Development of a robotic mission to Mars is essential for the future of manned space flight. The Rover will depart Cape Canaveral launch site using a industry developed chemical rocket (Space-X) [1] , once in orbit and after final assessment onboard the ISS, the rovers transport vehicle will embark on its journey using VASIMR spaceflight transport developed by Ad. Astra Rocket Company.[2] Following a successful vehicle transfer the craft will enter Mars orbit and jettison into its atmosphere. The MARVIN-X project sets to work as a surveying, repair, test, communication , exploration and sample return vehicle to enhance NASA's Aerial Regional-scale Environmental Survey of Mars (ARES) Vehicle.[3] The sample return mission will entitle a two-way orbital flight trajectory from Earth to Mars.

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1. Mission Scope Design:

Need:

Identify signs of past or present life sustainability within Mars.

Goal(s):

Science:

- Identify possible underground water deposits
- Identify Methane Plume Sources
- Identify overlapping (1) and (2) locations.
- Search for elements of life sustainability
- Search of possible single celled extremophobic bacteria bellow Martian surface
- Contain Selected Samples
- Return Samples to Earth

Engineering:

- Successfully Jettison Orbiter from Mother-Craft.
- Obiter achieves orbital flight and docks with the ISS for final assessment prior to Trans Martian injection.
- Perform a controlled landing on Mars.
- Perform Predetermined Scientific Experiments.
- Successful interface with ARES into Martian orbit.
- Launch from Martian surface.

Objective(s):

(1) Identify possible underground water deposits
  (1.A) Search Martian geological features similar to Earth water deposits.
  (1.B) Identify optimum drilling sites within features.

(2) Identify Methane Plume Sources
  (2.A) Trace orbiter and rover data to possible geological features related to methane plumes.
  (2.B) Identify optimum drilling sites within features.

(3) Identify overlapping (1) and (2) locations.

(3.A) Study previous current and previous rover data.
(3.B) Study UAV and Orbiter atmospheric data.

(4) Search for elements of life sustainability and Analyze sample data for:
(4.A) Signs of bacterial life forms

(5) Search of possible single celled extremophobic bacteria bellow Martian surface

(6) Contain Selected Samples
(5.A)Isolate Samples
(5.B)Prepare Samples for departure
(7) Return Samples to Earth

Mission:

To successfully design, build, test and operate a spacecraft set to collect and return Martian Samples to Earth, while establishing the United States as the Leader in Space Exploration, enhancing commercial, academic and international partnerships. Paving the way for future manned missions to Mars.

Constraints:

Orbital Mechanics (Physics and Scheduling)

Politics (Change of Administrations)

Public Support

Budget/ Funding

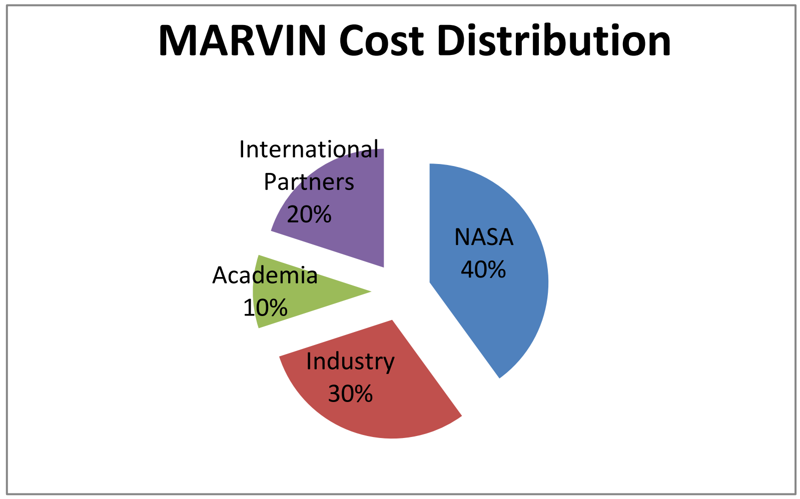
Technology Development

Communication Issues

Onboard Navigation and decision making required.

Craft Design, Development and Implementation work breakdown structure tree.

Budget:



The Mars Exploration vehicle (MARVIN) program will seek to revolutionize systems engineering cooperation between government, industry and academia, in an effort to expand human knowledge about the red planet, and serve as a paving stone for future manned missions. Given the high costs of space exploration, funding will be distributed by program objectives listed in the abstract. The MARVIN program will be expected to be developed built and delivered to the launch pad for a cost of 3 Billion USD. Because the high cost of space exploration [4], the program budget will be divided as shown in Chart 01, further encouraging industry development of space exploration technology as set forth by President Obama's Administration in his April 15 2010 address[5] outlining NASA's new vision for space exploration President Obama said "it will be quicker and less costly to let private companies develop new spacecraft." The two mayor industry partners will be: Ad. Astra Rocket Company led by former astronaut Dr. Chang-Diaz (Who will develop the Trans Martian Transport Vehicle using VASIMR technology) and SpaceX which will develop their Falcon Heavy launch vehicle [6] estimated to save "97% reduction in launch costs"[7] when compared to other technologies currently in use, such as the Atlas and Delta Rockets. When comparing Falcon Heavy to the United States Air Force's Delta 4 Heavy the advantages are evident [Table 1].

BOOSTER PARAMETER	**FALCON HEAVY**	**DELTA IV HEAVY**	**RATIO: FH/D4H**
Metric tons to LEO (200 KM 28 deg)	53.0 m. tons	22.98 m. tons	2.31
Pounds to LEO (200 km 28 deg)	116,600 lbs	50,550 lbs	2.31
Cost per launch (avg. posted value)	$100,000,000	$435,000,000	0.23 ~ **(1/4)**
Cost per metric ton to LEO	$1,890,000	$18,930,000	0.0998 (**1/10**)
Cost per pound to LEO	$858	$8,605	0.0997 (**1/10**)
Table Provided by, National Space Society [5]			

Scientific tools and experiments will be developed by a chosen group of colleges and universities with assistance from industry and international partners such as Canada who is developing the rover's robotic arm given their experience with CANADARM 1 and 2[8] and x-ray instruments[9] such as the ones already present in NASA's Mars Laboratory exploration vehicle. Additionally to the Canadian space agency, the European space agency will provide the crew intended to survey and analyze the rover craft ,while docked with the international space station prior to Trans Martian injection. An outreach program will be implemented through NASA's Johnson Space Center's Reduced Gravity Program [10] to design and fly experiments to be tested on the Martian surface. This program will allow the public to interact with the program and at the same time inspire the future generations of explores, scientists and engineers. All these entities will work in cohesion to develop the future of space exploration which is MARVIN.

The Overall cost Breakdown for the MARVIN Program reads as follows:

NASA (40% = 1,200,000,000.000 USD)

- Exploration Vehicle
- Launch Operations
- Outreach

Industry(30% = 900,000,000.000 USD)

- Launch Vehicle
- Transport Vehicle

International Partners(20% = 600,000,000.000 USD)

- Astronaut Training
- Robotic Arm

Academia (10% = 300,000,000.000 USD)

- Experiments and Tools
- Outreach

Total Cost (100% = 3000000000.000 USD)

The total cost can be summed up as 3 billion USD, including 2.16 billion USD for spacecraft development and scientific investigations, additional budget amounts intended for launch and mission operations. The figures listed in the cost break down do not fully reflect the exact purpose of funds given the interactions between entities. In other words just because the funds are under any given entity it does not mean that they don't interact with others.

Instrumentation

Scientific tools and experiments will be developed by a chosen group of colleges and universities with assistance from industry and international partners such as Canada who is developing the rover's robotic arm given their experience with CANADARM 1 and 2 and x-ray instruments such as the ones already present in NASA's Mars Laboratory exploration vehicle. The two robotic arms will have a belt design allowing for a full vehicle range of motion.

The European Space Agency will design and build a mass spectrometer similar to that present onboard the Mars Express Spacecraft and Reconnaissance Orbiter which first identified the potential of Mawrth Vallis.

The rover will be equipped with two redundant command system modules as a means of failure prevention

. An alpha particle spectrometer has been designed for a 20 year lifespan, with an integrated solid-state cooling system, allowing for 24 hour a day operation.

Marvin is equipped with everybody's favorite instrument, a set of multiple lenses and resolution cameras, with a 360 degree rotation capability.

The power system will be composed of 4 independent battery sources each capable of powering all essential vehicle systems. The use of solar array panels will provide an estimated 350watts, which is 115% over the estimated high peak operation power consumption. Much like a cell phone battery, the cells within the battery will degrade over time,

The guidance system designed for Marvin is similar to that of any conventional global position system (GPS) present on earth. The only difference being that MARVIN will use existing reconnaissance and exploration satellites on Mars orbit to communicate back to earth. Additionally its interaction with ARES will allow relay of information through ARES onto any other close by exploration vehicle.

The vehicle will be propelled by 8 robotic legs, the first of their kind allowing for full range of motion for dealing with rugged terrain. Each leg will be connected to the main chassis on one side and all terrain tires on the other.

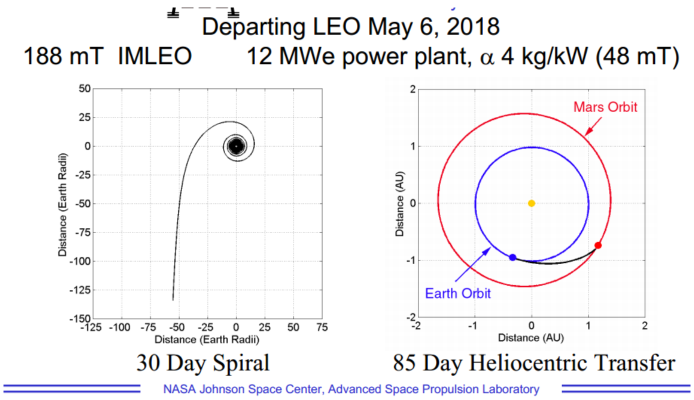
Among the exploration instruments a set of lasers will be deployed within the robotic arms, these instruments alongside an integrated drill will allow for geological analysis of mineral composition as well as the composition of any life form encountered.

The cargo bay will be given a detachment capability, given the possible future transportation of its content in subsequent missions back to earth.

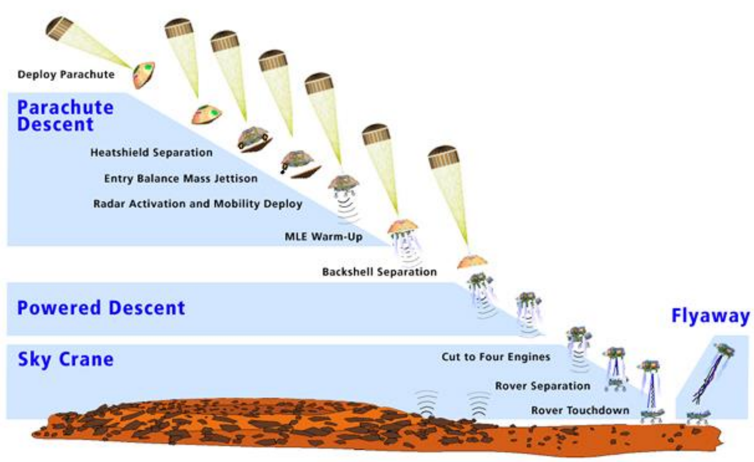
Drilling sample instruments have been developed by Harry Stamper Oil Company.

Engineers have also integrated, given the size of MARVIN (Slightly larger than a standardized car) a future Mars Buggy option, provided future manned missions bring the conversion systems with them.

Schedule:

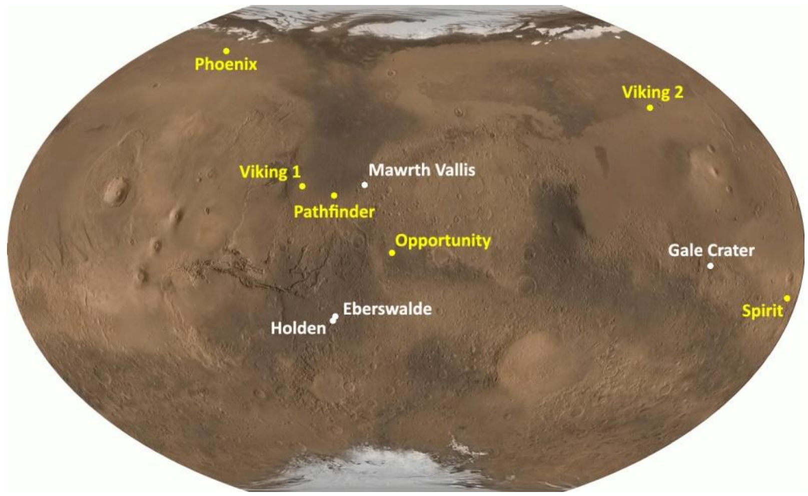


Project planning and design between NASA, Industry, Academia and International Partners is set to begin during the fall of 2014, provided the authorization and acquisition of funds. The rover and mission development is expected to take around 8 years. The MARVIN exploration program is set to launch from Kennedy Space Center on Feb 2nd 2024, and will dock with the International Space Station in preparation for departure of lower earth orbit set for Feb 4th 2024, date chosen as it matches Ad Astra and Johnson Space Center projected VASIMR Martian cargo transport Trans Martian Injection. [11] For a 12MW power plant the transfer ellipse as shown in the Hohmann Transfer figure would last 85 days[9]. Given this time frame MARVIN is set to arrive in Mars's orbit on June 30th 2024. The transfer craft will then enter into Lower Martian Orbit (LMO) and orbit the Red Planet for 3 days while teams at NASA's Jet Propulsion Lab, assess the final decisions on the predetermined landing sites. Once authorized, the landing sequence will start, delivering MARVIN on the Martian surface on July 2nd 2024. (In a similar procedure to that of the Mars Science Laboratory shown [12]) Once on Martian soil, the rover will see its first Martian light on July 3rd, due to system and subsystem assessments as well as power up procedures. MARVIN's life time will be of 1374 earth days or approximately 2 Martian years, but much like its predecessors (Spirit/Opportunity 2004) it will be called to push the boundaries beyond such a date.

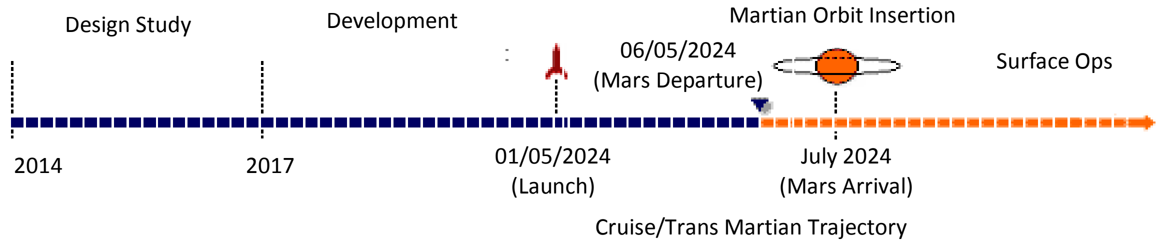


Landing Site

After careful consideration and debate between engineering and scientific communities, the MARVIN exploration vehicle is set to explore the clay sediments of Mawrth Va llis, which are totally unique. Such sediments believed to be leftover bits and pieces of ancient bodies of water once existent on the Martian surface. The exact location has an elevation of two kilometers and coordinates of 22.3°N, 343.5°E. Engineer as stated in the 2011 Mars Science Laboratory Smithsonian press conference are confident that the site is acceptable for a rover in the Curiosity and Marvin family of vehicles to perform successfully on its surface. Scientist's advocating for this site are especially interested in the previously mentioned clay deposits or phyllosillicate, which are only known to form in the close vicinity of water. Such sediments are also a good at preserving traces of ancient life that could have once roamed Mawrth Vallis. Given its ancient background Mawrth is believed to be a great location for the search of Martian life as well as maybe the source of life on earth.



Martian Transfer Summary:



Prelaunch Activities: Preparation for the mission, Design, landing site selection, assembly and testing

Launch: Delivery to Facility and Lift-off to LEO

Orbital Transfer : Planetary Space Trip

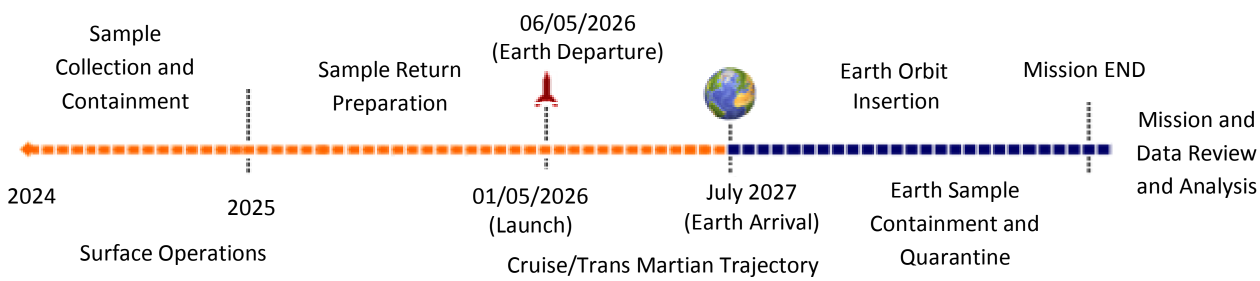
Approach: Nearing the Marian orbit

Capture: Entering Orbit

Entry, Descent, and Landing: Surviving entry of Martian atmosphere to the surface

Life and Instrument Checks: Rover responds as planned

Earth Transfer Summary:



Surface Operations: Learning about Mars through the day-to-day activities of the rover

Launch: Lift-off from Earth

Orbital Transfer: Voyage through space

Approach: Nearing the Earth

Capture: Entering Orbit

Entry, Descent, and Landing: Entry and splashdown in Earth Ocean.

Authority & Responsibility:

The need for different levels of system engineering management is imperative for mission success and communication between Federal Agencies, Corporate Industries and Academia involved.

Engineering and project Management will be under the supervision of the Jet Propulsion Laboratory (JPL) in Pasadena California.

Godard Space Flight Center will coordinate and control the development of scientific instruments. The main contract for instrument development going to the European Space Agency, while minor instruments are set to be developed by Academia.

Launch is yet to be determined between NASA launch sites in Virginia or Florida Pending availability.

Assuming SpaceX will gain the ground to LEO contract, a POC will be assigned to liaison on behave of NASA's interests. [13]

Marshall Space Flight Center and Ad Astra Rocket Company alongside the Department of Energy (given the use of nuclear energy) will develop the transfer vehicle VASIMR engines needed to reduce transfer time to 3 months.

Spacecraft is expected to dock with ISS prior to Martian transfer for final check. Johnson Space center will coordinate docking maneuvers while any additional robotic work will be coordinated by the Canadian Space Agency.

The NATO Member Nations will spear head recovery efforts after splash down in the Atlantic Ocean with United States Navy leading the effort. Sample Containment will be controlled by Military and Center of Disease Control personnel.

Assumptions:

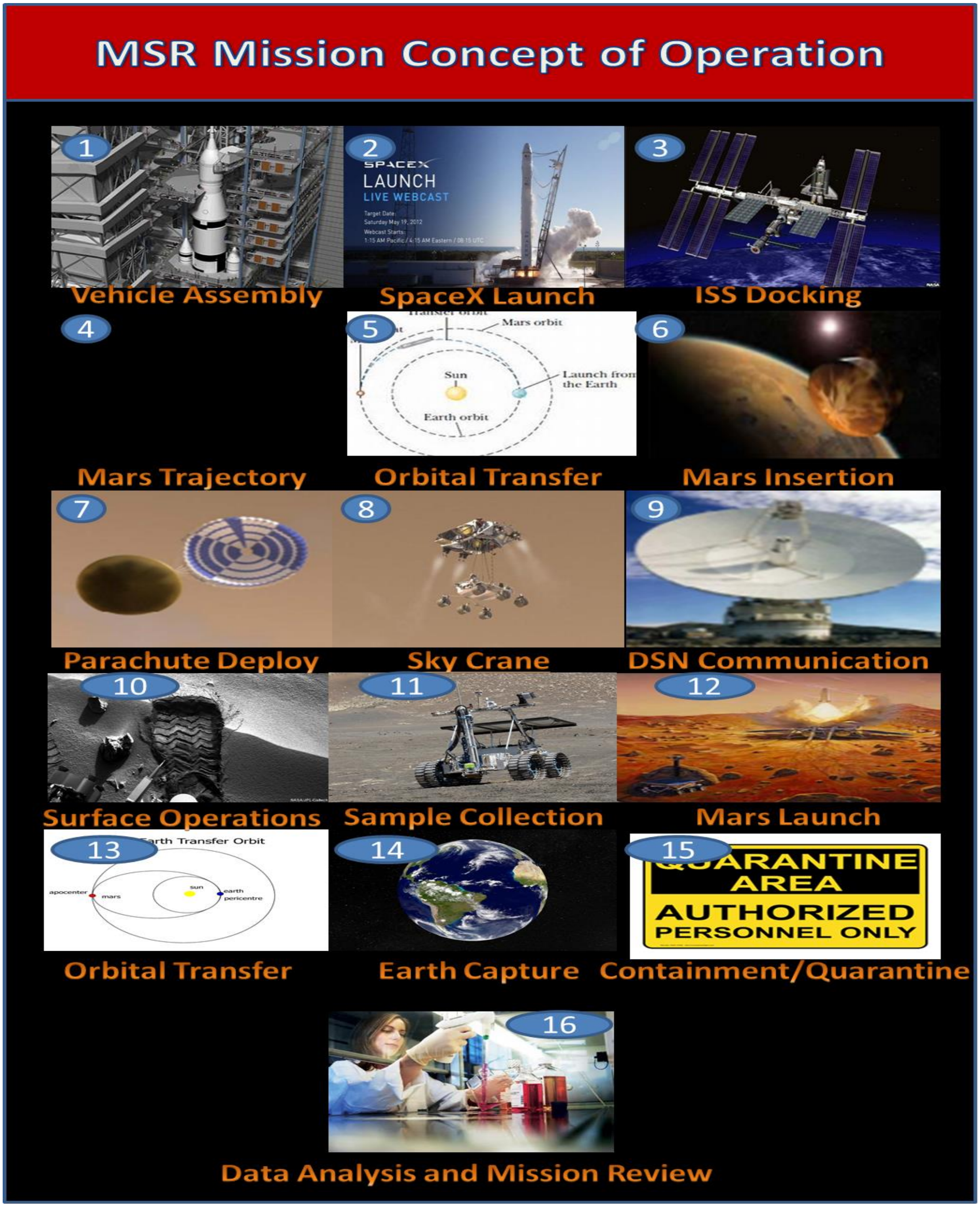
Technologies Will Mature by time of Project Development

Orbital Mechanics of mission and propulsive technologies will perform as planned.

International relations will develop strong ties between countries

Funding will be approved as needed for project success

2. Develop a high-level Concept of Operations for your MSR mission.



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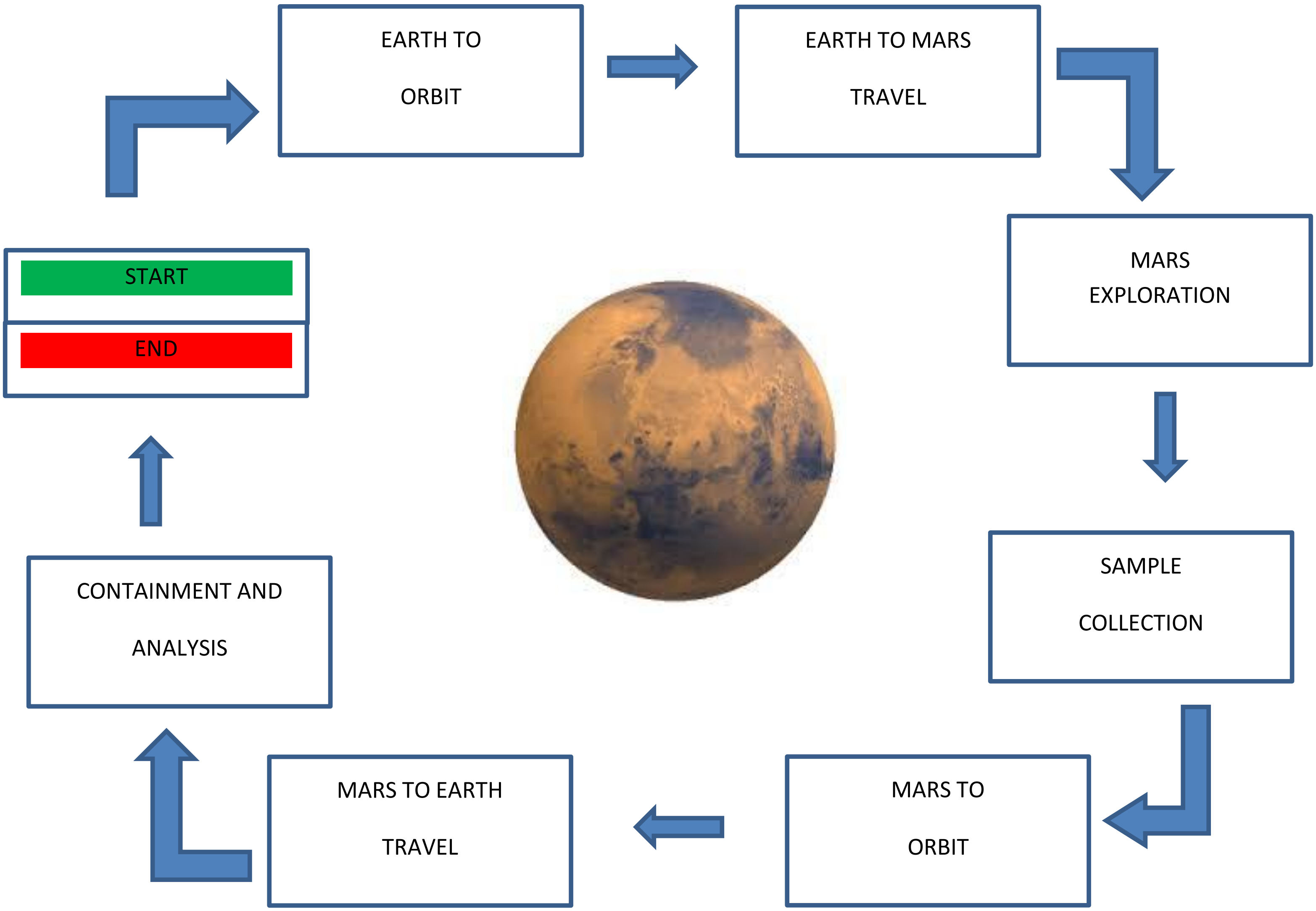
3. Develop a high-level Architecture for your MSR mission.



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4.a Product Breakdown Structure

- Mars Sample Return Mission
  - Exposure
    - Social Media
    - Magazines
    - Televison
    - Museums
    - Academic
    - Industry
  - Ground to LEO
    - Vehicle
      - Command and Data Handling
      - Power
      - Avionics
      - Structural
      - Propulsion
    - Facilities
      - Assembly Building
      - Launch Platform
      - Ground Communications
  - Orbital Transfer Vehicle
    - Command and Data Handling
    - Power
    - Avionics
    - Communications
    - Instrumentation
    - Structural
    - Propulsion
  - Ground Control
    - Deep Space Network Communications Antenna
    - NASA Center Flight Operation Facilities
    - New compatible computer systems with flight systems.
  - Rover
    - Command and Data Handling
    - Power
    - Communications
    - Instrumentation
    - Structural
  - Sample Return
    - Command and Data Handling
    - Power
    - Communications
    - Instrumentation
    - Structural
    - Propulsion
  - Support Vehicles
    - Mars Orbiter
    - Mars UAV
    - Rover Engineering Model
    - Mobile Sample Recovery and Isolation Vehicle

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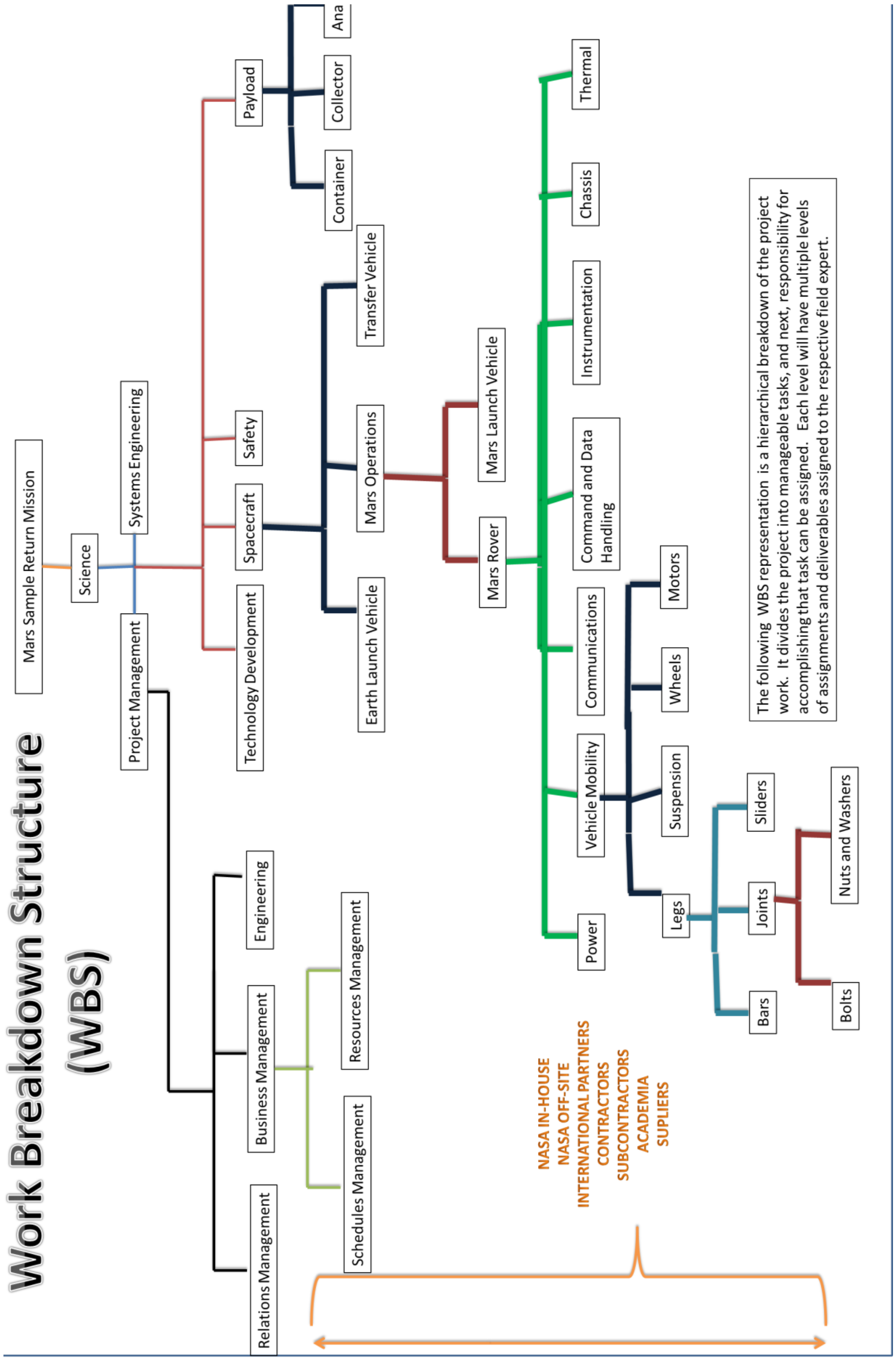
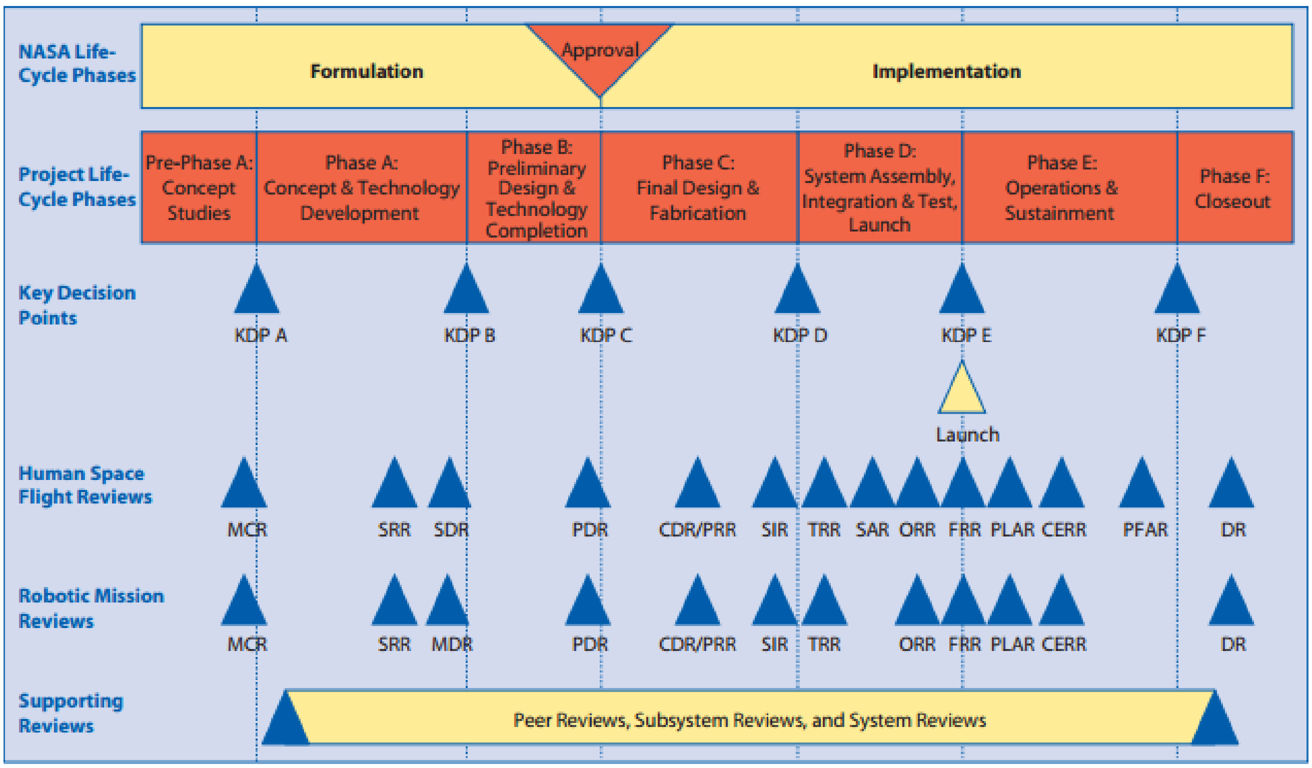
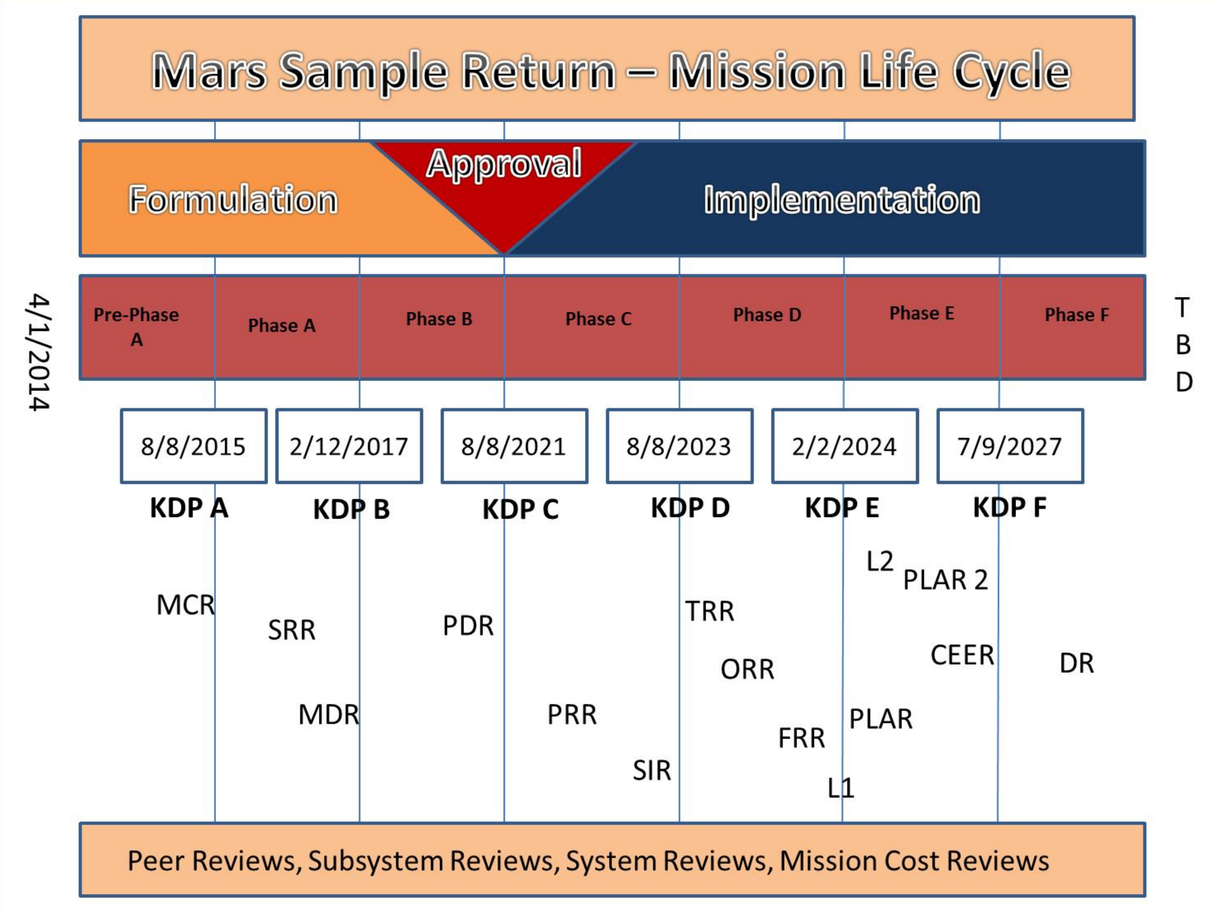
5. Work Breakdown Structure.



6. Develop a lifecycle schedule for your MSR mission that shows key milestones, technical and programmatic reviews, decision points, and the transitions between project phases.



Using NASA's life cycle chart and referring to our previously designed timeline schedule, it is possible to provide a tentative, yet accurate mission life cycle review (Next Page).



Acronyms:

L = Launch
KDP = Key Decision Point
MCR= Mission Concept Review
SRR = System Requirement Review
MDR= Mission Definition Review
PDR =Preliminary Design Review
PRR =Production Readiness Review
SIR = System Integration Review
TRR = Test Readiness Review
ORR = Operational Design Review
FRR = Flight Readiness Review
PLAR= Post Launch Assessment Review
CEER= Critical Event Design Review
DR = Decommissioning Review

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Pre-Phase A:

Beginning April 1st 2014, a panel of engineers and scientists from several NASA Research Centers, have been tasked with discussing feasible options form Mars sample return. Such team will work hand in hand with the Jet Propulsion Laboratory's Team X, producing a broad spectrum of ideas and alternatives concepts. "Team X is a cross-functional multidisciplinary team of engineers that utilizes concurrent engineering methodologies to complete rapid design, analysis and evaluation of mission concept designs." [14] Such concepts and designs will be rated against each other in a loosely manner allowing design flexibility. Most studies performed by Team X are done in 3 days, additional time has been budgeted into the schedule to allow for muti-center and partner interaction. A year after researcher announcements have been made on April 4th 2015 all parties are set to convene at Active Corpus Callosum Building at the Jet propulsion Laboratory culminating Pre-Phase A on April 8th 2015.

MCR = 8/82015

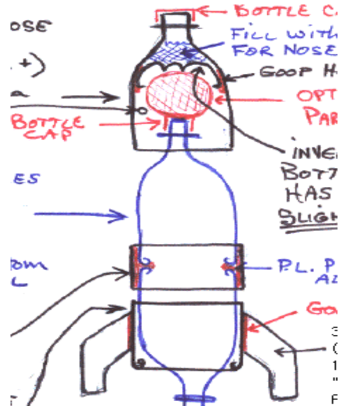
Phase A:

After culmination of the Team X study, System engineers, Chief Scientists and Subsystem Leads will be assigned to each independent piece of the space craft development. Knowing these positions and analyzing the study results will narrow down the feasibility and desirability of a suggested overall new major system. Such decision will evolve during a 2 year period of iterative meetings and technology design advancements. By December 2nd 2017 a finalized craft design, system architecture and Concept of operations are set to be created. Such information will allow System Engineers, Project Management, and Stake Holders to give budget estimates and allocate funding according to subsystem needs.

SSR =15/11/2017

MDR =02/12/2017

Phase B:



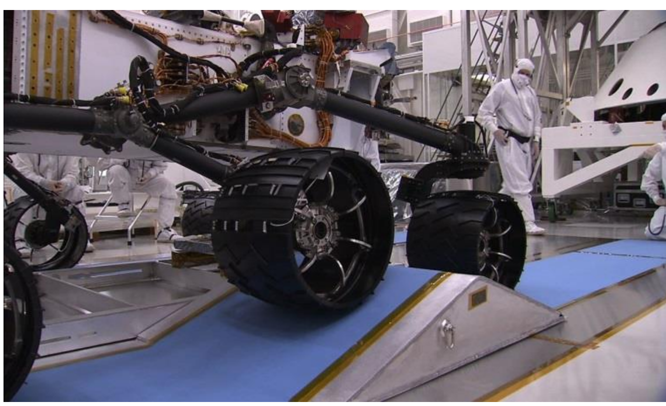
Preliminary Design that has no unresolved design or technology issues. Review of all contractors and technology development projects. The Preliminary Design shall meet the system requirements with acceptable risk and within cost and schedule constraints. (Trade-Off-Study)

Phase C:

To complete a detailed final design of hardware and software (i.e. drawings and specifications to fabricate or procure the hardware and code software, and to assemble systems and subsystems).

Phase D:

Assembly of parts and components to create the subsystems and subsystems to make the entire system. Flight and engineering models will be built and tested at JPL. After acceptable operation and testing, spacecraft shipping preparation will begin and staged within JPL.   All flight spacecraft will be shipped 1 month ahead of launch date.



Phase E:

Operate the system

Phase F:

Decommission pending science an analysis, funding and system life.

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7. Identify 5 Figures of Merit that could be used to evaluate your MSR mission architecture options

Orbital Mechanics Scheduling
Mass Earth to Lower Earth Orbit
Power Supply Lifespan
Mars to Lower Mars Orbit
Inter-institutional Coordination and Communication

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