A common language for the future of cities and road traffic safety

SG-DSSAD-18
Conference Call
30th January 2024

oxa Universal Autonomy

Main themes

1. Cities and road traffic need a common language for the Connected, Cooperative, Automated Mobility (CCAM) future.
2. Let’s all speak the same language!
3. Time and space are the common foundation;
   a. Collision investigation
   b. Explainability for automated vehicle behavior
   c. Compatible and comparable with connected vehicles and smart infrastructure

[Vehicle-to-Everything (V2X) Deployment]

The 5Ws: What? Where? When? Who? Why?

- What was the event?
- When and where did the event take place?
- Who was involved in the event?
- Why did the event happen?

The 5Ws: What? Where? When? Who? Why?

1. **What was the event?**
   a. Collision, near-miss or traffic infraction
   b. Requires data for relative movement of road-users to each other and infrastructure.
2. **When and where did the event take place?**
   a. Time and location
3. **Who was involved in the event?**
   a. Road user classification
4. **Why did the event happen?**
   a. Requires analysis of relative movement of road-users to each other and infrastructure.
   b. Requires information about each road users “world model”.

The Molly Problem for Self-Driving Vehicles

- ***A young girl called Molly is crossing the road alone and is hit by unoccupied self-driving vehicle. There are no eye-witnesses.***

- ITU FG-AI4AD developed a automated driving safety data protocol specification to help answer the 5Ws.

- The protocol speaks the same “common language” allowing direct comparison with the *world model* captured by the city’s intelligent transport system.

Situational Awareness

99% **expect recall of the *time* of the collision**

99% **expect recall of the *location* of the collision**

98% **expect recall of the *speed* at point of the collision**

The Molly Problem: A young girl called Molly is crossing the road alone and is hit by unoccupied self-driving vehicle. There are no eye-witnesses. What should happen next?

Hazard Awareness

96% expect recall of ***when*** the collision risk was identified

93% expect recall of ***if*** Molly was detected

96% expect recall of ***when*** Molly was detected

91% expect recall of ***if*** Molly was detected as a ***human***

90% expect recall of ***when*** Molly was detected as a ***human***

The Molly Problem: A young girl called Molly is crossing the road alone and is hit by unoccupied self-driving vehicle. There are no eye-witnesses. What should happen next?

Mitigating Action

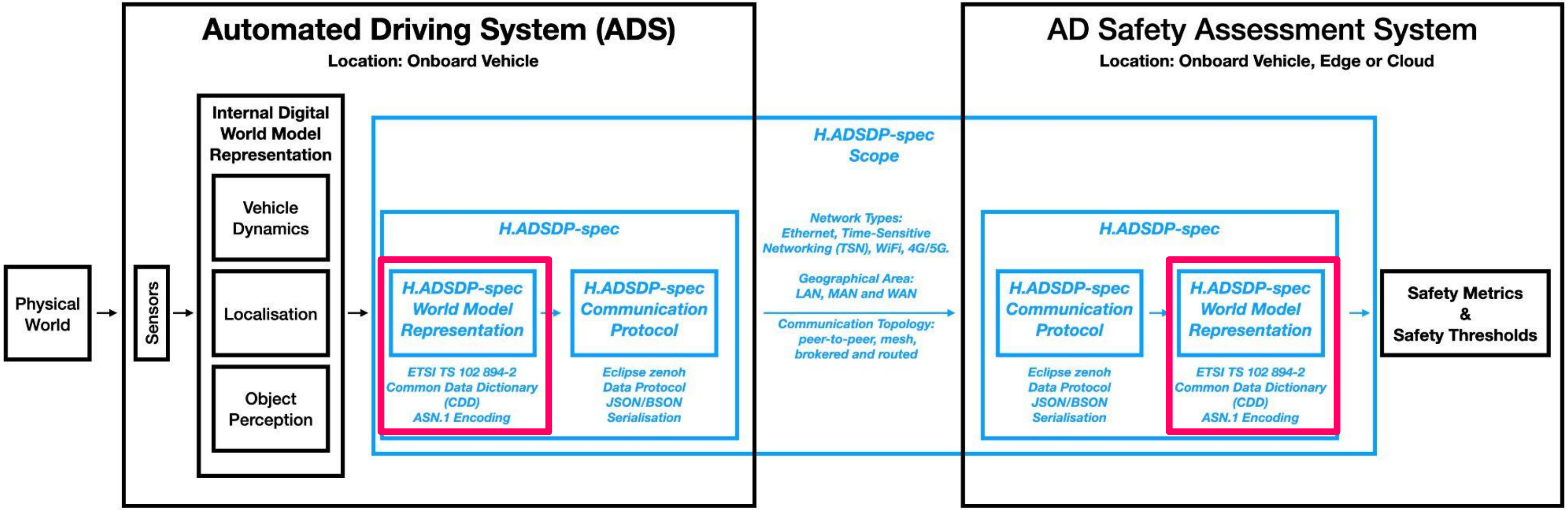
98% **expect recall of *whether* mitigating action was taken**

97% **expect recall of *when* mitigating action was taken**

96% **expect recall of *what* mitigating action was taken**

The Molly Problem: A young girl called Molly is crossing the road alone and is hit by unoccupied self-driving vehicle. There are no eye-witnesses. What should happen next?

FG-AI4AD - Proposed H.ADSDP-spec



[ITU FG-AI4AD]

H.ADSDP-spec World Model Data

- Time (TIA)
- Location in a Global Coordinate System (WGS 84)
- Vehicle identification (ISO 3779:2009)
- Vehicle coordinate system (ISO 8855:2011)
- Vehicle types (ISO 3833:1977)
- Road User Types (ETSI TS 102 894-2)
- **Ego Vehicle Data (ETSI EN 302 637-3, ETSI TR 103 562)**
- **Other road user data (ETSI TR 103 562)**

Ego vehicle high frequency data (Cooperative Awareness Message)

- **Heading, speed**, driving direction, accelerations (longitudinal, lateral, vertical), vehicle dimensions (length, width), curvature, yaw rate, steering wheel angle, lane position.

Other road user data (Collective Perception Message)

- **Object ID**, **Time**, **XYZ coordinate**, **XYZ velocity**, XYZ acceleration, Roll/Pitch/Yaw (angle, speed acceleration), object dimensions, object ref point, object age, object confidence, classification

The 5Ws: What? Where? When? Who? Why?

1. What was the event?
   a. ***<u>Relative movement of road-users to each other and infrastructure</u>***
   b. **Vehicle coordinate system (ISO 8855:2011)**
   c. **Ego vehicle high frequency data (Cooperative Awareness Message)**
      i. Heading, speed, driving direction, accelerations (longitudinal, lateral, vertical), vehicle dimensions (length, width), curvature, yaw rate, steering wheel angle, lane position.
   d. **Other road user data (Collective Perception Message)**
      i. Object ID, Time, XYZ coordinate, XYZ velocity, XYZ acceleration, Roll/Pitch/Yaw (angle, speed acceleration), object dimensions, object ref point, object age, object confidence, classification

The 5Ws: What? Where? When? Who? Why?

1. When and where did the event take place?
   a. ***<u>Time and location</u>***
   b. **Time (TIA)**
   c. **Location in a Global Coordinate System (WGS 84)**
2. Who was involved in the event?
   a. ***<u>Road user classification</u>***
   b. Vehicle identification (ISO 3779:2009)
   c. Vehicle types (ISO 3833:1977)
   d. Road User Types (ETSI TS 102 894-2)

The 5Ws: What? Where? When? Who? Why?

1. Why did the event happen?
   a. ***Requires analysis of relative movement of road-users to each other and infrastructure.***
   b. ***Requires information about each road users "world model".***
      i. **Ego vehicle high frequency data (Cooperative Awareness Message:** Heading, speed, driving direction, accelerations (longitudinal, lateral, vertical), vehicle dimensions (length, width), curvature, yaw rate, steering wheel angle, lane position.
      ii. **Other road user data (Collective Perception Message):** Object ID, Time, XYZ coordinate, XYZ velocity, XYZ acceleration, Roll/Pitch/Yaw (angle, speed acceleration), object dimensions, object ref point, object age, object confidence, classification

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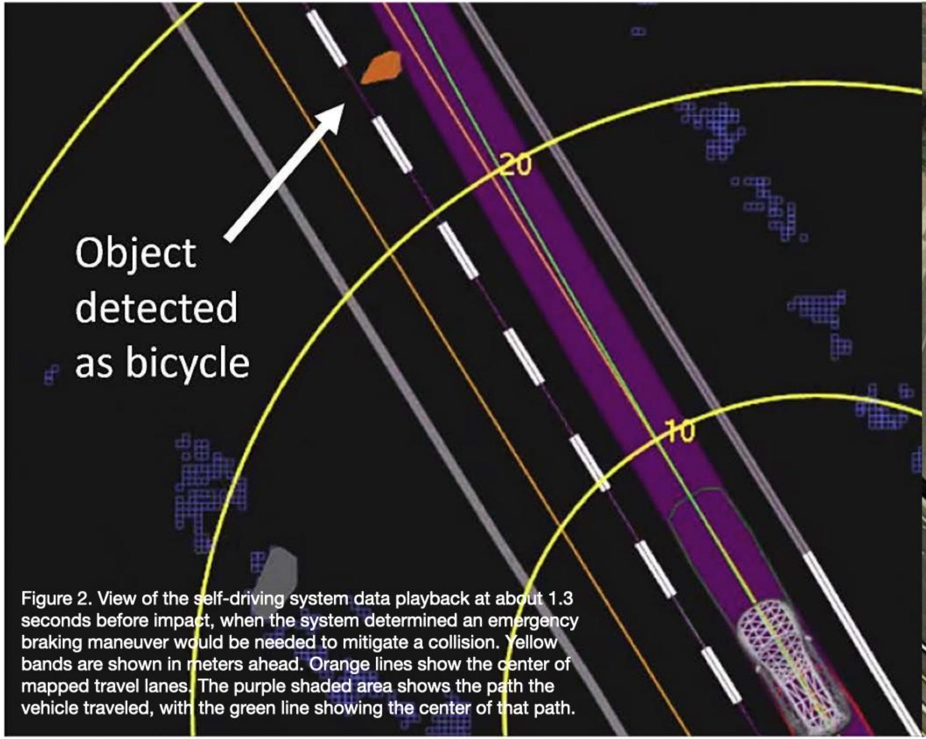
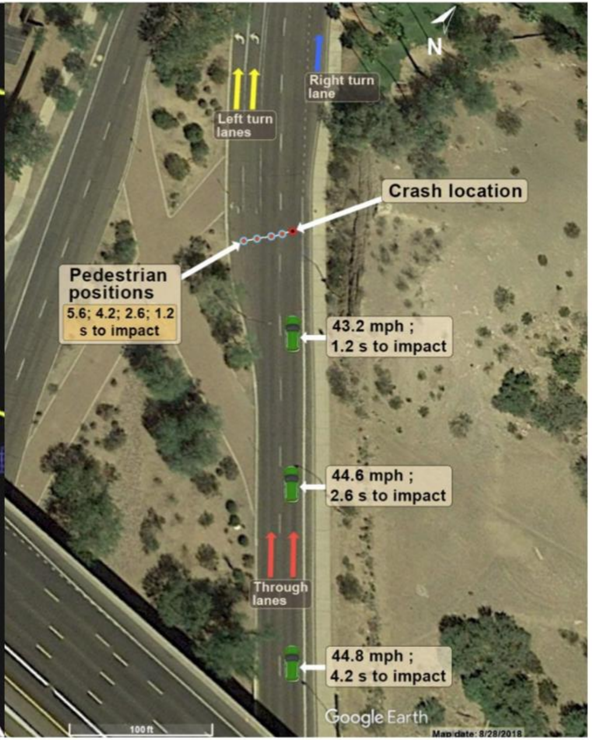


Figure 2. View of the self-driving system data playback at about 1.3 seconds before impact, when the system determined an emergency braking maneuver would be needed to mitigate a collision. Yellow bands are shown in meters ahead. Orange lines show the center of mapped travel lanes. The purple shaded area shows the path the vehicle traveled, with the green line showing the center of that path.



https://www.ntsb.gov/investigations/pages/hwy18fh010.aspx

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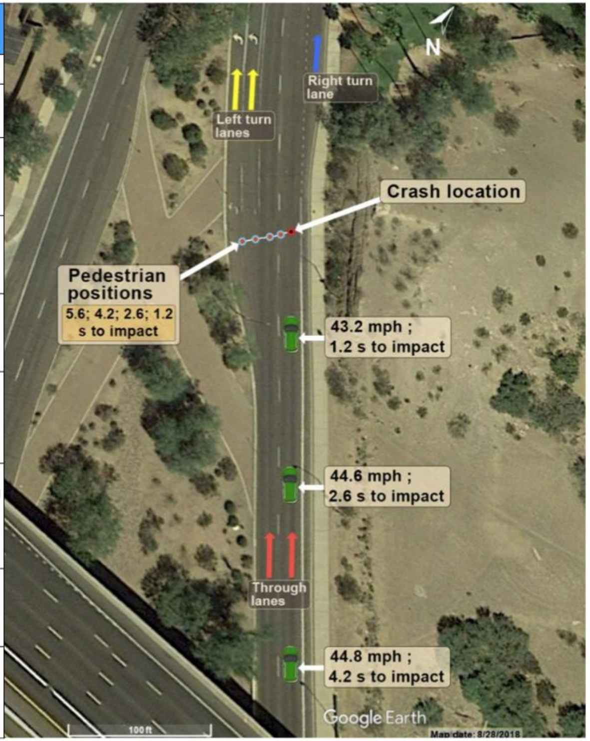
Time (s) relative to impact	Speed (mph)	Classification and Path Prediction[a]	Other Events / Details[b]
-9.9	35		Vehicle begins to accelerate from 35 mph due to an increased speed limit
-5.8	44		Vehicle reaches the speed of 44 mph
-5.6	**44**	**Classification: Vehicle - by radar** **Path prediction: None; not on the path of the SUV**	**Radar makes the first detection of the pedestrian and estimates its speed.**
-5.2	45	Classification: **Other** - by lidar Path prediction: Static; not on the path of the SUV	Lidar detects an unknown object; this is the first detection of that object by lidar, the tracking history is unavailable, and its velocity cannot be determined. ADS predicts the object's path as static.
-4.2	**45**	**Classification: Vehicle - by lidar** **Path prediction: Static; not on the path of the SUV**	**Lidar classifies a detected object as a vehicle; this is a changed classification of an object and without a tracking history. ADS predicts the object's path as static.**
-3.9		Classification: Vehicle - by lidar Path prediction: The left through lane (adjacent to the SUV); not on the path of the SUV	Lidar retains the classification "vehicle", and based on the tracking history and the assigned goal, ADS predicts the object's path as traveling in the left through lane.
3.8 > - 2.7	45	Classification: alternated several times between **vehicle and other** - by lidar Path prediction: alternated between static and left lane; neither were considered on the path of the SUV	The object's classification alternates several times between vehicle and an unknown. At each change, the object's tracking history is unavailable, and ADS predicts the object's path as static. When the detected object's classification remained the same, ADS predicts the path as traveling in the left through lane.
-2.6	**45**	**Classification: Bicycle - by lidar** **Path prediction: Static; not on the path of the SUV**	**Lidar classifies a detected object as a bicycle; this is a changed classification of the object, and without a tracking history. ADS predicts the bicycle's path as static.**
-2.5	45	Classification: **Bicycle** - by lidar Path prediction: The left through lane (adjacent to the SUV); not on the path of the SUV	Lidar retains the classification "bicycle" and based on the tracking history and the assigned goal, ADS predicts the bicycle's path as traveling in the left through lane.



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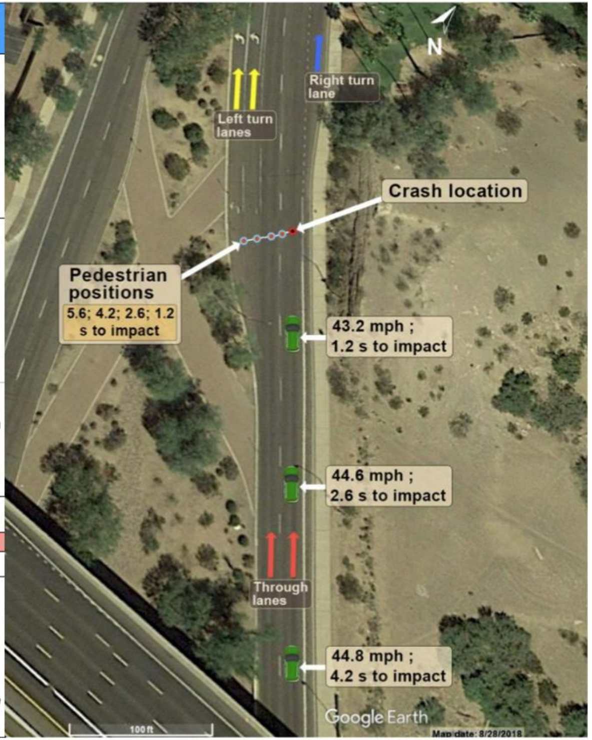
Time (s) relative to impact	Speed (mph)	Classification and Path Prediction[a]	Other Events / Details[b]
-1.5	*44*[c]	Classification: ***Unknown*** - by lidar Path prediction: *Static*; partially on the path of the SUV	Lidar detects an unknown object; since this is a changed classification, and an unknown object, it lacks tracking history and is not assigned a goal. ADS predicts the object's path as static. Although the detected object is partially in the SUV's lane of travel, the ADS generates a motion plan around the object (maneuver to the right of the object); this motion plan remains valid—avoiding the object—for the next two data points.
-1.2	**43**	**Classification: *Bicycle* - by lidar** **Path prediction: The travel lane of the SUV; fully on the path of the SUV**	**Lidar detects a bicycle; although this is a changed classification and without a tracking history, it was assigned a goal. ADS predicts the bicycle to be on the path of the SUV.** **The ADS motion plan—generated 300 msec earlier—for steering around the bicycle was no longer possible; as such, this situation becomes hazardous.** **- Action suppression begins**
-0.2	40	Classification: ***Bicycle*** - by lidar Path prediction: The travel lane of the SUV; fully on the path of the SUV	Action suppression ends 1 second after it begins. The situation remains hazardous; as such, ADS initiates a plan for vehicle slowdown. *An auditory alert was presented to indicate that the controlled slowdown was initiating* [d]
-0.02	39		Vehicle operator takes control of the steering wheel, disengaging the ADS.
IMPACT			
0.7	37		Vehicle operator brakes

[a] Only changes in object classification and path prediction are reported in the table.The last reported values persist until a new one is reported.

[b] The process of predicting a path of a detected object is complex and relies on the examination of numerous factors, beyond the details described in this column

c The vehicle started decelerating due to the approaching intersection, where the pre-planned route includes a right turn at Curry Road. The deceleration plan was generated 3.6 seconds before impact.

[d] *While the system generated a plan for the vehicle slowdown, due to a slight communication delay, the data is unclear on whether the implementation of the slowdown plan started before the operator took control prior to impact.*



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Thank you

+44 (0)1865 433 998
bryn.balcombe@oxa.tech
oxa.tech

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