Test and Evaluation of Autonomous Ground Robots
Panel Members:

Jeff Jaczkowski, RSJPO
Gary Frost, US Army REF
Myron Mills, Lockheed Martin Corp

with an introduction by:

Kelly Swinson, ATC
The AGV Test Perspective

NDIA Ground Robotics Capabilities Conference and Exhibition

Kelly Swinson
US Army Aberdeen Test Center
23 March 2012
Purpose

To describe the capabilities the US Army Aberdeen Test Center (ATC) currently possesses to test today’s Autonomous Ground Vehicles (AGVs) and to identify what must occur for ATC to test the next generation of higher autonomy.
Testing

• ATEC has conducted over 100 robotic tests over 15 years

• Generation 0 - Teleoperated Systems
  – Test requirements dependent on system specifications vice the mission the system is intended to fulfill
  – Currently set test methodologies – evolved over time

• Next Generation – Semi-Autonomy and Beyond
  – Software intensive systems
  – Pose additional test complications (perception, detection, reasoning)
Safety Releases vs Safety Confirmations

• Safety Releases specify constraints required to ensure Soldier safety when using experimental equipment at a specific place during a limited time period.

• Safety Confirmations indicate overall safety of the system and identify hazards not adequately controlled/mitigated, lists technical or operational limitations, and highlights safety problems that require further investigation/testing.

TESTING FOR OUR ULTIMATE CUSTOMER – THE WARFIGHTER
AGV Use

• AGVs inherently present catastrophic risks.
  – Can be documented and controlled only to the extent they’re understood and proven

• Need to develop Safety Releases to enable closer and more realistic Soldier interaction with SUT

• Need to develop Safety Confirmations with lower Risk Assessment Codes (RACs)
What’s the Problem?

• Fundamental Design Documentation
  – Software/Hardware Architecture

• System/Subsystem Test Data
  – DTP/Final Report

• Verified & Validated Models

All have not been made available

With these, the test community can tailor final verification test events
What’s the Solution?

• Prepare contracts to allow the sharing of software and system design documentation
• Developers establish a system safety plan IAW MIL-STD-882D and software safety engineering program using JSSSEH as general guidance
  – ID, document and track all system and sub-system level hazards; create closed loop hazard tracking database
  – Determine software influence on above hazards
### What ATC Provides

<table>
<thead>
<tr>
<th>System Development</th>
<th>Formal Testing</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Testing</td>
<td>Technical Testing&lt;br&gt;Performance, Endurance, RAM, RSV, Mobility</td>
<td>Data Reduction</td>
</tr>
<tr>
<td>Documentation Review</td>
<td>Safety Testing&lt;br&gt;Software, System Safety, Fault Isolation, Troubleshooting</td>
<td>Data Analysis</td>
</tr>
<tr>
<td>Detailed Test Plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embedded Instrumentation</td>
<td>Facilities&lt;br&gt;Automotive Courses, Climatic, EMI, C4, Weapons Accuracy, Sensor Tech</td>
<td>Test Incident Reports&lt;br&gt;Data quality, scoring support</td>
</tr>
<tr>
<td>“On Location” Test Observation</td>
<td>“On Location” Test Execution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test Methodology Development</td>
<td></td>
</tr>
</tbody>
</table>

[www.atc.army.mil](http://www.atc.army.mil)
Kelly Swinson
Unmanned Ground Vehicles
US Army Aberdeen Test Center
400 Colleran Road
Aberdeen Proving Ground, MD 21005
(410) 278-4735
DSN 298-4735
kelly.k.swinson.civ@mail.mil
BACK-UP SLIDES
REFERENCES

- AR 385-16 “System Safety Engineering and Management”
- AR 73-1
- AR 700-142
- AR 385-10
- DA PAM 73-1
- JSSSEH
- MIL-STD-882
<table>
<thead>
<tr>
<th>HAZARD SEVERITY</th>
<th>SPECIFIC INDIVIDUAL ITEM</th>
<th>FLEET OR INVENTORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATASTROPHIC I</td>
<td>Likely to occur frequently</td>
<td>Continuously experienced</td>
</tr>
<tr>
<td>May cause death or system loss</td>
<td>Will occur several times in the life of the item</td>
<td>Will occur frequently</td>
</tr>
<tr>
<td>CRITICAL II</td>
<td>Likely to occur sometime in the life of the item</td>
<td>Will occur several times</td>
</tr>
<tr>
<td>May cause severe injury, severe occupational illness, or major system damage</td>
<td>Unlikely but possible to occur in the life of an item</td>
<td>Unlikely but can reasonably be expected to occur</td>
</tr>
<tr>
<td>MARGINAL III</td>
<td>Unlikely but possible to occur</td>
<td>Unlikely to occur but possible</td>
</tr>
<tr>
<td>May cause minor injury, minor occupational illness, or minor system damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEGLIGIBLE IV</td>
<td>So unlikely it can be assumed the occurrence may not be experienced</td>
<td></td>
</tr>
<tr>
<td>May cause less than minor injury, occupational illness, or system damage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HAZARD PROBABILITY</th>
<th>FREQUENT</th>
<th>PROBABLE</th>
<th>OCCASIONAL</th>
<th>REMOTE</th>
<th>IMPROBABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFIC INDIVIDUAL ITEM</td>
<td>Likely to occur frequently</td>
<td>Will occur several times in the life of the item</td>
<td>Likely to occur sometime in the life of the item</td>
<td>Unlikely but possible to occur in the life of an item</td>
<td>So unlikely it can be assumed the occurrence may not be experienced</td>
</tr>
<tr>
<td>FLEET OR INVENTORY</td>
<td>Continuously experienced</td>
<td>Will occur frequently</td>
<td>Will occur several times</td>
<td>Unlikely but can reasonably be expected to occur</td>
<td>Unlikely to occur but possible</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>HAZARD SEVERITY</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>CATASTROPHIC I</td>
<td>HIGH</td>
<td>HIGH</td>
<td>HIGH</td>
<td>SERIOUS</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>CRITICAL II</td>
<td>HIGH</td>
<td>HIGH</td>
<td>SERIOUS</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>MARGINAL III</td>
<td>SERIOUS</td>
<td>SERIOUS</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
</tr>
<tr>
<td>NEGLIGIBLE IV</td>
<td>MEDIUM</td>
<td>MEDIUM</td>
<td>LOW</td>
<td>LOW</td>
<td>LOW</td>
</tr>
</tbody>
</table>
ASTERS
Objectives & Challenges

• ASTERS will assess the current state of:
  – Emerging AGV Technologies
  – Emerging AGV Requirements
  – Current test (DT/OT) and evaluation capabilities

• Challenges
  – Effective T&E
  – Unique considerations of AGVs through T&E
Methodology/Process

- Requirements Analysis & Development
- Emerging AGV Technologies
- Assess Current AGV T&E Capabilities
- Identify T&E Gaps
- Solutions to T&E Gaps
- Definition of Autonomy
- Test Matrices

Roadmap

US Army Aberdeen Test Center
Deliverables

- September 2011 – Terms of Reference
- May 2012 – Updated TRL List
- May 2012 – Requirements List
- May 2012 – T&E Capabilities
- June 2012 – Prioritized T&E Gaps
- August 2012 – Definitions of Autonomy
- November 2012 – Solutions to T&E Gaps