



Space Missions



Hercules et al: Canadian Exploration Rover Prototypes

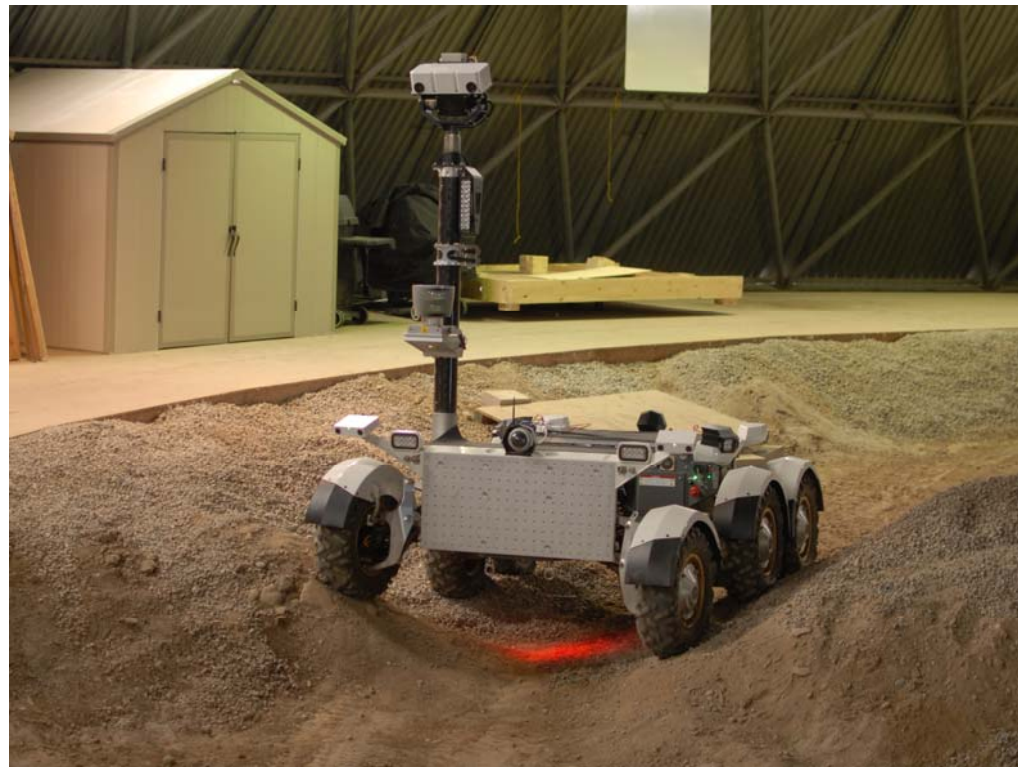
ICRA 2013

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

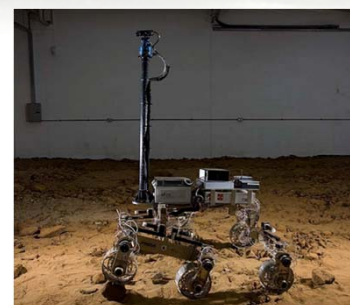


ESM

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

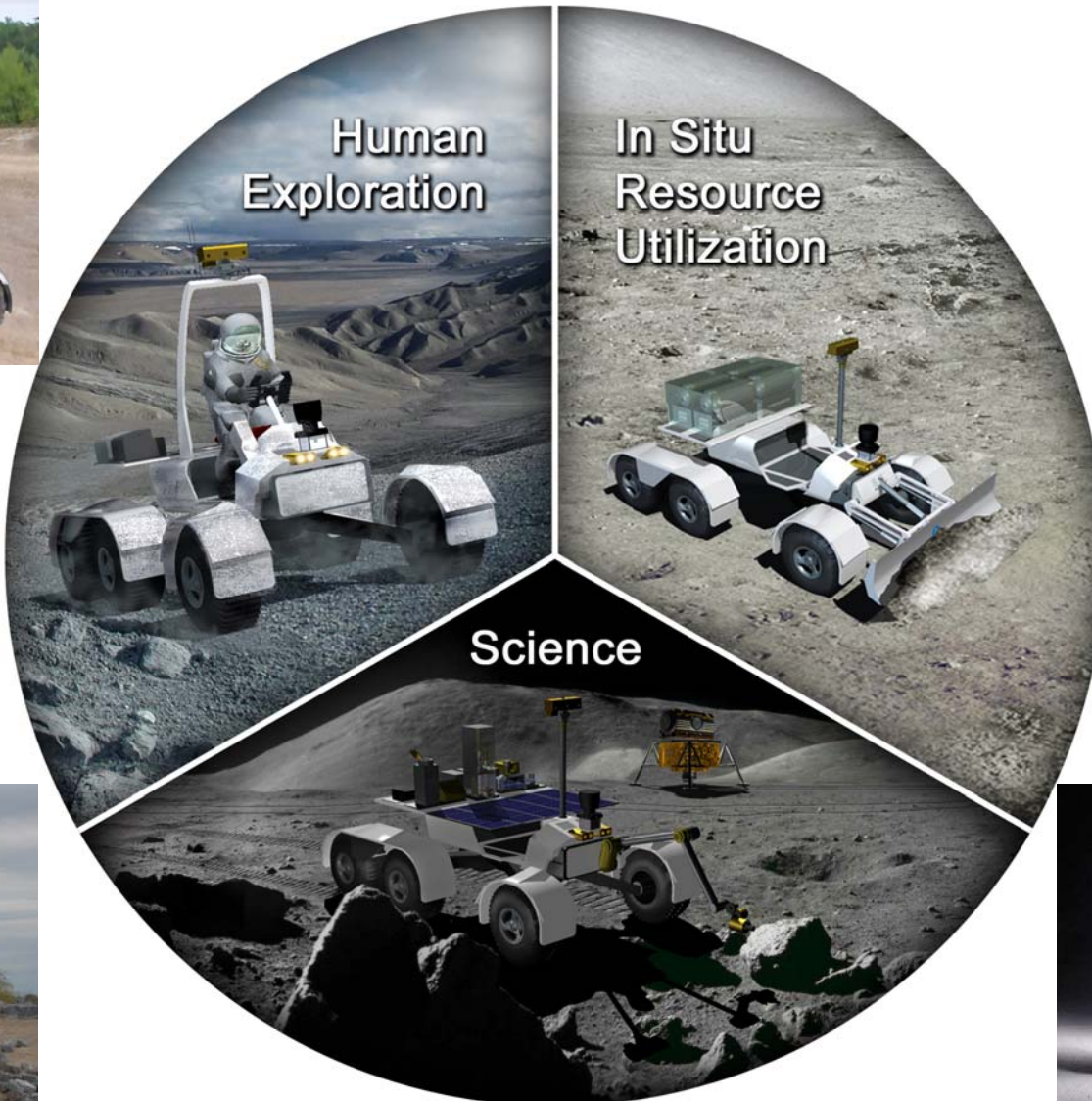
CANADIAN LUNAR ROVER PROTOTYPE

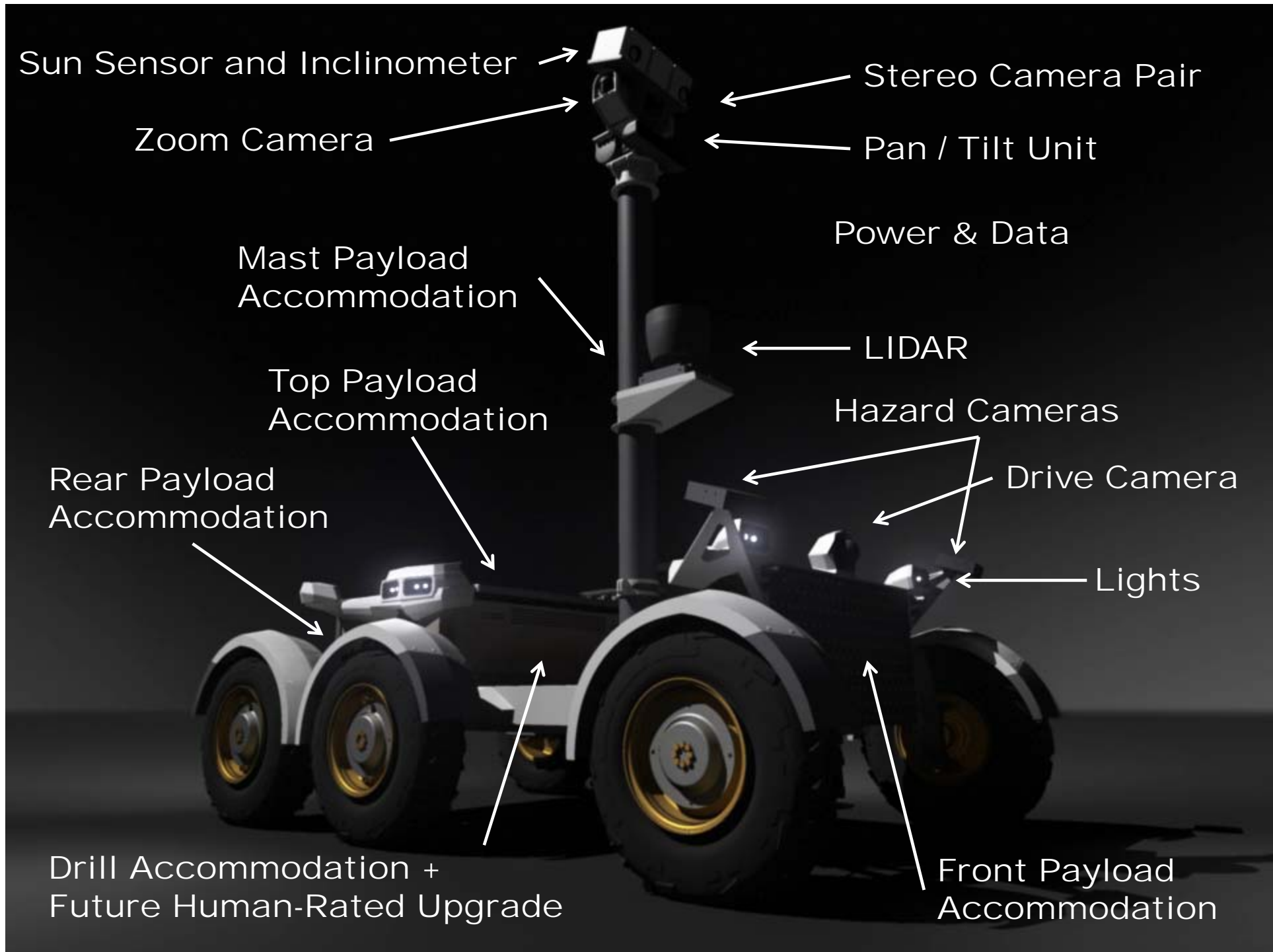


Hercules – Reference Missions



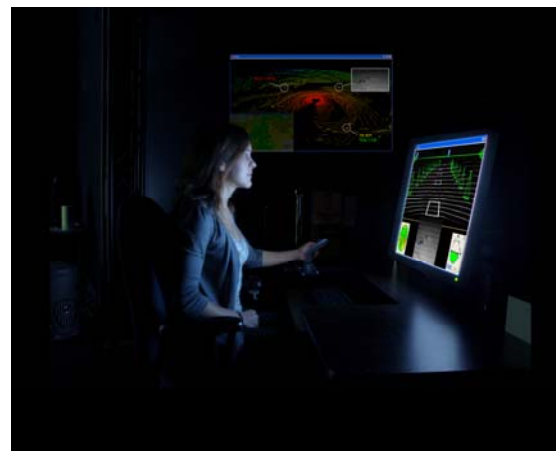
**Test configuration*







- 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

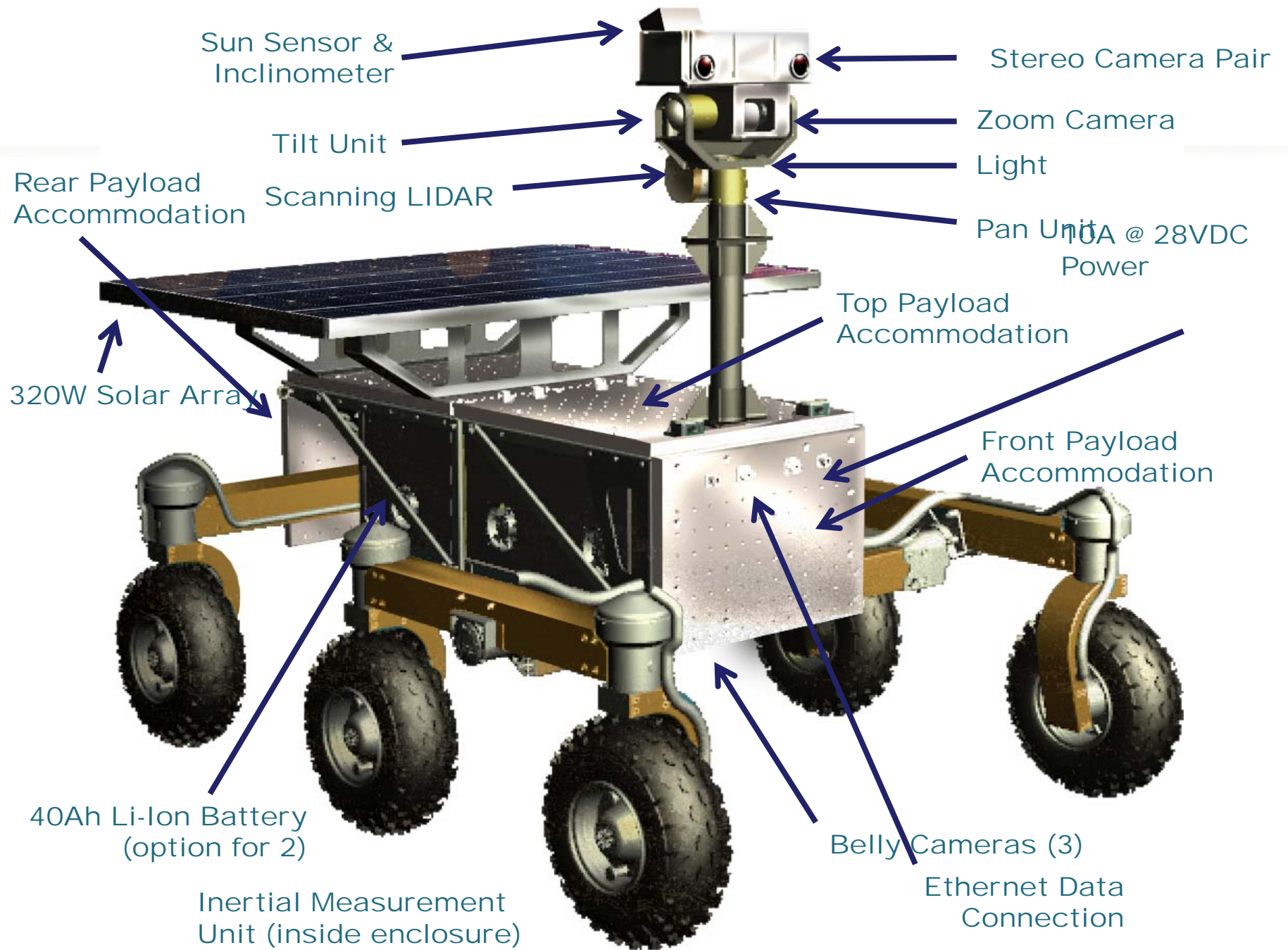


- Full-speed LELR development testbed for s/w, nav, payloads, ops
- Versatile analogue support with multi-mode autonomy
 - Manual astronaut drive
 - Safeguarded teleoperation
 - Point-and-go autonomy
- CSA ESM payload interfaces
- Evolved BRP Commander into BRP's 1st full electric vehicle
 - Direct and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



Mars
Exploration
Science
Rover







- 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

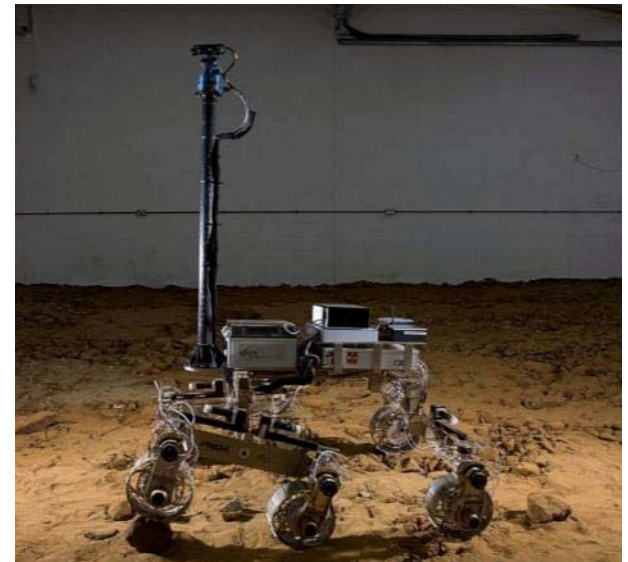


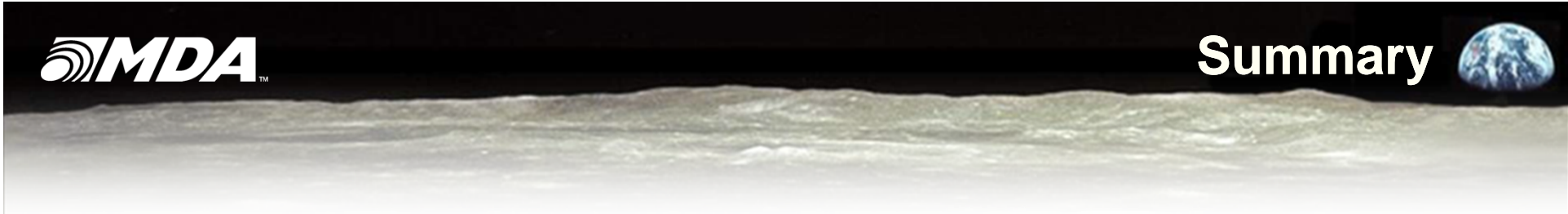
Remote Operations



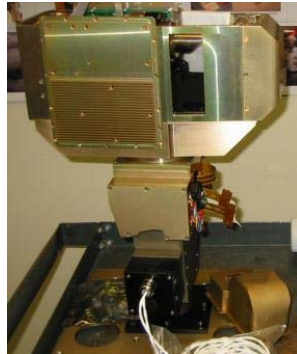


- Derived from ExoMars flight rover locomotion design, developed for European Space Agency (Mk 3)
- Incorporates advanced rover GN&C package, compatible with ESM arch
- Deployed in CDN-US Mars Sample Return demo in Arizona with Arm from NASA MER rover + corer
- Remote operations carried out from the 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

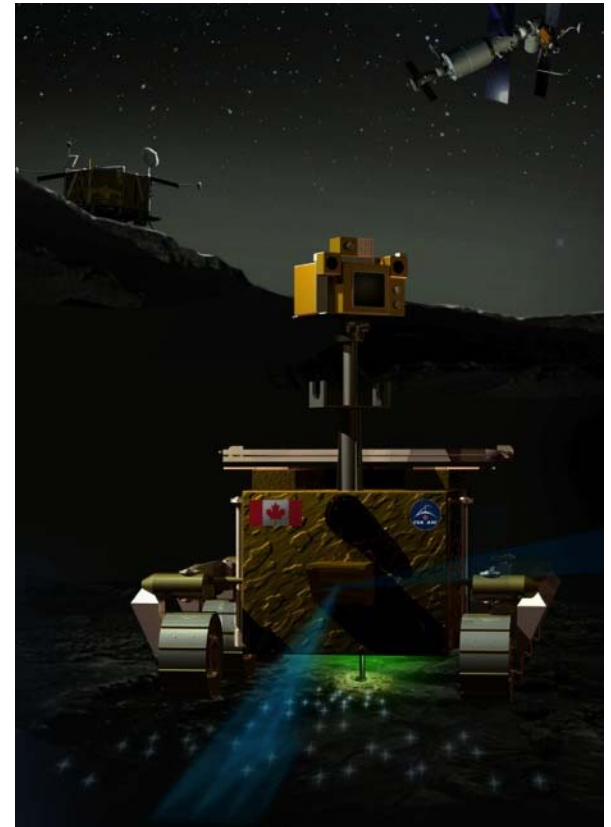
BEMA 

ADE 

ExoMars Rover Locomotion



- 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