# Rover Modelling and Dynamic Simulation on Soft Terrain for Planetary Exploration

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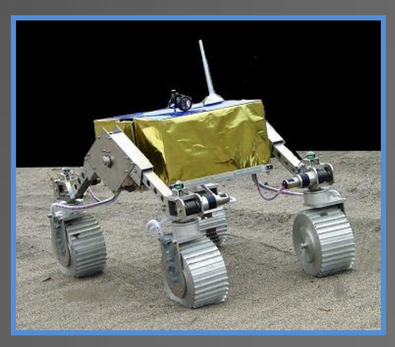
## Objectives

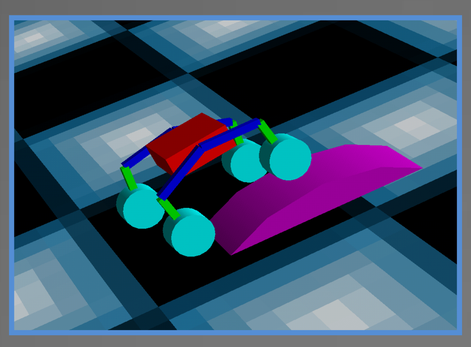
- Surface mobility – priority area of the Canadian space program
- Important for lunar missions and planetary exploration
- Mobile Robotics Development Platform using Vortex

## Vortex Multibody Simulation Library

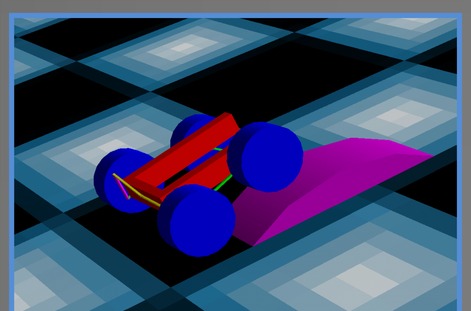
- Real-time, high fidelity, rigid body dynamics
- Extensive set of Multibody Constraints (2 to 6+ bodies)
- Collision Detection and Response
- LCP and Iterative solvers on Lagrangian formulation
- Advanced Modules: Cables, Vehicles, Soft Terrain, Fluid
- C++ Toolkit and Visual Editor

Tohoku

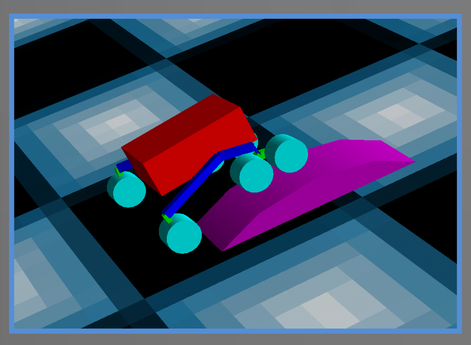




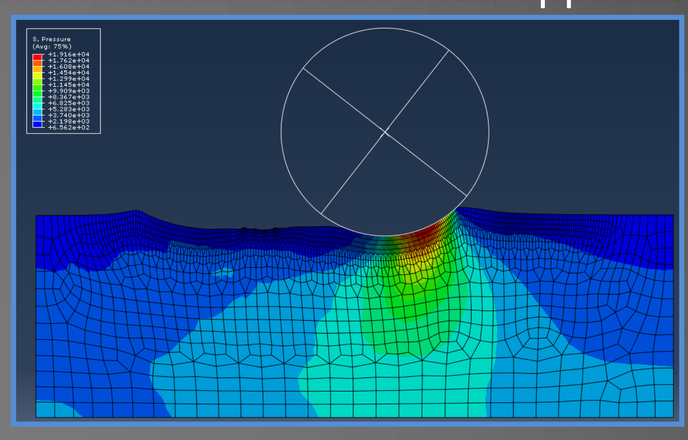
Juno



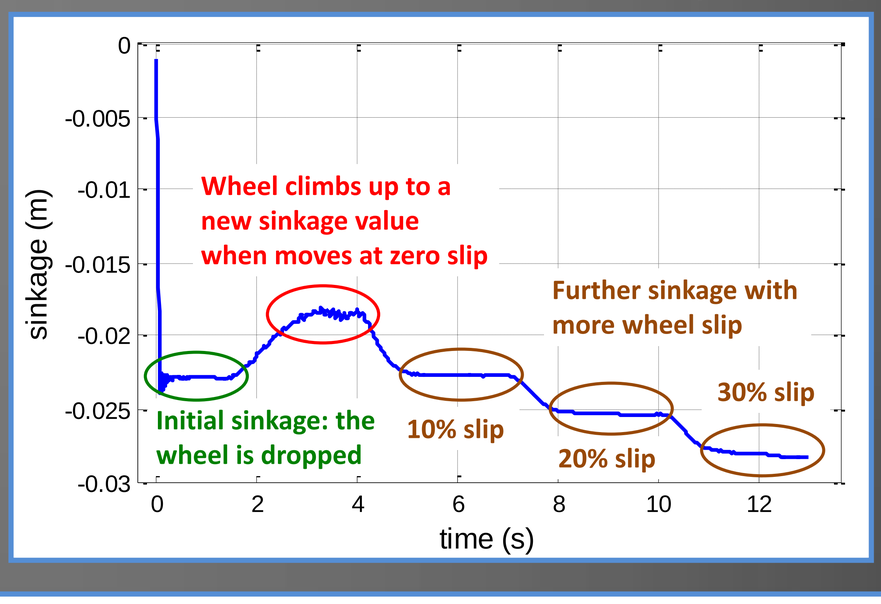
Rocky 7



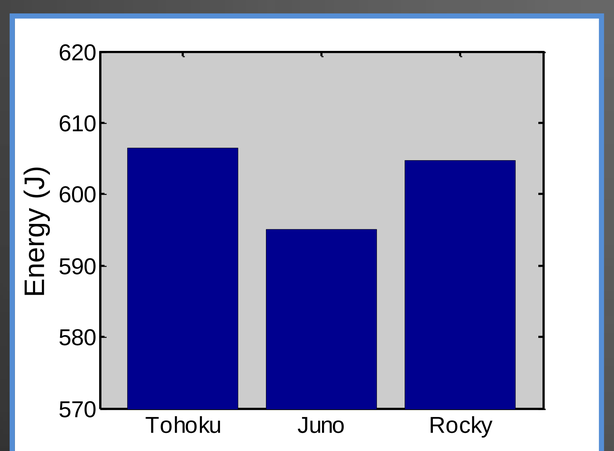
Detailed FEM simulation using Abaqus/Explicit: not suitable for real-time applications



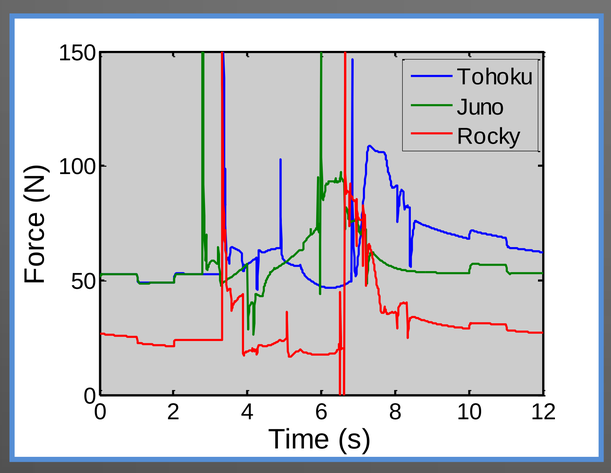

A novel model based on Plasticity Theory




Energy expenditure of rovers climbing 15° slope with obstacle



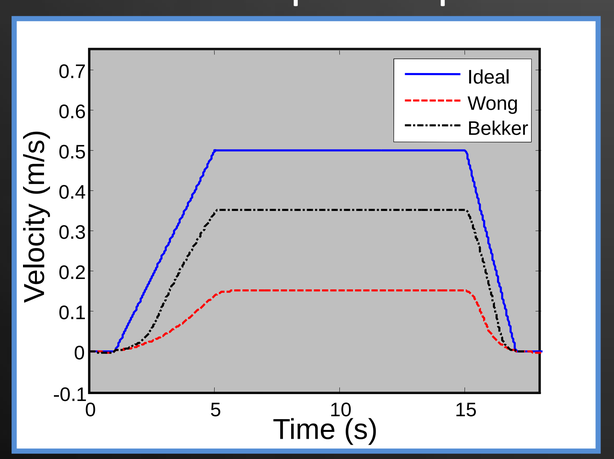

Tangential force of right-front wheel on 15° slope with obstacle




**The novel plasticity-based model**

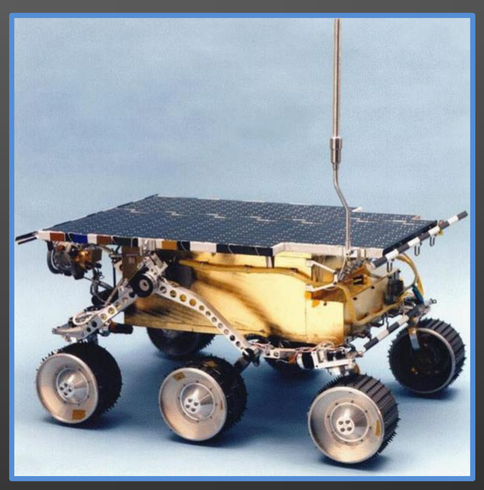
- Captures dynamic phenomena
- Addresses slip-sinkage effects and interaction
- Incorporates soil compaction and hardening (multipass)
- Appropriate for real-time applications

Travel up 5° slope




| Soil Model | Distance travelled | Energy expended |
|---|---|---|
| Bekker | 4.42 m | 675.7 J |
| Wong | 1.87 m | 914.4 J |

Sojourner rover



High-fidelity model in Vortex with soil compaction and hardening