# Design and Fabrication of Alternative Traction Elements for Lunar and Martian Surfaces

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# Introduction to ODG / Argo

# Vehicle Division

Argo 8x8
Avenger 750 EFI

Argo 6x6
Frontier 650

CENTAUR®

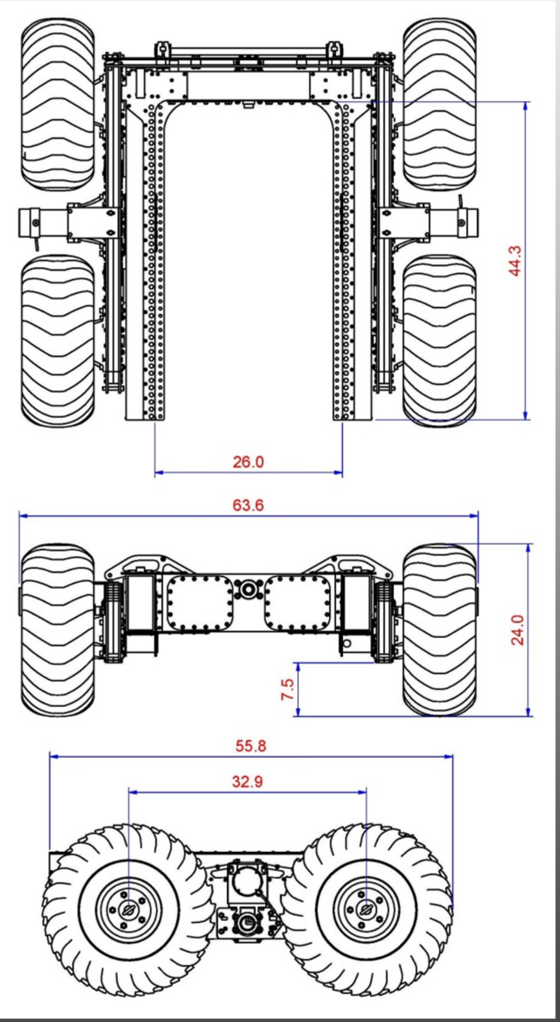
# Utility Rover Traction Systems

- Rovers currently in development are analogous to utility tractors rather than golfcarts.
- Ground-working tasks require an abundance of net traction.
- Current wheel designs on planetary rovers are likely inadequate for this scenario.

The Most Versatile Off-Road Vehicle in the World

# Juno I Rover

| | |
|---|---|
| ODG/Argo | Com Dev |
| Neptec | McGill University |
| Norcat | NGC Aerospace |

# Field demo:  ground-working and prospecting

# Slope testing

- Extreme terrain testing on Mauna Kea.
- Only wheeled vehicle to successfully drive out of crater.

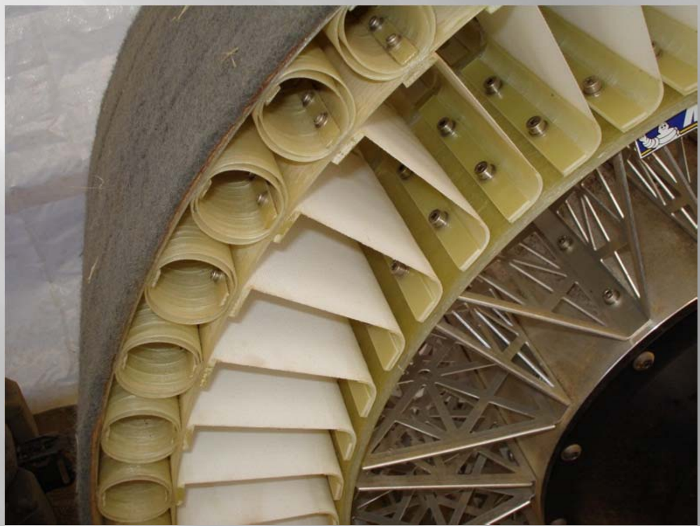
# Field testing – soft sand and extreme terrain

## The Rubber Gap:  It’s Here, Now What Do We Do?

The low pressure pneumatic tire is the most common solution for terrestrial solutions.

BUT…

It is unlikely that rubber can withstand the moon’s environment.

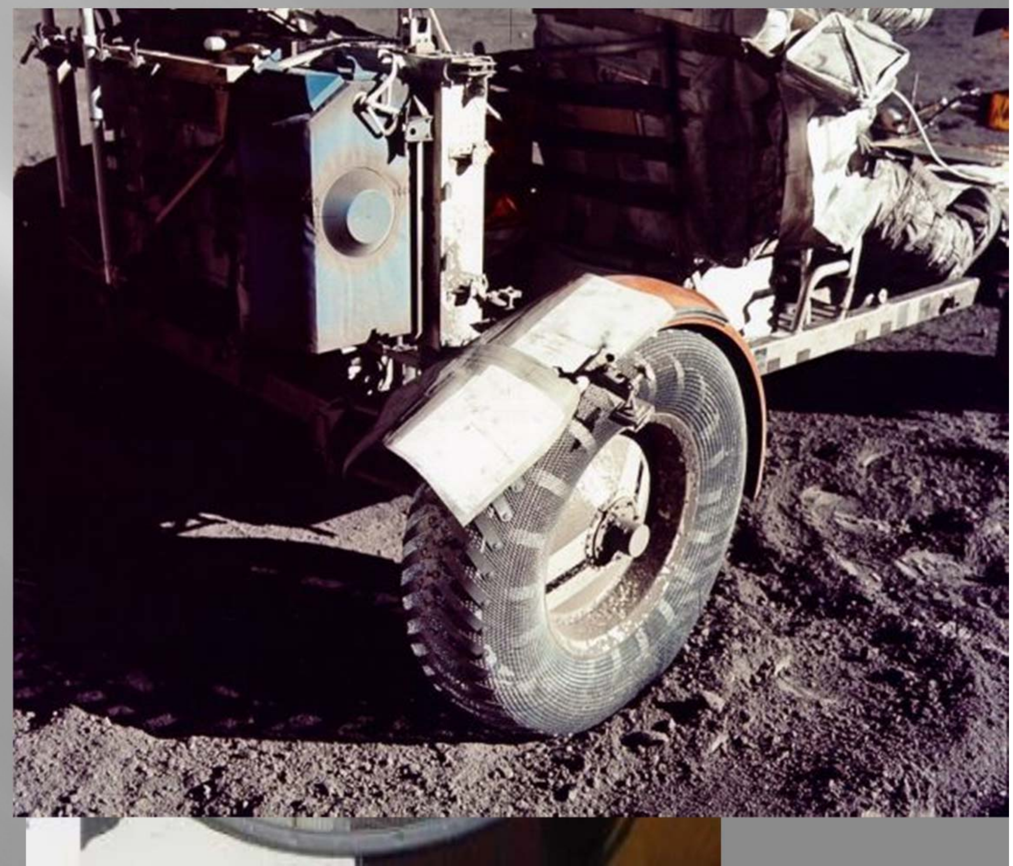


# Tweels in soft sand required a tacking maneuver.

On unprepared, soft, and steep surfaces, rubber tracks offer unparalleled traction and flotation.

# Current space exploration wheel solutions

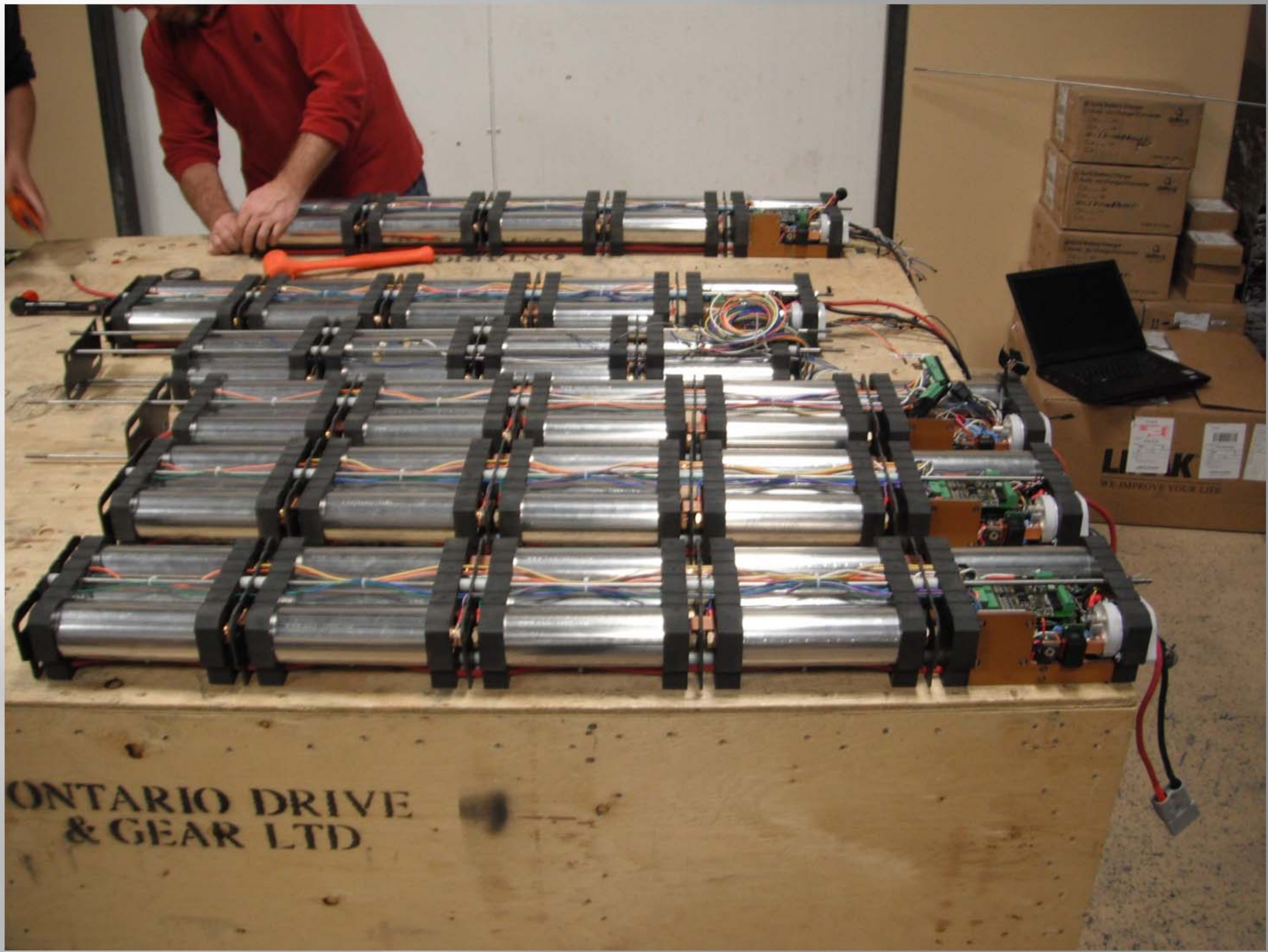
- Lunokhod wheel
- LRV wheel
- Mars rover wheels



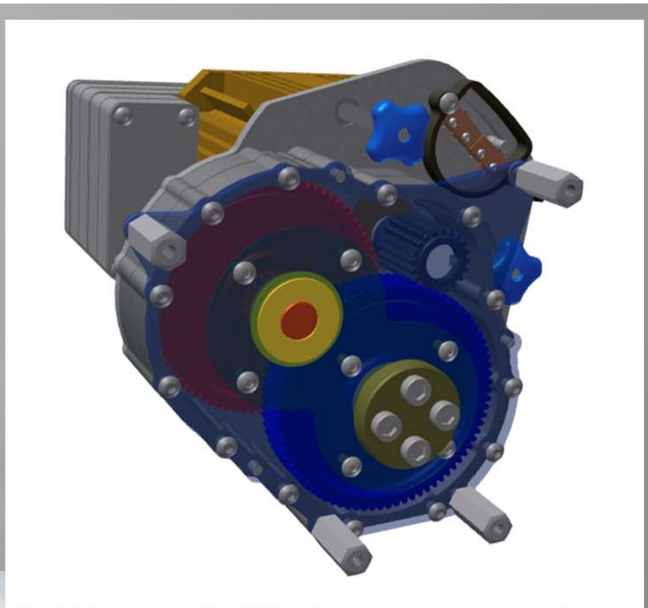
# Primary test vehicle – Juno II Rover

- More powerful BLDC motors
  - 1200W continuous
  - Integrated magnetic brake and delta-wye relay
- Lighter, more energy dense Lithium batteries
  - 35% reduction in mass (50kg vs 77.5 kg.)
  - 5.1 kWhr (up from 2.4 kWhr)
  - Combined with new motor, 3-fold increase in run time.
- Two speed manual shift transmission
- Payload power and data ports
- Pitch control (Split Actuated Differential Link)
- Neptec, ODG, ASI, CrossChasm, LTC, Ottawa U, McGill

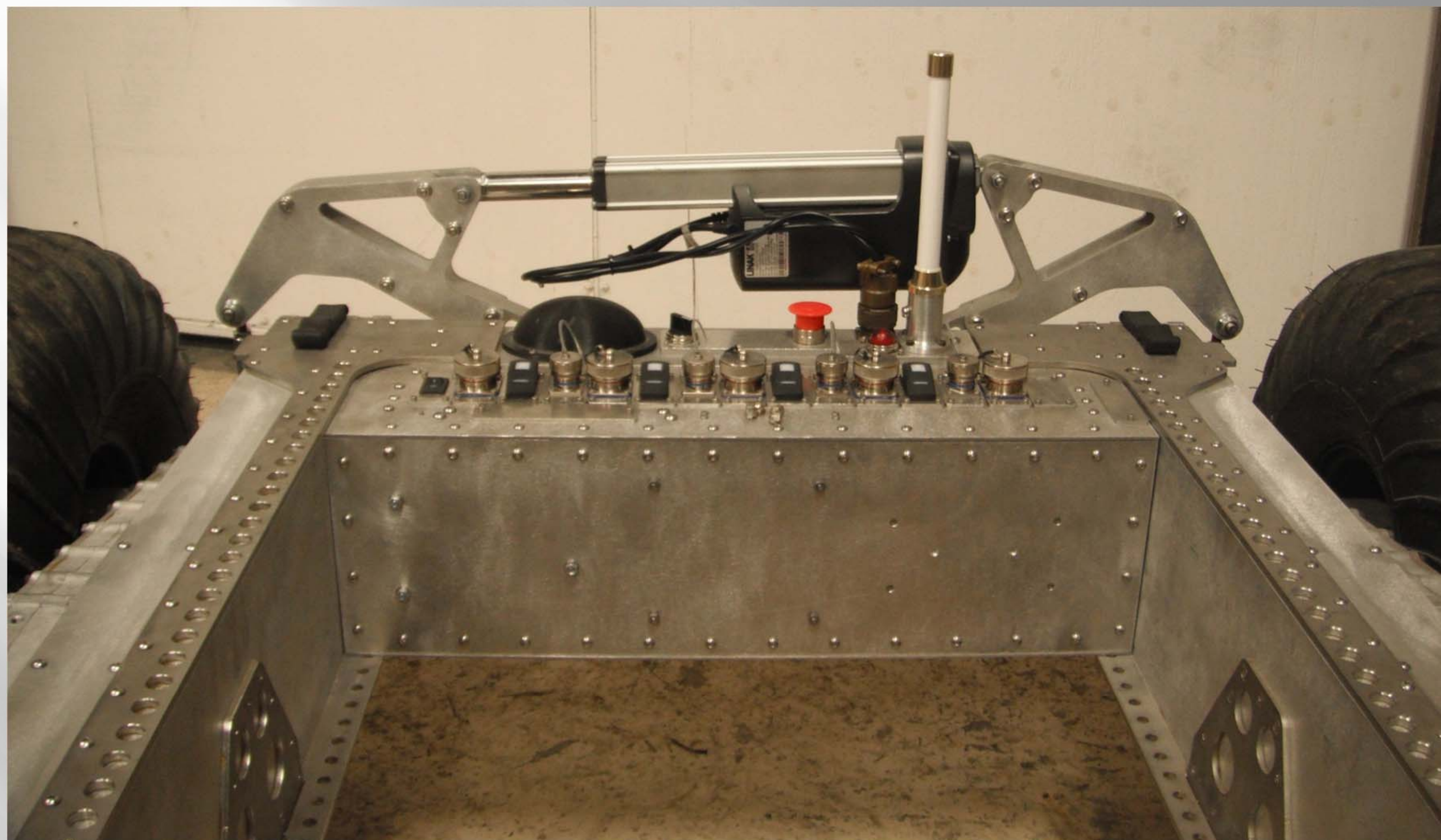
- Battery packs
  - 27 kg mass reduction, over double the energy capacity.



- Four speeds
  - Low wye – 1.8 km/h
  - Low delta – 3.5 km/h
  - High wye – 7.0 km/h
  - High delta – 9.5+ km/h



- Payload power and data ports



- Split Actuated Differential Link (SADL) pitch control

# Constraints and considerations for a utility rover traction system

- Traction
- Durability
- Mass
- Torsional rigidity
- Lateral stiffness
- Response to load

All of these constraints must be considered in order to achieve an optimal result.  The best compromise between these constraints will result in the best solution.

# ODG Non-Rubber Wheel

- Origins
  - Internal project that we started based on lessons learned from track development

- When to use wheels
  - Reduced mass is a priority
  - Non-groundworking tasks

# Wheel Development/Testing

- Gen I
  - Materials:
    - 0.050″ 1075 Spring Steel hardened to Rc 44
    - 0.100″ 304 Stainless
    - Sandwich Construction Rim in Al 6061
    - MIL-Spec aircraft cable
  - Final Weight = 16 kg

# Wheel Development/Testing

- Gen I
  - Testing environments: sand, rocks, turf, asphalt, snow
  - Testing = 25 extreme km’s

# Current version - Gen II Wheels

- Increased use of lightweight metals (titanium)
- Separate spring and traction functions

**T**itanium **I**nterlaced **R**im for **E**xtreme **L**unar **E**nvironment **S**urface**S** (TIRELESS)

- Gen II – Design and Materials
  - 0.050″ 1095 Blue Spring Steel
  - 0.050″ Titanium 6Al-4V (10 pieces for testing)
  - 0.093″ 1075 Spring Steel hardened to Rc 44
  - Sandwich Construction Rim in Al 6061
  - MIL-Spec aircraft cable

# Wheel Development/Testing

- Gen II Testing
  - Juno II Rover will be used for short term testing
  - Larger LELR rover (ARTEMIS) will be used for further testing and validation
  - Additional rover variations used for testing
    - Artemis Jr. Design 2 (ArJuD2)
    - Artemis Breadboard – Hardly Integrated Partially Operational Artemis (HIPO-Artemis)

# Design Goals

- Weight Savings
  - Hardware Reduction (rivets and titanium)
  - Titanium lugs (testing underway for performance capabilities and durability)
  - Only slight re-design required
  - Final target weight =

10 kg

# Design Goals

- Traction
- Skid Steering – optimize amount of lateral resistance
- Transmissibility
- Terrain confomability

# Future Work

- Testing to come….
  - Durability – most critical (5000 km target)
  - Performance (drawbar, steering resistance, deflection versus load, performance in various analogue terrains)
- Design work…
  - Weight savings
  - Testing on different rovers