired from any angle up to ninety degrees.

The lengthy Lander allows for a longer Mars Ascent Vehicle and would allow for a heavier payload to ascend from the Martian Surface. This increase in internal and external volume enhances the mission's ability to hold redundant systems, and additional fuel for a proximity landing descent. This multi-functional capability between the Lander, the MAV, and any scientific instruments on board that can be stored means for greater mission return of investment beyond just landing and obtaining samples. The Back-up systems also equal increased mission endurance. This justifies the need for a new re-entry system that can land heavier payloads as they are capable of being much more versatile (despite its stationary position).




2FT
1 FT
6”
2”
20’ 4.8”
LANDER LENGTH
NASA
CSA
ESA
MSR
FRONT/REAR VIEW
(LANDING LEGS UP)
MSR “SILO”
FINAL
TOP VIEW
6’ LANDER
WIDTH

SILO Interior Structural Layout



BLUE- SILO WALL
MAIN FRAME FOR
LANDER

GOLD- LANDING LEG SUB-SECTION
HOLDS AND ELEVATES ENTIRE
LANDER SO 2020 ROVER CAN IN-
TERACT

FRONT- MID- END SECTIONS CUT OUT FOR DESCENT THRUSTERS PLACEMENT

BROWN- INTERIOR WALL
-INCREASE INTEGRITY
-PRIMARY WALLING FOR LANDER LEGS, HIGH PRESSURE PUMPS TO PUMP FUEL TO DE-
SCENT THRUSTERS

ORANGE - MULTI-VARIABLE-SUB-SECTION
USED PRIMARILY TO STORE COMMUNICATIONS OR ??? CAMERA SURVEILLANCE SYSTEM

SILO INTERIOR STRUCTURE

PART-A SYSTEMS AND INTEGRATION

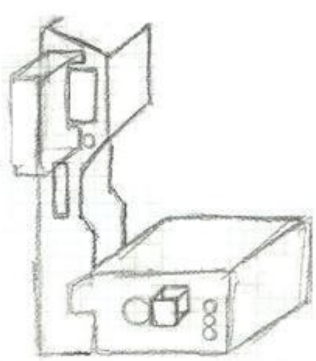
CYAN- SUB-SYSTEM ROUTING AND ELECTRONICS STORAGE-
LANDING INSTRUMENTS AND RADAR
-ALLOCATION OF COMPUTER HARDWARE SYSTEMS,
THEIR PAIR AND REDUNDANT SYSTEMS

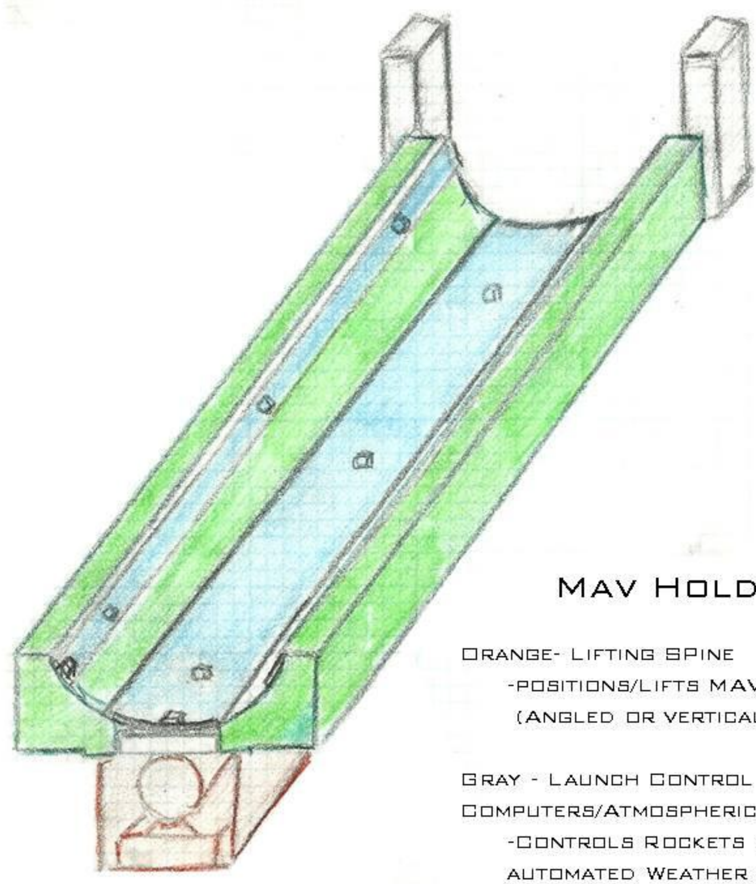
ORANGE- HYDRAULIC ROCKET LIFTING SPINE
- TO PLACE ROCKET INTO VERTICAL
POSITION/LAUNCH POSITION

GREEN- ON BOARD SCIENTIFIC INSTRUMENTS, COUNTER-
WEIGHTS TO BALANCE LANDER

SWISS CHEESE INTEGRITY
-INTERIOR WALL (PRIMARILY) AND BOTTOM SECTIONS ARE CUT-OUT TO BE ABLE
TO FLOW WIRES, FLUIDS, AND SUB-SYSTEM FRAME WORK THROUGH THE
LANDER. ALLOWS HIGH FLEXIBILITY/ADAPTATION WITHOUT COMPROMISING
STRUCTURAL STRENGTH.

SUB-SYSTEM
ROUTING AND
SUB-SYSTEM
STRUCTURES





MAV Holding Bay

Orange- Lifting Spine
- -Positions/Lifts MAV into Firing Angle (Angled or vertical)

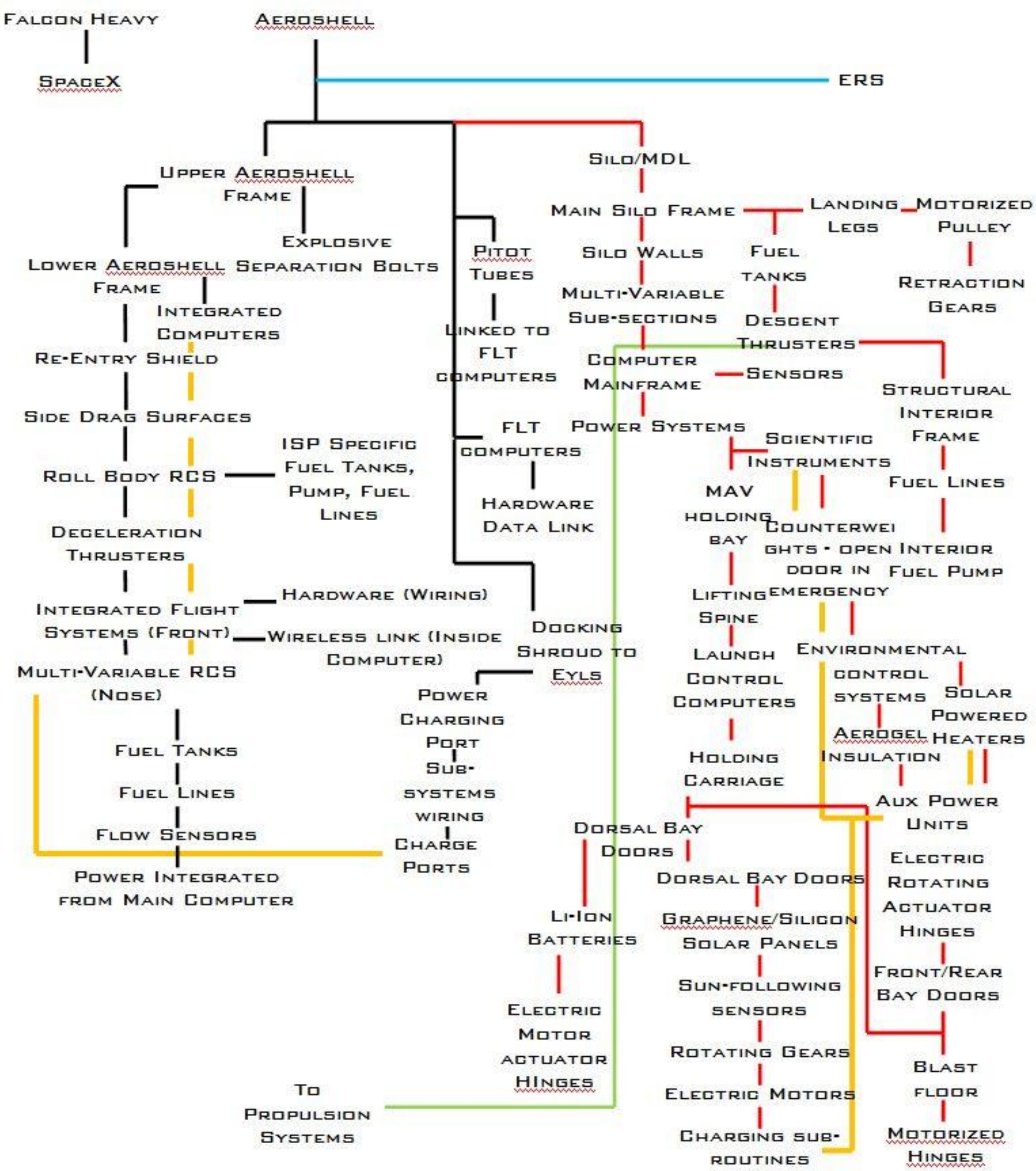
Gray - Launch Control Computers/Atmospheric sensors
- -Controls Rockets Flight path and gives automated Weather reports

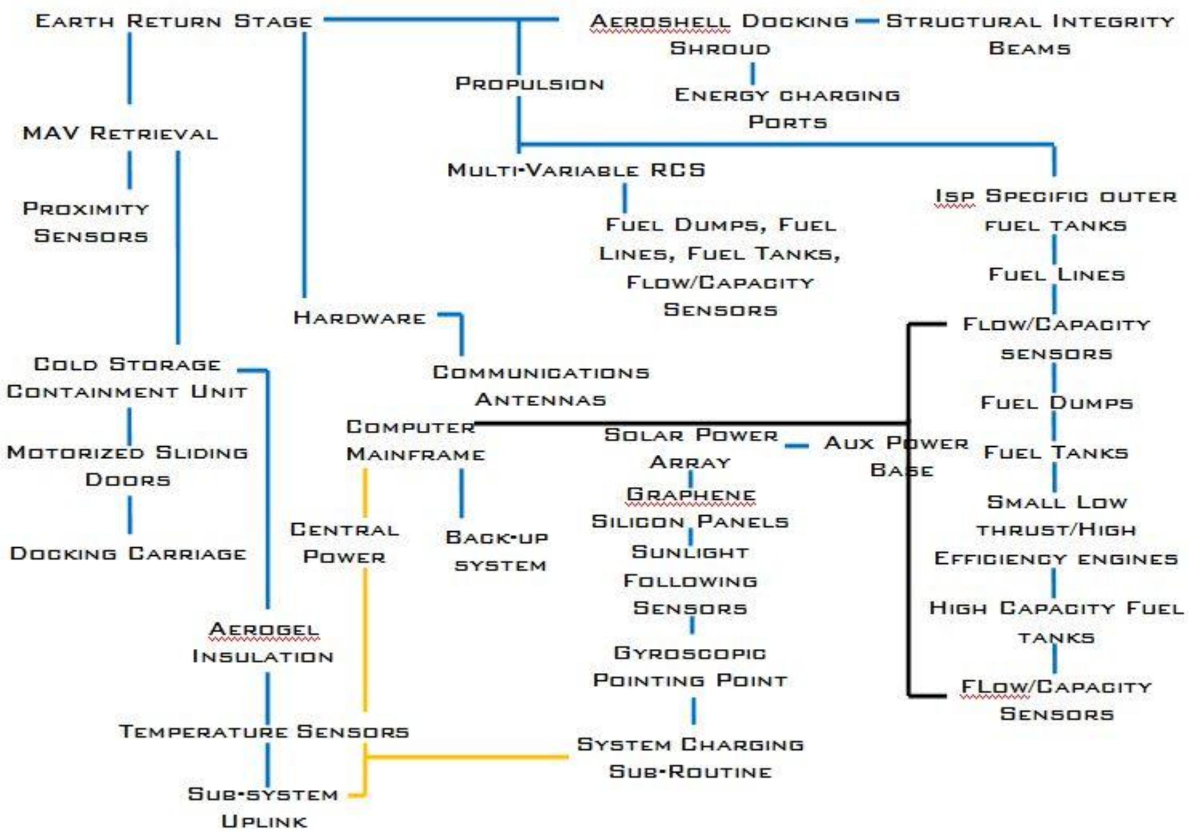
Green- Holding Half-pipe
- -Keeps MAV in place during Mission
- -Absorbs Shocks and Vibrations

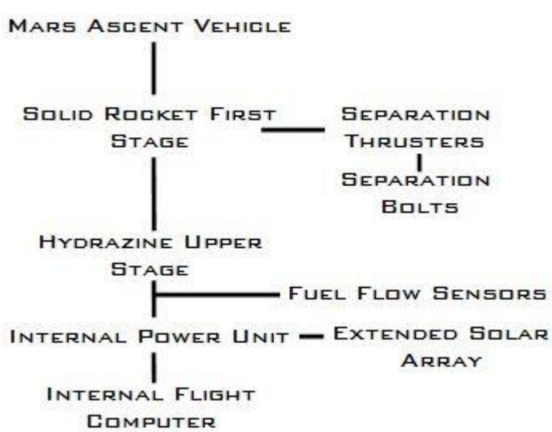
Blue- Latch Lines
- -3 Point System where MAV is attached to lander-spans holding bay
- -Integrated with Launch control to unlatch when ignition is initiated

Silo Interior
Part 2

Product Breakdown Structure/ Work Breakdown Structure of MSR Crimson Shift







The ability to diversify the Elements into 4 parts will require 4 dedicated Departments of teams that work their own designated section of the MSR Mission. This minimizes huge conglomerate groups to finish the mission as a whole.

Concept of Operations

Major Phases

Our mission will utilize the capabilities of the Mars 2020 rover to retrieve a Martian soil sample. The Mars 2020 rover will launch in July or August 2020 on top of an Atlas V launch vehicle and be placed into low Earth orbit. The spacecraft will make its way towards Mars, taking eight to nine months, arriving between January and March 2021. The rover will transfer into low Mars orbit and proceed to descend to the Martian surface via Sky Crane in a manner similar to the Curiosity mission.

The Mars 2020 rover will collect and store the Martian soil sample in the sample core container. This sample will be stored on the rover until our lander meets up with the rover to return the sample to earth.

The lander will be an Aeroshell shaped spacecraft. The lander will be launched in 2024 on top of a Falcon Heavy launch vehicle, supplied by SpaceX. Once the Aeroshell spacecraft and ERS Payload is in low Earth orbit, it will cruise towards Mars using the last stage of the Falcon Heavy. It will then transfers into low Mars orbit by means of an aero capture maneuver to slow down the MSR Payload and establish a stable orbit for the ERS. The Aeroshell shall descend into the atmosphere and make its glided deceleration flight descent to the Martian surface. The spacecraft will land in proximity to the Mars 2020 rover, close enough to retrieve the samples in a short period of time.

The aeroshell contains the Mars Descent Lander "SILO". The SILO includes the Sample Extraction Ascent System (SEAS). The SEAS is used to retrieve the Martian soil sample from the Mars 2020 rover and place it in low Mars orbit via rocket. The SEAS contains a cold storage unit in a Cubesat that will hold the soil samples at constant temperature throughout the journey back to low Earth orbit, where it will rendezvous with the International Space Station (ISS), assuming the ISS is still in operation, and will undergo a biohazard evaluation to determine that the samples are biologically safe to return to Earth for further studying. The sample will be transported back to Earth in a commercial or government sponsored space vehicle.

Timeline of Events

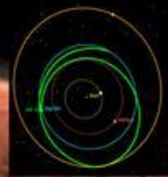
- Mars 2020 rover launches in July or August 2020
- Mars 2020 rover arrives at Mars between January and March 2021
- SILO lander will be launched late 2024 and arrive at Mars mid-2025
- MAV launches from the SILO mid-2025, returns to Earth by early to mid-2026
- Biohazard testing of samples mid-2026
- Analysis of samples on Earth 2026 and beyond.

Please refer to the Graphic Panel Below on the next page for better Details

Crimson Shift MSR Mission ConOps Panel

Launch

-MSR Payload and Falcon Heavy Systems Integrated
-Falcon Heavy brought to designated Launch Pad
-FH launches into space
-Stage Separation (Initiate Landing Sequence) or (Stages fall into Ocean)



Trans-Mars Injection

-Mars Stage Separation: Put MSR on trajectory to Mars
-Solar Panels Deployed on ERS to provide power to Aeroshell
-SILO Internal Systems Check before Hibernation
-MSR Payload Systems go to Idle

Aerocapture

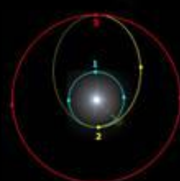
-Systems Reboot and Check prior to encountering Mars
-ERS Adjusts Trajectory for Aerocapture Maneuver over the Atmosphere
-MSR Payload Decelerates and establishes orbit over Mars
-Mission Logistics check (MRO, MGS support) ERS Relaying Data
-Aeroshell Separates once flight path to Mars 2020 Rover is Determined

Re-Entry

-Aeroshell commences final systems check RCS adjustments before decelerating into atmosphere
-Pierces ionized layer of Martian Atmosphere
-Initiates deceleration thrusters to drastically slow velocity
-Aeroshell Engages drag surfaces and flight surfaces to generate lift and adjusting speed for glided flight

Landing

-Aeroshell follows pre-determined flight path to Mars 2020 Rover
-Reaches separation point. Aeroshell separates
-MDL SILO initiates descent thrusters for final descent and course corrections
-Landing legs extend. SILO Lander touch down.



Launch & Earth Transfer

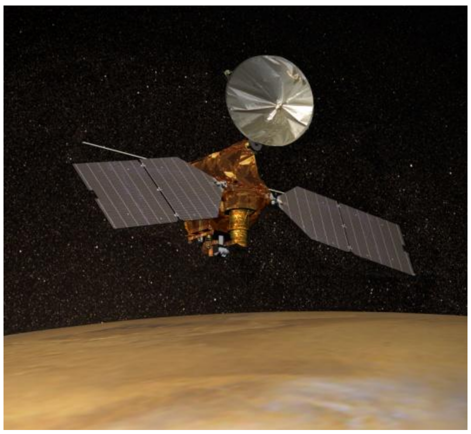
-Samples Acquired by Mars 2020 Rover. MAV Ready for Launch
-MAV is Launched. Follows trajectory to put SEAS Upper Stage high above atmosphere
-Sample Extraction Ascent System Establishes Orbit. Rendezvous with ERS
-ERS and SEAS Dock successfully.
-Earth Return Stage adjusts trajectory for Trans-Earth Injection

Recovery at ISS

-ERS Reaches Earth Orbit
-Adjusts Trajectory to be put on path toward ISS or Rendezvous Craft
-ERS Docking Successful
-ISS with ERS Samples confirm interaction with limited samples.
-Samples obtained by manned spacecraft to return to Earth

Communications Strategy

We will be using existing hardware from previous missions as communication tools. Existing hardware includes communication satellites and ground dish antennas will reduce the cost of mission operations because there is no need to create new communication facilities and dish relays. We will use a combination of autonomous and remote controlled machines and robotics during this mission. Existing architecture examples are mission control rooms, satellite relay facilities, and communication arrays currently used by NASA at their various facilities or adjunct bases across America.



Command and Data Architecture

The Earth Return Stage (ERS) is capable and stores onboard communications antennae and relays. We will be using the same communication satellites from past Mars missions to assist with data and tracking uplinks. Two functioning examples of current NASA Architecture in Mars Orbit is the Mars Reconnaissance Orbiter and Mars Global Surveyor.

Operational Facilities

A new facility will be constructed to handle the majority of the requirements that the Mars Descent Lander "SILO", Sample Extraction Ascent System (SEAS) and return sample craft. This multi-level facility will be able to handle the additional requirements concerning research, development, and sample quarantine and containment once the sample is returned to Earth. This facility will serve as primary control for technology development, fabrication, testing, and assembly of components that are required for the SILO and SEAS spacecraft. Primary testing would be held at existing NASA facilities for hardware integrity, vibrations and shock, Lander stability and Aeroshell aerodynamics.

The facility will also include the required areas to conduct design and testing of integrated components from contracted companies. It is proposed that the facility would be built in a location that already has the capabilities to handle various research and development of rocket technologies so that some of the technology for the SILO and SEAS spacecraft can be done with existing developmental facilities. Onsite storage and quarantine will also be built within the structure until initial research concludes that the Martian samples meet the requirements of safety prior to distribution to the appropriate research facilities.

Other Mission Related Facilities are the Following with their specific function:

1) **The Mars 2020 Rover will be a NASA rover operated by the Jet Propulsion Laboratory in California.**

2) **The Atlas V Launch Vehicle is built by The United Launch Alliance (ULA). Their headquarters and control are located in Colorado.**

3) Space X is responsible for the launch of the MSR Payload and Earth Return Stage (ERS) away from Earth using a Falcon Heavy series Rocket. Their headquarters and mission control are located in California.

4) The International Space Station's primary mission control is conducted by the Christopher C. Kraft Jr. Mission Control Center.

Integrated Logistics Support

COMSAT facilities on the ground normally used for relaying data from previous outgoing Mars Missions and ongoing Mars missions in orbit such as the MRO and Global Surveyor will serve as relays for tracking of the mission and ground surveillance. Additional Satellites controlled by other NASA Facilities will be requested for monitoring mission progress and back up data retrieval. Other bases may request mission data as it comes regarding surface mission or flight mission progress.

FIGURE 6- DIAGRAM OF NASA FACILITIES AND ADJUNCT BASES

Figures of Merit

Launch System	The SpaceX Falcon Heavy, Put in a Trade Studies scenario against the Delta IV Heavy, Atlas V and Arianne Series Rockets, The Falcon Heavy is the only rocket in its class capable of launching a large payload under its own power.
Payload Configuration	The Trade Tree for the type of payload configurations and launches required concluded that an all-in-one launch system was the most realistic as this prevents the need of a second rocket. The current Aeroshell concept design containing the SILO Lander made excellent use of vertical volume space in the payload fairing as opposed to a diameter based capsule. It allowed for more systems to be and Earth Return Stage Most importantly, the launch system of choice is reusable.
Mission Endurance	Due to the Landers ability to hold back up and redundant systems of the mission hardware within the volume available and the set up of the Landers ability to withstand the Martian Elements and protect internal hardware, proves very viable as a long term mission asset.
Entry, Descent Landing	The new EDL Method of using the Aeroshell for re-entry and glided flight to target site is an important asset as it not only designed to carry the SILO Lander, but shall be capable of rapid deceleration through the Martian atmosphere and its ability to execute a proximity landing maneuver near the Mars 2020 Rover.

Mission Goals	Due to the Nature of the Landers design, it is able to carry lots of volume. The SILOs ability to land a MAV with Additional Scientific Instruments to conduct additional experiments beyond the MSR Mission will be an invaluable asset for scientific research on Mars.
Re-entry Vehicle	The Aero shell concept will be a technology maturated ready system by the time the MSR mission is ready. It's ability to hold a large payload and to fly it/ decelerate it over the Martian Atmosphere, along with proximity landing is testament to NASAs need to prove the technology is possible and applicable for an eventual Manned Mission to Mars.
Mission Architecture	To remove the need of developing a new rover to grab Martian Samples in replacement of enhancing an upcoming Mars Mission designed to carry samples, it was considered optimal for this MSR Mission to rendezvous with a Rover Asset already on the ground no matter where it is located. It reinforces the need for new technology.
Budget	The $6.25 Billion Cost is not just for the Mars 2020 Rover or the MSR Mission, but also an investment to prove that these technologies can be used successfully and repeatedly for future missions.

Citations and References

Photos and discussion of Recurring Slope Lineae can be viewed at the following links:

"Puzzling Streaks On Mars May Be From Flowing Water" by Denise Chow
http://www.space.com/23905-mars-liquid-water-seasonal-streaks.html

"Strange Dark Streaks on Mars Get More and More Mysterious" by Adam Mann
http://www.wired.com/2014/02/flowing-lineae-water-mars/

Discussion of the Mars 2020 Rover, including cost estimates:

"NASA's Next Mars Rover Will Search for Signs of Life" by Mike Wall
http://www.space.com/21901-nasa-mars-rover-2020-life-signs.html