# The Robotic All-Terrain Lunar Exploration Rover (RATLER) — Increased Mobility Through Simplicity

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# Abstract

**The Robotic All-Terrain Lunar Exploration Rover (RATLER)**
**- Increased Mobility through Simplicity**

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*A new concept mobility chassis for a robotic rover is described which is inherently simple with few moving parts or complex linkages. The RATLER design utilizes a four-wheel drive, skid steered propulsion system in conjunction with passive articulation of the dual body vehicle. This uniquely simple method of chassis articulation allows all four wheels to remain in contact with the ground even while climbing obstacles as large as 1.3 wheel diameters. A prototype mobility platform has been built which is approximately 1 $m^2$ with 0.5 m diameter wheels and all-wheel electric drive. The theoretical mobility limitations are discussed and compared with the results of field trials of the prototype platform. The theoretical model contrasted with measured performance is then used to predict the expected mobility of the RATLER design on the Lunar surface.*

# Sandia National Laboratories
# Transportation Systems Center
# Advanced Vehicle Development Department
# Robotic Vehicle Range

- **Research and Development:**
  - Mobile Robotics
  - Mobile Manipulators
  - Man-Machine Interfaces
- **Applications Programs:**
  - Intelligent Vehicle Highway Systems (IVHS)
  - Lunar Surface Exploration
  - Military Battlefield
  - DOE & DoD Physical Security

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# The Robotic All-Terrain Lunar Exploration Rover (RATLER) Increased Mobility Through Simplicity

- **Outline**
  - Description of RATLER
  - Lunar surface characteristics
  - Results of pathfinder field trials
  - Summary

*This project is funded by the DOE Laboratory Directed Research and Development (LDRD) Program, Sandia National Laboratories LDRD Project Office.*

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# RATLER Key Characteristics

- **Articulated chassis**
  - Central pivot
- **Four wheel electric drive**
  - All wheels remain in contact with terrain
  - 1/2 torque of conventional four wheeled vehicle for climbing
- **Simple construction**

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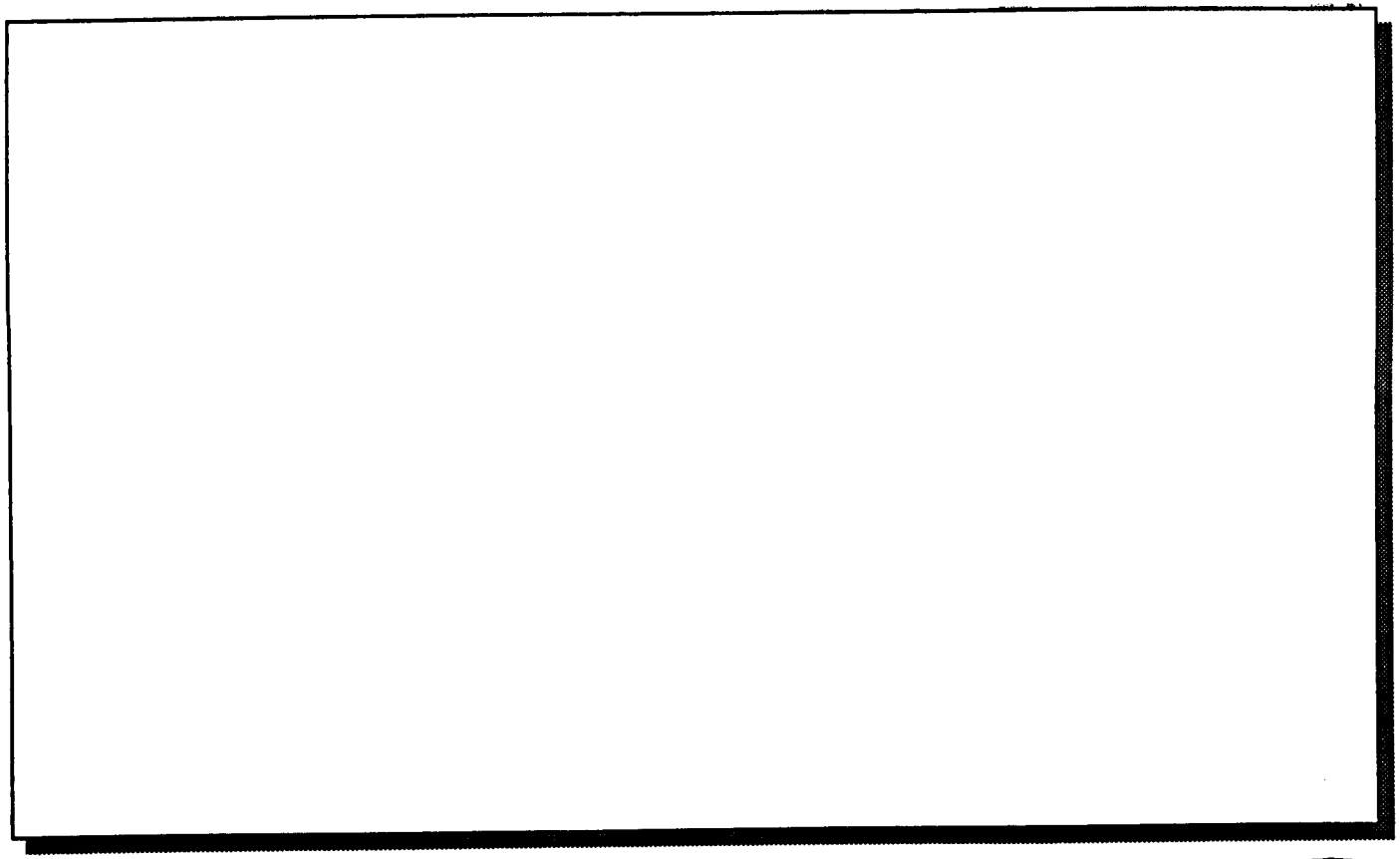
# RATLER Photo



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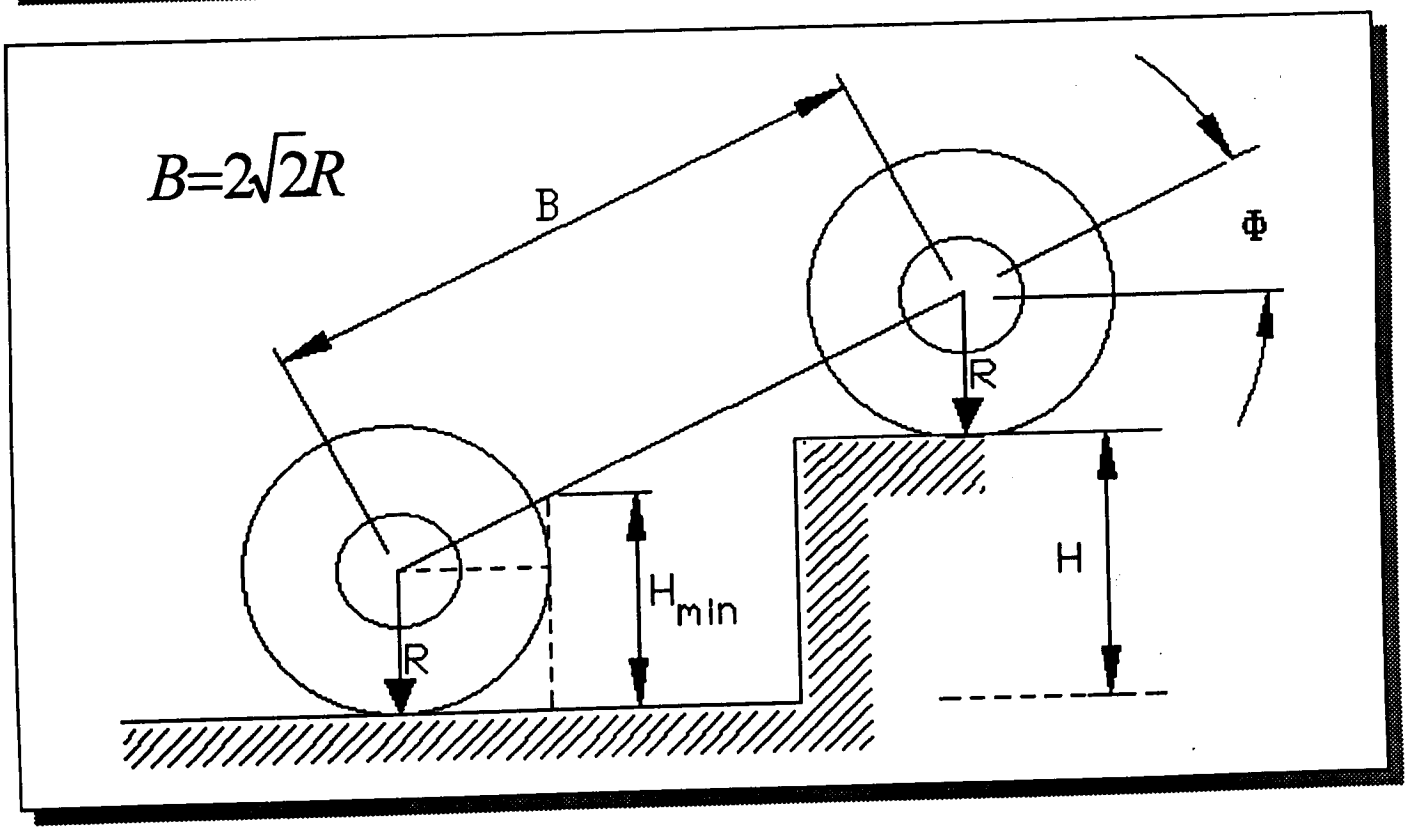
# RATLER Optimum Wheel Base

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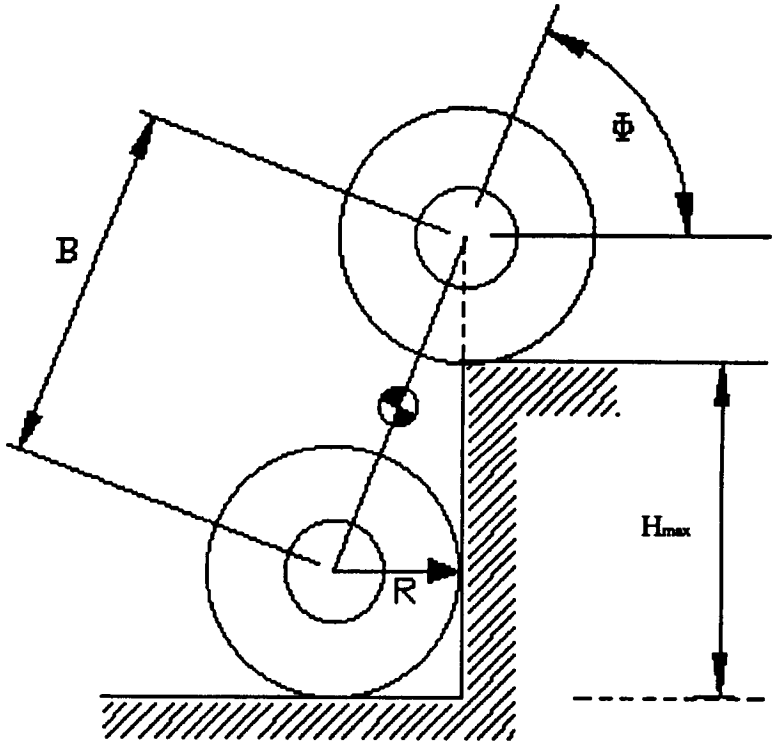
# RATLER Maximum Step Height

$H_{max}=\sqrt{7}R$

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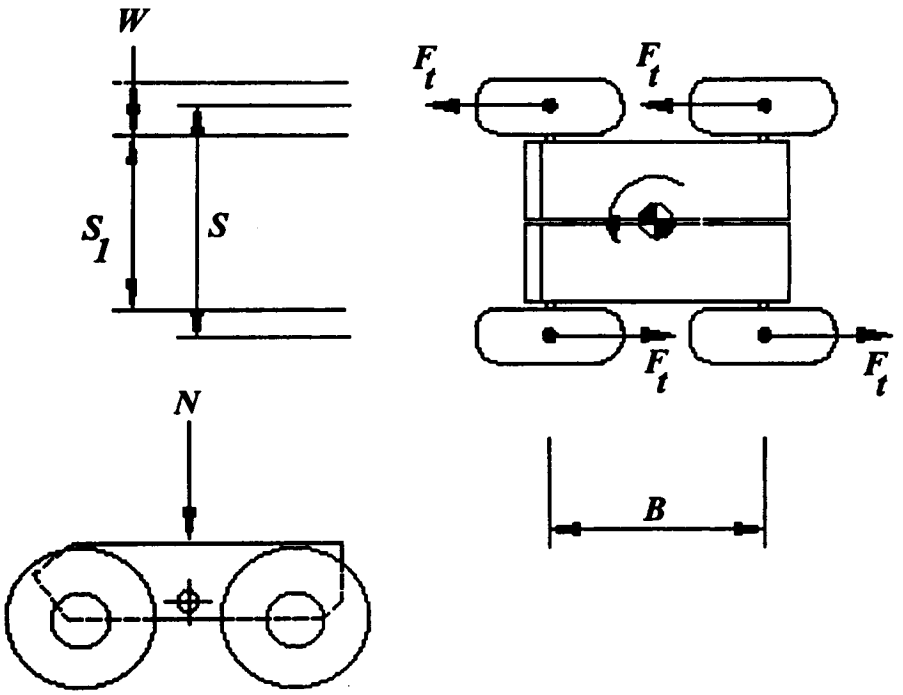
# RATLER Optimum Stance

$$S \geq B\mu_s/\mu$$

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# RATLER Pathfinder Configuration

| » *Parameter* | | *Units* |
|---|---|---|
| » Wheel Radius | 24.8 | cm |
| » Wheel Width | 17 | cm |
| » Wheelbase | 72.4 | cm |
| » Stance | 81.3 | cm |
| » Total mass | 63 | kg |
| » Total volume | .6 | meters$^3$ |
| » Maximum dimension | 122 | cm |
| » Slope Stability | ~45 | degrees |
| » Slope Climbing | 22 | degrees |
| » Crater Depth (traversable) | 50 | cm |
| » Boulder Height (traversable) | 65 | cm |
| » Ground Contact Pressure | 3 | kPa |

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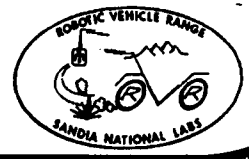

## Lunar Surface Characteristics
## Slopes

- **Crater sides typically 10-30 deg**
  - Fresh craters may have slopes up to 45 deg
- **Mountains may possess slopes up to 40 deg**

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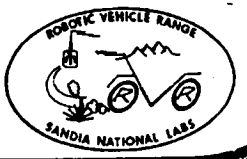

# Lunar Surface Characteristics
## Craters

- Consider only craters < 500 m in diameter
- 100 - 1000 craters/$Km^2$ in size of interest
- 70 - 90% of these are of the older degraded type

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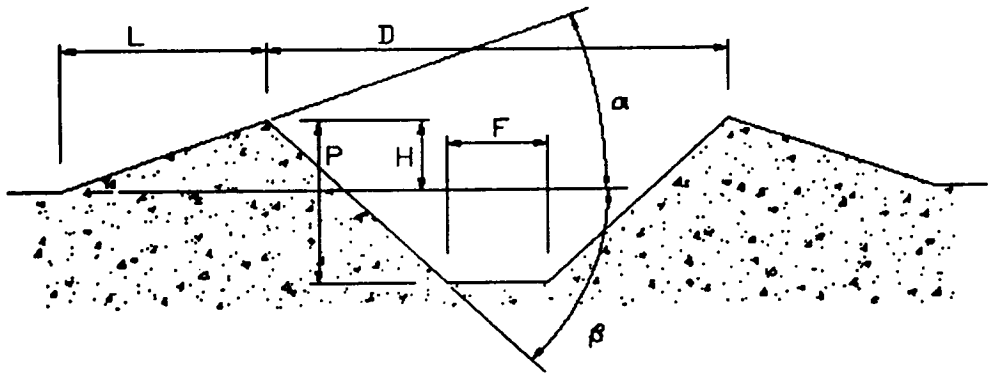
# Degraded Crater Model




| D | H | P | F | L | α | β |
|---|---|---|---|---|---|---|
| meters | meters | meters | meters | meters | degrees | degrees |
| 0.5 | 0.016 | 0.091 | 4.62E-05 | 0.118 | 7.8 | 20 |
| 50 | 1.726 | 9.511 | 0.157 | 12.433 | 7.9 | 20.9 |
| 5000 | 184.102 | 995.9 | 530.938 | 1307.952 | 8 | 24 |

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# Lunar Surface Characteristics
## Boulders

- **Boulder distribution from Lunokhod mission to Le Monier Crater**

| Size | # Observed | Area |
|---|---|---|
| Sb > 1 m | 0 | 100 $m^2$ |
| 20 cm < Sb < 1 m | 3 | 100 $m^2$ |
| 10 cm < Sb < 20 cm | 10 | 100 $m^2$ |

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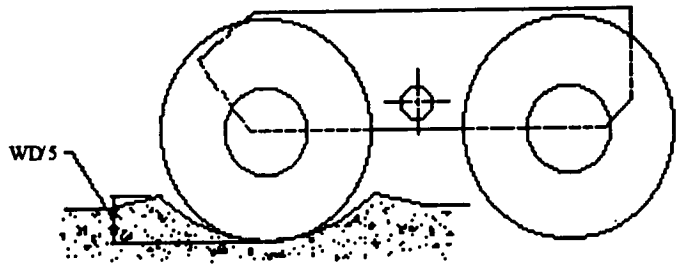
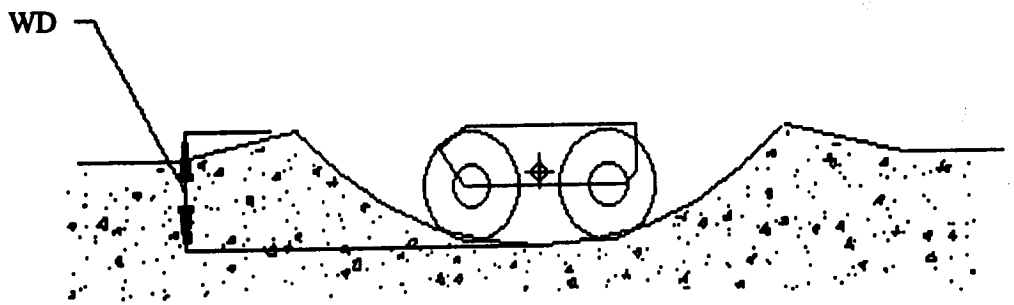
# Lunar Surface Characteristics
# Minimum and Maximum Significant Craters




Minimum Significant Crater Depth




Maximum Significant Crater Depth

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# RATLER Functional Requirements

| Parameter | Upper Bound | Lower Bound | Units |
|---|---|---|---|
| Slope Climbing & Stability | 45 | 0 | degrees |
| Crater Depth (traversable) | WD | WD/5 | wheel dia (meters) |
| Boulder Height (traversable) | WD*1.3 | WD/10 | wheel dia (meters) |
| Lander Deployment Height | 1.4 | ~0.1 | meters |
| Ground Contact Pressure | 7 | ? | kPa |
| Total mass | 65 | ~15 | kg |
| Total volume | 5.1 | ~0.75 | meters$^3$ |
| Maximum Dimension | 2.8 | ~0.9 | meters |

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# RATLER Pathfinder Field Trial Results

- 80:1 pancake motors, 15.9 Nm torque per wheel
  - successfully climbing 30 - 40 cm step-like rocks
  - 22 deg slope climbing
  - spin turns on high friction surfaces are difficult
- Higher torque in actual design should provide better climbing performance
  - 150:1 gearheads provide 22.7 Nm continuous torque



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# RATLER Mechanical Design

- Pathfinder experience was very useful
- Initial layout concept done to fit current bodies
  - » 150:1 pancake motors; 1 ea, per wheel
  - » ~ 0.6 m/s top speed
  - » ~ 30° slope climbing capability
  - » ~ 40° static slope stability
  - » ~ 70 kg rover w/o payload
  - » ~ 18 kg payload capacity
  - » ~ 25° slope climbing w/ 18 kg payload

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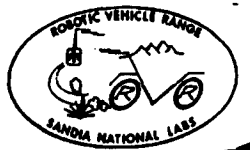

# RATLER Expected Lunar Mobility

- Limited surface information exists in fine detail
- Most boulder fields will not present significant obstacles
- Slope climbing is not a problem on older "degraded" craters
- Steep slopes in "new" craters and on mountainsides can be scaled via switchbacks



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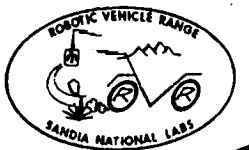

# Summary

- **RATLER Design's Advantages:**
  - Simpler than competing designs
  - Very good mobility characteristics
  - Compact, scales well
- **Current Program Status:**
  - Scale Models tested & documented
  - Analysis is ongoing
  - Pathfinder completed
  - Prototype development is underway
  - Initial Operational Capability projected for August 1993

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