Automated Vehicle Safety Consortium™

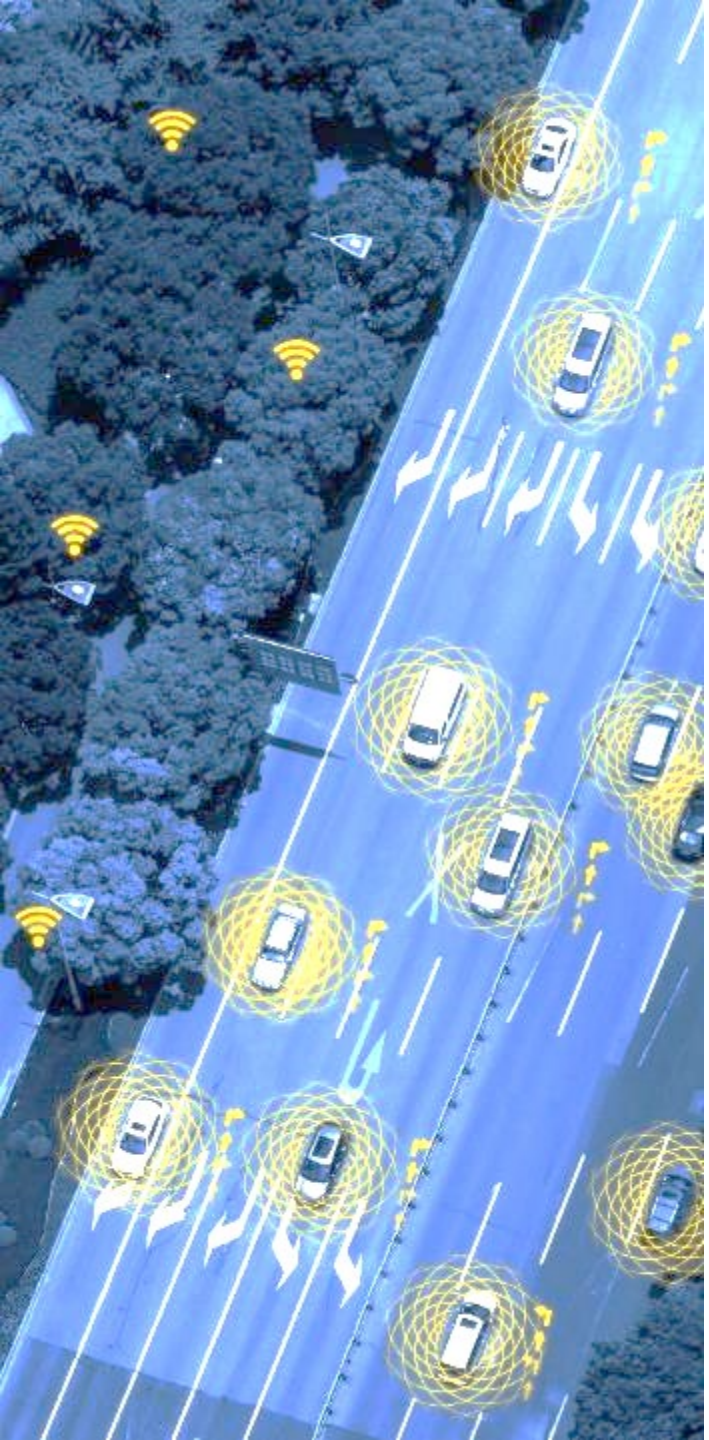
A Program of SAE ITC

2021

Building Public Awareness and Trust in Automated Driving Systems

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

https://avsc.sae-itc.org/



Agenda

- Who is AVSC
- How we work
- Accelerating Standards Development
- Data Collection pub. Sept 2020
- Metrics and Methods pub. March 2021
- Future Collaboration

AVSC Member Team

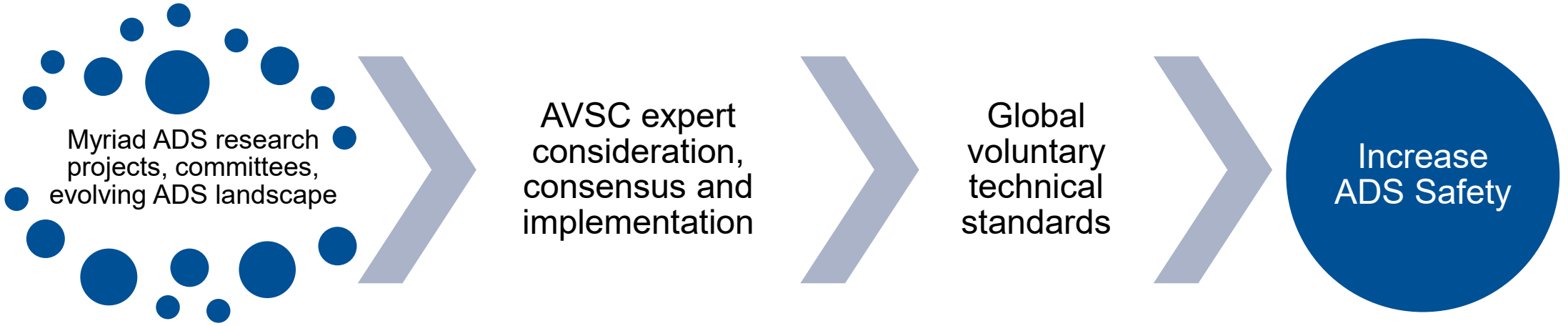
TOYOTA

VOLKSWAGEN

GROUP OF AMERICA

AVSC's 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.



"AVSC is small enough to come to agreement faster than often happens with technical standards,…"
~Safe Enough: Approaches to Assessing Acceptable Safety for Automated Vehicles, RAND 2020

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

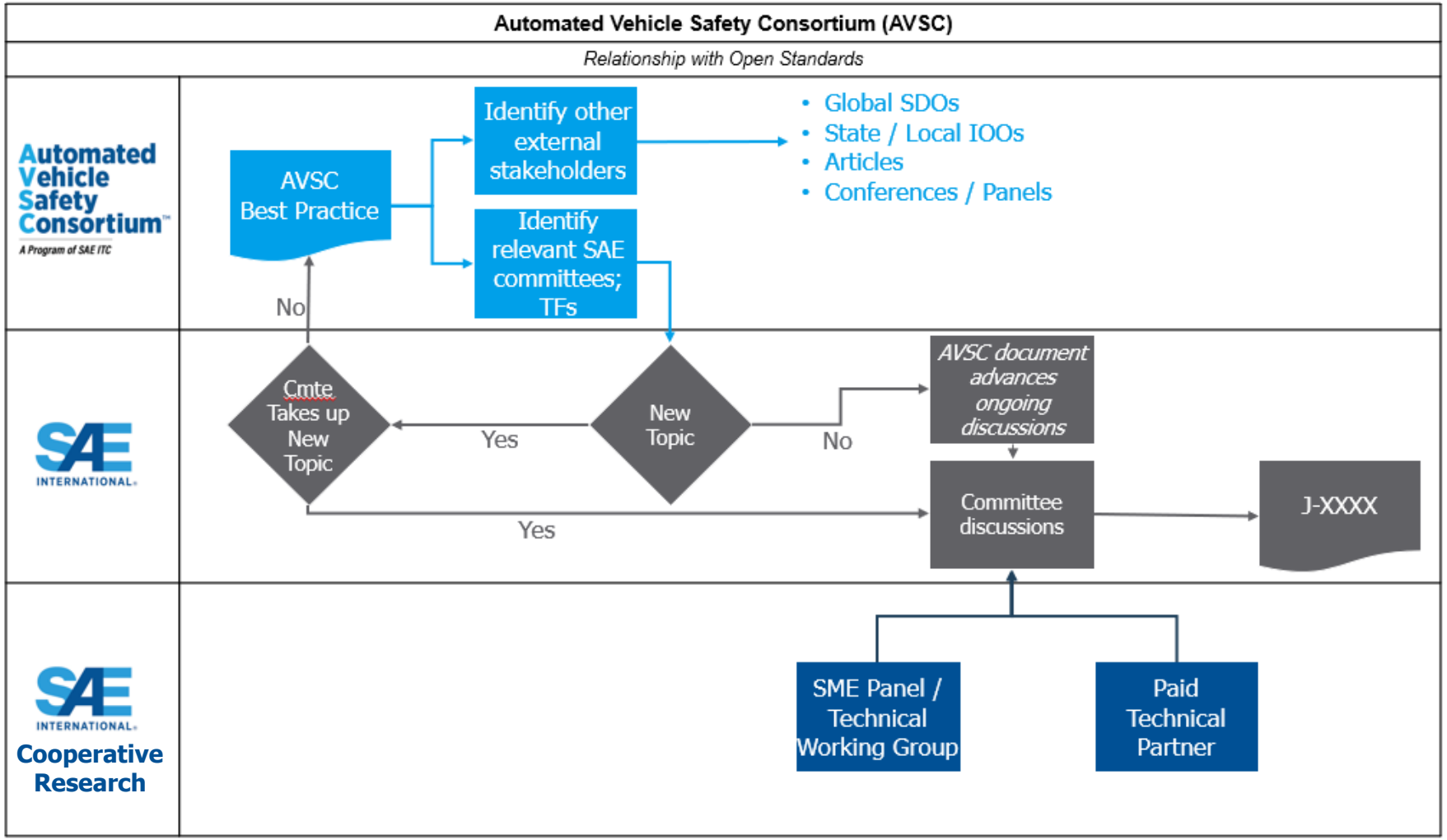
- Openly share current practices of common interest
- Describe challenges to consensus

Accelerate standards

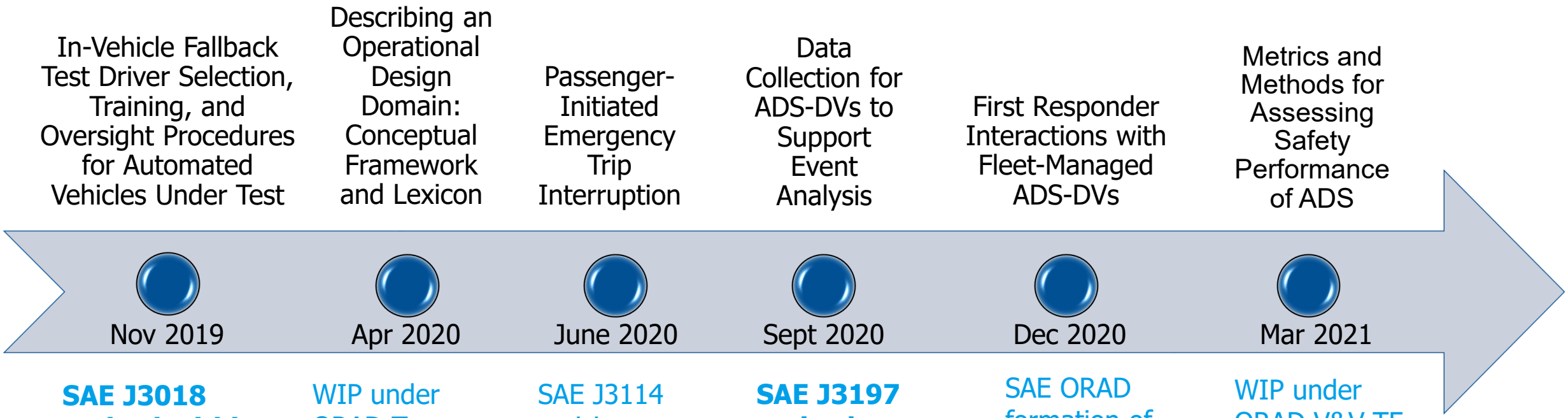
- Introduce work to SAE and global SDOs
- Best practices are easily accessible

Accelerate Standards Development

AVSC best practices introduced into committees for discussion, modification, and potential inclusion into SAE J-standards and / or other global standards development work



AVSC Best Practice Development



Data Collection for ADS-DVs to Support Event Analysis

Why -

- Data recording important for crash reconstruction, system performance investigation & event analysis to improve industry-wide safety
- Data recording needs are evolving as ADS takes on the DDT
  - Perceives the environment
  - Handles vehicle motion control
- Current definition of impact based on triggers no longer sufficient to capture collisions traditionally detected by humans

What -

- Addresses common data collection practices for SAE L4/L5 AVs, for the purpose of event analysis and producing lessons learned
- Compliments current motor vehicle event data collection standards (including SAE J1698-1 and SAE J3197) and clarifies areas specific to ADS-DVs
- Provides definition of data elements, considerations for data prioritization, retrievability, survivability, storage, and traceability

Definition of event

- Event defined as collision or collision-like situation
- Lack of consensus for what constitutes a collision for event reporting makes it challenging for ADS-DVs to determine
  - State reporting requirements vary
  - Criteria described in terms of dollar value
  - Impacts with domesticated but not undomesticated animals
- In addition to triggering conditions specified in SAE J1698 family of standards:
  - Deployment of a non-reversible restraint, such as airbags
  - Change in vehicle velocity that equals or exceeds 8 km/h within a 150 ms interval
  - Events causing failures that result in the ADS performing DDT fallback
  - Other events

Data Elements

Thirty-nine (39) data elements recommended for ADS-DVs to collect to support event analysis

- **Fourteen (14) new data elements** specific to ADS-DVs
- Twenty-five (25) identified from previously defined or legacy data collection standards

Breakdown of data elements by relation to other SAE data collection standards

New data elements	Adapted from SAE J3197 (different)	Adapted from SAE J1698 (different)	From SAE J3197 (used "as is")	From SAE J1698 (used "as is")
14	8	8	4	5

Vehicle Control
"What the ADS did"

- ADS Action
  – ADS Requested Hazard Flasher
  – ADS Requested Headlights
  – ADS Requested Turn Signals
- Vehicle Indicated
  – Hazard Flasher Status (from SAE J1698-1)
  – Headlight Status (adapted from SAE J1698-1)
  – Turn Signal Status (from SAE J1698-1)

- ADS Mode (adapted from SAE J1698-1)
- ADS Action – ADS Requested Pedestrian Communication Device
- Failure Mitigation Strategy Activated
- (from SAE J1698-1)

- ADS Determined – Reference Vehicle Speed (adapted from SAE J1698-1)
- Vehicle Indicated – Speed (adapted from SAE J1698-1)

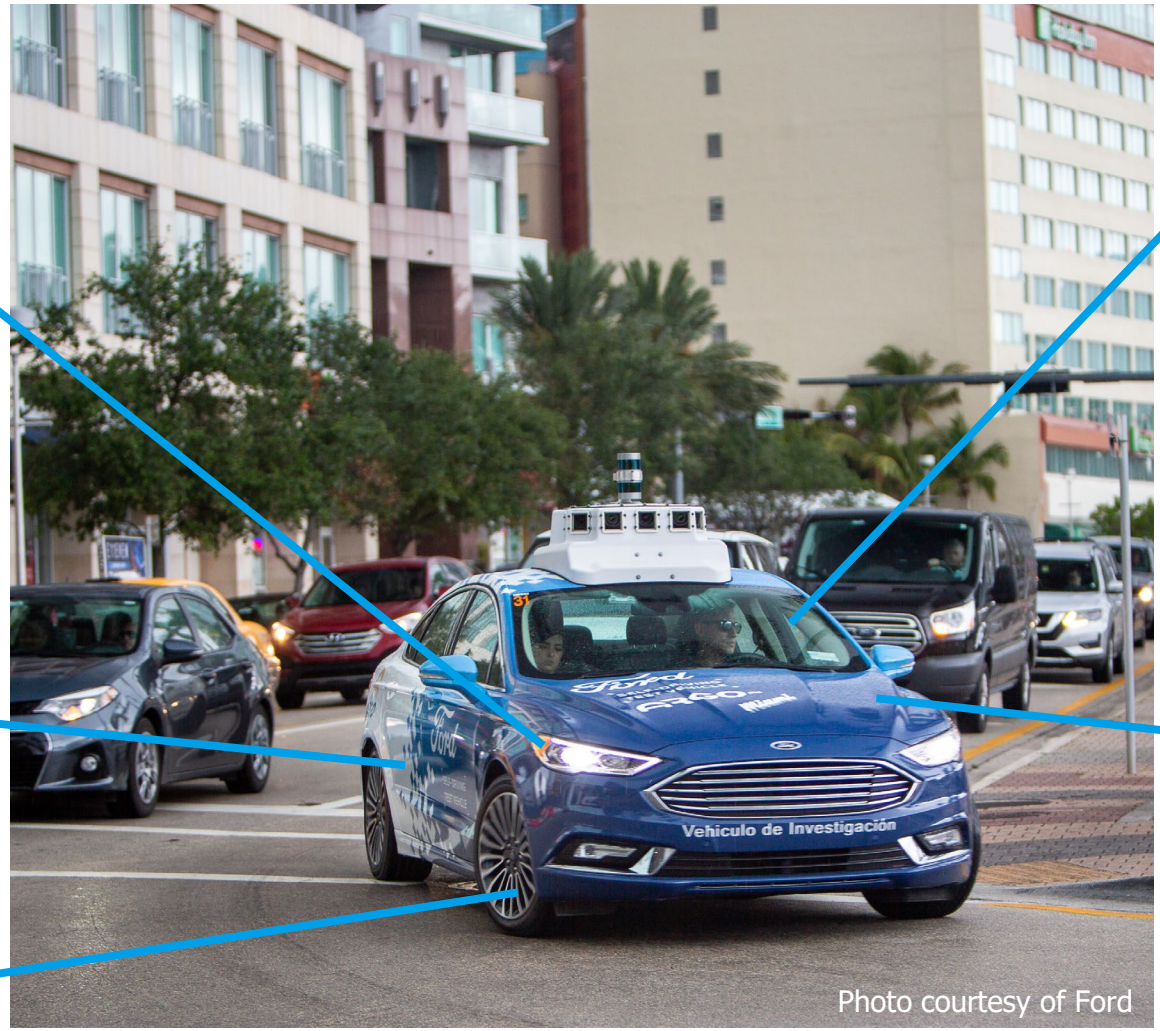


Photo courtesy of Ford

- ADS Determined – Reference Vehicle Steering Position
- Vehicle Indicated – Steering Position Actual (adapted from SAE J1698-1)

- Vehicle Indicated – Gear Position (from SAE J1698-1)
- ADS Action
  – ADS Requested Gear (from SAE J3197)
  – ADS Requested Lateral Vehicle Motion Control (adapted from SAE J3197)
  – ADS Requested Longitudinal Vehicle Motion Control (adapted from SAE J3197)

Saliency
"What the ADS thought was important"

Salient Object(s) Detected
– Vehicle Backup Light Status
– Vehicle Brake Lights Status
– Vehicle Emergency Light Status
– Vehicle Hazard Flasher Status
– Vehicle Turn Signal Status

Salient Object(s) Detected
– Classification
– Identification Number (ID)

Salient Object(s) Detected
– Relative Position (from SAE J3197)
– Relative Velocity
(adapted from SAE J3197)

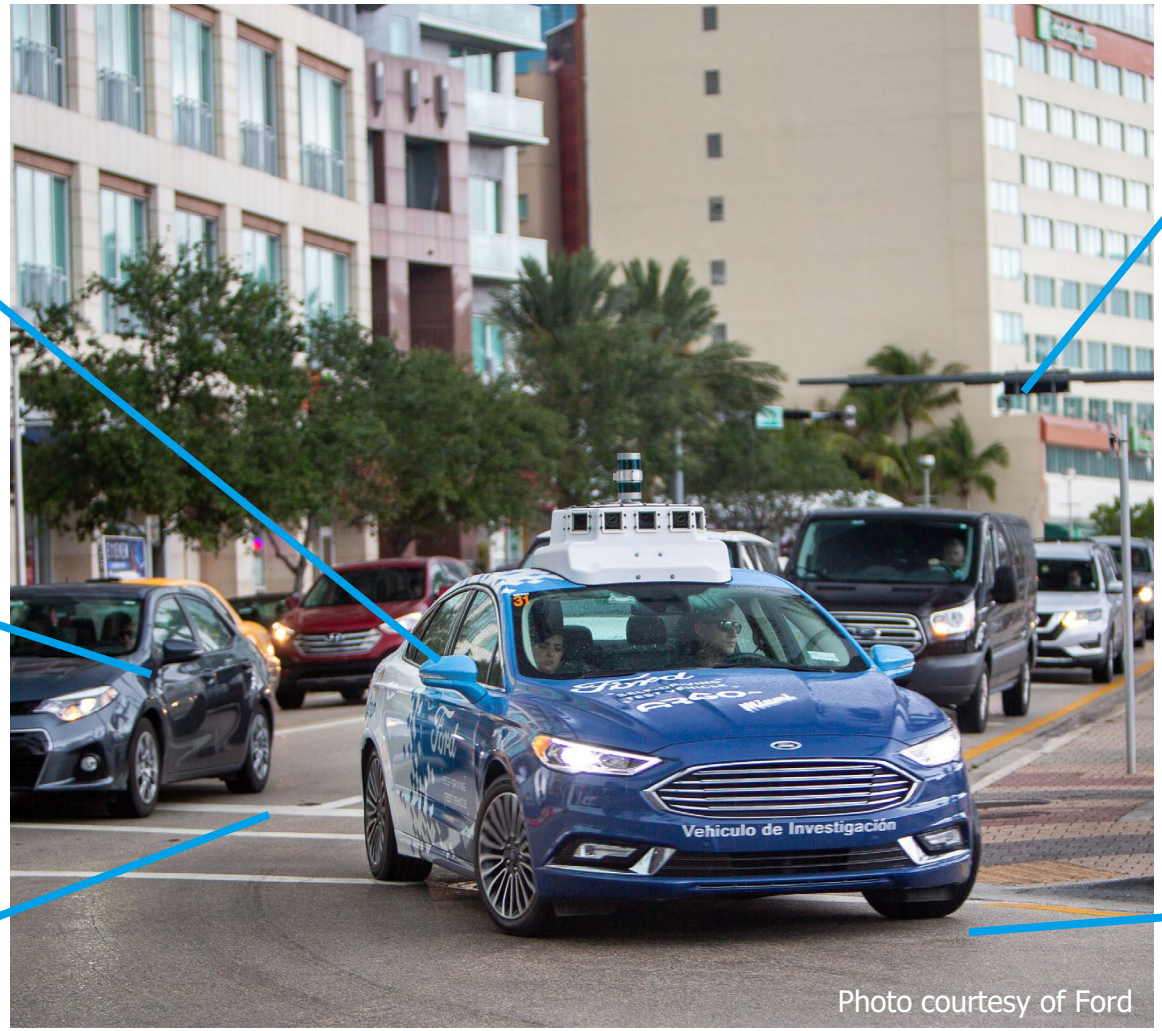


Photo courtesy of Ford

Salient Object(s) Detected – Traffic Control Device State
(adapted from SAE J3197)

Salient Emergency Vehicle Warning(s) Detected
(from SAE J3197)

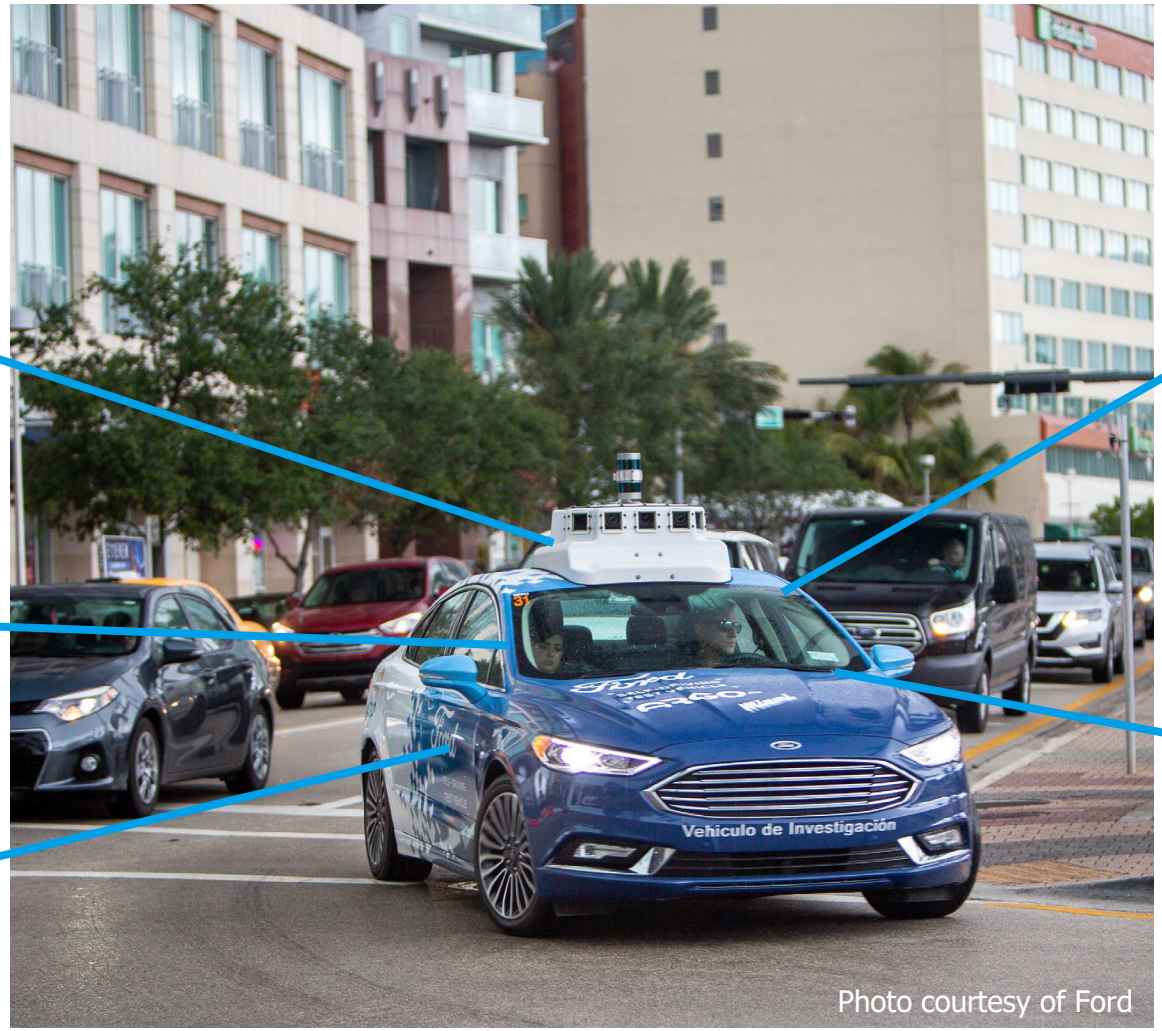
Salient Object(s) Detected – Lane Delineation and Channelization

Sensing and General Parameters
"What the sensors saw"

- Visual Representation (adapted from SAE J3197)
- Other Sensor and Input Data

Passenger-Initiated Emergency Trip Interruption Activation (adapted from SAE J3197)

- ADS Relevant Health Status (adapted from SAE J1698-1)
- Data Record Trigger Type (adapted from SAE J3197)



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- Time of day (adapted from SAE J3197)
- Vehicle Location (adapted from SAE J3197)

Vehicle Identification Number (VIN) (from SAE J1698-1)

Metrics and Methods for Assessing Safety Performance

Released March 25th

Why -

- Credible, practicable, and consistent ways to measure ADS performance are essential to garner public trust and confidence
- Several ways have been put forward, but not widely adopted
- Measuring safety outcomes is a complex task; requiring considerable time and exposure to achieve statistical significance

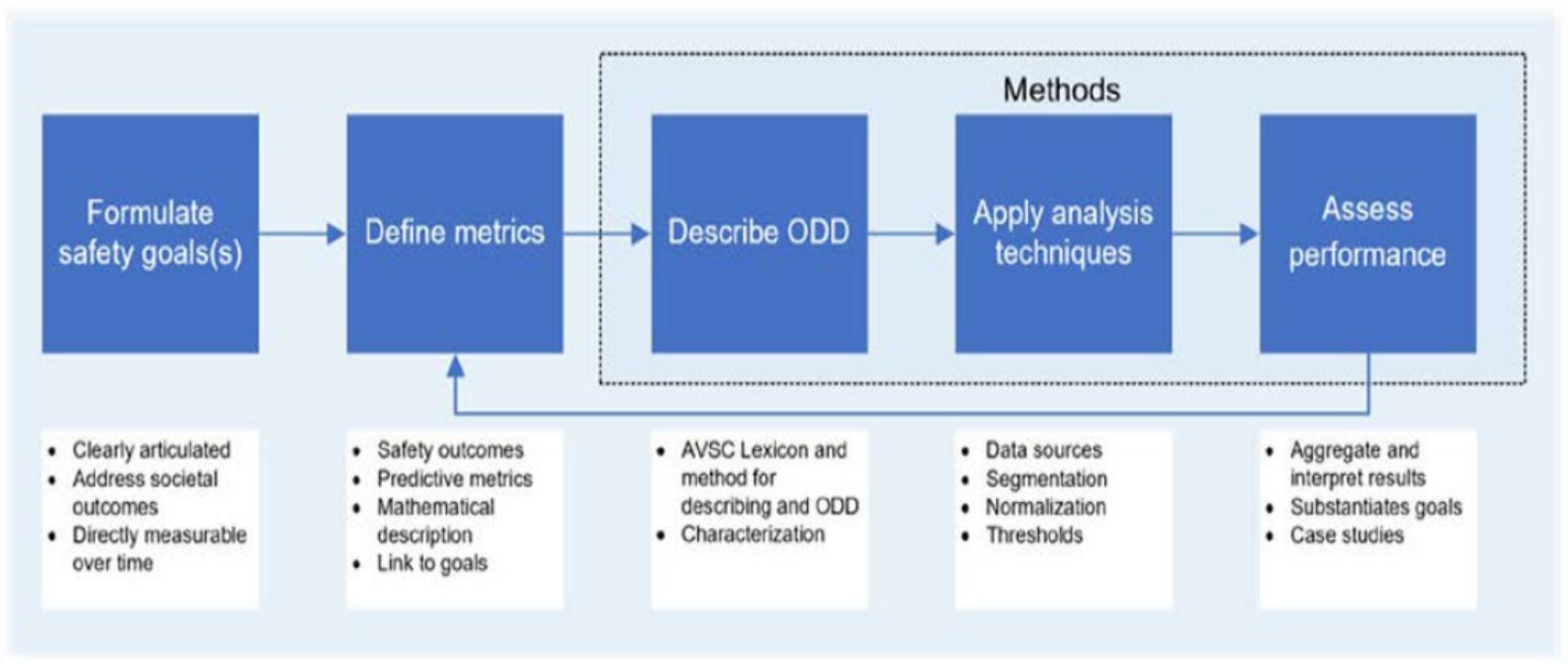
What -

- Foundational set of common, system-level metrics
  - Intended for use in combination with developer's customized metrics
- Enables consistency of safety performance assessment for deployment of fleet-operated/managed SAE level 4 and 5 ADS-equipped vehicles
  - Serve as predictive indicators in the near- to mid-term
  - Support safety outcomes in the long term

Metrics to Support ADS Safety

ADS developers and manufacturers should build evidence, including metrics, to support the argument that their ADS is acceptably safe to operate on public roads.

FIGURE 1 Recommended process to provide evidence of safety performance.



Metrics to Support ADS Safety (continued)

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

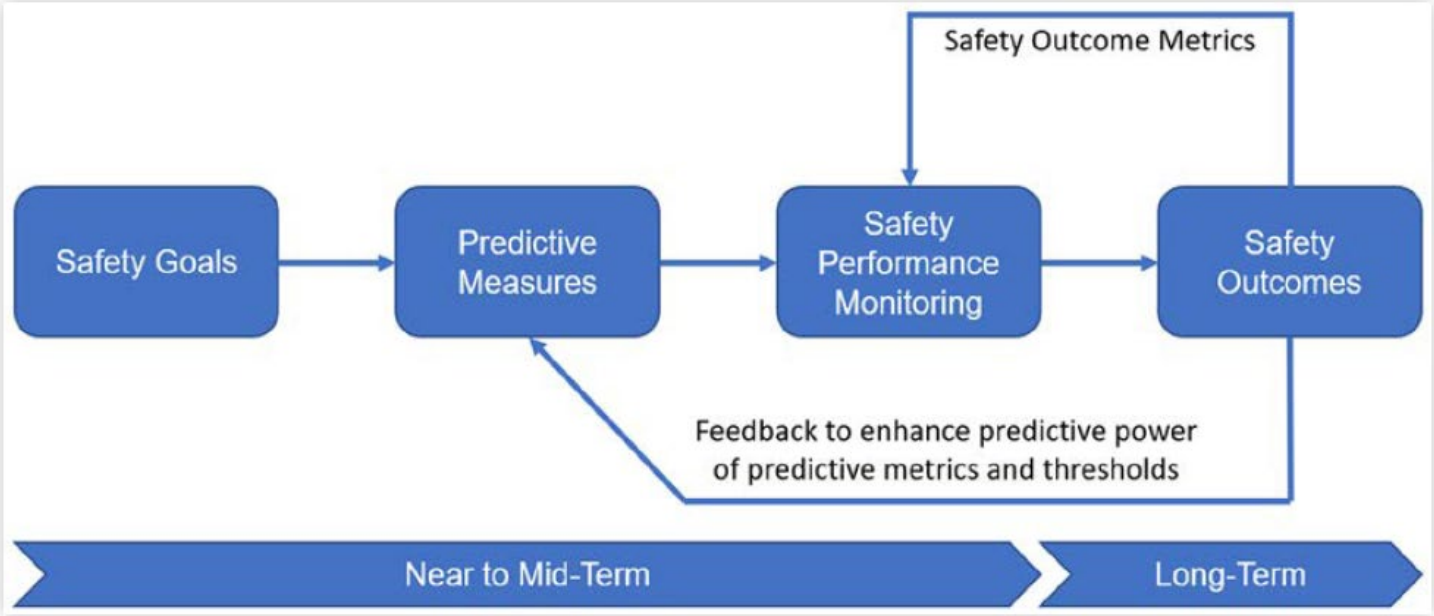
Table 1: Recommended set of safety performance metrics for ADS developers and manufacturers

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

Recommended Predictive [Safety] Metrics

Metrics should be assessed periodically by the ADS DV-developer to verify the correlation between predictive metrics and safety outcomes is maintained through a feedback loop.

FIGURE 2 Predictive metrics and safety outcome metrics support risk management by helping predict future safety outcomes.



Recommended Predictive [Safety] Metrics

ADS developers and manufacturers should use predictive metrics, based on their correlations to safety outcomes.

Table 3: Recommended predictive [safety] metrics

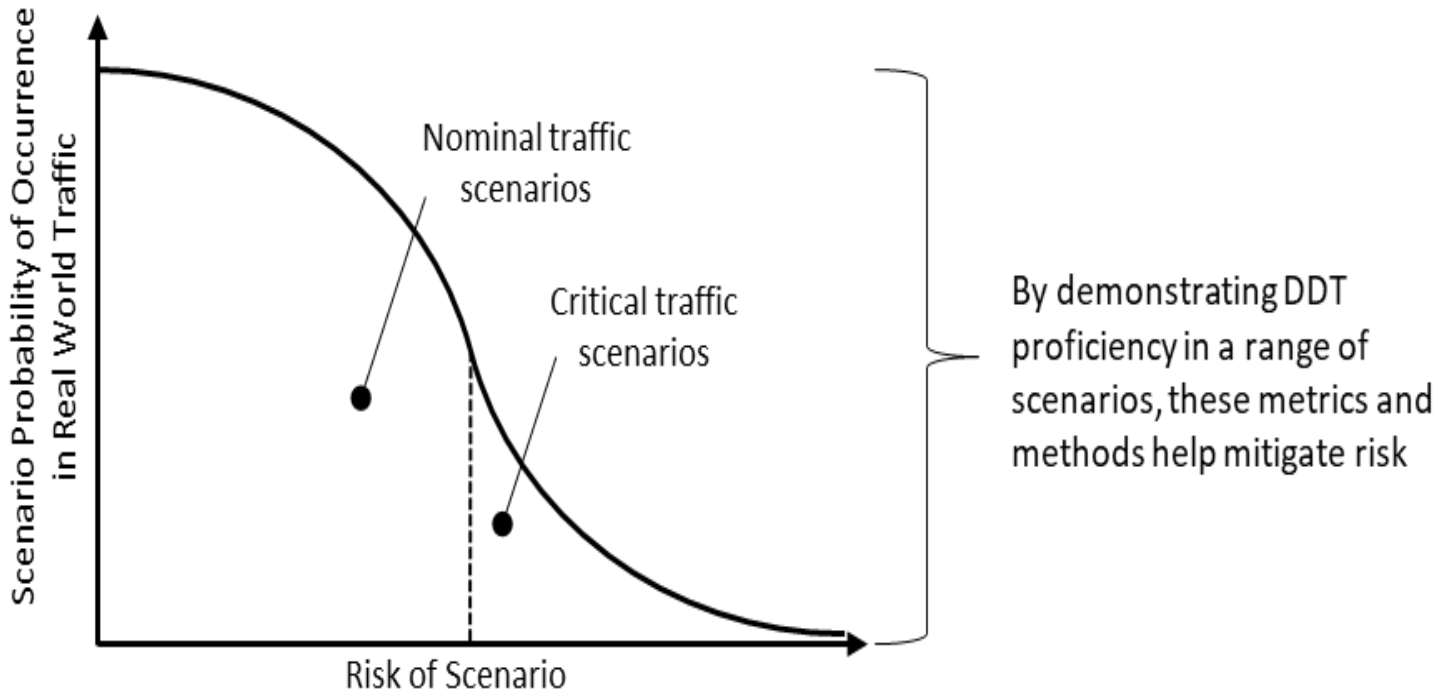
Category	Metric Parameters
Maintain a safety envelope	Longitudinal and lateral distance
Exhibit contextually safe vehicle motion control	Acceleration (longitudinal and lateral) Jerk (longitudinal and lateral)
Object and Event Detection and Response (OEDR)	OEDR reaction time

Take into consideration that predictive indicators:

- May help provide advance indication of safety outcomes
- Should be based on sufficient data
- Can provide higher confidence earlier than exposures typically needed to assess safety outcomes
- Can be assessed using various methods of data collection and analysis

Methods for Assessing DDT Safety Performance

The metrics recommended in this best practice can be used to assess ADS safety in a range of scenarios. They can be used consistently across simulation, track, and on-road test venues in pre-deployment test and development and post-deployment monitoring.



Methods for Assessing DDT Safety Performance

- **Data sources and collection** - Effective analysis of metrics includes collecting data with sufficient exposure for typical scenarios and might include crash databases, naturalistic driving data, state safety offices, etc.

- **Thresholds** – Establish practicable safety performance thresholds specific to ADS design, ODD, usage specification and considering context (driving environment and vehicle capabilities).

- **Analysis and Context** - Aggregate the results of several metrics, evaluate them in context, and use the findings in combination with other elements of overall safety performance evaluation in of deployment decisions.
  - Exposure, Segmentation, Normalization

Future Collaboration

Awareness

- SAE Motor Vehicle Council updates
- Event appearances
- General nature of work

Information Exchange

- SAE committee Chair / Vice Chair briefings
- Global SDOs and stakeholder briefings
- Working concepts

Coordination

- Individual SAE Chair / Vice Chair, global SDO, and stakeholder meetings
- Liaise with committees and other stakeholders

Collaboration

- As requested, work with committees, SDOs and stakeholders as best practice is considered in their future work

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THANK YOU

SAE Group

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IRC 501(c)(6)

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