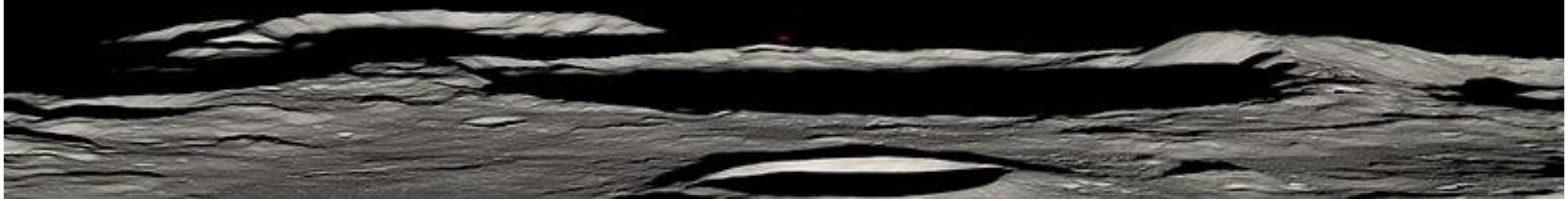
POWRS

Powered Optimizing Wheeled Rescue System



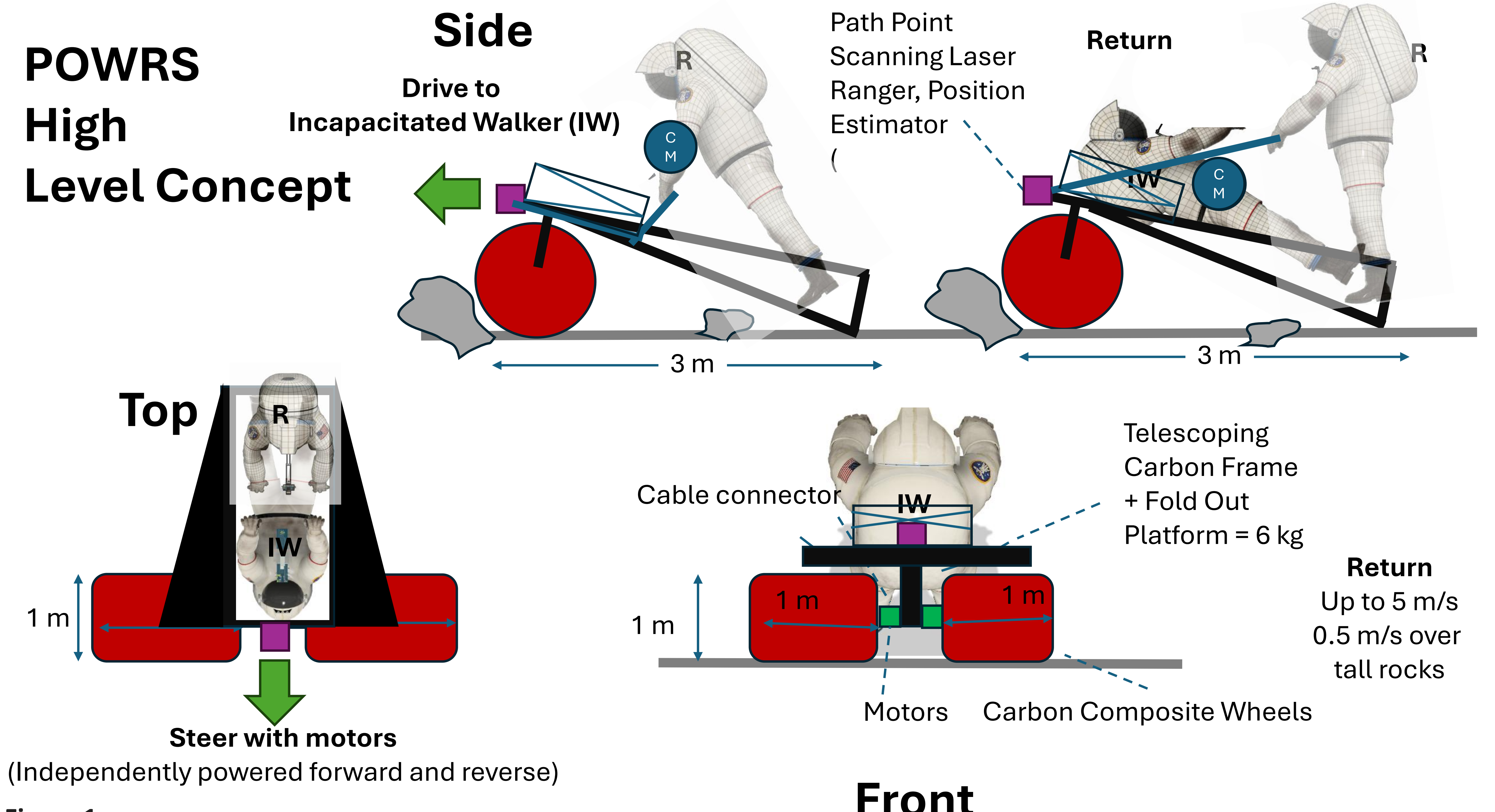
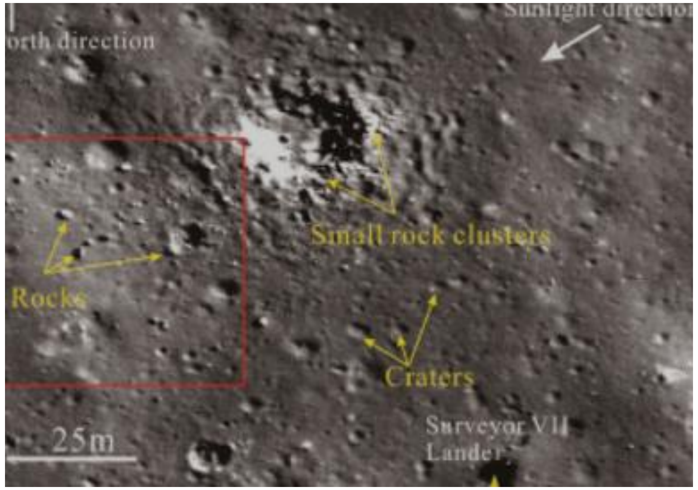
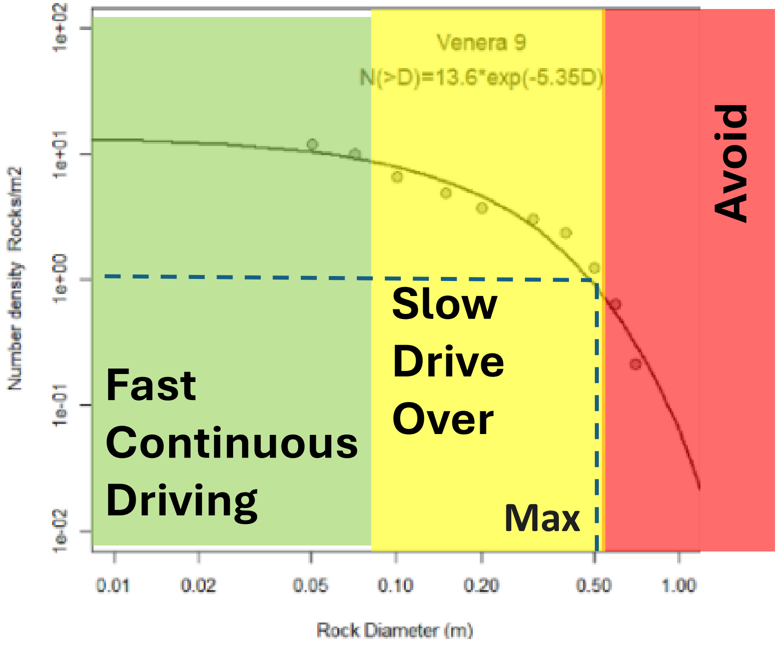

POWRS
High
Level Concept
Side
Drive to
Incapacitated Walker (IW)
R
C
M
Path Point
Scanning Laser
Ranger, Position
Estimator
(
Return
R
IW
C
M
3 m
3 m
Top
R
IW
1 m
Steer with motors
(Independently powered forward and reverse)
Cable connector
IW
Telescoping
Carbon Frame
+ Fold Out
Platform = 6 kg
Return
Up to 5 m/s
0.5 m/s over
tall rocks
1 m
1 m
1 m
Motors
Carbon Composite Wheels
Front

Figure 1

The Terrain Challenge

Fortunately, there are several studies about lunar rock size distribution:
https://www.sciencedirect.com/science/article/pii/S0032063323000892





LOTS OF ROCKS ARE PROBABLE!

THUS, OPTIMAL PATH SENSING WITH DYNAMIC PATH PLANNING IS IMPORTANT

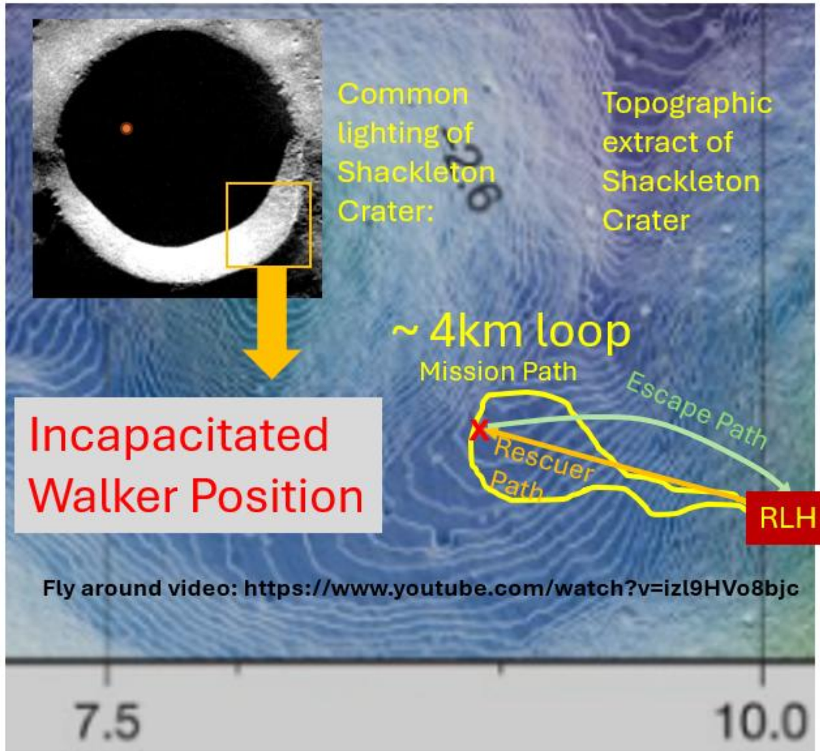
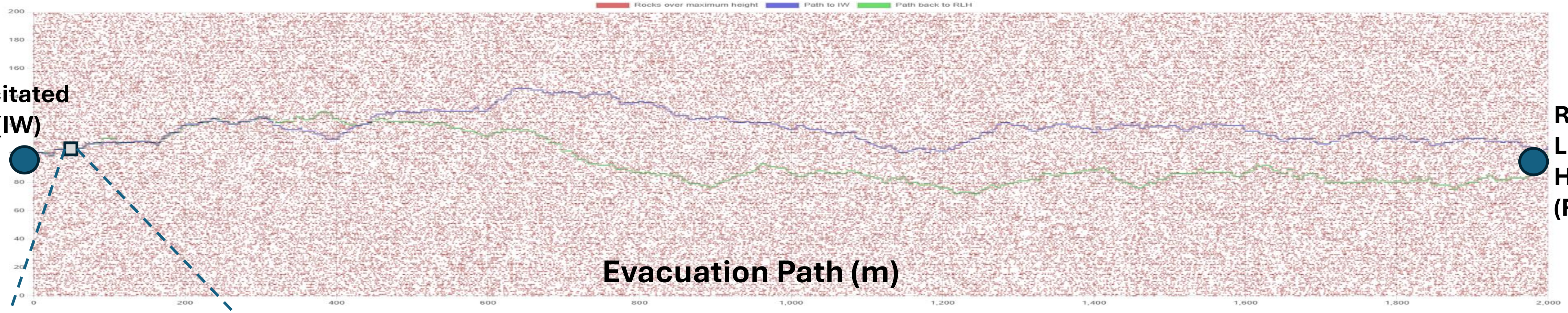


Figure 2

POWRS Modelling and simulating the challenge:

ROCK DIFFICULTY = 5, SLOPE = 10 DEG, FLAT V = 5 m/s, CLIMB OVER = 5 cm, CLIMB OVER V = 0.5 m/s



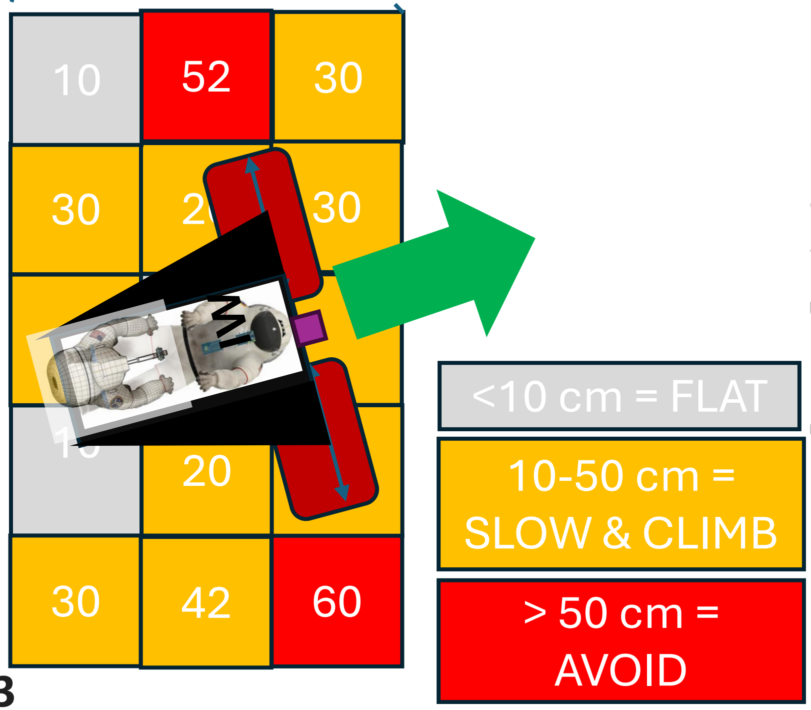
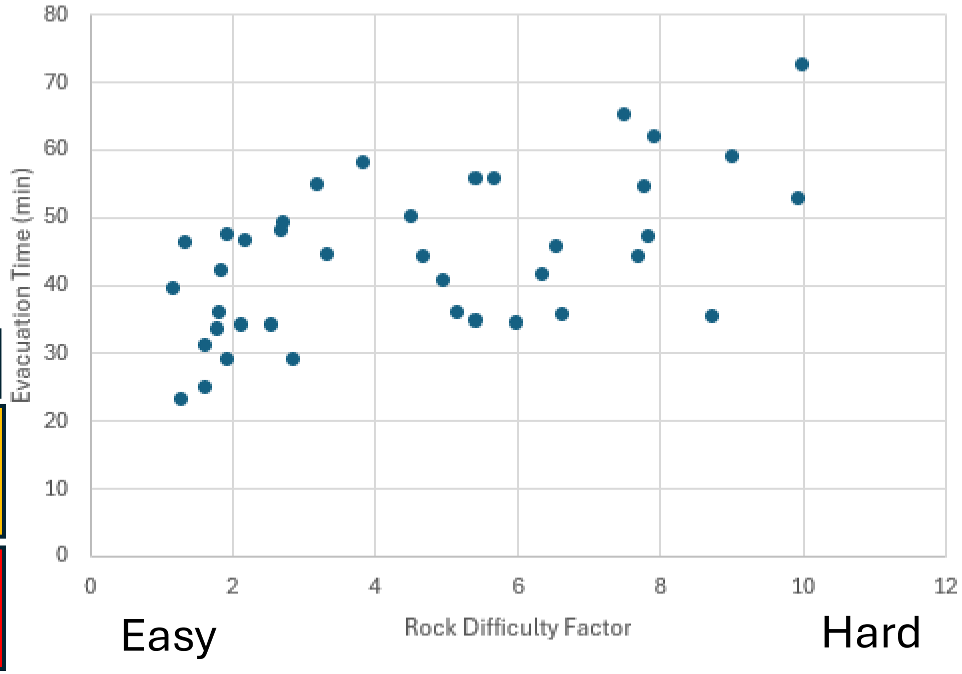


Figure 3



The terrain itself is rugged and uneven, characterized by a multitude of geological features, including:

•Rocks (Blocks): The surface is strewn with rocks ranging from approximately 0.15 meters to 20 meters in diameter, with a height-to-diameter ratio of 0.5. These blocks can impede movement and create hazardous conditions for traversal.

•Craters: Craters vary in size from 1 meter to 30 meters in diameter, with a depth-to-diameter ratio of 0.12. Navigating around or across these craters requires careful planning and significant physical effort.

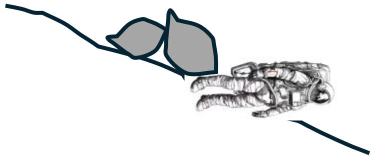
•Slopes: up to 20 degrees (up, down, or cross slopes)

Rescue Modes Contingencies

First: Found Situations

Surface Issue

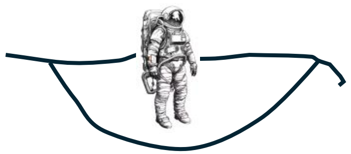
Pinned By Slide



POWRS motors can pull the cable to lift rocks

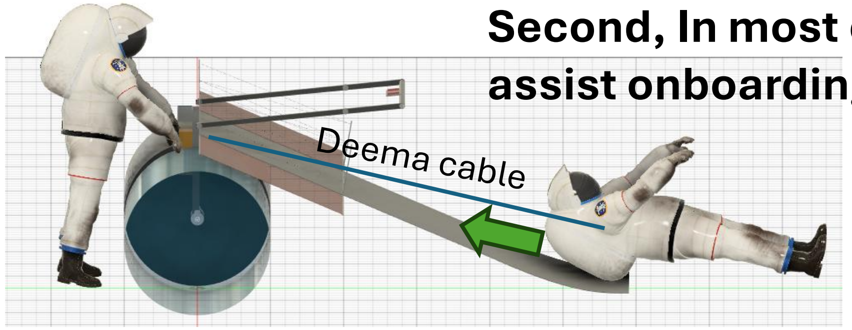
Dust Trap

(Lunar Quicksand)



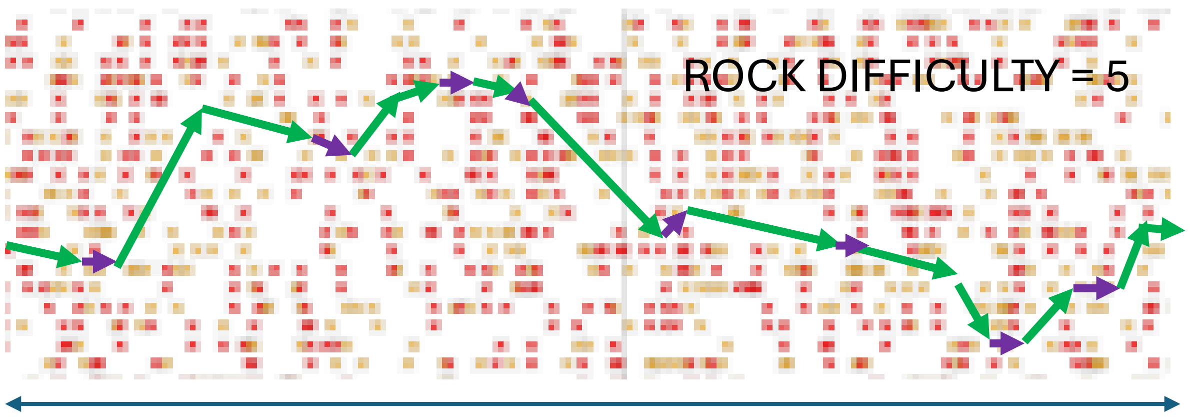
POWRS can be extended to the walker and then the motors pull the walker out

Second, In most cases: power assist onboarding



Finally, Evacuation Mode

(Red can't be crossed, Orange can slowly be driven across, White is fast driving)

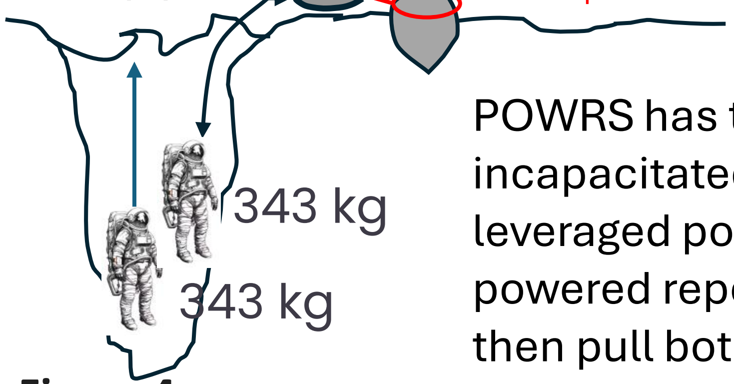


200 m

Fast = 5 m/s

Slow = 0.5 m/s

Deep pit

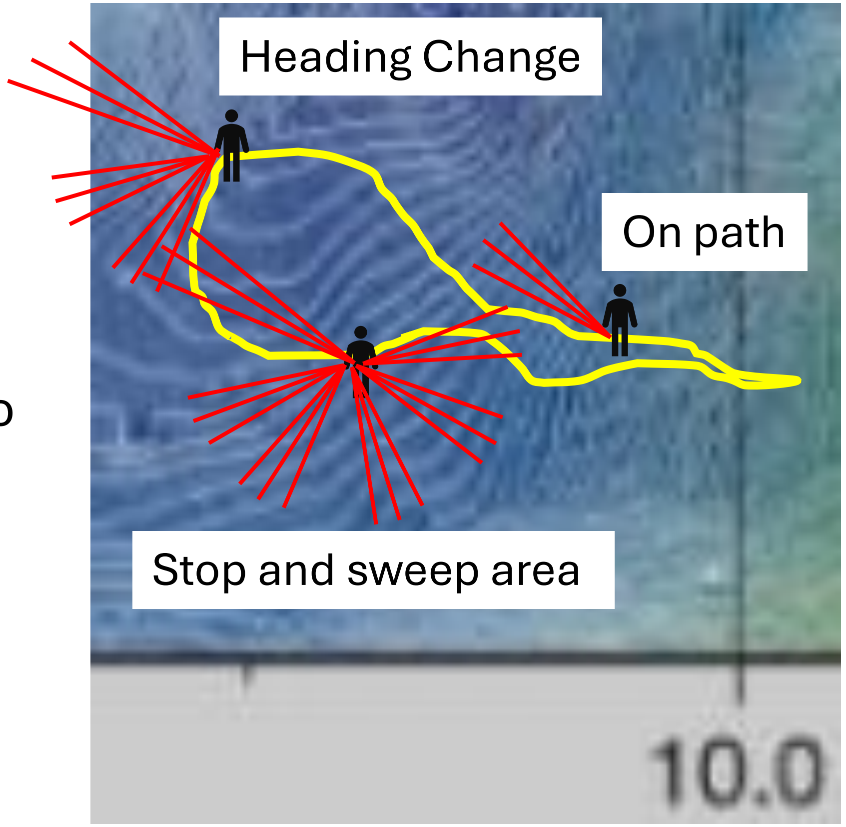


POWRS has the power to lift up the walker. If the walker is incapacitated the rescuer can leave the POWRS in a leveraged position with a rock loop and perform a powered repel to the IW and attach a tow cable (high risk) then pull both up one at a time **(1200 N needed for both)**

Figure 4

Path Indicator / Range Finder Laser

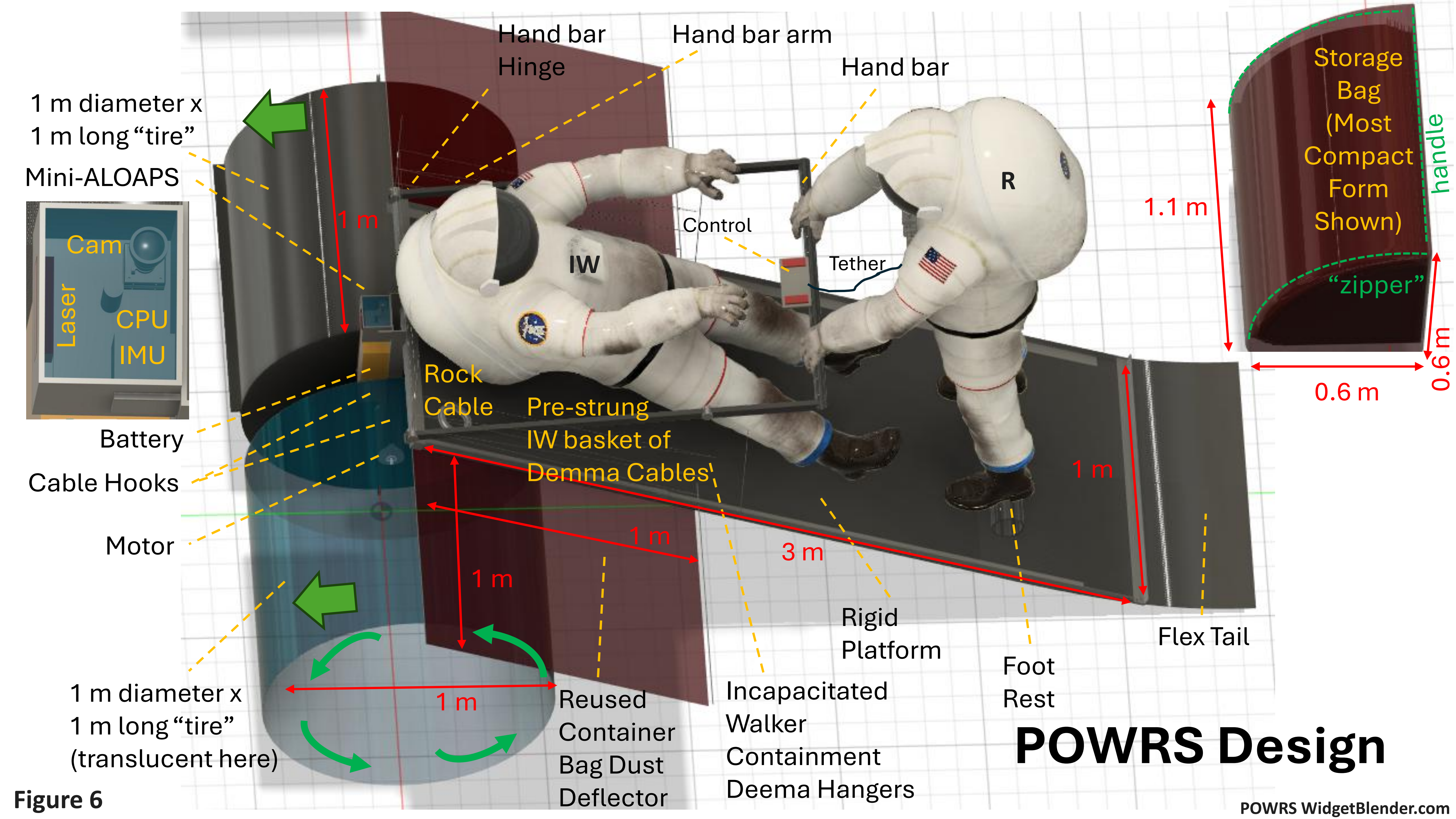
Given a previous position, the Range Finder by itself could often determine position within 50m, but this is combined with IMU data to probably return 10m resolution. It can also spot cube shapes rocks to avoid if possible.



Normal movement will sweep the beam center up and down and side to side by at least 10 deg, gathering more information

Figure 5

https://www.researchgate.net/publication/3450110_A_Novel_Filter_for_Terrain_Mapping_With_Laser_Rangefinders



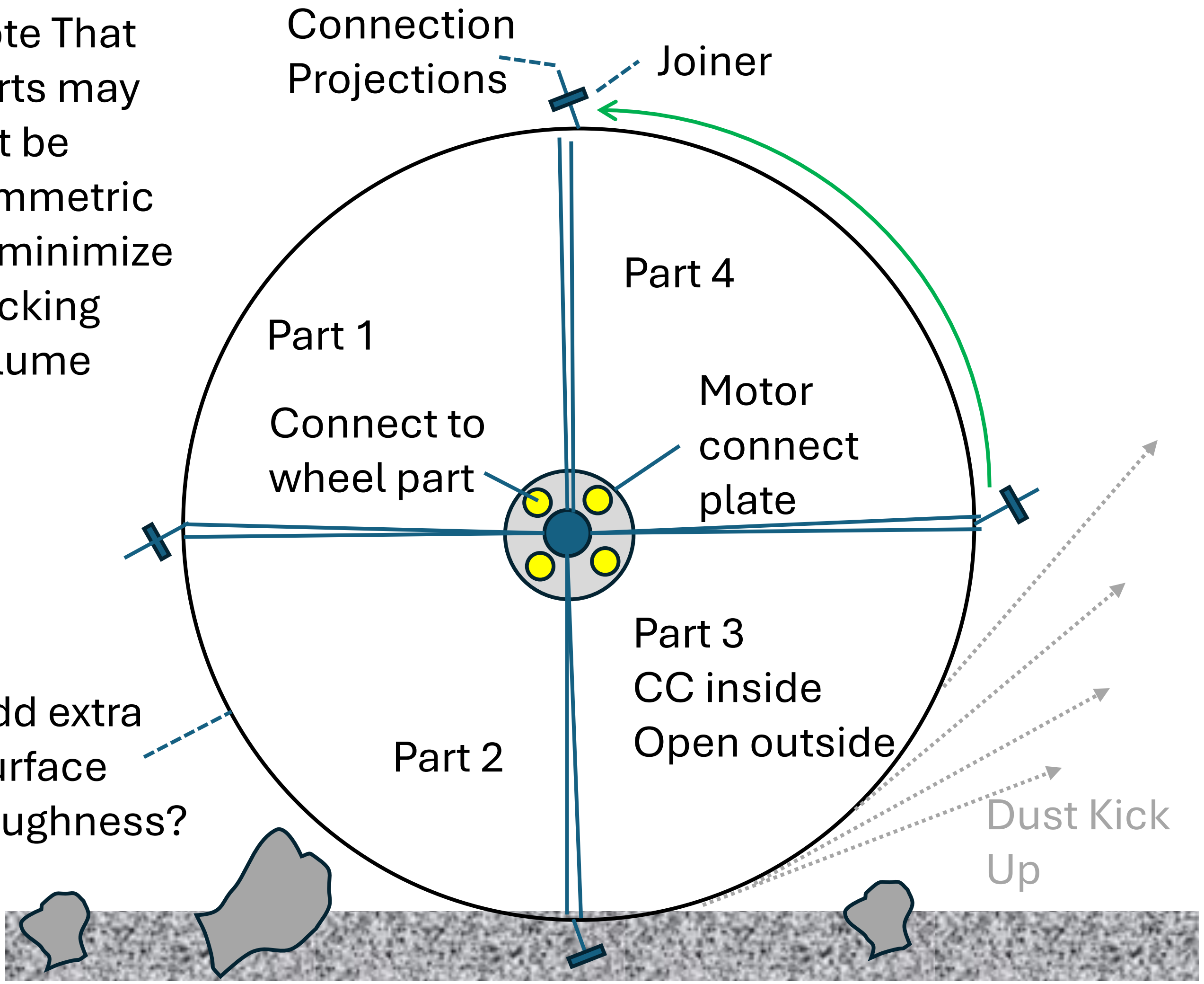
Hand bar
Hinge
Hand bar arm
Hand bar
1 m diameter x
1 m long "tire"
Mini-ALOAPS
Cam
Laser
CPU
IMU
1 m
Control
Tether
IW
R
Storage
Bag
(Most
Compact
Form
Shown)
handle
1.1 m
"zipper"
0.6 m
0.6 m
Rock
Cable
Pre-strung
IW basket of
Demma Cables
Battery
Cable Hooks
Motor
1 m
1 m
3 m
1 m
1 m
Rigid
Platform
Flex Tail
Foot
Rest
1 m diameter x
1 m long "tire"
(translucent here)
1 m
Reused
Container
Bag Dust
Deflector
Incapacitated
Walker
Containment
Deema Hangers
POWRS Design
POWRS WidgetBlender.com

Figure 6

Designing the Carbon Composite Tires

(lunar wire tire inspired, but lighter)

Note That Parts may not be symmetric to minimize packing volume



Lunar Regolith (Abrasive Glassy Dust)

Figure 7

Key variables:

Inner (closed) Diameter (1 – 1.2m)
Outer (open) Diameter (1 – 1.2 m)
Length (1 – 1.5 m)
Pieces (1-6)
Connection Projection Length (2 – 4 cm)
Connector Projection Angle (90 deg – 75 deg)
Connectors on Projection (2 - 4)
Surface Opening % (0 – 50%)
Opening Size (1 mm – 5 cm)
Extra surface roughness?

Powered Assembly Tool

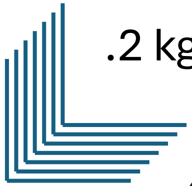
It expected that some trial and error of prototypes will be needed to optimize the exact tire variables

Russian rover inspired

Other parts

Bag/Dust Deflector = **1 kg**

Powered Assembly Tool = **0.5 kg**

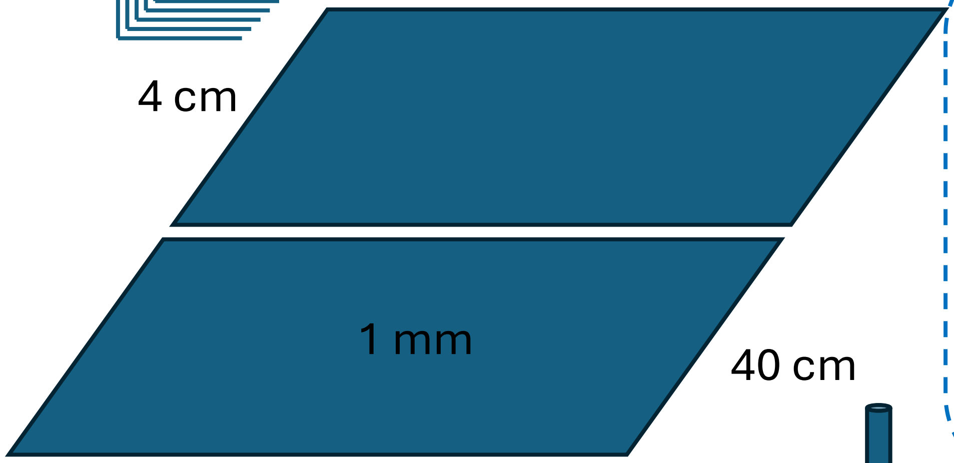


4 cm

4 cm

.2 kg each, 8 needed = **1.6 kg**

3 10 m Demma rescue cable, 0.2 kg each = **.2 kg**



1 mm

40 cm

1 m

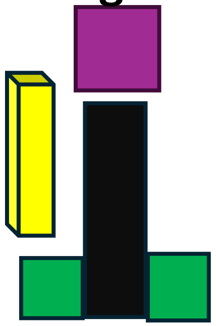
.46 kg each, 7 needed = **3.5 kg**

4, 1 m long projections .2 kg each = **0.8 kg**

4, 50 cm long projections .15 kg each = **0.6 kg**

10 m Demma cable for IW basket = **0.1 kg**

Front Assembly Already Joined



Mini-ALOPS = **1 kg**

Battery = **3 kg**

Vertical connector 0.5 kg, 1 needed = **0.5 kg**

Motors + connectors = 1 kg each 2 needed = **2 kg**

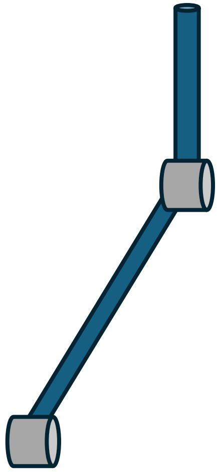
1 m

Hand bar

.5 kg, 1 needed = **0.5 kg**

Display /Controller/Tether

.5 kg, 1 needed = **0.5 kg**



Hand bar arm + hinges

1 kg each, 2 needed = **2 kg**

		mass	#	total
Bag/Dust Deflector	mylar	1	1	1
1 m 4cm x 4 cm long Stiff Frames	cc	0.2	8	1.6
1 m x 40 cm platform segments	cc	0.46	7	3.22
1 m long foot frame	cc	0.5	1	0.5
1 m long projections	cc	0.2	4	0.8
50 cm long projections	cc	0.15	4	0.6
10 m thin demma cable	deema	0.05	1	0.05
1 m Handbar	cc	0.5	1	0.5
Display/Controller	many	0.5	1	0.5
Hand bar arm + hinges	cc+	1	2	2
Mini-ALOPS	many	1	1	1
Vertical connector	cc	0.5	1	0.5
Battery (1200 Wh)	many	3	1	3
Motors + wheel connectors	many	1	2	2
Powered Assembly Tool	many	0.5	1	0.5
10 M Deema rescue cable with clips	deema	0.2	3	0.6
Tire	cc	2	2	4
				22.37

Figure 8

Assembly

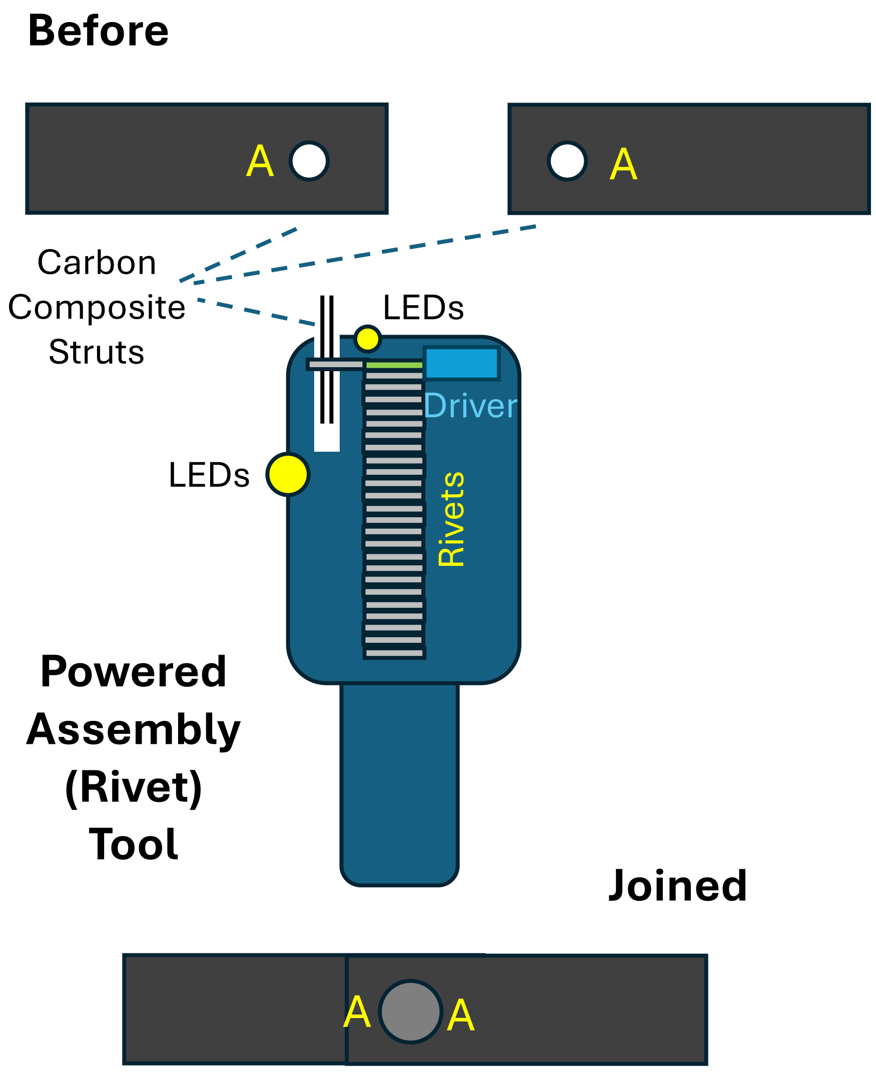


Figure 9

FOR MOST COMPACT (0.24 m^3) PACKAGING (~44 minutes):

1. Unbag, and lay out for as an assembly area tarp = 2 minutes
2. Join Tire Parts (4 parts per tire, 2 tires) = 5 minutes
3. Join Frame Parts (8 parts) = 5 minutes
4. Join Platform parts (7 total) inside frame = 5 minutes
5. Join Tires to Front Assembly (2 sets of 12 joins) = 5 minutes
6. Joint Frame to Front Assembly (4 joins) = 2 minutes
7. Join IW basket to Frame = 5 Minutes
8. Join Long Projections to Frame = 2 minutes
9. Stretch Mylar Bag to Attach to Long Projections = 4 minutes
10. Turn on and test mini-ALOAPS and motor operations = 5 minutes

FOR LESS COMPACT (0.84 m^3) PACKAGING (~ 35 minutes)

1. Unbag, and lay out for as an assembly area tarp = 2 minutes
2. Join Frame Parts (8 parts) = 5 minutes
3. Join Platform parts (4 total) inside frame = 3 minutes
4. Join Tires to Front Assembly (2 sets of 12 joins) = 5 minutes
5. Joint Frame to Front Assembly (4 joins) = 2 minutes
6. Join IW basket to Frame = 5 Minutes
7. Join Long Projections to Frame = 2 minutes
8. Stretch Mylar Bag to Attach to Long Projections = 4 minutes
9. Turn on and test mini-ALOAPS and motor operations = 5 minutes

FOR LEAST COMPACT (2 m^3) PACKAGING (~ 20 minutes)

1. Unbag, and lay out for as an assembly area tarp = 2 minutes
2. Join Frame Parts (2 parts) = 2 minutes
3. Join Tires to Front Assembly (2 sets of 12 joins) = 5 minutes
4. Joint Frame to Front Assembly (4 joins) = 2 minutes
5. Stretch Mylar Bag to Attach to Long Projections = 4 minutes
6. Turn on and test mini-ALOAPS and motor operations = 5 minutes

Nominal voltage	36 V
No load speed	3070 rpm
No load current	420 mA
Nominal speed	2630 rpm
Nominal torque (max. continuous torque)	457 mNm
Nominal current (max. continuous current)	4.12 A
Stall torque	5000 mNm
Stall current	70 A
Max. efficiency	85 %
CHARACTERISTICS	
Terminal resistance	0.514 Ω
Terminal inductance	0.554 mH
Torque constant	110 mNm/A
Speed constant	86.8 rpm/V
Speed / torque gradient	0.406 rpm/mNm
Mechanical time constant	13.5 ms
Rotor inertia	3170 gcm²
THERMAL DATA	
Thermal resistance housing-ambient	1.78 K/W
Thermal resistance winding-housing	3.7 K/W
Thermal time constant winding	68.1 s
Thermal time constant motor	264 s
Ambient temperature	-40...+100 °C
Max. winding temperature	+125 °C
MECHANICAL DATA	
Bearing type	ball bearings
Max. speed	5000 rpm
Axial play	{0} {1}, at radial load {2} {3} {4}
	0.14 mm, at radial load > 58 N
Max. axial load (dynamic)	34 N
Max. force for press fits (static)	440 N
(static, shaft supported)	8000 N
Max. radial load	100 N, 10 mm from flange
OTHER SPECIFICATIONS	
Number of pole pairs	11
Number of phases	3
Number of autoclave cycles	0
PRODUCT	
Weight	635 g

https://www.maxongroup.com/maxon/view/product/motor/ecmotor/ecflat/ecflat90/505592

HG1120 IMU TYPICAL KEY CHARACTERISTICS	
Gyroscope Operating Range	-500°/sec to +500°/sec
Accelerometer Operating Range	-16g to +16g
Magnetometer Operating Range	-16 gauss to +16 gauss
Supply Voltage	+3.0 to +5.5 VDC
Power Consumption	< 0.4 Watts
Operating Temperature Range	-40°C to 85°C
Volume / Size	29 cm^3 (1.7in^3),4.70 cm x 4.39 cm x 1.41 cm
Weight	54 grams (0.12 lbs) Typical
Selectable Data Rates	Incremental/Control Data Rates of 100 Hz/600 Hz or 300 Hz/1800 Hz
Baud Rate	1MBit CAN/RS422, 2-9 MBit SPI
Dual Navigation/ Control Serial Outputs	Fully Compensated Incremental/Delta Outputs are Ready for Integration into Position/Attitude Control Message Optimizes Latency & Bandwidth Without Sacrificing Accuracy

HG1120 IMU STANDARD MODELS TYPICAL PERFORMANCE - STABLE ROOM TEMPERATURE

Marketing Part Number[1]	Gyro Bias Repeatability (°/hr, 1σ)	Gyro Bias In-Run Stability (°/hr, 1σ)	ARW (°/√hr)	Accel Bias Repeatability (mg, 1σ)	AccelBias In-run Stability (mg, 1σ)	VRW (m/s/√hr)
HG1120CA50	260	10	0.3	5	0.03	0.04
HG1120BA50	520	24	0.4	10	0.05	0.06
HG1120AA50	780	48	0.5	15	0.08	0.10

HG1120 IMU TYPICAL PERFORMANCE OVER FULL TEMPERATURE RANGE

Marketing Part Number[1]	Gyro Bias Repeatability (°/hr, 1σ)	Gyro Bias In-run Stability (°/hr, 1σ)	ARW (°/√hr)	Accel Bias Repeatability (mg, 1σ)	AccelBias In-run Stability (mg, 1σ)	VRW (m/s/√hr)
HG1120CA50	500	38	0.6	8	0.11	0.06
HG1120BA50	720	65	0.7	16	0.15	0.09
HG1120AA50	1080	120	1.3	24	0.20	0.15

file:///C:/Users/jmors/Downloads/N61-1524-000-004-HG1120-MEMS-Inertial-Measurement-Unit-bro.pdf