Breakout Session 18

Objectives
• Determine needs: TCD adaptation for machine vision systems
• Learn about machine vision system shortfalls and planned improvements
• Better define role of mapping in navigation and infrastructure identification
• Identify state of readiness initiatives worldwide (Colorado, EU from 3 countries)
• Determine path forward for readiness framework development in North America

Summary of Key Findings and Lessons Learned
• Consistency and logical application may be more important than compliance
• MV manufacturers expect use of best/established practices, will work with that
• Large shortfalls exist in MV capabilities relative to more complex environments
• Readiness framework development goes beyond Level of Automation or Operating Domain
• Readiness ratings will require multi-criteria topology and uniform assessment practices
Breakout Session 18
RECOMMENDED ACTION ITEMS

• Connect MV experts with TSMO engineers, traffic design engineers and TCD manufacturers
  • Need to identify shortcomings on both sides and collaborative gap-filling
  • Planning a “Sensors 101” plenary panel for 2018

• Use human factors primacy triangle to better understand driving task
  • Emphasize driver assistance devices as means of countering human shortfalls
  • Delineation far more important than signing, excepting regulatory signs in low-information environments

• Recognize that 2009 was a LONG time ago in this business
  • MUTCD (23 CFR 655) is not timely enough to set the standards upon which MV applications can rely
  • TCD policymakers must develop new consistency criteria that focus on critical devices

• Convene independent consortium to develop readiness criteria, assessment methodologies, and rating/needs identification databases; key in determining minimum investment required
  • Identify risk of “stamp of approval” in tort liability
  • Key component of interim need to identify handoff need/locations for various domains and regimes
3M has been supplying innovative highway infrastructure materials for more than 75 years.
• 3M has been supplying innovative highway infrastructure materials for more than 75 years
• Humans & CAVs will coexist on the roads for many years
• 3M has held more than 400 meetings with CAV stakeholders over ~2 years
• Our premise: Infrastructure has a key role to play in the successful migration to CAV’s
  o Simple solutions to enhance safety and redundancy
  o Corner cases include adverse weather and work zones
  o Redundancy is critical for robust and safe CAV decisions
Successful new product growth builds on uncommon connections.
Typical CAV sensor systems now and in the future

- Vision systems
- Radar
- Lidar
- Ultrasonics
- Other?

Goal: Design the infrastructure to serve the sensor and sensor fusion systems
IR reflection using 3M multilayer optical film
(used in building and automotive windows)

- Hundreds of layers of film precisely constructed
- Inspired by nature
- >200 layers in less than the thickness of human hair

Visibly transparent

Visible light
NIR

NIR Reflective
Machine-Readable Pavement Markings (PM)
PM solutions designed to increase sensor visibility in all weather conditions

380 Wet Reflective Tape

380-5 Contrast Tape

Side by Side
Conventional lane markings Wet reflective markings
Core technologies - WR PM
- Light management
- Ceramics
- Advanced materials

• 1.9 index beads when dry

Dry conditions

Optimal Refractive Index (RI) = 1.8 - 1.9

• 2.4 ceramic beads when wet

Wet conditions

Optimal Refractive Index (RI) = 2.4 - 2.5
Machine Readable Signage
Solutions that may enable more accurate sign detection and classification

Current 3M Signing
• Returns up to 58% of light to all drivers
• Maintains superior (human) legibility

Future Signing Performance Goals
• Embedded digital information
• Superior human legibility
• In concept evaluation
• Embedded metadata
• Dynamically changeable
• Digital certainty
• Sign class redundant

Human Optimized Diamond Grade™ (DG³)
Diamond Grade™ Fluorescent
Retroreflective 2D code in visible light
Black printing on white sign sheeting

Machine Vision Optimized with Decoded Metadata

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3M Corridors evaluations in process

Michigan I-75 Corridor Study Underway now Focus on signs and work zone materials

Michigan, California, Ohio, Virginia, Minnesota, Texas
3M Corridors evaluations in process

USA, Germany, China, Japan

Michigan, California, Ohio, Virginia, Minnesota, Texas

Ultimate goal: All the time, everywhere
3M Technology development and assessment

- Real world global evaluation
- For existing and evolving vehicle sensors
- Engagement and collaboration with all stakeholders
- Clarify value propositions
- Learn and pivot
I2V applications for intersections and transition areas

Dr. Jaap Vreeswijk  
MAP traffic management, the Netherlands

Automated Vehicle Symposium 2017, 12 July 2017, San Francisco  
Breakout 18: Reading the Road Ahead: Infrastructure Readiness

MAVEN is funded by the EC Horizon 2020 Research and Innovation Framework Programme, under Grant Agreement No. 690727
Safe and connected automation

H2020 call MG3.6a - 2015

Specific challenge: Automated and progressively autonomous driving applications in road transport, actively interacting with their intelligent environment could provide an answer to the EU objective of reconciling growing mobility needs with more efficient transport operations, lower environmental impacts and increased road safety.

... Automation in road transport should make best use of the evolution of Cooperative ITS and the benefits made available by satellite navigation systems, such as the increased accuracy and robustness.

... Novel transport, service and mobility concepts in real-life situations enabled by automated driving and connectivity. These services and concepts could benefit from cloud computing and data management and data aggregation techniques for road transport big data.
Road infrastructure to support the transition to automation

H2020 call ART-05 – 2016

Specific challenge: … highly automated vehicles will have to be managed in order to ensure an uninterrupted level of safety and efficiency. Road infrastructure will play a major role in managing this transition period.

…

Required forms of visual and electronic signalling and optical guidance, ensuring readability by both automated and conventional vehicles, and enabling automated driving in also adverse road weather conditions.

…

Best ways to enlarge the electronic road horizon for automated vehicle ensuring timely reaction to hazards ahead via real-time warnings and information, traffic management plans, up-to-date digital maps, etc.
Connected automation

**Connected Vehicle**
Communicates with nearby vehicles and infrastructure; Not automated

**Connected Automated Vehicle**
Leverages autonomous automated and connected vehicles

**Autonomous Vehicle**
Operates in isolation from other vehicles using internal sensors

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An intelligent environment *with infrastructure*

- Communication a precondition for highly automated driving
- ‘Public’ traffic management and control remains necessary
  - Safeguard societal interests
  - Setting constraints and rules
  - Intervene in case of oversaturated conditions

- Offers new possibilities for optimisation in traffic management and control
- Three operational perspectives:
  - Each vehicle individually (autonomous)
  - Vehicles part of a group process (e.g. platoon)
  - Vehicles part of a system process (e.g. intersection control)
Projects overview

- MAVEN (MG3.6a)
  - Managing Automated Vehicles Enhances Network
  - 01-09-2016 ~ 31-08-2019
  - Budget: EUR 3.149.661,25
  - Nine partners from five countries: DE, NL, CZ, BE, UK

- TransAID (ART-05)
  - Transition Areas for Infrastructure-Assisted Driving
  - 01-09-2017 ~ 31-08-2019
  - Budget: EUR 3.836.353,75
  - Seven partners from 6 countries: DE, UK, BE, NL, EL, ES

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MAVEN project summary

- MAVEN will develop **management regimes** for highly automated driving in **urban areas**.

- Road infrastructure will be able to **monitor, support and orchestrate** vehicle and VRU movements to guide vehicles at **signalized intersections** and corridors in urban areas.

- Beyond the state-of-the-art of ADAS and C-ITS services like GLOSA, by adding cooperative **platoon organization** and signal plan negotiation to **adaptive traffic light control**.

- Develop suitable enables technologies, e.g. **communication protocols**, and test and validate via simulation and real-world prototype (ITS-G5 based).
Infra-initiated and/or infra-assisted

- **Platoon management (group process)**
  - ✔ Forming, joining, progression, leaving, breaking a platoon

- **Infrastructure-to-vehicle interactions (system process)**
  - ✔ Negotiation (signal timing vs. arrival pattern), speed advisory, lane advisory

- **Traffic control optimization (and scheduling)**
  - ✔ Signal optimization, priority management, queue estimation, green wave

- **Conventional traffic and vulnerable road users**
  - ✔ Detection of non-cooperative vehicles, VRUs, emergency situations

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A broader context: TransAID project summary

- …what if your automated vehicle is not able to solve the situation ahead?
  - …what, if this happens not to single vehicles only, but to several?
  - …what, if it always happens on the same spot?

- Develop and demonstrate **infrastructure-assisted** traffic management procedures and protocols for smooth coexistence between automated, connected and conventional vehicles especially at **Transition Areas**.

- Infrastructure can:
  - Help to identify potential risks
  - Recommend solutions
  - Coordinate movements
Transition Areas

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TransAID scenarios and interventions

- **Scenarios**
  - Work zones
  - Signalized intersections
  - Merging sections / off-ramps
  - Incidents (accidents, sensors limitations)
  - Weather conditions
  - Any bottleneck…

- **Interventions**
  - Transition to different level of automation
  - Location and time of transitions
  - Traffic separation
  - Lane advisory
  - Speed advisory
  - Intersection pilot (MAVEN)
The case of Truck Platooning
Necessary V2X extensions

- **V2I – e.g. Cooperative Awareness Message (CAM)**
  - Planned manoeuvre (intention);
  - Desired speed range;
  - Platoon properties (size, length, roles, speed, headway, composition, etc.);
  - Acknowledgments of intentions and compliance (negotiation).

- **I2V – e.g. Signal Phase and Timing Message (SPAT) or new message (?)**
  - Differentiated speed advisory;
  - Lane advisory;
  - Appropriate headway;
  - Maximum platoon length or prohibition;
  - Feasible level of automated driving.
To conclude

- Infra-assistance for highly automated driving
  - Managing Automated Vehicles Enhances Network (MAVEN)
  - Transition Areas for Infrastructure-Assisted Driving (TransAID)
  - Truck Platooning (Real-Life Cases Program)

- A necessity but also a new dimension of Traffic Management and Control
  - Explicit intervention (control)
  - Implicit response (inform)

- Many ideas and concepts, equal amount of questions: explorative research!

- Great interest (local) road authorities in guidelines and broader city mobility context
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