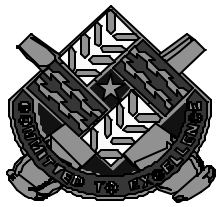

TACOM

Lethality, Survivability, Mobility and Sustainment for America's Army



# US Army TACOM-TARDEC Intelligent Mobility Program

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**Abstract**

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| | |
|---|---|
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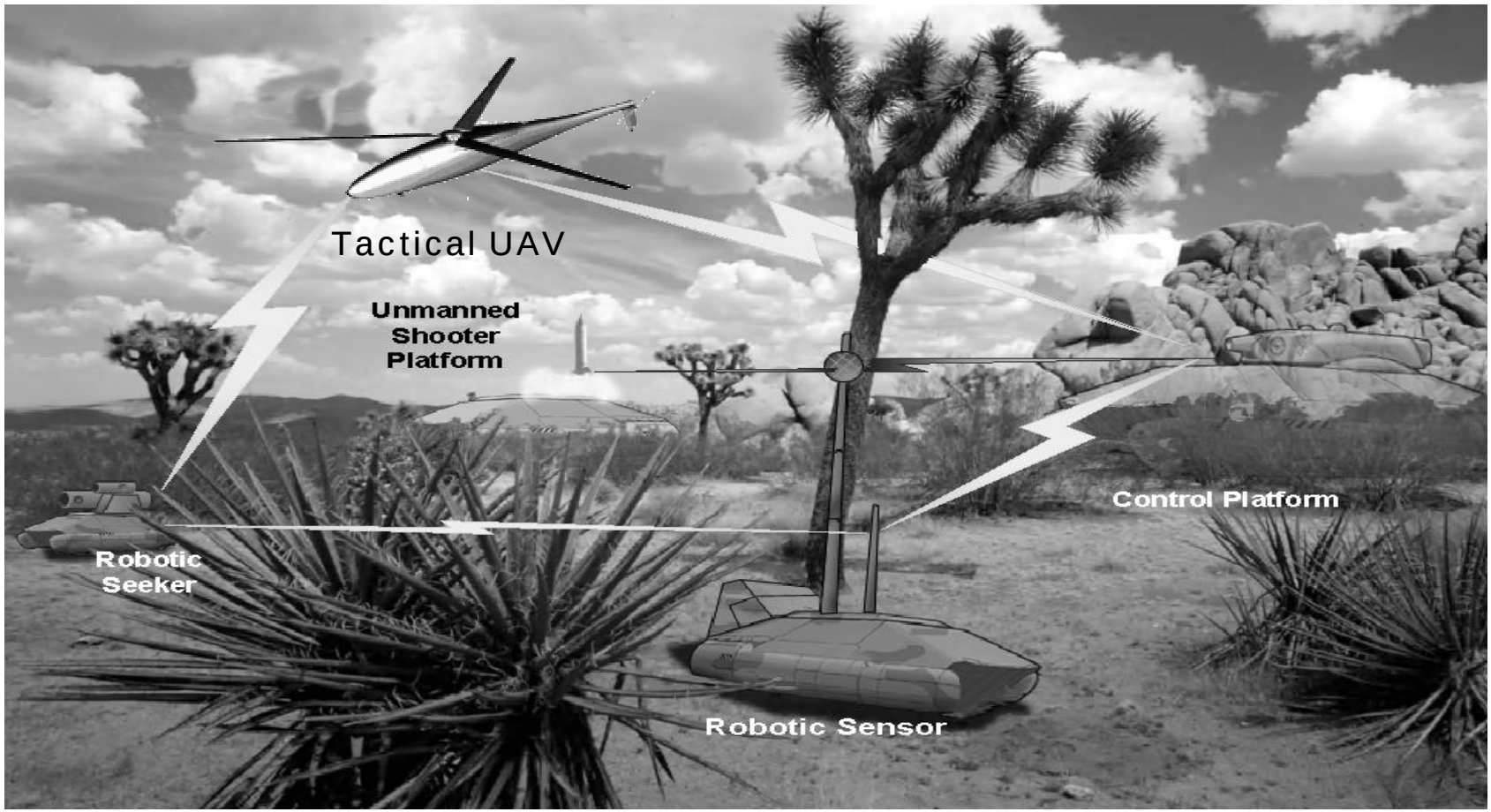
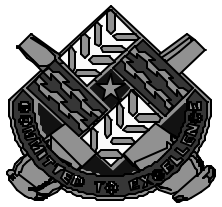
18

# Robotics “Vision” for FCS

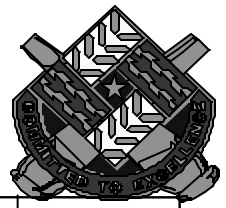


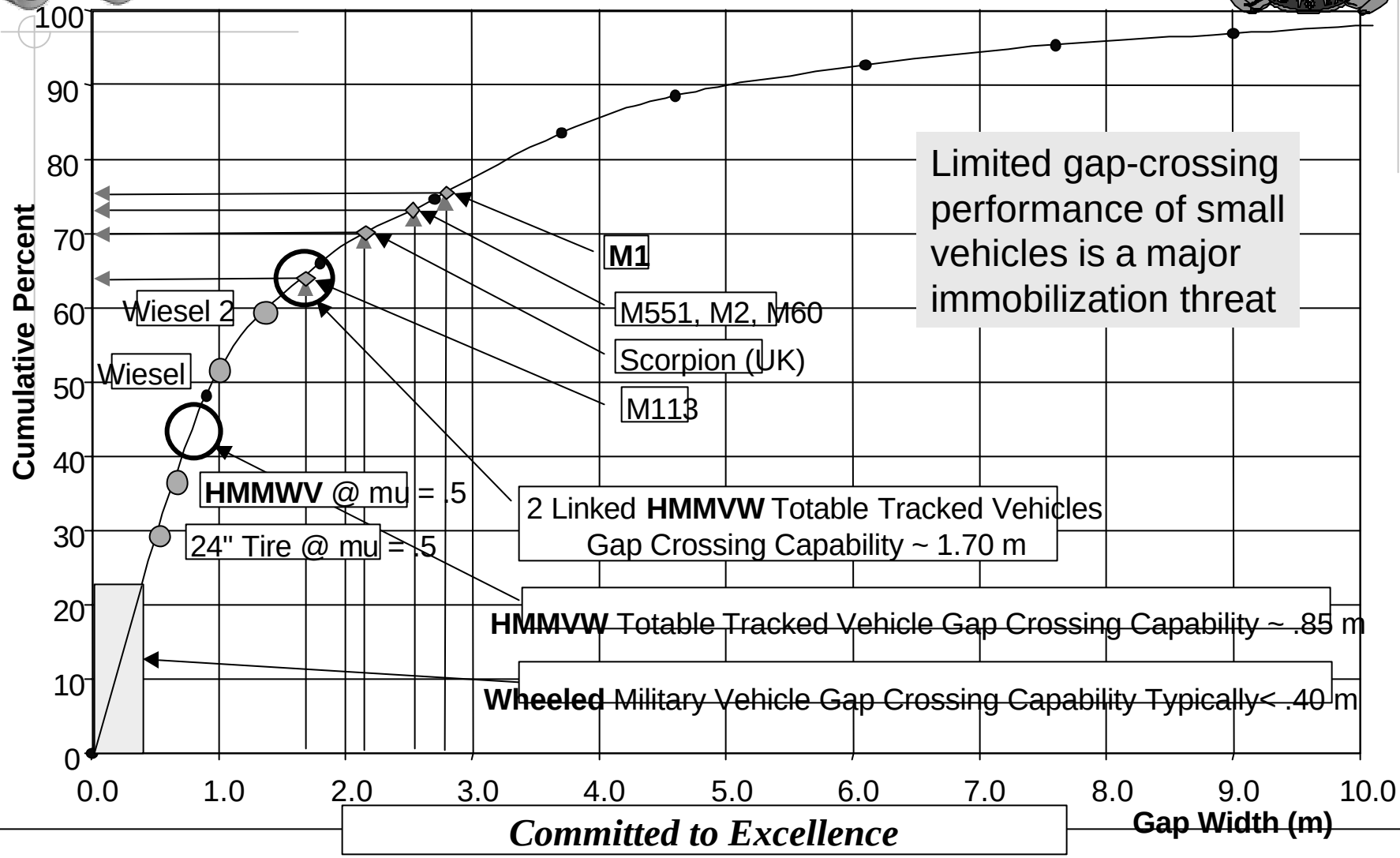

# UGV Mobility Issues



| Issues | Manned System | Unmanned System |
|---|---|---|
| Human Factors: | | |
| • Absorbed Power | • 6 watts (driver seat) | • ±30 g electronics |
| • Rollover | • No rollover / injury | • Self righting—operable |
| • Crash | • No crash / injury | • Crash tolerant—operable |
| • Mine | • No mine encounter | • Absorb blast—operable |
| • Hit Risk | • Minimize | • Absorb hit—operable |
| Net Mobility Effect | • Reduced cross country speed<br>• Complex suspension<br>• Limited route availability | Higher cross country speed<br>Simpler suspension<br>• Higher payload fraction<br>• Lower Cost<br>Better Trafficability<br>• No personnel risk |

# Gap Crossing Capability in Germany

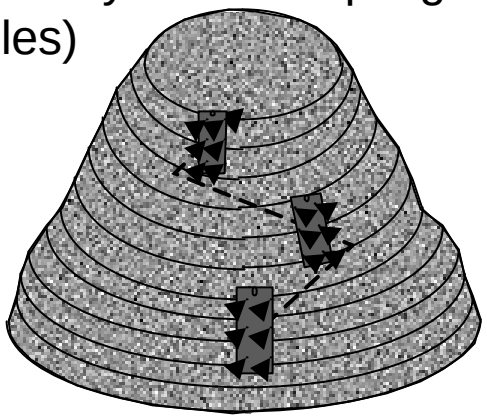



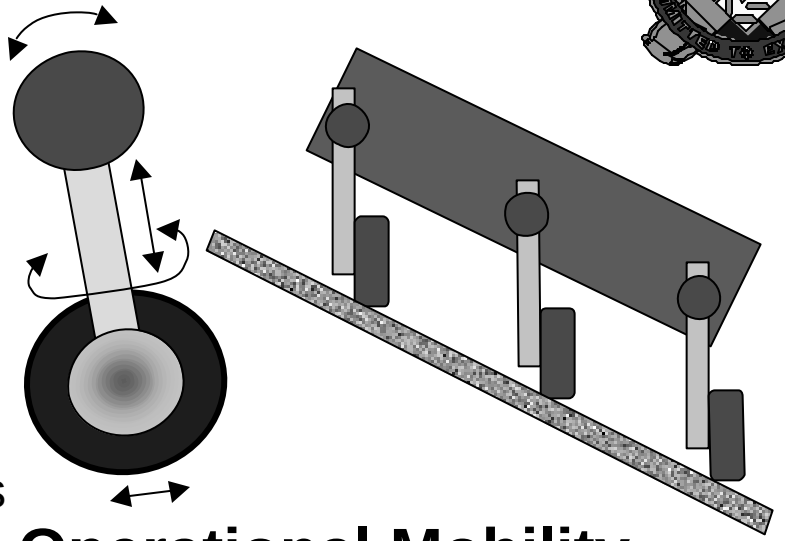


# What Is Intelligent Mobility?

## Inherent/Intrinsic Mobility

- Basic physical capability
- Ability to adjust the configuration and performance characteristics
- Governs the vehicle to execute commanded maneuvers and trajectories
- Advanced running gear, drive, control technologies and dynamic coupling (tandem vehicles)

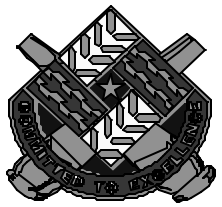




## Operational Mobility

- Applied mobility
- Governs and directs inherent mobility
- Selects the driving mode and route/velocity trajectory
- Advanced trajectory planning, navigation, learning and reactive behaviors

# Intelligent Mobility Program

**Ft. Benning**
**Ft. Knox**
**Ft. Leonard Wood**

**Tyndall AFRL**
**SPAWAR Navy**
**JPO Army**

**TRL***

**Direct tech transition from R&D to the user community**

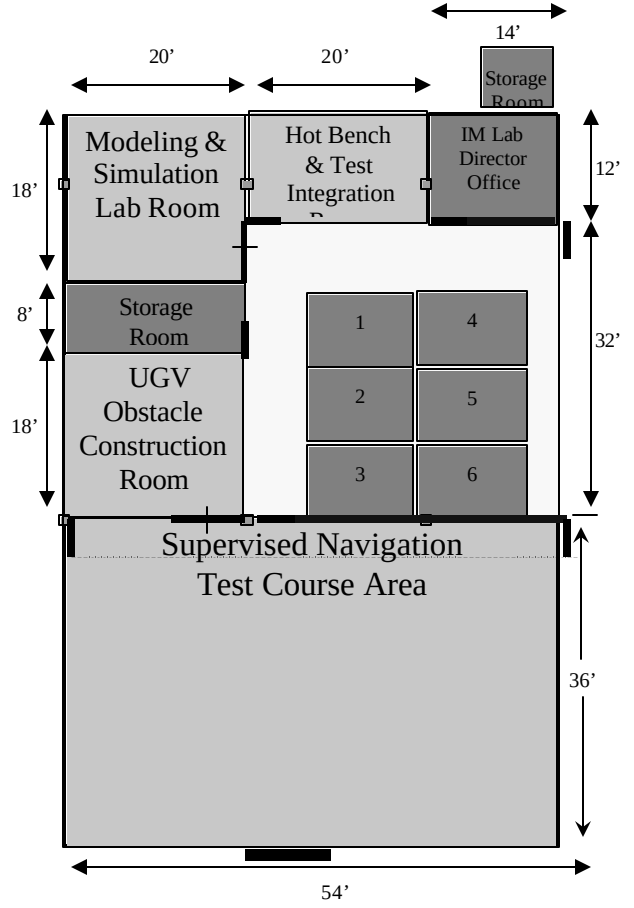
**Support to tri-service organizations & the Battlelabs**

***TRL - TARDEC Robotics Laboratory**

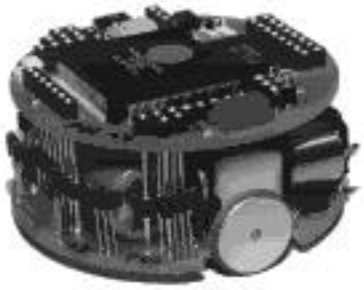
**Mix of research & customer funding**

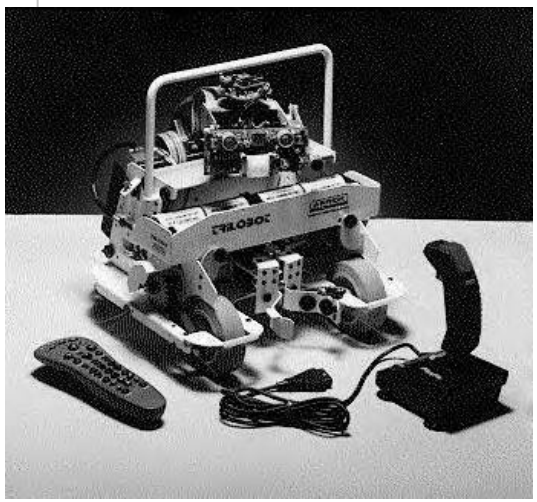
# TRL Facilities

- Office Space for 10 personnel
- Behavioral Robotics lab
- Electronics integration room
- Modeling and simulation room
- Hardware room
- T&E bay for robots



# Behavioral & Evolutionary Robotics Lab





- Creation of varying fidelity models of robots and sensors.
- Development of behavior-based navigation, mapping schemes.
- Transition to lab hardware and progressively larger, more complex robots (e.g predict performance).
- Development of Evolutionary Algorithms for tuning and improving robot performance.
- Evolve the controllers in simulation.
- Transition to robots to finish the job.

# Modeling & Simulation Lab

- Perform mobility simulations
- Perform model validations
- Drive any hardware-in-the-loop bench testing
- Assist NRMM upgrade?
- Wargaming scenarios
- Conduct “virtual” interactions with MOUT facilities via RAVENS

# RAVENS

RAVENS: Geographically distributed Soldier/Marine in-the-loop, Hardware in-the-loop, Software in-the-loop virtual & live analysis, test, & experiment architecture

- **Assist Users in Requirements Development Efforts**
- **Assist the S&T community in Developing & Evaluating Technologies**
- **Assist in Risk Reduction Efforts**
- **Assist in Developmental and Operational Tests**

**Vision - Applying SBA/SMART principles to minimize cost, speed development, reduce risk, & ensure that Soldiers and Marines remain at the center of all system development efforts**

# Terrain Classification Sub-System

## Objective & Approach

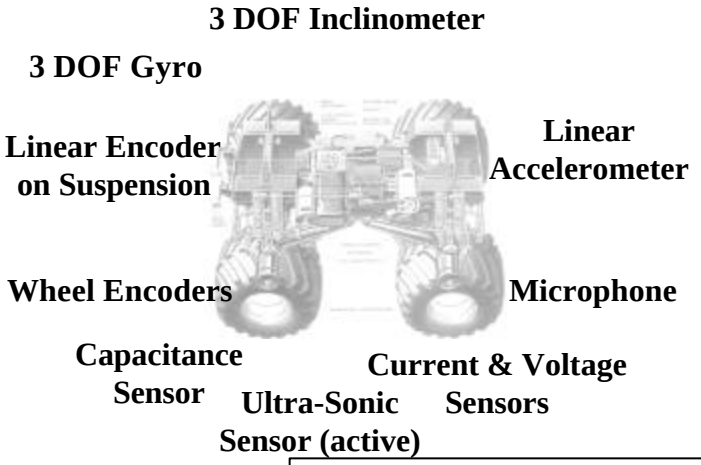
- Generic, low-cost, light-weight, low power sensor package to sense vehicle dynamics and terrain properties

- Machine learning algorithm to classify terrain type from sensor data

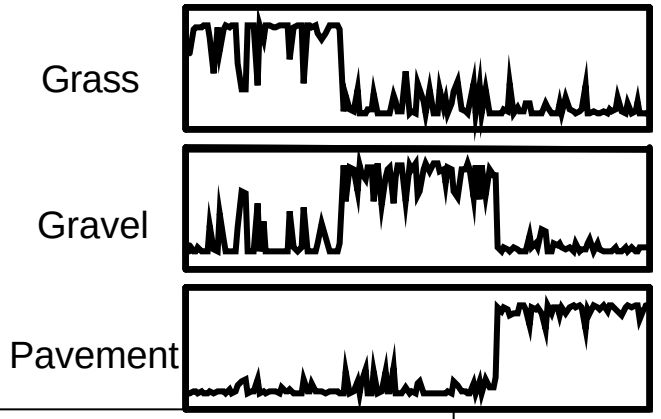
## FY 01 Milestones

- Demonstrate prototype system

- Evaluate on 6 terrain types




Neural Net Classifier (single sensor)

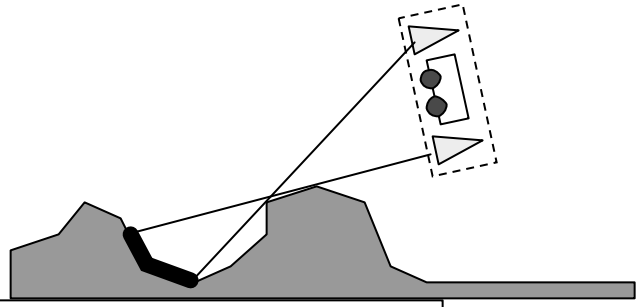


# Negative Obstacle Detection System

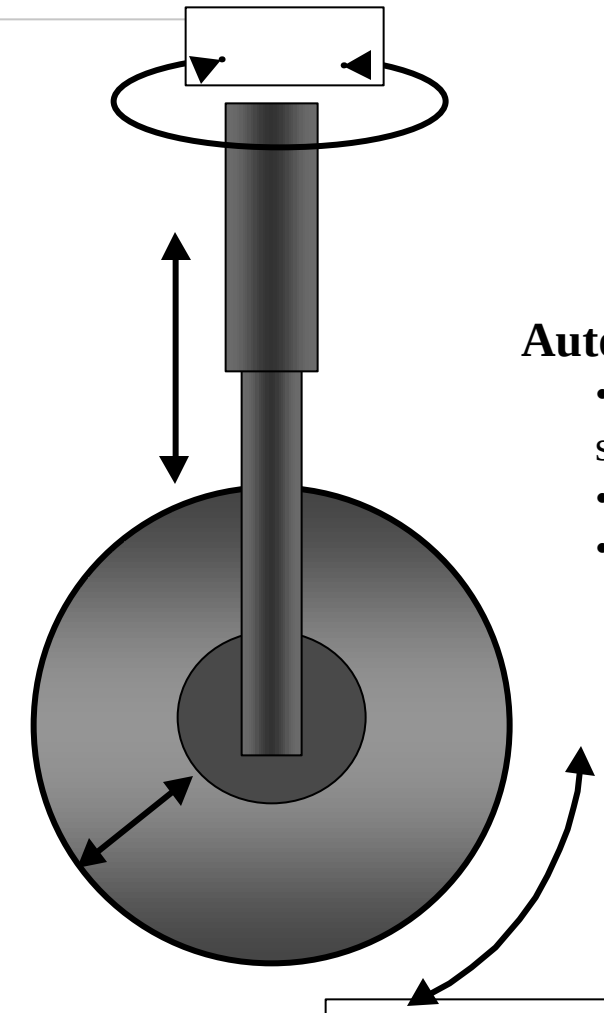
| Objective | FY 01 Milestones |
| --- | --- |
| - Navigation vision system integrating multi-source projected light and trinocular stereo vision<br><br>- Downstream SWIR system in 1.8 to 2.0 micron CO2 absorbing “dark band” | - Demonstrate prototype system<br><br>- Evaluate as a function of obstacle<br>• Size<br>• Distance<br>• Terrain cover |

Shadows isolation locates negative features from over-lit and under-lit images.

Vertical-offset stereo cameras provide range to horizontal shadows.



# Intelligent Wheel Module: Embedded Sensors, Controllers and Actuators



## Sensors measure forces and response

- Wheel spin rate and drive torque
- Vertical strain, rate and position
- Twist strain, rate and position
- Tire pressure

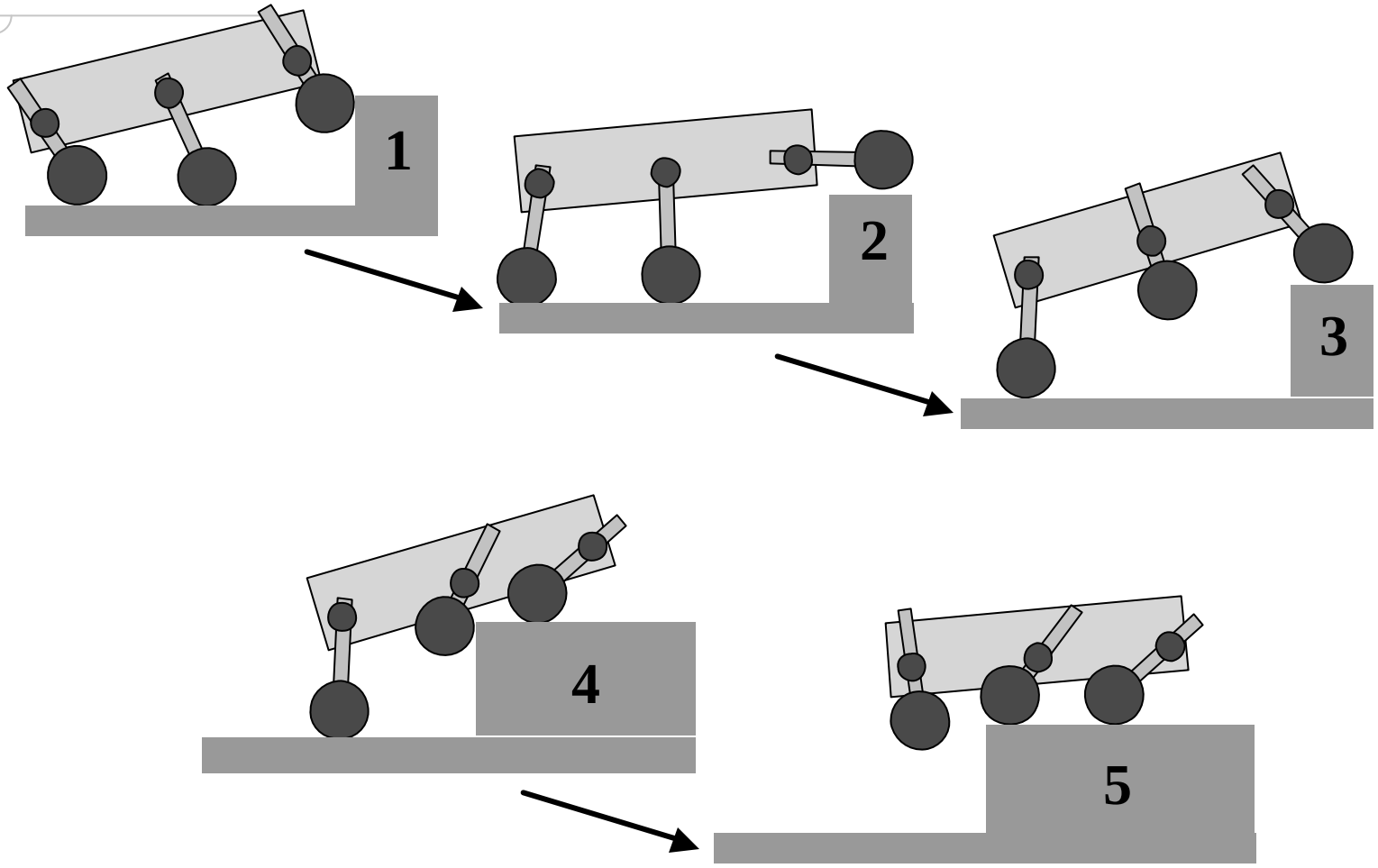
## Automatic controllers optimize mobility

- Minimize slip during acceleration, braking, steering and side slope traverse
- Minimize rolling resistance during on-road travel
- Minimize shock and vibration transmitted into the chassis

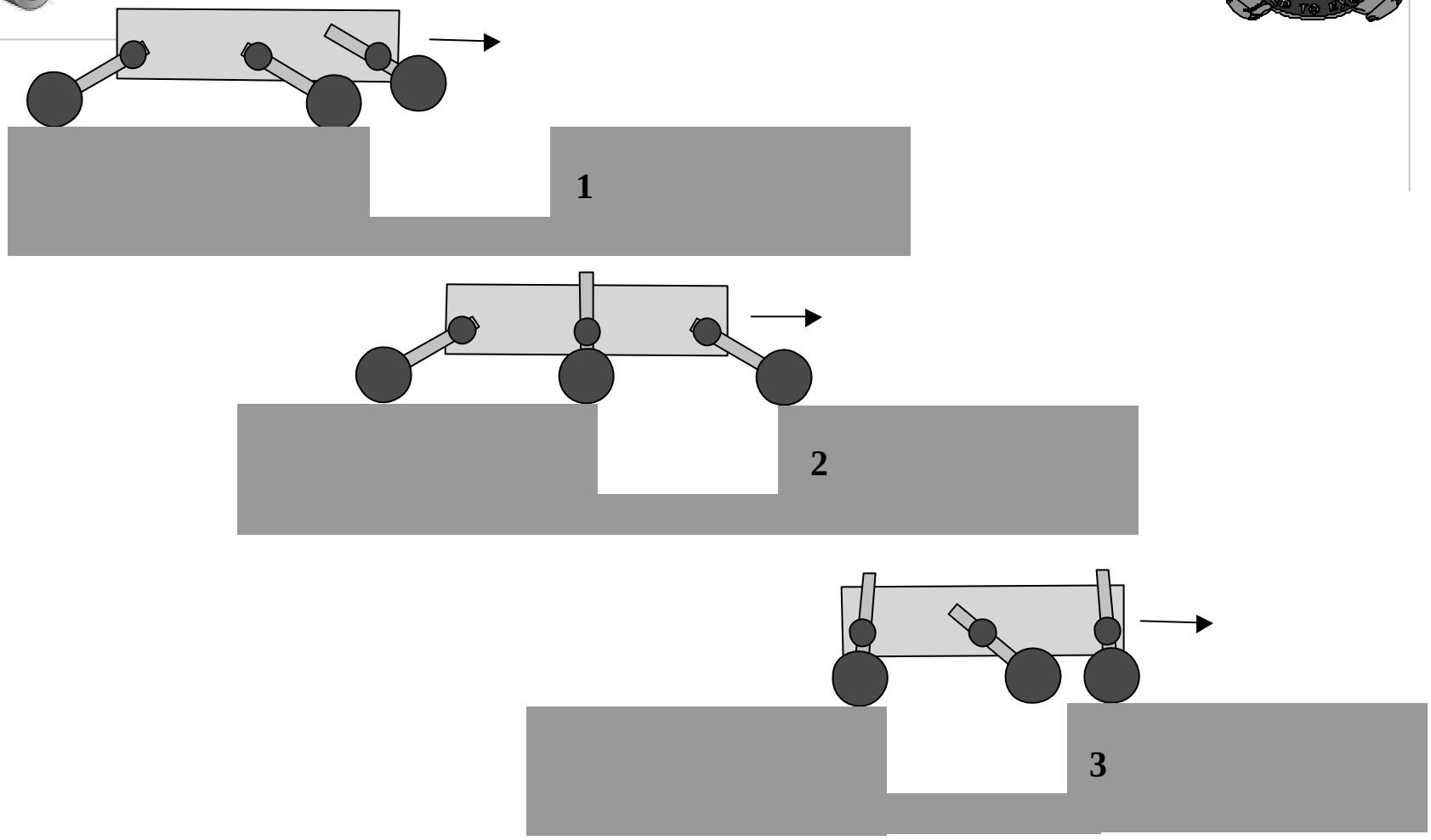
## Actuators control 4 degrees of freedom

- In-hub electric drive
- Vertical displacement, damping and adjustable/variable spring stiffness
- Steering
- Tire pressure

# Walking/Climbing Gait for Vertical Obstacles (6-Wheel Drive and 2-DOF Active Suspension)

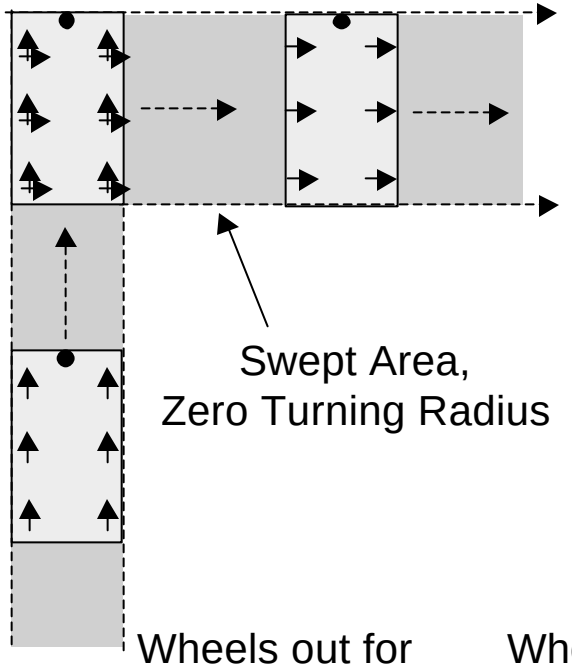


# Crevasse Crossing with 2-DOF Active Suspension

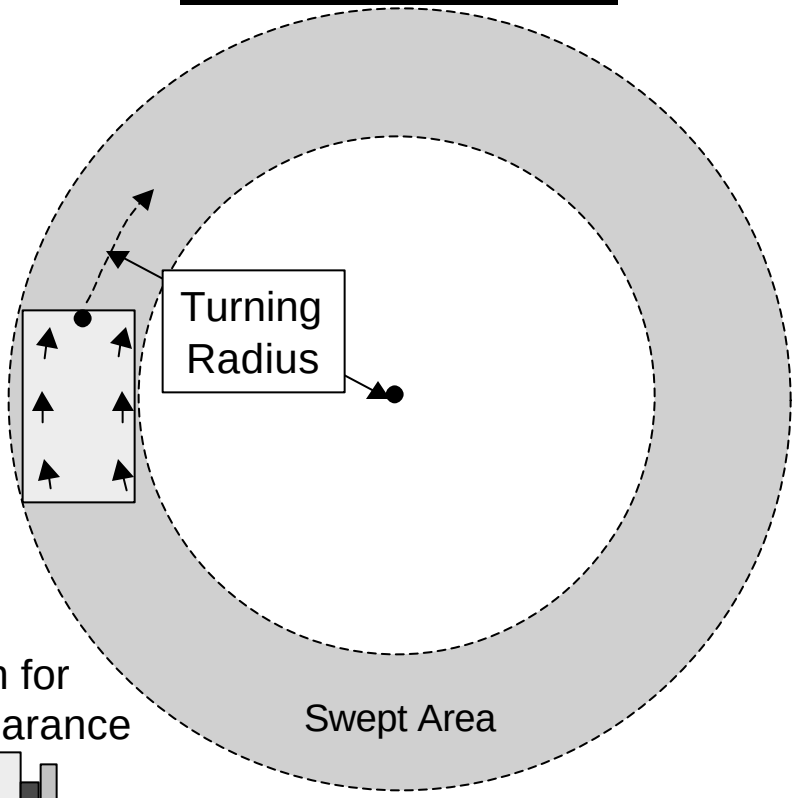


# Turning Maneuvers w/ Omni-Directional Drive
## (Turning Radius vs. Swept Area Tradeoff)

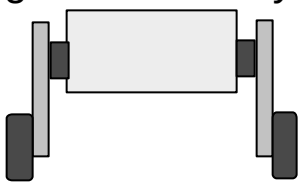
**Fixed Body Axis Steering**



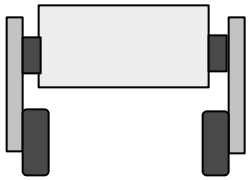

**Ackerman Steering**




Wheels out for greater stability



Wheels in for narrower clearance

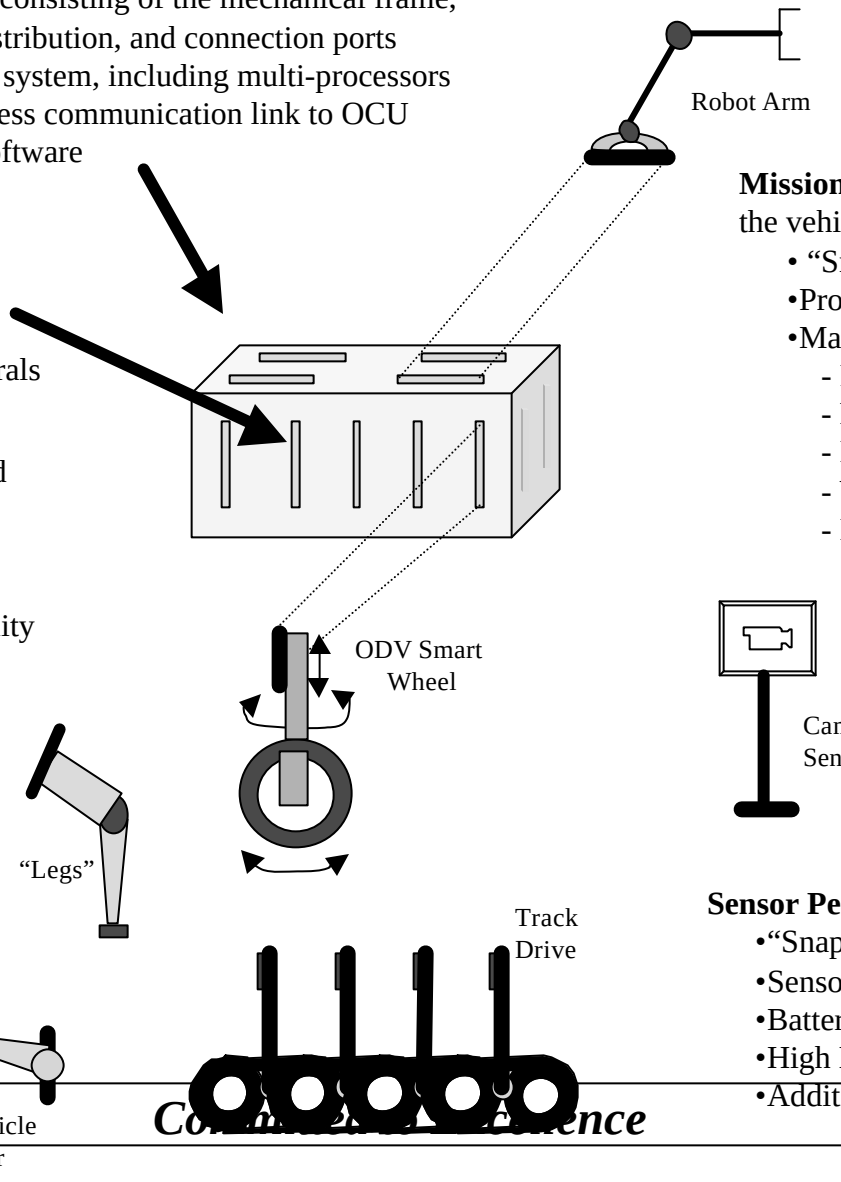


# FY01 and Beyond: The Modular Chassis

**Chassis** has three parts:
- Core unit consisting of the mechanical frame, power/distribution, and connection ports
- Vetronics system, including multi-processors and wireless communication link to OCU
- System software

**Connection Ports** supply
- "Plug and Play" connectivity
- Power to/from peripherals
- Data communications
- Structural support for peripherals

**Locomotion Peripherals** are used to provide mobility capability
- "Snap and Lock" connections
- Modular system concept
- Deploy and a variety of mobility concepts, such as
  - ODV smart wheel
  - Hybrid track wheel
  - "Legs"
  - Fixed wheels
  - Tracks/skid steer
  - Pontoons/propellers
  - Others
- Multi-vehicle coupling




**Mission Peripherals** provide the vehicle with a reason to exist
- "Snap and Lock" connections
- Provides variety of functionality
- Manipulation concepts such as
  - Robot arms and end effectors
  - Forklift mechanism
  - Explosive ordinance handling
  - Welding fixtures and torches
  - Mission-specific "jigs"




**Sensor Peripherals** enhance the chassis
- "Snap and Lock" connections
- Sensor packs
- Batteries/generators
- High BW Communications
- Additional computing capability

# T1, T2, T3, and ODIS