

I4AD Business Whitepaper

SCOPE & OBJECTIVE OF THIS DOCUMENT

*TPEG has been successful for delivering information to drivers.
Automated vehicles have different expectation from information.*

The Transport Protocol Experts Group (TPEG) set of protocols for traffic and traveller related information has been created as a protocol to deliver information to drivers to support them in their driving task. The range of message goes from safety-related message, to more supporting information of parking, refuelling, or points of interest.

With the advent of automated driving vehicles, the role of the driver is changing, as is her or his need for information. Also, the focus for information changes to the vehicle itself in a sense that the vehicle will process more and more information with increasing automation levels while the driver will be consuming less traffic related information. As the vehicle will be controlling its own trajectory, it will need more external *Information for Automated Driving (I4AD)* to do this safely. This paper focusses on *traffic-related* aspects of I4AD, but the scope of this is much broader; it aims at supporting the AD vehicle and its passengers in other aspects (e.g. weather) as well.

This paper discusses the impact that automated vehicles have on traffic and traveller information, TPEG in specific, from a **business perspective**. The paper starts with explaining the concepts behind TPEG2, and the impact of automated driving on the vehicle's information need. Finally, some ideas and concepts to address these requirements will be presented in brief. These concepts take into account that AD vehicles will be in a mixed-mode situation with human-drive vehicles.

For an in-depth discussion of technical solutions, the reader is referred to the **I4AD Technical Whitepaper** (TISA19015), which complements this Business Whitepaper.

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1 INTRODUCTION

1.1 Historical development of traffic information services – Context for this whitepaper

TPEG2 MESSAGE TRANSPORT

TPEG's history goes back to the European Broadcasting Union (EBU), which started its development in 1997. Apart from its inception by the EBU, it also is a further development of the “classic” traffic information as broadcast on radio channels, prior to today's digital technology.

Notwithstanding this, TPEG2 has grown into something far more capable than radio transmissions; it covers a broader set of application: traffic information, safety messages, parking, weather and more. Furthermore, it is also capable of accurately pinpointing where those events occur.



Originally, TPEG was conceived as a protocol to be transported over digital radio (DAB). This was still the assumption when TPEG2 was originally created. However, the advent and the omnipresence of mobile GSM communications opened up a second very useful method for message delivery, with potential for a back channel. This was not reflected in the basic model for information delivery; a set of messages is collected and sent as one batch to several vehicles. The messages are created with the intent to inform the driver in the best possible way on: what is happening, why, where, and what is the impact of an event.

AUTOMATED DRIVING

Automated Vehicles are able to drive autonomously, without the intervention of a driver for parts or the entirety on a trip. To be able to do this, the vehicle has to process information from all kind of sensors. Typically, it uses cameras, radar, LiDAR, and other sensors to determine where to drive, and how to avoid hitting something, or someone. Furthermore, GPS, maps, and other sensors are used to improve the vehicle's view of the world around it.

Given the limitation of an Automated Driving (AD) system compared to a human driver, some situation are more challenging than others: such as driving through heavy snow, for instance. Human drivers are more adept to react on unusual situation.

It is for this reason that Automated Driving Systems (ADS) have been classified by the SAE [1] into 5 levels of automation, from no automation (level 0) to full automation in all circumstances (level5). Currently production vehicles can support level 3 in some circumstances (motorway).

AUTOMATED DRIVING REQUIREMENTS

From an information point of view, there is a difference between human drivers and automated vehicles. The information currently sent to drivers aims at providing them with an insight in what is happening not just what and where, but also why.

An example of this is the information that a traffic jam is due to a jack-knifed lorry. An AD vehicle does not care about this information as it is not actionable. The AD vehicle only requires knowing what the situation is, and if it is relevant for its trajectory. Next to this, it also uses the information to determine if it is still working within its Operational Design Domain (ODD), or if it might encounter a situation that would require the driver to take over (i.e. leave its ODD).

The Operational Design Domain (ODD) is a concept defined in SAE J3016 pertaining to Automated Driving Systems (ADS).

The operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics.

Only when the vehicle operates within these conditions, its ADS is capable of driving the vehicle. The ODD may put limits on:

- the road and its environment
 - urban, rural, motorways
 - traffic volume(e.g. traffic jam)
 - weather conditions (snow)
 - light and visibility conditions (night, heavy rain, fog)
- the behaviour of the vehicle
 - e.g. speed limitations, complex manoeuvres
- state of the vehicle
 - vehicle load, problems (tire pressure, non-functioning headlights)

When a vehicle is outside its ODD, control has to be handed over to a human driver, or the vehicle will go into its Minimal risk Condition (MRC), e.g. park on the hard shoulder. Note that these restrictions only apply to Level 1-4 vehicles. Level 5 vehicles have an unlimited ODD.

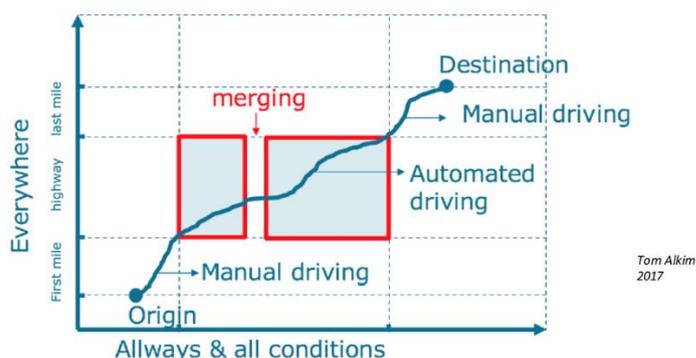


Figure 1: Impact of limitations of an AD vehicle's Operational Design Domain needing manual driving sections

Figure 1 demonstrates how a vehicle moves in and out of its ODD, given the road environment. Within the ODD, the ADS driving the vehicle is mostly interested in events happening within a short radius and within the next minute, as these events have an impact on the driving task: closed roads, vehicles stopped, adverse weather conditions. This information is also required to determine if the vehicle needs to hand over driving back to the passenger behind the wheel (leave the ODD) due to hazardous conditions, e.g. a snow-fall. Lack of such information could lead to a dangerous hand-over with very short notice, or a dangerous driving situation.

As the vehicle is also in charge of routing, it does want to be informed about other events; availability of parking or charging stations for electric vehicles. This information is less critical for a vehicle, as there is no imminent safety risk. Hence, aspects to be considered for Information for Automated Driving are the following:

Global-local: A distinction needs to be made between information that affects the automated vehicle's ODD and the information that effects the route. Also new types of information (i.e. application) relevant for AD systems will be needed. The ODD information is locally oriented, whereas the other information is application oriented: where one can e.g. park or charge a vehicle.

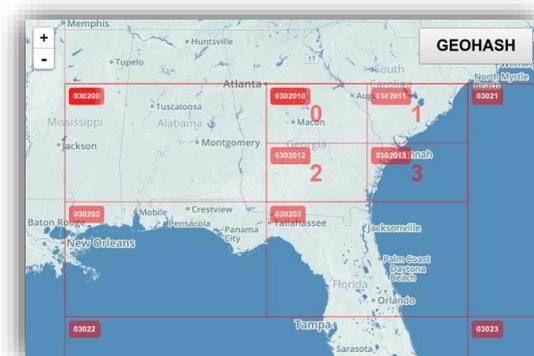
Safety: The information that effects the ODD is more location-centric than application-centric; the AD wants to know all the events it will be affected by, be it weather, traffic jams, or road closures. For safety reasons, the AD vehicle needs all available information instantaneously, not having to parse different data streams for useful information and filter many individual messages for relevant content.

Connectivity: Using the broadcast paradigm (i.e. identical information is sent to all recipients in the broadcast service area) will not be very efficient for AD vehicles. The delivery of message needs to be tailored to each individual vehicle, providing more fine-grained content. Vehicles should be able to get the information that is relevant for their specific driving task, prioritizing safety-related data over information that is targeting driving comfort or fuel efficiency.

TPEG for Automated Driving – Location

Current location referencing methods are limited by the accuracy of current navigation maps. A reference to a location for an AD vehicle needs to be more accurate, as it could potentially be used to avert a collision. It therefore needs to be able to pinpoint an event and needs to be lane-level accurate.

Only this accuracy makes the information relevant for the AD vehicle. Future referencing schemes may need access to accurate maps (possibly linked to technology like NDS (Navigation Data Standard¹) and should be developed.



Location referencing

as a key: AD systems need a method for efficiently subscribing to messages in a certain area. Current referencing schemes require too much computation to handle this subscription, as filtering would be required. A possible solution is to use geohashes as a method for location referencing. Geohashes are simple ASCII strings that link to any place in the world. The length of the string defines its accuracy, hence the size of the addressed area. The figure above right shows an example. A geohash can be used as a registration key for the vehicle to receive relevant information.

1.2 An example traffic situation: Precise Work Zones (PWZ)

Road traffic faces many dynamic changes or abnormalities that are not encoded on a digital map, such as traffic jams, accidents, road works, traffic deviations, adverse weather or road surface conditions, road closures, or objects on the driveway. In this whitepaper, we will use a road works example to illustrate problems, requirements or solutions and to support our reasoning. The main reasons for this choice are that road works often are a convolution of different traffic impairments, such as temporary road signage and

¹ <https://nds-association.org/>

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lane markings, varying speed limits, changes to the road structure (blocked or moved lanes, changes in lane width), congestions before and/or inside the road work zone, changes in road surface, temporary road furniture (cones, barriers) and objects or persons that are not actively participating in the traffic, but still can influence its flow (road construction machinery, workers).

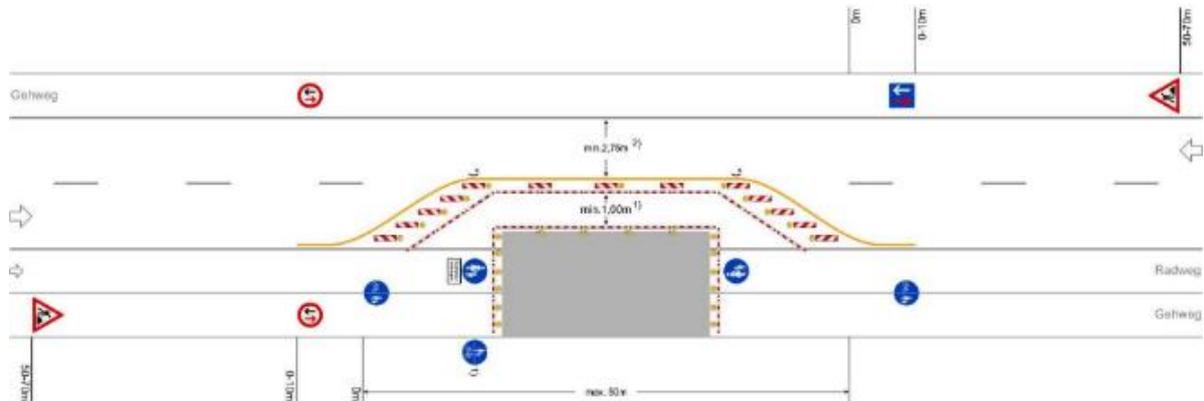


Figure 2: Example for a simple road works zone

Figure 2 shows an example road works zone, where one of the lanes is closed due to construction on the parallel bike and pedestrian paths. Due to these road works, only a single lane is available to traffic, imposing alternating traffic through the road works zone. The road works zone is signposted ahead and priorities for right-of-way are indicated. This figure represents a simple road works example; however, it shows the level of detail for the information that can be made available to describe a road works zone. The example is taken from German guidelines [2, 3] with rules how to properly setup a road works zone according to the traffic laws applicable in Germany. Similar descriptions do of course exist for other countries, for example in the UK [4].

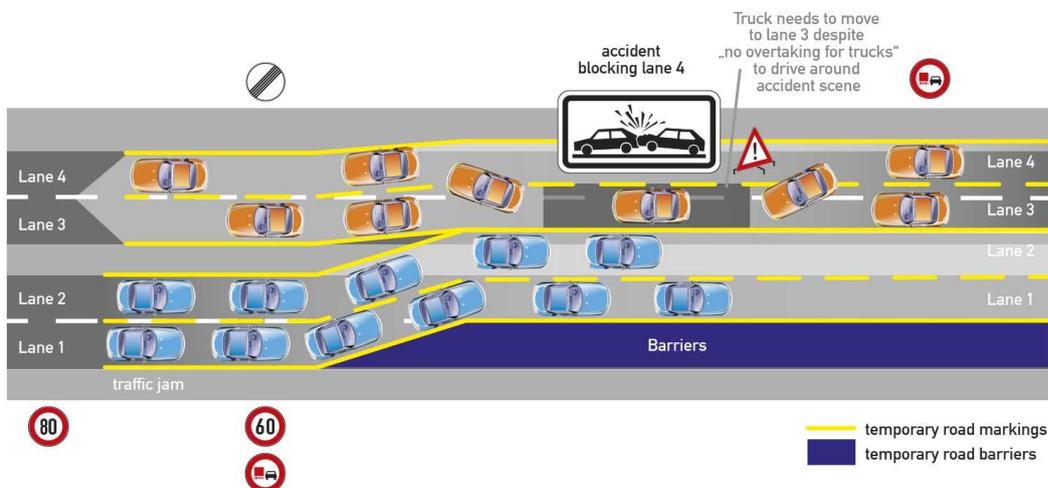


Figure 3: Example for a complex road works zone

Figure 3 shows a more complex road works situation with a stepwise speed limit reduction, temporary road markings and road furniture, lane changes, traffic congestions. An accident scene within the road works zone that poses an additional challenge to traffic, as it partially "breaks" the temporary traffic rules set up for the road works zone.

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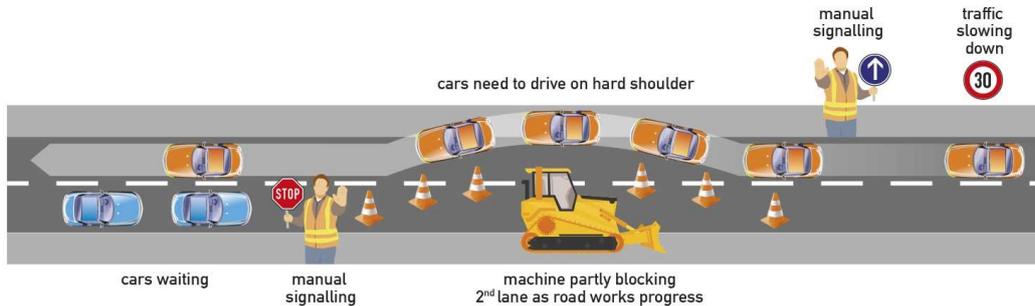


Figure 4: Example for a road works zone with workers and machinery

Figure 4 shows another example, where temporary road construction activities are impairing the traffic and where workers are manually signalling the right-of-way. As we will show later in this whitepaper, this example is particularly challenging for AD vehicles, because the signalling of priorities is difficult to detect and predict. Furthermore, there is no clear separation between the road works zone and the traffic moving around it.

2 MOTIVATION

2.1 Societal Trends

A number of trends, some long term, others short term, have come together recently to accelerate the development of self-driving vehicles. The main trends for this are the following:

- Safety
- Changing attitude to driving
- Compute capabilities

Safety

Improving safety has been a key trend since the foundation of the World Forum for Harmonization of Vehicle Regulations by United Nations in 1958. It has brought us, for instance, safety belts and ABS braking. The main innovation has been the improvement of vehicles' performance. The one area that has seen little development is the driver itself: Driver-related factors (i.e., error, impairment, fatigue, and distraction) were present in almost 90% of crashes². With this in mind, taking the driver out of the equation makes sense.

Millennials & Cars

Young drivers are less interested in owning a car: the requirements for a driving test are becoming more stringent, and thus more expensive. Next to the increased cost of education, for instance, also the cost of ownership of cars has become a problem: as young drivers are more likely to be involved in accidents, their insurance rates are very high. These effects are enhanced by trends as increased traffic, and the higher popularity of smartphones against cars make that millennials have a decreasing interest in driving. This is confirmed by the Michigan Transportation Research Institute: "at the tail end of the teen years, 69 percent of 19-year-olds had licenses in 2014, compared to 87.3 percent in 1983, a 21-percent decrease" [5].

² <https://driving-tests.org/driving-statistics/>

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Compute Capabilities

Only recently the compute and network facilities have become available to perform real-time computing needed to drive vehicles without the assistance of a human driver. It is therefore not surprising that this trend has resulted into non-traditional organisations investing heavily into this area. Waymo/Google and Baidu are examples of companies whose strength is developing and supplying compute facilities.

Others

Next to these trends, the increase in traffic means that driving is less pleasing as it involves spending time in traffic jams. Moreover, the advent of increased distraction (smartphones!) makes automated driving an appealing improvement

2.2 Trends within the domain of road traffic, ITS, mobility and automated driving

In the search for viable, affordable and broadly acceptable solutions to harness the ever-increasing road traffic, actors have different interests, motivations and are pushing for different solutions. This section outlines some fundamental trends that TISA identified within the ITS community.

OEMs

There seems to be a general acceptance among the OEMs that automated driving functions will in one form or the other be part of almost all road vehicles as they increase safety and driving comfort. Many vehicles already include Level 2 [1] driving assistance systems, while some premium OEMs have, or plan to start, enabling Level 3 systems, albeit only in limited situations (e.g. highway pilot or valet parking).

The success of such advanced AD features, especially on Level 4 and 5, is however the acceptance by the drivers. Drivers need to feel confident that the AD subsystems work reliably everywhere³, under any condition⁴ and predictably, i.e. as intended and with plausible reactions to the traffic situation. Otherwise, drivers will not gain trust, use such AD features and ultimately pay for them when purchasing a vehicle.

Road Operators & Public Authorities

Road Operators (ROs) and Public Authorities (PAs) generally welcome the safety benefits, i.e. the potentially reduced number of accidents caused by human error, if AD vehicles indeed fulfil their promise to be more reliable than human drivers. Furthermore, AD vehicles promise to have a smoothing effect on the overall traffic flow, since the AD algorithms will more strictly obey the traffic rules and follow traffic management advices. However, a main concern of ROs and PAs is to keep the AD vehicle traffic under a certain control in order to minimize traffic disruptions due to AD vehicles, e.g. by AD algorithms performing unreasonable/unpredictable manoeuvres, irritating human drivers in their proximity, or an uncooperative behaviour towards traffic advices provided by traffic management centres.

A key concern of RAs is therefore to ensure that AD vehicles reliably recognize and follow any traffic takes restrictions and regulations.

Drivers

If drivers, who are used to be aware and in control of the driving situation, are expected to surrender control to an AD algorithm inside the vehicle, the main concern becomes trust. The vehicle should perform the driving task: getting the passengers safely from A to B, prioritizing driving comfort, fuel economy, or time.

³ In this context, 'everywhere' refers to 'on all roads' as well as to 'in familiar environments' (e.g. routes frequently travelled) and 'in new environments' (routes that are new to the AD vehicle and where no historical data is available).

⁴ Including adverse weather, like heavy rain, fog, snowfall, or in complex traffic situations.

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This should be done reliably (everywhere and under all conditions) and predictably. The latter implies that the vehicle somehow informs the driver/passengers about its driving intentions so that passengers are not wondering what is going to happen next.

Should the vehicle encounter situations that it cannot manage in an automated fashion, the driver expects to be informed in due time, i.e. early enough so that the driver has enough time to observe the surroundings, understand the situation and plan the next driving actions before control is handed over from the AD vehicle. It is not possible to always guarantee timely delivery, so an element of risk will always exist. However, first vehicles encountering an situation can provide necessary details to enable later vehicles to minimize their impact of such unexpected situations.

Other Road Users

In an AD context, there is typically no, or only limited, communication between the driver and other road users by means of eye contact, gestures or clear driving manoeuvres. Hence, other road users expect a predictable behaviour of AD vehicles and a clear communication of its driving intentions, where the latter increases the confidence that AD vehicle behaves benign.

In context with the road works example described in Section 1.2, the safety of road workers is a concern. AD vehicles need to distinguish between 'driving in normal traffic' and 'driving through a road works zone', where in the latter an increased level of vigilance is required, and different rules apply. Building construction machinery and road workers follow different motion patterns than normal road users in normal traffic situations.

The Road Traffic Ecosystem at large

Maintaining mobility of people and goods in the context of increasing urbanization, ageing population and growing environmental constraints is important and AD is currently considered to be part of the solution. The society therefore expects AD vehicles to increase road traffic safety, improve traffic flow (i.e. potentially reduce congestions) and support new mobility needs: sharing economy, working or relaxing while driving, individual mobility for elderly people that are not able to drive by themselves any longer.

These expectations can only be met, if AD vehicles integrate well with these new mobility models and support smooth mixed traffic for the years to come when AD vehicles need to efficiently coexist and cooperate with manual driven cars on the same road.

Hypothesis 1: Efficient communication channels between all actors in the road traffic ecosystem will be a key enabler to facilitate a smooth and effective mixed traffic with AD vehicles and manual driven cars on the same roads.

Hypothesis 2: Real-time traffic information that is specifically tailored to AD algorithms will improve road safety, traffic flow and driving comfort, hence increasing the trust of passengers and other road users in the capabilities of AD vehicles.

This whitepaper addresses from a business perspective a communication channel into AD vehicles that spatially reaches beyond the AD vehicles' sensors and in the time domain provides real-time information beyond the (semi-)static information on digital maps in AD vehicles. For the remainder of this whitepaper, we will refer to this communication channel as TPEG3.

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2.3 Opportunities of using TPEG3

OEMs

The most tangible benefit for dedicated, real-time traffic information for AD vehicles is the opportunity to extend the limited range of the on-board sensors. The extension can be both in the spatial domain (beyond the sensor visibility horizon), as shown in Figure 5. However, it can also extend the sensor vision beyond the operational domain, e.g. when camera vision is obstructed by rain, fog, snowfall or sun glare, or when radar and LiDAR vision is obstructed by obstacles, such as the vehicle in front.

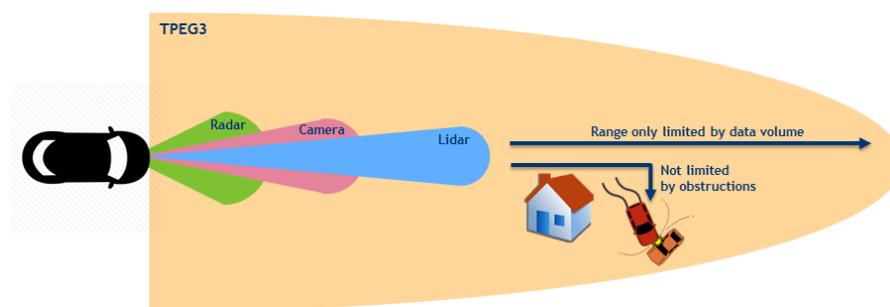


Figure 5: Extending the sensor vision in the spatial domain

Providing traffic information that is specifically tailored to the information needs⁵ of AD algorithms will reduce processing power requirements for analysing the situation ahead, since the information is encoded in a way that can be randomly parsed, quickly decoded and efficiently stored in the vehicle.

Such information will also help to increase the confidence of sensor information if the AD algorithms can validate a traffic situation based on a second, independent source. For example, if on-board sensors detect a stationary vehicle on the hard shoulder, confidence in this conclusion is significantly increased if for the same location a 'vehicle breakdown' message is received beforehand.

The early warning given by real-time traffic information furthermore ensures a timely decision-making of the AD vehicle. For example, if temporary road works is reported with road workers signalling traffic (see Figure 4), then the AD algorithms may not be prepared to handle such situation (i.e. the vehicle is forced to leave its ODD). In such situations, the vehicle can alert the driver of a pending hand-over of the driving task instead of resorting to uncomfortable, but safe manoeuvres (e.g. a rapid slow-down to safe speeds), or ultimately emergency braking, if the temporary road works are difficult to detect.

The combination of extending sensor range + increasing sensor confidence + early warning will potentially expand the 'AD drivable' area by extending the ODD, hence reducing or even closing 'gaps' where otherwise manual driving may be required. OEMs may furthermore use a dedicated TPEG3 information subset to individually and dynamically enable or disable unsupervised AD operation for their vehicles (AD clearance) depending on the traffic situation, historic data or other specific decision criteria.

Road Operators & Public Authorities

Using specifically tailored TPEG3 information, Road Operators or Public Authorities can explicitly grant or deny unsupervised AD operation on their roads even for AD vehicles otherwise operating within their ODD capabilities. This 'AD clearance' could depend on the traffic situation or special circumstances (e.g. rescue

⁵ As mentioned in Section 1.1, much of the traffic information destined to drivers is worthless to AI algorithms and the driving task of an AD vehicle, as it is meant to be 'mentally translated' and interpreted by a human.

vehicles in an area, people on the road, police forces' activities, public warnings and emergency alerts). Distributing information about restrictions, traffic rules, recommendations or other traffic-related regulations reduces the risk that signs are overlooked or misinterpreted by on-board sensors. Increasing the availability and correctness of such information in AD vehicles also increases the probability that the corresponding recommendations are properly followed rules are obeyed.

Road Operators can furthermore influence traffic in a certain manner such as to maximize traffic capacity of the road network and levelling the traffic flow by imposing rules or providing suitable recommendations.

Driver

For drivers and passengers of AD vehicles, specific AD real-time traffic information increases driving comfort by facilitating smooth manoeuvres, since the vehicle early evaluates situations that are beyond the sensor visibility and decide on a suitable approach towards the situation, consequently optimizing driving tactics for circumnavigating a situation in due time. The AD vehicle may announce early, oncoming traffic issues, motivate the planned manoeuvres (e.g. "initiating lane change due to a vehicle breakdown on the right lane in 500m"), thus avoiding 'alarm wakeup' situations in case obstacles are detected late, for example due to obstructed line-of-sight (e.g. "initiating emergency braking due to obstacle detected in the driving lane in 50m"). As a side effect, such information increases the confidence of the driver/passengers in the AD vehicle. An additional benefit, chances are that the ODD of the AD vehicle is increased and driver/passengers can enjoy longer periods of AD driving.

Other road users

The use of TPEG3 for AD vehicles will have positive secondary effects on other road users as well in mixed traffic, because AD vehicles behave benign, communicate their driving intentions and manoeuvres early enough for other road users to acknowledge them. They generally will blend in with the overall traffic also comprising of manually driven vehicles, pedestrians, bicyclists, road workers and others.

2.4 Problems and Needs

The following table outlines some problems and issues that need to be addressed in the context of AD vehicles. It furthermore describes how TPEG3 can provide a solution:

Table 1: TPEG3 addressing AD problems and needs

Problem/issue	Motivation	Solution provided by TPEG3
Limited range of on-board sensors	Provides only a limited look-ahead and therefore time to evaluate the traffic situation. Need to be extended to provide enough time for the on-board AI algorithms to prepare suitable action plans and optimize the driving tactics. In case the AD vehicle has to leave the ODD and handover the driving task to the driver, there need to be enough time to alert and inform the driver.	Real-time traffic information provides early warning of coming traffic incidents, possibly including recommendations on how to negotiate the situation.
Limited capabilities and operation environments AD sensors	AD algorithms process different inputs from various sources: camera, radar and/or LiDAR sensors with different capabilities. This can result in different 'observations of reality' that need to be amalgamated/interpreted by the AD algorithms in the vehicle and which can potentially produce	Information received via TPEG3 services provides an additional, independent source and can therefore increase the probability of correct interpretation/detection and potentially help resolve ambiguities.

Problem/issue	Motivation	Solution provided by TPEG3
	<p>conflicting results and hence ambiguities in the decision-making regarding what action to take.</p> <ul style="list-style-type: none"> Example: A dark spot on the pavement could be a deep pothole (requiring an avoiding manoeuvre or breaking), or a recently patched pothole that can be safely driven over. 	
Conflicting information from different sources	AD algorithms process data from different sources, such as on-board sensors and HD maps, or V2V / I2V communication streams. Information from these different sources may be inconclusive or conflicting.	TPEG3 provides an additional, independent information source. This is particularly helpful if that information stems from a validated/trusted source, such as road operators and public authorities.
Driving comfort	Due to the limited range of on-board sensors, AD vehicles may under certain circumstances be forced to make abrupt manoeuvres. Increased look-ahead will facilitate a smoother driving and avoid motion sickness of passengers.	Real-time traffic information based on TPEG3 provides a comprehensive picture of the coming traffic situation, possibly including recommendations that allow the evaluation of different driving tactics. This allows to optimize the driving path with respect to safety and passenger comfort.
Safe driving	Abrupt driving manoeuvres, such as emergency braking, are a threat to the safe driving of following vehicles.	
AD clearance	Road Operators or OEMs may allow or not allow unsupervised AD operation. If unsupervised AD is not allowed, then the driver must take full responsibility for the DDT.	Using TPEG3, Road Operators or OEMs can signal whether unsupervised AD operation is permitted or not for AD capable vehicles on certain sections of roads.
Alignment with applicable legislation	Dynamically changing traffic regulations (e.g. from VMS or temporary road signage) need to be detected and correctly interpreted by AD sensors and algorithms. Furthermore, certain traffic situations may require to temporarily overrule (relax, alter) the local traffic regulations (e.g. in case of accidents or public emergencies).	Using TPEG3, temporary and locally applicable changes to the traffic regulation can be communicated by road operators or public authorities, reducing the probability of ambiguities and misinterpretation. Furthermore, road operators, public authorities or police can temporarily restrict AD in a given area to enforce a certain traffic regime.

Concerning the conflicting information from different sensors, there are a number of overview publications and ongoing discussions [6, 7, 8, 9 and 10] about which sensor technology combination may be best suited to fulfil AD vehicle requirements from a physical/optical, technical or economic perspective. Optical cameras are typically good at lane detection and traffic sign recognition but suffer from poor night vision and impairments by rain, snow and fog. Radar sensors are good at object and movement detection even in rain/fog/snow or darkness, but do not provide a high spatial resolution and are poor at detecting flat surface textures. LiDAR sensors provide high-resolution data even at night but are impaired by rain/snow/fog and deliver inferior results in lane detection, traffic sign recognition and estimating object motion.

TISA is not in the position to take a stance or provide a recommendation. An important observation however: there is no silver bullet, or a one-size-fits-all solution. Sensor-based perception of AD vehicles will always

be an amalgamation of information from different sources. Real-time traffic information based on TPEG3 cannot resolve that issue either, however it can provide complementary information that can be correlated with the sensor-based data to increase the probability of a correct detection and interpretation. This is particularly true if that information stems from a validated source (e.g. aggregated information from many vehicles that recently passed a given traffic situation) and a trustworthy entity (e.g. a road accident confirmed by the police).

Explaining the problems and needs on the specific example of PWZ

Using different sensors, a vehicle can take actions on different situations on the road, if these situations are within range of the sensors. Receiving information on situations outside the scope of the sensors can provide additional safety and an ease of driving for the passengers. A practical example can elaborate on this.

An example is given where the left lane will disappear, and traffic should merge to the remaining lanes. In addition, the maximum allowed speed is limited in two different steps.



Figure 6: Phases when approaching a work zone

A road works zone can get more complicated by adding multiple components, but it will still result in the same phases. For each of the phases the vehicle will need a different level of information and act differently. Depending on the vehicle brand, processing power or passenger settings, the size and level of detail of the phases can vary, but still can be defined as follows:

MISSION

At start-up of the vehicle, a route will be calculated to reach the desired destination. Information on situations on the route is essential on selecting the route. A longer route but completely in AD mode is perhaps preferred instead of a handover event to a driver through a road works zone.

During the route driving conditions will change due to regulations, traffic situations, as well as the weather. These changes will have an impact on the chosen route. Continual monitoring, i.e. recalculating and re-planning is happening to evaluate whether the chosen route is still the preferred one and whether another better route is desired.

In this phase no granular information is needed on cones, road signs, etc. The focus is more on travel time and whether AD is allowed and feasible on a specific route.

DECISION

Once rerouting is no longer an option, a plan must be created by the vehicle to take the necessary actions. In the example, a deceleration must be performed twice before a defined location and the vehicle should have moved away from the left lane before this lane ends. If regulations state AD is not allowed in the road works zone, the passenger must be alerted at a specific location.

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OPERATION

Once the locations have been reached that were decided in the previous phase, the actions should be performed. A deceleration is regulated at a specific location and heavy breaking should be avoided; thus the smooth deceleration is executed in time.

If the vehicle is driving on the left lane, actions shall be taken to move the vehicle away from this lane before the end of the lane is reached. Additionally, if the vehicle is driving on an inner or right lane it can be expected other vehicles will merge into this lane and caution is necessary.

In both the Decision-phase and Operation-phase, the necessary information must be of a high granularity. The location where the left lane will end does not have much freedom, for obvious reasons.

During and after the road works

This phase can be considered as a normal driving phase, as defined in the Mission-phase. Actions have been executed and the vehicle can continue its path. The planning phase will become active again for the next traffic situation.

The subject 'road works' is of no interest to a vehicle. The vehicle only knows actions that need to be taken such as slow down to 90 km/h. The reason of this deceleration is information that could be mentioned to the passenger to explain why certain actions are taken by the vehicle. This implies the described phases are defined for each of the actions to take, meaning twice for the decelerations and once for the lane merging.

3 BUSINESS ENVIRONMENT

3.1 Market – Where does TISA position itself?

Based on the current market positioning of TISA standards and members' commercial activities, TPEG3 will continue to address the over-the-air into the vehicle part of the value chain, i.e. the traditional TPEG2 market.

A possible and interesting extension to the above positioning is the path from-SP-to-OEM cloud, which is not a B2C environment with one-to-many communication requirements, where scalability and interoperability are critical. However, there is a fundamental benefit of using protocols that are at least similar to the end segment into the vehicle, effectively reducing the required transcoding in the OEM backend.

A second interesting extension is the V2V segment for negotiation and coordination between vehicles (cf. the use case 'Individualized traffic control'⁶ in the Technical Whitepaper). The communication path and encoding strategies for TPEG3 will suit well the communication needs between vehicles, again reducing encoding/transcoding/decoding requirements in client devices (since a TPEG3 decoder will be there anyway).

A third possible extension of the current TISA market is to address the I2V segment of the value chain. It is not an entirely new segment of the value chain to TISA, as core TPEG2 technology is embedded in C-ITS. It has been proven to work properly (at least from a technical viewpoint), providing a "proof-of-concept".

⁶ See also the Inframix project for more information: <https://www.inframix.eu/>

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3.2 *Parallel initiatives*

While addressing the core TISA market in the AD realm with TPEG3, there are parallel initiatives from other, neighbouring markets, which could potentially enter the current TISA domain, providing substitute products and solutions that in the end could hamper TISA from successfully entering the AD ecosystem:

- High Definition (HD) maps with 'live map updates' will be developed into a direction to provide near-real-time updates for information that is related to the HD maps
- Distribution of *cooperative ITS* information over mobile networks
- Monolithic (single stack) approaches, where a single organization develop the entire protocol stack in-house
- Road-side equipment manufacturers could enter the market of traffic service provisioning
- DATEX II could be extended and optimized towards being processed in an ECU
- Mobile Network Operators (MNOs) could combine statistical data from mobile phone motion patterns with 4G/5G connectivity for providing traffic-related services to AD vehicles

It is therefore advisable to closely monitor the AD eco-system and all parallel initiatives in order to coordinate work, exploit synergies, avoid redundant work and hence maintain the unique TISA value proposition.

3.3 *Opportunities*

For TISA members, the development of TPEG3 technology provides an opportunity to complement their own ongoing AD activities with the following objectives:

- Increase the reliability and safety of AD vehicles by increasing the 'preparedness' and decision-making lead times in case of traffic incidents or dynamically changing traffic situations with precise, quantified and qualified information, in particular concerning situations that are beyond the range of AD sensors.
- Considering this increased 'preparedness' and lead times for optimizing the driving tactics and AD manoeuvres in a given situation, TPEG3 offers a real potential to increase the ODD of AD vehicles, effectively enlarging the areas where AD can be engaged, because AD algorithms can handle situations where they currently have to surrender the driving task.
- Increase the acceptance of AD among drivers and other road users.
- Effectively manage traffic that includes AD vehicles in the interest of public safety, traffic flow and for the benefit of all road users.

Besides these technical benefits, there are a number of business benefits that play out in the entire ITS ecosystem:

- Keeping current actors, experienced players and existing value chains and place, thus avoiding the societal impacts of 'new beginners errors' of over-ambitious start-ups or the roll-out of immature products that 'mature with the customer' and may have adverse effects on traffic flow or road safety
- Maintain interoperability (keep relevant stakeholders in the loop) and avoid lock-in ecosystems
- Ensure cross-sector communication/collaboration (avoid dominance of stakeholders/sectors)
- Ensure smooth transition and synchronicity/linkage of "traffic for manual driving" to "traffic for AD"
- Finally, TPEG3 technology ensures that the TISA community stays a relevant actor in the ITS ecosystem and that TISA members stay in business.

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3.4 Problems

Self-driving vehicles are typically called autonomous vehicles. This is rightly so; they only rely on their internal sensors (cameras, radar, LiDAR, Global Navigation Satellite System (GNSS) to drive by themselves. They are mainly trying to “keep the vehicle on the road & don’t make it bump into something else”. However, for a vehicle to be able to drive at SAE Level 4 automation, this is not enough, as research from e.g. the L3 Pilot project has shown. External information is a key requirement to be able to look beyond the horizon of current sensors. Notwithstanding this, the OEMs engaged in automated driving are mainly focused on improving sensor capabilities and software to interpret information from these sensors. This presents an opportunity for TPEG.

Using TPEG2 for this purpose is not advisable. TPEG2 was developed with the driver in mind; its goal is to inform the driver of traffic conditions as well as other travel-related information, which is predominantly relevant to the driver (e.g. parking information). The driver can then take the necessary decisions. A protocol to support AD vehicles needs to target systems that take decisions autonomously and require information with an agreed quality. This is something TPEG2 was not developed for and cannot guarantee.

Another option would be to use C-ITS messages to supply the vehicle with external information. As C-ITS has a higher focus on safety, it addresses some of the problems with TPEG2. However, the C-ITS capabilities are currently limited in what they can express. The message set is quite limited, and due to the technology choices (ASN.1), extension to these is not trivial.

Given these observations, there is an opportunity for TISA and its members to develop an improved TPEG version (aka TPEG3) to specifically support automated vehicles. To be able to do so, a number of issues have to be addressed:

Engagement with Key Stakeholders

It is quintessential to fully understand what is required for TPEG3 engagement with key stakeholders inside and outside TISA, namely:

- OEMs
- Automotive suppliers

As they are the ones building such vehicles, TISA needs to understand what their requirements on connected services are. However, just asking what they want does not likely lead to answers. For a meaningful interaction, TISA must show our capabilities in this area as well.

Demonstrate Capabilities

The best way to engage with automotive suppliers and OEMs is to demonstrate what TPEG can do for automated driving. To do this, initial investment is required. Some investment has already been done by TISA and will deliver first ideas on how TPEG3 will look like. However, the result of this work is, by no means, sufficient to be used within an automated vehicle. Further development will be needed to demonstrate the early TPEG3 ideas in a realistic, real-life setting.

4 STAKEHOLDERS

4.1 Customers

To develop the TPEG3 technology in a way that it becomes a viable technical solution that addresses real customer needs and a successful business for all TISA members and the entire ITS ecosystem, the buy-in

of a number of important stakeholders must be ensured. Further, requirements from all relevant actors need to be collected, and support (both manpower for specification & standardization as well as financial support for implementation & testing) from all TISA members secured.

Table 2: TPEG3 stakeholders and involvement

Stakeholder group	Role	TISA plans to approach ...
Passenger cars	Definition of AD requirements for passenger cars (focus on driving comfort)	<ul style="list-style-type: none"> ▪ Car OEMs in Europe and their R&D subsidiaries or AD joint ventures ▪ Car OEMs in the USA ▪ Car OEMs in Asia ▪ Fleet operators with activities in the field of AD
Trucking business	Definition of specific AD requirements for trucks and fleets (more economic focus)	<ul style="list-style-type: none"> ▪ Truck OEMs ▪ Fleet/logistics operators
Road Operators & Public Authorities	Definition of requirements for traffic management approaches for AD vehicles; approaches for AD clearance and ODD restrictions	<ul style="list-style-type: none"> ▪ Road Operators and Public Authorities within the TISA membership
Tier-1 and Tier-2 Suppliers	Definition of viable solutions for OEM products and standardization support	<ul style="list-style-type: none"> ▪ Departments active in the area of AD within the Tier-1 and Tier-2 AD TISA members
Content and Service Providers	Definition of content, encoding, meta-data and quality management processes	<ul style="list-style-type: none"> ▪ Content and Service Providers among the TISA membership ▪ New types of providers with AD specific content and services
Mobile Network Operators	Definition of network architecture and adaptation layers	<ul style="list-style-type: none"> ▪ MNOs ▪ Mobile network equipment suppliers
Start-ups in the area of AD and AI	<i>The role of the start-up community for TPEG3 related activities and the approach chosen by TISA need to be discussed case-by-case.</i>	

4.2 Key drivers

We expect that TPEG3 will receive the main push from the following stakeholder groups:

Trucking business

The use of AD features promises substantial economic savings for fleet operators by extending the active driving time of trucks using truck platooning⁷ and by reducing fuel costs via optimized driving strategies. Furthermore, human error can be reduced, which is particularly valuable since accidents involving trucks bear the risk of substantially more severe damage and more fatalities compared to accidents involving only passenger vehicles.

⁷ See e.g. the European Truck Platooning Challenge: <http://road-transport-technology.org/Proceedings/HVTT%2014/Aarts%20-%20European%20truck%20platooning%20challenge.pdf>

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The same line of argumentation may apply in a similar way to bus operators, however the acceptance by the bus passengers poses a substantial threshold for the introduction of AD features in busses.

Passenger cars

We see a substantial push from companies like Uber or Didi/Baidu towards AD features to maximize utilization (i.e. active driving hours) of their vehicle fleet and improve driving comfort. AD features also allow new business models, like ordering/summoning a taxi pod or car sharing vehicle that then autonomously drives to pick up the customer – even if the customer wishes to drive manually.

Market/money pull vs. legislation push

TISA anticipates that the main push towards AD technology, and hence also the acceptance of TPEG3, will be economically motivated, e.g. by providing new mobility services (e.g. for elderly people that require economic transportation, but cannot drive themselves) or by significantly improving the economics of fleet vehicles (both passenger cars in taxi fleets or car sharing fleets as well as urban delivery trucks or long-distance trucks). Mobility services and fleets may represent the main business (in terms of revenues) for TPEG3 technology, however they will likely be the 2nd wave of technology adoption, building on proven and mature solutions.

Acknowledging that also a technology advantage over competitors can be a strong motivator for the introduction of a new technology, TISA sees passenger car OEMs as likely being the first wave of technology adoption, where premium OEMs will try to economize on the first-mover advantage. This type of economic push may be propelled by driver convenience and car buyers priding themselves with owning cars with superior features (and being willing to pay for it).

4.3 Concerns

The value of information for automated driving lies in those situations where on-board sensors and on-board maps are either insufficient, or not reliable enough to perform the task of automated driving up to applicable safety standards, as e.g. stipulated by standards such as ISO 26262 [11] towards covering (partial) failures of the Automated Driving Systems or ISO/PAS 21448 [12] toward covering performance limitations or insufficient situational awareness to perform the automated driving task. Examples where external, dynamic, information may augment on board sensors and data are the following:

- Information under what conditions, if at all, authorities permit automated driving on a specific stretch of road (e.g. conditional to weather or other factors)
- Information on upcoming roadworks with precise lane, geometry, and road furniture information and possibly recommended trajectories
- Information on dynamic restrictions (speed limits, overtaking restrictions)
- Information on changing road surface conditions, obstacles, accidents, or other unexpected situations which may impact safety.

As such the Information for Automated Driving may play a role in the safety-critical automated driving task to augment on-board sensor and other data, but also enable the automated vehicle to prepare ahead of time for unusual situations before they come in reach of on-board sensors.

Such information for Automated Driving is only valuable if both the information is technically good enough (in terms of quality and dependability) to supplement on-board automated driving data and if only the external information provisioning can be sustained business wise. The next subsections provide more detail on these two concerns.

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4.3.1 Information concerns

The information content and delivery need to be technically good enough to supplement on-board automated driving data. This means that the information quality and dependability must be sufficient for use in safety-critical situations that automated driving entails.

Information quality is the encompassing term for accuracy, consistency, completeness, timeliness.

- Information accuracy indicates the closeness to the actual value
- Information consistency indicates the repeatability of the accuracy over similar data points, i.e. a minimized degree of random errors
- Information completeness indicates the ability to provide a full description of relevant real-world phenomena
- Information timeliness indicates that the information arrives in time, especially important when the described real-world phenomena are dynamic

Information dependability is the encompassing term for availability, reliability, confidentiality, integrity, authenticity, and accountability.

- Information availability indicates the ability to access needed information in a specified location and in the correct format
- Information reliability indicates the degree to which the information gathering process produces stable and consistent results.
- Information confidentiality indicates the ability to protect the information from unauthorized access
- Information integrity indicates the of maintenance, and the assurance of the accuracy and consistency of data over its entire lifecycle.
- Information accountability indicates the degree of traceability of the creation of the information, both in actions and entities executing those actions
- Information authenticity indicates the degree of assurance that the information is from the source it claims to be from.

Information security is the encompassing term covering confidentiality, integrity, availability, accountability and authenticity.

4.3.2 Business concerns

Automated driving at SAE Level 3 and beyond needs a sustainable information provisioning yielding consistent high quality, dependable information content on a 24/7 basis at affordable cost. Hence, besides the information content being of sufficient quality and dependability also business concerns for the information content and delivery need to be addressed.

The following list presents a number of relevant business concerns:

- Cost of information sourcing and delivery
- Absence of information monopolies and vendor lock-in
- Reliable and sustainable sourcing chain for the needed information content
- Information coverage for relevant markets and geographic areas, preferably global.

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5 TECHNICAL CONCEPT IN BRIEF

5.1 *Brief Summary of Technical Requirements*

The starting point for the work on TPEG3 has been the following high-level requirements.

5.1.1 Information Needs to be Actionable

Human drivers are capable of interpreting TPEG information and take the right action. Moreover, for them it is key to understand the reason behind a traffic event. An AD vehicle is not interested in that information; it wants to know what action to perform; what to do, e.g. reduce speed, or what to avoid, e.g. drive around an obstacle.

5.1.2 Accurate Location Referencing

For an AD vehicle to be able to act on information, the location for that information needs to be accurate, i.e. ideally cm accuracy. This is more than currently is supported. If the information is to be a useful addition to existing visual sensors, it should be able to address location with lane level accuracy – especially when addressing a changed road layout (e.g. smaller lanes, double lane markings)

5.1.3 The Right Information at the Right Time

Information through connected services, like TPEG, can extend the vehicle's horizon from what is visible by radar, LiDAR and camera. To do this the information needs to arrive at the right time. Certainly, if the event is relatively close to the vehicle, it has to be made sure that the information content is correct. This also implies that this information needs to be right for the vehicle to act on.

5.1.4 Trusted Information

As the TPEG3 information can lead to actions that are potentially safety-critical, it has to be made sure that TPEG3 information cannot be tampered with. Also, a measure of quality is important, to denote the level of confidence with which it is to be treated by the AD system,

These are just the main high-level requirements. Further details can be found in the Technical Whitepaper.

5.2 *Brief Summary of the Proposed Concept and Technical Solution*

To address the requirements from the previous section, TPEG3 has adopted the following concepts

5.2.1 TPEG3 will be based on IP technology

The assumption under which TPEG2 was developed was the use of digital broadcast (e.g. DAB) as the medium to transfer information. TPEG3 will use TCP/IP as the only transport mechanism. Broadcast does not offer the required latency, nor can it address the fine-grained information need for specific vehicles. Moreover, IP technology offers mechanisms for secure transmission of data.

5.2.2 TPEG3 will use an efficient standard Communication protocol

TPEG3 will use both a standard encoding method for its information, as well as a standard wire protocol that is more suitable for the task than http. In specific, the protocol will support both request/response as well as a publish/subscribe pattern of communication. As encoding mechanisms protocols like Protocol Buffers, EXI or JSON-like encodings are under consideration. As communication protocols AMQP, MQTT are possible alternatives to HTTP. More details on these can be found in the Technical Paper

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5.2.3 Specific applications will be developed for AD

As stated in the previous section, an AD vehicle requires different information than a human driver. An example of this is the road condition. A human driver is able to handle complex road conditions due to a work zone: narrower lanes with double lane markings. The current state of the art of image recognition is not as competent as the human driver navigating through such a zone. Giving an AD vehicle information up front about this will mean that the vehicle can either handoff control to a human (SAE Level 3, 4), or setup its recognition software to cope with this (SAE Level 5).

5.2.4 TPEG3 is location-first

For an AD vehicle TPEG2 information typically is only needed in a planning phase. While driving it is primarily interested in what is happening around it; it extends the visual horizon of the vehicle. In this respect, location is far more important than application. The vehicle wants to know about possible events that impact its course. Next to this, more accurate location referencing schemes will be developed and adopted.

For further details, please refer to the Technical Whitepaper.

5.3 How Does the Proposed Solution Address the Needs?

The use of IP-based technology (5.2.1) together with standardized protocols (5.2.2) address the requirements to supply trusted information (5.1.4) with low latency (5.1.3). The use of standardized protocols also has the added benefit of easy adoption by the development community, both in industry and in research.

By focusing on location as a primary key (5.2.4), we also address the requirement to send the right information at the right time (5.1.3). Publish/subscribe (5.2.2) will offer the AD vehicle the opportunity to subscribe to information within a certain region (5.1.3).

Specific application for AD vehicles (5.2.3) will address AD specific information needs on e.g. road conditions (5.1.3) that is actionable (5.1.1). Finally, more advanced location referencing (5.1.2) with lane-level accuracy (~ 10cm) will help make it possible to navigate on complicated road geometries (e.g. with multiple lane markings).

6 SUMMARY & BUSINESS CONCLUSIONS

How does the proposed solution address the needs?

By providing an additional information source over a data channel that is optimized to the requirements of AD vehicles, TPEG3 is able to close a technology gap in the AD ecosystem at a critical point where the interest of multiple stakeholders come together:

- OEMs
- Road Operators and Public Authorities
- Content & Service Providers as well as Tier1 and Tier2 suppliers delivering services and hardware/software to the OEMs
- Fleet operators and trucking business, being large customers of OEMs and having to align with specific technical and business requirements and legislation from Road Operators and Public Authorities

This intersection point of technical interfaces and (partly diverging) business interests together with the requirements for cost efficient and economically scalable solution calls for interoperability and standardization. At this point, TISA can deliver a critical contribution to the AD ecosystem.

TPEG3 will combine a scalable hierarchical content encoding scheme with a very efficient and extensible serialization and a hybrid publish-subscribe/request-response over-the-air protocol. Based on that solution, TPEG3 can deliver information that:

- effectively extends the vision of the on-board sensors by providing information with scalable granularity in due time to prepare the AD vehicle for the coming traffic situation
- is tailored to the information needs of AD algorithms while minimizing memory footprint and computing requirements in the vehicle
- will provide an additional information source with rich meta-information about the quality and reliability of the content, potentially coming from a validated/certified source (e.g. road operators or public authorities)
- increases the reliability of detecting and handling dynamically changing traffic, road situations and incidents (i.e. situations that deviate from what is encoded on the HD map)
- may lead to a reduction of the required redundancy inside the vehicle (i.e. reducing the number of required sensors and/or processing power) by providing an additional, validated information source as input for the AD algorithms

7 BUSINESS QUANTIFICATION

7.1 Changing Automotive Market and Increasing Size of the Service Market around it

The market for automated driving vehicles is expected to grow rapidly in the coming years, with the Yole Development Group expecting that by Level 4 and Level 5 may reach the market by 2028 and 2040 respectively [13], as shown in Figure 7 below.

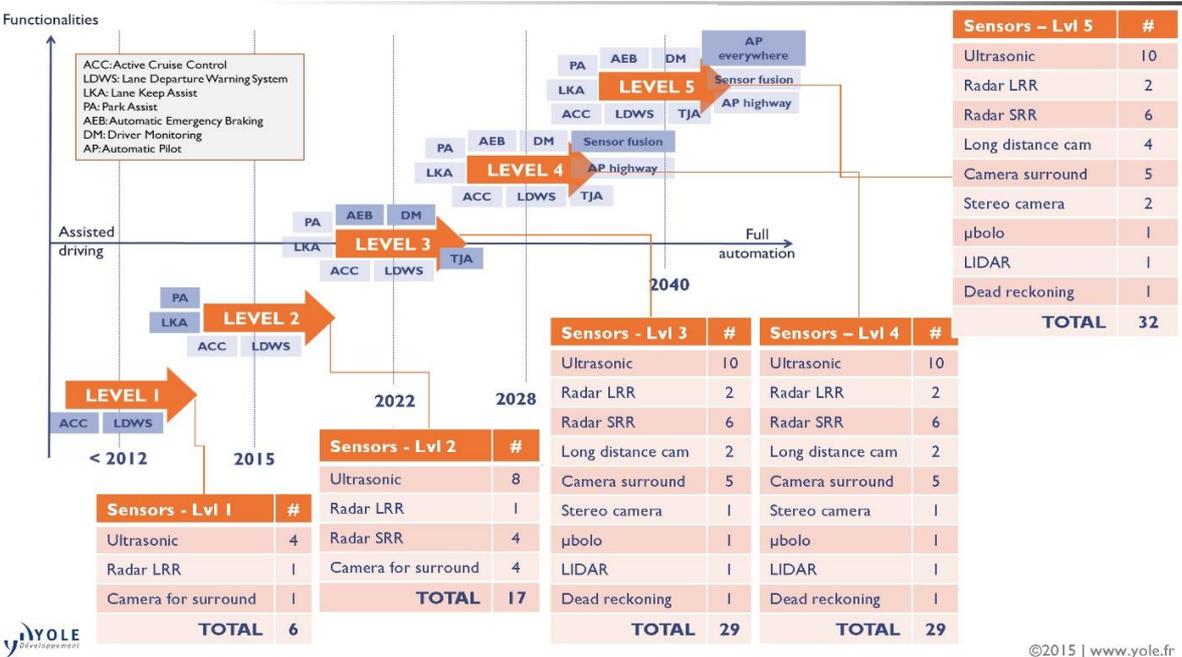


Figure 7: Sensor Technology Roadmap and Autonomous Functions, source: [13]

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The Yole Group furthermore anticipates that more than 10 million L4 cars will be sold by 2030 [14] as shown in the following Figure 8. By 2035, Yole expects that more than 50% of all vehicles sold will have Level 3 capabilities.

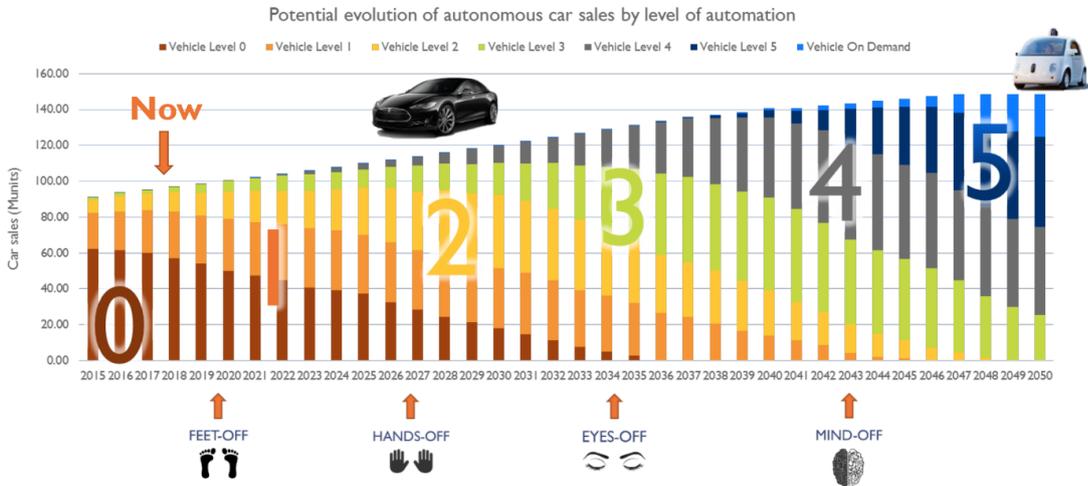


Figure 8: Expected sales for cars with different AD Levels, source: [14]

Apart from the increasing number of AD cars, which require connectivity and external data feeds (cf. Section 5.1, item 5.1.3), the overall automotive revenue pool will increase substantially until 2030 [15]. However, a large share of this increase will be associated with services around cars and mobility, as shown in Figure 9. In this growing connectivity ecosystem, new business opportunities around traffic & traveller information services and hence for TISA members will arise, if TISA lays the technology foundations now.

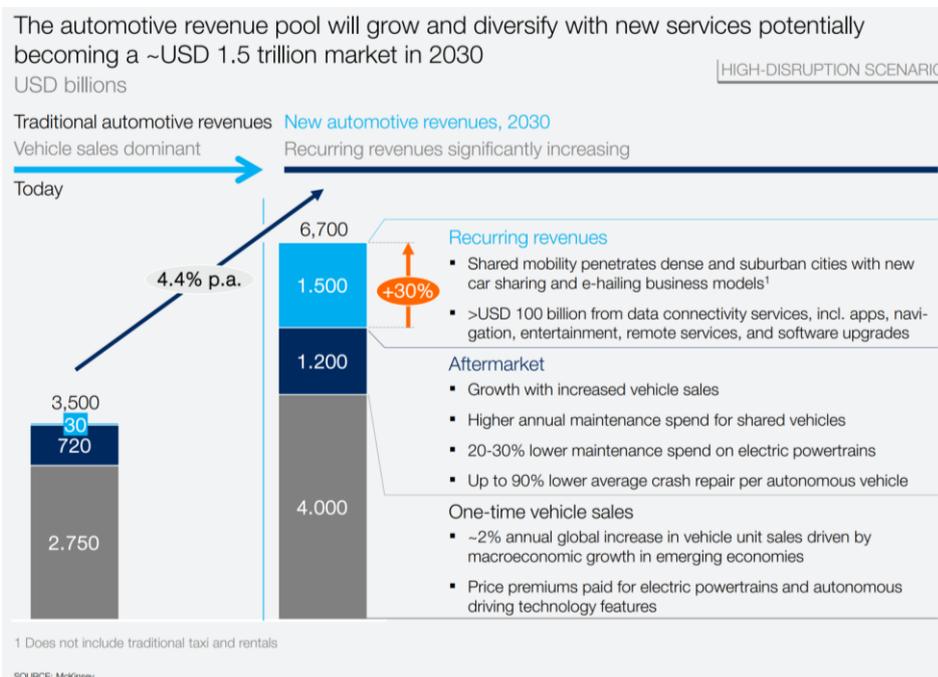


Figure 9: Growing automotive revenue pool, mainly fuelled by services associated with mobility (red highlight by the authors of this paper), source: [15]

7.2 Business opportunities for TISA members

The business environment, collaboration partners and technological interdependencies for automotive OEMs and suppliers will change dramatically during the coming years, as shown in Figure 10. This opens new opportunities for TISA members, requires however to widen the scope of liaison activities and open TISA to new market actors.

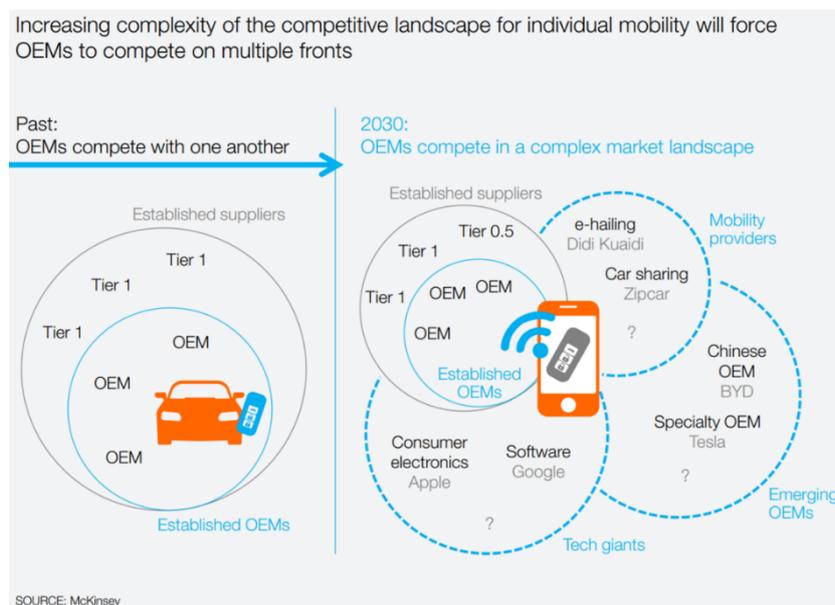


Figure 10: Changing business environment, source: [15]

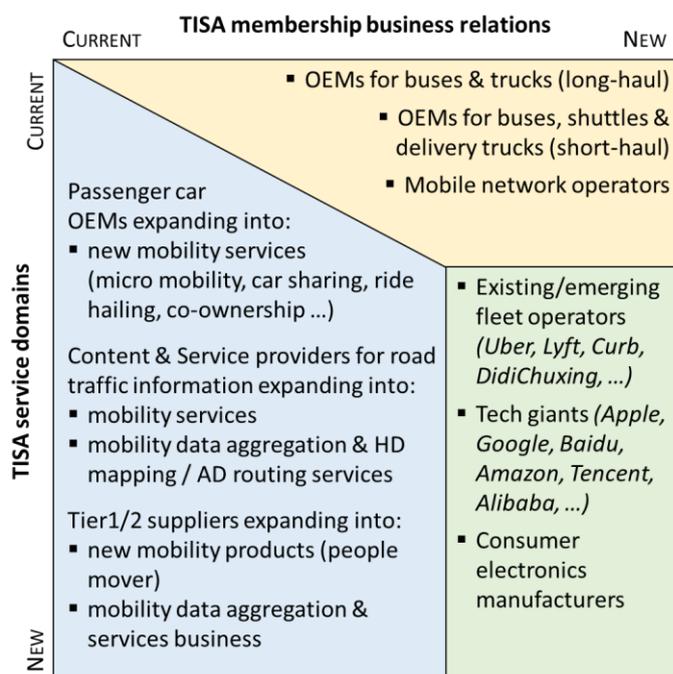
First and foremost, the current TISA membership can from their incumbent market position and based on their domain knowhow secure and expand existing business models into the domain of automation. TISA continues in its role as platform and community to foster business related to traffic and traveller information services as well as for the benefit of the society at large⁸:

- OEMs will continue to benefit from standardization as it enables open/fair markets and avoids vendor lock-in
- Map makers will be able to harness increased efforts due to AD requiring much faster map update cycles by augmenting HD maps with dynamic traffic data services for keeping maps current
- Content & service providers remain in a strong business position, since standardization effectively reduces the threat of vertical market integration in the ecosystem related to AD data & services
- Road authorities – avoid societal costs caused by fatalities caused by AD vehicles □ potential to reduce societal costs of accidents and fatalities

Driving automation will not only happen in the passenger car market, where TISA members currently see the major share of their business. It will also gain traction in the long-haul (trucks, buses) and short-haul (delivery trucks, buses, shuttles) transportation business – here mainly propelled by economic gains for the actors. Together with new services around road traffic-related mobility, a 2-dimensional space of new business opportunities for TISA members pans out as shown in the following Table 4.

⁸ TISA mission – see also <http://tisa.org/about-tisa/>

Table 3: New market opportunities and new business relation opportunities for the TISA membership, fuelled by increasing automation trends



In this table, the yellow segment in the top-right corner represents new business relations in the current TISA services domain and the blue segment in the bottom-left corner represents current TISA members entering into new service domains. The largest opportunity in terms of business volumes lies however in the intersection of new business relations and new service domains, depicted in Table 4 as the green segment in the bottom-right corner.

7.3 Risks

The main risks for the TPEG3 activities can be found in the following list. The list is ordered according to the risk's priority. The priority is calculated as the probability multiplied by the impact.

Table 4: Risks associated with the development of TPEG3

Risk ID	Risk	Probability (%)	Impact (1-5)	Priority (P*I)	Mitigation
1	EC/US legislate use of other technology	25	4	100	Investigate the use of C-ITS technology, and look at possible integration in TPEG3
2	Automotive Suppliers develop proprietary protocols	10	3	30	Try to engage as early as possible with them to show a solution in line with their expectations
3	Tech giants in the software/computer industry open-source their solution	25	4	100	As these parties do not have an automotive focus, and /or seen as a threat to existing partners, TISA should convince that TPEG3 is equally good solution

Risk ID	Risk	Probability (%)	Impact (1-5)	Priority (P*I)	Mitigation
4	Lack of development resources	60	4	120	If within TISA not enough resources can be made available, we should investigate the option to get non-members involved in a controlled manner
5	Lack of interest by OEMs or suppliers	25	5	125	Try to engage as early as possible with them to show a solution in line with their expectations
6	Lack of trust in solution	25	3	75	Trust should be built-in by developing the solution with security concepts included
7	Latency of messages is too high	25	4	100	As TPEG3 relies on underlying communication mechanisms it does not have any control over, it can only focus on an efficient encoding and decoding mechanism, as well as an efficient wire protocol

8 OUTLOOK

TISA is a well-networked, recognized and established player in the ITS ecosystem with an efficient, membership-driven process for producing industry-wide accepted solutions for traffic information. Recent developments in the area of AD suggest that now (2019-2020) is a critical time window to take action to secure that TISA:

- can deliver viable technical solutions for AD use cases that solve real customer problems for OEMs, Suppliers and Road Operators/Public Authorities
- stays a relevant actor, also in the area of AD
- continues to facilitate business and create opportunities for all TISA members in the area of AD

Recent developments furthermore suggest that the AD community will soon have solved the core AD problems (e.g. sensor vision, AI, keep the vehicle on the road, avoid any collisions, make safe manoeuvres) and turn to address issues beyond the current core problems. Considering the financial power of some of the actors, technical solutions that now project on the 'TISA turf' can be produced at a high speed, substituting the existing TISA business model for AD use cases.

The starting position for TISA is favourable, however TISA members now need to embrace change and engage in the development of a TPEG3 solution that addresses the needs of the AD community.

This Business Whitepaper summarized thoughts and conclusions of the past 3 years within the TISA community concerning how to tackle the AD ecosystem. In the Technical Whitepaper, a solution will be proposed that addresses the technological and societal trends and the needs of the AD stakeholders outlined in this Business Whitepaper.

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ANNEX A – ACRONYMS

Acronym	Verbose description	Comments
AD	Automated Driving	Refers to both automated (SAE levels 1 to 4) and fully autonomous (SAE level 5) driving
ADS	Automated Driving Systems	
AMQP	Advanced Message Queuing Protocol	An open standard application layer protocol for message-oriented middleware
ASN.1	Abstract Syntax Notation	Standard for serialization/deserialization of data, standardized by ITU-T
C-ITS	Cooperative ITS	
DAB	Digital Audio Broadcasting	A digital radio broadcasting system
DATEX II		Standard for exchanging traffic information between traffic management centres, maintained by CEN Technical Committee 278, see www.itsstandards.eu
DDT	Dynamic Driving Task	As defined in [1]
EBU	European Broadcasting Union	www.ebu.ch
EXI	Efficient XML Interchange	Binary XML format defined by the W3C
GPS	Global Positioning System	
HD maps	High-definition maps	Digital maps primarily used in context with AD vehicles
ISO	International Standardization Organization	www.iso.org
ITS	Intelligent Transport Systems	
ITU	International Telecommunications Union	www.itu.int
MQTT	Message Queuing Telemetry Transport	Publish-subscribe-based messaging protocol.
NDS	Navigation Data Standard	Standard for HD maps, see https://nds-association.org/
ODD	Operational Design Domain	As defined in [1]

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Acronym	Verbose description	Comments
OEM	Original Equipment Manufacturer	In the context of this document, OEM refers to automobile manufacturers
PWZ	Precise Work Zones	A road work zone that has an impact on the traffic flow and for which detailed information is available, currently work in progress within TISA
PA	Public Authority	
RO	Road Operator	
SAE	Society of Automotive Engineers	www.sae.org
TISA	Traveller Information Services Association	www.tisa.org
TPEG	Transport Protocol Experts Group	A set of standards published by TISA and by ISO for the distribution of traffic and traveller related information
TPEG2	TPEG version 2	A version of the TPEG standard destined to human drivers
TPEG3	TPEG version 3	A version of the TPEG standard destined to AD vehicles – currently under development within TISA
W3C	World Wide Web Consortium	www.w3.org
XML	Extensible Markup Language	Markup language for encoding documents, defined by W3C

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ANNEX B – SAE LEVELS OF DRIVING AUTOMATION

		SAE J3016™ LEVELS OF DRIVING AUTOMATION					
		SAE LEVEL 0	SAE LEVEL 1	SAE LEVEL 2	SAE LEVEL 3	SAE LEVEL 4	SAE LEVEL 5
What does the human in the driver's seat have to do?		You <u>are</u> driving whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You <u>are not</u> driving when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
		You must constantly supervise these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you must drive	These automated driving features will not require you to take over driving	
What do these features do?		These are driver support features			These are automated driving features		
		These features are limited to providing warnings and momentary assistance	These features provide steering OR brake/acceleration support to the driver	These features provide steering AND brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features		<ul style="list-style-type: none"> • automatic emergency braking • blind spot warning • lane departure warning 	<ul style="list-style-type: none"> • lane centering OR • adaptive cruise control 	<ul style="list-style-type: none"> • lane centering AND • adaptive cruise control at the same time 	<ul style="list-style-type: none"> • traffic jam chauffeur 	<ul style="list-style-type: none"> • local driverless taxi • pedals/steering wheel may or may not be installed 	<ul style="list-style-type: none"> • same as level 4, but feature can drive everywhere in all conditions
For a more complete description, please download a free copy of SAE J3016: https://www.sae.org/standards/content/J3016_201806/							

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