



*Space Missions*



# Hercules et al: Canadian Exploration Rover Prototypes

ICRA 2013

Ryan McCoubrey

MDA, Canada



- Exploration Surface Mobility program
- Description of some Canadian Exploration Rovers
- Summary of readiness and upcoming activities





- In 2010, the Canadian Space Agency (CSA) commenced a large program of exploration technology advancement, community development and international collaboration towards planetary exploration 
- The Exploration Surface Mobility (ESM) initiative funded the development of an architecture of systems with a focus on mobility, advanced payloads and science instruments
- With all systems complete and delivered to CSA, a strong CDN suite of exploration systems is being assembled at CSA for integration and a range of future exploration preparatory activities





# Canadian Exploration Rover Development



**ESM**

Credit: MPB

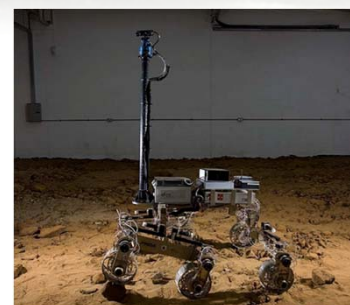


**ESM**

Credit: ESI



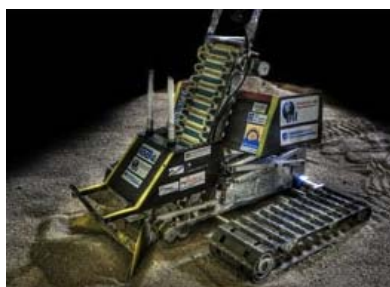
Credit: MDA



Credit: MDA / ESA



Credit: MDA



Credit: Penguin ASI



Credit: Optech / NASA



Credit: UTIAS



**ESM**

Credit: MDA



**ESM**

Credit: Neptec



Credit: MDA / NASA



Credit: Neptec



Credit: MDA



**ESM**

Credit: MDA



**ESM**

Credit: MDA



- A key aspect of the ESM program has been the development of the Canadian community – an essential step in building towards a flight rover mission







# HERCULES

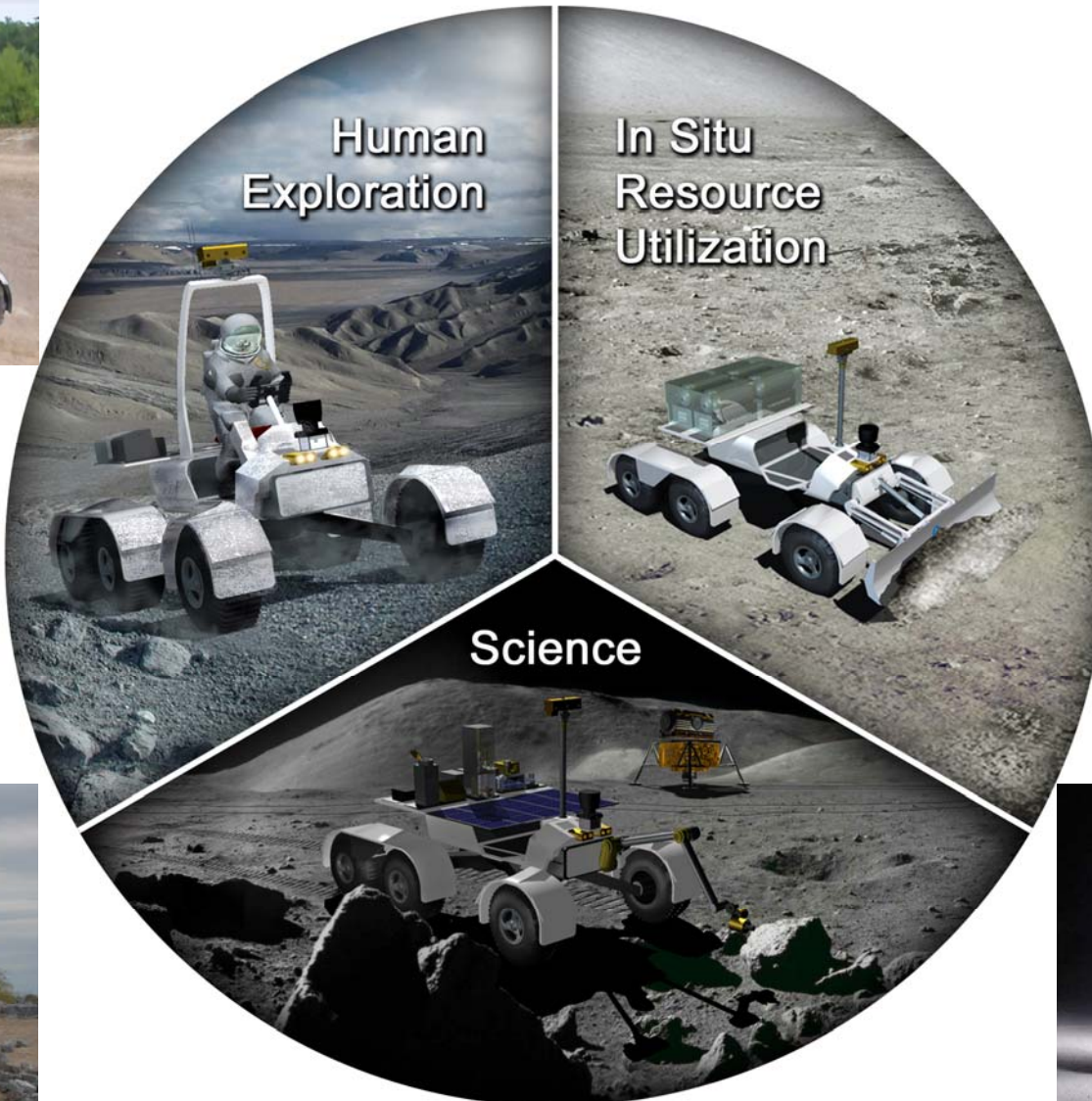
CANADIAN LUNAR ROVER PROTOTYPE



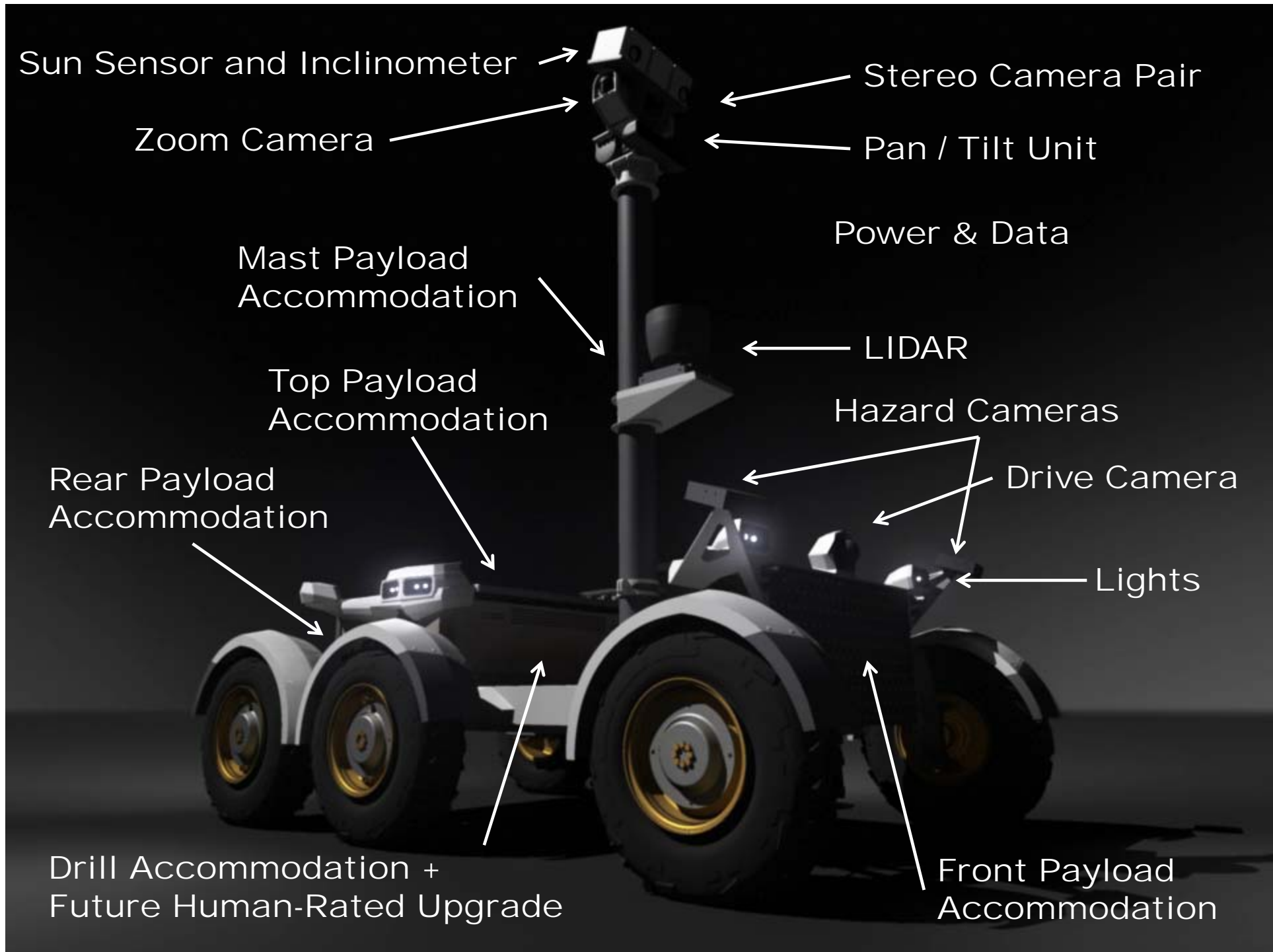
# Hercules – Reference Missions



*\*Test configuration*



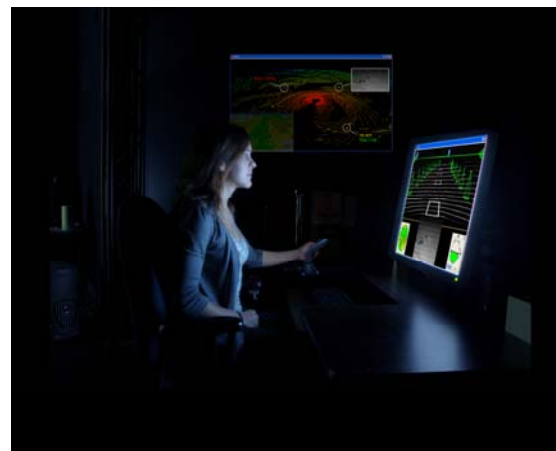








- Design for human compatibility
- Tele-operation at high speed under latency and bandwidth constraints
- Fast and accurate autonomous driving
- Accommodation of large payloads on steep slopes
- Combination of high speed dynamics and low speed kinematics
- Encapsulation of ROS-developed SW into flight SW architecture
- Rugged and durable for extended analogue operations





# Hercules – Highlight Reel







SL-Commander





# SL-Commander Highlights



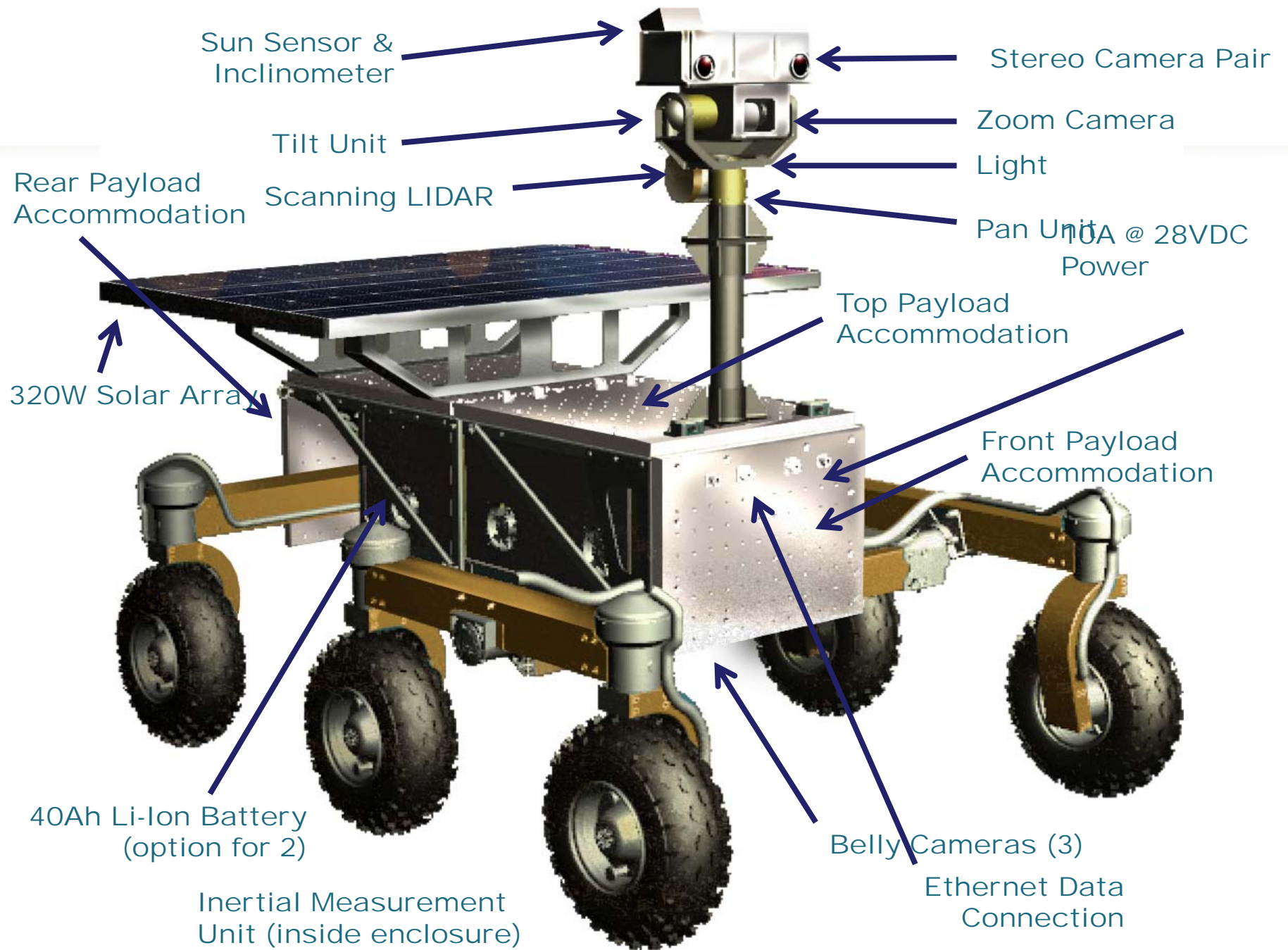
- Full-speed LELR development testbed for s/w, nav, payloads, ops
- Versatile analogue support with multi-mode autonomy
  - Manual astronaut drive
  - Safeguarded teleoperation
  - Point-and-go autonomy
- CSA ESM payload interfaces
- Evolved BRP Commander into BRP's 1<sup>st</sup> full electric vehicle
  - Direct and tangible commercial return on space investment (ESM)





Mars  
Exploration  
Science  
Rover





Sun Sensor & Inclinometer

Stereo Camera Pair

Tilt Unit

Zoom Camera

Light

Scanning LIDAR

Pan Unit @ 28VDC Power

Rear Payload Accommodation

Top Payload Accommodation

320W Solar Array

Front Payload Accommodation

40Ah Li-Ion Battery (option for 2)

Inertial Measurement Unit (inside enclosure)

Belly Cameras (3)

Ethernet Data Connection





- Builds on strong flight design heritage from ESA ExoMars Mission (Mk 4)
- Faster, precise long-range navigation
- Highly terrainable
- Deployment of tools and science payloads for sample return
- Path-to-flight power system based on Canadian micro-satellite heritage
- Flight software architecture with modular design
- Mars-representative command scheme, scripting language and telemetry prioritization for use under limited communication windows
- Heavy focus on rugged analogue ops







# Learning to Explore, Preparing to Discover: Analogue Research

**Mars Sample Return  
Technology Deployment**  
*US-CDN Mars Rover Prototype  
Deployment Flagstaff AZ, 2010*



*Science Drivers*



*Remote Operations*

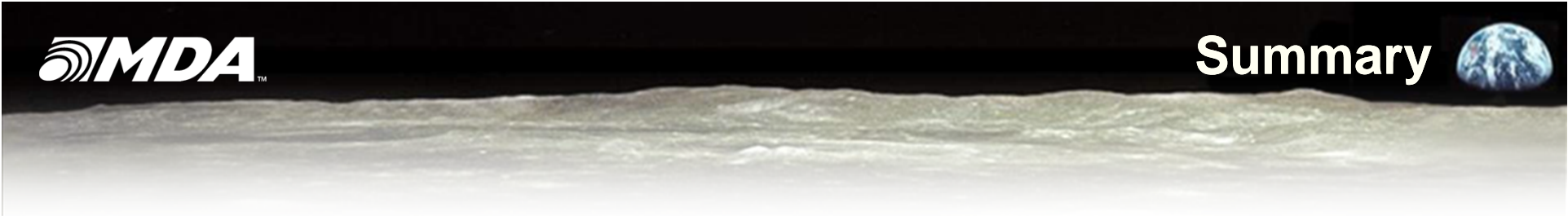




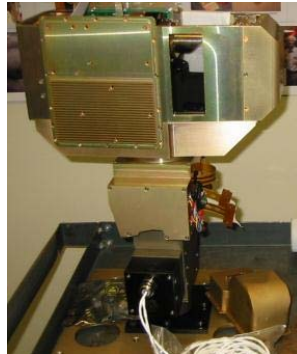


- Derived from ExoMars flight rover locomotion design, developed for European Space Agency (Mk 3)
- Incorporates advanced rover GN&C package, compatible with ESM arch
- Deployed in CDN-US Mars Sample Return demo in Arizona with Arm from NASA MER rover + corer
- Remote operations carried out from the CSA in Quebec, Canada
- Science team led present at mission control to lead exploration
- Delivered to CSA and now in use as science-class platform





- Exploration Surface Mobility has been very successful in building Canada's technology and expertise
- Program produced rovers, tools, payloads and science instruments – all of which are operational and ready for domestic and international analogue deployments



- Canada is leveraging experience gained from ESM, combined with its decades of space robotics expertise, to prepare for flight missions to the Moon and Mars





🇨🇦 2018 Rover Navcam  
(NDG)

🇨🇦 2016 Orbiter HGA  
(MDA)

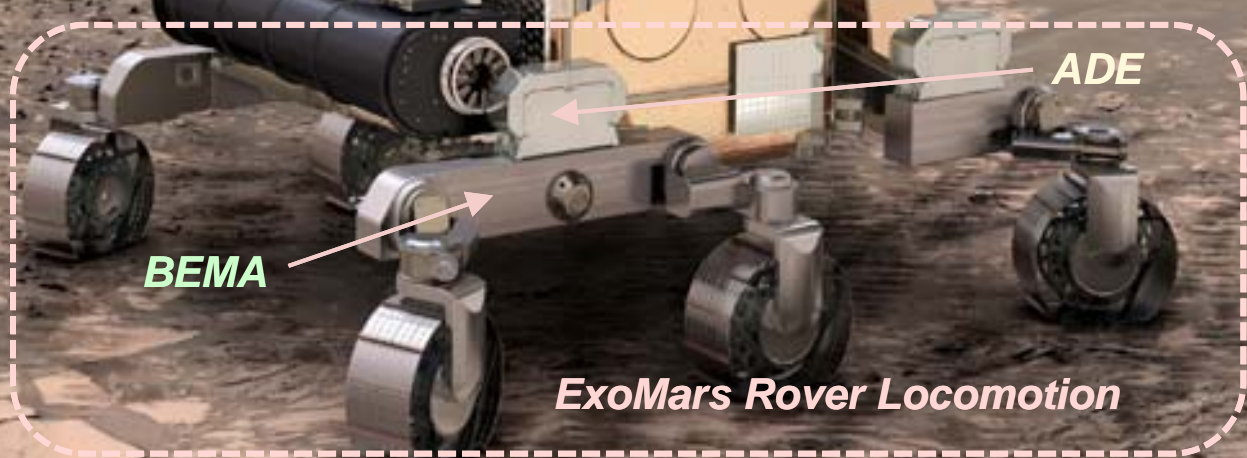


### Locomotion - Electromechanical

- “Bogie Electromech Assy” (BEMA)
- Bogies + Actuators + Wheels
- Highest-level mission criticality

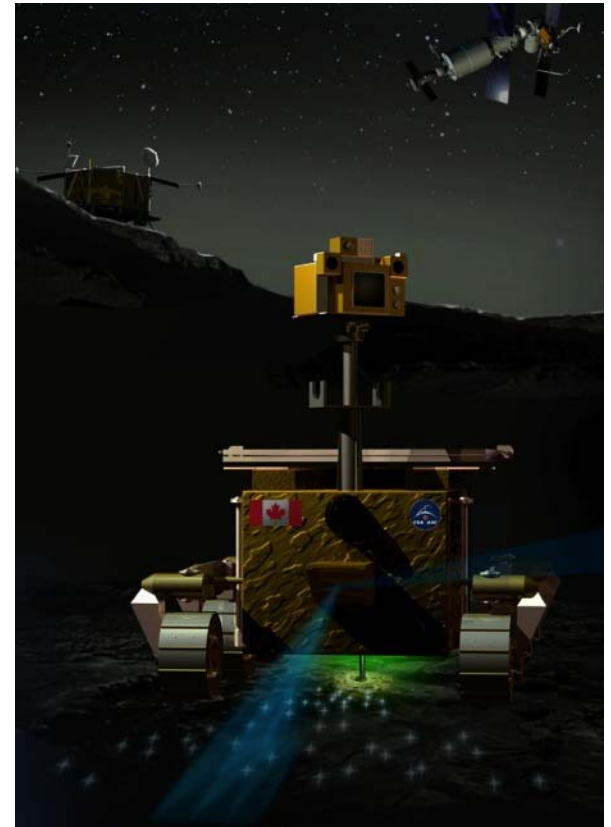
### Locomotion - Electronics

- Actuator Drive Electronics (ADE)
- Drives mechanisms across rover (mobility, mast, deployment, arrays)
- Cold-temp, extreme cycling





- NASA-CSA RESOLVE
  - Potential future lunar mission
  - Longstanding area of CSA / NASA cooperation
  - Focus on resource prospecting / extraction demonstration
    - Ground truth orbital data
    - Locate / characterize volatiles
    - Low cost, rapid schedule
    - Maximize flight heritage leverage
    - Measured risk posture
- 2013 CSA flight concept design contract







*Space Missions*



**Thank you**

**Ryan McCoubrey**

**[Ryan.McCoubrey@mdacorporation.com](mailto:Ryan.McCoubrey@mdacorporation.com)**