Autonomous Mobility Appliqué System (AMAS)
Bernard Theisen
MISSION: Provide full service life cycle engineering support to our TACOM LCMC customers (PEO GCS, PEO CS&CSS, ILSC) and PM FCS (BCT), to develop and integrate the right technology solutions to improve the effectiveness of the current force and realize the superior capability of the future force to facilitate army transformation.

VISION: Be the first choice of technology and engineering expertise for ground vehicle systems and support equipment - today and tomorrow.

TARDEC is responsible for research, development and engineering support to more than 2,800 Army systems and many of the Army’s and DoD’s top joint warfighter development programs.
How To Speak Army Robotics

TLA – Three Letter Acronym

UPI - UGCV (Unmanned Ground Combat Vehicle) PerceptOR (Perception for Off Road) Integration

Passive Safety – Vehicle features that warn/notify the drive, but do not control the vehicle

Active Safety – Vehicle features that augment the drives capabilities (braking, accelerating, steering)

Scalable Autonomy – With the turn of a knob to be able to select on the fly how autonomous a vehicle will perform

Robot – A ground, air, sea or underwater platform that can perform tasks remotely with or without human supervision.

OMV – Optional Manned Vehicle
Convoy Operations Can Be Dangerous for Different Reasons

• Major accidents due to driver error
  – Very long convoy missions—10 to 14 hours
  – Difficult, unpaved, rugged terrain
  – Inexperienced drivers—age 18 & 19 years
  – Collision (Front & Rear), Rollover, Roadway Departure, etc.

• Susceptibility to attack by adversary
  – Asymmetric warfare
    • Improvised explosive devices (IEDs)
    • Coordinated threat attack
AMAS will provide scalable autonomy in a single material solution agnostic of vehicle. For the AMAS JCTD, AMAS will be implemented in a vehicle specific By-wire kit that would provide the electronically controlled subsystems and interface for the common Autonomy Kit. The Autonomy kit, along with the By-wire kit, would provide Leader/Follower, waypoint navigation and advanced Convoy behaviors.

The AMAS JCTD will also address defining an open architecture for future autonomy enhancements. Along with Analysis of Alternatives for testing large unmanned ground vehicles (UGVs).
By-Wire Kit

**By Wire Kit - Active Safety and Control Interface**

- **Configuration:** Install Hardware and Software necessary to provide Active Safety Capability and Interface/Control of the Steering, Braking, Transmission, and Engine functions of the vehicle. Kit will be Interfaced Electronically and not Interfer with Egress/Ingress of Operator.

- **Problems addressed:** Prevent accidents through rollover and yaw stability (Over/Under steer) control, collision warning and mitigation, emergency brake, lane keeping; Reduce fatigue through Adaptive Cruise Control (ACC); Provide Interface to control the vehicle which would provide for future upgrades of robotic technology as needed. Current TRL: 6-7

- **Advantages:**
  
  **Active Safety** – Collision Mitigation, Stability Control, Emergency Braking, Adaptive Cruise Control, Roadway Departure Prevention
  1. 26% to 59% Reduction in Truck Related Accidents
  2. Improved Handling due to Stability Control
  3. Decrease in Physical Load on Operator

**Common Interface**

1. Vehicle Gateway/Control for Scalable Robotics(Autonomy Kit Interface)
2. Enabling Increase in Future Capability
Autonomy Kit

**Autonomy Kit – Convoy Capability**

- **Configuration**: Interface with By-Wire Kit and provide Leader/Follower, Waypoint Navigation, and Obstacle Detection/Avoidance Features to implement a Convoy Capability that can be operated in a Manned or Unmanned Mode.

- **Problems addressed**: Save lives and increase combat power and situational awareness through semi-autonomous convoy operations; Reduce accidents through obstacle detection/avoidance, road keeping (unpaved), and night vision enhancement; Save fuel in convoy operations; Support logistics operations. Current TRL: 5-6

- **Advantages**:
  - **Fuel Savings** - 7% or more in Unmanned/Manned Mode due to Optimized and Fuel Efficient Automated Driving Cycles. (Eliminates Human Variability Between Drivers)
  - **Increased Night Ops and OpTempo**
  - **Manned** - Driving is automated and Operator can Manually Override.
    1. Decreased Mental Load
    2. Increased Situational Awareness due to Driving Cognitive Load Reduction
    3. Further Decrease in physical Load on Driver
    4. Force Multiplier - Ability to decrease Manning in Vehicles and Reassign
    5. Estimated 2.5 Billion Dollars in net Savings for the Army due to Reduction in Force Structure for Convoy Operations
  - **Unmanned Mode** - Every Other Vehicle in Convoy Unmanned.
    1. Significant decrease in Casualties caused by Accidents and IEDs
    2. Estimated 3.7 Billion dollars in Net Savings for the Army due to reduction in Force Structure
Notional Implementation on FMTV

- Electronic Brake System (ELB) w/ Electronic Stability Control (ESC)
- Wheel Speed Sensors
- ESC Accelerometer/Rate Gyro
- Electric Power Assist Steering (EPAS)
- Steering Position Sensor
- Steering Torque Sensor
- Transmission Controller
- Engine Controller
- Stereo Camera
- Automotive Radar
- Comm Antenna
- Lidar
- GPS Antenna
- Side Blind Zone Radar
- Wheel Speed Sensors
- Electronic Brake System (ELB) w/ Electronic Stability Control (ESC)

UNCLASSIFIED
## Capabilities of Scalable Autonomy

<table>
<thead>
<tr>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td><strong>Passive Driver Assist</strong></td>
<td><strong>Active Driver Assist</strong></td>
<td><strong>Automated Driving</strong></td>
</tr>
</tbody>
</table>
| • Increase Situational Awareness  
  • Environment and Surroundings  
  • Vehicle Capabilities and Configuration | • Active Intervention  
  • Maintain Lane Control  
  • Tip-Over Prevention  
  • Collision avoidance and mitigation  
  • Stability Control  
  • Enables operator to focus on other convoy mission tasks while the vehicle safely operates itself. | • Leader/Follower Capabilities  
  • Increase Operational Tempo  
  • Run faster with disciplined spacing  
  • Increased convoy capacity though unmanned vehicles  
  • Increase throughput and efficiencies  
  • Dynamic planning and re-planning  
  • Flexibility in convoy composition and routing  
  • Re-acquire route after dispersal  
  • Re-plan route to alternate |
| • Improved Safety  
  • Collision Warnings  
  • Lane Departure Warnings  
  • Tip Over Warnings  
  • Reinforces Experienced drivers  
  • Increase Capabilities of inexperienced Drivers | | |
<table>
<thead>
<tr>
<th>Major Tasks</th>
<th>Year 1</th>
<th>Year 2</th>
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<tr>
<td>Implementation Directive (ID)</td>
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<tr>
<td>RFP/Contract negotiations (RTC Contract 105 days)</td>
<td>1Q</td>
<td>2Q</td>
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<tr>
<td>Management Plan (60 Days After JCTD Start)</td>
<td>1Q</td>
<td>2Q</td>
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<tr>
<td>Develop By-wire and Autonomous Kit SOPs</td>
<td>1Q</td>
<td>2Q</td>
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<tr>
<td>Develop and update Design and Plans</td>
<td>1Q</td>
<td>2Q</td>
</tr>
<tr>
<td>Integrate &amp; Deploy Software/Hardware Components</td>
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<td>1Q</td>
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<tr>
<td>Install Integrated System</td>
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<td>1Q</td>
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<tr>
<td>Technical Demonstrations</td>
<td></td>
<td>1Q</td>
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<tr>
<td>ATEC Limited Safety Release and Assessment</td>
<td>1Q</td>
<td>2Q</td>
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<tr>
<td>Operator Training</td>
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<td>1Q</td>
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<tr>
<td>Operational Demonstration and Assessment</td>
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<td>Military Utility Assessment Reports</td>
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Why AMAS JCTD

• Will Accelerate Transition of Technology to the Warfighter
  – AMAS JCTD is Directly Aligned with RS JPO’s AMAS Initiative
  – JCTD will compress the Current RS JPO AMAS Program Schedule
  – Will define the Open Architecture and Interfaces standards for the AMAS program
  – Provide the Robotic System Joint Program Office (RS JPO) an investment Strategy for RDTE POR Funds.
  – Provide RS JPO with a Concept of Operations, TTP’s, and testing methodology

• Joint Program
  – USMC has Significant Resources Invested
  – AMAS JCTD will Accelerate this Technology into Marine Platforms
AMAS JCTD Benefits for AMAS POR

• JCTD will compress AMAS Program Schedule
• Accelerate Technical Maturation
• Provide Open Architecture and Interfaces
• Standardized Metrics and Test Procedures
• Framework for Validation of Requirements
• Early identification of risk areas
  – Allows RS JPO to make informed decisions on where to invest RDTE POR dollars to reduce program risk
• Lessons Learned (Concept of Operations, TTP’s, testing methodology)

The AMAS JCTD will provide Risk Reduction to the AMAS Program
Questions?
CAST Overview

CAST addresses the operational need to project and sustain forces in distant, anti-access environments that pose challenges for combatant commanders.

CAST addresses new operational challenges, providing the ability to conduct sustainment convoy operations across operationally feasible times and distances on the battlefield.

By automating the driving function, operators are given an increased opportunity to raise awareness of their environment through scanning and surveillance, and vehicle systems have a decreased threat of collision.
**Physiological Effects**

- No reported central, peripheral, gastrointestinal motion sickness issues
- 20-25% increase in number of threat detections while CAST engaged
- 3-5 second increased response time
- Participants reported with significance less fatigue and ease of convoy execution while CAST engaged

**Vehicle System Performance**

- Gap distance formation maintenance shows 150% improvement with CAST
- Cross track error consistency data shows 15% improvement with CAST
- Successful daylight driving at 85kph
- Successful blackout driving at 70kph
- Data shows 85% improvement in panic stopping distance with CAST
Hart and Staveland’s NASA Task Load Index (TLX):

- **Mental Demand**: How mentally demanding was the task
- **Physical Demand**: How physically demanding was the task
- **Temporal Demand**: How hurried or rushed was the pace of the task
- **Effort**: How hard did you have to work to accomplish your level of performance
References


4. CASCOM CCD Concepts Division. (Sep 2011). Draft Calculations for AMAS CDD Cost Benefit Analysis. CASCOM.


6. Assumption - Work is ongoing to quantify cost and benefit. This statements are based on the performance increases observed. No data is readily available or it cannot be easily measured.

7. PEO CS&CSS. (Dec 2007) Perspective on Condition Based Maintenance. PM Tactical Vehicle


9. Based on responses received from AMAS JCTD RFI.


11. Based on Safety Center numbers over 10 Year period for Class A, B, and C Accidents in CONUS and Theater. Total Damage Cost equaled 177 Million for all 3 accident categories. Assumed 100% indirect cost for recovery and labor.