Critical Design Review

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Project Background

The Psyche Rover design team has been tasked with conceiving a robotic explorer to assist in the examination and analysis of the 16 Psyche asteroid. It is hypothesized that the asteroid is mainly metallic in composition, being comprised of metallic iron and nickel. Due to this composition, the asteroid is of significant interest, as scientists believe that Psyche may be the exposed core of an early planet. As the first investigation of a world of metal, the Psyche mission may provide insight on the history of planetary collisions and what may lie at the Earth's core (In Depth, 2021).

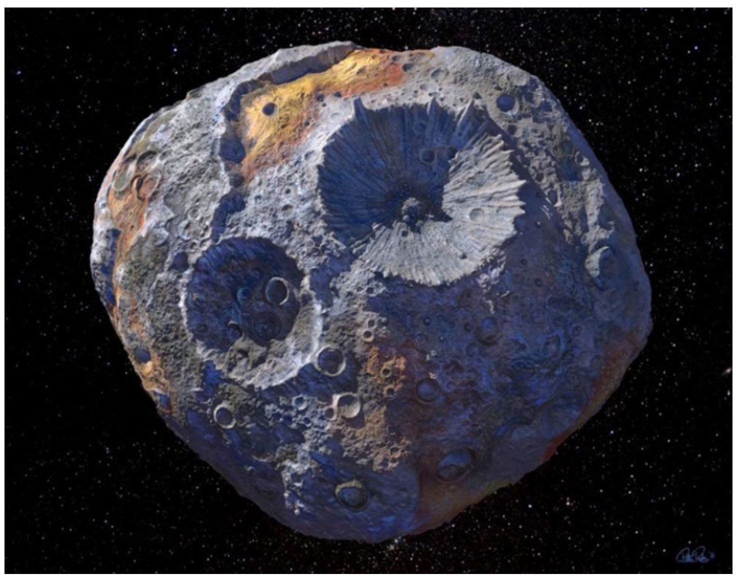


Figure 1 - Artist Concept of Psyche, Credit: Maxar/ASU/P.Rubin/NASA/JPL-Caltech

Project Charter Revisions

The design team made several changes to the project assumptions as the final concept was developed and the project scope was altered. The initial assumptions versus the revised assumptions are compared in Table 1.

Project Charter Assumption Comparison	
Initial Assumptions	**Revised Assumptions**
Communication devices, such as satellites, are designated and available	Utilized methods of communication resemble those available to the Psyche Mission (Bluetooth, satellite, RF, etc.)
External transport to asteroid is provided	External transport to asteroid is provided
Power provision is local to the rover	Power provision is local to the rover
Earth's gravitational environment is sufficient for prototyping	Earth's gravitational environment is sufficient for prototyping locomotion
Ambient local environment - no extreme conditions	Ambient local environment - no extreme conditions
Rover will not operate completely autonomously	Rover will not operate completely autonomously
Necessary peripheral equipment is specified in advance of CAD design	Necessary peripheral equipment is specified in advance of CAD design
Rover is not required to be amphibious	Rover is not required to be amphibious
	Material lead times do not exceed 3 weeks

Table 1 - Assumption Comparisons

The design team clarified the communication assumption for prototyping purposes, allowing for the inclusion of several familiar methods, such as RF and Bluetooth. Although they function more as a constraint, material lead times were included in the revised assumptions. The design team is moving forward with concept prototyping, though the current shipping climate may be prohibitive in the production of the conceived model.

Project Plan

The design team is tentatively following the schedule detailed in Figure 2. The intent of the schedule is to outline critical administrative submissions, but also to provide a visual representation for critical path identification. The design team did not include construction and troubleshooting projections in the schedule, as material lead times for the items in the initial purchase request, Appendix A, may result in schedule fluctuations. The initial purchase request was delivered to the Faculty Advisor on May 24 for review, approval, and purchasing.

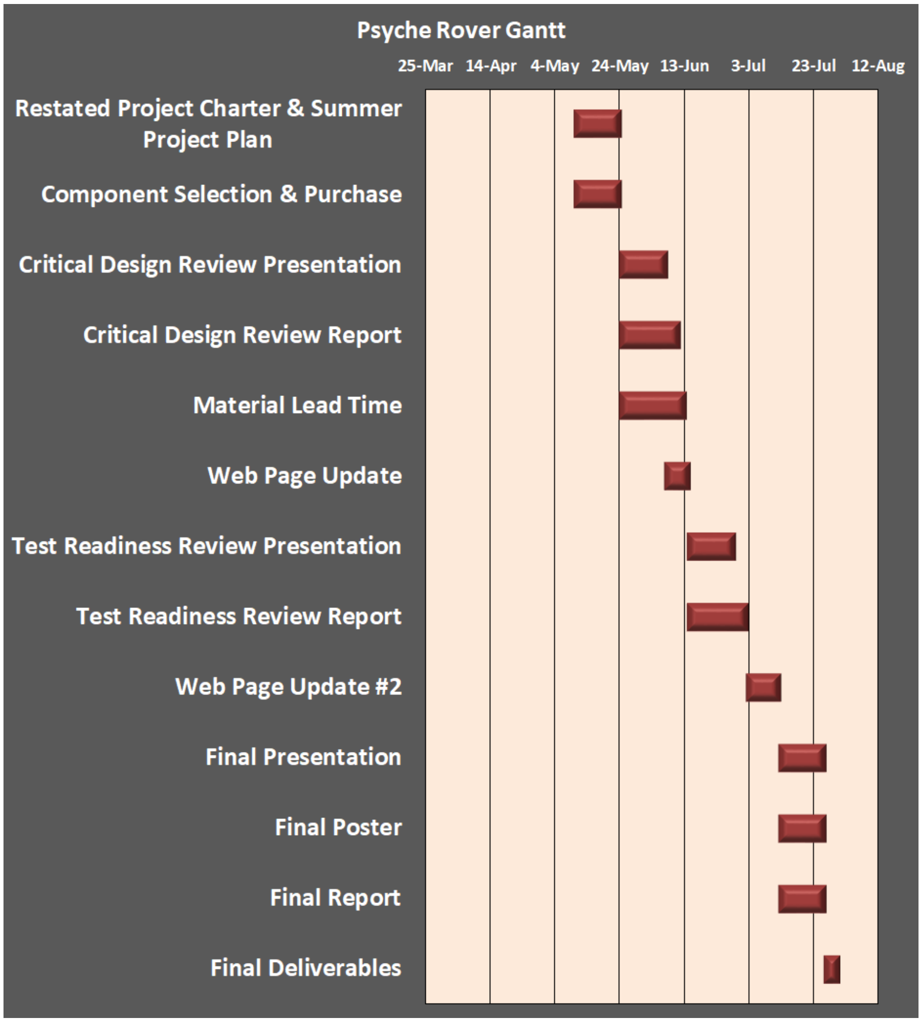


Figure 2 – Project Schedule Gantt Chart

Revised Requirements & Specifications

The design team developed targets and metrics during the initial phases of concept generation. Critical targets and metrics were identified and are detailed in Appendix B. Although the input lag metrics remain a requirement the design team intends to assess, the method to achieve the *Send Signals* and *Receive Signals* functions has changed from wireless communication to radio frequency transmission. The other listed critical targets and metrics remain unaltered; however, revisions will likely occur as the design team empirically tests the feasibility of the design and selected components after construction.

Current System Design

The design team's focus has rested heavily on the locomotion aspect of the robotic explorer. Initially, the locomotion targets were intended to be achieved through the employment of wheels with in-hub motors, Figure 3.

Figure 3 - In-Hub Motor Wheel

Although this proposal allows for a simpler integration into the rocker-bogie suspension system, the in-hub motors are brushed and require a compatible motor driver that the design team is unfamiliar with. The design team is still exploring the feasibility of this locomotion style, as several in-hub wheel manufacturers also produce compatible motor driving accessories.

The complexity of the in-hub motors necessitated additional research on how to effectively propel the wheeled rover. The design team investigated several different worm and planetary gear motors before arriving at their proposed 12V planetary DC motor option, Figure 4. The design team is familiar with integrating this type of brushless motor with various motor drivers, with the selected Sabertooth motor driver being depicted in Figure 5.

Figure 4 - 12V DC Motor

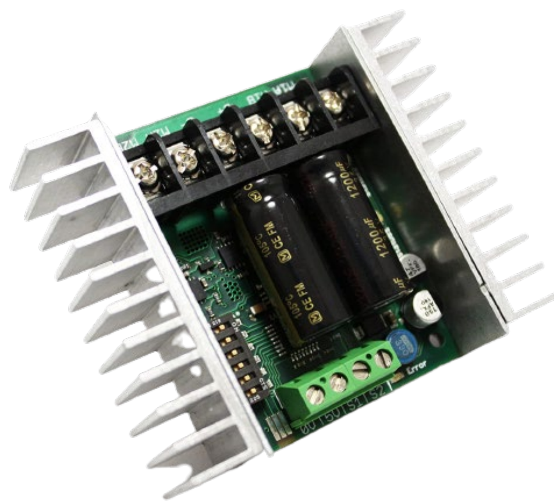


Figure 5 - Sabertooth Dual 25A

Although the integration of the selected motor and motor driver is more familiar to the design team, the mechanical installation is more involved with this configuration. The motors, six in total, must be fitted and mounted to the rocker-bogie suspension. Additionally, the motor shaft must be adapted to fit the hub of the chosen wheel (not currently selected or proposed). After the wheel is mounted to the motor shaft, it must be secured through the installation of an additional component such as a hex key or cotter-style pin. The design team intentionally selected a motor with a common nominal shaft dimension to ease the burden of this adaptation.

The design team intends to operate the six motors in two 3-motor banks, with one bank serving one side of the drivetrain, and one serving the opposite side. With each motor operating at a nominal 6 amp maximum, this results in the independent banks requiring 18 amps each to operate. The Sabertooth motor driver is capable of handling this load, as it can supply 25 amps to two separate motor banks.

The design team projected a worst-case load of all six motors operating at 4 amps when selecting the battery. With a 24-amp draw, the chosen 12V battery, Figure 6, could provide power to the rover for approximately 30 minutes. The design team is anticipating this to be sufficient, as the rover will not need to relocate frequently and is intended to be operated under minimal loads.

Figure 6 - 12V, 12AH Battery

The design team chose the Flysky FS-i6, Figure 7, as the remote control and receiver combination, which uses RF transmission; a deviation from the initial wireless/Bluetooth projection. The integration of this component makes conceptual sense to the design team, though some installation research and troubleshooting is anticipated, as the controller is capable of complex integrations.

Figure 7 - Flysky FS-i6

Conclusion

The design team has continued moving forward with the final selection, Appendix C, and has proposed an initial purchase list to begin rover construction. There are several outstanding components to be selected and integrated, such as the camera, camera mount, wheels, and enclosure, though the bulk of the concept can be implemented and constructed from the list detailed in Appendix A. The selected components were intended to alleviate the burden of the controls engineering, though it is recognized that an additional mechanical burden may be incurred.

References

Bogie Runt Rover. RobotShop. (n.d.). https://www.robotshop.com/en/bogie-runt-rover.html.

Hub Motor for Ranger X2. (n.d.). Retrieved from https://backfireboardsusa.com/products/hub-motors-set-for-ranger-x2?variant=31697285415043

In Depth. (2021, January 12). Retrieved January 18, 2021, from https://solarsystem.nasa.gov/asteroids-comets-and-meteors/asteroids/16-psyche/in-depth/

Nfornavin. (2017, August 11). How to Make a Mars Rover / Rocker bogie Robot - Stair climbing. Retrieved from https://www.youtube.com/watch?v=3Zx7tGtwF5g

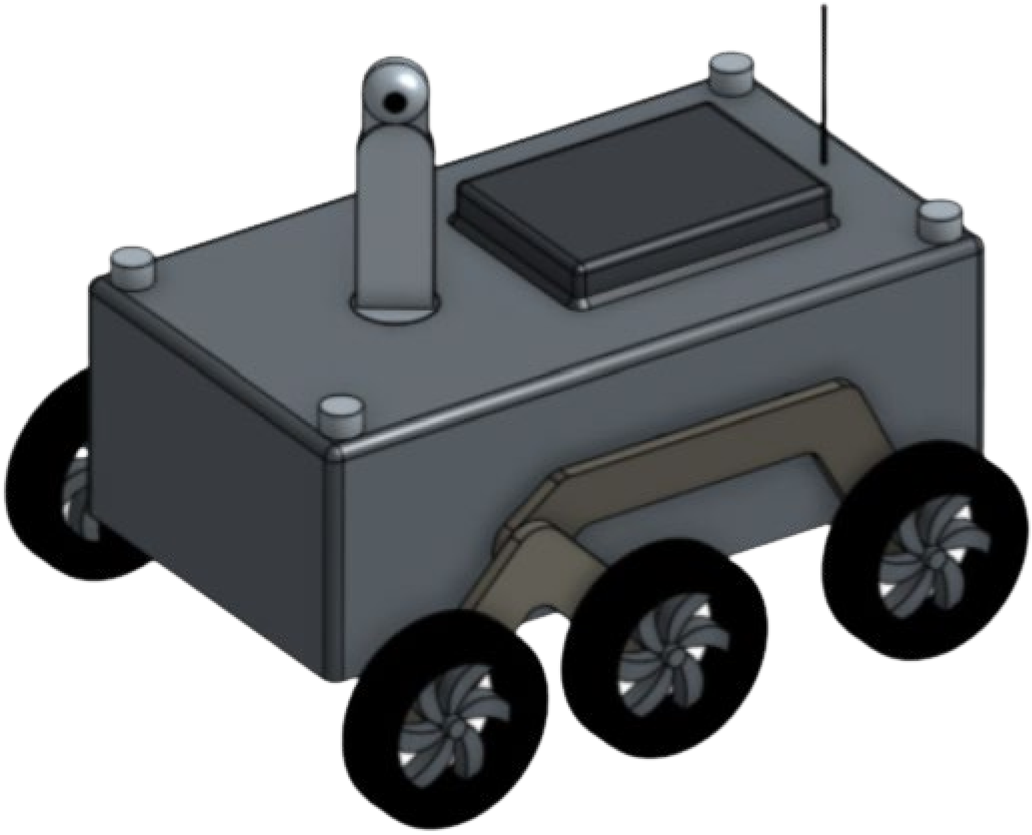
Appendix A – Initial Purchase List

Initial Purchase Request - 525PC Psyche Rover					
Component	**Quantity**	**Unit Price**	**Total Price**	**Link**	**Shipping Details**
Motors	6	$74.00	$444.00	https://makermotor.com/pn01007-38-3-8-d-shaft-electric-gear-motor-12v-low-speed-50-rpm-gearmotor-dc/	free shipping $70.39 for 3day
Motor Driver	1	$119.99	$119.99	https://www.amazon.com/Sabertooth-Dual-25A-Motor-	free shipping
Battery Charger	1	$39.99	$39.99	https://www.amazon.com/Dakota-Lithium-Batteries-Battery-BATCHAR1/dp/B07MHP8653/ref=sr_1_3?dchild=1&keywords=DAKOTA+LITHIUM+12V+3A+LIFEPO4+BATTERY+CHARGER&qid=1621802027&sr=8-3	Amazon
Battery	1	$67.59	$67.59	https://www.amazon.com/gp/product/B07JF56C7L/ref=crt_ewc_ti	Amazon
Controller & Receiver	1	$52.99	$52.99	https://www.amazon.com/Flysky-Transmitter-Multirotor-Helicopter-	Amazon
Voltage Step-Down	1	$10.17	$10.17	https://www.amazon.com/gp/product/B00JUFJ1GA/ref=as_li_tl?tag=droking-	Amazon
Total:			**$734.73**		

Appendix B – Targets & Metrics

Critical Functions, Targets, & Metrics		
Function	**Metric**	**Target**
Convert Energy	Percentage Converted to Useful Work	80+%
Store Energy	Operational Longevity	60-90 days
	Driving Duty Cycle	20%
Send Signals	Wi-fi Connection Output Lag	802.11 2.4 GHz or 5 GHz 802.11 0.5 seconds
Receive Signals	Wi-fi Connection Input Lag	802.11 2.4 GHz or 5 GHz 0.5 seconds
Detect Obstacles	Terrain Slope	20^o + incline 20^o + decline
	Obstacle Size	Diameter: 8 in Length/Width/Height: 6 in
Maneuver Terrain	Velocity	0.10 ft/s
Navigate Obstacles	Terrain Slope	20^o > incline 20^o > decline
	Obstacle Size	Diameter: 8 in > Length/Width/Height: 6 in >
House Equipment	Enclosure Volume	$0.5ft^3$ (8"x10"x12")
Maintain Stability	Center of Gravity	Low (CG < H/2)
Durable	Withstands Environmental Conditions	Yes

Appendix C – Final Selection



Final Selection Including Changes		
Subproblem category	**Initial Selection**	**Final Selection**
Energy Conversion*	Solar Photovoltaic	Electrical to Mechanical Battery Powered
Signal Type*	Wi-fi connection	RF
Enclosure Geometry	Rectangular	Rectangular
Visual Detection*	360-degree	Go-Pro
Physical Detection	Lidar	Lidar
Locomotion	Roll	Roll
Locomotion Style*	Omnidirectional Wheels	Plain Wheels
Traction Type	Tread	Tread