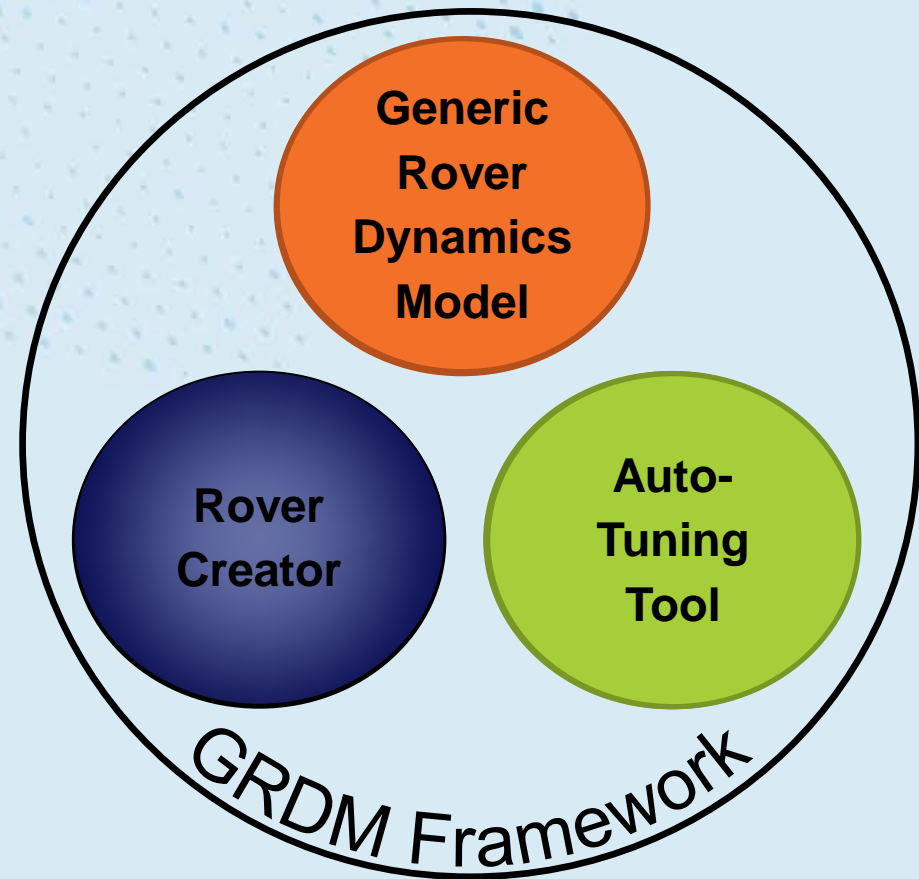


# UK Space Agency CREST-2 **GRDM** Generic Rover Dynamics Model Framework for Autonomous Capability Development, Verification and Validation

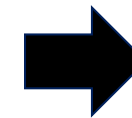
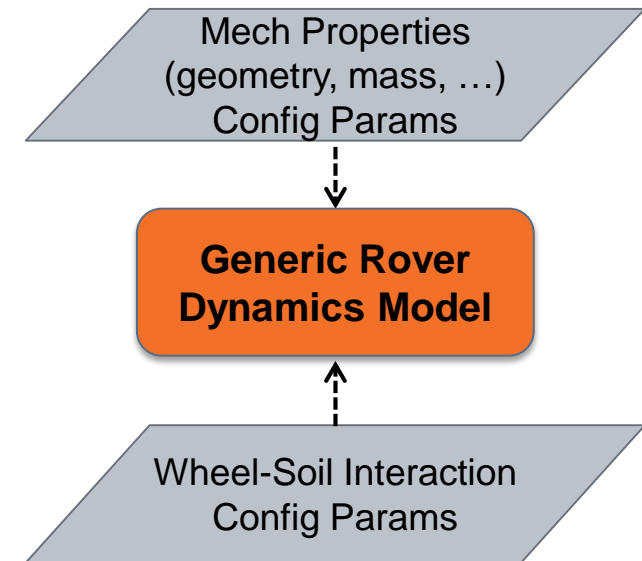
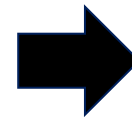
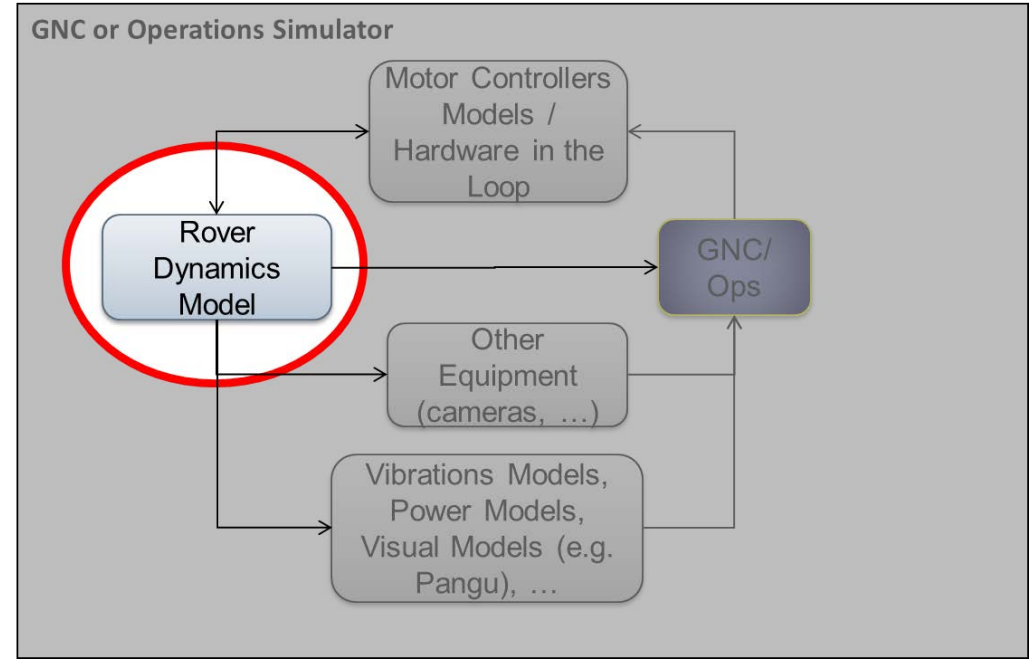
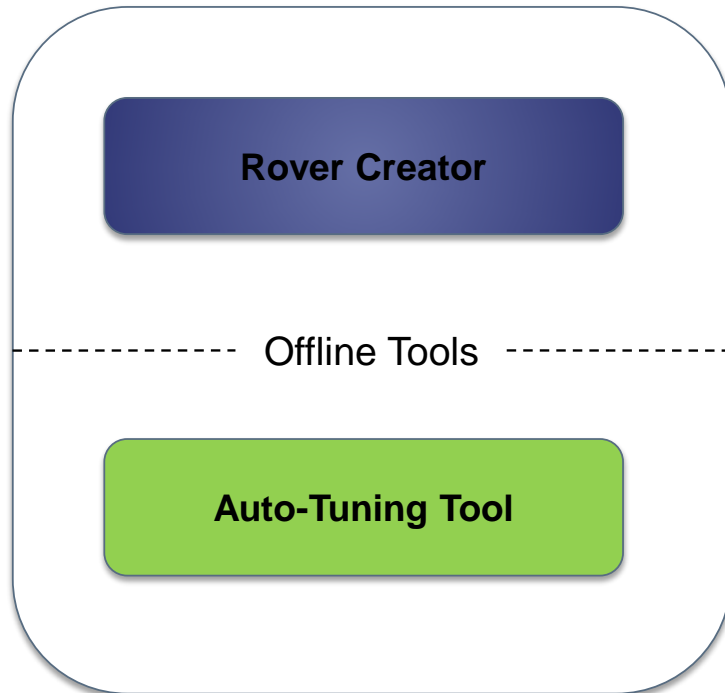
ESA ASTRA Conference  
May 2015



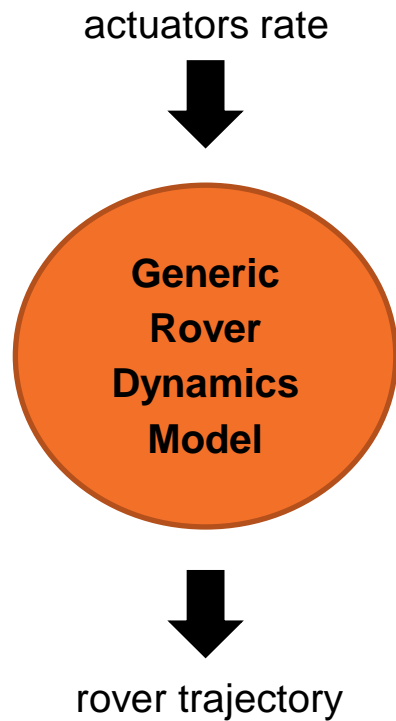
*Daisy Lachat*  
*GRDM Framework Project Manager & Technical Lead*  
*Airbus Defence and Space Ltd.*

# Introduction

- Building block of a GNC/Ops simulator
- Rapid development iterations in simulation for various mission scenario
- Includes offline tools to create new tuned rovers



# Overview: The Model

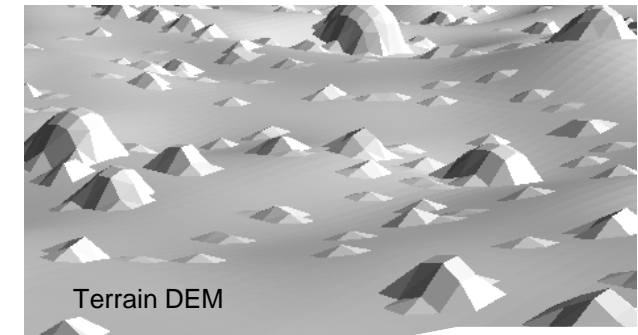
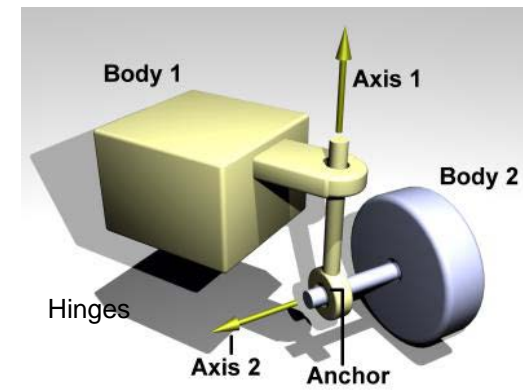
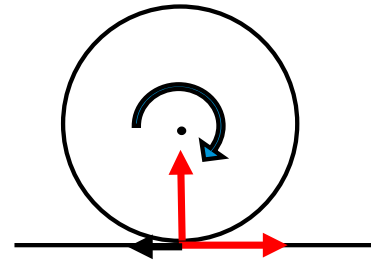


- Simulate the dynamics of a wheeled rover on an unstructured terrain, including slippage on sand and rock climbing ability
- Is a performance model of rover dynamics
- C++ SMP-2 compatible dynamic/shared library which can be used in conjunction with a simulator
- The purpose of this model is to offer a tool to support the study of rover GNC and operations as well as for the preparation, rehearsal and replay of field trials.
- This tool is not suitable for the study of locomotion performance: the model is not used to *study* locomotion performance, it *reproduces* locomotion performance for the purpose of the study of GNC/Operations

# GRDM – The Model

## GRDM includes

- Articulated rigid bodies dynamics calculation
- Hard contact constraints: collision detection, contact enforcement
- State integration between time steps, i.e. including solver of the dynamic system

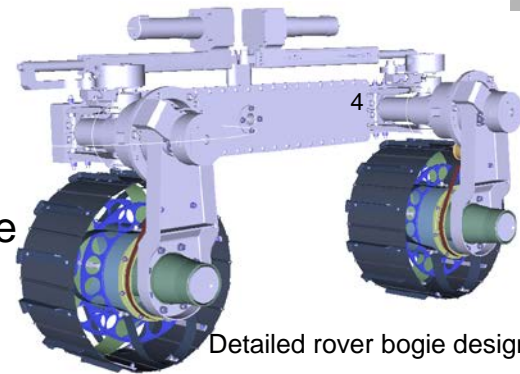


## Terrain Model

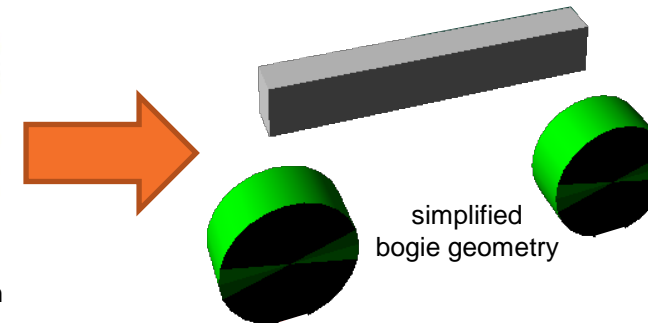
- Digital elevation map into non-deformable triangular mesh
- Rocks are incorporated within the mesh
- Soil properties associated to each triangle

## Rover Model

- Chassis, bogies, wheels, active&passive hinge



Detailed rover bogie design

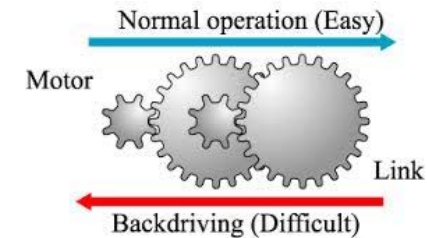


## Collision Model

- Collision detected between the terrain and the rover parts

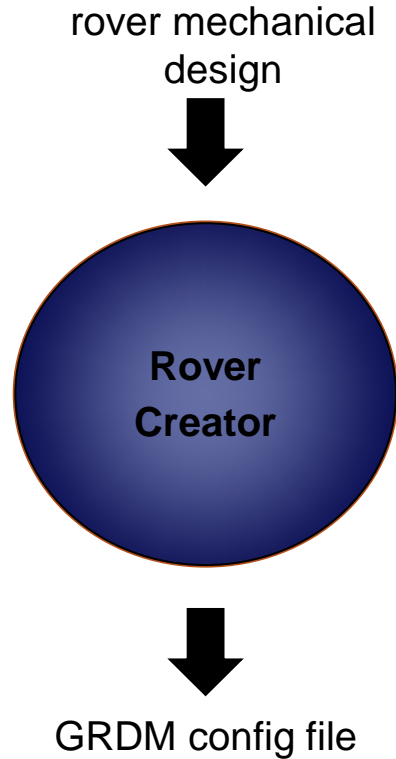
## Motor Model

- GRDM includes a partial motor model: backdrivability, torque limit, mechanical stops



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# Overview: Rover Creator

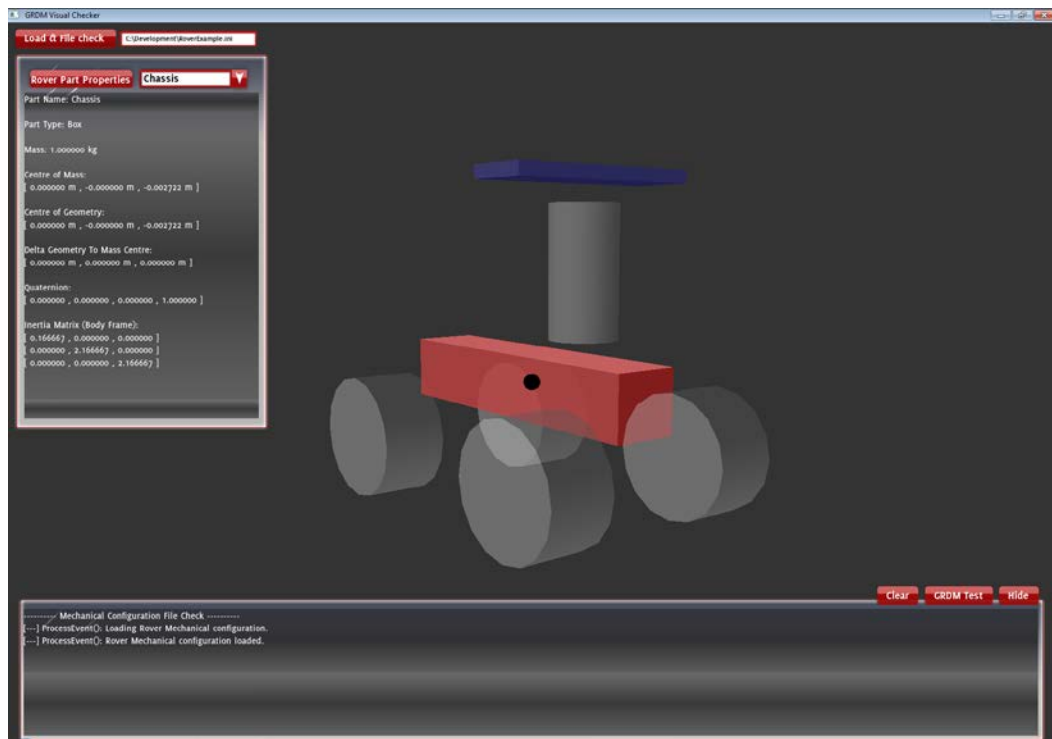


- Tool provided to create the rover mechanical configuration file required by the model
- Human readable file format
- Visual Checker application
- Using off-the-shelf 3D editor (Blender) and add-in for exporting the file

# GRDM Rover Creator: Two Ways to Create the Configuration

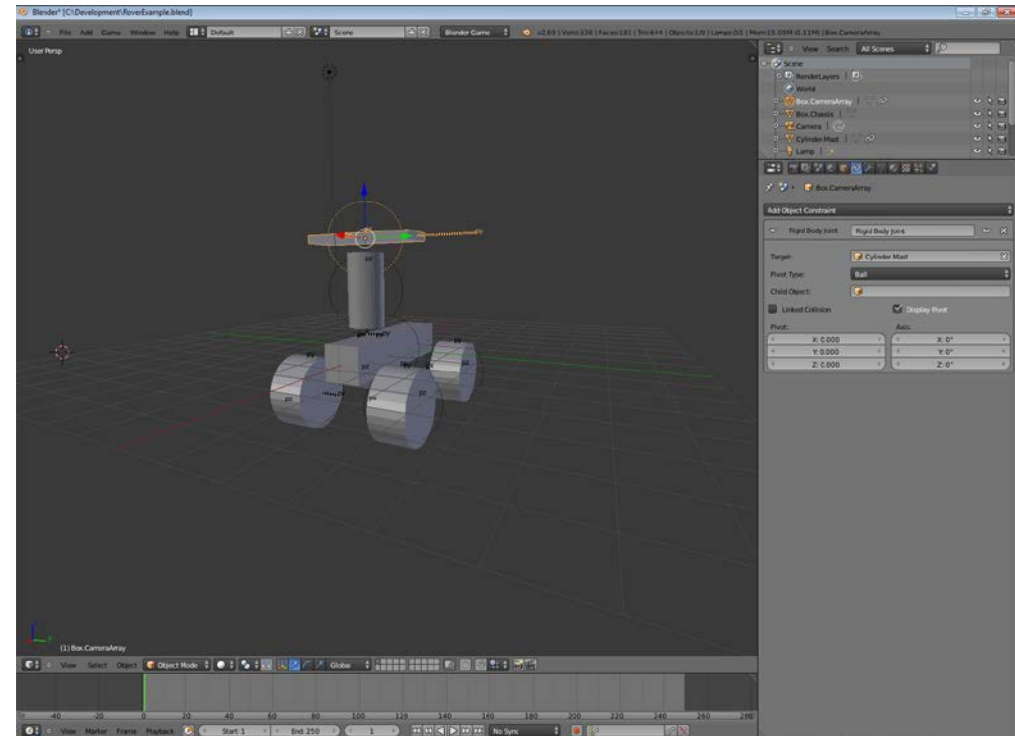
## Fully documented simple file format + Visual Checker tool:

- Rapidly perform a visual check of what has been defined in the file
- Performs a simulation check which runs the GRDM for one simulation step to test if any errors are observed



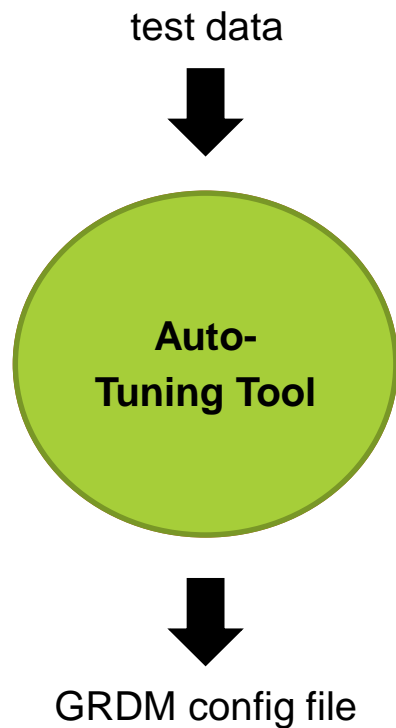
## Using existing 3D editor:

- Blender and an Add-in for exporting config file
- Step by step guide
- Can also use Visual Checker tool after export



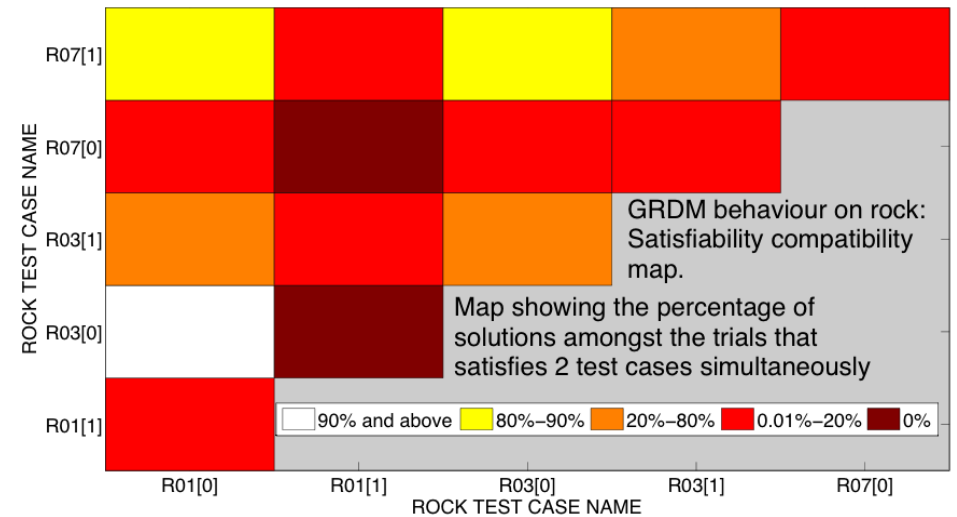
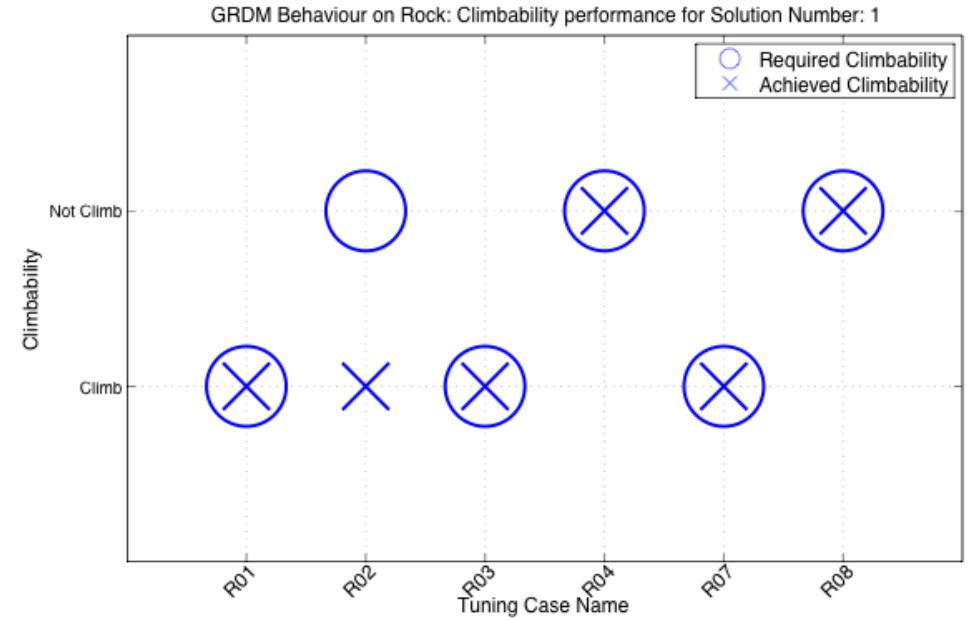
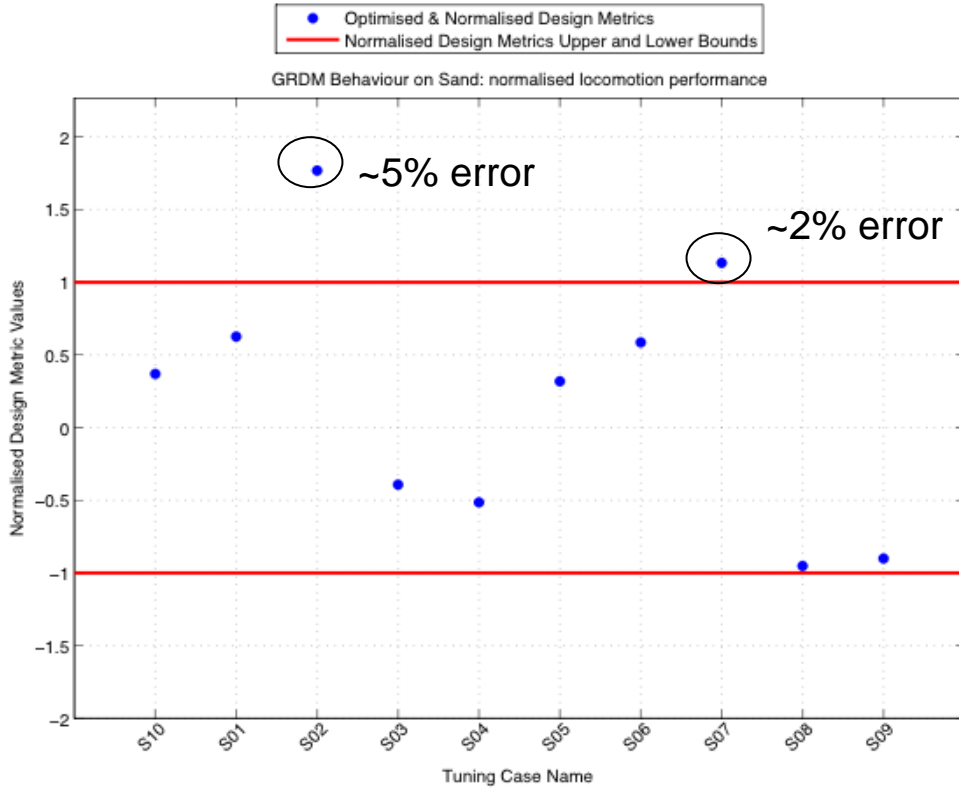
➔ GRDM reads the Rover Configuration file and create a rover based on the configuration defined within the file.

# Overview: Auto-Tuning Tool



- Tool provided to create the wheel-terrain interaction configuration file required by the model
- Performs tuning of the model parameters to define the locomotion behaviour
- Aims to match the model behaviour to testing data of locomotion performance
- Needed as the model is a performance model which implements a simplified wheel-terrain interaction model (needed to have much faster than real-time simulations)
- Also characterise the model: tuned model may not perfectly match the required locomotion performance

# Auto-Tuning Tool: Results using the ExoMars LPM dataset



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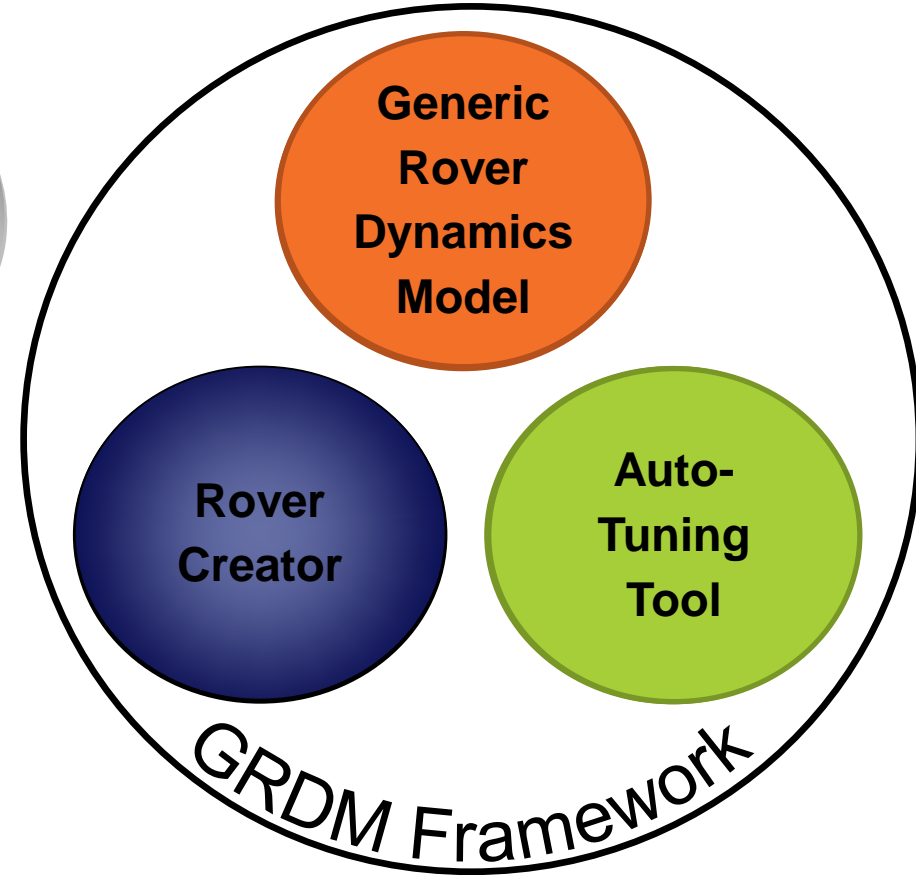
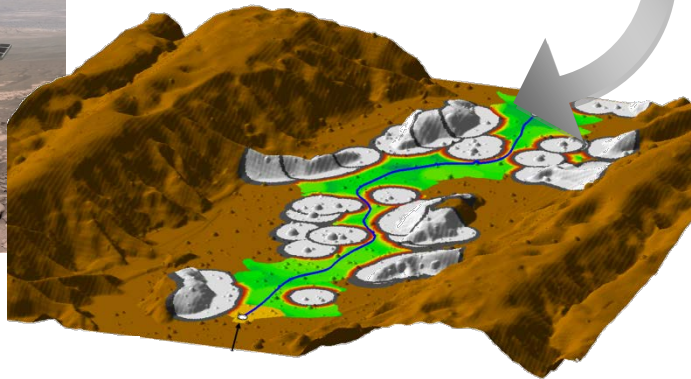
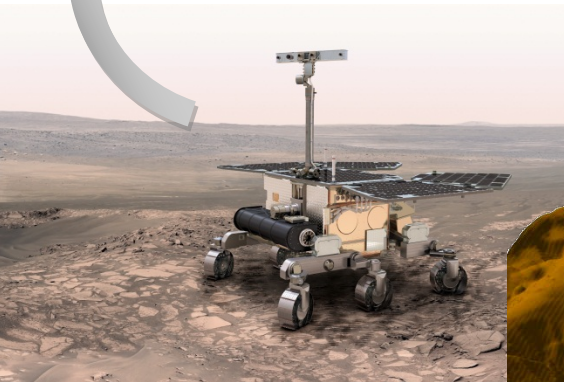
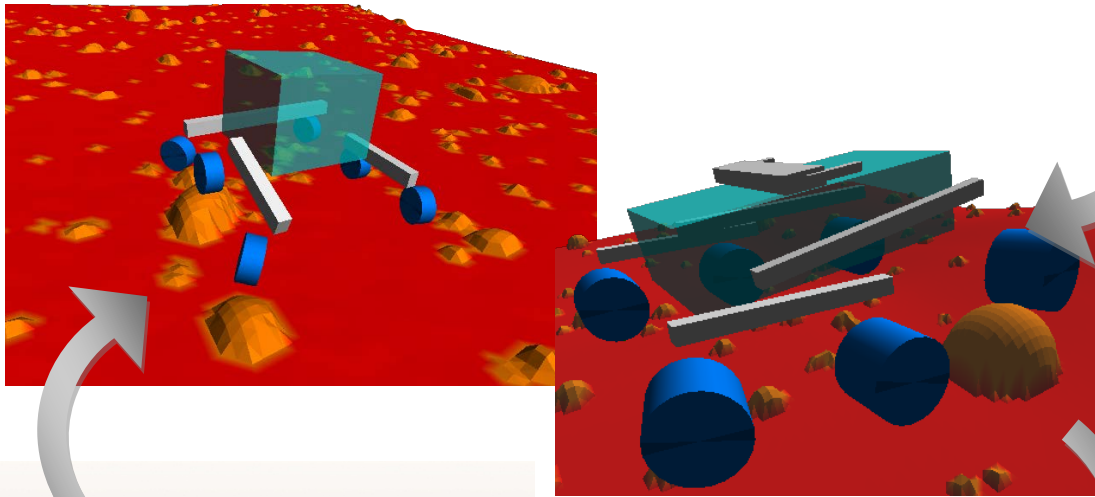
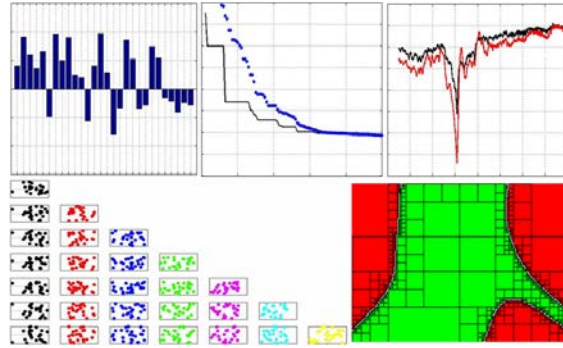


## Conclusion and Next Steps

- First version of GRDM Framework developed
  - Essential building block of a GNC/Ops simulator
  - Simulates a rover's capability to traverse an unstructured environment including slippage on sand and rock climbing ability
  - Includes tools to rapidly create new tuned rovers
  - Now commercially available
- **Model: adequate runtime performance**
  - **Optimisation & additional features possible**
  - **Viewer tool for dev/debug would be useful**
- **Auto-Tuning Tool**
  - **Very good results, room for improvement**
  - **Testing with different rover datasets & evolve optimisation algos would be very beneficial**
- **Rover Creator: two fully working options**
  - **More file formats support would be good (e.g. vrml, catia)**

- **Currently being used:**
  - **University of Glasgow: rover autonomous guidance using inverse modelling technique**
  - **Integration demonstration case for the ESA Harwell Robotics Autonomous Facility (HRAF) pilot project 1**

# Video & Questions



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