Mars Sample Return Mission

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The Scoping Elements of the Mars Sample Return Mission

Need:

The need to execute the Mars Sample Return Mission is explained in the "Overview and History," for the Mars Sample Return Mission prompt. It was explained in the prompt, that this particular mission would help alleviate the need on about half of the desired investigations sought by NASA's Mars Planning Group.[1]

Goal(s):

To successfully launch a probe into space that will reach Mars, land on Mars, collect samples from Mars, and return to the Chinese Space Station. The Chinese crew will then safely transport the Mars sample and outside contaminants of the Mars probe to Earth.

Objective(s):

-Successfully launch the Mars Probe on a heavy rocket.

-Fully automated Mars carrier vessel successfully travels from Earth to a Mars orbit.

-The Mars probe safely lands on the Martian surface.

-The Mars Probe automatically picks up the desired amount of samples (volume based with implications on mass).

-The probe launches off the Martian surface after it has been confirmed that it has collected a sufficient amount of samples.

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1 . "Mars Sample Return Mission," Saylor.org, April 15, 2014, http://resources.saylor.org.s3.amazonaws.com/NASA/MSRMissonnew.html#Rubric.

-The probe reconnects with the carrier vessel.

-The carrier vessel safely travels to the Chinese Space Station, and docks with the Chinese Space Station where the crew of the will then remove the sample from the probe.

-The Chinese crew will collect any other outside samples from the probe to gain a better understanding of any possible contamination.

-The Chinese crew will then send the samples on the next return crew mission to Earth, where the samples may then be analyzed in laboratories.

-If the probe is deemed contaminated, or it has no further uses, then it should be placed in a decaying orbit where it will burn up on reentry.

Mission:

To send a probe to Mars to collect Martian samples and return to the Chinese Space Station so that the crew will then bring the samples to Earth, and explore the probe for outside contaminants.

Constraints:

One of the biggest constraints would be the budget, which is why there will be three countries involved in the mission. Another constraint would be the problem of creating new spacecraft, thus much of the products used would be based off of the USA's Curiosity and Russia's (Formerly USSR) Luna Program. Both of those technologies have proved that they

work well, and there is not a tremendous need to develop new craft. Also, basing product designs on formerly used spacecraft would save on program costs. Another constraint would be the amount of samples gathered. The three countries involved in the project would have to come to an understanding on how much of Mars they would like to come to Earth, or share between themselves.

Budget:

There will be a five billion dollar budget. The dollar amount is based on Curiosity's program costs, which was $2.5 billion.[2] The Mars Sample Return Mission double Curiosity's budget, because there will be samples that need to come back to Earth.

Schedule:

Launch date January 2024.

About eight months travel.[3]

Landing august/September 2024.

The probe will spend less than a day in collecting Mars samples (basing the time frame off or Luna 24's collection of Moon samples in 1976).[4]

Departure September 2024

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2 . Jean Folger, "Why Curiosity Cost $2.5 Billion," *YAHOO! Finance,* September 5, 2012, http://finance.yahoo.com/news/why-curiosity-cost-2-5-203931082.html;_ylt=A0LEV76t.E1TmSgAaQIPxQt.;_ylu=X3oDMTByODJtaWUzBHNlYwNzcgRwb3MDMwRjb2xvA2JmMQR2dGlkAw--

3 . Sarah Loff, "Mars Planning Frequency Asked Questions," *NASA,* October 10, 2012, http://www.nasa.gov/offices/marsplanning/faqs/index.html.

4 . Ed Grayzeck, "Luna 24," *National Aeronautics and Space Administration,* April 15, 2014, http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=1976-081A.

Arrival to Earth's orbit at Chinese Space Station in March 2025.

Authority & Responsibility:

This mission would be a joint operation between China, Russia, the United States and their respective space agencies. This project would be similar in nature to the Apollo Soyuz Test Project, that showed countries with competing agendas can show the world that they can be productive in the vastness of space.[5]

Assumptions:

Having three superpowers involved in the sample return effort would offset the other country in case of a lapse of funding from either country Each country is capable of launching the spacecraft, along with each country able to capture the spacecraft on its return flight via space stations. Another assumption is that the spacecraft upon returning to Earth would be contaminated, and procedures must be put in place to deal with the contaminated probe that has returned to Earth's orbit.

5 . Charles Redmond, "The Flight of Apollo-Soyuz," *NASA History,* October 22, 2004, http://history.nasa.gov/apollo/apsoyhist.html.

The High-Level Concept of Operations for the Mars Sample Return Mission

The high-level concept of operations for the mission are largely based off of Figure 4.1-3 from the *NASA Systems Engineering Handbook:*

-Operational Requirements: A spacecraft that can travel from Earth to Mars, collect samples, and return to Earth.

-Project Operations Time line: See pages 12-14

-Operational Configurations: See "Objectives"

-Critical events: Establishment of launch site, landing site, amount of desired return sample, launch date, Mars orbit date, Mars landing date, Mars launch date, and space station return date.

-Organizational Responsibilities: USA – Curiosity type spacecraft for the carrier vessel, Russia – Luna type spacecraft for the sample collection, and China – for the space station support and decontamination.

-Operational Facilities: The three space agencies and their corresponding satellites, including the International Space Station.

-End-to-End Communication Links: Communication links would be maintained via satellites and ground antennas to the carrier vessel and probe.

-Operational Flight Segment Drivers: The Martian probe would be

attached to the space station docking capable carrier vessel. They will both sit upon a heavy rocket which will propel them into space. A carrier vessel is needed for the extra fuel needed to return the probe to Earth for the collection of the samples.

-Operational Ground Segment Drivers: Joint coordination and communication should be institute for this multinational project to avoid project delays, communications errors, and budget shortfalls.

-Operational Launch Segment Drivers:[6] Since the carrier vessel's primary target on return to Earth is the Chinese Space Station, it makes sense that the Chinese would return the sample to Earth. However, the three countries would have to a consensus on whom is to launch the spacecraft. Most likely it would be the USA, because the carrier vessel would be based off of an American design that is already paired with a heavy rocket (the exception in this case is that the American design will have to forgo the rover and add a Soviet Luna lander).

6 "Systems Engineering Handbook," NASA, December, 2007, http://www.saylor.org/site/wp-content/uploads/2013/08/NASA_SE_Handbook_2007.pdf#page=215.

The High-Level Architecture for the Mars Sample Return Mission

The high-level architectural model for this mission will be highly dependent upon the interactions of the space agencies of the three participating countries. As long as the space agencies are coordinating efforts, it adds to the ease of incorporating the space station aspect of the mission. It would still need to be determined as to which space station the carrier vessel will rendezvous with when returning to Earth. The primary space station for a rendezvous would be the Chinese Space Station, but if there is an issue whatsoever at the Chinese Space Station then the International Space Station would be the backup facility. The reason why the International Space Station is not the primary target for the returning carrier vessel is that there are many other countries involved with that space project other than Russia and the USA – China is not part of the International Space Station, and allowing the Chinese to capture the carrier vessel would allow them to have more transparency in the mission as well as equal responsibility in the project. Earth's satellites and ground antennas would maintain contact with the carrier vessel and probe, and the probe carrier would maintain contact on the mission to ensure redundancy.

The Product Breakdown Structure for the Mars Sample Return Mission

The Product Breakdown Structure is largely based upon Figure 4.3-2, from the *NASA Systems Engineering Handbook:*

-Flight Segment/Mars Bound Spacecraft

-Payload Element/Mars Landing Probe

-Sample Gathering Equipment: This element of the Martian Probe will be comprised of an arm that is capable of digging into the Martian soil, and then placing the samples into sealed containers aboard the probe. The amount of containers, and the capacity that they can carry will be dependent upon the three countries' desired amount of return, or the amount that might satisfy their needs. Since the Mars Probe will be based off of the former Soviet Luna 24, it is probable that this mission would be able to return at least 170.1 grams of Mars (which is the amount of the Moon that Luna 24 returned from the Moon).[7]

-Detectors

-Electronics

-Spacecraft/Payload Interface

7 . Ed Grayzeck, "Luna 24," *National Aeronautics and Space Administration,* April 15, 2014, http://nssdc.gsfc.nasa.gov/nmc/masterCatalog.do?sc=1976-081A.

-Launching/Landing Capabilities

-Structure

-Power

-Guidance/Navigation/Control

-Command/Data

-Propulsion

-Mechanics

-Spacecraft Bus/Mars Carrier Vessel

-Structure

-Power

-Electrical

-Thermal

-Spacecraft/Payload interface

-Command/Data

-Guidance/Navigation/Control

-Propulsion

-Mechanics

-Communications

-Launch Accommodations/Either USA, Russia, or China

-Payload Attached Fitting

-Electrical

-Supply[8]

The Work Breakdown Structure for the Mars Sample Return Mission

The life cycle schedule for the Mars Sample Return Mission is developed based upon the phases presented in the *NASA Systems Engineering Handbook:*

Pre-Phase A: Concept Studies

January 2014: Getting ideas on how to bring Martian Samples to Earth.

Reviews: MCR and Informal Proposal Review

Phase A: Concept and Technology Development

January 2016: Make sure that this project is feasible and truly desirable.

Reviews: SRR and MDR

Phase B: Preliminary Design and Technology Completion

January 2018: Define the baseline project.

Reviews: PDR and Safety review

Phase C: Final Design and Fabrication

January 2020: Finalize the design, and create the necessary hardware and software to facilitate this mission.

8 "Systems Engineering Handbook," NASA, December, 2007, http://www.saylor.org/site/wp-content/uploads/2013/08/NASA_SE_Handbook_2007.pdf#page=215.

Reviews: CDR and PRR

Phase D: System Assembly, Integration, Test, and Launch

January 2021: Start Building Components of Carrier Vessel with capability of returning the probe, orbit mars, rendezvous with Chinese Space Station. Also, start building the components of Martian probe for Mars landing/escape.

January 2021: Choose Launching Pad, and begin testing.

Reviews: TRR, ORR, FRR, System Functional and Physical Configuration Audits, and Safety Review

Phase E: Operations and Sustainability

Launch date January 2024.

About Eight Months Travel.

Orbit Mars

Landing august/September 2024.

Probe Retrieves Desired Amount of Samples

Probe Launches off of Mars to Rendezvous with Carrier Vessel

Departure September 2024

Carrier Vessel Makes the Necessary Burns to Put it into a Trajectory to Earth to be Caught in its Orbit

8 Month Trip

Arrival to Earth's orbit at Chinese Space Station in March 2025.

Sample gathered

Space Walk takes Place to Gather any Possible Contaminants on Craft for Further Examination

Samples Remain on-board Until the Next Crew Rotation of the Space Station

Crew Provides Samples to Agency Scientists upon Return for Analysis

Reviews: PLAR, CERR, System Upgrade Review, and Safety Review

Phase F: Closeout

Spend the next six months reviewing the mission to see what mistakes were made, and what could have improved.

Review: DR[9]

9 "Systems Engineering Handbook," NASA, December, 2007, http://www.saylor.org/site/wp-content/uploads/2013/08/NASA_SE_Handbook_2007.pdf#page=215.

Five Figures of Merit

Here are five figures of merit that could be used to evaluate the Mars Sample Return Mission architecture options:

1. By having three space agencies and two space stations involved with the mission, communications overlays can be achieved by avoiding a connection loss with the Mars bound spacecraft.
2. In addition to having three space agencies involved with the mission, there will be three countries involved with the mission to help support the program's budget in case one or two countries skimps on project funding.
3. There will be added mission support with the carrier vessel to monitor the Martian probe, and the carrier vessel will make secondary investigations of the planet and area of space while on route to Mars' orbit.
4. Also, by creating products on proven technology (Curiosity and Luna) avoids possible technological/mission failures.
5. Finally, having the carrier vessel rendezvous at a space station prior to bring the samples to Earth, there will be an avoidance of possible Earth contamination or vehicle loss on reentry.

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