

# 2019 DVN US WORKSHOP

*Safer, Smaller, Smarter Lighting Technologies*

Rochester, MI, USA **January 16, 2019**

Status report on...

SAE J3134 Recommended Practice  
Automated Driving System (ADS) Lamps

UN Taskforce  
Autonomous Vehicle Signaling Requirements (AVSR)

<b>SURFACE VEHICLE RECOMMENDED PRACTICE</b>	<b>J3134™</b>	
	Issued	20xx-xx
	Revised	Proposed Draft Superseding – N.A.
Automated Driving System (ADS) Marker Lamps		



## **Background info on ADS lighting**

- Video
- Research studies on vehicle to pedestrian communication

## **Report on SAE J3134**

- Task Force information
- Key discussion points addressed in J3134 rationale

## **Report on the GRE AVSR Taskforce**

- Creation of the AVSR task force
- Current activities

## What are Automated Driving System (ADS) lamps?

Vehicle to pedestrian signals that communicate...

- the ADS status (on)
- the ADS / vehicle's intentions (e.g. yield, stop, go)



*80% of all  
pedestrians  
seek eye contact  
with the driver.*

## “CityMobil2” – EU Questionnaire with Automated Bus



What **messages** do road users want the automated to communicate to them and what type of signals can be used to communicate the messages?

## “Duke-Display” - Duke University Field study with Communication Display



What is the effectiveness of new methods of vehicle-to-pedestrian communication?

## *“Ghost Driver”- Stanford University Field study*



How will pedestrians and bicyclists interact with automated vehicles when there is no human driver?

## *Chalmers University field study in Sweden – visible driver*



Can pedestrians recognize an automated vehicle’s signals and can the signals provide any aid for pedestrians in the interaction with an automated vehicle?

## Lighting for Automated Driving Systems - Universität Darmstadt



Which symbols were effective in communicating the vehicle's intent?

## Ford and Virginia Tech study



How will road users interact with automated vehicles and will they understand the automated vehicle's signals?

# Background on ADS lighting – Study Results

Study	Result
Stanford University	People need acknowledgement that they have been noticed to be comfortable walking or bicycling in front of autonomous cars
Duke University	There is a need for new methods of vehicle to pedestrian communication to communicate intent information in the immediate area
CityMobil2 project in Europe	The most important message that needs to be communicated to cyclists and pedestrians is whether they have been detected...
Chalmers University of Technology	There is a need for external communication interface between pedestrians and automated vehicles to compensate for the loss of the driver and perceived safety.
Semcom's Smiling Car Experiment	80% of all respondents said that, as pedestrians, they seek eye contact with the driver. Self-driving cars need to communicate in a way that feels familiar and creates trust
Darmstadt University	Communication is desired...Direction of communication at the front of a car is very important
Ford	There needs to be a standard way for autonomous vehicles to easily communicate their intention to people on the streets

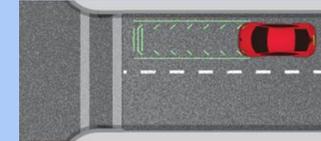
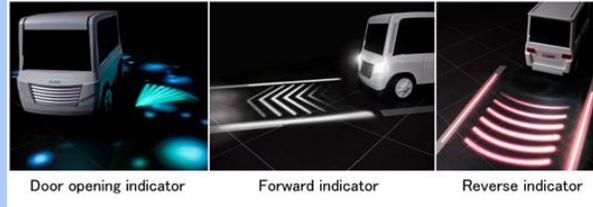
# Background on ADS lighting – NHTSA Guidance



AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY – September 2017

Considerations should be made for the human driver, operator, occupant(s), and external actors with whom the ADS may have interactions, including other vehicles (both traditional and those with ADSs), motorcyclists, bicyclists, and pedestrians. HMI **design should also consider the need to communicate information regarding the ADS's state of operation** relevant to the various interactions it may encounter and how this information should be communicated.

# ADS lighting – Concepts / Examples





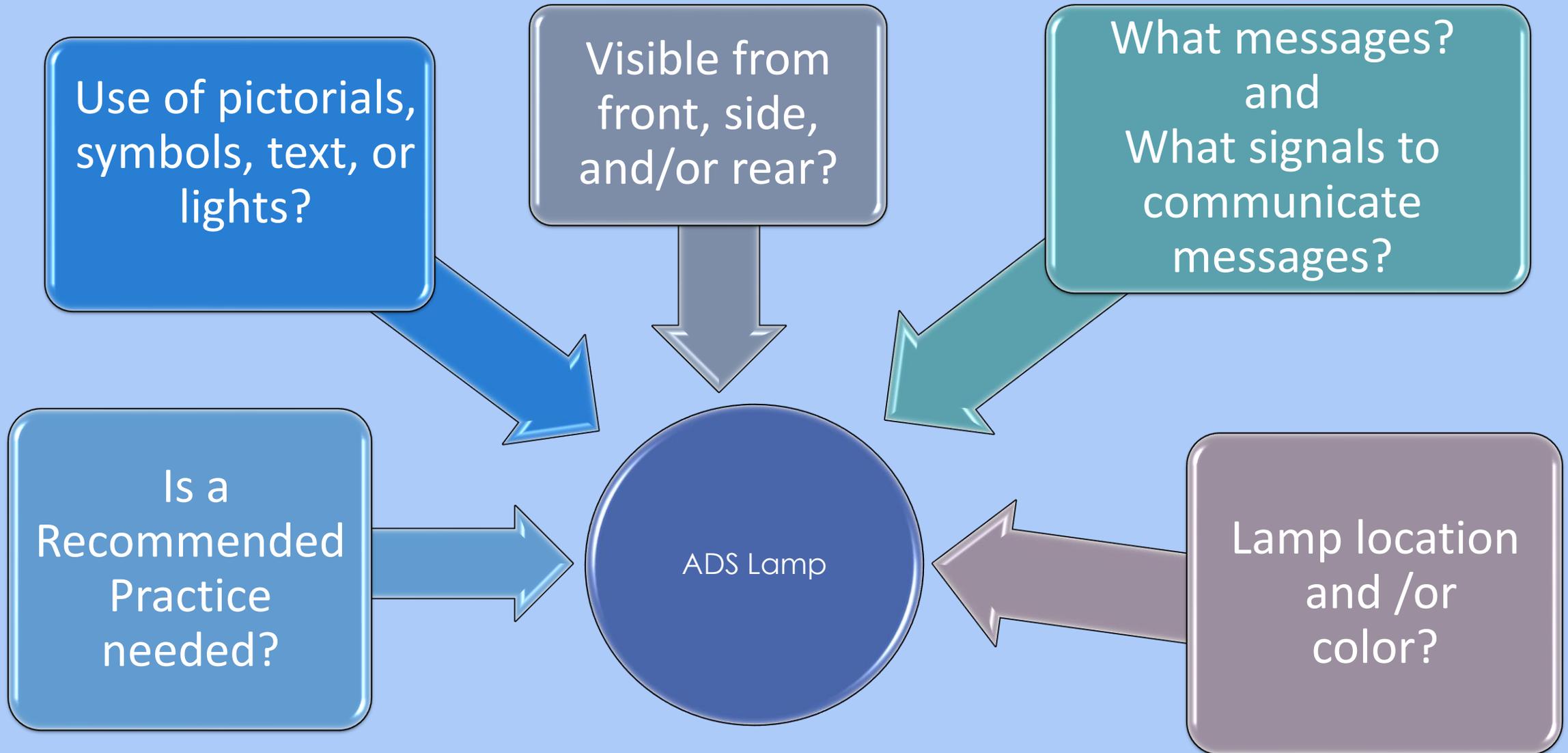
# Status report on SAE J3134

- The SAE J3134 task force met monthly.
- Currently has over 75 members. Included as members in the task force are most of the major OEMs, tier 1 and 2 lighting suppliers, academia; NHTSA and Transport Canada, GTB members.
- Goal is to develop an ADS lighting Recommended Practice that is or can be globally harmonized

# Status report on SAE J3134

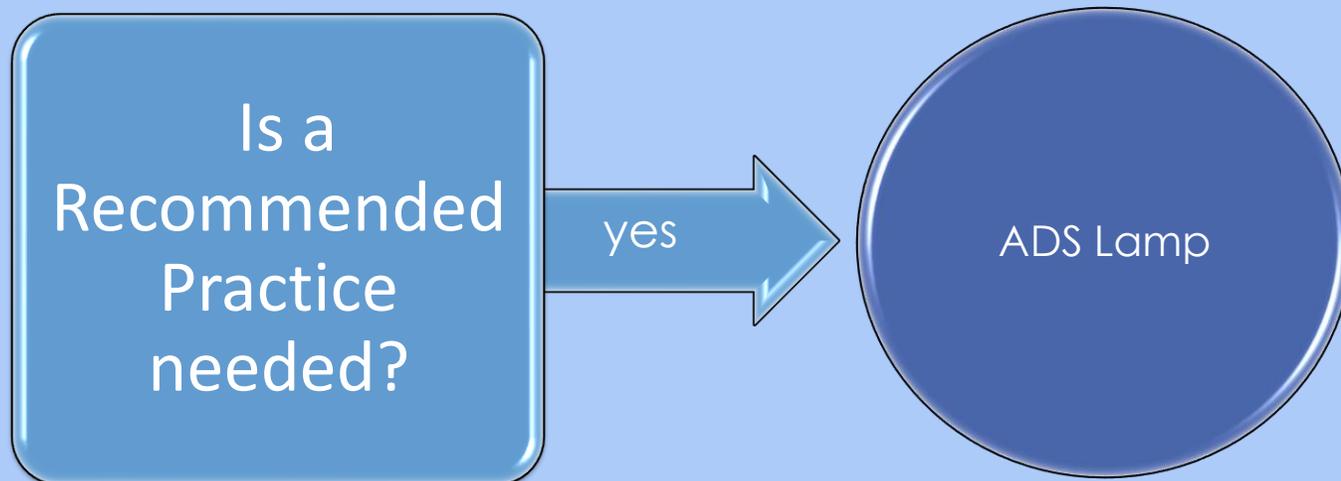
- **December 2015 - UMTRI, Ann Arbor, MI.** The subject of Automated-Driving Vehicle lighting was brought up for discussion during the SAE Lighting Committee meeting. Because of the increased development of automated vehicles, the SAE Lighting Committee thought it would be a good idea to look into developing automated vehicle lighting.
- **September 2016 – Portland, Oregon.** The status on the development of automated vehicles and examples of automated vehicle lighting was presented. It was decided to form a task force to investigate automated vehicle lighting
- **November 2016** - SAE J3134 Recommended Practice was opened
- **February 2017** – First task force meeting
- **September 2018**– First ballot
- **November 2018** – Second ballot
- **January 2019** – Third ballot

# Status report on SAE J3134 – Key discussion points



# Status report on SAE J3134 – Key discussion points

- Automated Driving System (ADS)-equipped vehicles are becoming a reality in the market.
- Studies suggest that road users prefer ADS-equipped vehicles to have additional signals to indicate when the vehicle's ADS is engaged and to indicate the vehicle's intended movement.
- Additional lamps are a means of identifying ADS-equipped vehicles and communicating the ADS-equipped vehicle's movement or intended movement.
- There are many lighting concepts and proposals for ADS-equipped vehicles within the US and internationally.
- There is no standard today.
- It is important to create and establish a standard for ADS lamps that are harmonized and recognized internationally to avoid confusion and complexity.



# Status report on SAE J3134 – Key discussion points

Use of pictorials,  
symbols, text, or  
lights

lights

Is a  
Recommended  
Practice  
needed?

yes

ADS Lamp

- Pictorials, symbols, text and other forms of communication are not addressed in this document as they were deemed to fall outside the scope of the Task force members' expertise.
- Pictorials, symbols, text difficult to globally harmonize. Communicating effectively with limited assumptions on common language, or symbology, is very challenging. There are thousands of languages throughout the world, and many countries have more than one official language, which makes it nearly impossible to ensure text-based signals can effectively communicate with the greatest number of people.

- This document is not intended to preclude the use of such types of communication, however, it is strongly encouraged for manufacturers to consider certain aspects of J3134 when using illuminated pictorials, symbols, and text including color, photometry, installation location, and visibility.

# Status report on SAE J3134 – Key discussion points

## Ford and Virginia Tech study



[https://media.ford.com/content/dam/fordmedia/pdf/Ford\\_AV\\_LLC\\_FINAL\\_HR\\_2.pdf](https://media.ford.com/content/dam/fordmedia/pdf/Ford_AV_LLC_FINAL_HR_2.pdf)

“In the end, the researchers decided **lighting signals are the most effective** means for creating a visual communications protocol for self-driving vehicles. As light signals for turning and braking indication are already standardized and widely understood, they determined the use of lighting signals is **best to communicate** whether the vehicle is in automated drive mode, beginning to yield, or about to accelerate from a stop.”

## “CityMobil2” – EU



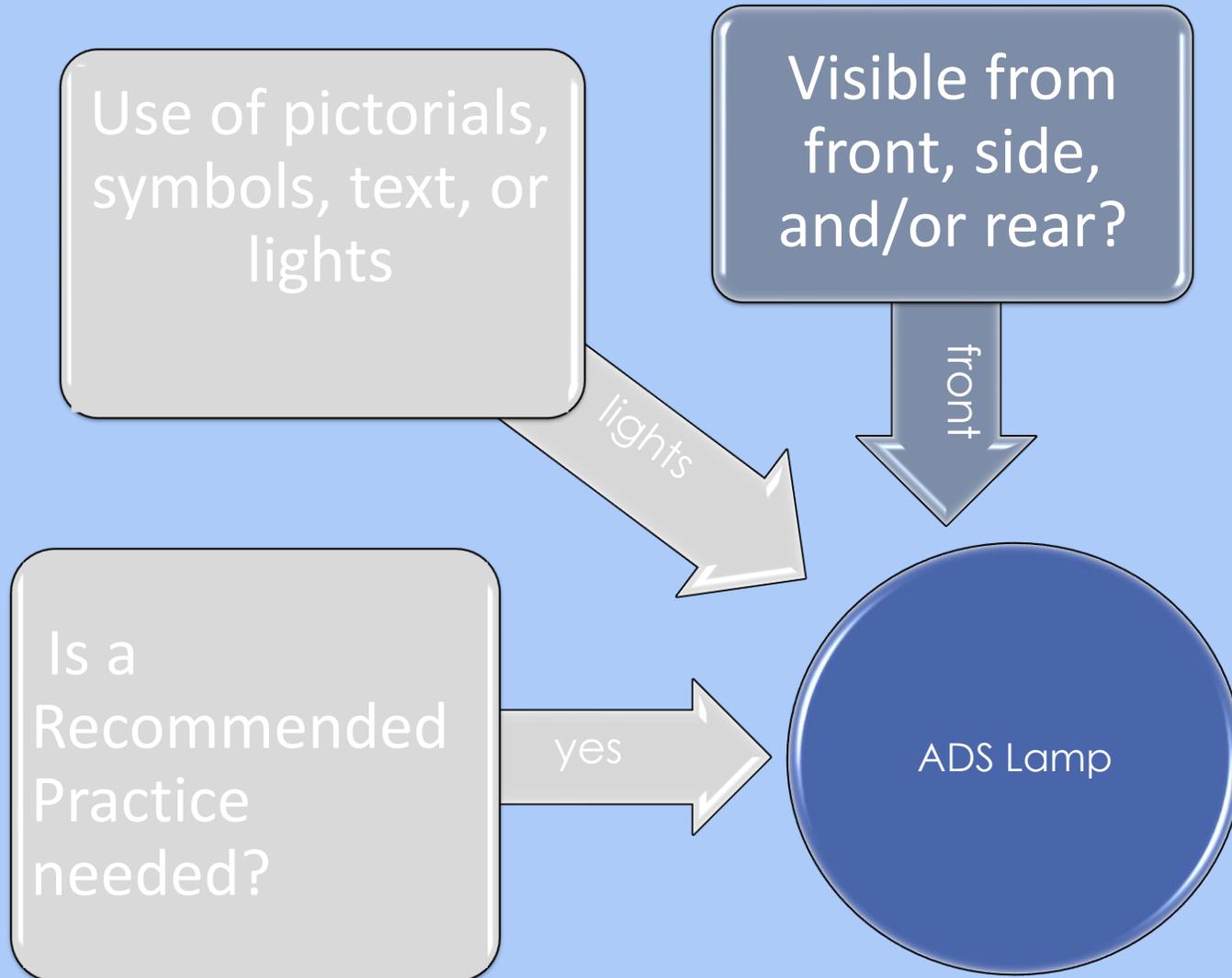
- ➔ Visual (Lights)
- ➔ Visual (words)
- ➔ Auditory (tones/signals)
- ➔ Auditory (words)

La Rochelle, France – **Lights** for turning, sounds for moving and detection

Lausanne, Switzerland – **Lights** for all manouvres

Trikala, Greece – **Lights** for turning and stopping, sound for detection

# Status report on SAE J3134 – Key discussion points



- ADS lamps in this recommended practice are intended to be visible from the front of the vehicle.
- These ADS lamps provide information to the road user, in the absence of a driver, as to the vehicles' ADS status and intent, and may provide comfort and ease of acceptance as ADS-equipped vehicles are introduced into the market.
- ADS lights to the side and rear are not covered in this document, because the intent of these lamps is to make road users feel comfortable in the absence of a conventional driver as seen from the front of the vehicle, but they are not prohibited.

# Status report on SAE J3134 – Key discussion points

- Early in the development of this document, the task force considered the following ADS messages: 1) ADS status (on or off), 2) yielding, 3) ready to go.
- These messages were matched with the following light signals from simplest to more complex: 1) steady, 2) flash or sweeping, 3) flash or sweeping.
- As the document progressed, the task force recognized that further research and studies are needed to evaluate the use and effectiveness of flashing and sweeping light signals to communicate the ADS yield and ready to go messages.
- As a result, this document currently only focuses on a marker light to indicate the ADS status.

What messages?  
and  
What signals to  
communicate  
messages?

ADS "on"  
...for now

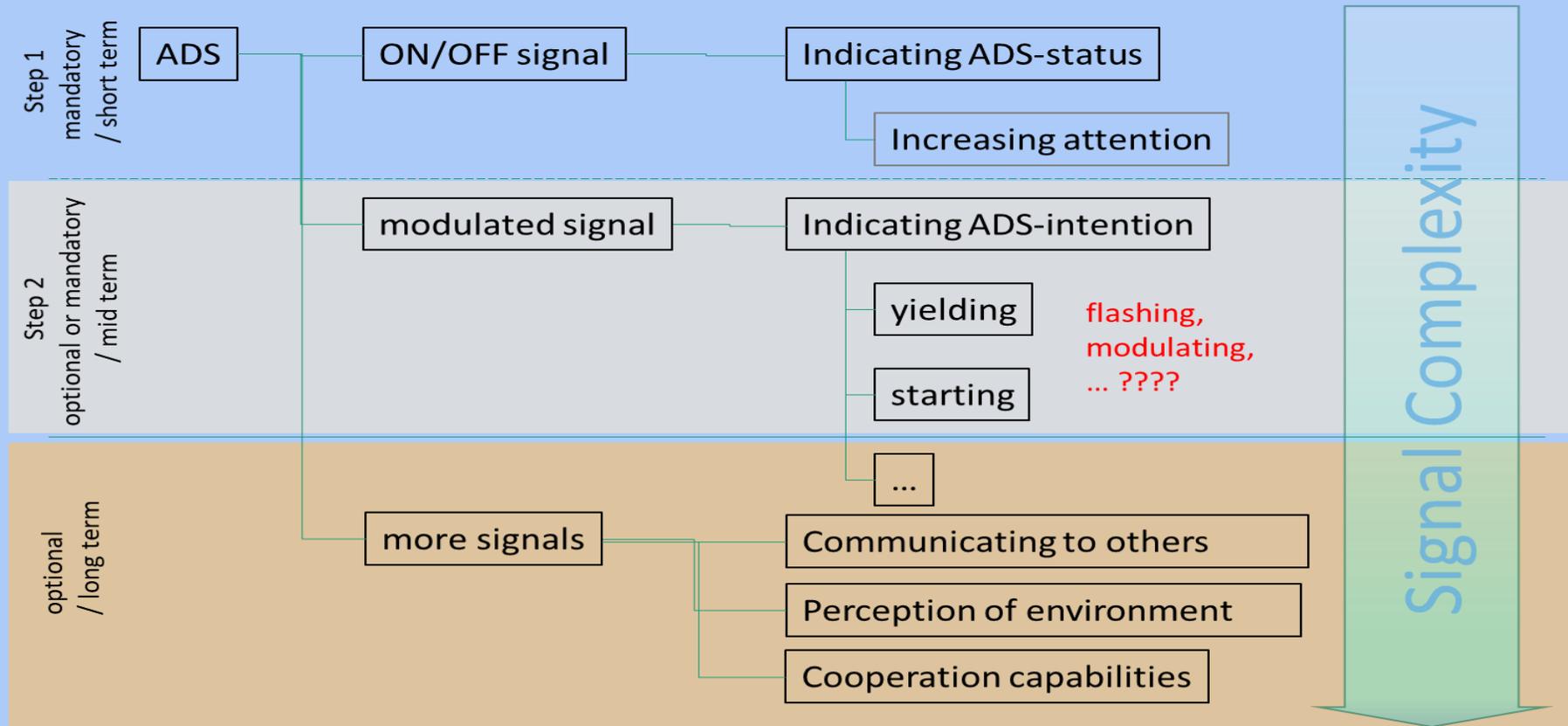


Message Priority	Message	Light Signal
1	ADS engaged	Steady Light
<del>2</del>	<del>ADS yielding</del>	<del>Slow Flash</del>
<del>3</del>	<del>ADS about to move...transition from yielding to not yielding</del>	<del>Fast Flash</del>

# Status report on SAE J3134 – GTB Approach

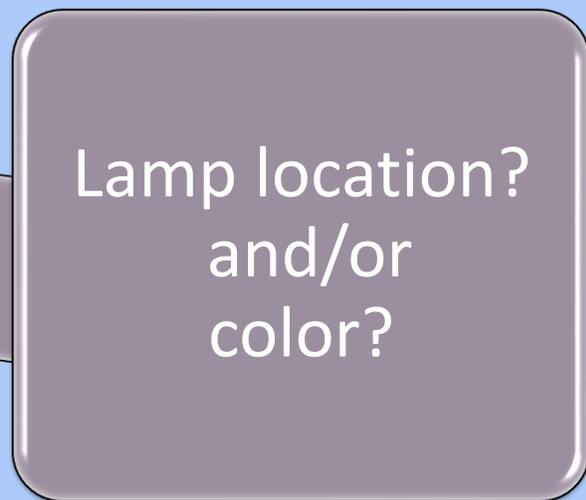
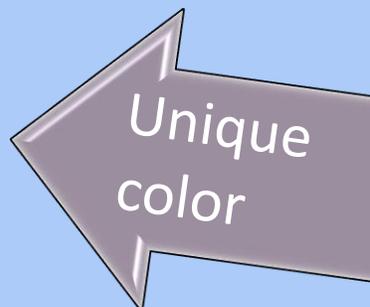
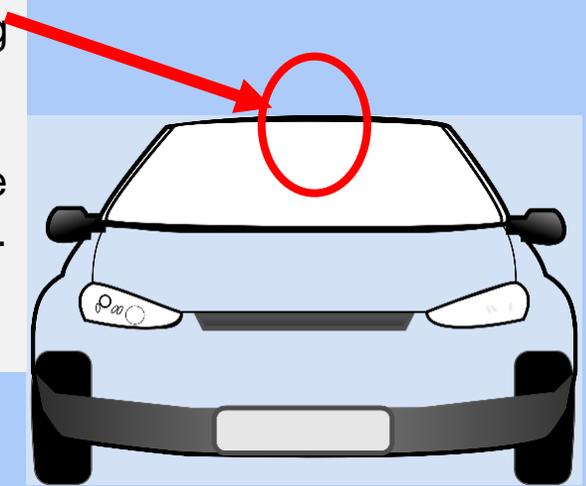
Updated since April 2018

## What kind of communication is needed for ADS? Single vs. multi-step communication



# Status report on SAE J3134 – Key discussion points

- Early in the development of this document, the task force considered using an existing approved lamp color, e.g. white, and yellow and limiting the ADS lamp to a unique location, e.g. around the top and center of the windshield, to differentiate the ADS lamp from existing required lamps.
- As the document progressed, the task force determined that the limiting the mounting of the ADS lamp to a unique location posed significant design constraints and installation issues. The task force decided to not limit the installation location of the ADS lamp.
- This then created a concern of using existing colors for the ADS lamp...depending on the location, the use of these regulatory-prescribed colors for ADS lamps could be confused with existing required lamps.



- A unique color would be needed for the ADS lamps.

# Status report on SAE J3134

So after...



Hundreds  
of  
doughnuts,  
bagels



1000+  
man and woman  
hours

## SURFACE VEHICLE RECOMMENDED PRACTICE

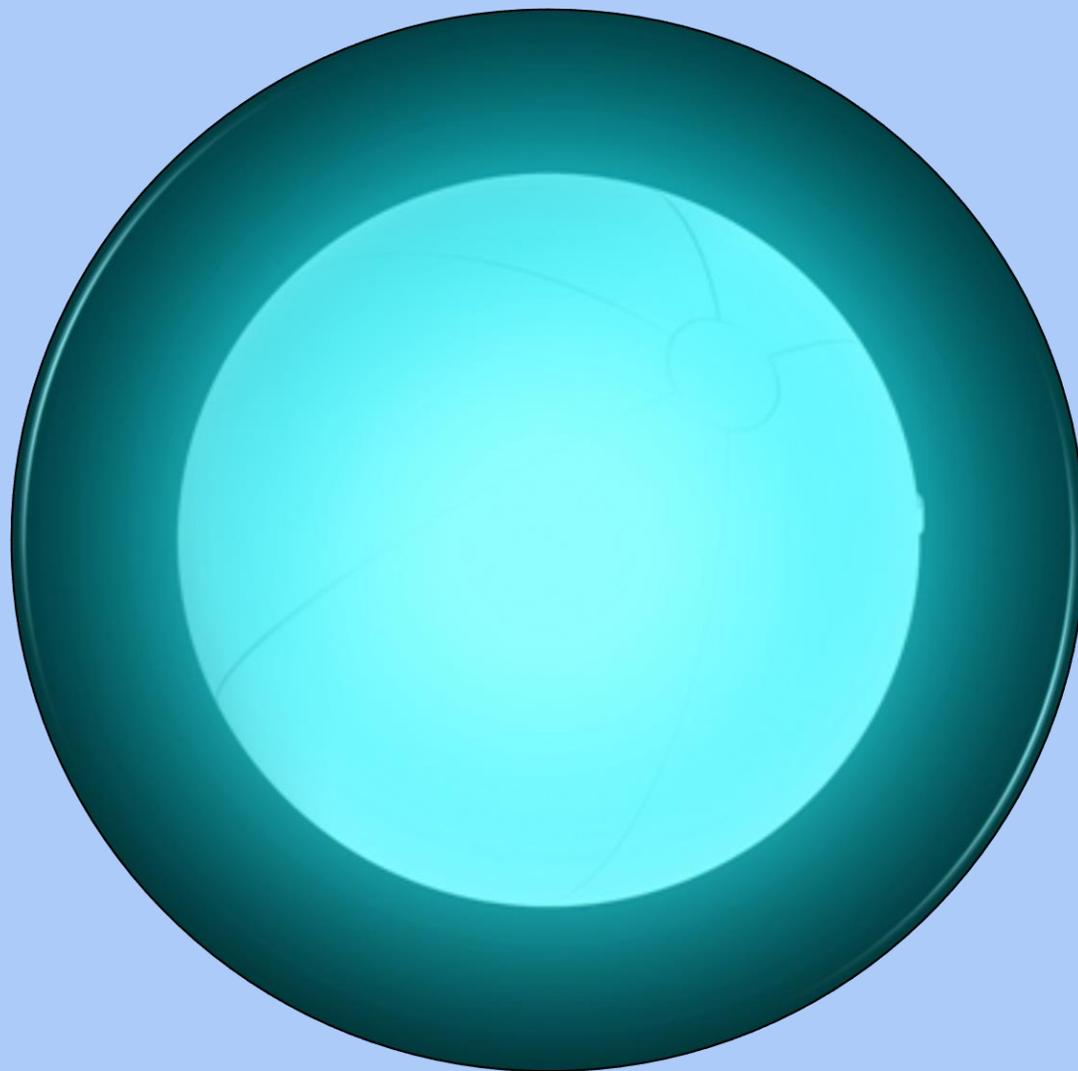
J3134™

Issued	20xx-xx
Revised	Proposed Draft
	Superseding – N.A.

Automated Driving System (ADS) Marker Lamps

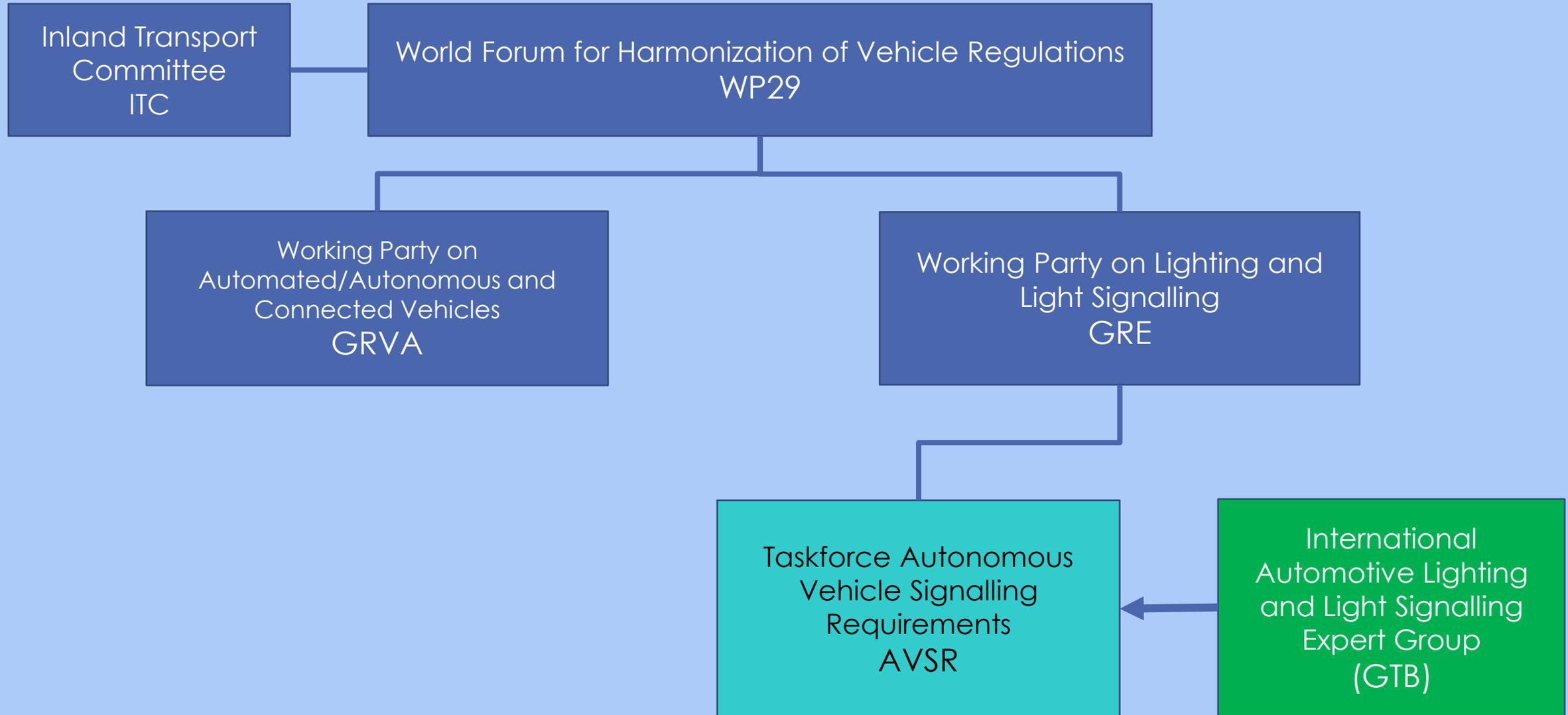
30+  
revisions

# Status report on SAE J3134



## Status of The Working Party on Lighting and Light Signalling (GRE) Autonomous Vehicle Signalling Requirements (AVSR) Taskforce

# Status report on the GRE AVSR Taskforce

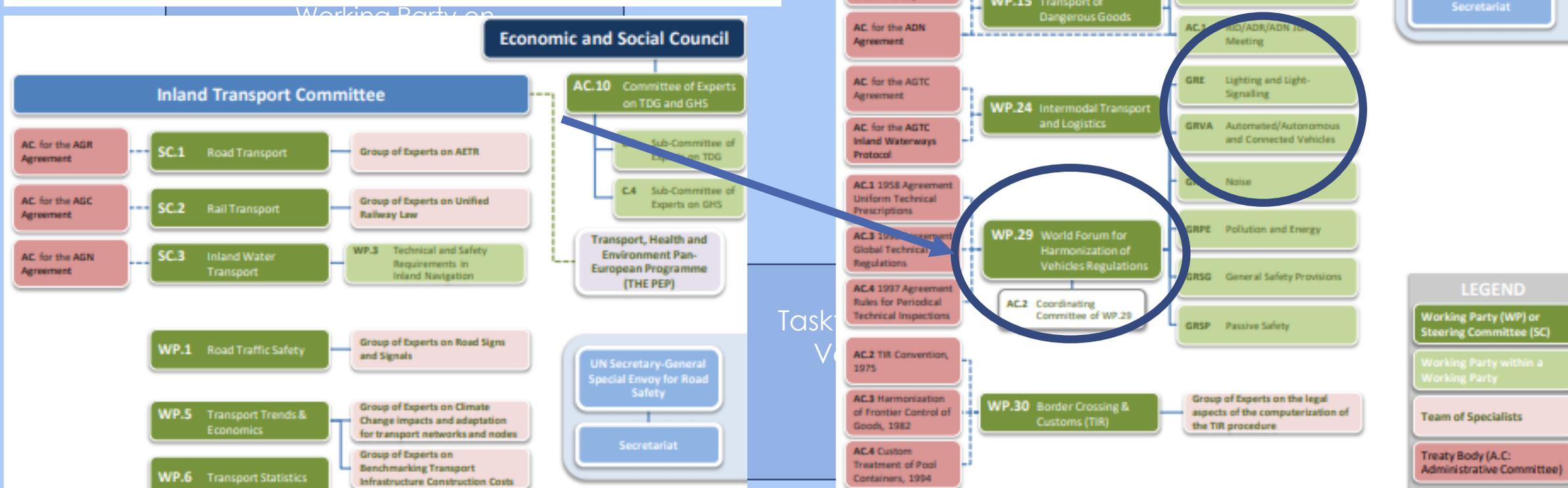


# Status report on the GRE AVSR Taskforce

Inland Transport Committee  
ITC

World Forum for Harmonization of Vehicle Regulations  
WP29

The Inland Transport Committee (ITC) is the highest policy-making body of the UNECE in the field of transport.

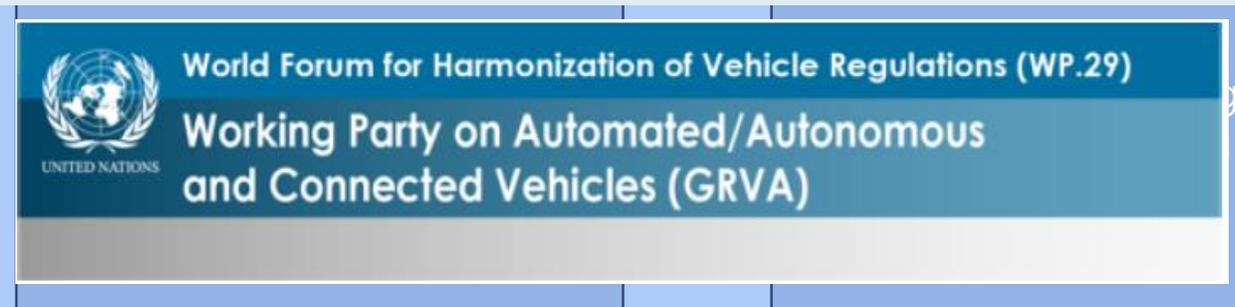


# Status report on the GRE AVSR Taskforce



**At the February 2018 session**, the Inland Transport Committee (ITC) acknowledged the importance of WP.29 activities related to automated, autonomous and connected vehicles and requested WP.29 to consider establishing a dedicated subsidiary Working Party (Groupe de Rapporteurs - GR).

Following this request, **WP.29, at its June 2018 session**, decided to convert the Working Party on Brakes and Running Gear (GRRF) into a **new Working Party on Automated/Autonomous and Connected Vehicles (GRVA)**.



# Status report on the GRE AVSR Taskforce

## **GTB**

### **The International Automotive Lighting and Light Signalling Expert Group Groupe de Travail "Bruxelles 1952"**

*Since 1952 the GTB has been recognized as the global group of vehicle manufacturers, system suppliers, light source manufacturers, testing laboratories and academia working to assure regulation and safety of automotive lighting systems and their installation.*

*GTB membership includes 19 delegations from countries including Europe, North America and Asia. Representation in national delegations comes from industry, approval testing laboratories, regulatory agencies and academia.*

## Venue & Date of the forum

**Mercure Hotel Den Haag Centraal**  
Spui 180  
2511 BW DEN HAAG (The Netherlands)

**Tuesday, February 27, 2018**

Tuesday	27 Feb 2018	09:00 – 12:00	Forum on ADS Lighting
		13:00 – 17:30	WG SL (Focus group on ADS Lighting and Vehicle Communication)

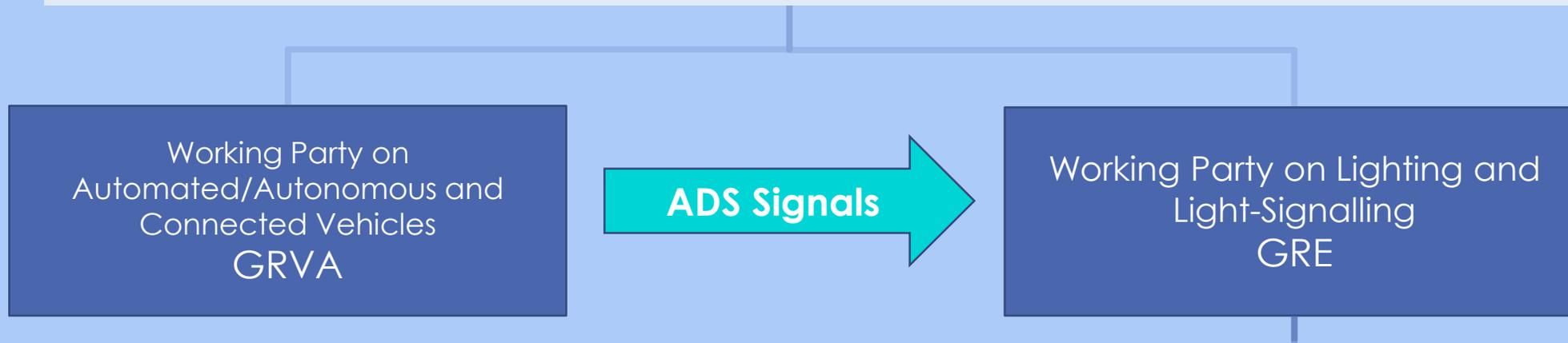
Taskforce Autonomous  
Vehicle Signalling  
Requirements  
AVSR

International  
Automotive Lighting  
and Light Signalling  
Expert Group  
GTB



# Status report on the GRE AVSR Taskforce

...at the 1st session of the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) in September 2018...GTB introduced informal document GRVA-01-06 (Considerations Concerning Lighting and Light-Signalling) and proposed that the topic should be added to the list of priorities...



- The topic of signals, to indicate the status and intended actions of AV's, is **outside of the scope of GRVA...**
- If research findings identify that signals (visual, audible, or a combination) are required,
  - GRVA will have the responsibility to define the characteristics of the control signal.**

The concern remains that the opportunity to create a global solution will be lost as national and standardisation groups reach their own conclusions. **Consequently, it may be appropriate for GRE to consider taking charge of this subject** by establishing (or supporting) an activity to encourage the various stakeholders to cooperate, with a view to identifying a common approach.

# Status report on the GRE AVSR Taskforce

Report of the Working Party on Lighting and Light Signalling (GRE) on its eightieth session - ECE/TRANS/WP.29/GRE/80

XI. Direction of future work of GRE (agenda item 10)  
 Documentation: Informal document GRE-80-16-Rev.1

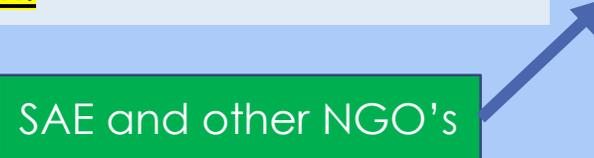
40. ...GRE discussed at length how to pursue considering the signalling requirements for AVs, and **came to a conclusion that a task force (TF) would be most appropriate for this purpose.** The expert from Germany, who was leading TF SR, also agreed to take the lead in the new TF. The experts from UK, GTB and OICA expressed their support to TF. GRE agreed that **TF should evaluate and report on the safety needs for AVs to signal their status and communicate their next intended actions using visual or audible signals or a combination of both.**

SAE and other NGO's

Working Party on Lighting and Light Signalling  
 GRE

Taskforce Autonomous Vehicle Signalling Requirements  
 AVSR

International Automotive Lighting and Light Signalling Expert Group  
 GTB



# Status report on the GRE AVSR Taskforce

## Participation at 2nd AVSR meeting 20 December 2018

Anette SAWONSKI (GTB)  
Antoine PAMART (FR)  
Azra HABIBOVIC (SE)  
Bart TERBURG (GTB)  
Benony GRIGORESCU (GTB)  
Davide PUGLISI (GTB)  
Erik VANDERVREKEN (CLEPA)  
Francois BEDU (OICA)  
Gary KING (SAE)  
Geoff DRAPER (GTB)  
Helmut TIESLER-WITTIG (GTB)  
Jean-Marc PRIGENT (OICA)  
Johannes RESCHKE (OICA)  
Karl MANZ (DE, AVSR CHAIR)  
Keisuke IKEDA (JP)  
Larry SMYTHE (ISO)  
Laurette GUYONVARCH (ISO)

Lukas SCHWENKSCHUSTER (GTB, AVSR SECRETARY)  
Michael PERNKOPF (GTB)  
Michele DIELI (OICA)  
Michiaki SEKINE (JP)  
Oliver BARTELS (DE)  
Paul-Henri MATHA (GTB)  
Phil BAILEY (UK)  
Philipp PLATHNER (IEC)  
Rainer KRAUTSCHEID (DE)  
Rolf KOPPERMANN (OICA)  
Romeo SAMOY (SAE)  
Sarah CHAUDEURGE (FR)  
Takahiro KOYAMA (JASIC)  
Thomas BAUCKHAGE (CLEPA)  
Thomas GOLDBACH (OICA)  
Toshimichi ANZAI (JASIC)

Apologies received from:

- Mrs. Hannelore WILDE (OICA)
- Mrs. Joanne HARBLUK (ISO)
- Mr. John SHUTKO (ISO)

# Status report on the GRE AVSR Taskforce

## Notes from 2<sup>nd</sup> AVSR session (WebEx) on December 20<sup>th</sup> 2018

Creating a list of studies and documents on ADS equipped vehicle communication...this is not complete list..currently about 40 which will be available by the end of January

Short title	Full title	Origin
AVIP	Autonomous vehicles´ interaction with pedestrians	Chalmers University of Technology, SE
CityMobil2	What do Vulnerable Road Users think about ARTS?	ITS, University of Leeds / DLR, German Aerospace, UK / DE
Duke Display	Evaluation of Vehicle-to-Pedestrian Communication Displays for Autonomous Vehicles	Duke University, US
Ghost Driver	A Field Study Investigating the Interaction between Pedestrians and Driverless Vehicles	Stanford Center for Design Research, US
interACT	Deliverable 1.1 Definition of interACT use cases and scenarios	DLR, German Aerospace, DE
SWOV	Safe interaction between cyclists, pedestrians and automated vehicles	SWOV Institute for Road Safety Research, NL
InMotion-Summary	Light-based communication between automated vehicles and other road users (Summary)	Chemnitz University of Technology, DE
Daimler-eHMI	eHMI of Autonomous Vehicles Should autonomous vehicles communicate with pedestrians, and if so, how?	Daimler AG, DE
ISO	AV Exterior Communications ISO TC 22/SC 39	ISO
GTB	Lighting for automated vehicles – Discussion on ways forward	GTB-Forum, Pernkopf / Tiesler-Wittig
Ford	VR light bar results	Ford, US
Audi-VDI	VDI-Paper_Reschke_et_al_(German_only)	Audi AG, DE
Audi-SAE	Ideas for Next Lighting Generations in Digitalization and Autonomous Driving	Audi AG, DE
Audi	Assistance System for Vehicle-Pedestrian-Interaction	Audi AG, DE
InMotion	Light-based communication between automated vehicles and other road users	Chemnitz University of Technology, DE
PIRE	Communication and Interaction between Automated Vehicles and other Road Users	Munich University of Technology, DE
SAE	Abstract of J3134	SAE, US
BASt_d	Statement BASt - Evaluation of state of knowledge regarding eHMI for AV (German only)	Federal Highway Research Institute, DE
BASt_e	Statement BASt - Evaluation of state of knowledge regarding eHMI for AV (English translation)	Federal Highway Research Institute, DE

## Notes from 2<sup>nd</sup> AVSR session (WebEx) on December 20<sup>th</sup>

### Answer questions

- Does the research shows a need for an operational state HMI (AV signal)
- Does the research shows a need for a HMI of the vehicle intent
- Which level of automation should be addressed, e.g. L3, L4, L5
- Should such signal be visible or audible
- Additional information about best practice

### Next meeting(s)

- 22nd January 2019, Face2Face-meeting Bonn, Germany, Min. of Transport (BMVI), 10:30 – 17:00 CET, Room 0.120, Registration is appreciated (means of WebEx will be provided). How to reach BMVI: <https://www.bmvi.de/EN/The-Ministry/How-To-Reach-Us/how-to-reach-us.html> - goal is to draft the document for GRE
- 18th February 2019, WebEx-meeting, 12:00 – 14:00 CET (6:00 am EST) - to review draft

## Potential Global Technical Regulation (GTR)?

**1998 Agreement on Global Technical Regulations**

### GLOBAL REGISTRY



Created on 18 November 2004, pursuant to Article 6 of the  
AGREEMENT CONCERNING THE ESTABLISHING OF GLOBAL TECHNICAL  
REGULATIONS FOR WHEELED VEHICLES, EQUIPMENT AND PARTS WHICH CAN  
BE FITTED AND/OR BE USED ON WHEELED VEHICLES

(ECE/TRANS/132 and Corr.1)  
Done at Geneva on 25 June 1998

# 2019 DVN US WORKSHOP

*Safer, Smaller, Smarter Lighting Technologies*

Rochester, MI, USA **January 16, 2019**



