Exploration Technology Development Program

# 2009 Human Robotic Systems Overview

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# Outline

Project overview and background

2009 Accomplishments

2010 Plans

# Approach

Multi-center team engaging the challenges of humans working with, commanding and supervising lunar exploration robots

Tight coupling with the architecture community

The Moon is not Mars (or the ISS):

- Lunar architectures will need to maintain and operate equipment for long periods of time between crews.
- Previous laboratory experiments and field tests suggest a much more interactive mode of robot operations than we have enjoyed on Mars.
- When crews arrive, the equipment must transition to a support role, being safe, efficient and responsive to human command.
- Robotics for support of human exploration is significantly different from that for purely robotic exploration.

# Lunar Surface Robotics

## Un-crewed Missions

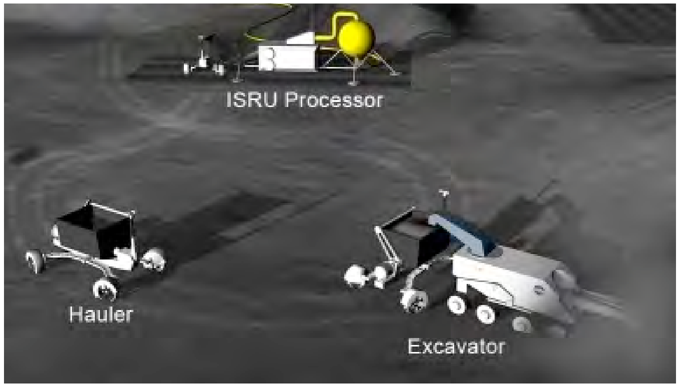
- Characterize environment
- Prepare for crew
- Build infrastructure

## Short-stay Missions

- EVA support: expand range and capability of sorties
- Off-load repetitive and time consuming tasks

## Outpost Missions

- Routine tasks: maintenance, ops support, survey, etc.
- Heavy duty: large payload transport, construction, etc.




# HRS Project Goals

## Surface Mobility: Expand range of operations for the surface crew

- Go further, beyond walking range
- Carry more payload
- Access extreme lunar terrain

## Surface Handling: Transport, position and connect surface equipment

- Deploy, setup and maintain work site
- Provide alternatives for dull, dirty & dangerous tasks
- Site preparation, excavation

## Human-Systems Interaction: Enhance operability

- Enable operations when crew are not resident
- Reduce crew overhead
- Reduce the risk of EVA
- Improve remote operations across time delay

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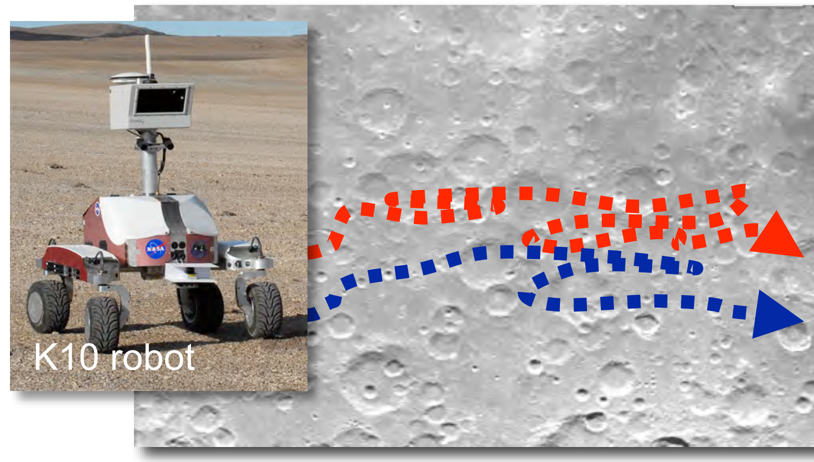
# Robotic Recon Experiment

## Focus

- Test robotic recon in advance of crew (LER-based mission)
- Test coordinated human-robot field exploration technique
- Improve productivity & science during human exploration missions

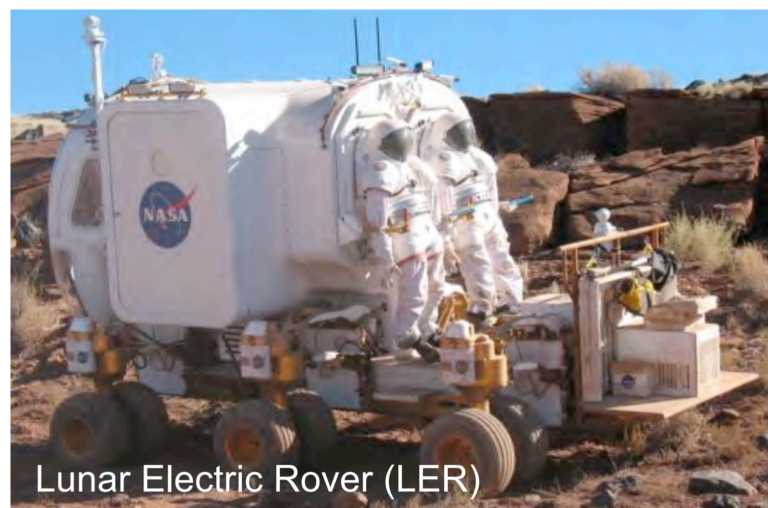


K10 robot

robot ■ ■ ■ crew ■ ■ ■

## Objectives

- Assess effect of robotic recon on traverse planning & crew productivity
- Capture requirements (instruments, comm, nav, etc.) for robotic recon
- Provide recommendations to lunar architecture and exploration planning



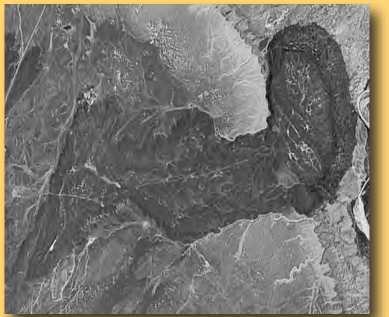
Lunar Electric Rover (LER)

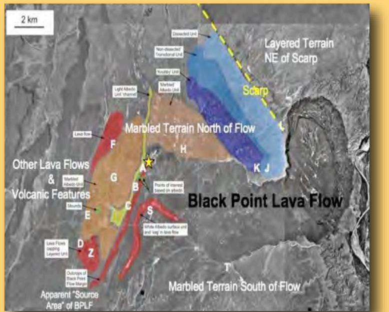
Lead centers: ARC, JSC

lunarscience.nasa.gov/roboticrecon

# Experimental Design

## Pre-Recon






**Mar 1 – June 1**

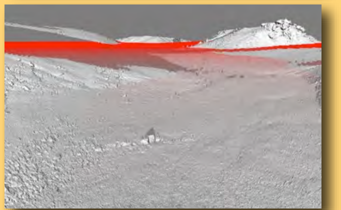
- Satellite images
- Geologic map

## Robotic Recon Mission

**June 14 – 26**

- K10 at BPLF
- Ground control at NLSI

## Pre-Crew



**July 1 – Aug 15**

- Satellite images
- Robotic recon data

## Crew Mission

**Aug 29 – Sep 3**

- LER at BPLF
- Science backroom at BPLF

# Robotic Recon Mission (June 2009)

# September 2009 D-RATS Field Test

Chariot A: LER 14 day mission, 200+ km

Robotic reconnaissance experiment crew mission

Tri-ATHLETE: offloading

Chariot B: engineering break-in

# Crew Mission (September 2009)

## Lunar Electric Rover (LER)

- Prototype pressurized crew vehicle for lunar operations
- Two “suit ports” for rapid (15 min) egress and ingress
- 20 km/hr max, active suspension
- 3.5 x 5 m (wheelbase x length)

## Crew A

- Mike Gernhardt & Brent Garry
- W1 (pre-recon) + N2 (post-recon) traverses

## Crew B

- Andy Thomas & Jake Bleacher
- N1 (pre-recon) + W2 (post-recon) traverses


# Crew Mission (September 2009)

# Robotic Recon Experiment Results

## Benefits of robotic recon

- Precursor science: inform understanding → retire traverse objectives
- Logistics: inform operations → reduce risk (route, hazards, etc.)

## Lunar science operations

- Interactivity enables flexibility (can stop / discard / modify a plan)
- Real-time monitoring enables real-time science (like ROV ops)
- Rapid data acquisition + real-time operations = hectic
  (“Mars ops” seems sedate by comparison!)

## Robotics for human exploration

- Fundamentally different than “robot as explorer” (e.g., MER)
- Critical to optimize human-robot teaming (tasks, coordination, etc.)
- Potentially “game changing” for planetary exploration

# Tri-ATHLETE

## Technologies

- Wheel-on-limb Mobility
- Mobility & manipulation
- Active suspension
- Payload offloading
- Habitat docking
- Hatch mating

## Lead center: JPL

## Tri-ATHLETE built in <2 months

## September Test

- Offloading
- Digging
- Tool use
- Stepping

# Chariot B

## Technologies

- Novel chassis kinematics
- Active/Passive suspension
- Small Pressurized Rover Ops
- Chassis leveling

## New chassis built 2009

## September Test:

- Break-in
- Extreme terrain
- 200+ km

## Lead center: JSC

# Other 2009 Accomplishments

LER Presidential Inaugural Parade

Quick Attach for LANCE/Chariot

Lunar wheels test

Testing GRC transmission on Chariot

Traction testing on Scarab

Lunar Surface Manipulator System (LSMS)

- End effectors
- Composites
- HRS remote control

Outreach, robotics education, media

# 2009 Inaugural Parade

# Scarab

Technologies

- Novel chassis kinematics
- Integrated drill
- Wheel spikes for drilling
- Dark navigation

Traction Testing:

- Inch worming

Lead orgs: Carnegie Mellon University, GRC

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FY09 Accomplishments

FY10 Plans

# 2010 Plans

Support LSS Lunar Surface Concept Review

- Technology demonstrations

Design of 2nd generation systems

- LSMS
- Chariot

Small rover development

- Digging, sensing and manipulation

Integration of K10 software onto LER

Continued Tri-ATHLETE development

Demonstrate RAPID on core HRS assets

Advancing wheel development