**Convoy Active Safety Technology - Information Brief**

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**The original document contains color images.**

**Security Classification of:**
- Report: unclassified
- Abstract: unclassified
- This Page: unclassified
Convoy operations are inherently dangerous due to numerous threats on the battlefield while having limited defensive capability. Increased situational awareness and reduced fatigue can mitigate threats resulting in improved survivability and sustainment throughput.
• Convoy operations
  – Limited MSRs/ASRs
  – Long / Short Haul duration
  – High speeds

• Operating conditions
  – Visibility
  – Extreme Climates
  – Threat
  – Terrain

• Multiple range of operations
  – Peacetime Military Engagement
  – Major Combat Operations

• Limited situational awareness
  – Operator and Co-operator (Observer)
  – Limited comms
Employing a semi-autonomous (hands-off) operator-in-the-cab enabler, CAST provides the following:

- **Increase Safety and Security**
  - Disciplined speeds, proper distance between vehicles
  - Less accordion effect, less bunching
- **Increase Situational Awareness**
  - Dedicate time to observe activity
  - Increase readiness and reaction time to relevant information
- **Decrease Fatigue/Stress**
  - Decrease multi-tasking time
  - Focus concentration on a single set of operations
- **Accident Avoidance**
  - Collision
  - Rollover
<table>
<thead>
<tr>
<th>GPS Leader-Follower</th>
<th>Radar/Vision Tracking</th>
<th>Vision Based Route Following</th>
<th>Safe Distance Maintenance</th>
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</thead>
<tbody>
<tr>
<td>• Lead Vehicle Provides Trail of GPS Waypoints</td>
<td>• Follow Vehicle Uses a Combination of Radar and Vision to Estimate Trajectory of Lead Vehicle</td>
<td>• Lead Vehicle Reports Position on Route</td>
<td>• Safety Aid to Prevent Rear End Collisions</td>
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<tr>
<td>• Simple Approach Available in Most Locations</td>
<td>• Enables High Speed Following at Close Distance</td>
<td>• Follow Vehicle Uses Road Following and Obstacle Avoidance to Navigate on Route</td>
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<td></td>
<td>• Reduces ‘Cut in’ Disruption</td>
<td>• Enables Following at Large Separation Distances</td>
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</tr>
</tbody>
</table>

Multiple Modes Enable Operations in GPS and Communications Denied Areas
- Modes of Operation –
  Improved Roads

- High algorithmic confidences
- Full sensor data usage
- 55 mph capability
- Modes of Operation –
  Un-improved roads

• High algorithmic confidences
  • UWB, IR tracking

• Nominal algorithmic confidences
  • Color camera road / vehicle following, LADAR tracking

• 35-45 mph capability
- Modes of Operation – Night Operations

- High algorithmic confidences
  - UWB, IR, LADAR

- Low algorithmic confidences
  - Color camera road / vehicle following

- 15-30 mph capability
- Modes of Operation –
  Emergency Stops

- Friendly blue-on-blue collisions current operational hazard
- Accordion effect mitigation
- Statistically relevant improvement
- Modes of Operation –
  POV Insertion

- Relative sensing of non-convoy vehicles
- Active response to “cutting in” convoy formation
- Modes of Operation – OD/OA

- LADAR / MMW sensor usage
- Range / speed considerations
- Rollover considerations
- Other sensing modalities
Development of Capability to Track Multiple Vehicles

- Operate Multiple Tracking Channels Simultaneously
- Reorder Vehicles and Detect New Vehicle Ordering
- Requires Adaptive Power Management to compensate for near – far problem caused by channel delay spread
2. Development of Novel Capability that minimizes Geometric Dilution of Percision (GDOP)

- GDOP is related to the area of the parallelogram formed by 2 range errors and is proportional to 
  \[ \left( \frac{\varepsilon_{r1} \varepsilon_{r2}}{\sin \theta_b} \right) \]
- this area is minimal for the minimum vertex angle, \( \theta_b(x,y) \)
- the controller selects radios that minimize the angle \( \theta_b(x,y) \)
Warfighter Experiment 1&2 Synopsis

**Experiment I**
- 6 weeks @ Ft. A.P. Hill, VA
- 12 drivers – retired Army
- Speeds varied from 20Kph to 60 Kph
- Terrain included paved and dirt roads
- Participants completed 6 driving trials
  - 3 with CAST engaged (4 hours)
  - 3 with CAST disengaged (4 hours)
- Participants were asked to:
  - Scan for targets
  - Maintain a set following distance
  - React to unanticipated stops
- Vehicle performance tracked:
  - Cross- track error
  - Gap distance maintenance

**Experiment II**
- 5 weeks @ Nevada Auto Test Center, NV
- 25 drivers – active duty 88 Mike
- Speeds varied from 30Kph to 85 Kph
- Participants completed 4 driving trials
  - 2 with CAST engaged
  - 2 with CAST disengaged
  - each mode in day and blackout
- Participants were asked to:
  - Scan for targets
  - Maintain a set following distance
- Vehicle performance tracked:
  - Cross- track error
  - Gap distance maintenance
- EEG and eye – tracking data collected

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Warfighter Experimentation Results

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

Change in Gap Distance After Emergency Breaking

\( \text{Change in Gap Distance (meters)/s} \)

- CAST Gap
- Manual Gap

\( \text{Speed (kph)} \)

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Road Ahead

• FY10 Development Phase
  • Dynamic rollover mitigation
  • Intelligent tele-operation of lead vehicle
  • Robust networking implementation
  • Fuel efficiency study
Summary and Payoffs

• **Enhanced Situational Awareness**
  – Visual scanning
  – Monitoring network comms

• **Increases probability of IED detection and avoidance**
  – Mitigates loss of life/limb
  – Mitigates lost of equipment and cargo
  – Fewer rescue and recovery operations

• **Improved convoy discipline and operational effectiveness**
  – Convoy integrity (no accordion effects)
  – Fewer lost/broken convoys
  – On-time arrivals/mission completion

• **Soldier effectiveness increased**
  – Cognitive skills
  – Physical bearing