VIRTUAL PROVING GROUNDS-EMERGING VEHICLE DEVELOPMENT TOOLS

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PRESENTATION OUTLINE

- National Research Council, Board on Army Science and Technology (BAST) Study; *Reducing the Logistics Burden for the Army After Next*
  - Modeling and simulation recommendations
  - ARC opportunity
- Emerging Virtual Proving Grounds
- Virtual Proving Ground Developments with TARDEC
ARMY AFTER NEXT BATTLE FORCE CONCEPT

- Up to 8000 Soldiers, 2000 Vehicles
- Projected From U.S. (To Staging Area)
- Transported From Staging to Battle Area
- Maneuver in Battle Area at 200 Km/h
- Self-sustaining for 14 Days
- Logistics Activity Between Combat Pulses
REPORT HIGHLIGHTS

- Emphasizes Priority Should Be Given to Logistical Considerations in Developing AAN Concepts and Systems
- Identifies Research and Technology Development to Reduce Logistics Support Requirements for Future Combat Systems
- Describes Modeling and Simulation Tools As Essential to Reduce Logistics Demand and to Plan AAN Systems and Engagement Doctrine
- Focuses on AAN Mission-reliability Metrics, Vice “Ultrareliability”
- Encourages “Jointness” in Operations and R&D
AAN LOGISTICS STUDY EMPHASIZES MODELING/SIMULATION

- Modeling and Simulation Critical For Trade-Off Analysis
- Emphasis on Advanced Off-Road Mobility
  - Cross-country speed; 80 mph desired
  - Vehicle weight; 15 tons desired
  - Fuel consumption; Major logistics driver to be minimized
  - Enhanced durability for 14 day mission self-sufficiency
- Presentations to Senior Army Management Well Received
- Supports Simulation-Based Acquisition Approach
- Partnering with the Commercial Sector Recommended
- ARC Well Placed to Participate
MISSION SELF-SUSTAINMENT REQUIREMENT MUST DICTATE MATERIEL DESIGN

• Traditional Model
  – Given the force, how can we sustain it?; Design-driven logistics
  – Accept existing system reliability; Unreliable systems

• AAN Model
  – Design a self-sustaining force; Logistics-driven design
  – Design systems for AAN missions; AAN mission reliable systems
CRITICAL M&S NEEDS FOR AAN TRADE-OFF ANALYSIS

- **High-Speed Cross-Country Mobility**
  - Vehicle system/subsystem trade-offs; *75 to 15 tons and 80 mph provides a multitude of alternatives*
  - Driver training to achieve mobility objectives; *Soldier performance critical for high cross-country speed*

- **Materiel Reliability**
  - Mechanisms of failure modeling; *Design to avoid failures*
  - Uncertainty modeling; *Understand and control effects of uncertainties*
  - Human factors modeling; *Soldier performance with advanced systems*

- **Small Unit and Force-on-Force Engagement**
  - Integration with engineering models; *Realistic performance/cost*
  - Sort out trade-offs; *Everything Depends on Everything Else*
HIERARCHICAL M&S SYSTEM FOR VEHICLE TRADE-OFF ANALYSIS

- Force-on Force
  - Strategy
  - Tactics
- Multiple Vehicles with Operators
  - Operational History
  - Average Loads
  - Peak Loads
- Single Vehicle with Operator/Hardware Loop
  - System Architecture
  - Subsystem Architecture
  - Component Design
- Force Performance and Cost
  - System Vol., Wt., Range, Cost, Perf.
  - Vehicle Vol., Wt., Efficiency, Cost, Perf.
  - Subsystem Vol., Wt., Efficiency, Cost, Perf.
  - Component Vol., Wt., Efficiency, Cost, Perf.
- Duty Cycle Requirements
- Performance Characteristics/Cost
- Operations Simulation
  - Simulation Based Design
- I/UCRC
- DARPA
- NADS
- SAC
- NSF
- My Logo
COMPONENT DESIGN CONSIDERATIONS

Component Design

- Fuel Consumption
- Communications Bandwidth
- Sensor Performance
- Material Selection Analysis
- Dynamic Analysis
- Stress Analysis
- Reliability Analysis

Stresses
Capabilities
STATUS OF MOBILITY M&S

• NATO Reference Mobility Model (NRMM) Developed in 1960s and 70s
  – Terrain databases characterize fields of operation
  – Predict time required to traverse tactical environment
  – Validated and used constructively for two decades

• NRMM Based on Empirical Speed and Tractability Parameters
  – Models influenced by historical vehicle characteristics

• Fidelity of Vehicle Modeling in NRMM Inadequate to Assess Benefits of Advanced Vehicle Concepts and Technologies for AAN
  – Active suspension
  – Active traction control
  – Electric drive powertrains
  – Semi-automated/autonomous vehicles

• High Fidelity Simulator-Based Vehicle Virtual Proving Grounds Emerging
MOBILITY M&S TECHNOLOGY DEVELOPMENTS NEEDED

- Model AAN Environment
  - Soil characteristics
  - Terrain geometry/features
- Model Tractability for High Speed on Soft Soils
- Develop Fuel Consumption Models That Account for
  - Energy dissipation at tire/track-soil interface
  - Active suspension/traction
  - Hybrid-electric powertrains
  - Vehicle speed and maneuver
- Develop Real-Time Models for Hardware- and Soldier-in-the-loop Simulation
  - Tire/track-soil interaction
  - Active traction and suspension
  - Hybrid-electric powertrains
- Validate Models
  - Experiment with existing AAN-like vehicles
  - Experiment with AAN rapid prototypes
- Implement Virtual Proving Grounds for Vehicle Trade-Offs
FACILITATING AAN LOGISTICS
TRADE-OFF ANALYSIS

- Define Priorities for M&S Development to Meet AAN Needs
- Secure Buy-In and Commitment
  - Army Labs
  - Defense vehicle manufacturers
  - Agricultural and construction equipment manufacturers
  - University research centers
- Focus on AAN Logistics Trade-Offs
  - Build upon existing infrastructure
  - Apply throughout AAN process

- Continuously Develop Tools and Technology, Based on Need
  - Advance technology to fill voids
  - Integrate engineering and operational simulation tools

- Validate Models Based on Rapid Prototype Testing
  - Carry out design excursions with validated models
  - Support AAN trade-offs and materiel design
EMERGING VIRTUAL PROVING GROUNDS

• Advanced Driving Simulators
  – Daimler-Chrysler Simulator
  – Iowa Driving Simulator
  – Army Turret Motion Base Simulator
  – Army Ride Motion Simulator
  – National Advanced Driving Simulator

• Virtual Proving Ground Leveraging
TYPICAL DRIVING SIMULATOR
DAIMLER-CHRYSLER SIMULATOR
IOWA DRIVING SIMULATOR
ARMY TURRET MOTION BASE SIMULATOR
ARMY RIDE MOTION SIMULATOR
NATIONAL ADVANCED DRIVING SIMULATOR
Two Joint Projects with TARDEC to Refine/Implement ARC-I Developments
- Laboratory modernization project
- Dual use simulator development and linking

ARC-II Synthetic and Virtual Environment Projects Contributing
- Off-road synthetic environment modeling and simulation
- Numerical methods for high fidelity, real-time simulation
- Parallel computation for high fidelity real-time simulation
- Integrated ARC tools for virtual proving ground simulation

Integrating Programs for Optimum Leveraging
OFF-ROAD PROVING GROUND
VIRTUAL PROVING GROUND DEVELOPMENTS WITH TARDEC

- ARC Developed Real-Time Vehicle Dynamics
  - NADS
  - TARDEC RMS and TMBS
- Compatible Simulator Operating Environments for Interactive Simulation
  - NADS, RMS, and TMBS
- CAVE Implementation