EML4551-2

LSS ASSEMBLY TOOL

TEAM: 516

Jacob Hackett
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NASA Marshall Space Flight Center
LSS Assembly Tool
Team 516

Jacob Hackett
Controls Engineer

Caleb Jansen
Communications Engineer

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Vehicle Design Engineer

Kyle Nulty
Logic and Processing Design Engineer

Hannah Rodgers
Robotic Design Engineer

Hannah Rodgers

Advisor and Sponsor

Faculty Advisor:
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FAMU-FSU College of Engineering

Project Sponsor:
Justin Rowe
NASA Marshall Space Flight Center

Hannah Rodgers

Project Requirements and Scope:

Project Scope

Project Requirements

Hannah Rodgers

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.

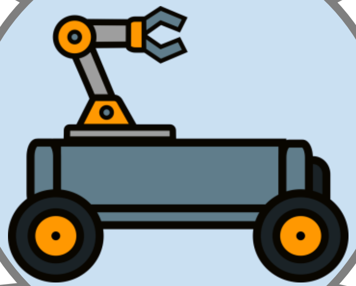
Hannah Rodgers

Project Requirements

Need to lift a 300kg load

Prototype no smaller than laptop

The vehicle's range is 1.5 kilometers.



Remote control operated

Must reach payload, which will be on a lander that is 30 feet tall.

Fully assembled upon arrival disregarding minor adjustments

Hannah Rodgers

Concept Generation

Brainstorming

Medium Fidelity

High Fidelity

Kyle Nulty

Brainstorming

Loading

Motion

Environmental Conditions

&

Carrying

Unloading

Kyle Nulty

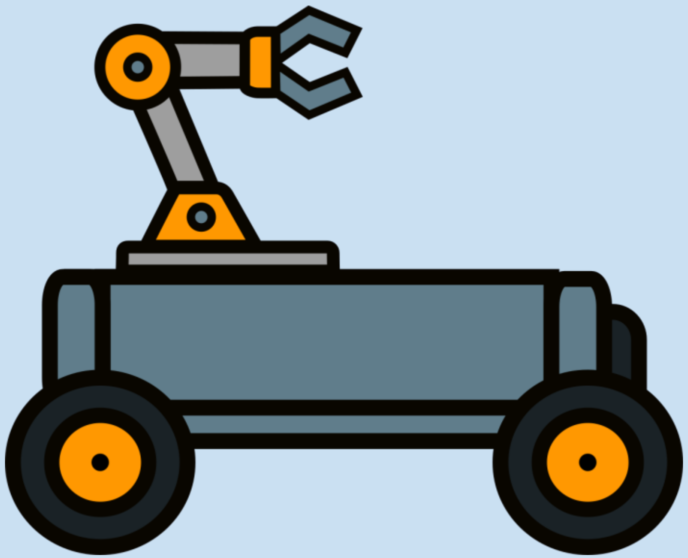
Medium Fidelity

- Wheeled Climbing Robot
  - Legs are wheeled
  - Grippers to secure payload
- Forklift
  - Reaches Payload from ground level
- Scissor Link Vehicle
  - Large platform for Payload
  - Arm to place on platform
- Shipyard Crane
  - Stable
  - Secures Payload
  - Motion Done by Nasa
- Wall-E Robot
  - Treaded
  - Gripper for Payload
  - Stores inside its body

Kyle Nulty

High Fidelity

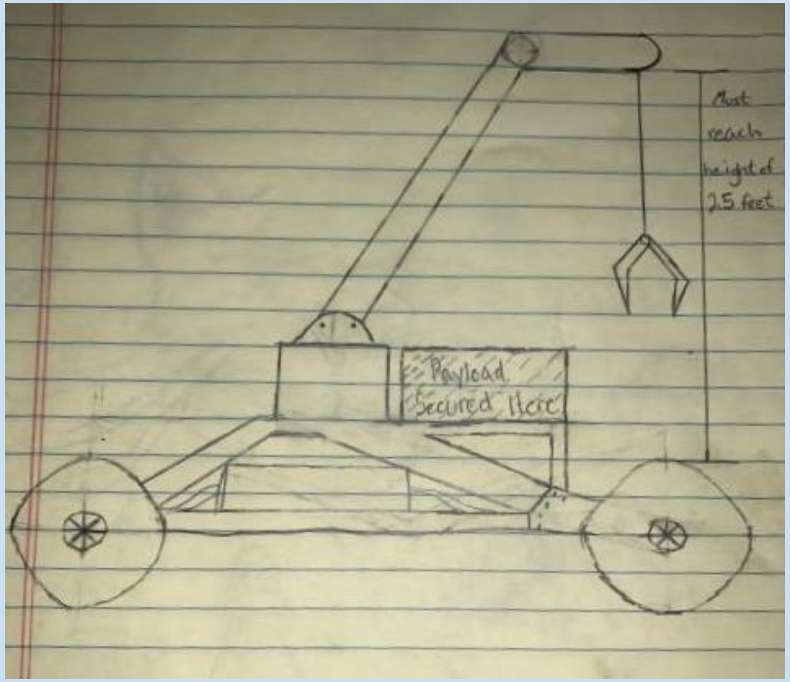
- Smart Truck
  - Arms used to grab the payload
  - Gyroscope to not tip the contents
  - Secures on its back
  - Payload has two secure points
  - Wheeled



Kyle Nulty

High Fidelity

- Portable Crane
  - Crane used to grab the payload
  - Secures on vehicle
  - Crane retracts during movement
  - Payload has one secure point
  - Wheeled



Kyle Nulty

High Fidelity

- RHex Robot
  - Utilizes a gait for movement
  - Climbs up lander to secure payload
  - Legs comprised of spring dampers

Kyle Nulty

Concept Selection:

Selection Process

Final Design

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

Comparison Matrix										
	Lift	Size	Power	Assembly	Close Control Proximity	Weight	Regolith	Solution	Control Mechanism	
										Total
Lift Payload	-	1	0	1	1	1	1	1	1	7
Size	0	-	0	1	1	1	0	1	1	5
Power Delivery	1	1	-	1	1	1	1	1	1	8
Minimal Assembly	0	0	0	-	0	0	1	1	0	2
Close Control Proximity	0	0	0	1	-	0	0	1	0	2
Weight	0	0	0	1	1	-	0	1	0	3
Regolith - manuver	0	1	0	0	1	1	-	1	1	5
Unique Solution	0	0	0	0	0	0	0	-	0	0
Controller Mechanism	0	0	0	1	1	1	0	1	-	4
Total	1	3	0	6	6	5	3	8	4	

Noah Lang

The Selection Process

1. Comparison Matrix
2. House of Quality
3. Pugh Charts
4. Analytical Hierarchy Process

Comparison Matrix

	Lift	Size	Power	Assembly	Close Control Proximity	Weight	Regolith	Solution	Control Mechanism	Total
Lift Payload	-	1	0	1	1	1	1	1	1	7
Size	0	-	0	1	1	1	0	1	1	5
Power Delivery	1	1	-	1	1	1	1	1	1	8
Minimal Assembly	0	0	0	-	0	0	1	1	0	2
Close Control Proximity	0	0	0	1	-	0	0	1	0	2
Weight	0	0	0	1	1	-	0	1	0	3
Regolith - manuver	0	1	0	0	1	1	-	1	1	5
Unique Solution	0	0	0	0	0	0	0	-	0	0
Controller Mechanism	0	0	0	1	1	1	0	1	-	4
Total	1	3	0	6	6	5	3	8	4	

Noah Lang

The Selection Process

Comparison Matrix

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Pugh Charts

Analytical Hierarchy Process

Comparison Matrix

	Lift	Size	Power	Assembly	Close Control Proximity	Weight	Regolith	Solution	Control Mechanism	Total
Lift Payload	-	1	0	1	1	1	1	1	1	7
Size	0	-	0	1	1	1	0	1	1	5
Power Delivery	1	1	-	1	1	1	1	1	1	8
Minimal Assembly	0	0	0	-	0	0	1	1	0	2
Close Control Proximity	0	0	0	1	-	0	0	1	0	2
Weight	0	0	0	1	1	-	0	1	0	3
Regolith - manuver	0	1	0	0	1	1	-	1	1	5
Unique Solution	0	0	0	0	0	0	0	-	0	0
Controller Mechanism	0	0	0	1	1	1	0	1	-	4
Total	1	3	0	6	6	5	3	8	4	

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

House of Quality

Engineering Characteristics

Customer Requirement	Importance Weight Factor	Transmit Power	Store Power	Receive Power	Send Communication Signal	Broadcast Signal	Receive Signal	Process Signal	Identify Signal	Detect Signal	Translate Vehicle	Rotate Vehicle	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	Size	Remote Controlled	Autonomy	Power Port
Improvement Direction		-	↑	-	↑	↑	↑	↓	↓	↑	↑	-	-	↑	-	-	↑	-	-	-	-	↑	↓	↑	-	-
Units		kW	h	h	m	m	m	ms	ms	m	m	deg	Nm	km^2	deg	deg	m	N	deg	Nm	Nm	kg	m^2	m	SAE Level 1	V
Lift Payload	7	9	1	9	0	0	0	0	0	0	0	0	0	0	5	0	9	9	9	9	9	9	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	0	5	5	3	5	0	0	0	0	0	0	0	0	9	0	1	1
Power Delivery	8	9	5	9	0	0	0	1	1	0	7	7	9	1	1	1	7	3	7	9	9	3	1	0	0	9
Minimal Assembly	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
Close Control Proximity	2	0	0	0	1	1	1	1	1	1	9	9	0	5	3	3	0	0	0	0	0	0	0	0	9	0
Weight	3	0	0	0	0	0	0	0	0	0	9	9	5	9	0	1	9	0	0	0	0	0	5	0	0	0
Regolith	5	0	0	0	0	0	0	0	0	0	9	9	3	9	0	3	0	0	0	0	0	0	0	0	0	0
Unique Solution	0	0	0	0	0	0	0	0	0	0	9	0	0	9	0	0	9	3	0	0	0	9	1	1	0	0
Control Mechanism	4	0	0	0	9	9	9	0	1	9	1	1	0	3	9	0	1	1	1	0	0	1	0	9	9	0
Raw Score	2189	135	47	135	38	38	38	10	14	38	175	175	117	127	85	32	150	91	123	135	135	91	78	36	59	87
Relative Weight	%	###	###	###	1.74	###	###	###	###	###	###	###	5.34	###	###	1.46	###	###	###	6.17	6.17	###	###	1.64	2.70	3.97
Rank Order		4	17	4	18	18	18	25	24	18	1	1	10	8	14	23	3	11	9	4	4	11	15	22	16	13

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

House of Quality

		Engineering Characteristics											
Improvement Direction		-	↑	-	↑	↑	↑	↓	↓	↑	↑	-	-
Units		kW	h	h	m	m	m	ms	ms	m	m	deg	Nm
Customer Requirement	Importance Weight Factor	Transmit Power	Store Power	Receive Power	Send Communication Signal	Broadcast Signal	Receive Signal	Process Signal	Identify Signal	Detect Signal	Translate Vehicle	Rotate Vehicle	Convert Electricity to Rotational Motion
Lift Payload	7	9	1	9	0	0	0	0	0	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	0	5	5	3
Power Delivery	8	9	5	9	0	0	0	1	1	0	7	7	9
Minimal Assembly	2	0	0	0	0	0	0	0	0	0	0	0	0
Close Control Proximity	2	0	0	0	1	1	1	1	1	1	9	9	0
Weight	3	0	0	0	0	0	0	0	0	0	9	9	5
Regolith	5	0	0	0	0	0	0	0	0	0	9	9	3
Unique Solution	0	0	0	0	0	0	0	0	0	0	9	0	0
Control Mechanism	4	0	0	0	9	9	9	0	1	9	1	1	0
Raw Score	2189	135	47	135	38	38	38	10	14	38	175	175	117
Relative Weight	%	###	###	###	1.74	###	###	###	###	###	###	###	5.34
	Rank Order	4	17	4	18	18	18	25	24	18	1	1	10

	Engineering Characteristics												
Improvement Direction	↑	-	-	↑	-	-	-	-	↑	↓	↑	-	-
Units	km^2	deg	deg	m	N	deg	Nm	Nm	kg	m^2	m	SAE Level 1	V
Customer Requirement	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	Size	Remote Controlled	Autonomy	Power Port
Lift Payload	0	5	0	9	9	9	9	9	9	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	9	0	1	1
Power Delivery	1	1	1	7	3	7	9	9	3	1	0	0	9
Minimal Assembly	0	0	0	0	0	0	0	0	0	5	0	0	5
Close Control Proximity	5	3	3	0	0	0	0	0	0	0	0	9	0
Weight	9	0	1	9	0	0	0	0	0	5	0	0	0
Regolith	9	0	3	0	0	0	0	0	0	0	0	0	0
Unique Solution	9	0	0	9	3	0	0	0	9	1	1	0	0
Control Mechanism	3	9	0	1	1	1	0	0	1	0	9	9	0
Raw Score	127	85	32	150	91	123	135	135	91	78	36	59	87
Relative Weight	###	###	1.46	###	###	###	6.17	6.17	###	###	1.64	2.70	3.97
Rank Order	8	14	23	3	11	9	4	4	11	15	22	16	13

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

House of Quality

		Engineering Characteristics																								
Improvement Direction		-	↑	-	↑	↑	↑	↓	↓	↑	↑	-	-	↑	-	-	↑	-	-	-	-	↑	↓	↑	-	-
Units		kW	h	h	m	m	m	ms	ms	m	m	deg	Nm	km^2	deg	deg	m	N	deg	Nm	Nm	kg	m^2	m	SAE Level 1	V
Customer Requirement	Importance Weight Factor	Transmit Power	Store Power	Receive Power	Send Communication Signal	Broadcast Signal	Receive Signal	Process Signal	Identify Signal	Detect Signal	Translate Vehicle	Rotate Vehicle	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	Size	Remote Controlled	Autonomy	Power Port
Lift Payload	7	9	1	9	0	0	0	0	0	0	0	0	0	0	5	0	9	9	9	9	9	9	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	0	5	5	3	5	0	0	0	0	0	0	0	0	9	0	1	1
Power Delivery	8	9	5	9	0	0	0	1	1	0	7	7	9	1	1	1	7	3	7	9	9	3	1	0	0	9
Minimal Assembly	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
Close Control Proximity	2	0	0	0	1	1	1	1	1	1	9	9	0	5	3	3	0	0	0	0	0	0	0	0	9	0
Weight	3	0	0	0	0	0	0	0	0	0	9	9	5	9	0	1	9	0	0	0	0	0	5	0	0	0
Regolith	5	0	0	0	0	0	0	0	0	0	9	9	3	9	0	3	0	0	0	0	0	0	0	0	0	0
Unique Solution	0	0	0	0	0	0	0	0	0	0	9	0	0	9	0	0	9	3	0	0	0	9	1	1	0	0
Control Mechanism	4	0	0	0	9	9	9	0	1	9	1	1	0	3	9	0	1	1	1	0	0	1	0	9	9	0
Raw Score	2189	135	47	135	38	38	38	10	14	38	175	175	117	127	85	32	150	91	123	135	135	91	78	36	59	87
Relative Weight	%	###	###	###	1.74	###	###	###	###	###	###	###	5.34	###	###	1.46	###	###	###	6.17	6.17	###	###	1.64	2.70	3.97
Rank Order		4	17	4	18	18	18	25	24	18	1	1	10	8	14	23	3	11	9	4	4	11	15	22	16	13

Noah Lang

The Selection Process

- Comparison Matrix
- House of Quality
- Pugh Charts
- Analytical Hierarchy Process

House of Quality																										
		Engineering Characteristics																								
Improvement Direction		-	↑	-	↑	↑	↑	↓	↓	↑	↑	-	-	↑	-	-	↑	-	-	-	-	↑	↓	↑	-	-
Units		kW	h	h	m	m	m	ms	ms	m	m	deg	Nm	km^2	deg	deg	m	N	deg	Nm	Nm	kg	m^2	m	SAE Level 1	V
Customer Requirement	Importance Weight Factor	Transmit Power	Store Power	Receive Power	Send Communication Signal	Broadcast Signal	Receive Signal	Process Signal	Identify Signal	Detect Signal	Translate Vehicle	Rotate Vehicle	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	Size	Remote Controlled	Autonomy	Power Port
Lift Payload	7	9	1	9	0	0	0	0	0	0	0	0	0	0	5	0	9	9	9	9	9	9	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	0	5	5	3	5	0	0	0	0	0	0	0	0	9	0	1	1
Power Delivery	8	9	5	9	0	0	0	1	1	0	7	7	9	1	1	1	7	3	7	9	9	3	1	0	0	9
Minimal Assembly	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
Close Control Proximity	2	0	0	0	1	1	1	1	1	1	9	9	0	5	3	3	0	0	0	0	0	0	0	0	9	0
Weight	3	0	0	0	0	0	0	0	0	0	9	9	5	9	0	1	9	0	0	0	0	0	5	0	0	0
Regolith	5	0	0	0	0	0	0	0	0	0	9	9	3	9	0	3	0	0	0	0	0	0	0	0	0	0
Unique Solution	0	0	0	0	0	0	0	0	0	0	9	0	0	9	0	0	9	3	0	0	0	9	1	1	0	0
Control Mechanism	4	0	0	0	9	9	9	0	1	9	1	1	0	3	9	0	1	1	1	0	0	1	0	9	9	0
Raw Score	2189	135	47	135	38	38	38	10	14	38	175	175	117	127	85	32	150	91	123	135	135	91	78	36	59	87
Relative Weight	%	###	###	###	1.74	###	###	###	###	###	###	###	5.34	###	###	1.46	###	###	###	6.17	6.17	###	###	1.64	2.70	3.97
Rank Order		4	17	4	18	18	18	25	24	18	1	1	10	8	14	23	3	11	9	4	4	11	15	22	16	13

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

Selection Criteria	ATHLETE	Wheeled Climbing Robot	Forklift	Shipyard Crane	Wall-E Rover	Scissor Link Vehicle	Smart Truck with Arms	Portable Crane	RHex Robot
Lift Payload		-	+	+	-	+	+	+	-
Size		+	+	-	+	+	+	-	+
Simulation Model		S	+	+	-	+	+	-	S
Power Delivery		S	+	+	S	+	+	+	-
Minimal Assembly		+	+	-	S	+	+	-	+
Close Control Proximity	Datum	S	+	+	S	+	+	+	+
Weight		+	+	-	+	+	S	-	+
Regolith - manuver		+	+	S	+	S	+	S	-
Unique Solution		+	-	+	+	+	+	-	+
Controller Mechanism		S	+	+	S	+	+	+	+
# of Pluses		5	9	6	4	9	9	4	6
# of Minuses		1	1	3	2	0	0	5	3

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The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

Selection Criteria	Forklift	Smart Truck with Arms	Scissor Link Vehicle
Lift Payload		+	-
Size		-	S
Simulation Model		S	-
Power Delivery		S	-
Minimal Assembly		S	-
Close Control Proximity	Datum	-	S
Weight			S
Regolith - manuver		S	S
Unique Solution		+	+
Controller Mechanism		S	-
# of Pluses		1	1
# of Minuses		3	5

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

- Final decision Pugh Chart
- Eliminated Scissor Link Vehicle
- Arrived at final design selection: “Truck” with arms

Selection Criteria	Forklift	Smart Truck with Arms	Scissor Link Vehicle
Lift Payload	Datum	+	-
Size		-	S
Simulation Model		S	-
Power Delivery		S	-
Minimal Assembly		S	-
Close Control Proximity		-	S
Weight			S
Regolith - manuver		S	S
Unique Solution		+	+
Controller Mechanism		S	-
# of Pluses		1	1
# of Minuses		3	5

Noah Lang

The Selection Process

Comparison Matrix

House of Quality

Pugh Charts

Analytical Hierarchy Process

- Compared:
  - Material
  - Repairability
  - Durability
  - Reliability
  - Time to Produce
- Checked Consistency of Selected design
- Found unbiased design selection:
  - “Smart Truck”

Noah Lang

Final Design Selection

Final Selected Design:
Robotic Actuated Payload Transport Rover (RAPTOR)

- Four wheeled vehicle base
- Full suspension
- Tweels
- Platform to place Payload
- Arm to retrieve payload
  - Capable of 2 Degrees of Freedom

Noah Lang

Upcoming Work

- Bill of Materials
- Start of Initial Design
- Purchase of primary materials
- Presentation to NASA Sponsors and Stakeholders (11/22)
- Start simulation of parts and systems in our design in Simscape
- Start research into viability of regolith simulation
- Start work on poster for VDR3
- Draft a Spring project plan

Hannah Rodgers

EML4551-2

LSS ASSEMBLY TOOL

TEAM: 516

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Kyle Nulty
Hannah Rodgers

References

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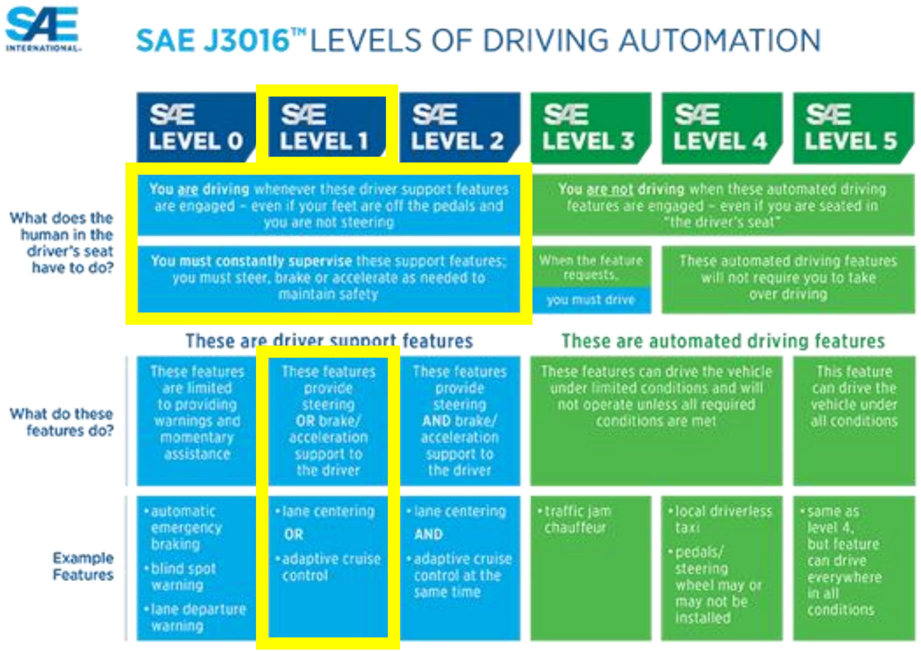
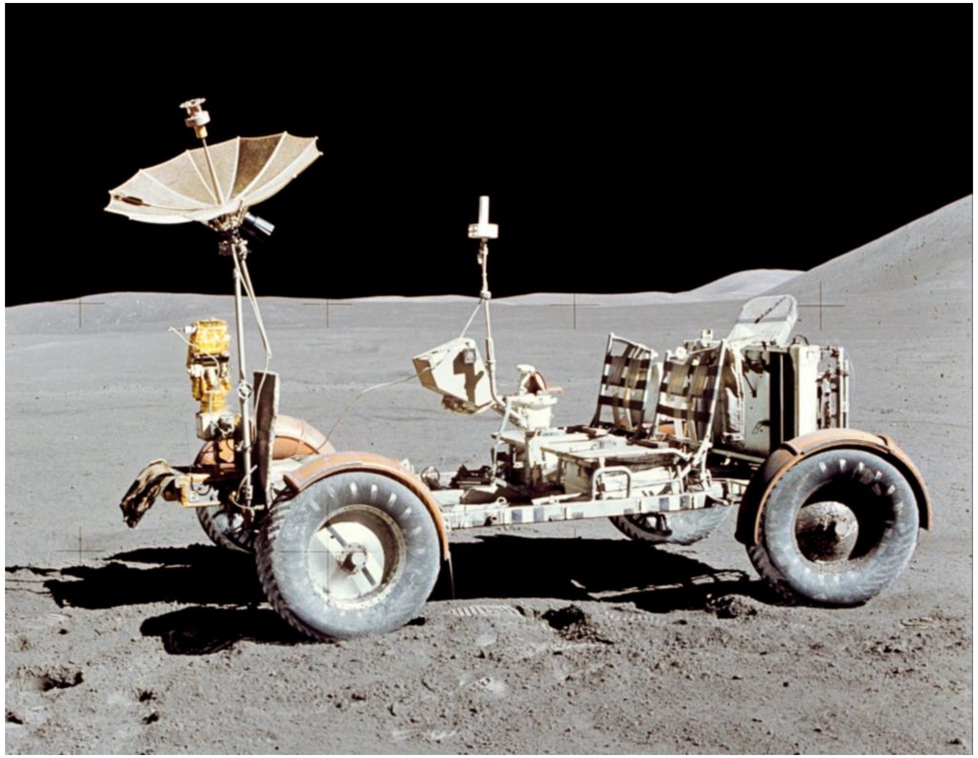
SAE Level 1 Autonomy Graphic



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

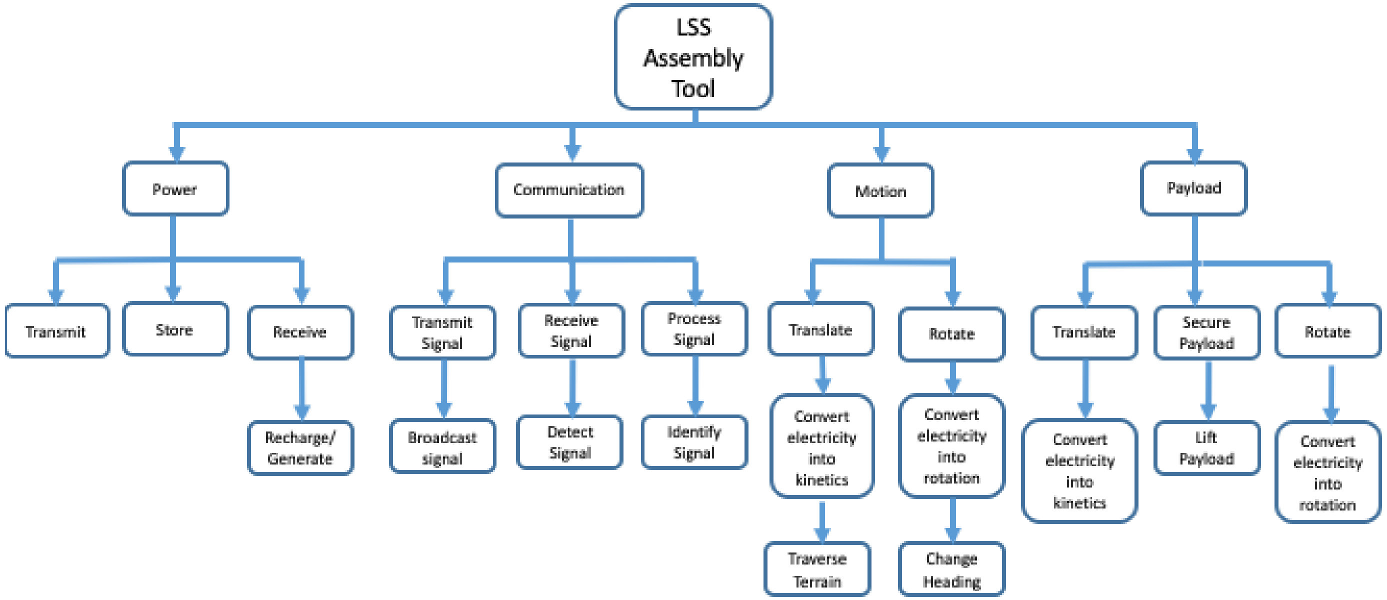
Customer Need Table

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.

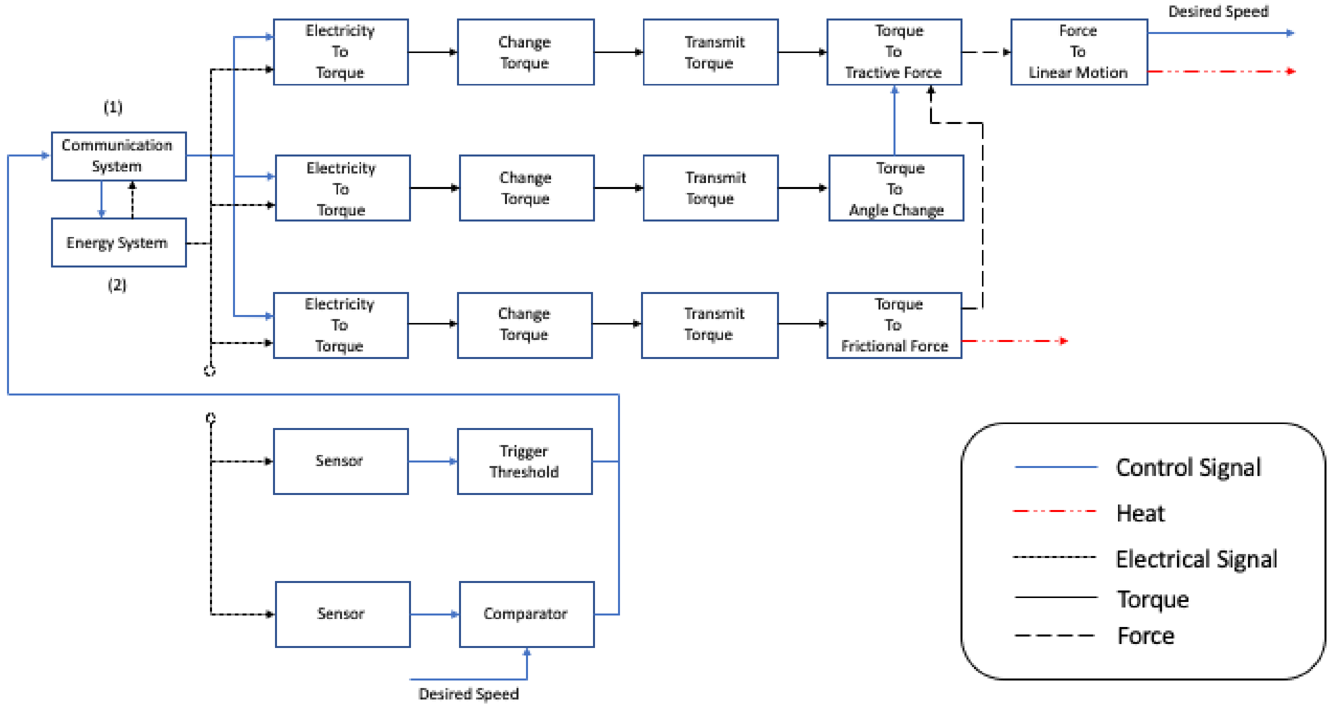
Functional Decomposition

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		+			



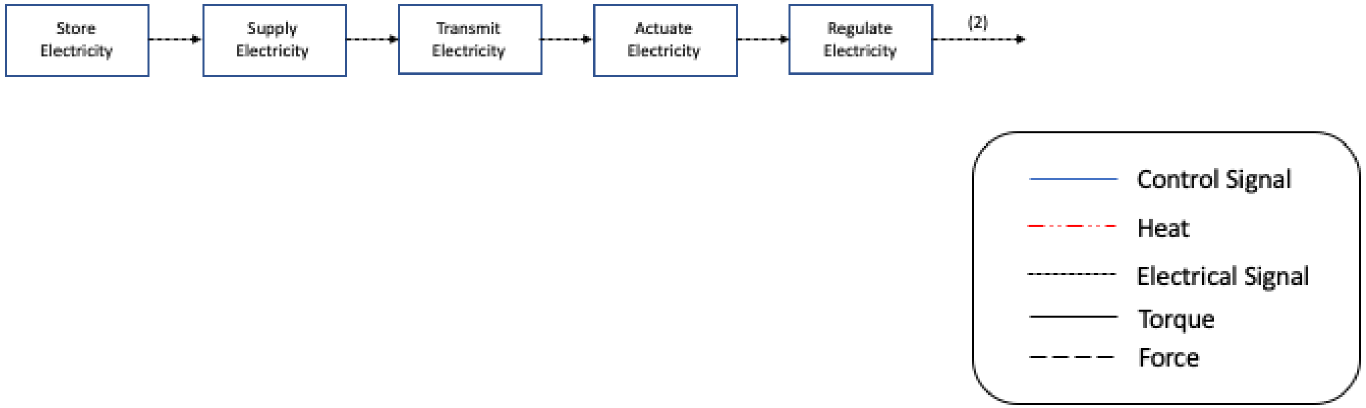
Functional Decomposition

Flow Chart of Motion



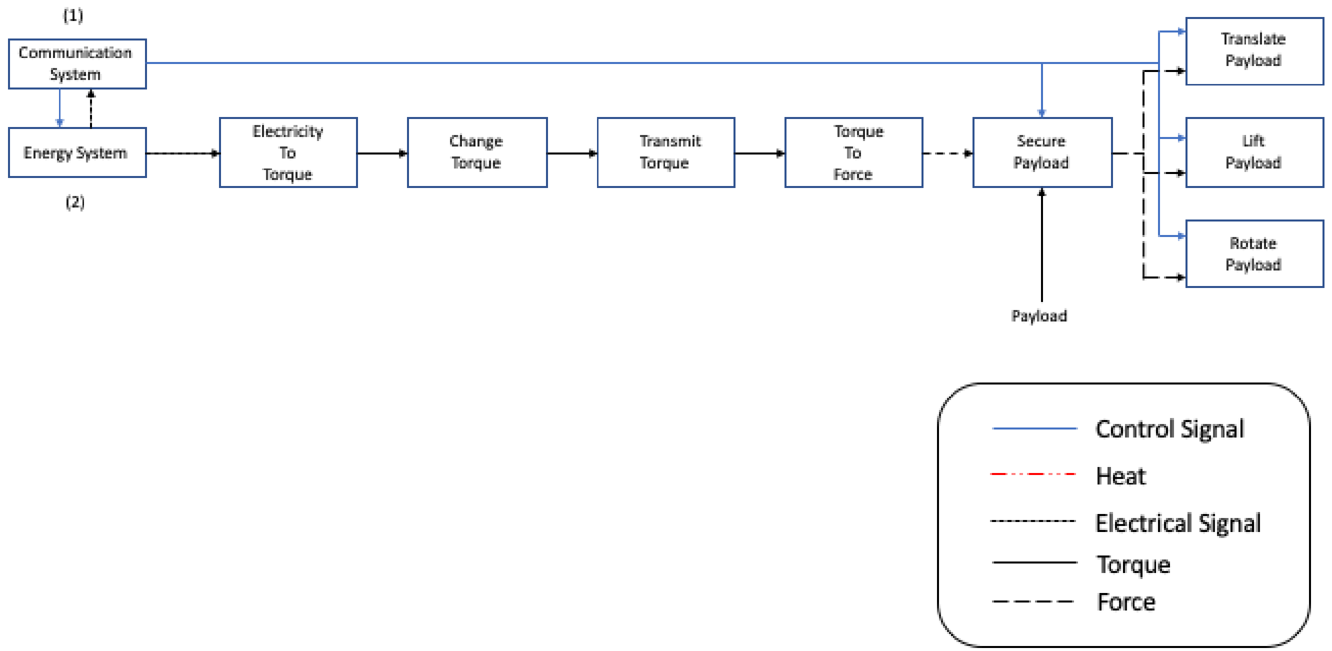
Functional Decomposition

Flow Chart of Energy



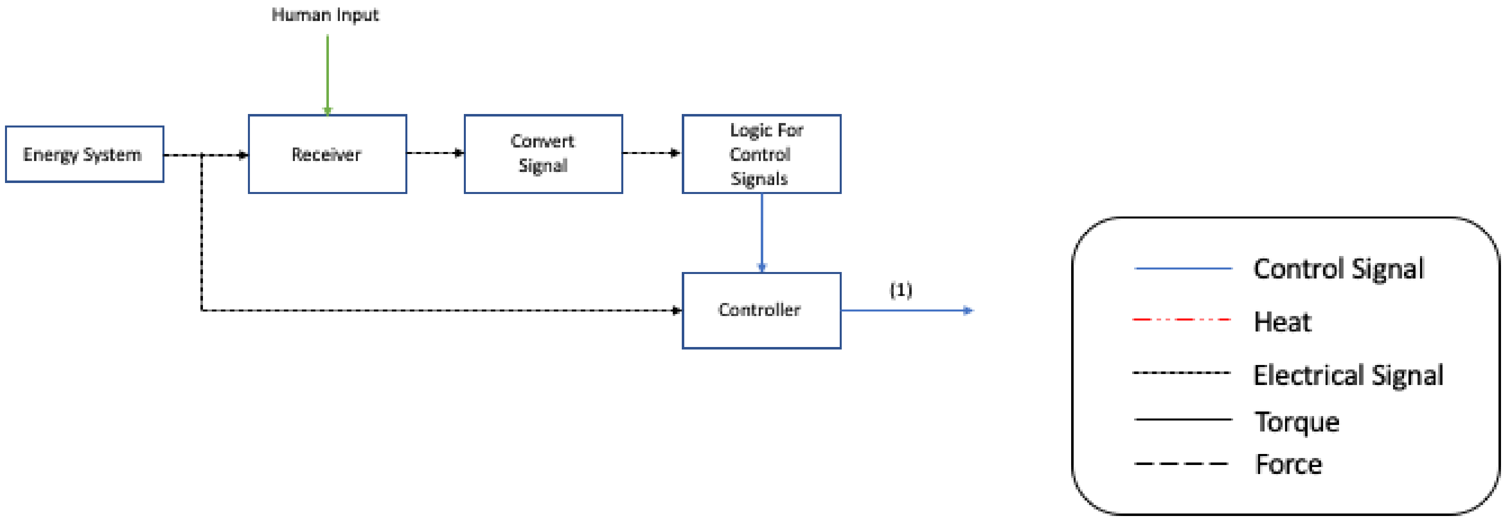
Functional Decomposition

Flow Chart of Payload



Functional Decomposition

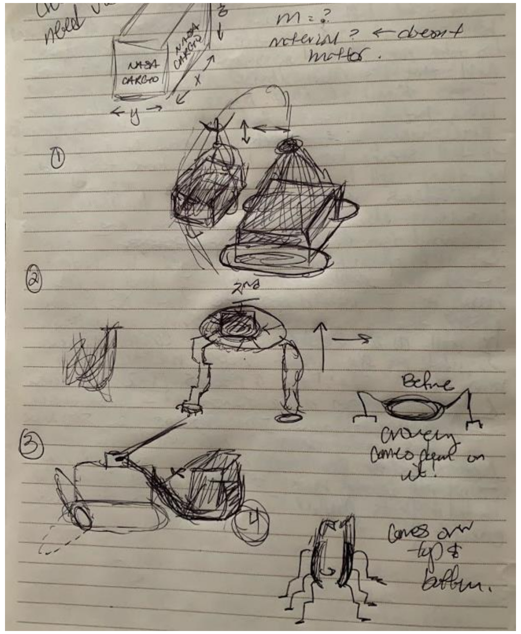
Flow Chart of Communication



Targets

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	$16m^2$
Remote Controlled	100m
Autonomy	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



Current Bill of Materials

T516: LSS Assembly Tool								
Bill of Materials								
Category	**Major Componen**	**Quantity**	**Purpose**	**Part Number**	**Purchase Source**	**Price**	**Ordered?**	**Arrived?**
Vehicle	Wheel	4	Adhesion to ground	3669A	https://traxxas.com/products/parts/3669A	$ 62.00	0	0
Vehicle	Control Arm	4	Connect rover to hub	9056K89	https://www.mcmaster.com/structural-framing-tubing	$ 23.58	0	No
Vehicle	Wheel Hub	4	Mount wheel to arm	1654	https://traxxas.com/products/parts/1654	$ 4.00	0	No
Vehicle	Strut/Shock	4	Control Motion of wheel rebound	B07P5X2H8F	https://www.amazon.com/FASTACE-Mountain-Bicycle-Shock-160x42mm/dp/B07P5X2H8F/ref=lp_6389390011_1_13?s=outdoor-recreation&ie=UTF8&qid=1572483457&sr=1-13	$ 100.00	0	No
Vehicle	Chassis	1	Body of vehicle	4698T32 4698T112 9056K89	https://www.mcmaster.com/structural-framing-tubing	$ 286.32	0	No
Vehicle	Motor	2	Motion of wheel			$ 600.00	0	No
Robotic Arm	Base Motor	2	Motion for each linkage	563-2085-ND	https://www.digikey.com/short/pddb8b	$ 75.50	0	No
Robotic Arm	Base Gear Train	1	Higher torque	276-2169	https://www.robotshop.com/en/vex-gear-kit.html	$ 12.99	0	No
Robotic Arm	Arduino Microcontroller	1	Controlling arm	#########	https://store.arduino.cc/usa/mega-2560-r3	$ 38.50	0	No
Robotic Arm	Aluminum Linkages	1	Linkages of Arm	9146T64	https://www.mcmaster.com/9146t64-9146T641	$ 3.41	0	No
Robotic Arm	Gripper Linkages	2	Grab payload	9146T11	https://www.mcmaster.com/9146t11-9146T113	$ 1.80	0	No
Robotic Arm	Gripper Motor	1	To grab the payload	1738-1270-ND	https://www.digikey.com/short/pdd92w	$ 7.62	0	No
Robotic Arm	Gripper Motor Gears	1	Get necessary torque	FIT0098-ND	https://www.digikey.com/product-detail/en/dfrobot/FIT0098/FIT0098-ND/7597183	$ 13.52	0	No
Robotic Arm	Weight	1	Scaled payload	301837041	https://www.homedepot.com/p/2-in-x-4-in-x-8-ft	$ 3.27	0	No
Controls	MEMS	1				$ -	0	No
Controls	IR Distance Sensor	4	Collision/Hazard Detection			$ 40.00	0	No
Controls	Radio Receiver/Transmitter Pair	1	Control device through user			$ -	1	Yes
Computation/Signal Processing	Arduino Microcontroller	1	Includes ADC and processor necessary for calculations	#########	https://store.arduino.cc/usa/mega-2560-r3	$ 38.50	1	Yes
Computation/Signal Processing	Motor Drivers	2	Control Motors	L298N	https://www.amazon.com/Stepper-Driver-H-bridge-Controller-Arduino/dp/B07SGX6YR7	$ 11.98	0	No
Simulation	Matlab Simscape	NA	Simuation of vehicle	NA	NA	$ -	1	Yes
Simulation	Multisim	NA	Simuation of vehicle	NA	NA	$ -	1	Yes
Electronics	Wires (Shielded)	5	Electricity Conductor	TE-273-004	hop/item.aspx/24awg-shielded-4-conductor-stranded-hookup-wire-by-the-foot/2024/	$ 0.39	0	No

T516: LSS Assembly Tool								
Bill of Materials								
Category	**Major Component**	**Quantity**	**Purpose**	**Part Number**	**Purchase Source**	**Price**	**Ordered?**	**Arrived**
Vehicle	Wheel	4	Adhesion to ground	3669A	https://traxxas.com/products/parts/3669A	$ 62.00	0	0
Vehicle	Control Arm	4	Connect rover to hub	9056K89	https://www.mcmaster.com/structural-framing-tubing	$ 23.58	0	No
Vehicle	Wheel Hub	4	Mount wheel to arm	1654	https://traxxas.com/products/parts/1654	$ 4.00	0	No
Vehicle	Strut/Shock	4	Control Motion of wheel rebound	B07P5X2H8F	https://www.amazon.com/FASTACE-Mountain-Bicycle-Shock-160x42mm/dp/B07P5X2H8F/ref=lp_6389390011_1_13?s=outdoor-recreation&ie=UTF8&qid=1572483457&sr=1-13	$ 100.00	0	No
Vehicle	Chassis	1	Body of vehicle	4698T32 4698T112 9056K89	https://www.mcmaster.com/structural-framing-tubing	$ 286.32	0	No
Vehicle	Motor	2	Motion of wheel			$ 600.00	0	No
Robotic Arm	Base Motor	2	Motion for each linkage	563-2085-ND	https://www.digikey.com/short/pddb8b	$ 75.50	0	No
Robotic Arm	Base Gear Train	1	Higher torque	276-2169	https://www.robotshop.com/en/vex-gear-kit.html	$ 12.99	0	No
Robotic Arm	Arduino Microcontroller	1	Controlling arm	8058333490083	https://store.arduino.cc/usa/mega-2560-r3	$ 38.50	0	No
Robotic Arm	Aluminum Linkages	1	Linkages of Arm	9146T64	https://www.mcmaster.com/9146t64-9146T641	$ 3.41	0	No
Robotic Arm	Gripper Linkages	2	Grab payload	9146T11	https://www.mcmaster.com/9146t11-			

Some of the materials we expect to need, we already have- i.e. Arduino Mega

The Selection Process

- Comparison Matrix
- House of Quality
- Pugh Charts
- Analytical Hierarchy Process

House of Quality

		Engineering Characteristics																								
	Improvement Direction	-	↑	-	↑	↑	↑	↓	↓	↑	↑	-	-	↑	-	-	↑	-	-	-	-	↑	↓	↑	-	-
	Units	kW	h	h	m	m	m	ms	ms	m	m	deg	Nm	km^2	deg	deg	m	N	deg	Nm	Nm	kg	m^2	m	SAE Level 1	V
Customer Requirement	Importance Weight Factor	Tra nsm	Stor e	Rec eive	d Co mm	Bro adc	Rec eive	Pro cess	Iden tify	Det ect	Tra nsla	Rot ate	Con vert Elec trici	Trav erse	Tak e	cate Ang	Tra nsla	Sec ure	Rot ate	vert Elec trici	vert Elec trici	Lift Payl	Size	mot e	Aut ono my	Pow er Port
Lift Payload	7	9	1	9	0	0	0	0	0	0	0	0	0	0	5	0	9	9	9	9	9	9	0	0	0	0
Size	5	0	0	0	0	0	0	0	0	0	5	5	3	5	0	0	0	0	0	0	0	0	9	0	1	1
Power Delivery	8	9	5	9	0	0	0	1	1	0	7	7	9	1	1	1	7	3	7	9	9	3	1	0	0	9
Minimal Assembly	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5
Close Control Proximity	2	0	0	0	1	1	1	1	1	1	9	9	0	5	3	3	0	0	0	0	0	0	0	0	9	0
Weight	3	0	0	0	0	0	0	0	0	0	9	9	5	9	0	1	9	0	0	0	0	0	5	0	0	0
Regolith	5	0	0	0	0	0	0	0	0	0	9	9	3	9	0	3	0	0	0	0	0	0	0	0	0	0
Unique Solution	0	0	0	0	0	0	0	0	0	0	9	0	0	9	0	0	9	3	0	0	0	9	1	1	0	0
Control Mechanism	4	0	0	0	9	9	9	0	1	9	1	1	0	3	9	0	1	1	1	0	0	1	0	9	9	0
Raw Score	2189	135	47	135	38	38	38	10	14	38	175	175	117	127	85	32	150	91	123	135	135	91	78	36	59	87
Relative Weight	%	6.17	2.15	6.17	1.74	1.74	1.74	0.46	0.64	1.74	7.99	7.99	5.34	5.80	3.88	1.46	6.85	4.16	5.62	6.17	6.17	4.16	3.56	1.64	2.70	3.97
	Rank Order	4	17	4	18	18	18	25	24	18	1	1	10	8	14	23	3	11	9	4	4	11	15	22	16	13

Noah Lang

Color Pallet