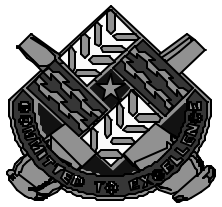
TACOM

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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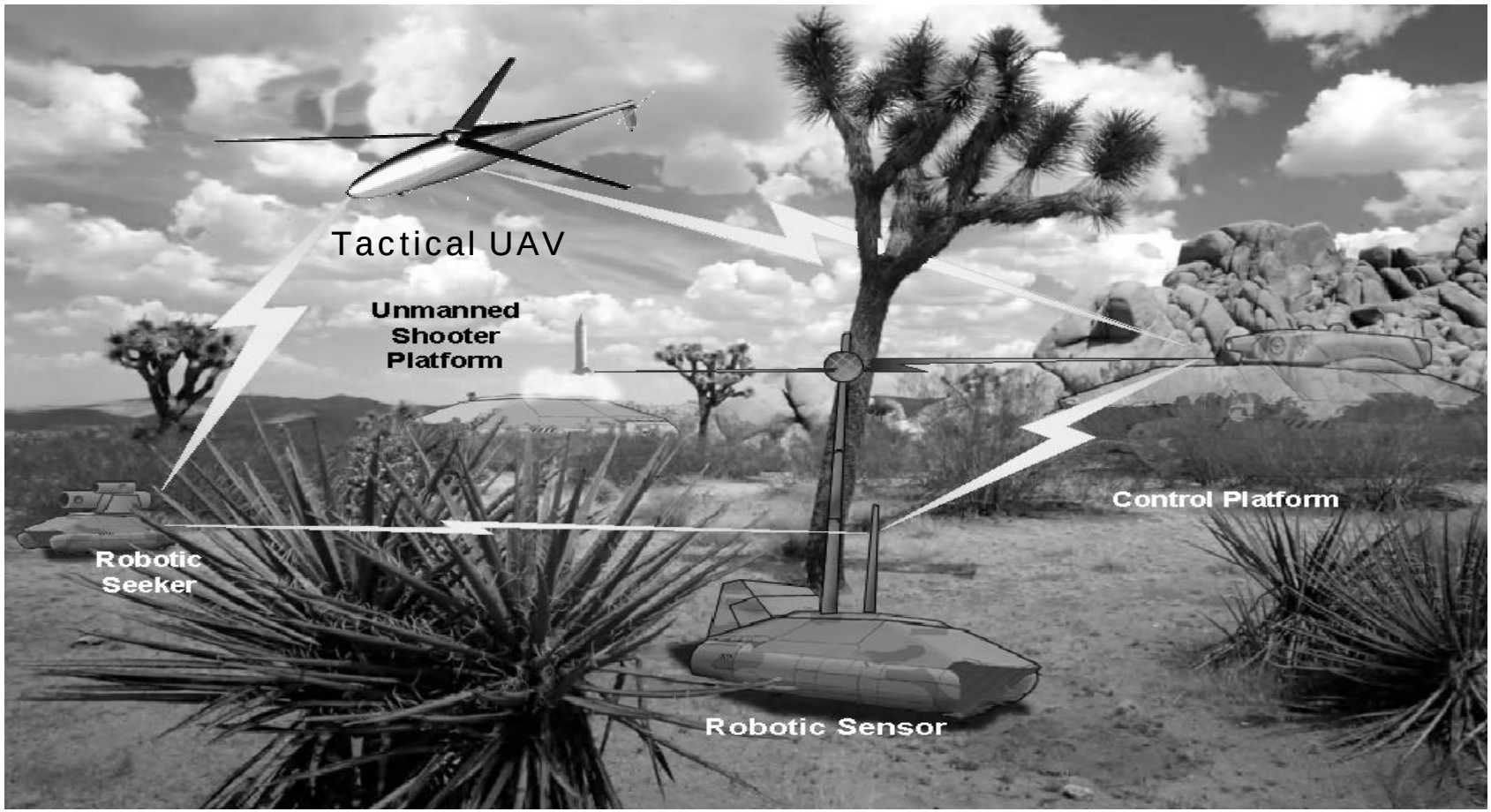
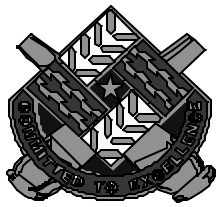
Robotics “Vision” for FCS

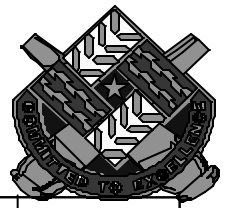


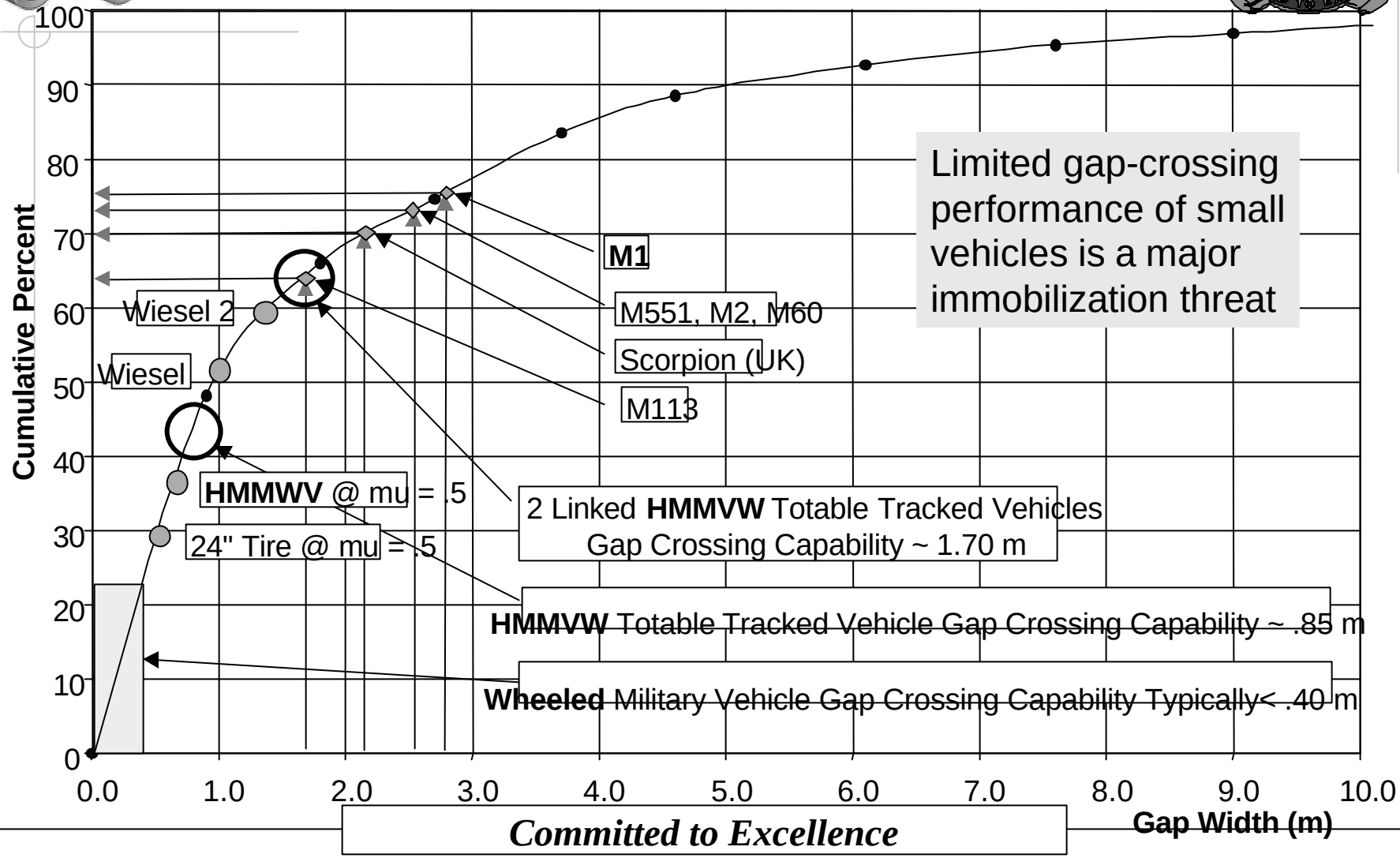
UGV Mobility Issues



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 • Complex suspension • Limited route availability	Higher cross country speed Simpler suspension • Higher payload fraction • Lower Cost Better Trafficability • No personnel risk

Gap Crossing Capability in Germany

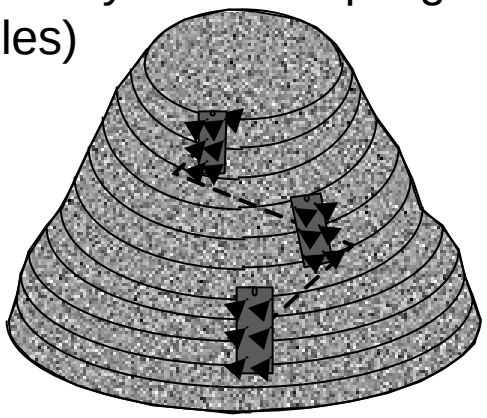


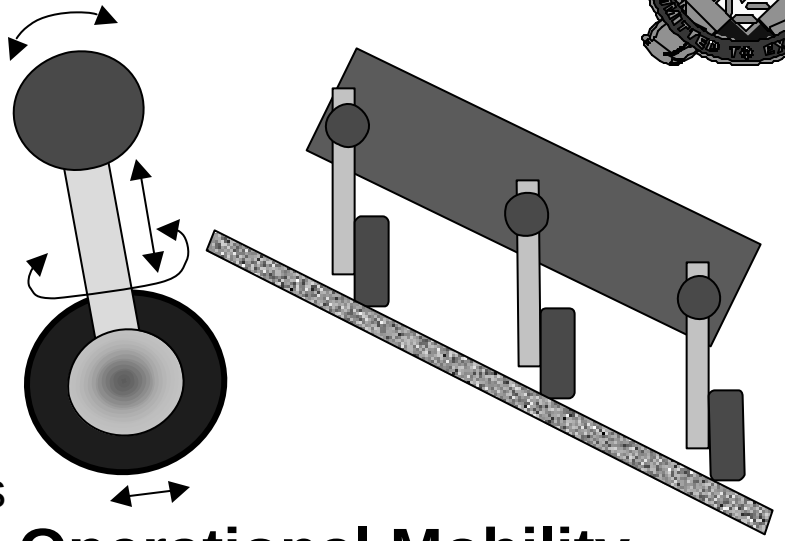


What Is Intelligent Mobility?

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)

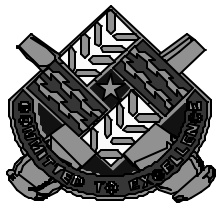




Operational Mobility

- 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

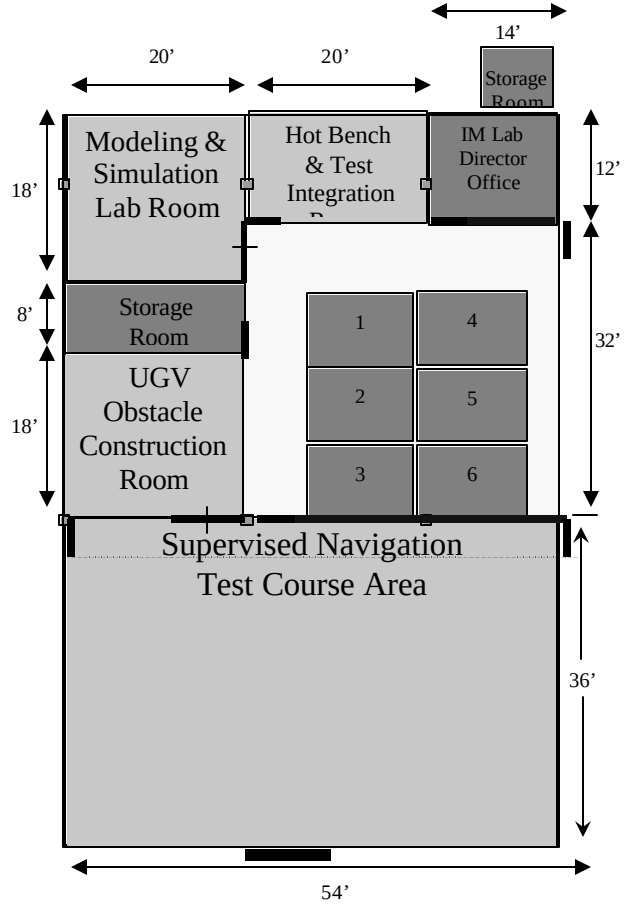
Support to tri-service organizations & the Battlelabs

***TRL - TARDEC Robotics Laboratory**

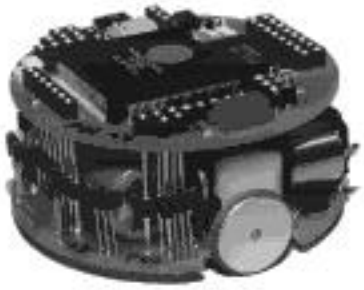
Mix of research & customer funding

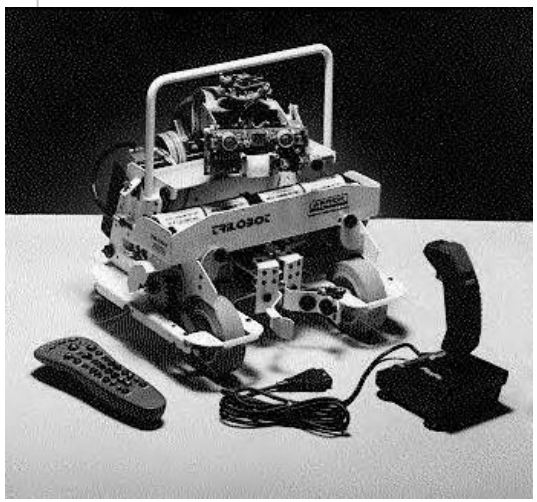
TRL Facilities

- 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

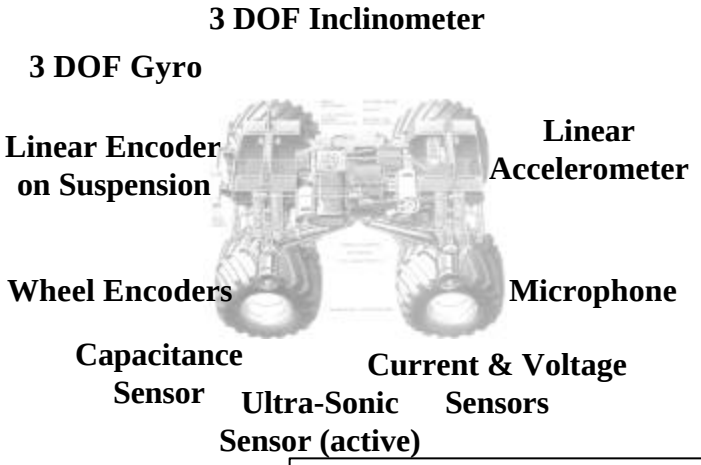
- Generic, low-cost, light-weight, low power sensor package to sense vehicle dynamics and terrain properties

- Machine learning algorithm to classify terrain type from sensor data

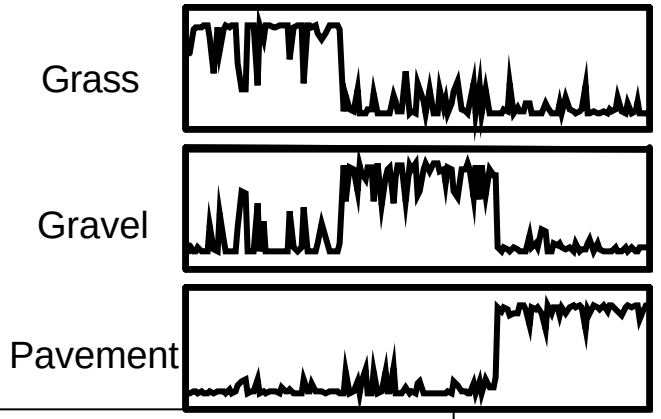
FY 01 Milestones

- Demonstrate prototype system

- Evaluate on 6 terrain types



Neural Net Classifier (single sensor)

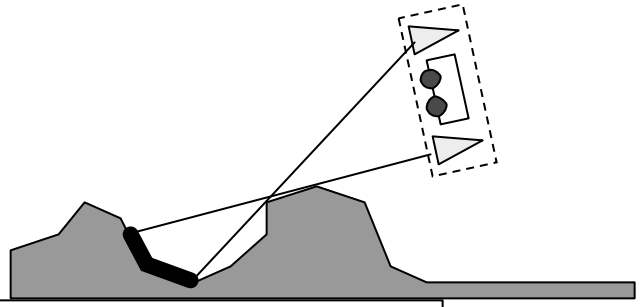


Negative Obstacle Detection System

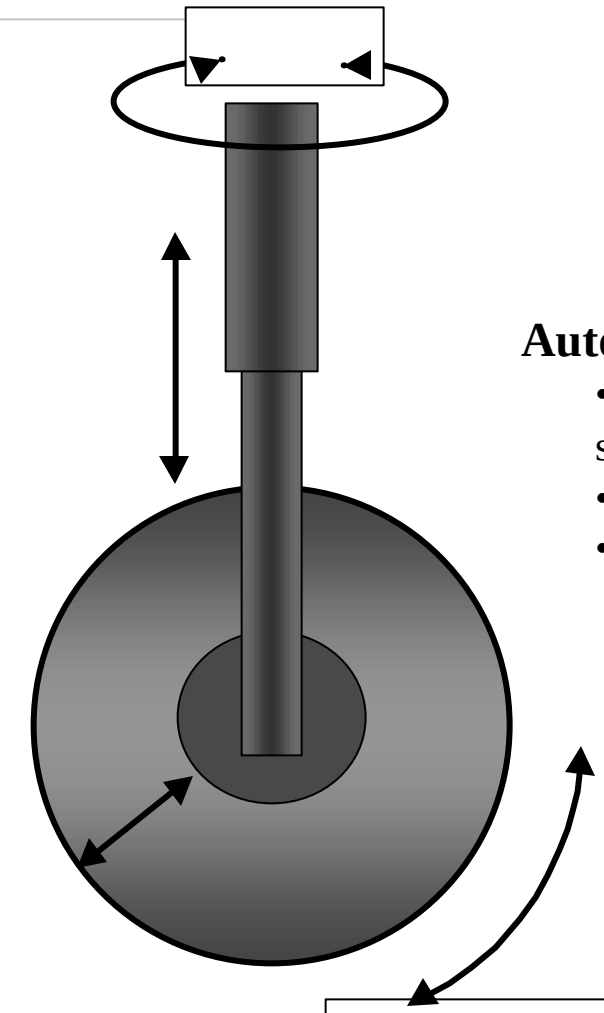
Objective	FY 01 Milestones
- Navigation vision system integrating multi-source projected light and trinocular stereo vision - Downstream SWIR system in 1.8 to 2.0 micron CO2 absorbing “dark band”	- Demonstrate prototype system - Evaluate as a function of obstacle • Size • Distance • Terrain cover

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

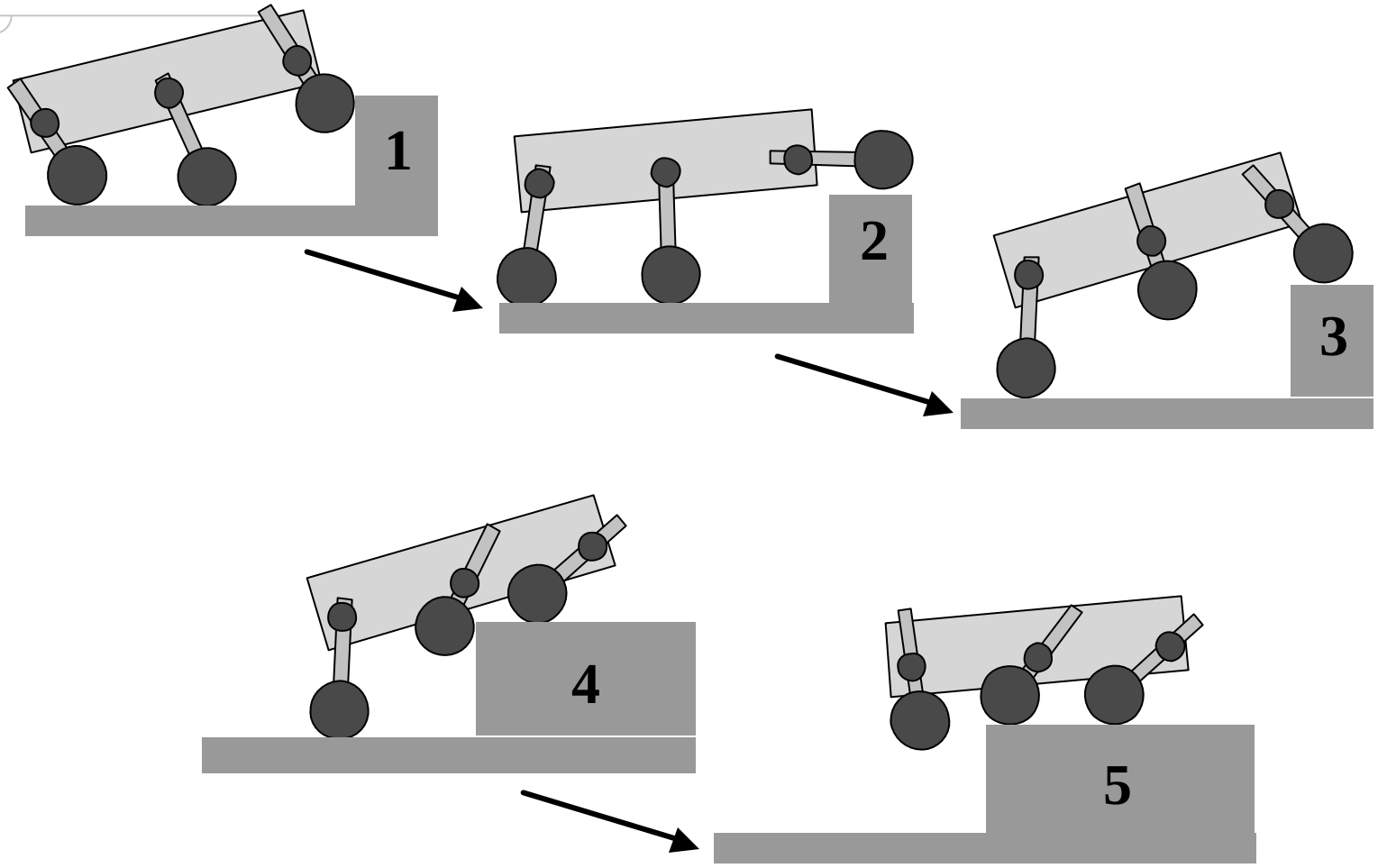
Automatic controllers optimize mobility

- 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

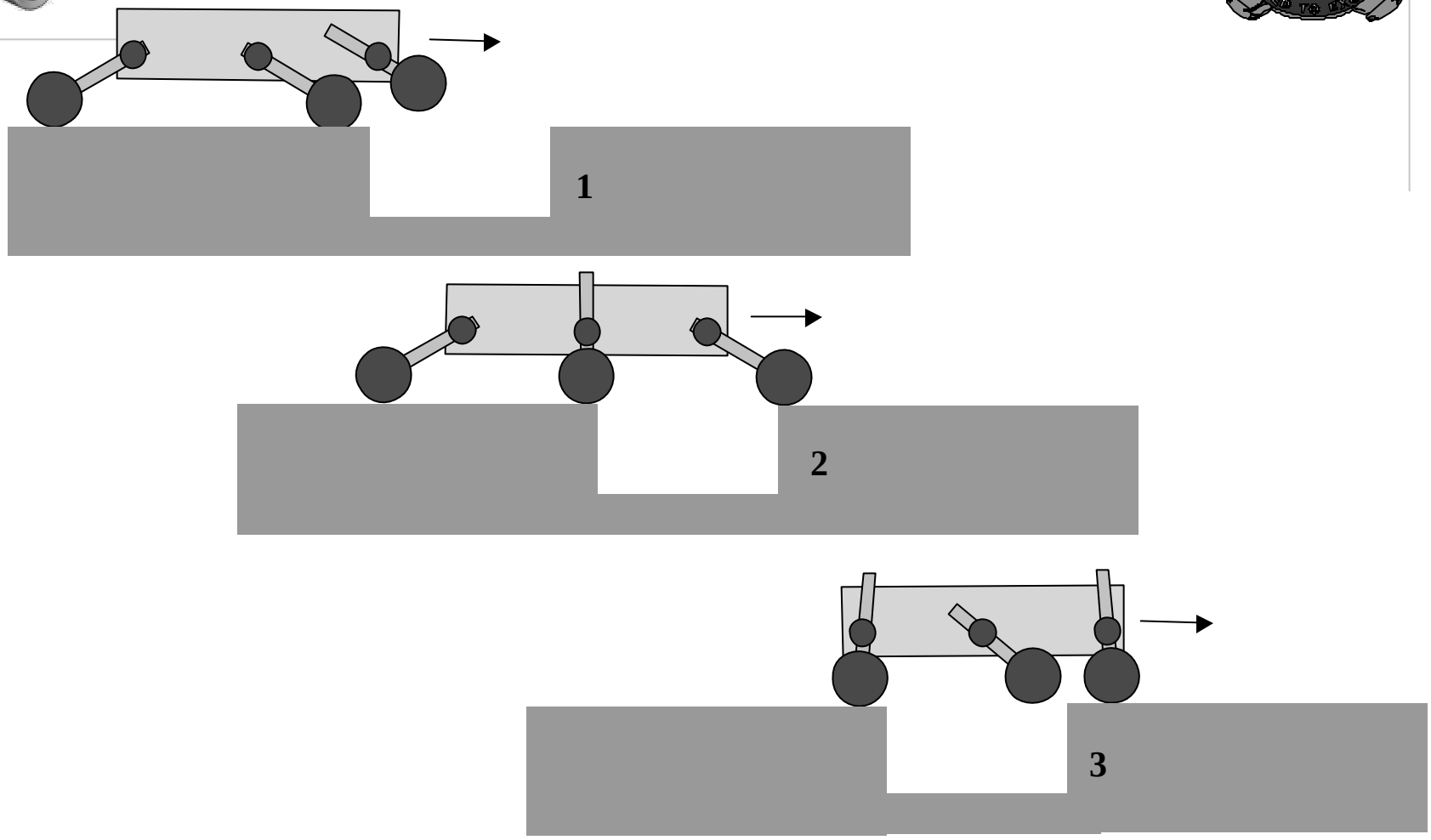
Actuators control 4 degrees of freedom

- 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)

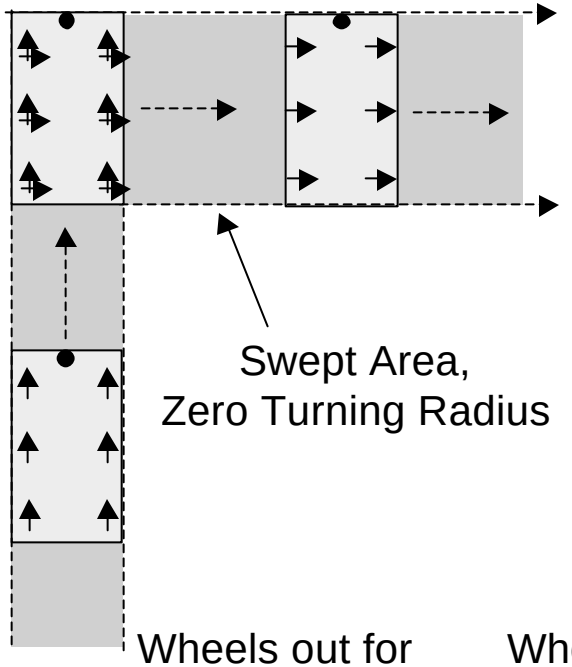


Crevasse Crossing with 2-DOF Active Suspension

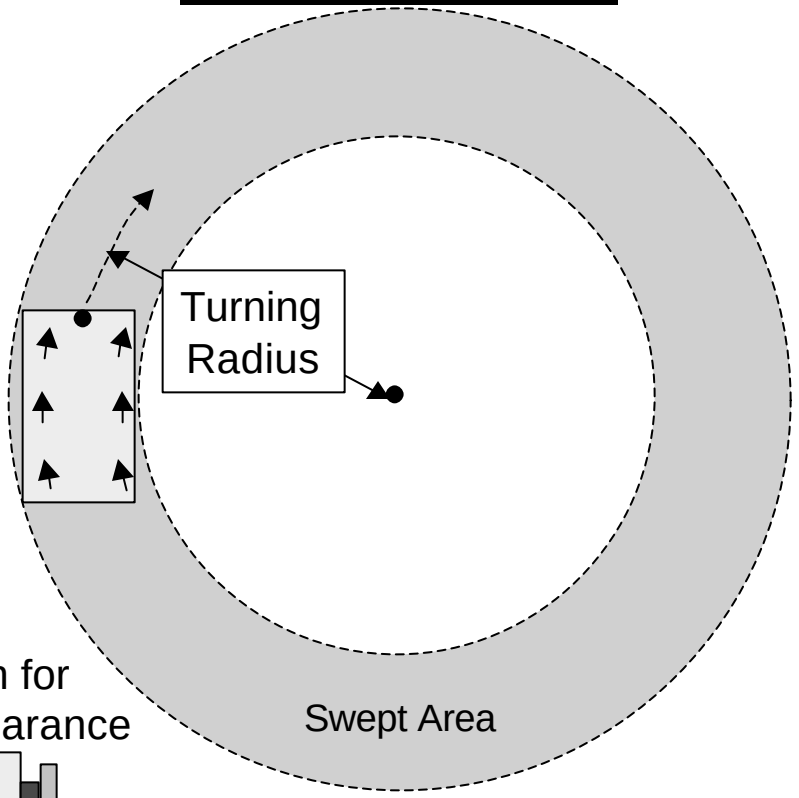


Turning Maneuvers w/ Omni-Directional Drive
(Turning Radius vs. Swept Area Tradeoff)

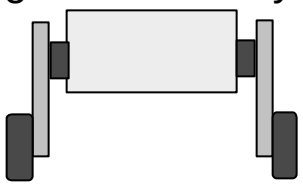
Fixed Body Axis Steering



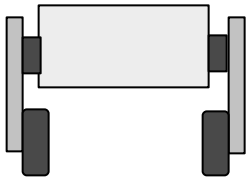
Ackerman Steering



Wheels out for greater stability



Wheels in for narrower clearance

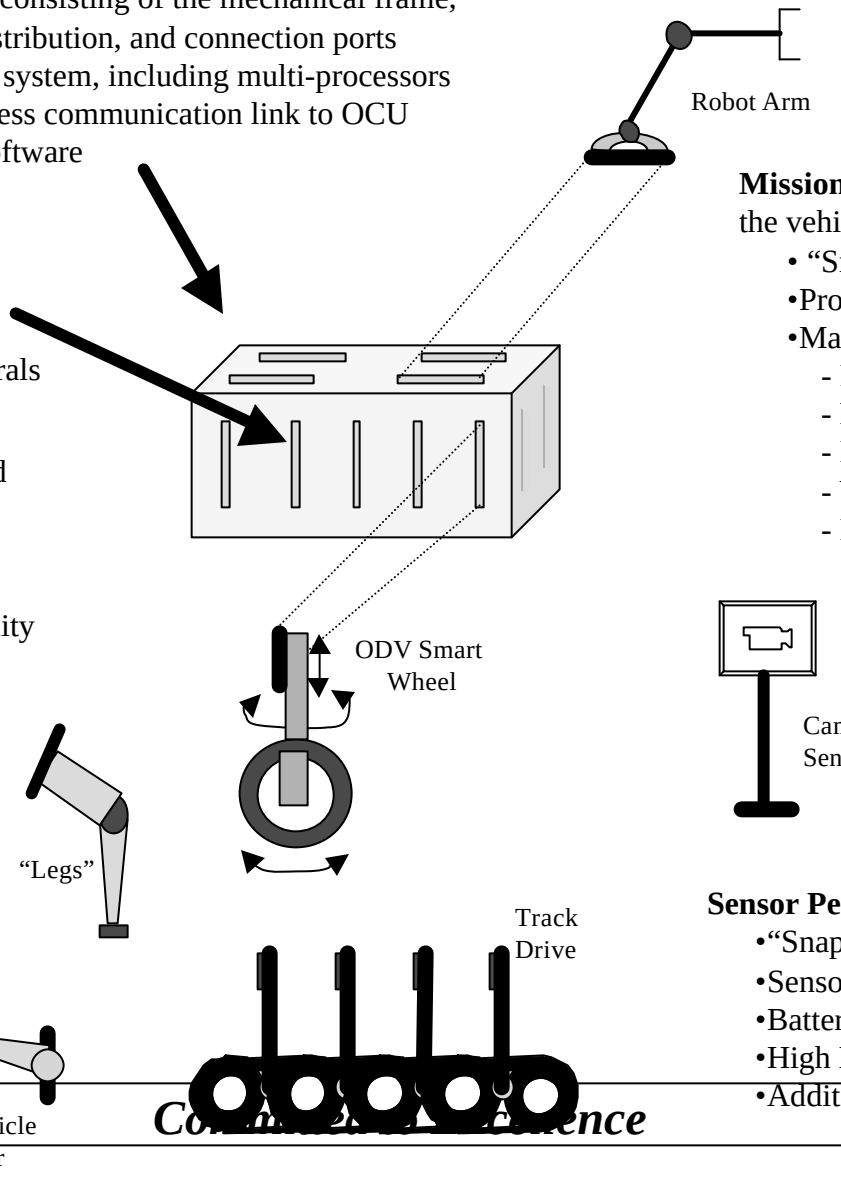


FY01 and Beyond: The Modular Chassis

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