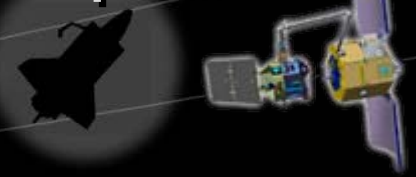
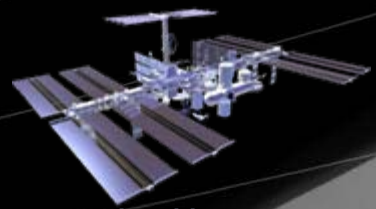
Canadian Robotic Technologies For Lunar Surface Exploration

Frank Teti
MDA

A New Exploration Era

20th Century Exploration





Low-earth Orbit Human Space infrastructure

End of Shuttle Program…

De-emphasis on Human exploration of LEO…

Deeper Space Infrastructure

Planetary surface exploration

Increased Human / robotic collaboration

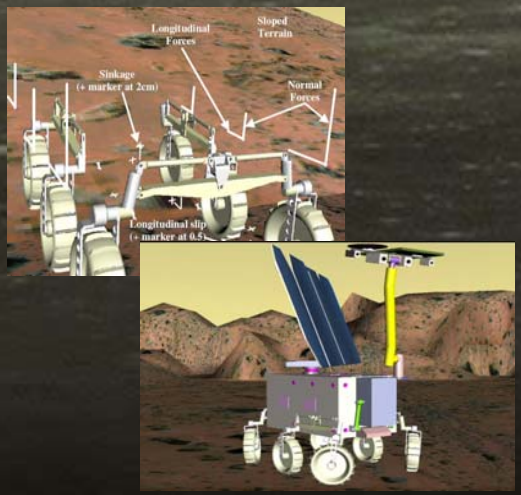
International Cooperation

International Human Exploration

21st Century Exploration

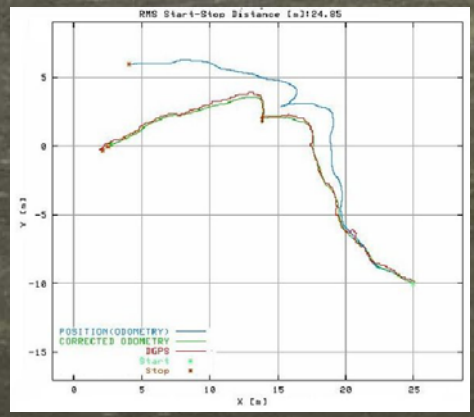
Mobility - Locomotion

- Rapid chassis design & evaluation
- Representative rover chassis prototyping
  - RCP, ExoMars Ph. B1 BB
- Controlled-environment field validation



Mobility - Autonomous Navigation

Credit: MDA



Credit: MDA

Credit: MDA

- Increased rover autonomy
  - Terrain assessment & global path planning
  - Obstacle avoidance & local path planning
  - Visual Motion Estimation & localization (slip mitigation)
- "Visual odometry" field demonstrations

Autonomous Vehicles

- MDA has successfully developed a **software and controls solution** for an underground autonomous vehicle to improve safety and productivity

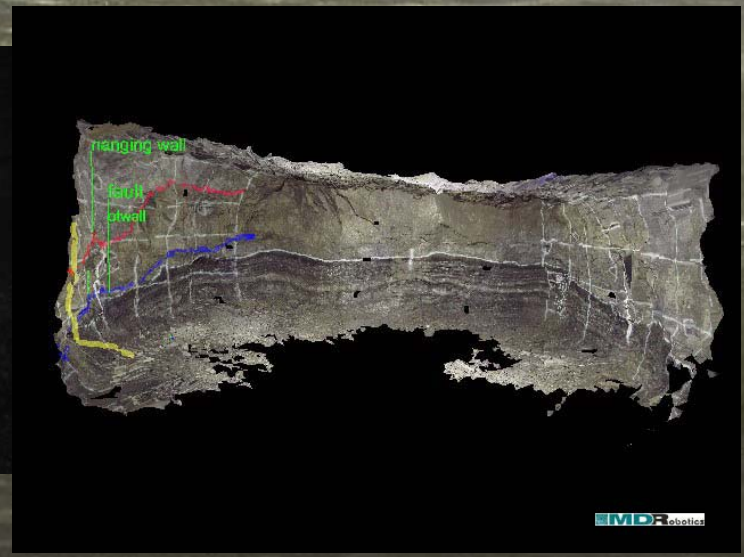
Mobility - Field test sites

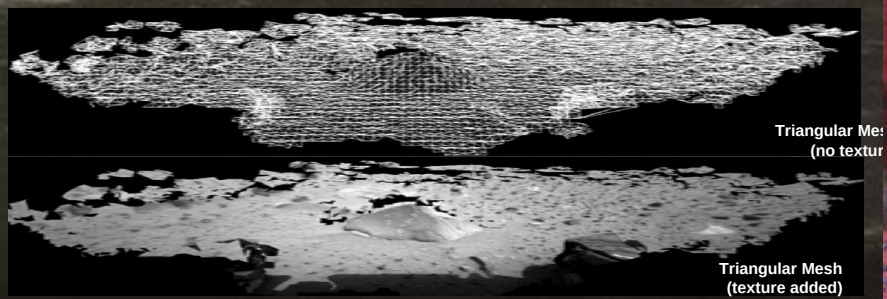
- CSA Mars Yard
- All-season rover mobility test facility
  - Mars Dome
- Analogue sites
  - Mojave desert
  - Canadian Arctic Analogue Research Network

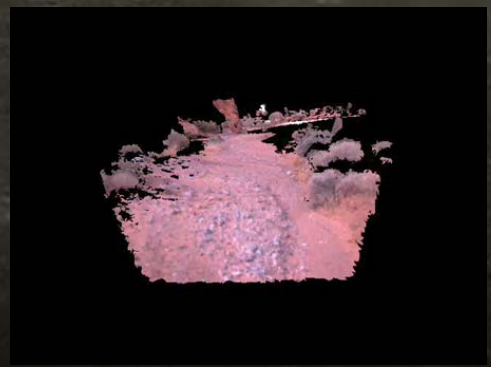
Advanced Vision - Camera Based

- Vision-based scene modeling
  - Rapid in-situ photo-real scene modeling
- Handheld & vehicle-mounted options
- Technologies being applied in mining, forensic & security industries
  - Autonomous site characterization & prospecting
  - Survey & contextual imaging (tele-op geology)
  - 3D sample acquisition monitoring (e.g. drilling)
  - Cost mapping for autonomous navigation
  - Data-storage & bandwidth efficiency

Credit: MDA



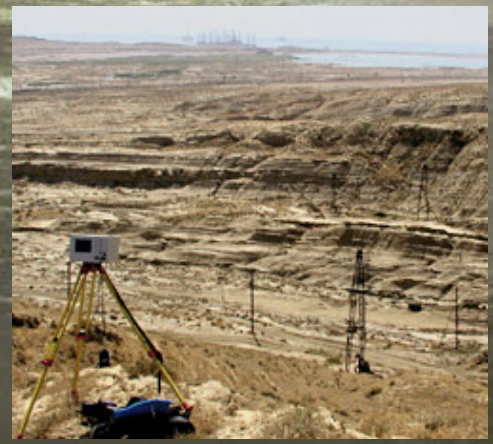




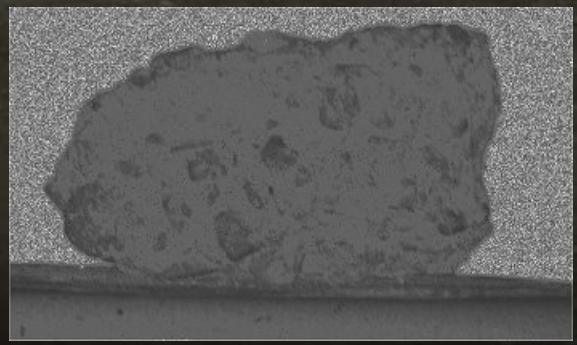
Advanced Vision - Laser based

Optech

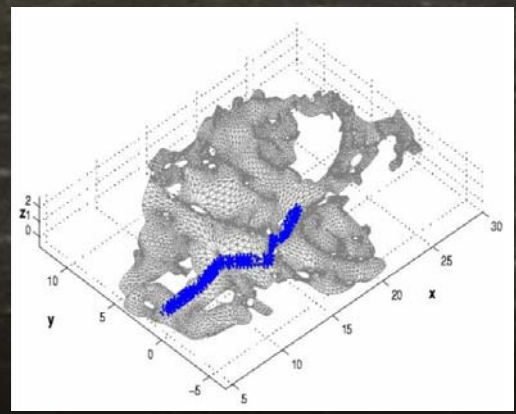
- Lidar-based scene modeling
  - Ultra-high accuracy
  - Range independent
  - Lighting and contrast independent
- Applications
  - Lunar shadowed region scene modelling
  - Lunar shadowed region rover navigation
  - Geological sample classification
- Optech lidar recently utilized at Haughton Crater with NASA Ames Human-Robot Site Survey Project



Credit: Optech



Credit: Optech

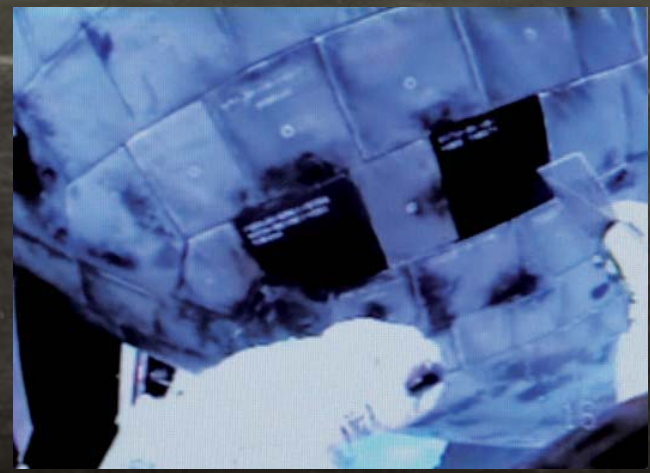


Credit: UNB / Optech

Credit: Optech / NASA

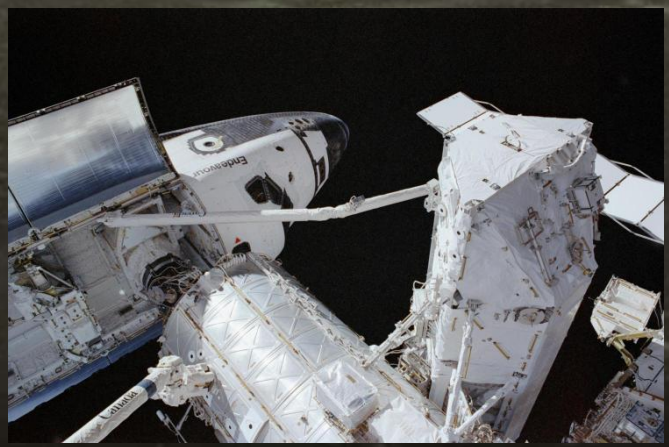
Inspection & servicing

- Laser & Camera based visual inspections
  - Shuttle & ISS safety & logistics
  - Orbital Express satellite inspection
- Autonomous vehicle docking & servicing
  - XSS-11, Orbital Express



Deployment & assembly

- 25 yrs of robotic deployment & assembly of large-scale human space infrastructure on Shuttle & ISS
  - Heavy cargo transport & deployment
  - Infrastructure assembly & configuration
  - Infrastructure inspection & maintenance
  - Vehicle docking & berthing

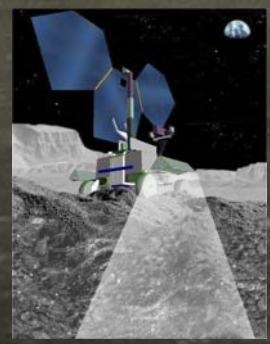


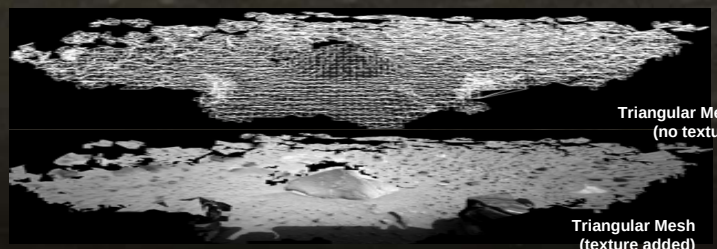
Human-robot interface

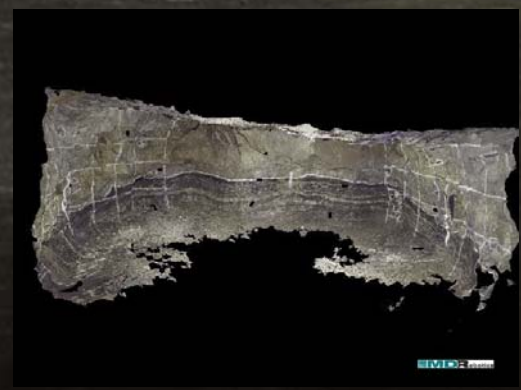
- 25 years heritage in manned space robotics
  - Safety-criticality & ultra-reliability
  - Physical & operational interfaces
  - Control interfaces & variable autonomy
- 82% EVAs employ shuttle robotics for astronaut transport & monitoring

Prospecting & advance scouting

- Remote / advance prospecting, mapping and resource assessment
  - Autonomous field geologist
  - Surface & subsurface
- Pre-EVA tele-op / autonomous scout
  - Site survey (laser + camera)
  - Operations planning
  - Hazard assessment
  - Time, risk conservation

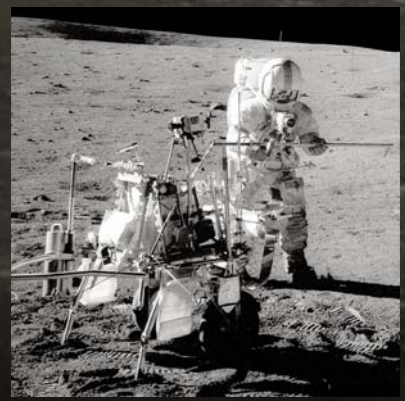






Astronaut Field Assistance

- Increased EVA efficiency
  - Mundane, repetitive or potentially hazardous tasks
  - High-strength, dexterity & mobility tasks
- Potential robotic surface EVA tasks:
  - Pre-EVA Site Survey (prospector dual role)
  - Astronaut “Caddie” & on-site data management
  - Instrument platform & payload deployment (MULE)
- Crucial experience from last 25 years astronaut-robotic partnership in orbit
  - Ultra-high reliability, safety criticality

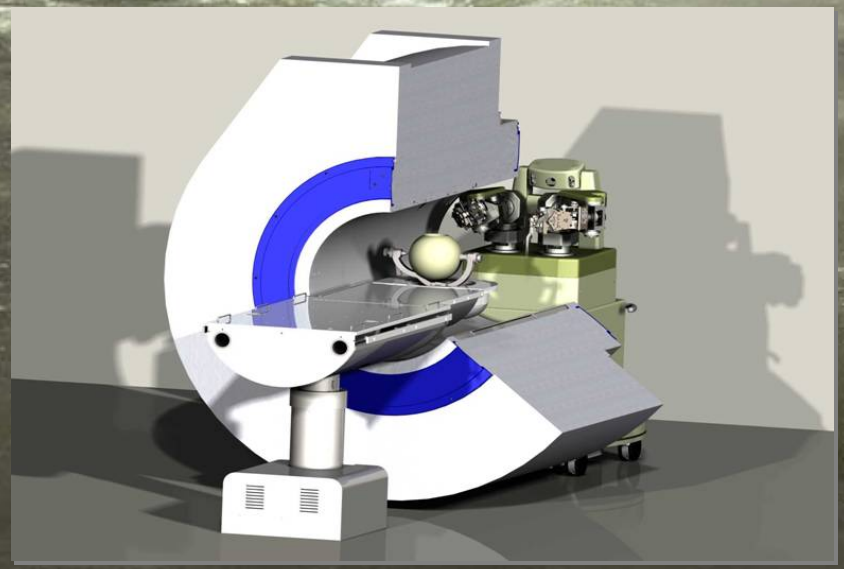


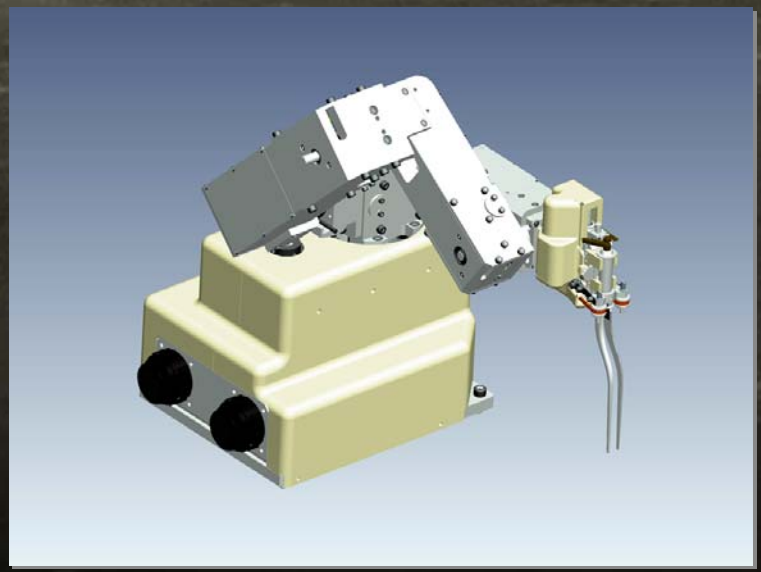
Infrastructure Assembly & Maintenance

- Shuttle and ISS assembly heritage supporting manned assembly
  - Heavy lift capability
  - Deployment & transport
  - Construction & configuration
  - Safety inspection
  - Astronaut transport / elevation for servicing
- Remote, or pre/post human deployment

Credit: NASA

Computer Assisted Surgical Interface (CASI)





Conclusion

- Robotics systems have supported sustainable human space exploration infrastructure for 30 yrs
- Scouts, field-scientists and prospectors for planetary have been provided by robotic systems
- 21st Century space exploration will see a convergence between planetary exploration and human spaceflight
- Expertise & heritage from both will be crucial to the new era of human lunar surface infrastructure
- Many key technologies exist now that will form the basis of the early human-robotic activities on the lunar surface