LSS ASSEMBLY TOOL

TEAM: 516

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Caleb Jansen
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NASA Marshall Space Flight Center
LSS Assembly Tool
Team 516

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Controls Engineer

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Communications Engineer

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Advisor and Sponsor

Faculty Advisor:
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Project Sponsor:
Justin Rowe
NASA Marshall Space Flight Center

Jacob Hackett

Project Scope:

Project Description

Objective

Key Goals

Assumptions

Jacob Hackett

Project Scope:

Project Description:

- NASA wants the ability to relocate their lunar bases to different areas on the surface of the Moon.
- NASA's proposed solution is an assembly tool that can relocate their life support system (LSS) to nearby locations on the lunar surface.

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Project Scope:

Objective: Move the LSS payload around the lunar surface

Develop a full-scale simulation and scaled prototype of the assembly tool to transport modules of the life support system on the surface of the Moon.

Identify methodology for scalability of the LSS Assembly Tool.

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Project Scope:

Key Goals:

01 Create a full-scale simulation

02 Traverse obstacles present on the lunar surface

03 Create scaled prototype to move scaled payloads of NASA's equipment

04 Controlled via remote control

05 SAE level 1 autonomy

Jacob Hackett

Project Scope:

Assumptions:

Responsible only for the design and production of the scaled mechanism prototype to move the LSS or other payloads.

- Not responsible for the transportation of the LSS assembly tool to the lunar surface.

All testing and verification will be conducted under Earth's atmosphere and on terrain analogous to lunar conditions.

Existing software and hardware components will be utilized as needed.

Jacob Hackett

Project Background:

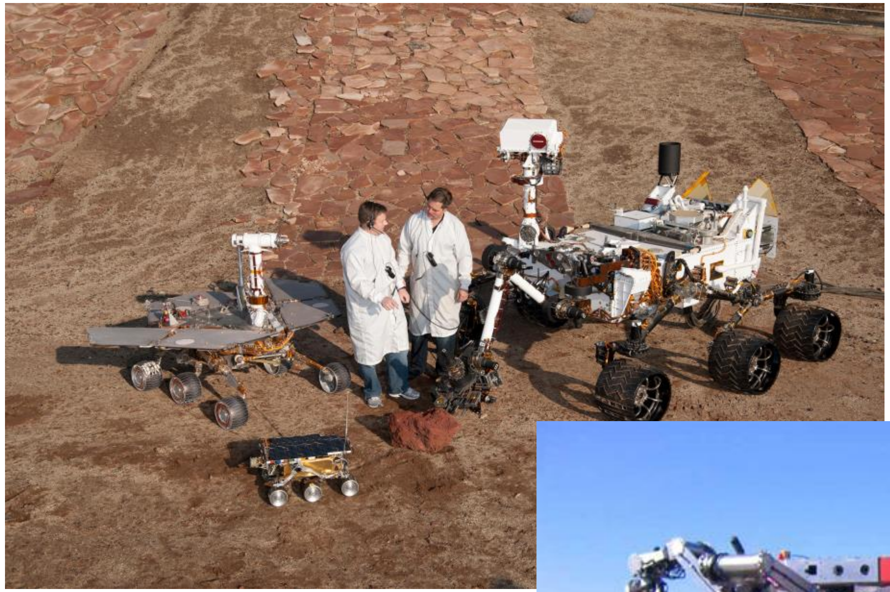
Technology

Research

Caleb Jansen

Project Background

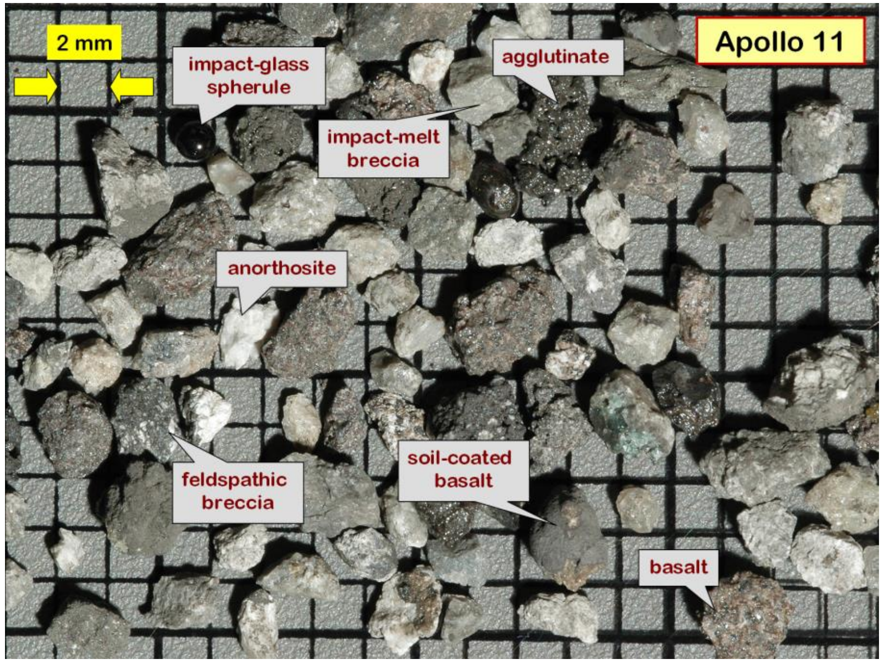
- Design Requirements
  - Comparable to current infrastructure machine
  - Payload Equipment for a unique environment
- Lunar Rover Design
  - Comparable to current rover technology
  - Focus on ability to move payload
  - Combustion power not viable
  - Current Technology-
    - Mars Exploration Rovers Spirit and Opportunity
    - ATHLETE Rover



Caleb Jansen

Project Background

- Preparation for Unique Obstacles
  - Lunar Environment Studies
    - “Zap Pits” – Micro-meteor impact sites
    - Regolith
    - Atmospheric Conditions / Dangers
  - Lunar Architecture/NASA Goals
    - Plans for long term base on lunar surface
  - Full-Scale Simulations
    - Need application to simulate full force simulations
    - Simscape with additional toolboxes



Caleb Jansen

Customer Needs:

Synthesis of customer responses into needs

Caleb Jansen

Customer Needs

Questions

- How big is the payload we will be lifting?

Interpreted Responses

- Need to lift a 300kg load

Caleb Jansen

Customer Needs

Questions

- How big is the payload we will be lifting?
- What scale of a model do you expect?

Interpreted Responses

- Need to lift a 300kg load
- Various scaled models

Caleb Jansen

Customer Needs

Questions

- How big is the payload we will be lifting?
- What scale of a model do you expect?
- How detailed of a simulation would you like?

Interpreted Responses

- Need to lift a 300kg load
- Various scaled models
- A full scaled model for simulation

Caleb Jansen

Customer Needs

Questions

- How big is the payload we will be lifting?
- What scale of a model do you expect?
- How detailed of a simulation would you like?
- Does the assembly tool need to be fully assembled when it arrives on the moon?

Interpreted Responses

- Need to lift a 300kg load
- Various scaled models
- A full scaled model for simulation
- The assembly tool will be fully assembly, excluding possible hand tool assembly

Caleb Jansen

Functional Decomposition:

Power

Communications

Motion

Payload

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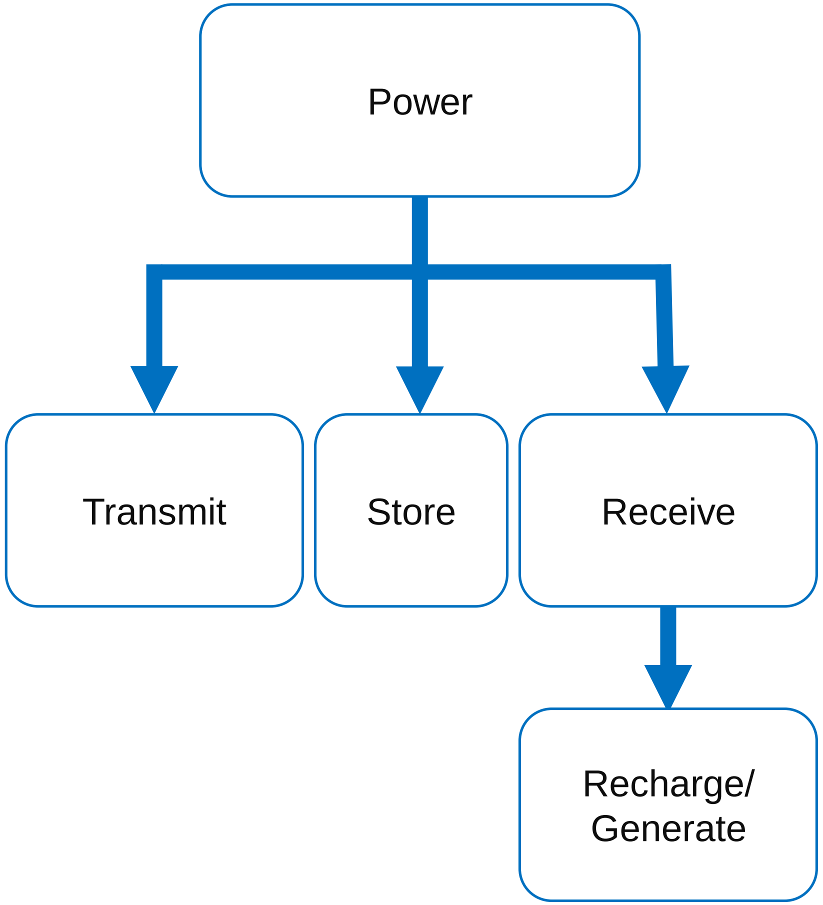
Functional Decomposition

Power



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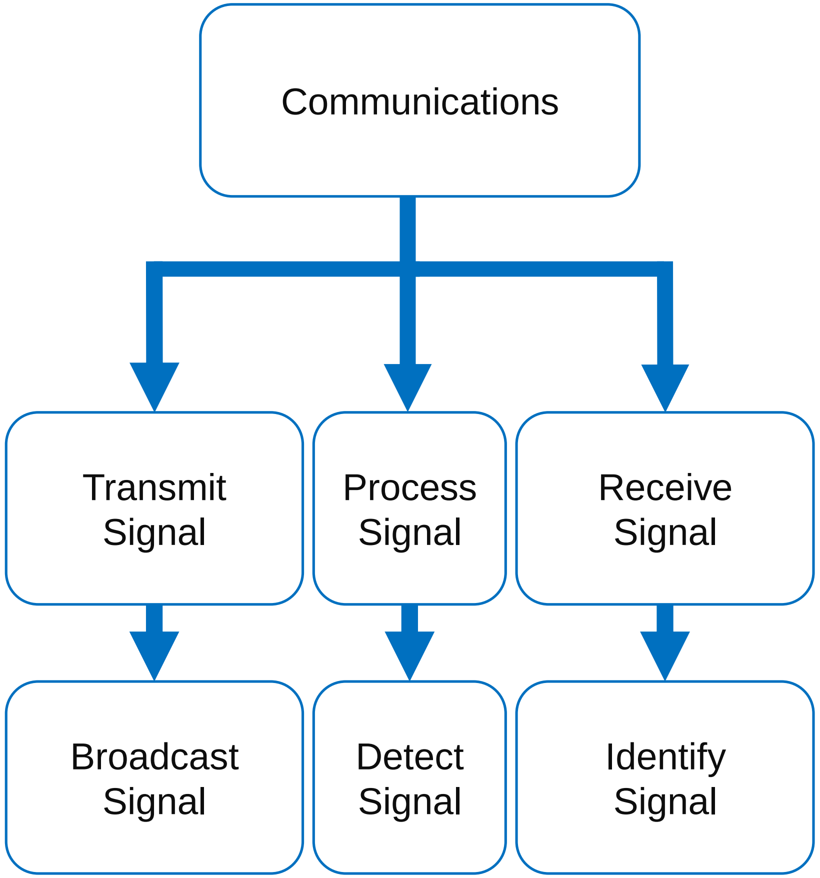
Functional Decomposition

Power

Communications



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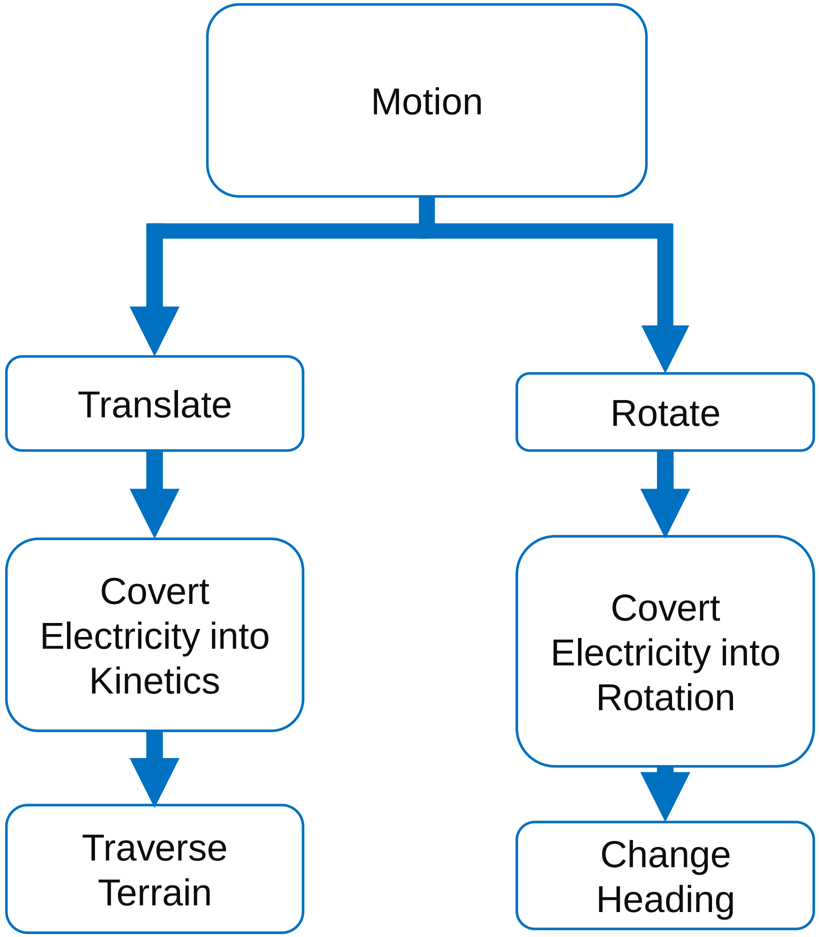
Functional Decomposition

Power

Communications

Motion



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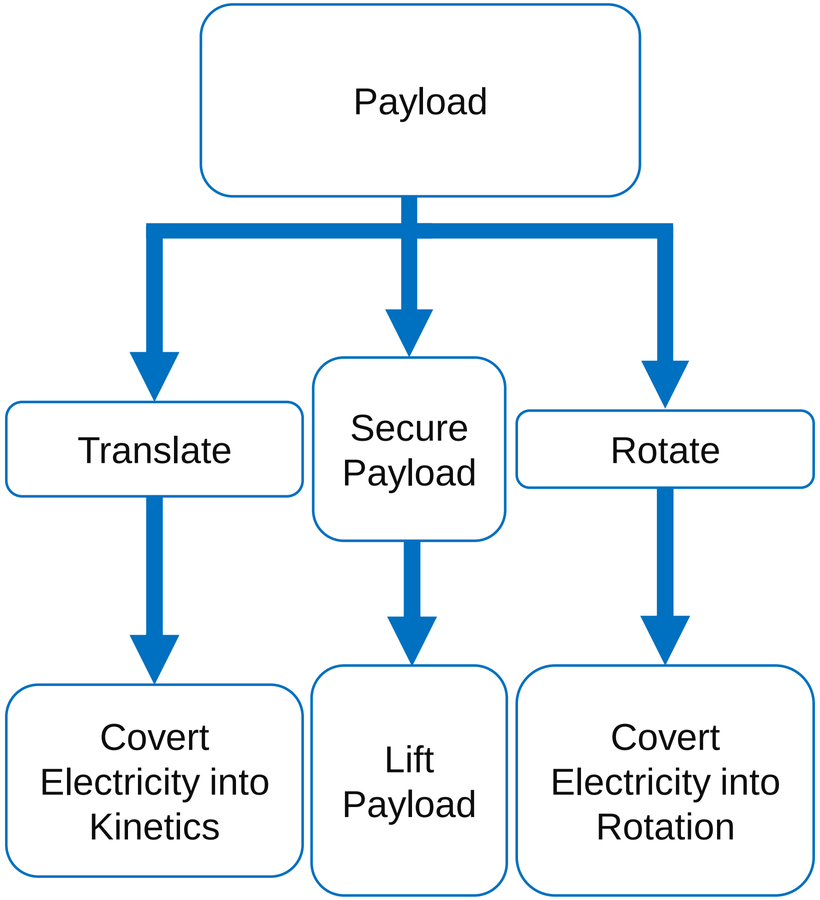
Functional Decomposition

- Power
- Communications
- Motion
- Payload



Jacob Hackett

EML4551-2

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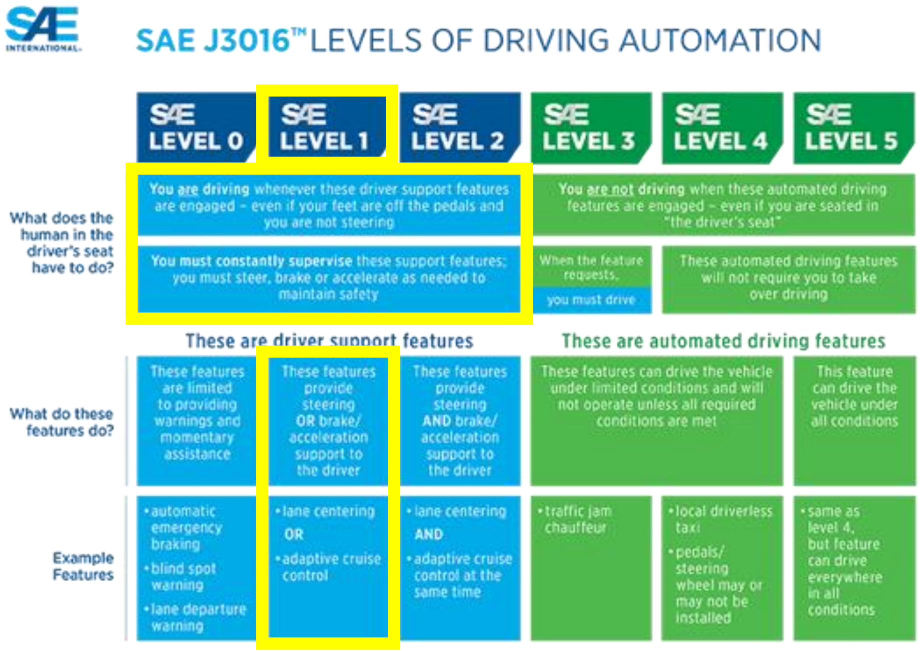
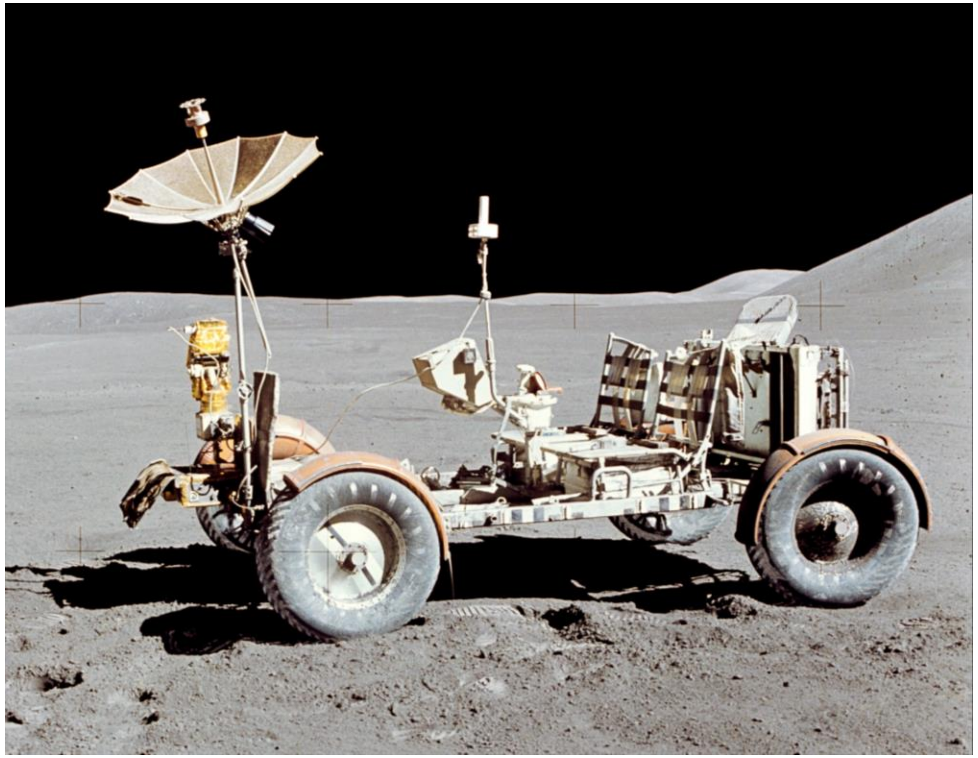
SAE Level 1 Autonomy Graphic



Existing Technology

ATHELE Rover from JPL



Lunar Rover Vehicle from Apollo Missions

Regolith

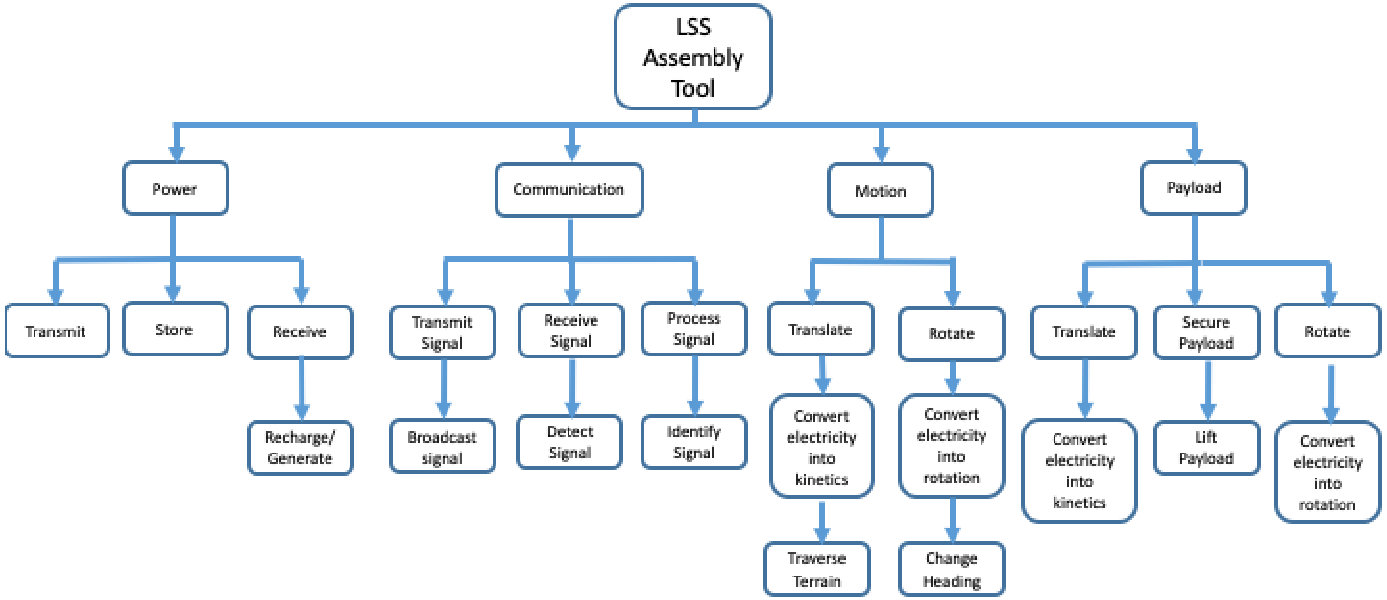
- Properties
  - Thickness of about 5 m to 10 m depending on location
  - Fine gray soil, with rock fragments throughout
  - Constantly bombarded by micrometeorites and solar wind irradiation
    - Glass can be found at the bottom of craters

Customer Need Table

Questions	Response	Interpretation
1. How big is the payload we will be lifting?	"300 kg in earth's gravity"	The LSS assembly tool will need to lift a payload with a mass of 300 kilograms.
2. What are the size constraints of the system?	"4m x 4m"	The LSS assembly tool will need to fit in an area of 16 meters squared, fully assembled.
3. What scale of a model do you expect?	"I would like this to be truly parametric which I can use a slider gain to scale down the model."	The simulation will need to have various scaled models available for the customer.
4. How detailed of a simulation?	"As a customer I would answer this with I want a full animated simulation including full physics model."	A full physics model is needed for the simulation- it must lift and transport the payload.
5. Do we need to worry about how to power the system?	"This is going to be heavy machinery on the moon so I am looking for you to determine how this would be powered. I assume solar."	Powering the LSS assembly tool will be the responsibility of the team.
6. Do you want it to be fully assembled when we get there?	"As a customer of course, I want it fully assembled. My expectation would be that the any assembly needed would only require the hand tools."	Upon arrival to the Moon, the LSS assembly tool will be able to begin lifting/transporting payloads, disregarding minor hand tool adjustments.
7. Will the operator be on the Moon or on Earth?	"The operator would be on same 'planet' as the machine"	The operator of the LSS assembly tool will be relatively close to the system.
8. Do we have mass constraints? Material requirements?	"Less than 805 kg. No specific requirements on materials."	The LSS assembly tool will be less than 805 kilograms of mass. There are no specific materials that need be used.
9. Will the system need to lift the payload and then attach it to another part of the lunar base (a docking mechanism)?		
10. Besides lifting and transporting the payload, should the LSS assembly tool do anything else?		
11. What range do you desire?		
12. How high is the platform that we will be moving the payload from/to?		
13. Are you concerned about regolith?	"TBD, assume yes until clarified"	Yes, the design will account for locomotion over regolith.
14. Is there a specific program or software package the simulation should be done in?	"One that is industry friendly and can be shared if necessary."	Until further notice, the team will use the simulation tool recommended by our faculty adviser.
15. Is there a preferred controller for the "driver" to use?	"No."	The control system to be used by the driver is at the discretion of the team.
17. Is there a concern for the time needed to move a payload?	"Yes, but this will be determined later."	This is not the current focus of the design.

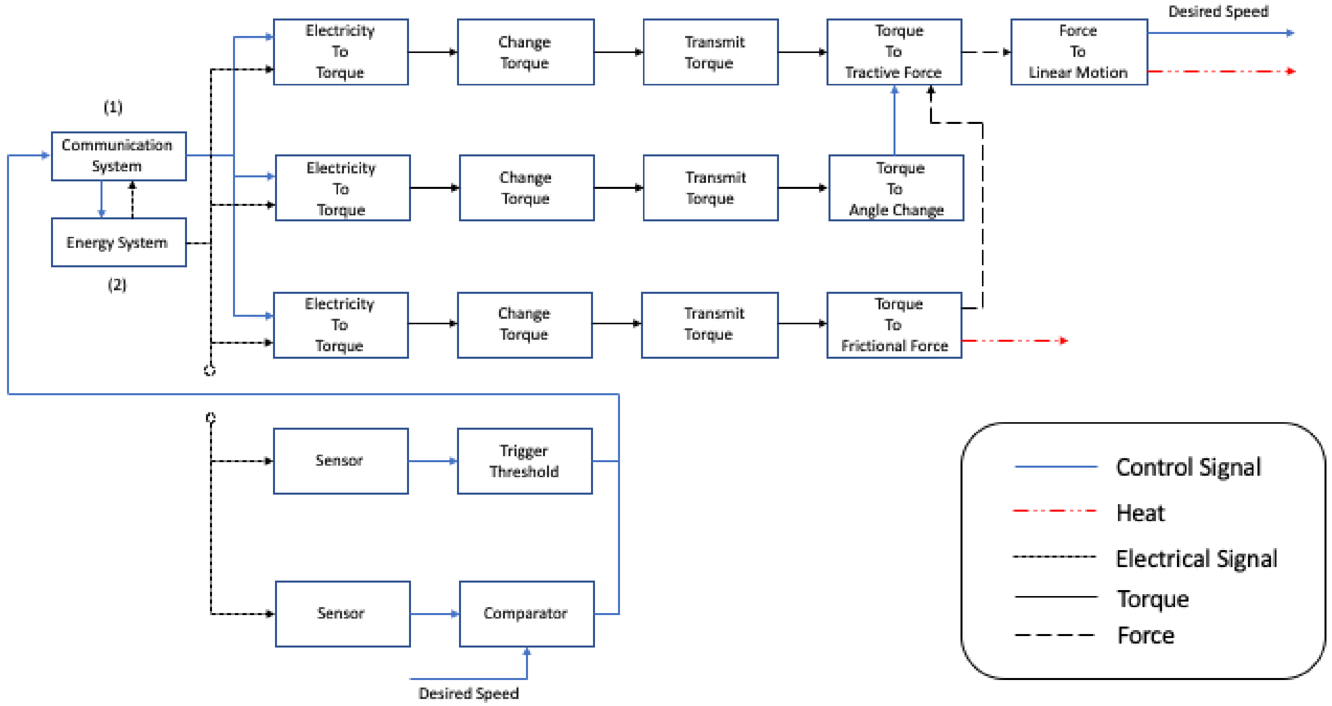
Functional Decomposition

System Functional Decomposition					
Function	*Measure*	*Transfer*	*Control Magnitude*	*Provide*	*Convert*
Transmit Power		+			
Store Power				+	
Receive Power		+			
Regenerate Power			+		+
Send Communication Signals		+			
Broadcast Signal		+	+		
Receive Signal		+			
Process Signal		+	+		+
Identify Signal	+	+			
Detect Signal	+	+			
Translate Vehicle		+			
Rotate Vehicle		+			
Convert Electricity to Translational Motion					+
Convert Electricity to Rotational Motion					+
Traverse Terrain		+			
Take Angle Input	+				
Indicate Angle Change		+			
Translate Payload		+			
Secure Payload		+			
Rotate Payload		+			
Convert Electricity to Payload Rotation					+
Convert Electricity to Payload Translation					+
Lift Payload		+			



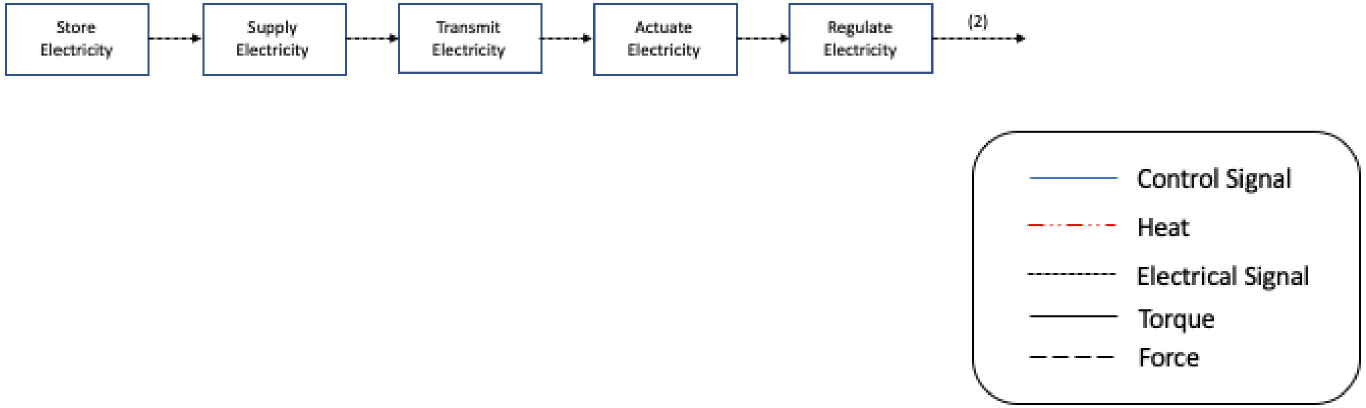
Functional Decomposition

Flow Chart of Motion



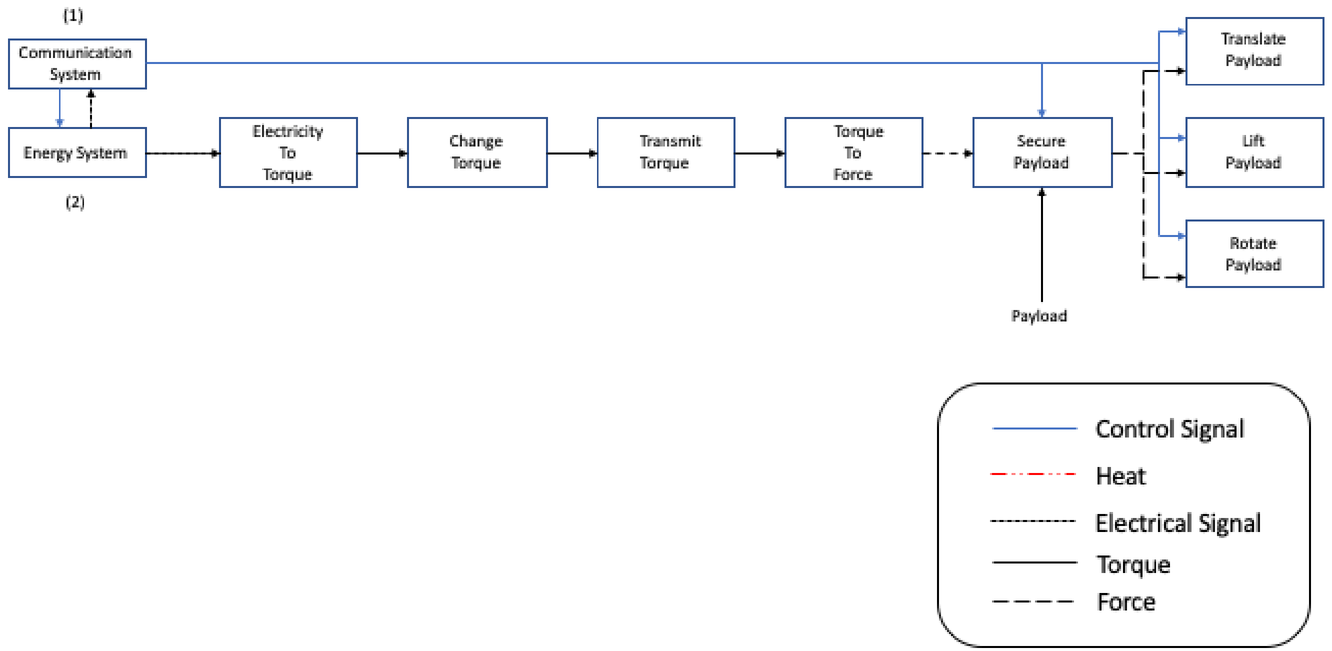
Functional Decomposition

Flow Chart of Energy



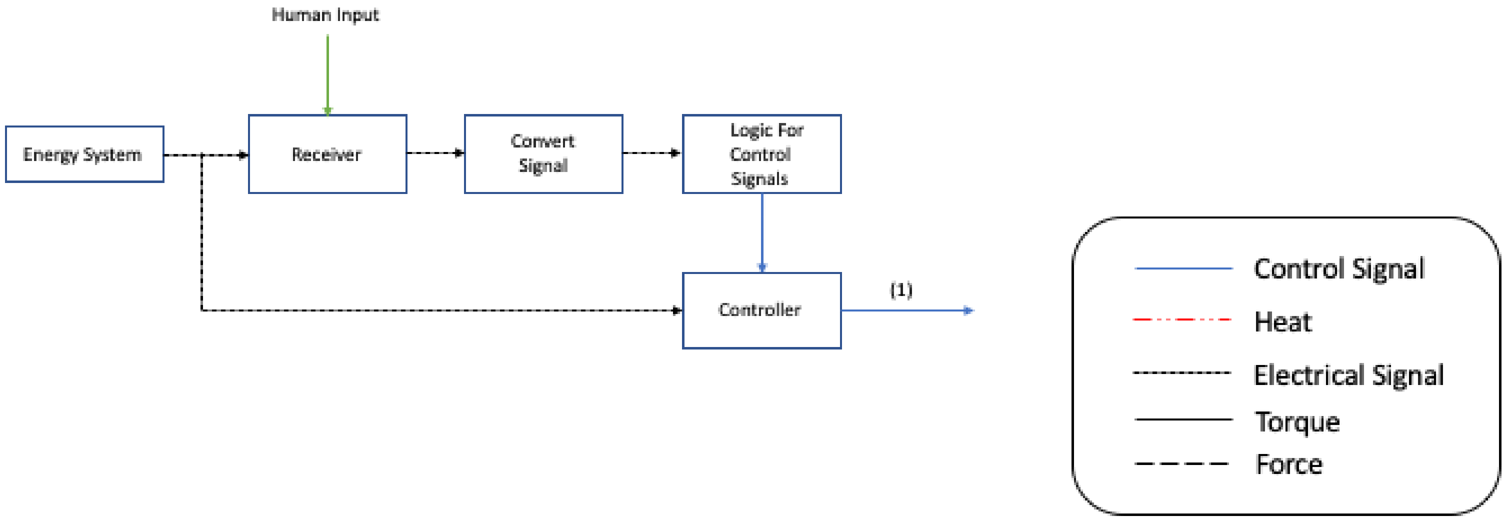
Functional Decomposition

Flow Chart of Payload



Functional Decomposition

Flow Chart of Communication



Current Progress

Attributes	Target (Simulation)
Transmit Power	4kW
Store Power	1-hour max stress operation / 8-hours normal operations
Receive Power	16-hour recharge time
Send Communication Signal	100 m
Broadcast Signal	100 m
Receive Signal	100 m
Process Signal	0.250 ms (Response Time)
Identify Signal	0.250 ms (Response Time)
Detect Signal	100 m
Translate Vehicle	100 m
Rotate Vehicle	360°
Convert Electricity to Rotational Motion	500 Nm
Traverse Terrain	5 km^2
Take Angle Input	0-360°
Indicate Angle Change	0-360°
Translate Payload	2 m
Secure Payload	1500 N
Rotate Payload	360°
Convert Electricity to Payload Rotation	500 Nm
Convert Electricity to Payload Translation	500 Nm
Lift Payload	300kg
Size Remote Controlled Autonomy	16m^2 100m SAE Level 1
Powerport	120V/230V

Attributes	Metric (Simulation/Prototype)
Transmit Power	Simscape/Multimeter. Based off requirement for electric motor of typical forklift and requirement to lift 300 kg payloads
Store Power	Simscape/Multimeter, Clock
Receive Power	Simscape/Multimeter, Clock
Send Communication Signal	Simscape/Test signal at varies range until no signal is found