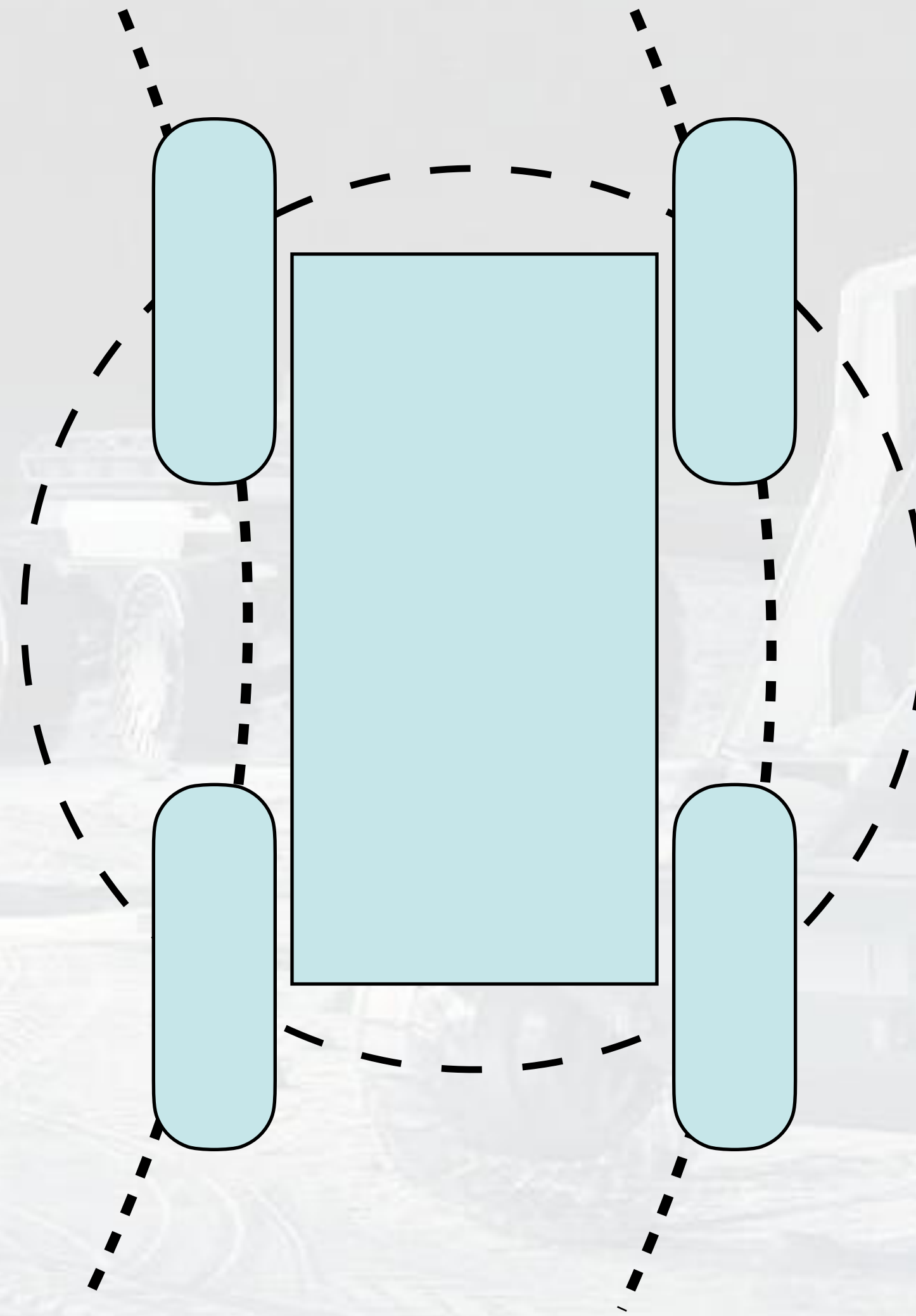


Steering and Suspension Systems Overview

- Steering Systems
 - Skid-Steer
 - Differential drive
 - Trailer steering
 - Ackerman steering
 - Actively controlled steering (Independent/explicit)
 - Holonomic vs. Nonholonomic Systems
- Suspension Systems
 - Rigid Suspension
 - Independent Suspension
 - Articulated / Split-Body Suspension
 - Rocker-Bogie Configurations
 - Segmented-Body Rovers
 - Active Suspension

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Skid Steering (Skid-Slip Steering)



Rigid Suspension, Skid Steer



Electric Tractor, NASA Johnson Space Center



Electric Tractor Drive System



Rigid Suspension in Hilly Terrain



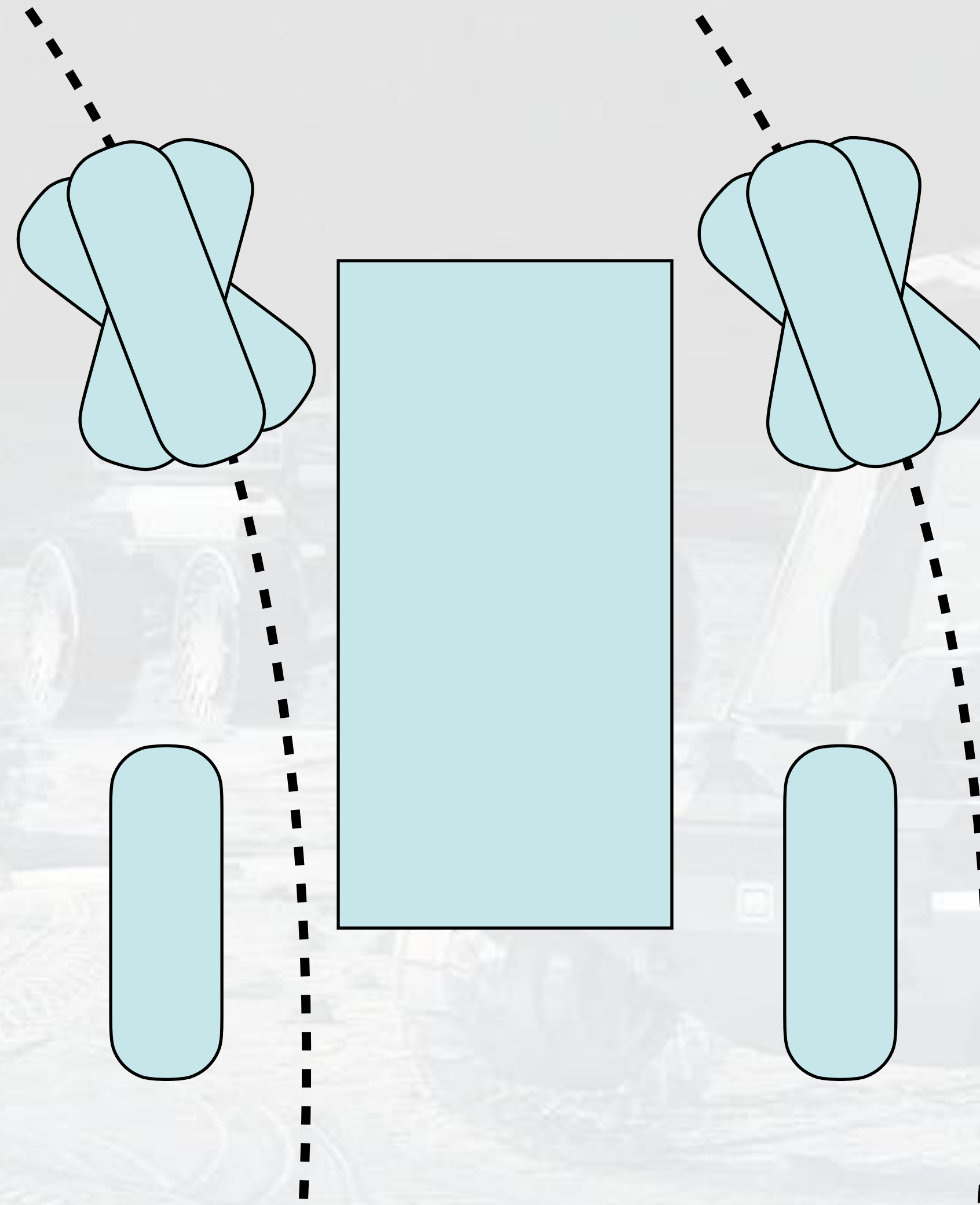
ATRV Skid-Steer Robots



RAVEN (4-wheel configuration)



Differential Drive (Swiveling Wheels)



Laboratory Robot (CMU)



Laboratory Robot (CMU)



RAVEN (UMd/ASU)



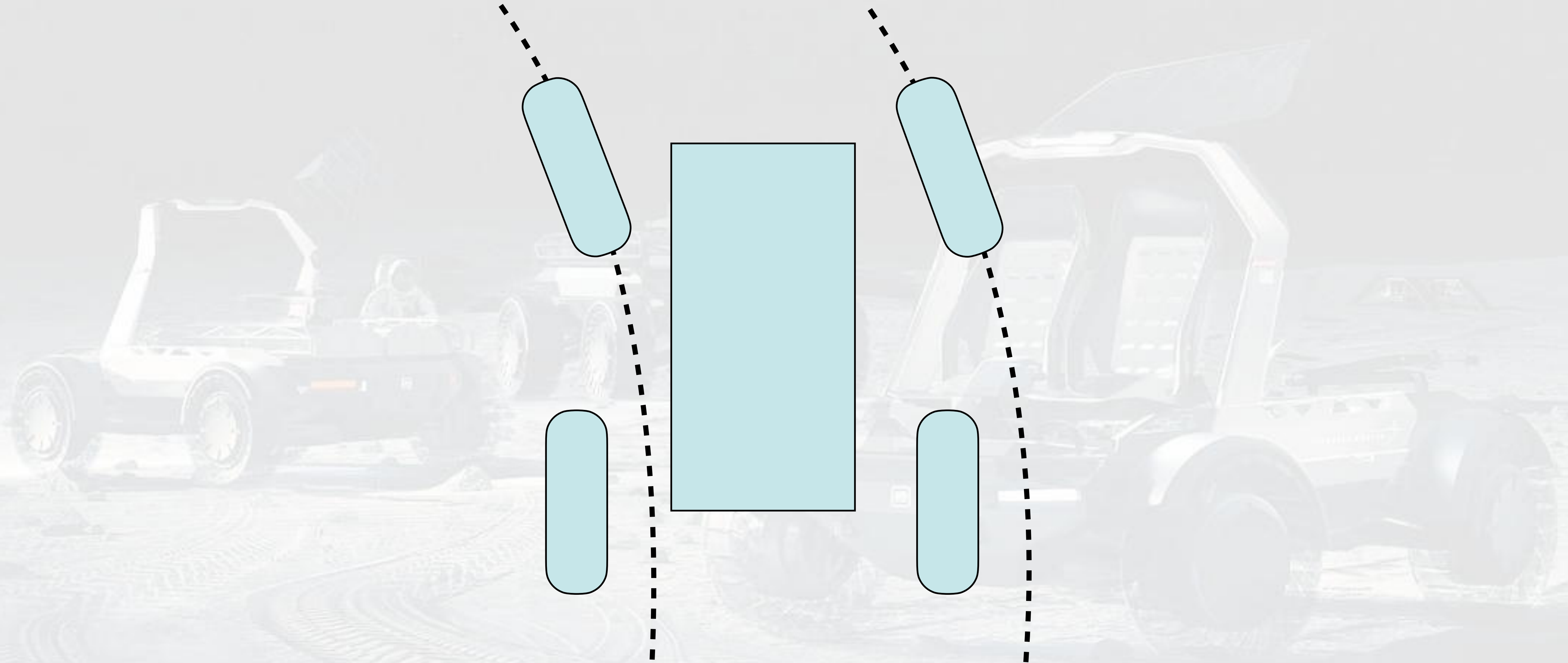
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Steering and Suspension Systems Overview
ENAE 788X - Planetary Surface Robotics

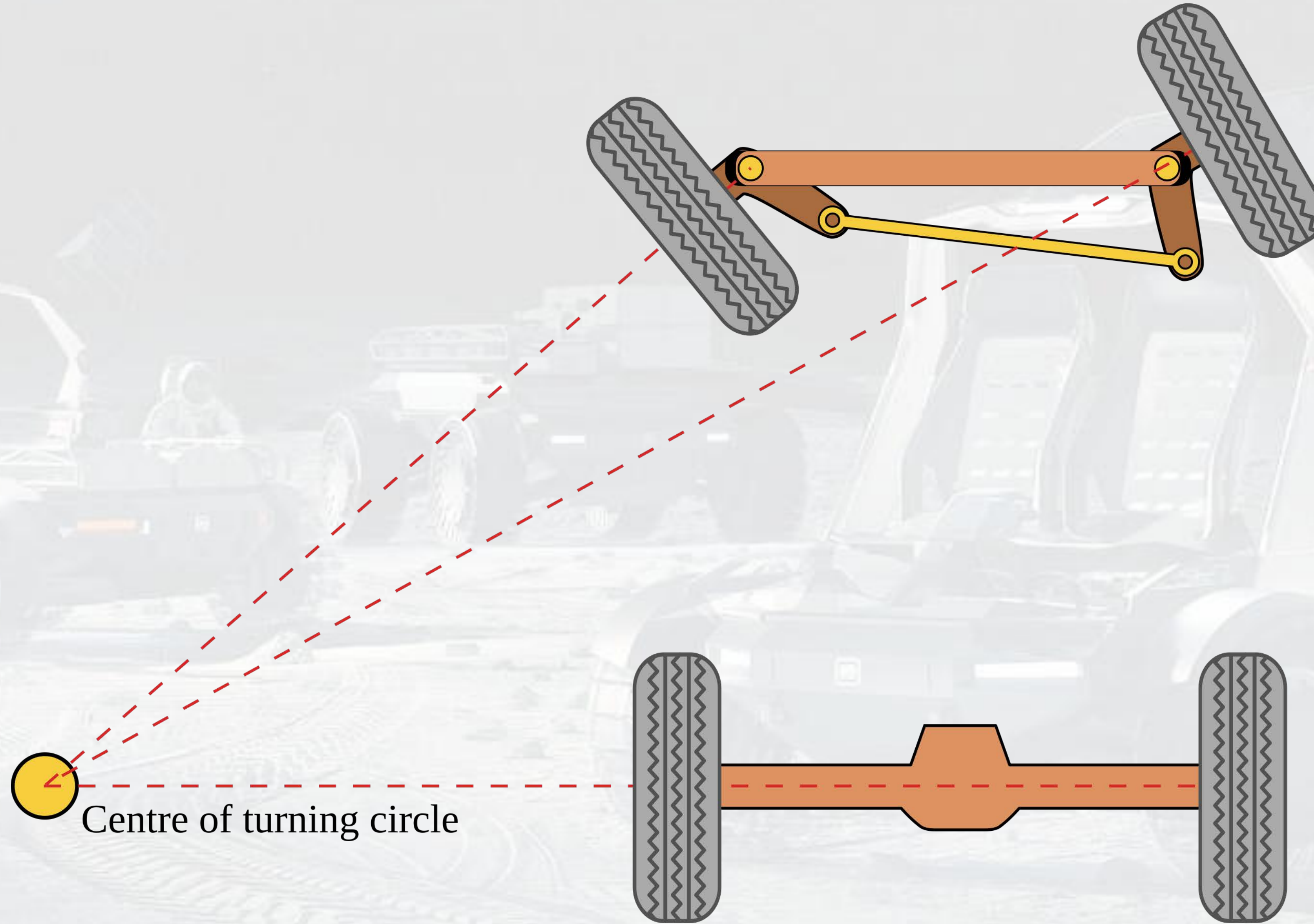
RAVEN in Mobility Testing



Ackermann Steering



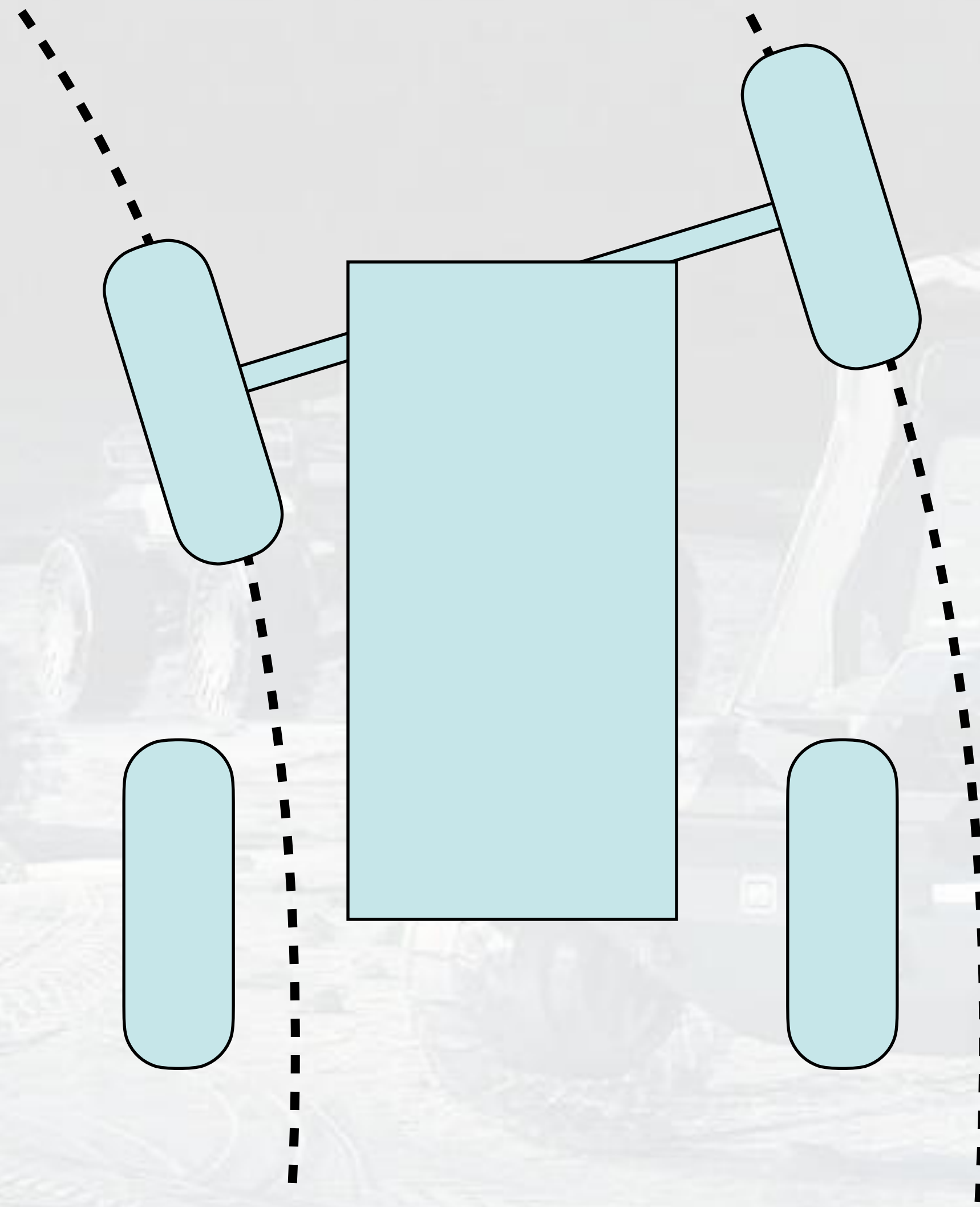
Ackermann Steering Geometry



Tooth (JPL) - Ackermann Steering



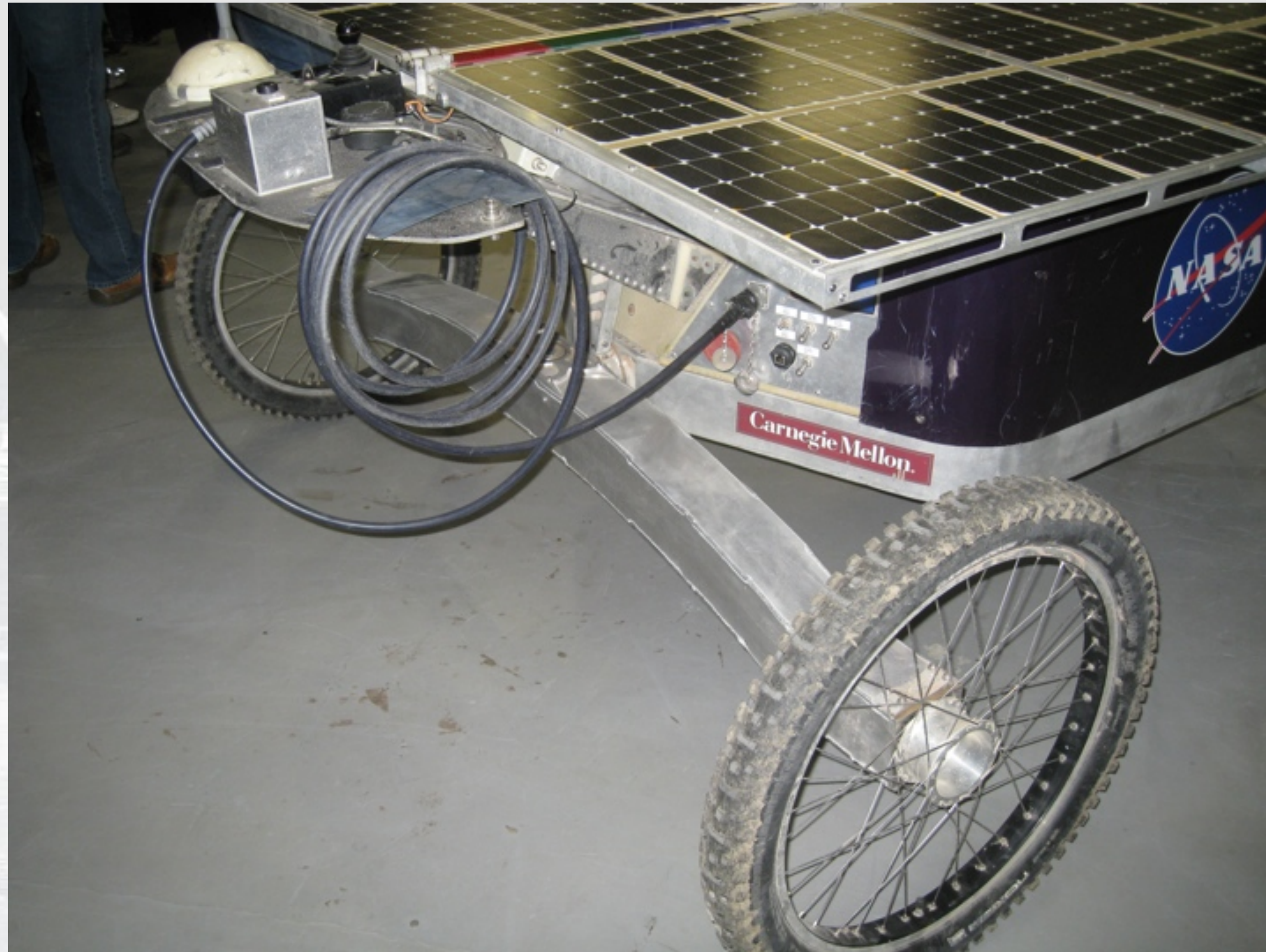
Trailer Steering



Hyperion (CMU)



Hyperion (CMU) - Trailer Steering



Independent Suspension (Towed Vehicle)



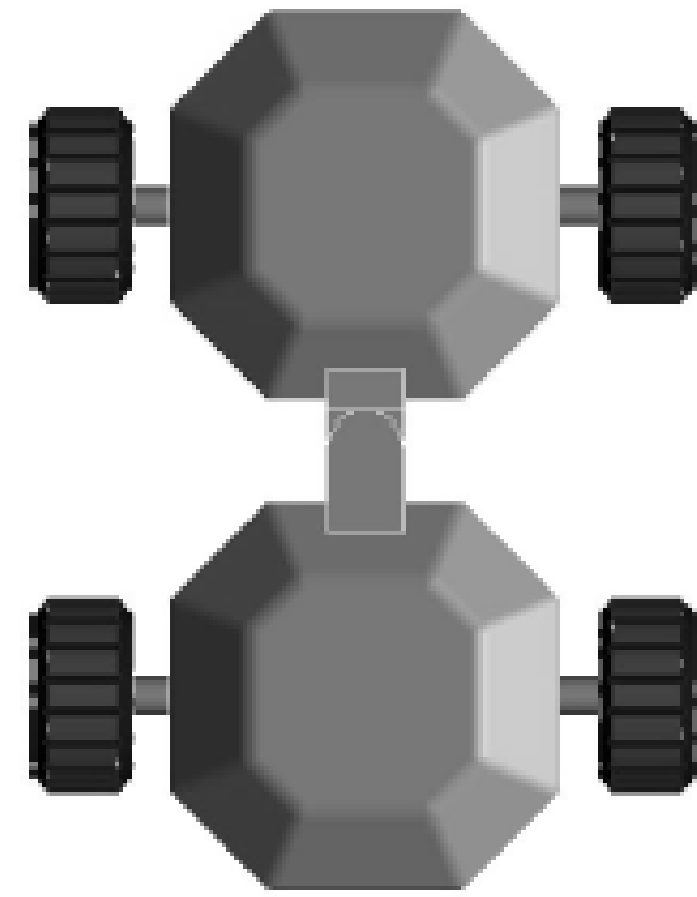
SCOUT Astronaut Support Rover (JSC)



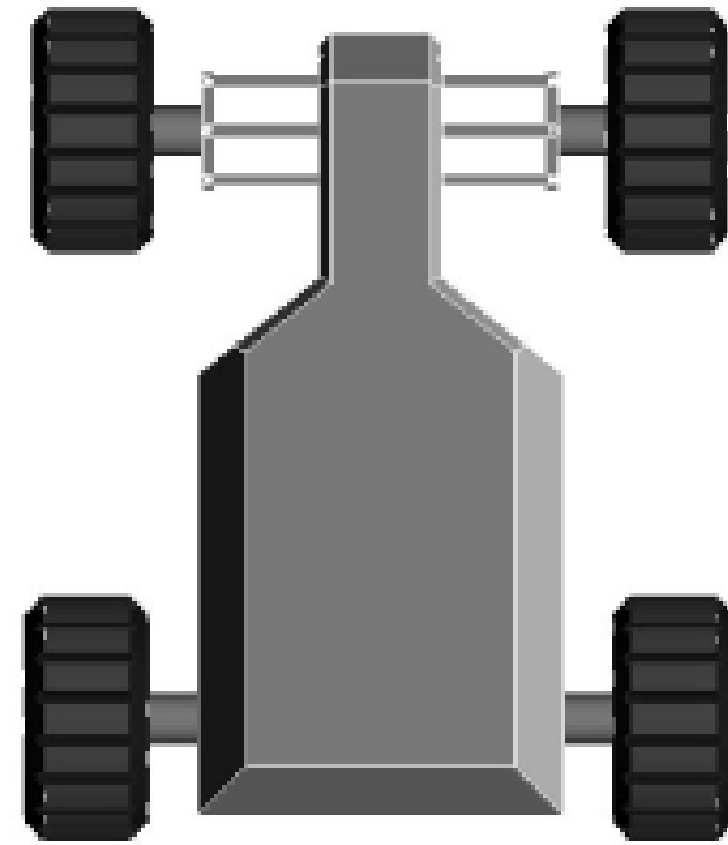
SCOUT Suspension and Steering System



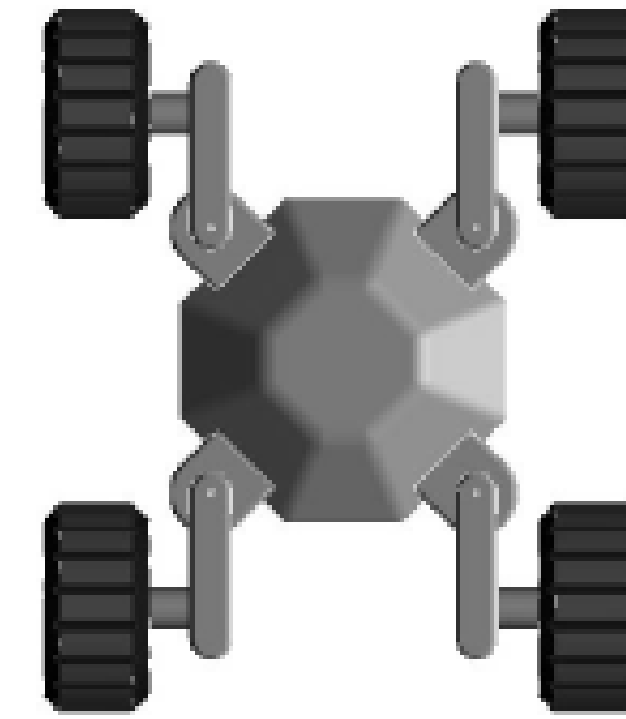
Steering Schemes



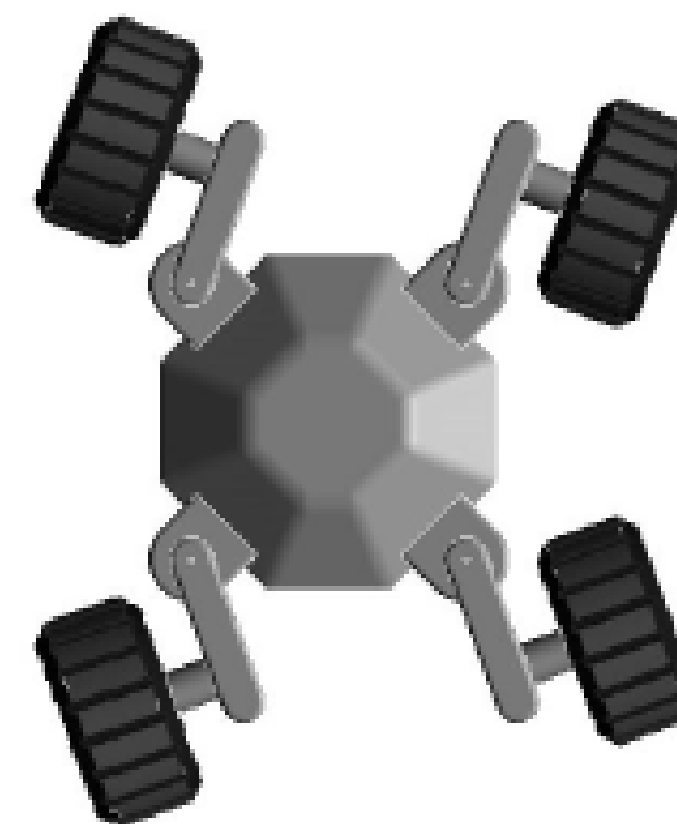
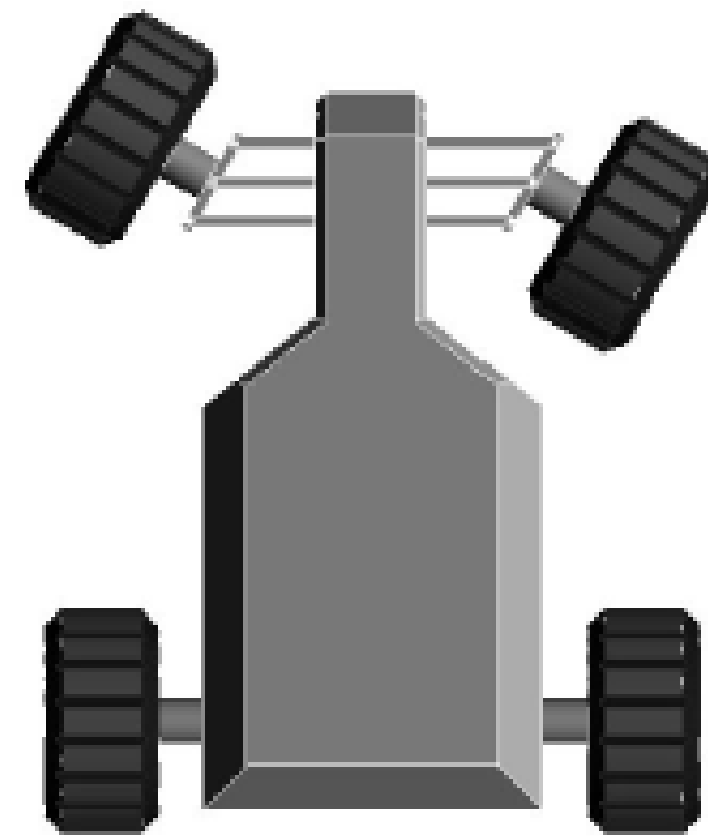
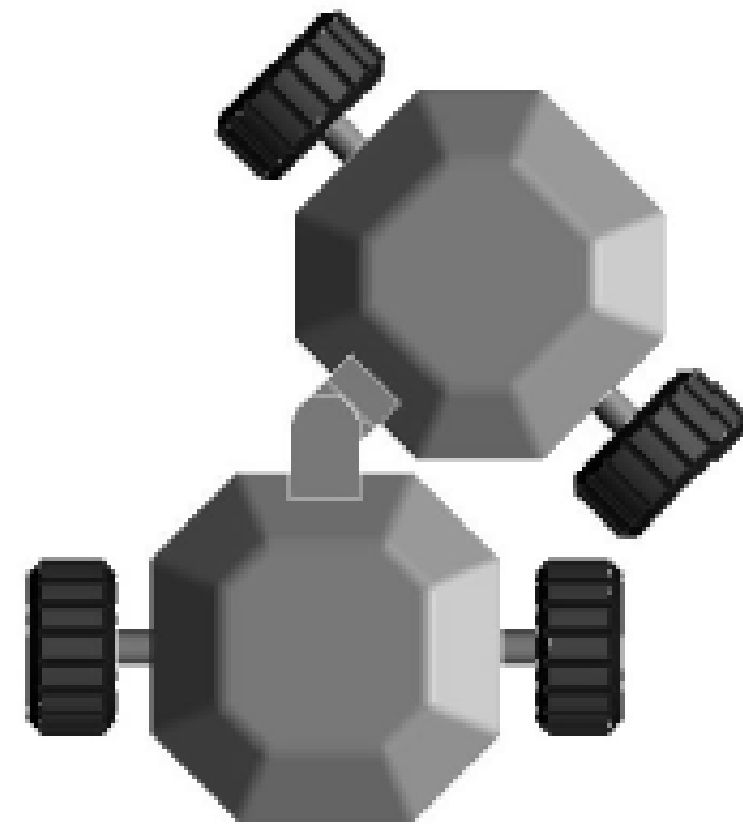
ARTICULATED



COORDINATED
(Ackermann Type)



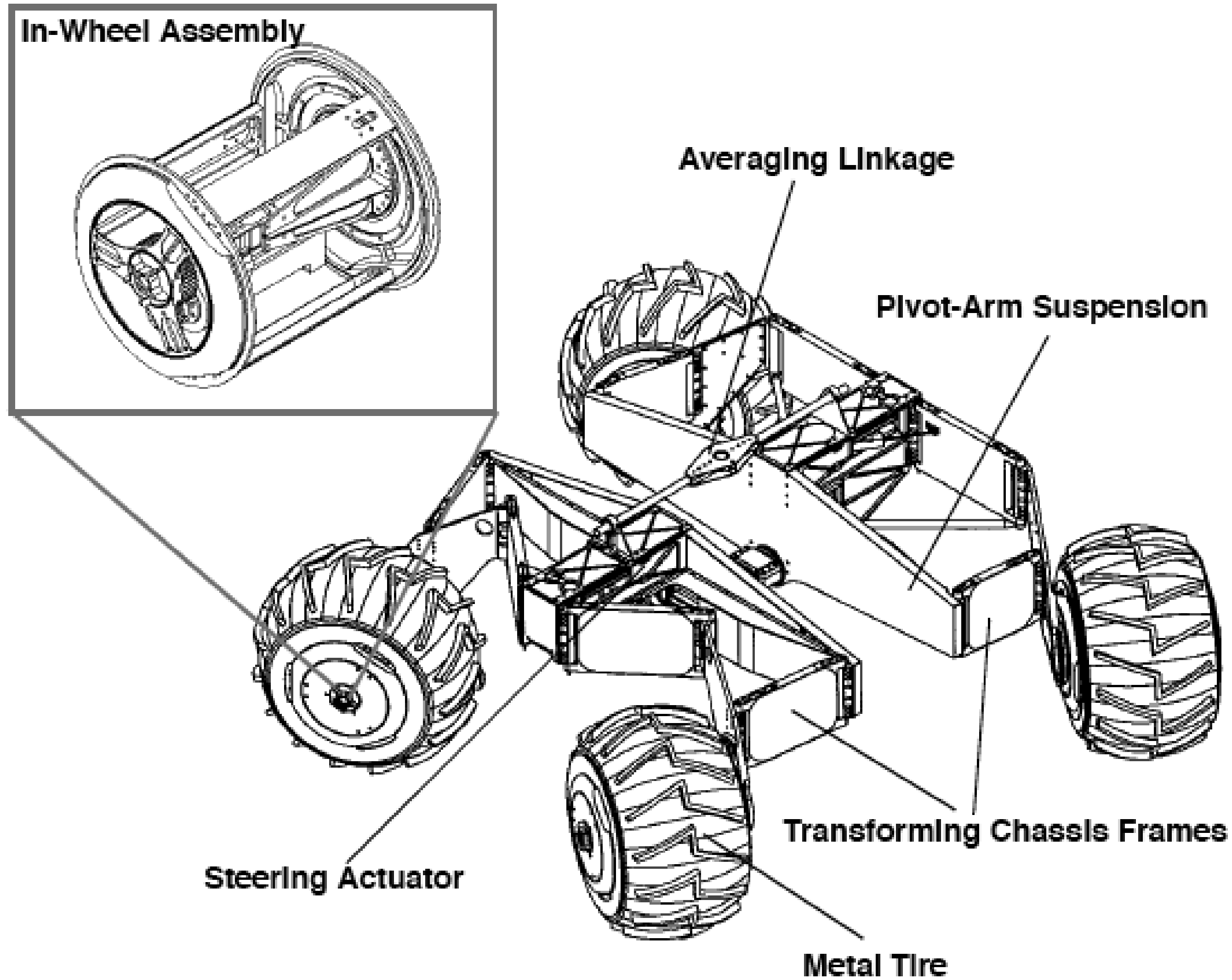
INDEPENDENT
EXPLICIT



Articulating Suspension - Nomad (CMU)



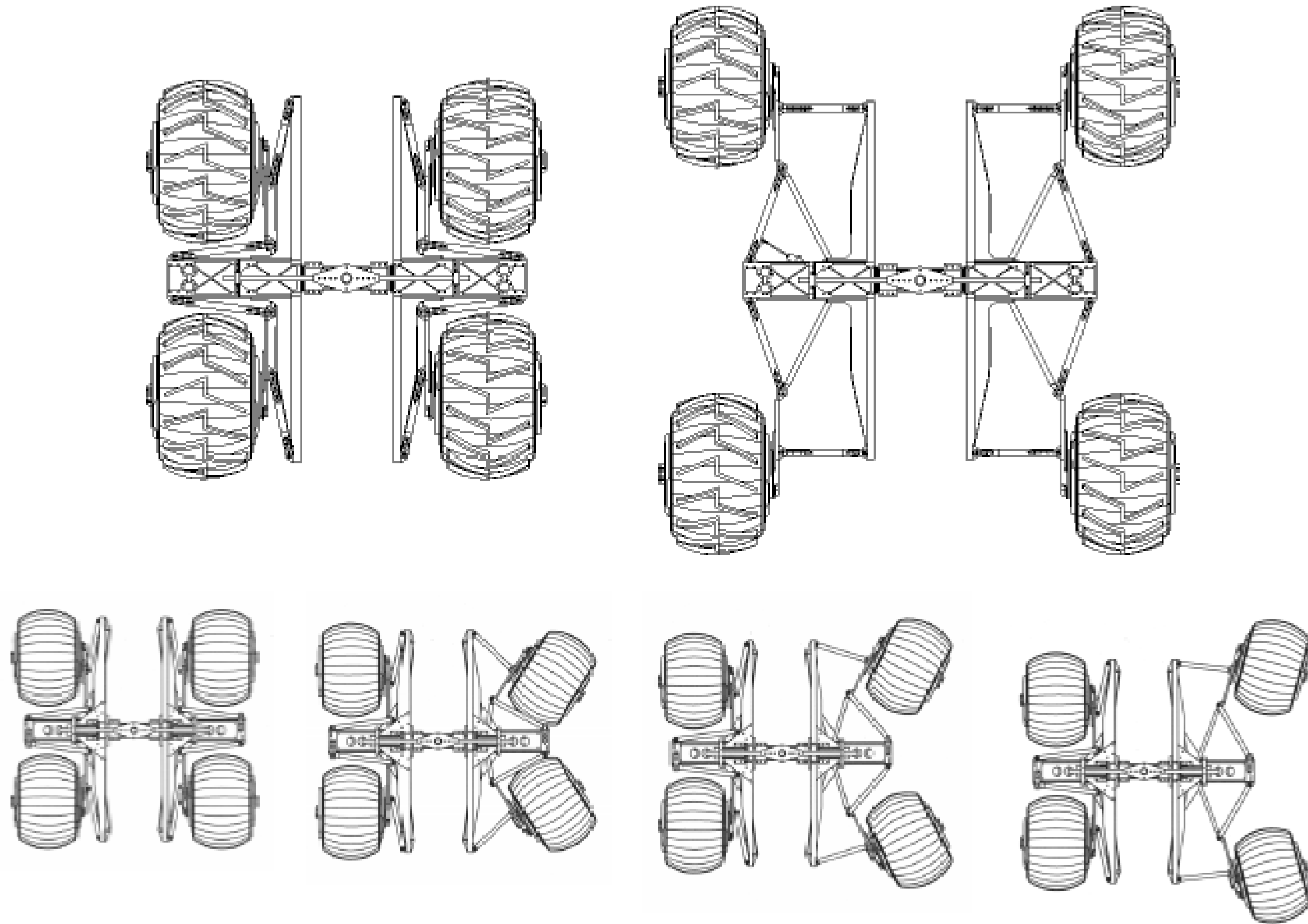
Nomad Transforming Chassis



Nomad in Rough Terrain



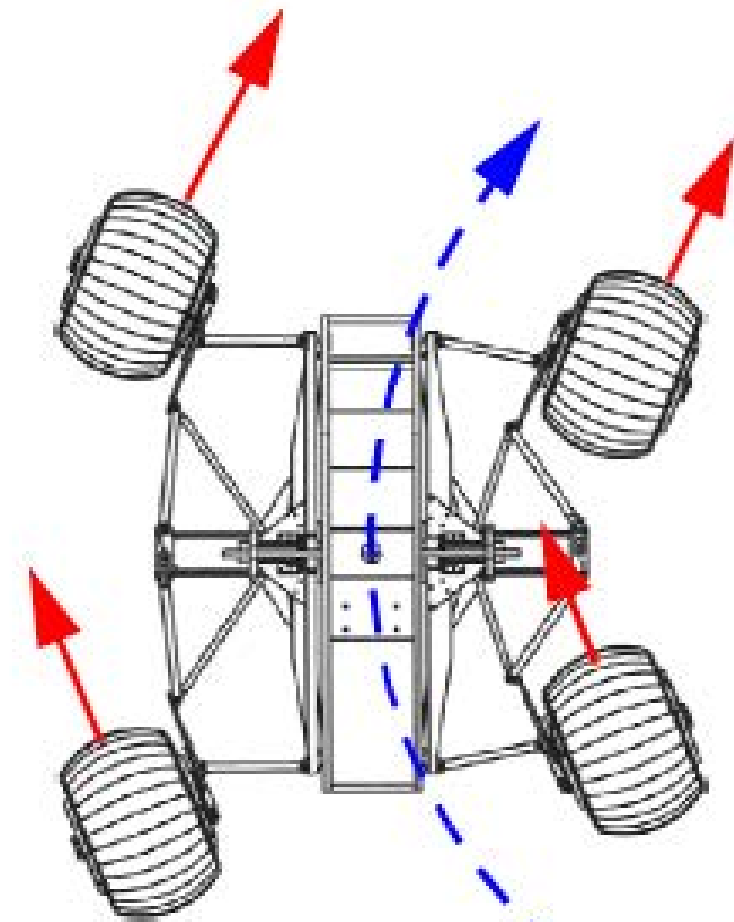
Nomad Chassis/Steering System



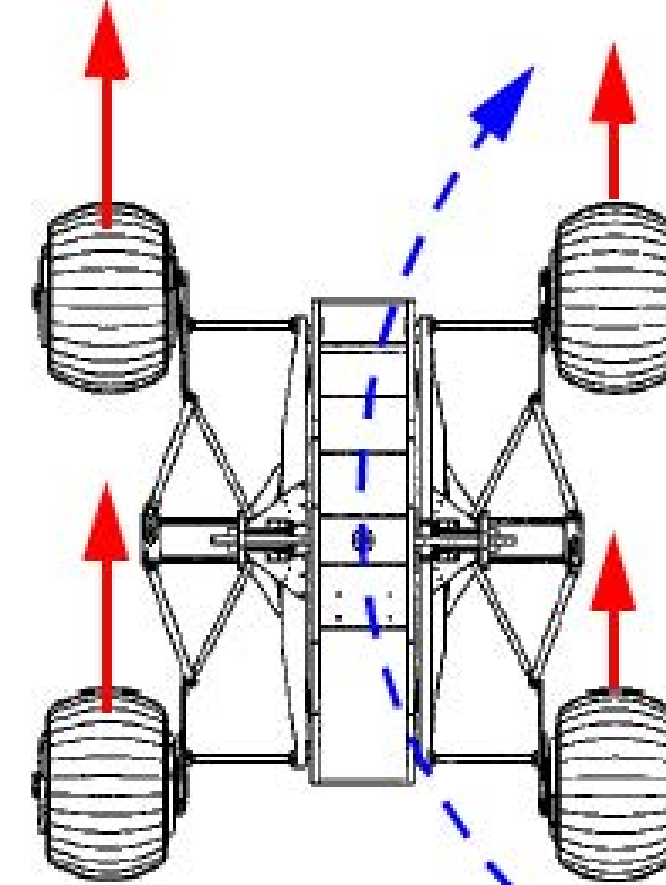
Nomad with Wheels Stowed



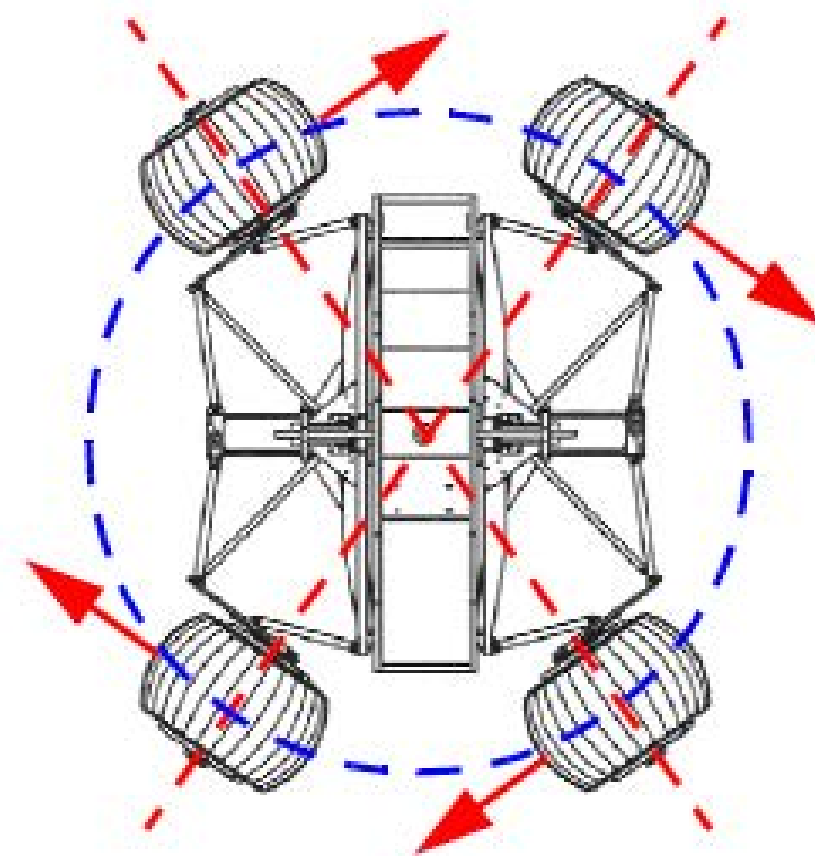
Nomad Steering Schemes



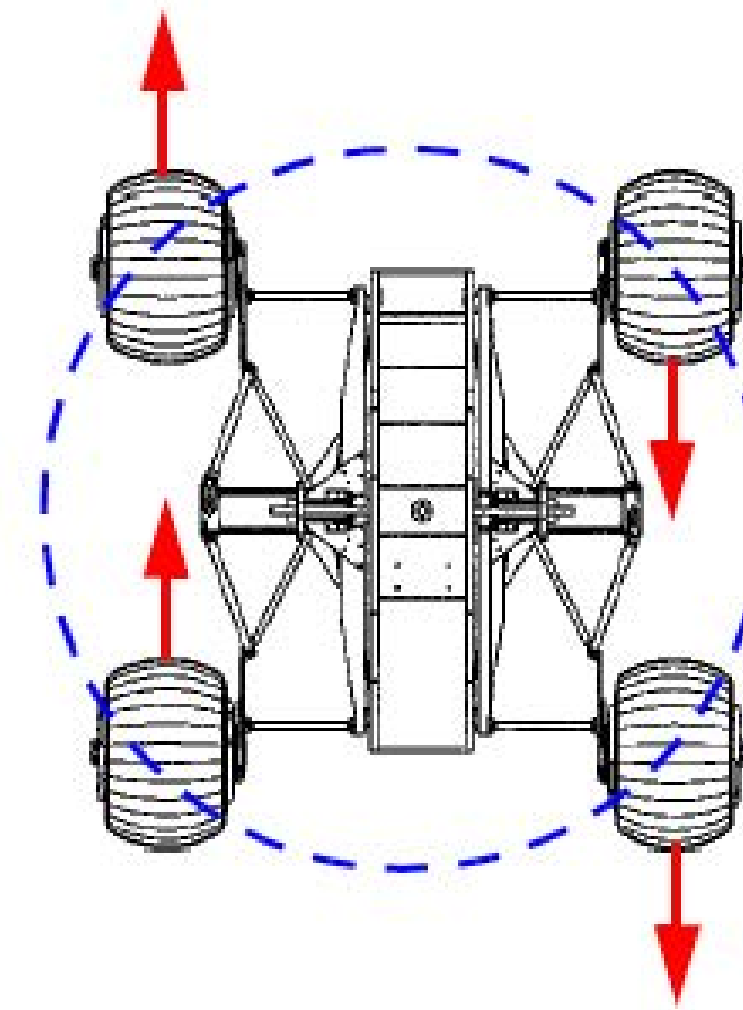
Dual Ackermann



Differential Skid Steering



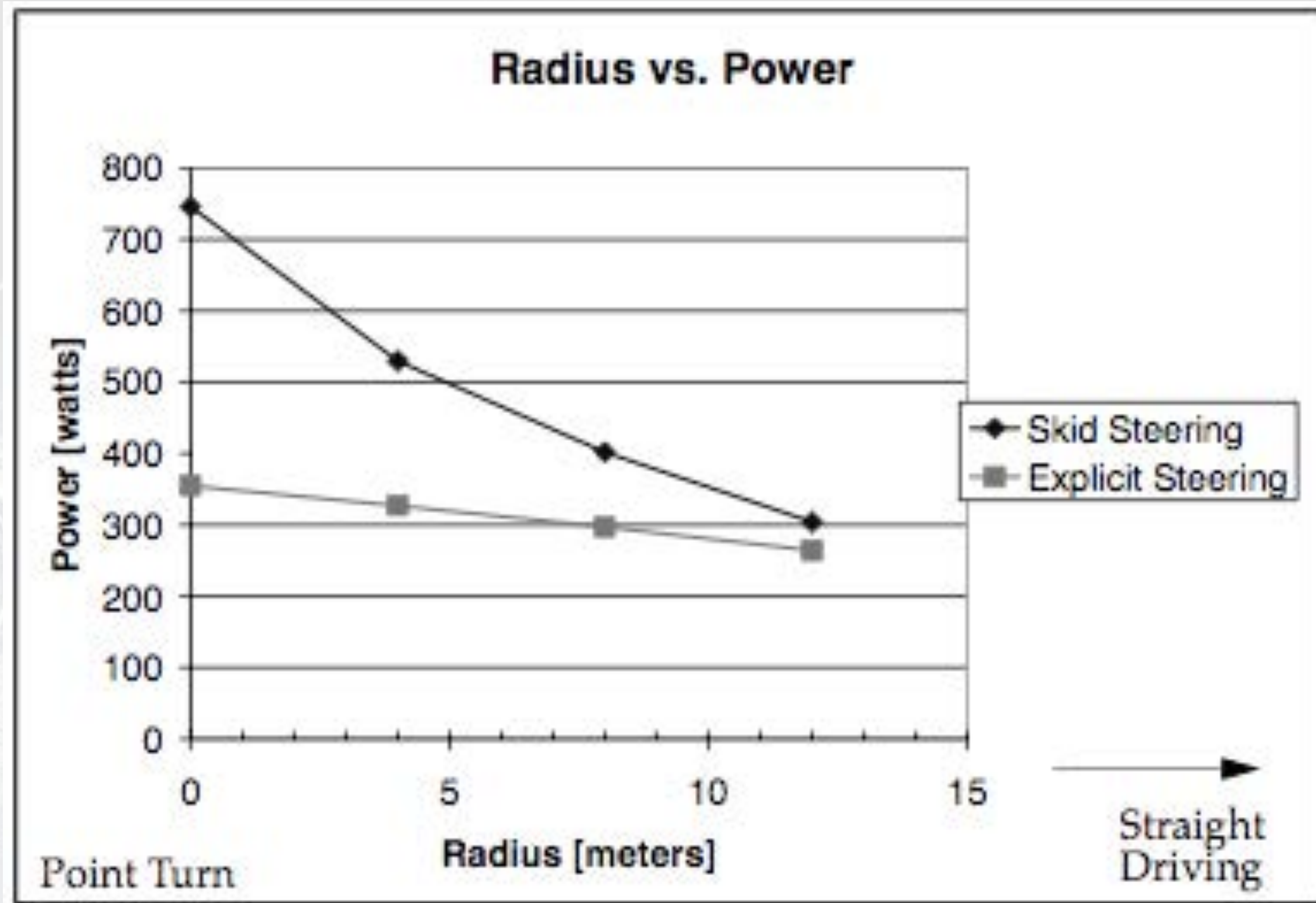
Rolling Point Turn



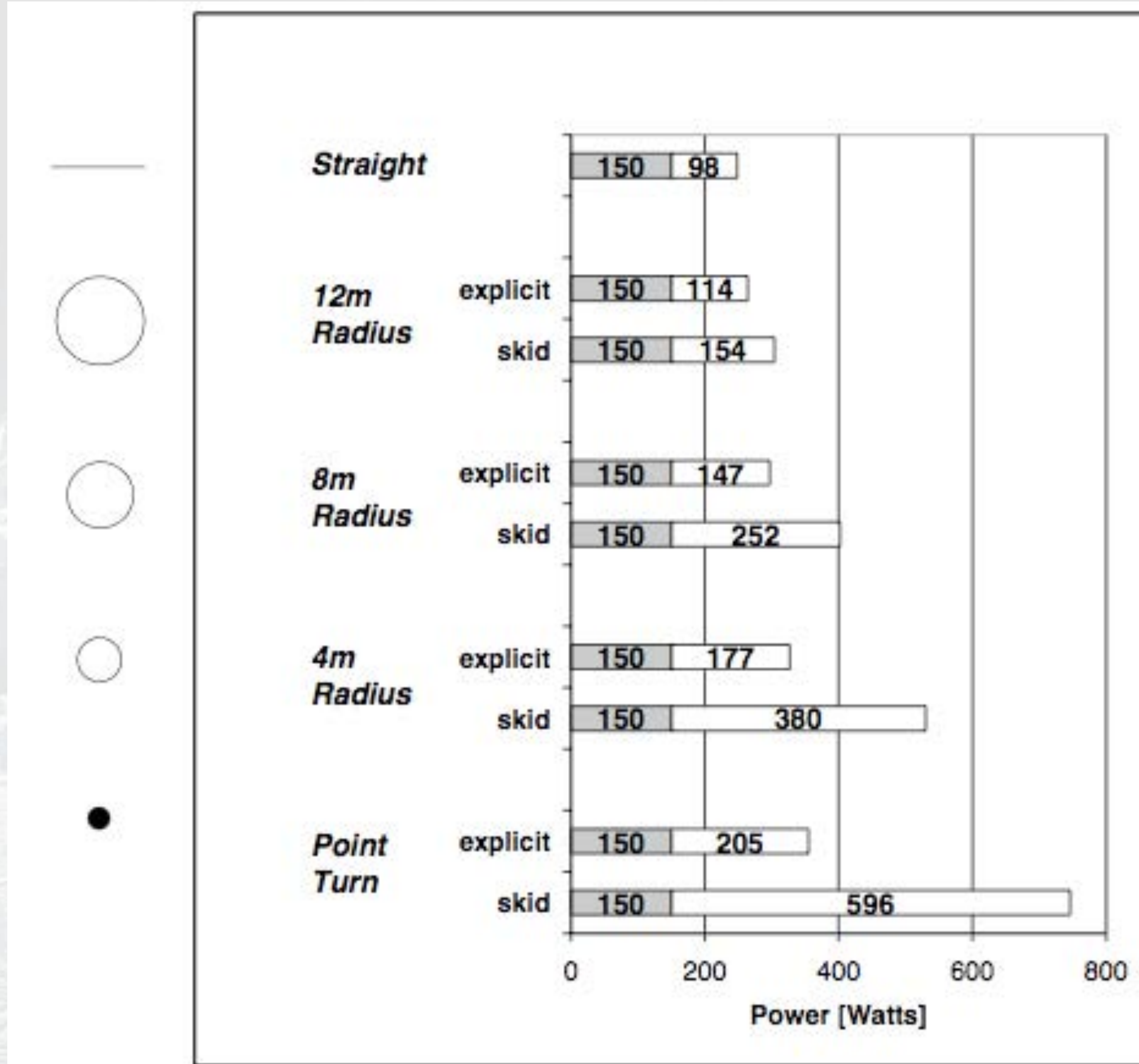
Skid Steering Point Turn



Nomad Power in Skid and Explicit Turns

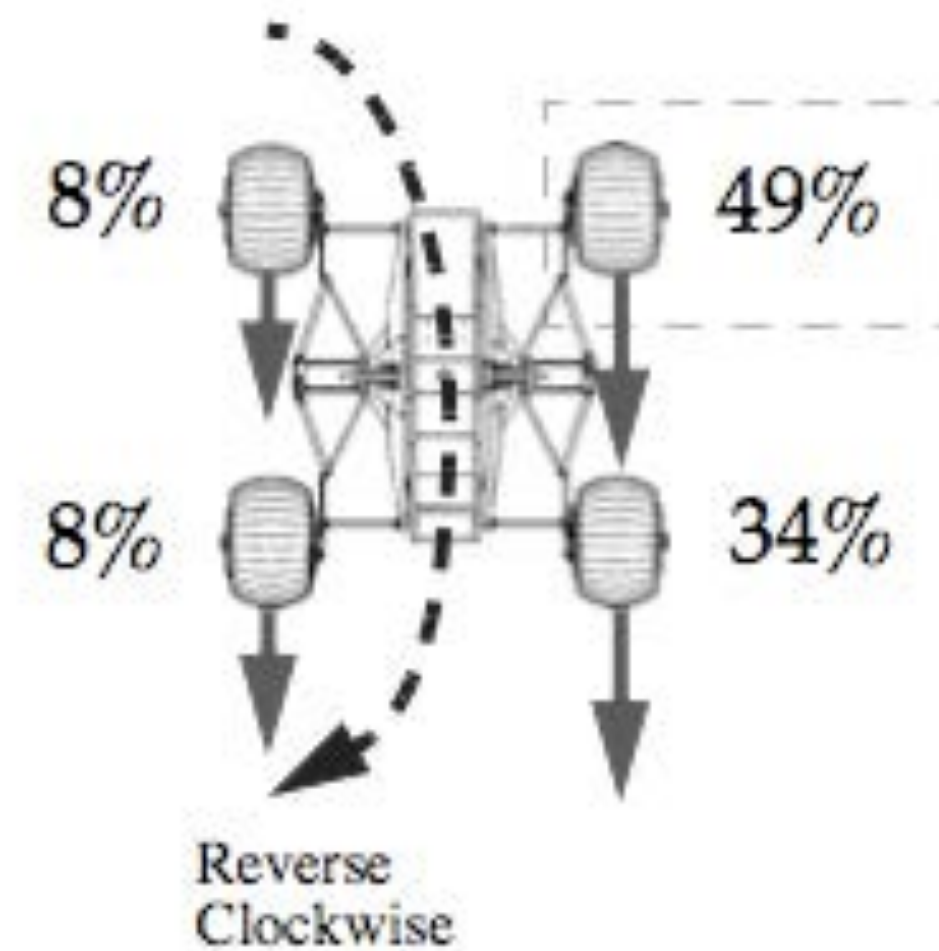
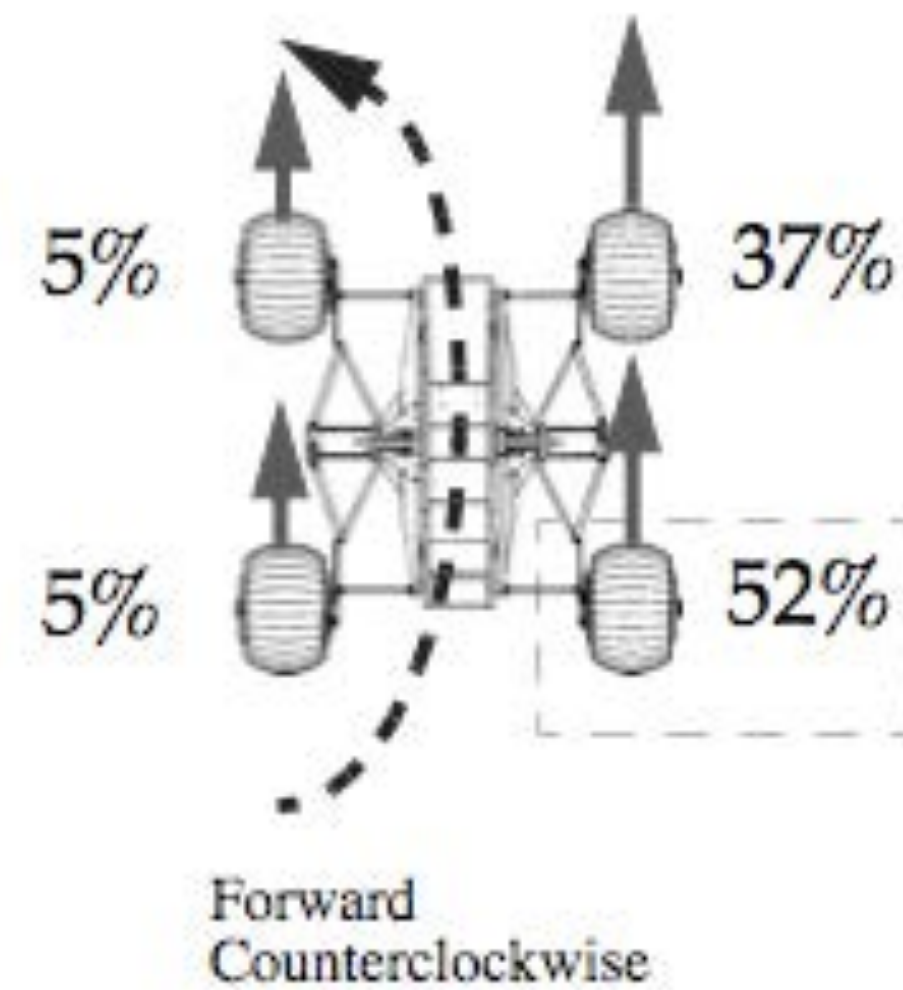
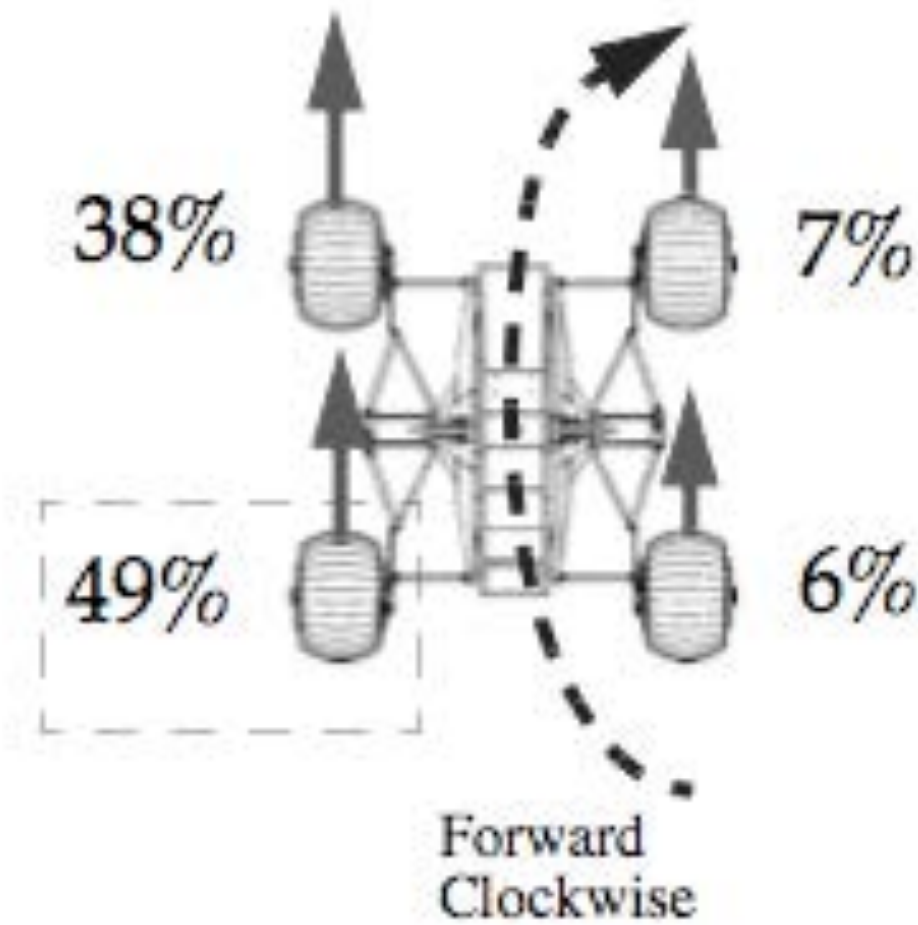


Steering Power Comparison with Fixed Loads



Nomad Wheel Torques in Skid Turn

% of total torque contribution by each wheel for 4m radius skid steering turns



Split-Body Rovers (Sandia Labs)



Ratler (Sandia Labs)



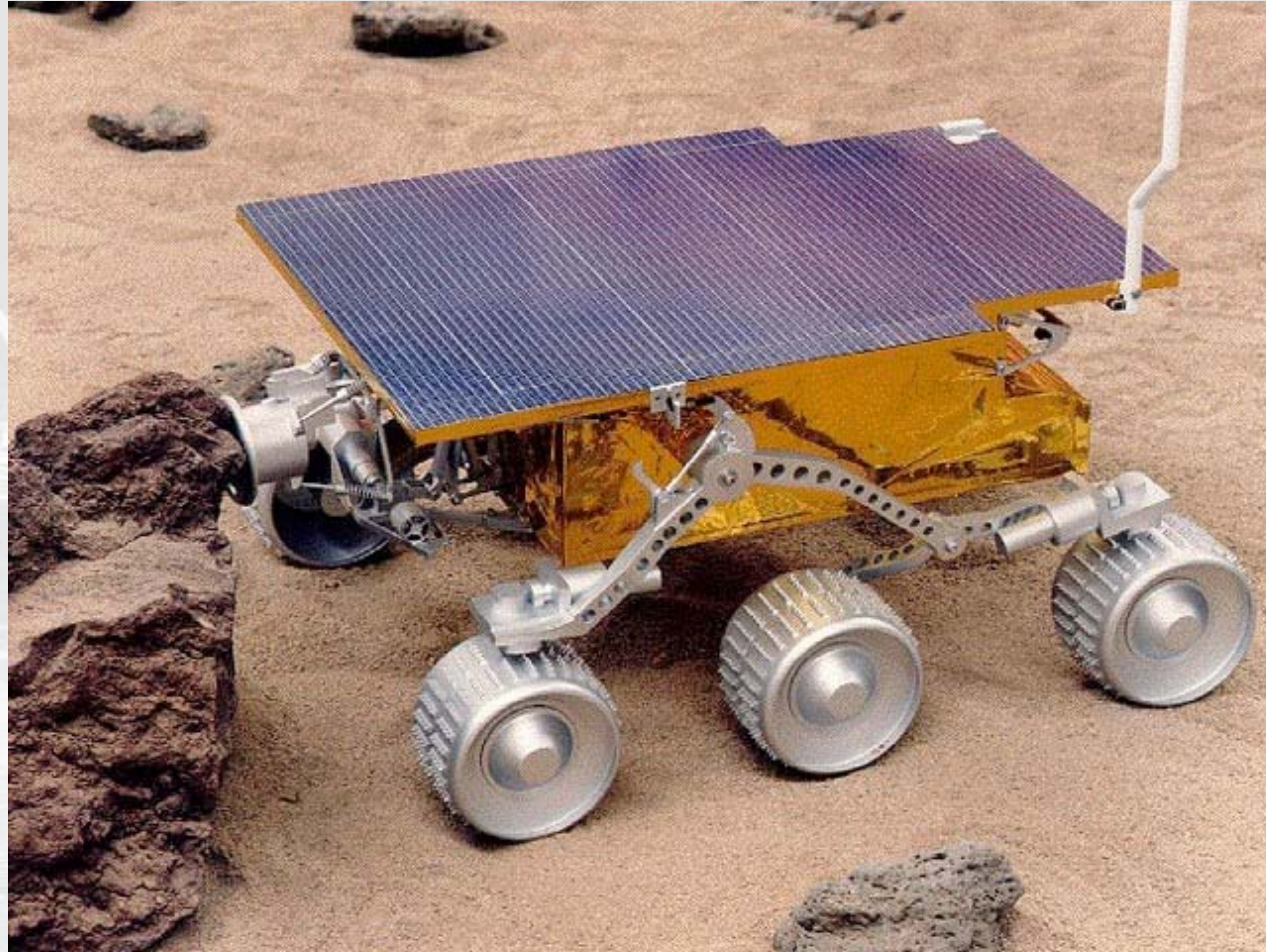
Rocker-Bogie – Rocky 4



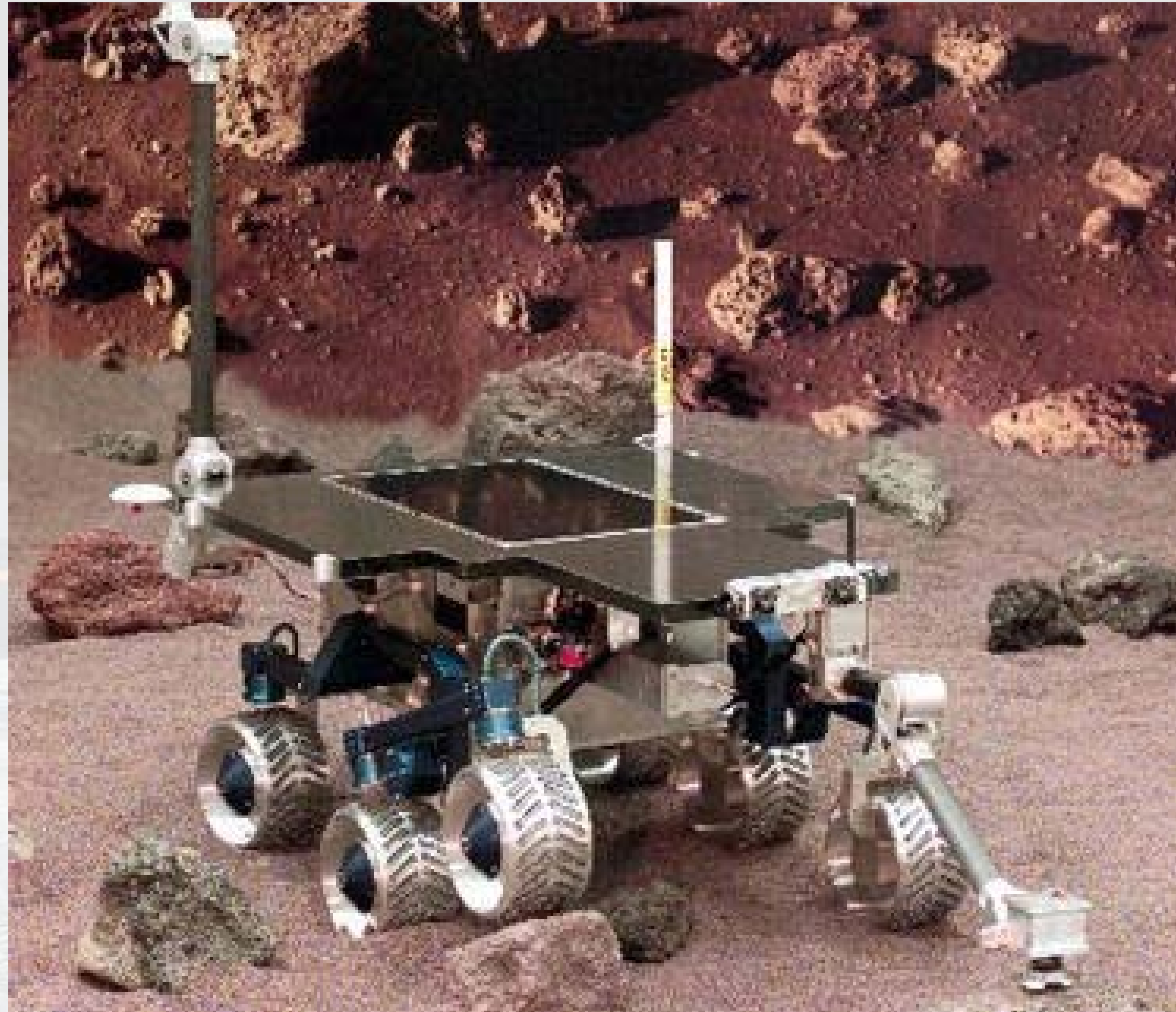
Rocky 7



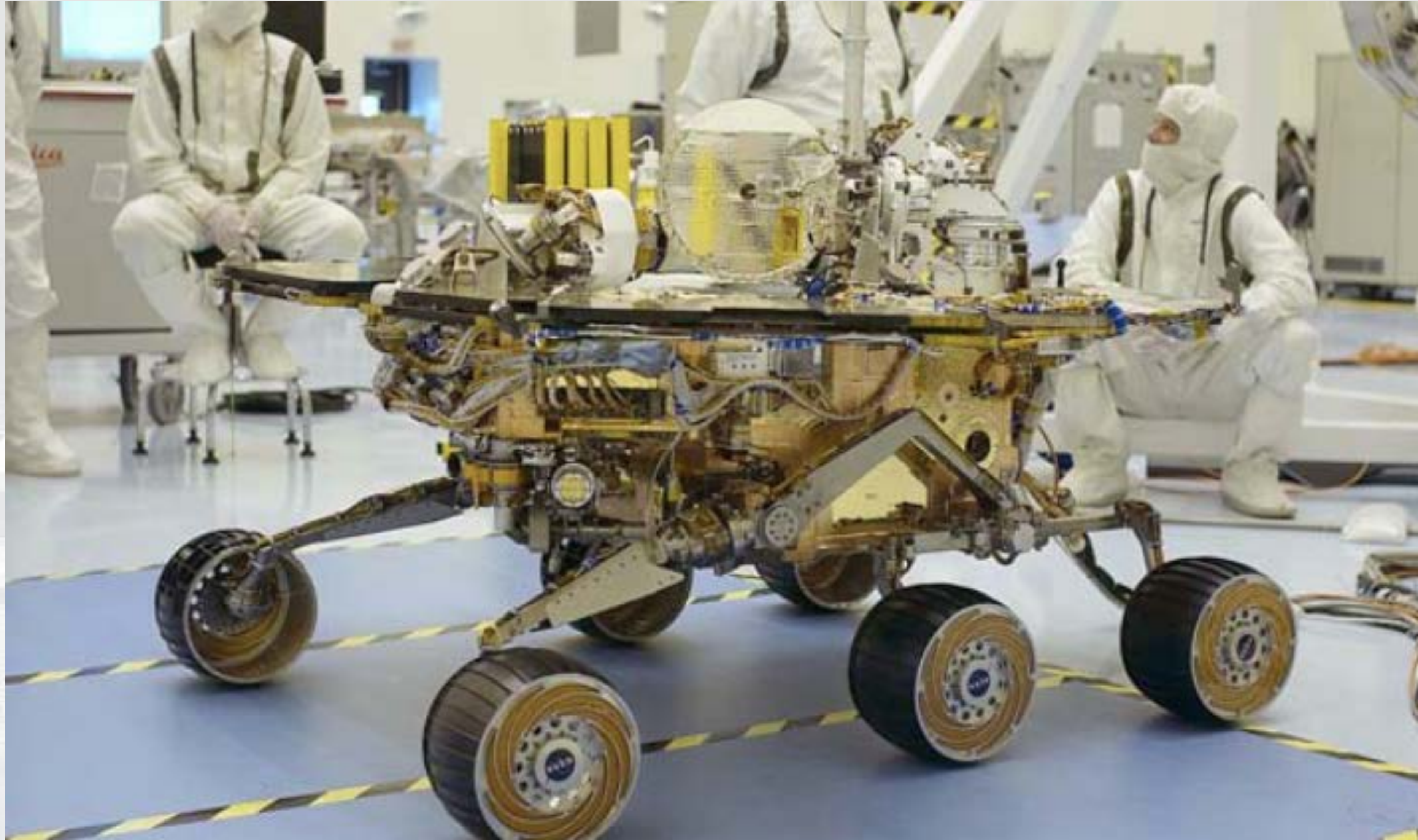
Sojourner



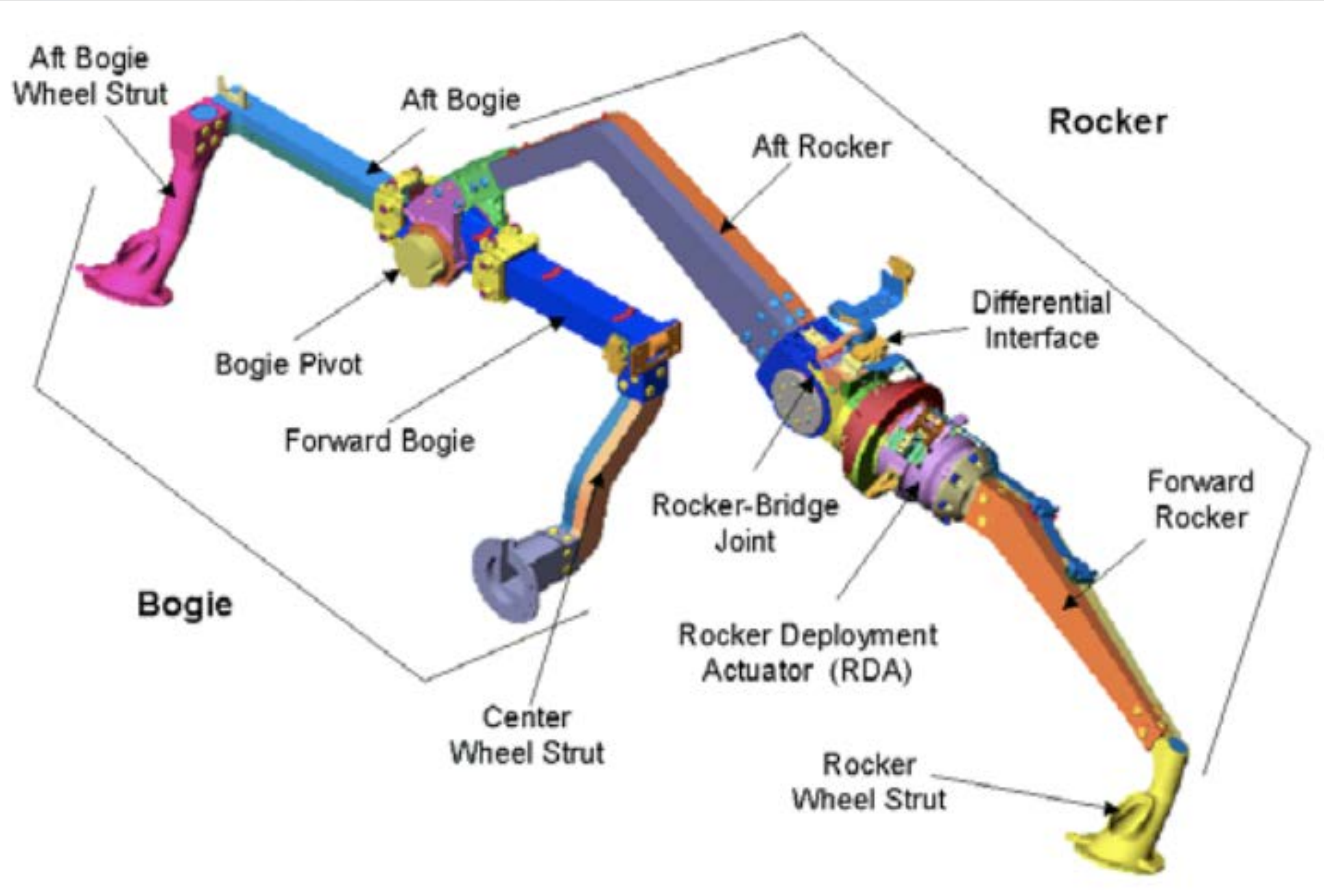
FIDO (JPL)



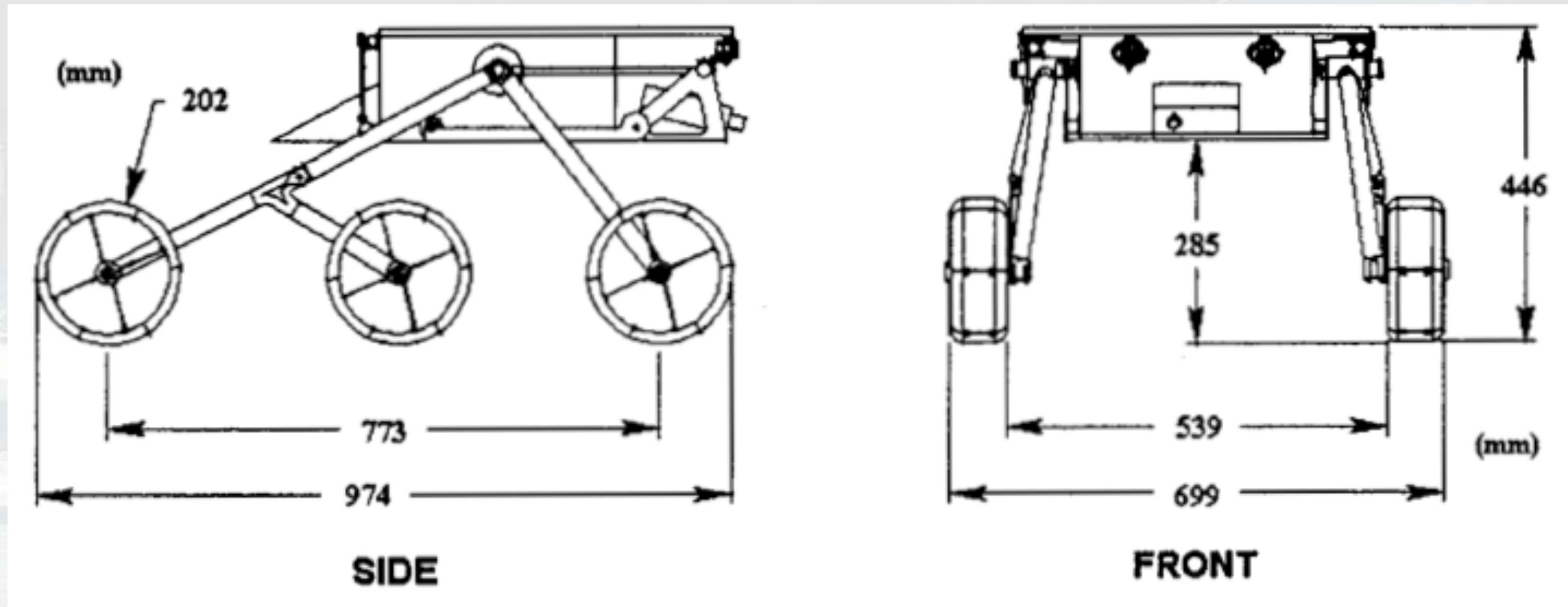
Mars Exploration Rover "Spirit"



MER Rocker-Bogie Configuration



Lightweight Survivable Rover Dimensions



Mars Science Laboratory Development Unit



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MSL Engineering Development Unit

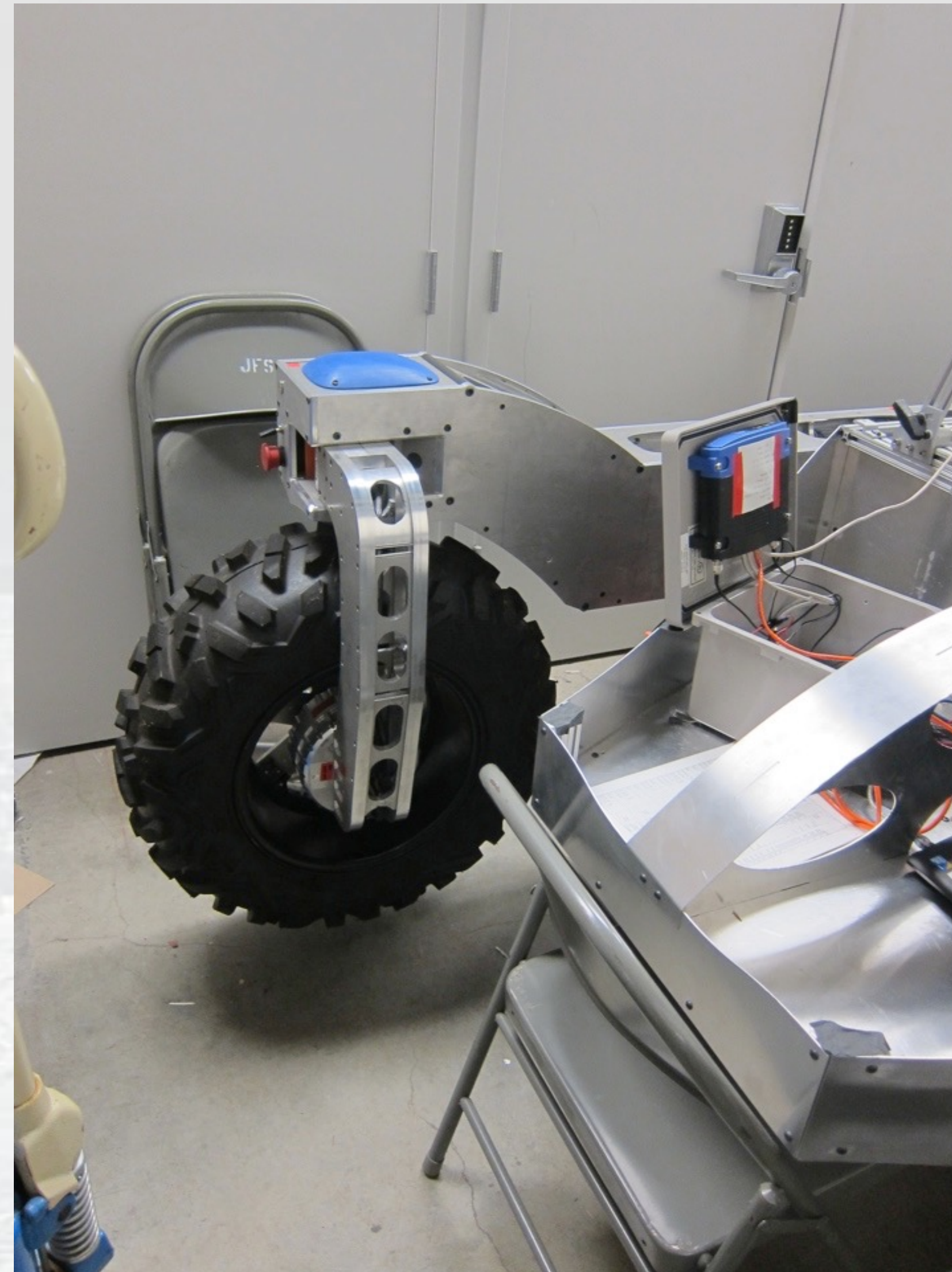


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K-Rex Rover (CMU for NASA Ames)



K-Rex Wheel Drive/Steering System



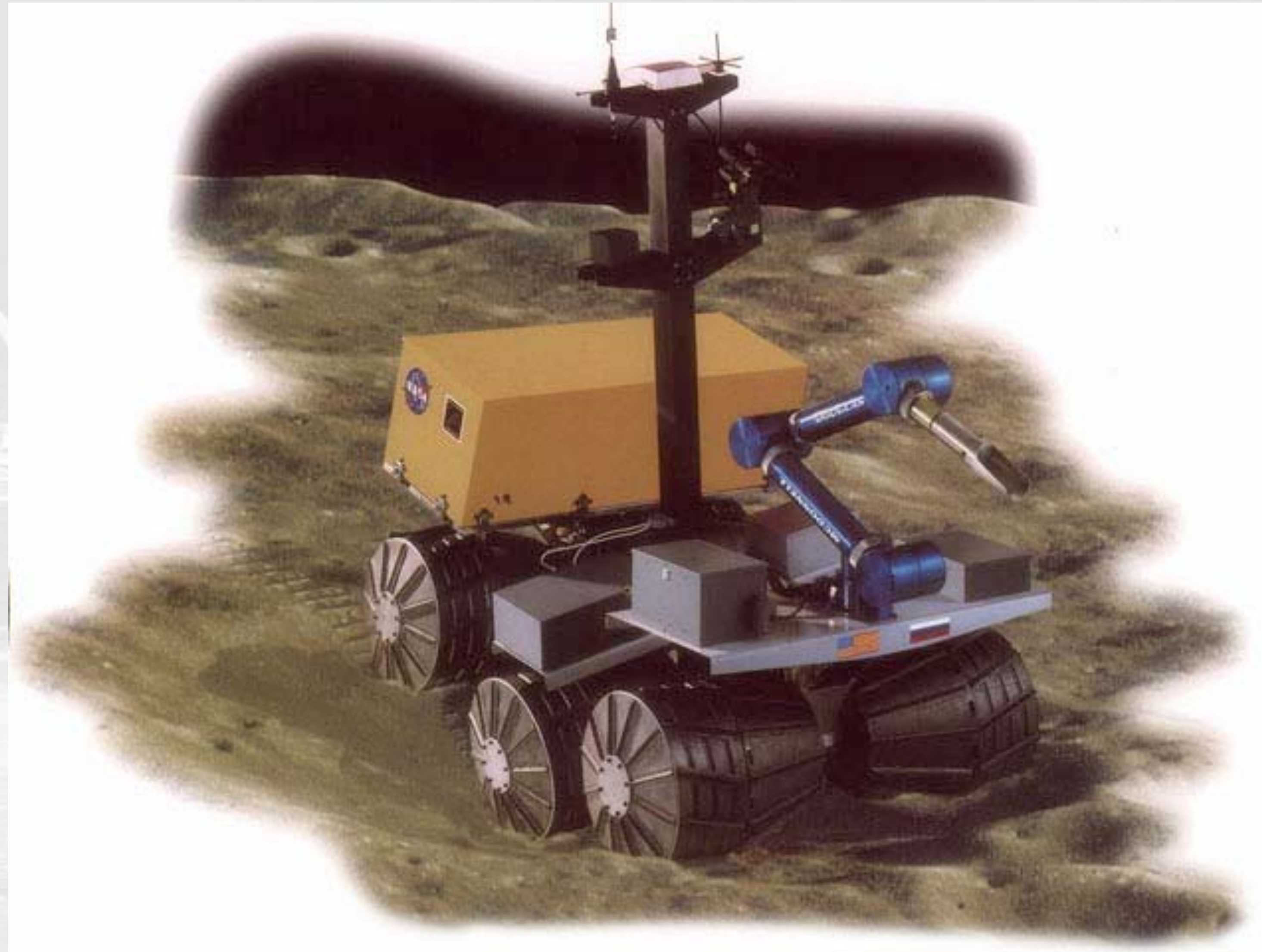
Lunar X-Prize (CMU)



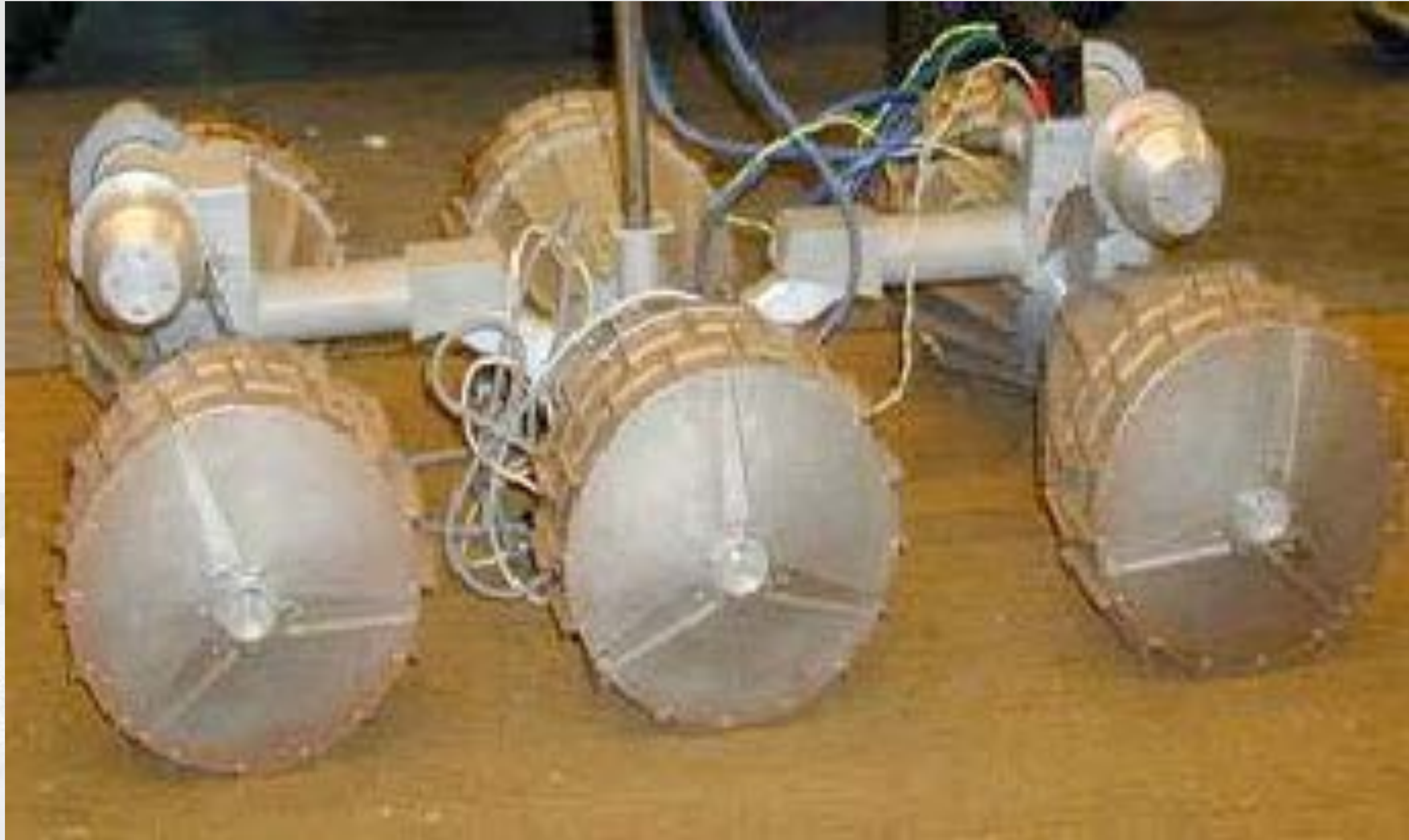
Articulated Bogey Configuration



Segmented Body - Marsokhod



Marsokhod Chassis



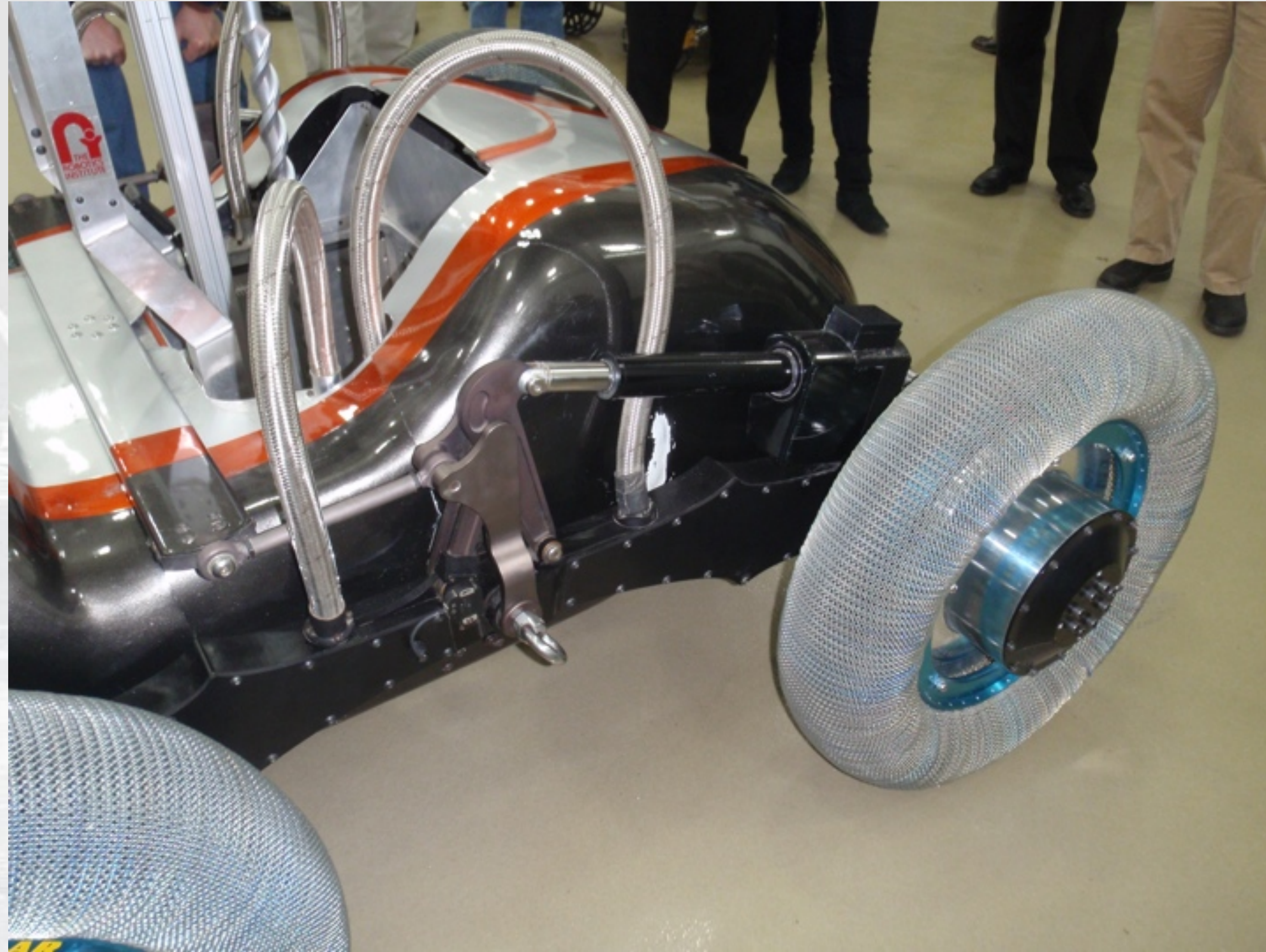
Robby (JPL)



SCARAB (CMU)



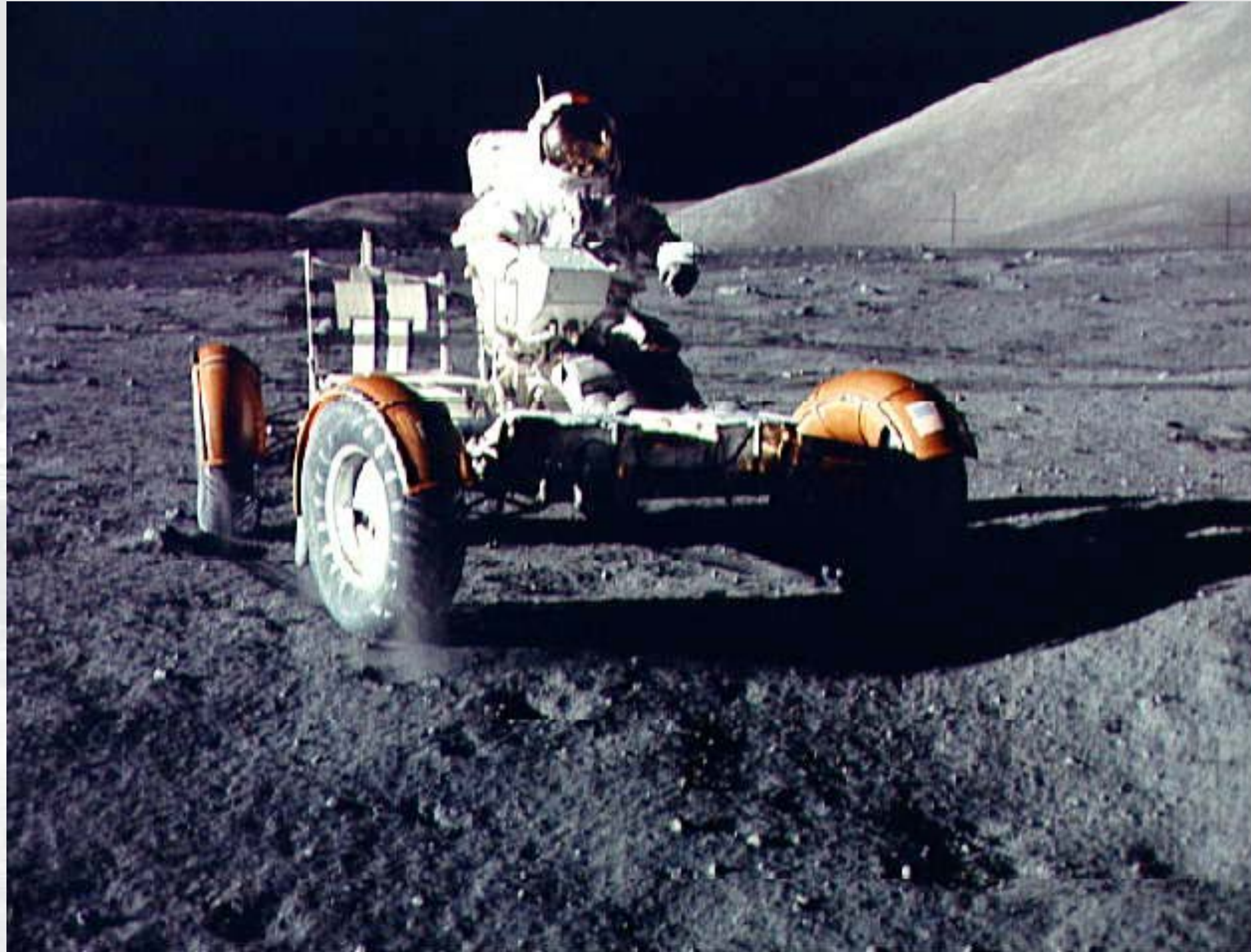
Scarab Wheel Articulation (CMU)



SCARAB at Full Extension (CMU)



Apollo Lunar Roving Vehicle



SCOUT Rover (JSC)



Electric Tractor and Chariot (JSC)



Active Suspension - Chariot



RAVEN in Field Trials



SEV Driving Onto $\sim 20^\circ$ Slope



SEV on $\sim 20^\circ$ Slope



SEV Dual Bogie Soil Contact



ATHLETE (JPL)



Centaur with Robonaut (JSC)



Centaur Body Pose and Turning



VERTEX Rover in BioBot Testing



VERTEX Steering/Suspension Configurations



Go-For (JPL)



Mars Rover (VNIITransmash - Russia)



Tessellator (CMU) (Holonomic)

