National Aeronautics and Space Administration

FY23 Strategic Initiatives Research and Technology Development (SRTD)

Steep terrain mobility for Mars and the Moon

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Strategic Focus Area: Lunar Science/ Moon and Mars Extreme Cold, Steep Terrain Rover | **Strategic Initiative Leader:** John D Baker

Objectives:

- Demonstrate a low-cost, flight-relevant surface mobility vehicle capable of traversing steep slopes up to 30º to TRL 4
- Develop mobility strategies for the exploration of craters on the Moon and at mid- and high latitudes on Martian terrain
- Performance targets:
  - 30-degree slope traversals on lunar analogue regolith
  - Equal or fewer number of actuators compared with existing Mars rovers
  - Traverse over positive (boulders) and negative (craters) obstacles up to a wheel radius in size
  - Drive speeds up to 1 km/hour
- FY23: select and develop an optimal vehicle mobility configuration to meet the performance targets for operating at the Moon and Mars

Figure 1. Asterix (left) and Obelix (right) concept vehicles developed in FY22 and used in FY23 in the experimental campaign to evaluate performance.

Background:

- JPL's rocker-bogey (R-B) planetary rover design was developed more than 30 years ago; R-B rovers are limited to traverse slopes <15º on loose soils
- New surface mobility technologies and active suspension systems have been shown to improve mobility performance over passive R-B systems

Approach and Results:

- Built (Fig 1) and evaluated (Fig 2) alternative mobility designs in a comprehensive experimental campaign
- Results (Fig 3) showed that there is a minimal vehicle configuration that has superior slope-climbing performance
- Selected configuration also has ability to climb over wheel-height obstacles and extricate itself from weak soils
- Began development of new rover configuration (Fig 4) with an active gimbaled rocker (AGR) suspension

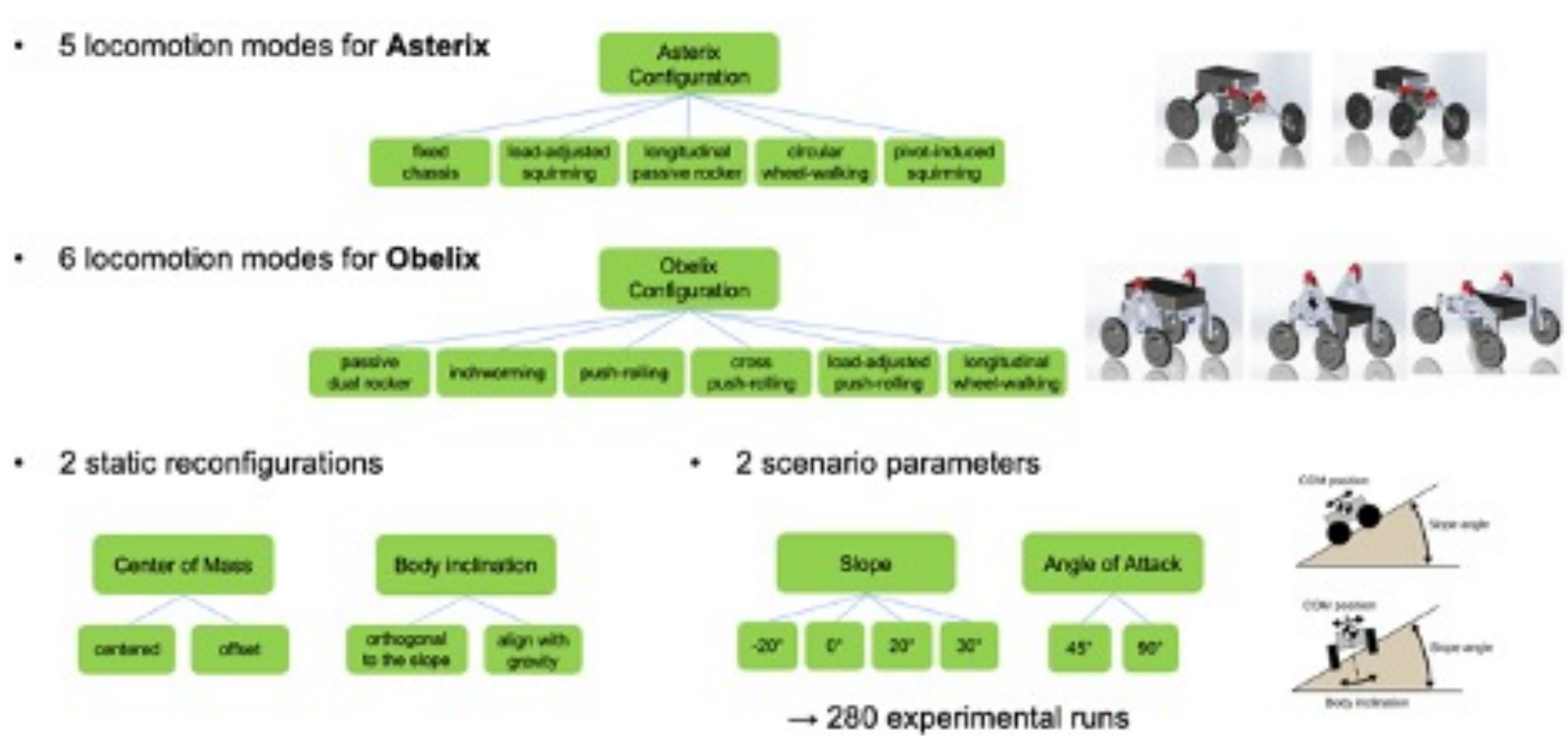

Figure 2. The variables in the comprehensive experimental campaign to evaluate the effect on performance of features of ground mobility vehicles. The tests were conducted on the GRC-1 lunar regolith simulant material.

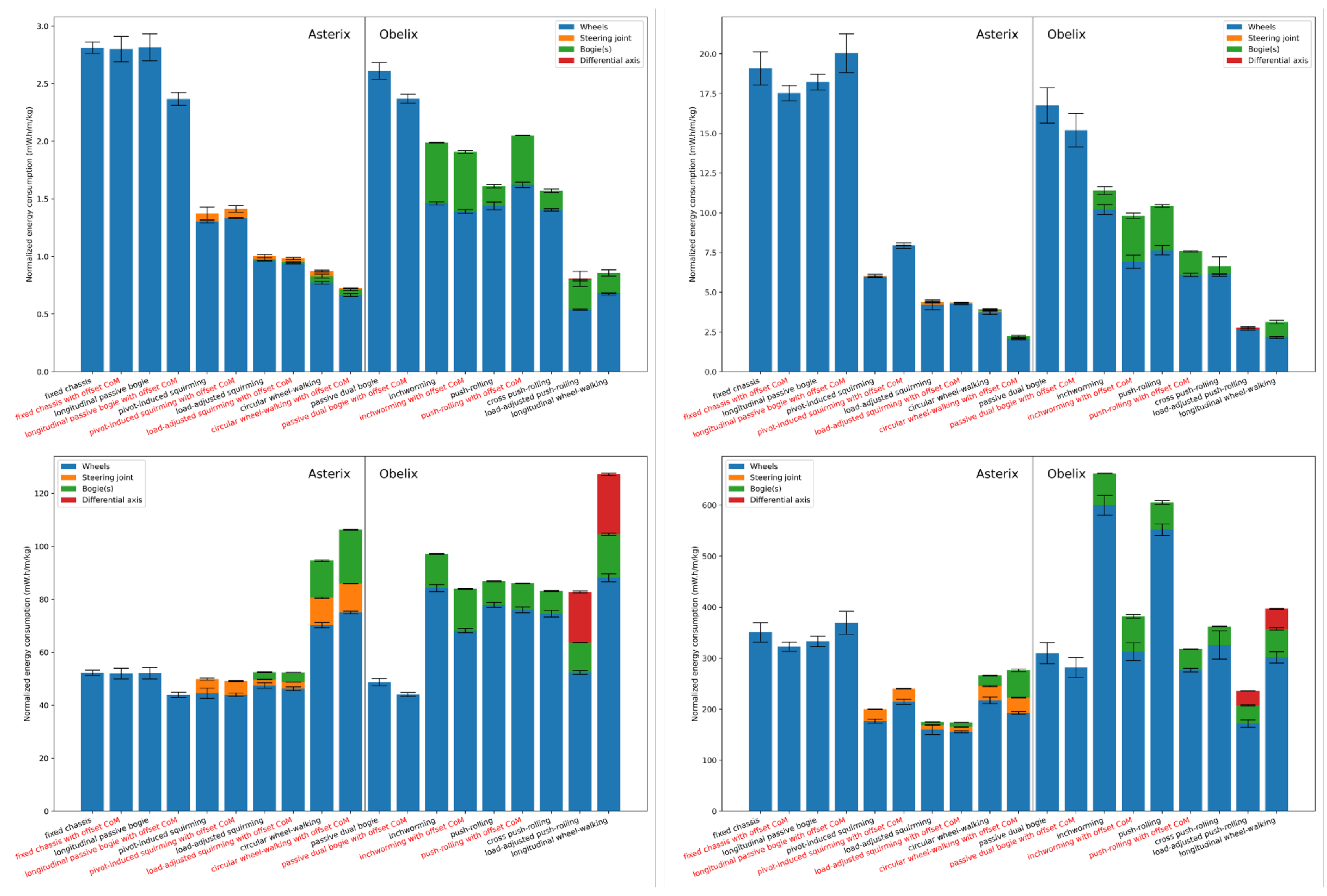

Figure 3. Cost of transport metric using mechanical (top) and electrical energy (bottom) for the different configurations of vehicles driving on GRC-1 at 20º (left) and 30º (right) slopes. A lower cost of transport is better.

Significance/Benefits to JPL and NASA:

- New surface mobility vehicle design has excellent performance on steep slopes up to 30º over loose, weak granular material
- Has minimal number of degrees of freedom
- Able to extricate itself from embedded situations in weak soils
- Able to climb over wheel-height obstacles

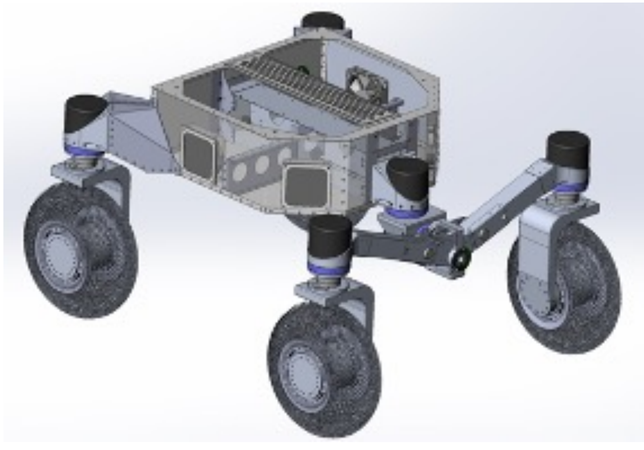

Figure 4. Detail design drawing of one-third sub-scale vehicle model being developed for in-depth testing.

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Publications:

Bouton, A, Reid, W., Brown, T., Daca, A., Sabzehi, M., Nayar, H., "A comparative study of alternative rover configurations and mobility modes for planetary exploration," IEEE Aerospace Conf, Big Sky, MT, 2023.

Nguyen, M., Bouton, A, Nayar, A., Suntup, M., Brown, T., Reid, W., "Trajectory Optimization Methods for Energy Efficient Gait Transitions on Multi-Modal Robots," submitted to IEEE Aerospace Conf, Big Sky, MT, 2024.

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