Residential Internship
John F. Kennedy Space Center
Project M: An Assessment of Mission Assumptions
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Student Signature

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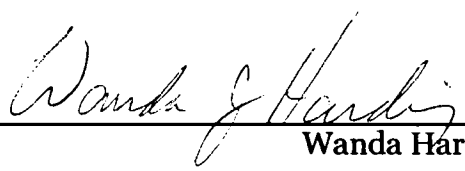

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Project M: An Assessment of Mission Assumptions
NASA/INSPIRE
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Wanda Harding
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Project M: An Assessment of Mission Assumptions

Project M is a mission Johnson Space Center is working on to send an autonomous humanoid robot to the moon (also known as Robonaut 2) in 1000 days. The robot will be in a lander, fueled by liquid oxygen and liquid methane, and land on the moon, avoiding any hazardous obstacles. It will perform tasks like maintenance, construction, and simple student experiments. This mission is also being used as inspiration for new advancements in technology. I am considering three of the design assumptions that contribute to determining the mission feasibility: maturity of robotic technology, launch vehicle determination, and the LOX/Methane fueled spacecraft.

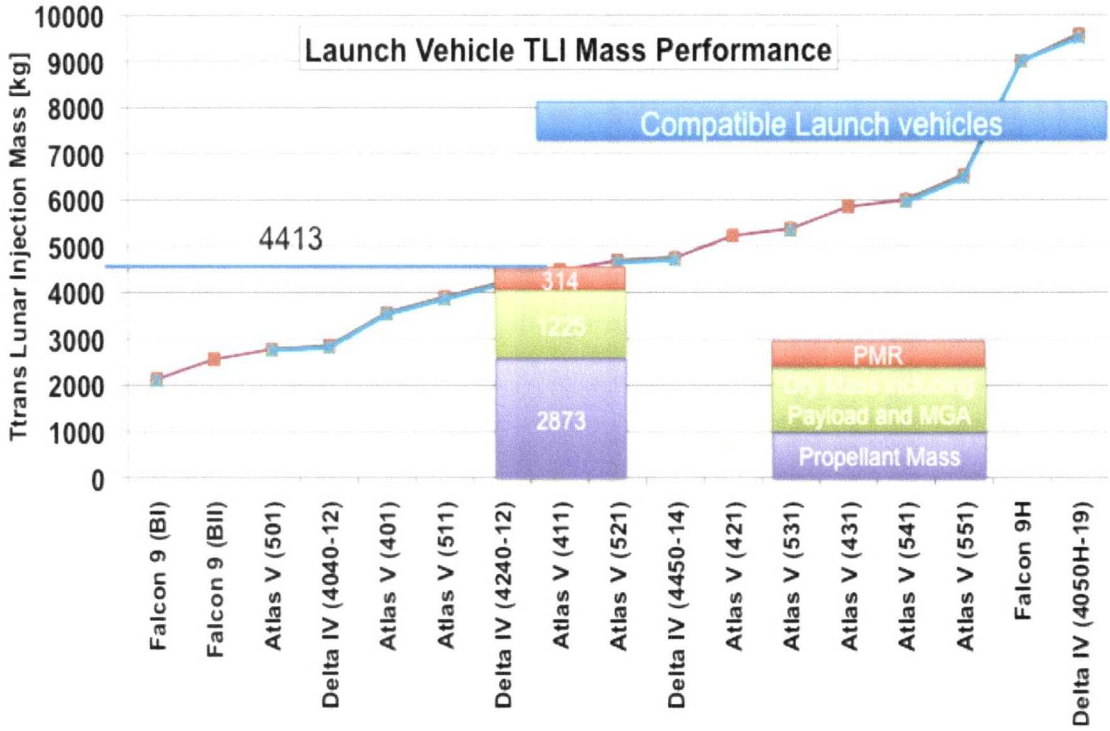
Humanoid Robot (Robonaut)

NASA and General Motors worked together to build the humanoid robot, using aluminum for most of the structure, and standard aerospace material for wirings and coatings. They thought designing the robot with a human form was best because it was able to use the same tools and work in the same work space as a human, which eliminated the need for special tools. It is compact, skilled with its hands, and includes a deep and wide sensing range. This robot has the ability to test systems in space, providing data for future missions. Robonaut 2 currently has a TRL (technology readiness level) of 6, which means it is ready to be tested in the proper environment (in this case, space).

A current problem with the robot: it has no legs so it isn't able to walk. However, NASA is also partnered with the Institute for Human and Machine Cognition to produce a way for the robot to walk. They are also working with Purdue University to make effective motor designs to get the legs moving. They are working on this, not only for the robot, but also other high performance systems.

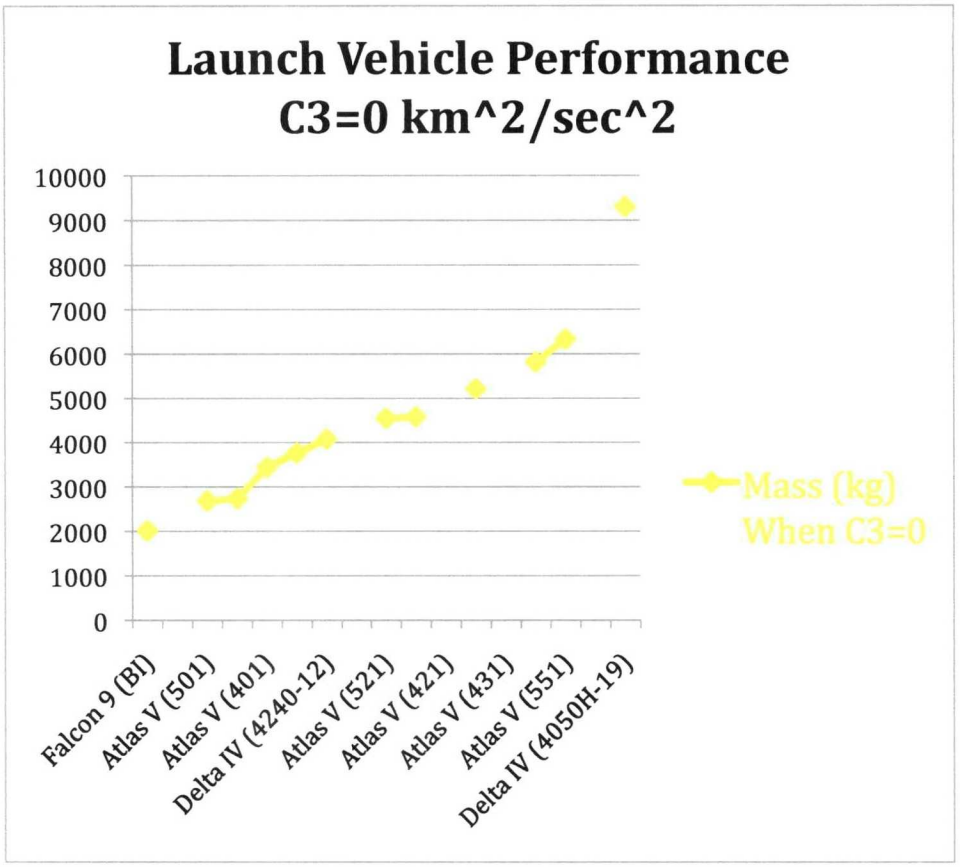
Launch Vehicle

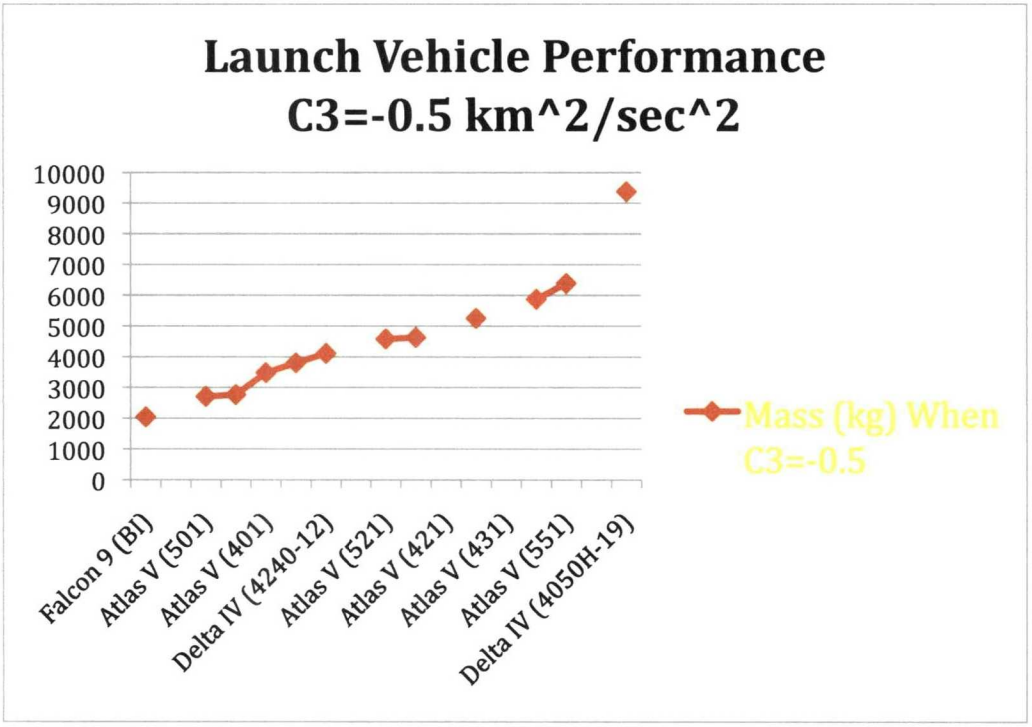
The commercial launch vehicle will be launched from the Kennedy Space Center and inserted into a trans-lunar trajectory, but mission operations will occur at Johnson Space Center. After estimating the amount of mass that the payload will be, NASA engineers from the Project M team came to the conclusion that the launch vehicle used would need to hold a payload capacity of at least 4,413 kilograms. The vehicles capable of doing this are a part of the Atlas V, Delta IV, and Falcon families.

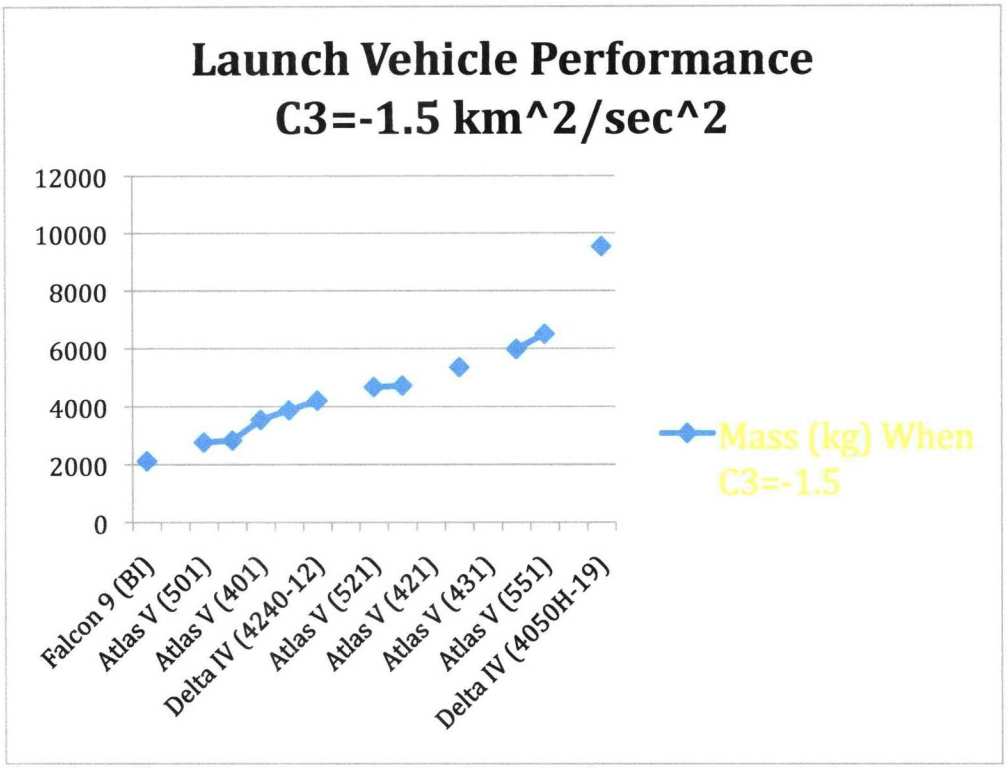


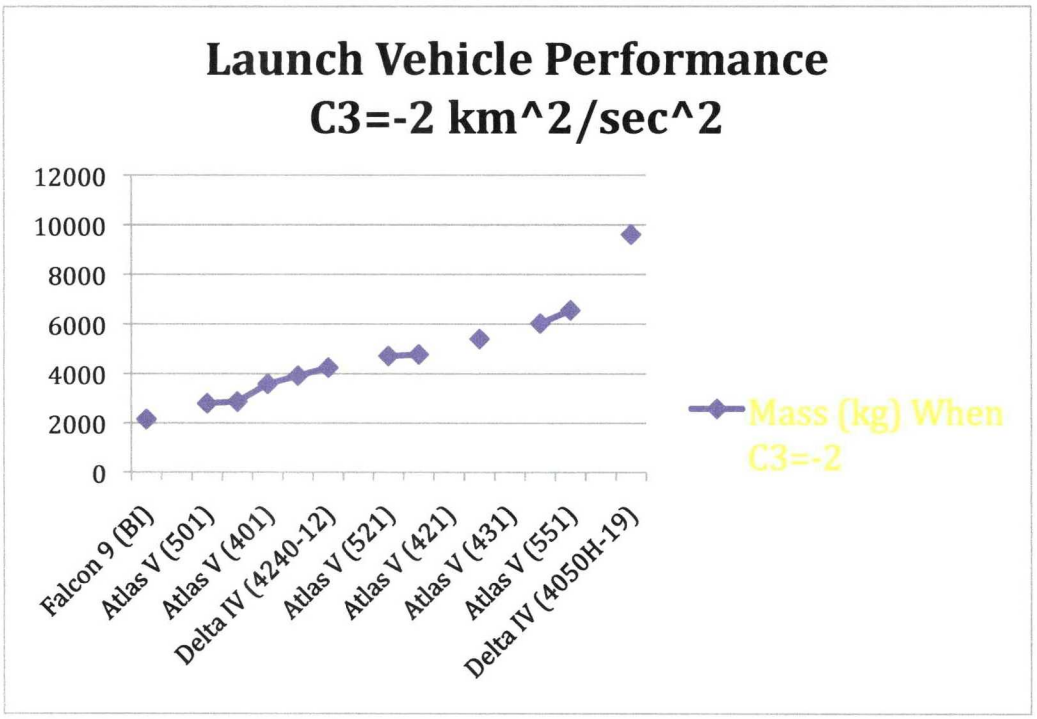
Project M White Paper Graph

Using the LSP website to get the numbers for the payload, I made my own graphs to compare to their mass requirements (mass load the vehicle would have to hold and the amount of energy-C3-needed to take the vehicle out of low earth orbit), and, for the most part, we had the same calculations. However, for some of the vehicles, I wasn't able to find the amount of mass they could hold because they weren't under the NSL contract, so I couldn't verify those amounts.


Launch Vehicle Performance
C3=0 km^2/sec^2
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Falcon 9 (BI)
Atlas V (501)
Atlas V (401)
Delta IV (4240-12)
Atlas V (521)
Atlas V (421)
Atlas V (431)
Atlas V (551)
Delta IV (4050H-19)
Mass (kg) When C3=0


Launch Vehicle Performance
C3=-0.5 km^2/sec^2
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Falcon 9 (BI)
Atlas V (501)
Atlas V (401)
Delta IV (4240-12)
Atlas V (521)
Atlas V (421)
Atlas V (431)
Atlas V (551)
Delta IV (4050H-19)
Mass (kg) When C3=-0.5





I used C3 intervals of: 0, -0.5, -1.5, and -2 because these are different intervals used to take a launch vehicle to the moon. I experimented with these numbers because I didn't get an exact C3 measurement from the Project M White Paper.

LOX/Methane Fueling

Liquid oxygen and liquid methane will be used to fuel the lunar lander. Because this is a long duration exploration, there is a need for easily storable propellants with higher densities than liquid hydrogen and hydrazine (which is commonly used for spacecraft). LOX and Methane also make a non-toxic combination, which allows easy and efficient ground and flight testing to be carried out routinely.

The problem with this fueling is: the LSP needs a way to provide fueling for the launch pad. The spacecraft using the hydrazine are fueled before transporting the encapsulated spacecraft (one that is on the LV adapter and enclosed in the fairing) to the launch pad. Although it may be more expensive, one ideal option is to provide the fuel to the encapsulated lander/spacecraft through an umbilical at the launch pad.

I believe this mission is feasible and is a stepping stone in advancing our future technology. The robot is almost completely built and has a TRL of 6, which means it is ready to be tested in its proper environment. The Project M team has a good idea on what type of launch vehicle they want to use (Atlas V-411) because they found the payload capacity needed for the mission (4,413 kg) and the amount of energy needed to carry the vehicle to the moon. The LOX/Methane is routinely tested because it is non-hazardous to the environment and the people working with it and has proven to be efficient in its proper environment.

References

•White Paper:

-Landing a Humanoid Robot on the Moon in 1000 Days "Project M", May 3, 2010

•People:

-Wesley Johnson, Kennedy Space Center, Cryogenic Test Laboratory

-Stephen Huff, Kennedy Space Center, Cryogenic Technology Lab

-Eric Haddox, Kennedy Space Center, Flight Dynamics Branch

-Eblan Farris, Kennedy Space Center

-Matt Ondler, Johnson Space Center, Project M

•Websites:

-http://www.youtube.com

-http://elvperf.ksc.nasa.gov/elvMap/