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# AMAS ROBOTICS SEMINAR BRIEF

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19 July 2011

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| a. REPORT<br><b>unclassified</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | b. ABSTRACT<br><b>unclassified</b> | c. THIS PAGE<br><b>unclassified</b> |                                                                      |                                                              |                                    |



# Robotic Systems Joint Project Office

## MISSION

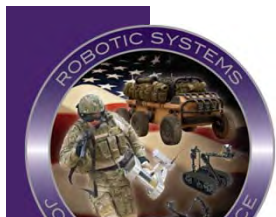
Lead the development, systems engineering, integration, acquisition, testing, fielding, sustainment and improvement of unmanned systems for the Joint Warfighter to ensure safe, effective and supportable capabilities are provided while meeting cost, schedule and performance.

## VISION

Continuous improvement of unmanned system capabilities to meet current and future Joint Warfighter objectives.







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# TARDEC – Who We Are



Combat Vehicles



Heavy Tactical Vehicle



Medium Tactical Vehicle



Light Tactical Vehicle



Countermine Equipment



Military Bridging



Fuel and Water Storage & Distribution Quality Surveillance Equipment

**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.

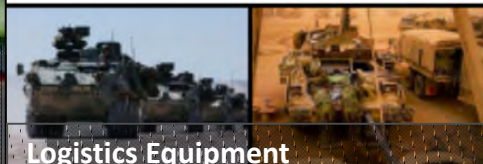
**VISION:** Be the first choice of technology and engineering expertise for ground vehicle systems and support equipment - today and tomorrow.



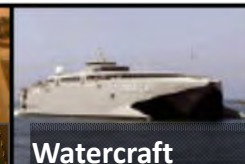
Trailers



Water Generation and Purification



Logistics Equipment



Watercraft



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.

Leadership • Service • Innovation

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# AMAS Operation modes and Outcomes

## AMAS Operation modes:

- Driver Assist
- Tele-operation
- Supervised autonomy
- Leader/follower
- Waypoint navigation
- Go to point/Dynamic Re-routing

## Operational Outcomes:

- Sustained unmanned or driver assisted Warfighter Functions.
- Improvements in Unmanned or Robot assisted vehicles allows Soldiers to Neutralize road-side threats, e.g. IEDs quicker, allowing them additional reaction time.
- Unmanned reconnaissance and surveillance.
- Commander's ability to reduce Soldier risk.



# AMAS JCTD – Technical Overview

- Provide scalable autonomy in a single material solution agnostic of platform
  - Autonomy Kit
    - » Autonomous Hardware and Sensors
  - By-wire Kit
    - » Vehicle Specific Devices to Retrofit Current Tactical Vehicles
  - Common Interfaces
  - Common Framework
- Scalable and flexible to address multiple task such as convoys, security, reconnaissance, sustainment, maneuver, maneuver support
- Operational scenario using a secure mixed manned/unmanned platform convoy
  - Year One Platforms - MTRV, LTV, HEMTT, M915 w/trailer
  - Year Two Platforms - PLS, HMMWV, MATV, FMTV w/trailer
  - Demonstrate increased vehicle safety with high op tempo in complex conditions
- Conduct Technical Demos and Operational Demo (CONUS): Manned, Driver Assist, Remote Control, and Semi- Autonomous Leader/Follower.



# AMAS JCTD – Key Metrics

| Capability                     | Tasks                    | Metric                          | Threshold                    | Objective                    |
|--------------------------------|--------------------------|---------------------------------|------------------------------|------------------------------|
| FOC 09-08<br>Soldier Support   | Operator Interventions   | Hours                           | TBD                          | TBD                          |
| Joint Land Ops                 | System Operation Range   | Distance in meters              | TBD                          | TBD                          |
| FOC 09-04<br>Operational Tempo | Speed                    | Kph                             | Max>40kph<br>Min <5kph       | Max>80kph<br>Min<1kph        |
| Joint Land Ops                 | Lateral Accuracy         | Centimeters from lead path      | 100cm                        | 50cm                         |
| Battle space Awareness         | Obstacle Avoidance       | Size in cm <sup>3</sup>         | TBD                          | TBD                          |
| FOC 07-01<br>Protect personnel | Situational Awareness    | Sighting increase %             | Target sighting increase 10% | Target sighting increase 20% |
| FOC 07-01<br>Protect personnel | Emergency braking        | Operator Interventions per hour | 1                            | 0                            |
| Tactical behaviors             | Multi-vehicle capability | Vehicles                        | 4                            | 20                           |
| Collaborative Operations       | Leader / follower swap   | Transition time in seconds      | Less than 30 seconds         | Less than 10 seconds         |
| FOC 09-04<br>Operational Tempo | Controlling Platform     | Distance from Operator          | LOS<br>2 km                  | NLOS<br>1 km                 |



# JCTD Transition Strategy

## AMAS JCTD

### Year One

- Contract Award
- 1<sup>st</sup> Tech Demo
- ATEC Reports

### Year Two

- 2<sup>nd</sup> Tech Demo
- Operation Utility Assessment (OUA)
- ATEC Reports

### Risk Reducers:

- Push AMAS Program Schedule to the Left
- Accelerate Technical Maturation
- Provide Open Architecture and Interfaces
- Standardized Metrics and Test Procedures
- Framework for Validation of Requirements
- Lessons Learned

## AMAS CDD/CPD

### Year One

- CDD Staffing

### Year One

- AROC/JROC Approval
- POM Line Establishment
- MDD Preparation

### Year Two

- » MDD
- » AOA Study Guidance
- » Solicitation Preparation and Acquisition Strategy for CDD

OR

- » Development of CPD

### Year Three (Transition Year)

- Milestone B
- EMD Contract Award(s)

OR

- CPD AROC/JROC Approval

The AMAS JCTD will provide Risk Reduction to the AMAS Program

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# AMAS – Capabilities of Scalable Autonomy

| Level 1<br>Driver Assist                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Level 2<br>Automated Driving                                                                                                                                                                                                                                                                                                                                                            | Level 3<br>Convoy Behaviors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• <b>Increase Situational Awareness</b> <ul style="list-style-type: none"> <li>• Environment and Surroundings</li> <li>• Vehicle Capabilities and Configuration</li> </ul> </li> <li>• <b>Improved Safety</b> <ul style="list-style-type: none"> <li>• Collision Warnings</li> <li>• Lane Departure Warnings</li> <li>• Tip Over Warnings</li> <li>• Stability Control</li> </ul> </li> <li>• <b>Reinforces Experienced drivers</b></li> <li>• <b>Increase Capabilities of inexperienced Drivers</b></li> </ul> | <ul style="list-style-type: none"> <li>• <b>Active Intervention</b> <ul style="list-style-type: none"> <li>• Maintain Lane Control</li> <li>• Tip-Over Prevention</li> <li>• Collision avoidance and mitigation</li> <li>• Stability Control</li> </ul> </li> <li>• <b>Enables operator to focus on other convoy mission tasks while the vehicle safely operates itself.</b></li> </ul> | <ul style="list-style-type: none"> <li>• <b>Leader/Follower Capabilities</b> <ul style="list-style-type: none"> <li>• Increase Operational Tempo</li> <li>• Run faster with disciplined spacing</li> <li>• Increased convoy capacity though unmanned vehicles</li> </ul> </li> <li>• <b>Increase throughput and efficiencies</b></li> <li>• <b>Dynamic planning and re-planning</b> <ul style="list-style-type: none"> <li>• Flexibility in convoy composition and routing</li> <li>• Re-acquire route after dispersal</li> <li>• Re-plan route to alternate</li> </ul> </li> </ul> |

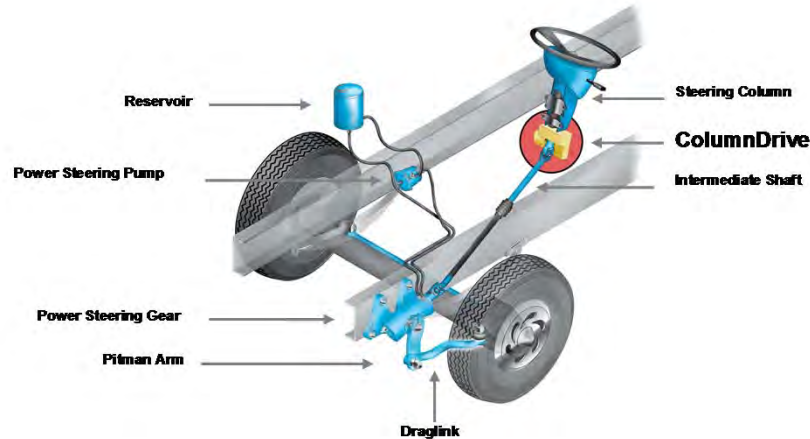


# Level I Technology: Driver Assist

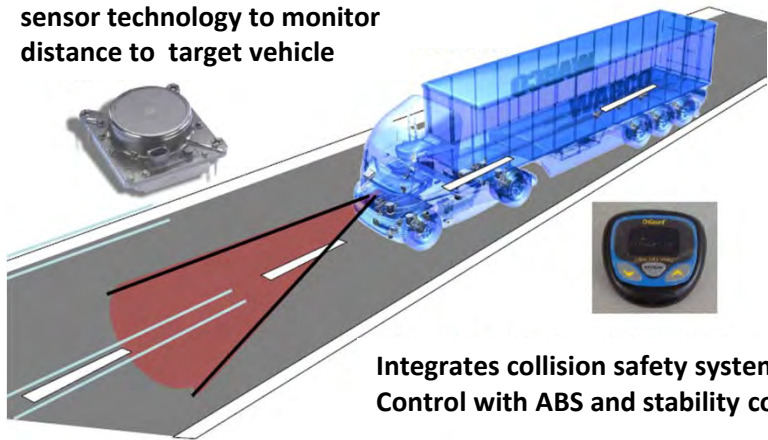
| Technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Achieved Capabilities                                                                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Drive By Wire</b></p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation (mostly)</li> <li>•&lt; \$5K per vehicle (avg; platform dependent)</li> <li>•&lt; 100 lbs (avg; platform dependent)</li> </ul> <p><b>Vehicle State Information</b></p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation</li> <li>•&lt; \$500</li> <li>• Minimal impact on weight and cube</li> </ul> <p><b>External Situation Awareness (sensors)</b></p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation</li> <li>•&lt; \$5K per vehicle</li> <li>•&lt; 10 lbs per vehicle (avg; platform dependent)</li> </ul> <p><b>Software</b></p> <ul style="list-style-type: none"> <li>•TRL 6, Integrating the separate pieces</li> <li>•Augmentation</li> <li>•Cost in development</li> <li>•No weight/cube impact</li> </ul> | <ul style="list-style-type: none"> <li>• <b>Increase Situational Awareness</b> <ul style="list-style-type: none"> <li>• Environment and Surroundings</li> <li>• Vehicle Capabilities and Configuration</li> </ul> </li> <li>• <b>Improved Safety</b> <ul style="list-style-type: none"> <li>• Collision Warnings</li> <li>• Lane Departure Warnings</li> <li>• Tip Over Warnings</li> <li>• Stability Control</li> </ul> </li> <li>• <b>Reinforces Experienced drivers</b></li> <li>• <b>Increase Capabilities of inexperienced Drivers</b></li> </ul> | <ul style="list-style-type: none"> <li>• Level 1 technologies enable higher levels required to meet the AMAS CDD Operational modes</li> </ul> |



# Level I Technology Examples



Uses forward looking radar sensor technology to monitor distance to target vehicle



Integrates collision safety system Control with ABS and stability control

## Vehicle Control Systems

### SmartTrac



Automatic Traction Control (ATC)

Hill Holder and Work Brake

Driveline Protection Management

### ABS



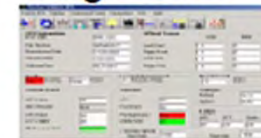
### OnGuard



SafetyDirect™  
Fleet Performance System

Brake Performance Monitoring (BPM)

### Diagnostics



Tire Pressure Monitoring (TPM)



## Level 2 Technology: Automated Driver

| Technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Outcomes                                                                                                                                                                                                                                                                                                                                                                                | Capabilities Achieved                                                                                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Advanced Sensors</p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation</li> <li>•&lt; \$10K per vehicle</li> <li>•&lt; 10 lbs (no major impact to vehicle)</li> </ul> <p>Software</p> <ul style="list-style-type: none"> <li>•TRL 6, Integrating the separate pieces</li> <li>•Augmentation</li> <li>•Cost in development<br/>Significantly greater than Level 1<br/>Software Cost</li> <li>•No weight/cube impact</li> </ul> | <ul style="list-style-type: none"> <li>• <b>Active Intervention</b> <ul style="list-style-type: none"> <li>• Maintain Lane Control</li> <li>• Tip-Over Prevention</li> <li>• Collision avoidance and mitigation</li> <li>• Stability Control</li> </ul> </li> <li>• <b>Enables operator to focus on other convoy mission tasks while the vehicle safely operates itself.</b></li> </ul> | <ul style="list-style-type: none"> <li>•Driver Assist</li> <li>•Supervised autonomy</li> <li>•Leader/follower</li> <li>•Waypoint navigation</li> <li>•Go to point/Dynamic Re-routing</li> </ul> |





# Level 2 Technology Examples

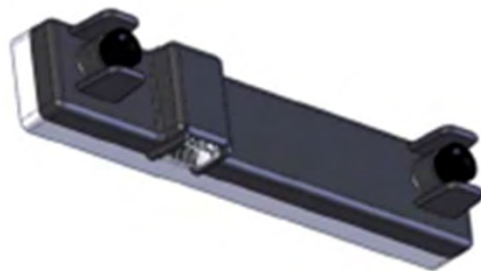
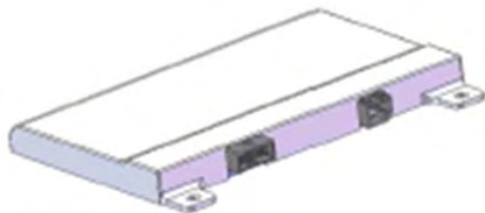
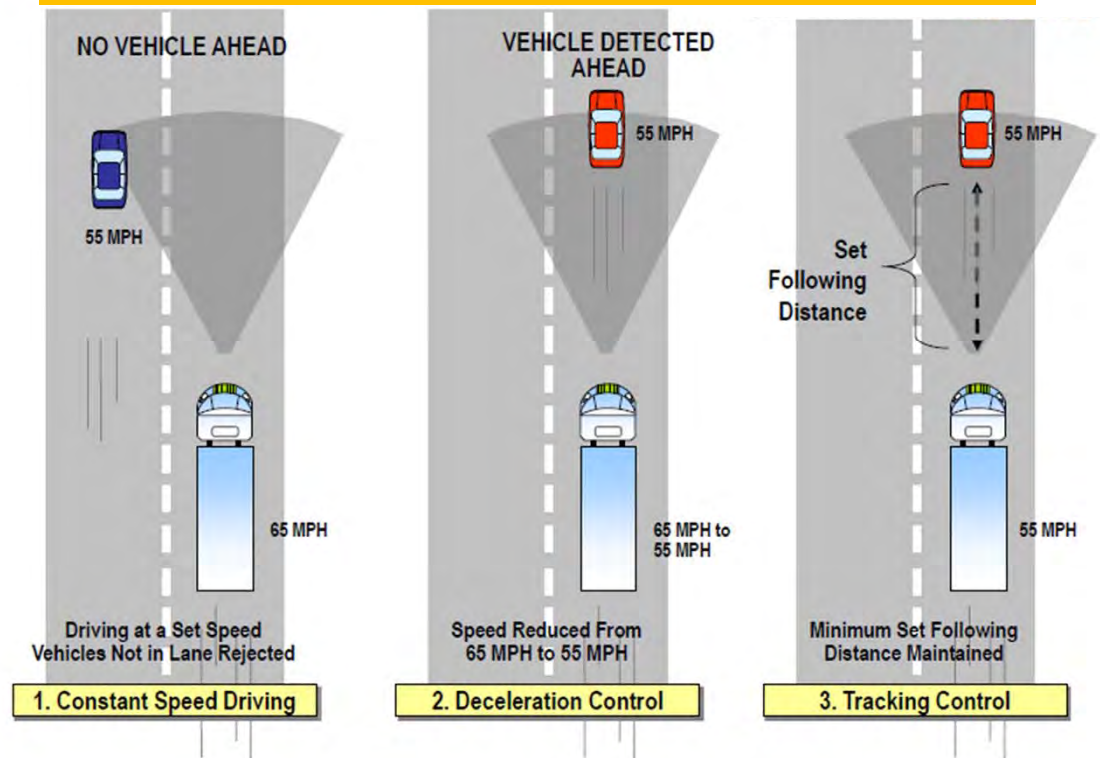


Image Sensor Module



Driver Assistance Safety Mod

## Automatic Cruise Control - Functionality





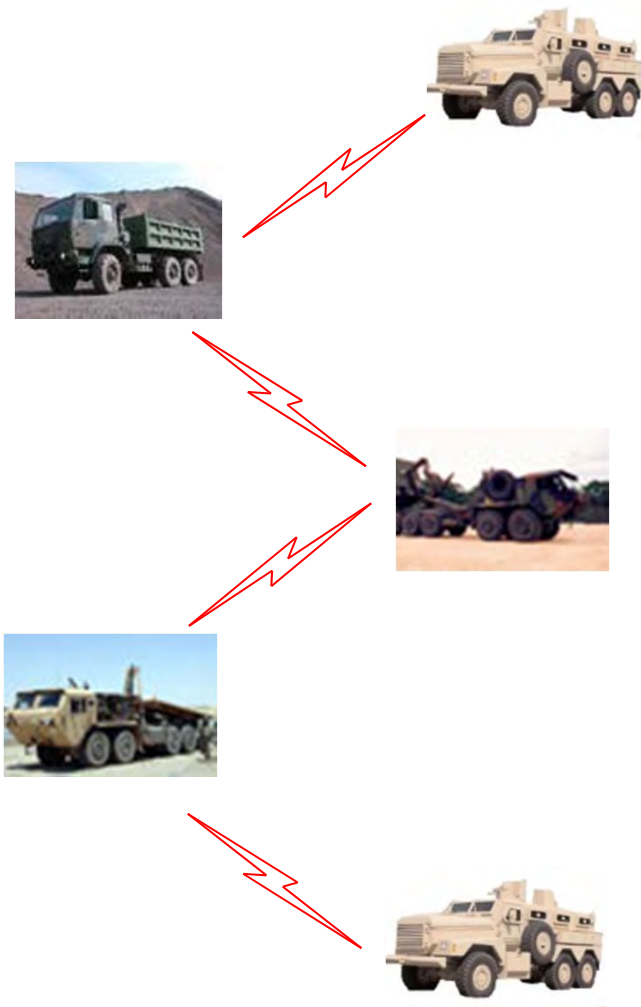
# Level 3 Technology: Convoy Behaviors

| Technologies                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Achieved Capabilities                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>No Tele-operation, vehicle to vehicle communications</p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation</li> <li>•&lt; \$10K per vehicle</li> <li>•&lt; 50 lbs</li> </ul> <p>Network, Command and Control (C<sup>2</sup>)</p> <ul style="list-style-type: none"> <li>•TRL 9, mature technology</li> <li>•Augmentation</li> <li>•&lt; \$20K per convoy (may already be on C<sup>2</sup> vehicles)</li> <li>• &lt; 50 lbs</li> </ul> <p>Advanced Software</p> <ul style="list-style-type: none"> <li>•TRL 6</li> <li>•Augmentation</li> <li>•Cost in development</li> <li>•Significantly greater than Level 2 Software Cost</li> <li>•No weight/cube impact</li> </ul> <p>Control/Monitor hardware above unit</p> <ul style="list-style-type: none"> <li>•TRL 6, Integrating the separate pieces</li> <li>•Augmentation</li> <li>•~ \$100K per vehicle based control station, &lt;\$5K per monitoring station</li> <li>•&lt; 400 lbs</li> </ul> | <ul style="list-style-type: none"> <li>• <b>Leader/Follower Capabilities</b> <ul style="list-style-type: none"> <li>• Increase Operational Tempo</li> <li>• Run faster with disciplined spacing</li> <li>• Increased convoy capacity though unmanned vehicles</li> </ul> </li> <li>• <b>Increase throughput and efficiencies</b></li> <li>• <b>Dynamic planning and re-planning</b> <ul style="list-style-type: none"> <li>• Flexibility in convoy composition and routing</li> <li>• Re-acquire route after dispersal</li> <li>• Re-plan route to alternate</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>•Driver Assist</li> <li>•Tele-operation</li> <li>•Supervised autonomy</li> <li>•Leader/follower</li> <li>•Waypoint navigation</li> <li>•Go to point/Dynamic Re-routing</li> </ul> |



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# Level 3 Technology Examples



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# QUESTIONS?

Leadership • Service • Innovation