Evaluation of Behavioral Competencies for Automated Driving System Dedicated Vehicles

Amy Chu, Director
amy.chu@sae-itc.org

For Informational Purposes Only
AVSC’s Mission

Vision: Public acceptance of SAE L4/L5 automated driving systems as a safe and beneficial component of transportation through industry consensus.

Mission: The mission of the Automated Vehicle Safety Consortium is to quickly establish safety principles, common terminology, and best safety practices, leading to standards to engender public confidence in the safe operation of SAE L4/L5 light duty passenger/cargo on-road vehicles ahead of their widespread deployment.

• Inform AV pilot projects / deployments as they become more widespread
• Leverage safety expertise and culture of safety
• Publish our work to accelerate formal, global standards
• Consortium Members implement as appropriate within their organizations
AVSC best practices introduced into committees for discussion, modification, and potential inclusion into SAE J-standards and/or other global standards development work.
How We Work

Technology neutral
• Describe the “what” and leave the “how” for each organization to determine

Complementary
• Leverage and reference the good work of others
• Complement the work of others, avoiding duplication

Common interest
• Openly share current practices of common interest
• Describe challenges to consensus

Accelerate standards
• Introduce work to SAE and global SDOs
• Best practices are easily accessible
Best practices and Standards Acceleration

In-Vehicle Fallback Test
Driver Selection, Training, and Oversight Procedures for
Automated Vehicles Under Test

Describing an Operational Design Domain

Passenger-Initiated Emergency Trip Interruption

Data Collection for ADS-DVs to Support Event Analysis

First Responder Interactions with Fleet-Managed ADS-DVs

Metrics and Methods for Assessing Safety Performance of ADS

Safety Management Systems (SMS) Information Report

Evaluation of Behavioral Competencies for ADS

Nov 2019
Apr 2020
June 2020
Sept 2020
Dec 2020
Mar 2021
July 2021
Nov 2021

SAE J3018
On-Road Testing of Prototype ADS (Dec 2020)

SAE J3206
Safety Principles for ADS (July 2021)

SAE J3259
(WIP)

SAE J3114
Human Factors for ADS (WIP)

SAE J3197
ADS Data Logger (July 2021)

SAE J3206
Safety Principles for ADS (July 2021)

SAE J3237
Operational Safety Metrics for ADS (WIP)

ISO 5083
(WIP)

SAE ORAD TBD

SAE ORAD TBD
Evaluation of Behavioral Competencies

Why -
• Driving safely is a complex task involving a broad range of skill sets invoked in a vast number of potential scenarios
• There is value in assessing a set of behavioral competencies as directional indication of safety performance
• Elemental Behaviors can be used as starting point for additional assessment

What -
• Clarity on lexicon and relationship between maneuvers, OEDR and behaviors
• Glimpse into how AVSC members are using behavioral competencies within their organizations as part of a safety assurance framework
• Elemental behavioral competency list can be used and customized by developers to demonstrate safety performance in whatever context they choose
• Example of a repeatable method to tie in previous work of AVSC (ODD, Metrics) to develop application-specific metrics, using “Maintaining a Lane” to illustrate.
Components of Behavioral Competencies

AVSC members recommend a lexicon to enable communication of safety performance and clarify across industry in terms of behavioral competency.

**ODD**
Roadway material, precipitation, sky condition, etc.

**Behavior**
Maintaining a lane while driving down a roadway

**Detection**
- Detect object type (lane markings, speed limit sign), location, and relevance, accounting for covariance and error estimates

**Response**
- Determine desired vehicle position relative to lane markings
- Determine desired speed

**Behavioral Competency**
Demonstrated by acceptable "wandering distance" from center of lane and speed less than speed limit, through a combination of on-road aggregate testing, track testing, and simulation

**Maneuver**
- Apply lateral control to achieve desired lane position
- Apply acceleration (+ or -) to achieve desired speed

**ODDR**

**PASS**

**FAIL**

Automated Vehicle Safety Consortium™
Defining Behavioral Competencies

AVSC members are using behavioral competencies within their organizations as part of a safety assurance framework.
Elemental Behavioral Competencies

ADS developers and manufacturers can use this elemental set of behavioral competencies as starting points for behavioral competency testing.

<table>
<thead>
<tr>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Roadway Infrastructure</strong></td>
</tr>
<tr>
<td>Maintaining a lane</td>
</tr>
<tr>
<td>Changing lanes</td>
</tr>
<tr>
<td>Navigating Intersection</td>
</tr>
<tr>
<td>Navigating, entering, exiting, unstructured roadways</td>
</tr>
<tr>
<td>Navigating pick up and drop off zones and parking situations</td>
</tr>
<tr>
<td><strong>Dynamic Conditions</strong></td>
</tr>
<tr>
<td>Responding to vulnerable road users (VRUs)</td>
</tr>
<tr>
<td>Responding to other vehicles</td>
</tr>
<tr>
<td>Responding to special purpose vehicles</td>
</tr>
<tr>
<td>Responding to lane obstructions and obstacles</td>
</tr>
<tr>
<td>Responding to confined road structures</td>
</tr>
<tr>
<td>Responding to work zones</td>
</tr>
<tr>
<td>Responding to DDT performance-relevant failure [SAE J3016]</td>
</tr>
<tr>
<td>Responding to relevant traffic control devices</td>
</tr>
</tbody>
</table>
Applying Metrics for Behavioral Competencies

Example of a repeatable method to tie in previous work of AVSC (ODD, Metrics) to develop application-specific metrics, using “Maintaining a Lane” to illustrate.

Select one or more behavioral competency
Identify contextual elements in ODD (AVSC00002202004)
Decompose into scenarios
Develop applicable metrics (AVSC0006202103)
Define relevant acceptance criteria

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roadway Infrastructure</td>
<td>Maintaining a lane</td>
</tr>
<tr>
<td>Dynamic Conditions</td>
<td>Responding to other vehicles</td>
</tr>
</tbody>
</table>

Lane marking type, width and quality
Precipitation type and intensity
Sky condition
Roadway material
Road surface condition
Presence of lead vehicle only (no cut ins, etc.)
Size/type of lead vehicle
AVSC Metrics to Support ADS Safety

High-level goals for desired societal impact were used as guidance:
• Reduce the number of severity of crashes
• Perform contextually safe vehicle motion control

Recommended metrics were developed based on:
• Established relationship to safety outcomes for human drivers
• Can be measured and assessed practicably
• Technology neutral, practicable, and can be consistently applied

Table 1: Recommended set of safety performance metrics for ADS developers and manufacturers

<table>
<thead>
<tr>
<th>Category</th>
<th>Safety Performance Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crashes</td>
<td>Crash severity and frequency</td>
</tr>
<tr>
<td>Compliance with traffic regulations</td>
<td>Severity and frequency of citable offense</td>
</tr>
<tr>
<td>Maintain a safety envelope</td>
<td>Longitudinal and lateral distance (may be a function of contextual modifiers)</td>
</tr>
<tr>
<td>Exhibit contextually safe vehicle motion control</td>
<td>Acceleration (longitudinal and lateral)</td>
</tr>
<tr>
<td></td>
<td>Jerk (longitudinal and lateral)</td>
</tr>
<tr>
<td>Object and event detection and response (OEDR)</td>
<td>OEDR reaction time</td>
</tr>
</tbody>
</table>
Contact Us

[Website link: https://avsc.sae-itc.org/]

**Edward Straub, DM**
Executive Director  
703.304.5958  
[Email: edward.straub@sae-itc.org]

**Amy Chu**
Director  
248.635.1190  
[Email: amy.chu@sae-itc.org]
Evaluation of Behavioral Competencies for Automated Driving System Dedicated Vehicles

THANK YOU