IAMTS (International Alliance for Mobility Testing and Standardization)

WHITE PAPER

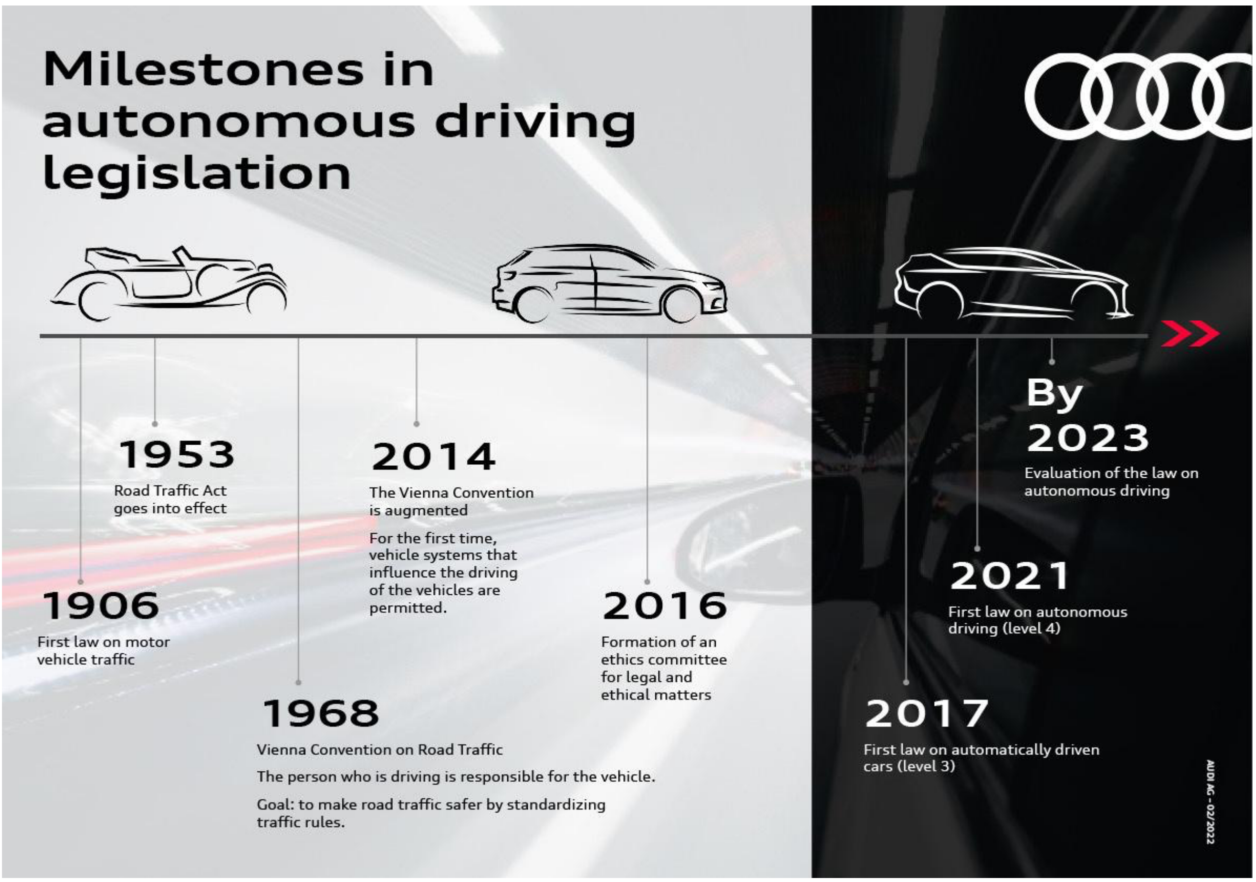
by Prof. Dr. Joachim G. Taiber, Founder and Managing Director International Operations IAMTS

August 2023

Background:

The world of automotive transportation is moving through a systemic change driven both by digitalization and electrification which has both a significant impact on an automotive company's capitalization and business model implementation as well as road infrastructure requirements and urban design architecture. The societal ambition around transportation is to scale decarbonization from the energy source across the supply chain to the end consumer of mobility services to support a sustainable lifestyle and at the same time to free up resources that are locked in unproductive manual operation of vehicles through automation. The old thinking of economic growth by producing more vehicles every year is replaced by a new thinking of consuming mobility as a service which comes along with more intensive utilization of the available vehicle fleet leveraging automated driving and reducing the space needed for car parking. The experience of the COVID pandemic demonstrated the possibilities of digital mobility versus physical mobility. It also emphasized the advantage of having a private protected space when being physically mobile.
Many governments encourage the use of zero-emission vehicles through subsidies and tight emission regulations in order to fight climate change. However, in order for the electric vehicle markets to scale on a global level, market driven principles of supply and demand are important. This is linked to the affordability of zero-emission vehicles to the average consumer and operational cost parity between ICE and EV's alongside practical considerations such as availability of charging infrastructure and avoidance of range anxiety. With respect to vehicle automation, there is no doubt that many automotive OEM's and suppliers came to the conclusion that the available market for ADAS (Advanced Driving Assistance Systems) is easier to reach because of the high technical and regulatory hurdles needed to overcome to scale AV (Autonomous Vehicle) deployment. This means that many

OEM's redimensioned their plans to bring fully automated vehicles to market quickly. They instead emphasized the market introduction of highly automated vehicles. Nevertheless – the need for regulatory guidance to bring highly and fully automated vehicles to market is unchanged – in particular with respect to large scale adoption of automated driving and the standardization of test procedures and test methods that comes along with it. Another aspect that should be considered is the utilization of road-side intelligence in the infrastructure to support the safe and secure operation of automated vehicles which will also require standardization.



Source: AUDI

Vehicle safety is a primary concern in the development and operation of cars. According to the Association for Safe International Road Travel about 1.3 million people are killed per year through road crashes, more than half of those are vulnerable road users – pedestrians, cyclists and motorcyclists. At least an additional 20 million people per year are seriously injured through road accidents

With the development of connected and automated vehicles, many countries adopted a "Vision Zero" strategy, which basically implies that due to technical progress ultimately nobody has to die in a traffic accident.

Although the introduction of autonomous driving has taken longer than originally expected by many industry experts and financial analysts, new vehicle models are continuously being updated with more sophisticated driving assistance systems. First regulatory frameworks for L3 and L4 driving have been introduced (e.g. UNECE R157, law of autonomous driving in Germany) and the EU has taken a lead role globally in making certain ADAS systems functional mandatory (vehicle general safety regulation introduced in 2022).

There is no doubt that in densely populated urban areas the congestion during peak traffic hours lead to massive losses both in personal and business productivity. This is one of the major reasons why people are highly interested in fully automated driving. On the other hand, mass public transportation solutions are limited in their effectiveness and reach during off-peak times as well as at the edges of urban areas outside of the main transportation corridors. Flexible mobility-as-a-service solutions such as ride share services provide an important alternative to public or personal transportation. These solutions, however, are still lacking in fully leveraging automation technologies and so far robotaxi deployments have been limited to pilot implementations. The COVID pandemic has given a massive boost to online shopping using home deliveries which led to an increased demand for delivery fleet vehicles. Although many solutions for automated delivery vehicles systems have been developed at a conceptual and pilot level, de facto deliveries are still human operated. Long distance truck operation is another strong candidate for automation, and although a variety of technical solutions have been developed up to pilot level, nothing has yet been deployed on a full scale.

A major global effort is the replacement of the use of fossil fuels in transportation through the use of renewable energy sources to reduce CO2 emissions (about 25% of the world energy use is related to transportation of freight and passengers[1]). With more than 1 billion[2] existing vehicles registered globally (about 1 billion cars and half a billion trucks and buses), about 80 million[3] new cars manufactured in 2021 and more than 10 million[4] electric vehicles (all electric and hybrid) manufactured in 2022 (with strong year to year growth rates) and considering an average vehicle life expectancy of more than 10 years it is clear that the transition period to decarbonized operation of the whole transportation sector will take decades. There are significant efforts to use renewable energy sources for synthetic fuel production which can help to extend the use of ICE vehicles in an environmentally responsible way.

An important development is the regulation of so-called non-tailpipe emissions, in particular from tires and brakes. The EU addressed this topic in their new EU 7 regulation[5].

[1] The Geography of Transport Systems, 2020 by Routledge

[2] US Department of Energy

[3] ACEA(European Automobile Manufacturer Association)

[4] EV Volumes.Com

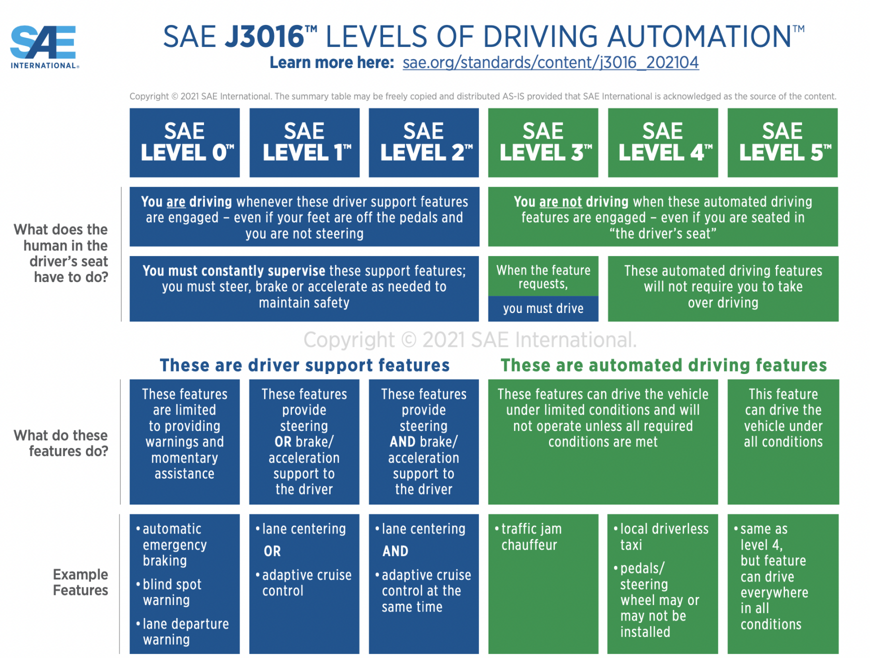
[5] https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6495

The use of cyberphysical testbeds to build a highly and fully automated mobility-as-a-service ecosystem :

It is to be expected that over the next five to ten years we will see a shift in consumer behavior regarding transportation because technology will allow for a service-centric model where the service delivery can be highly and fully automated.

As we continue to shift to a highly and fully automated mobility-as-a-service ecosystem, the existing automotive supplier system will also be impacted from component-centric to service-centric. As a result, established Automotive OEM's will be challenged by new competitors.

Until the development of automated driving became a top priority for many OEM's, the public perception of automotive testing was very much centered on crash safety and vehicle emissions. Testing active safety systems (ADAS) up to SAE Level 2 where the human operator is in control, is in general well understood.



SAE Automation Levels, Source: SAE International

Testing vehicles for SAE Automation Level 3 and higher requires a new approach to how the vehicles are being tested because the primary responsibility to control the vehicle is fully transferred from a human being to a machine. With Level 3, the fall back for driving situations that cannot be handled by the machine operator is the human operator in the vehicle. With Level 4, the human passenger in the vehicle is completely out of the loop but a teleoperator can act as a fall back to the machine operator in the vehicle. With Level 5, the assumption is that the vehicle can operate truly autonomously.

The key challenge is to replicate Operational Design Domains (ODD's) in physical testbeds (whether in closed or open test environments) that fit to the driving capabilities of the Automated Driving System (ADS) to be tested. In order to simulate a specific ODD in a virtual environment, it is important to capture data from the real world environment being simulated such as road or building information but also vulnerable road users (VRU's) in sufficient precision.

As it is impossible to accumulate sufficient physical test miles in an AV vehicle prototype on a real road system to demonstrate that their failure rate is statistically in the magnitude or lower than human fatal failure rate (which equals to 1.46 per 100 million miles[6]), the application of simulation tools in virtual environments for verification and validation of the ADS is crucial.

Very important is the understanding of the behavior of the automated vehicles when exposed to so-called edge cases which requires standardization of test scenarios. Those edge cases may occur rarely on public roads, if at all, and therefore need to be replicated in virtual test environments and in certain cases also in physical test environments.

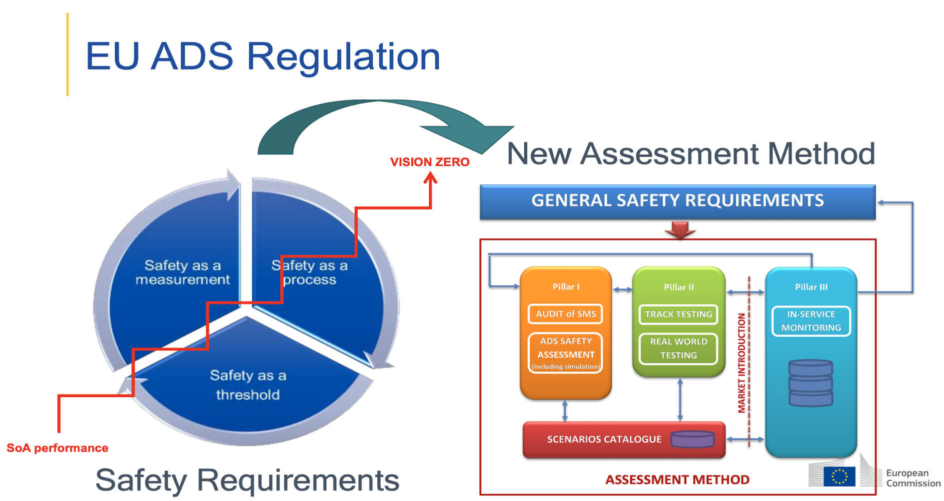
The vision of fully automated driving can only be fulfilled if the vehicle can handle any driving situation without limitations. It is safe to say that such a capability would have to be proven over a very long period of time over a very large road system with a sufficient number of vehicles. At the moment multiple OEM's and key suppliers are operating semi-automated vehicles fleets that collect data through sensors both in test vehicles but also customer-owned vehicles to train AI-based automated driving systems.

For the foreseeable future the realities of traffic will require both automated and non-automated traffic participants to co-exist. This means that behavioral patterns require an advanced level of understanding to ensure the highest level of transportation safety. Due to the percentage of automated traffic participants that will grow over time, the influence of automation on the behavioral patterns in traffic will become significant to a point where it can actually influence traffic flow and fleet energy consumption at large.

A type approval or certificate of conformity (homologation) is granted to a product if it meets a minimum set of regulatory, technical and safety requirements. In many countries a type approval is required before a product can be sold. In major automotive markets such as EU and China type approval for automotive vehicles is mandatory. In other major markets such as the USA, a self-certification process performed by the OEM is sufficient. This means that the OEM validates that the vehicle meets all regulatory requirements. The witnessing by a government authorized third party is not necessary. The self-certification process including proper documentation and evidence is required to demonstrate compliance. The government is authorized to test production vehicles to verify compliance.

[6] National Safety Council – Injury Facts

Both the US and China focused strongly on the development of robotaxi vehicles requiring Level 4 automation. This triggered regulatory efforts to allow testing of robotaxi vehicles on public roads without the need to have a human safety driver being on board. Furthermore, robotaxi vehicles typically have no pedals and steering wheels and vehicle regulations need to be adapted accordingly.
The USA and China are considered two of the largest potential markets for robotaxi operation. Both their approaches to test the technology have been incremental in geography and scale.
In the year 2022, the USA took an important step through the introduction of the final rule by NHTSA to ensure occupant safety for automated driving (Occupant Protection for Vehicles With Automated Driving Systems[7]). This will allow OEM's to mass deploy robotaxi vehicles without seeking a FMVSS (Federal Motor Vehicle Safety Standards) exemption and has no ceiling on the number of vehicles being operated on the roads per year.
In Europe the industry focused less on robotaxi deployment and more on the introduction of L3 driving in highway environments as well as the introduction of L4 parking. Germany, however, was the first country to introduce a comprehensive law for autonomous driving and has influenced EU regulations. It is safe to assume that the EU currently has the global lead in terms of type approval regulation readiness for automated driving systems. Back in 2022, the EU decided to implement the rules for the application of Regulation (EU) 2022/1426 which addresses uniform procedures and technical specifications for the type approval of motor vehicles with regard to their automated driving system (ADS).



Source: European Commission

[7] https://www.nhtsa.gov/press-releases/nhtsa-finalizes-first-occupant-protection-safety-standards-vehicles-without-driving

The UNECE R 157 regulation has been recently adopted to support higher speeds for automated lane keeping systems and to support lane change which is very relevant for highway operation of automated vehicles.

The US is placing a high priority on the development of the NHTSA Framework for Automated Driving System Safety[8]. This framework is still in development and has not yet entered the phase of NPRM (notice of proposed rulemaking).

Because of the strong emphasis of the automotive industry to develop highly automated and fully automated vehicles, a growing number of test facilities have been augmented towards ADS test capabilities and even some dedicated CAV facilities have been developed worldwide. Many of those facilities are designed for shared use among different stakeholders of the smart mobility ecosystem. As mentioned before, it is essential to verify and validate ADS systems in cyber physical testbeds which can be established both in closed as well as in open environments to support urban, rural and highway driving.

What is important to understand is that many Automotive OEM's are still focused on bringing a specific vehicle model with ADS functionality to market. Road operators, on the other hand, should take more of a "systems of systems" approach where vehicles of different makes and types should be "orchestrated" towards efficient, safe and secure traffic flows. Cities also need to take into consideration the efficient and safe management of parking and delivery spaces while leveraging ADS and they need to take measurements to protect VRU's. Therefore testing "coordinated driving" where teleoperation, telemonitoring, automated and connected vehicle driving need to complement each other becomes increasingly important. In this context sharing data between infrastructure service providers (in particular road operators) and infrastructure users (in particular road users) is essential. This requires standardized data formats and validated data to be shared.

Of growing concern both from regulators and OEM's is the upgrade of ADS capabilities of vehicles through their operational service life. The ultimate goal is to support most of these system upgrades through virtual testing via validated simulation tool chains.

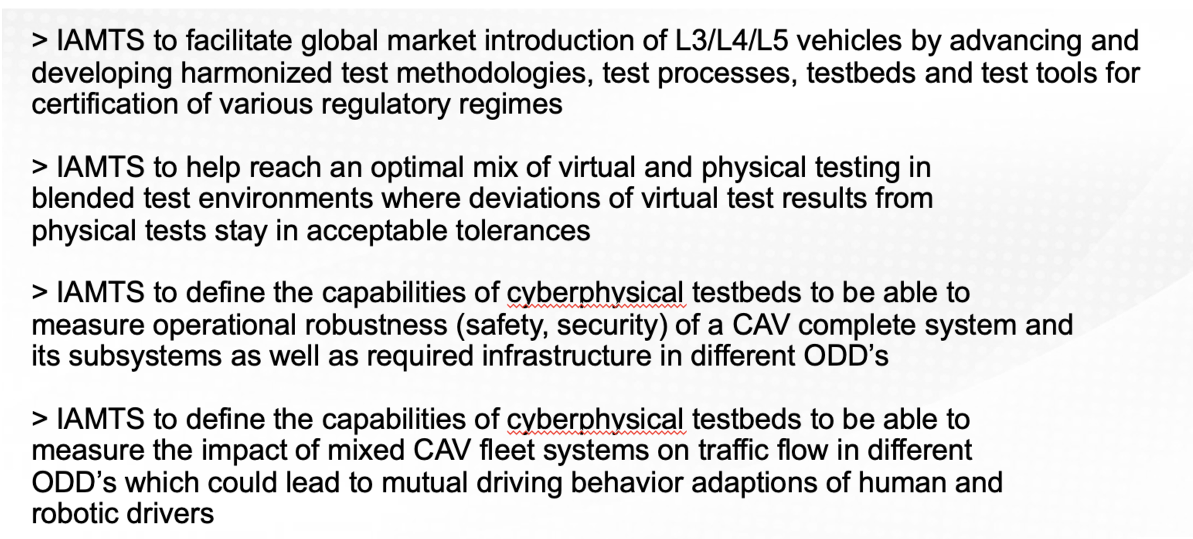
Another major concern is to ensure the security of the transportation system end-to-end. Because of this, the validation and use of UNECE R155, a cyber security regulation introduced in 2021 is of significant importance. Under this new regulation OEM's need to satisfy Cyber Security Management System (CSMS) requirements in order to be allowed to apply for type approval of specific vehicle types.

---

[8] https://www.federalregister.gov/documents/2020/12/03/2020-25930/framework-for-automated-driving-system-safety

The motivation for the implementation of the International Alliance for Mobility Testing and Standardization (IAMTS):

As mentioned in the previous chapter, a large number of testbeds are being established worldwide where the goal is to enable a highly and fully automated smart mobility ecosystem. Although the introduction of highly automated and fully automated driving system is very competitive, the consumer success will depend greatly on how well the mobility services can work in context. This means that highly automated mobility services also need to be tested in context. It requires the use of a “common language” to understand action-response patterns for well-defined driving situations. Additionally, regulatory compliance tests or type approval tests need to be performed in facilities that meet a minimum requirement standard in their capabilities. This can help to improve the overall quality level of test facilities that offer their services in the domain of highly automated and fully automated vehicle system development and certification. Another important aspect is the availability of suitable standards, regulations and methodological frameworks to the developer community in context of ADS testing to develop mobility solutions for the world market combined with best practice information and access to a global pool of subject matter experts.



Strategic goals addressed by IAMTS

The vision, mission and value proposition of IAMTS:

Vision of IAMTS:

Provide a globally accepted validation framework as best practices to scale automated vehicle adoption.

Mission of IAMTS:

To align international ecosystem stakeholders within an inclusive alliance that delivers actionable verification and validation methods to standards development as well as certification of automated mobility systems including cyber-physical testing infrastructure.

Value Proposition of IAMTS:

> Get access to and engage with a pool of global experts that can provide unbiased information about the latest developments in driving scenarios, regulations/policies, V&V methods, cyberphysical test infrastructure capabilities and terminology with respect to connected and automated driving technologies
> Benefit from and leverage close relationships to regulators and standards development organizations across all world market regions enabling relevant input in policy and standards development
> Increase the speed of adoption of best practices into your own organization by trusted interaction with the working groups through in-depth expert dialogue
> Get preferred access to specialized and customizable knowledge databases (e.g. scenario catalogues, cyberphysical testbed capabilities, CAV/ICV policies) to support your efforts to prepare for and continuously maintain regulatory compliance of highly and fully automated driving systems at a global scale

The Alliance:

- Undertakes activities and develop materials deemed necessary to meet the defined mission and vision
- Operates working groups to address relevant topics
- Engages the expertise of external stakeholders as needed
- Shares output / information with the global community
- Participates in specifications and standards activities

Bringing together testbed users and testbed operators, IAMTS negotiates discount rates of services for IAMTS members. IAMTS certified testbeds can leverage the IAMTS community to communicate their capabilities and attract users.

IAMTS educates its members regularly about progress of smart mobility technologies with a focus on highly and fully automated driving through training sessions and technology demonstration events at testbeds (which can also be combined with conference events where applicable).

IAMTS carefully selects providers for its membership services, defines applicable registration and qualification processes and approvals, and defines processes for regular review and confirmation based on customer feedback and performance. Contact information of registered and approved service providers will be made available via a database to the members.

The membership model of IAMTS:

IAMTS is made up of Member organizations which are engaged in the smart mobility ecosystem. To achieve its objectives, the Alliance has different levels of membership providing different levels of engagement and benefits. IAMTS offers memberships to both public and private, large and small organizations. The rationale behind this is to build a community of experts which can provide their knowledge and to build a community of corporations that can bring in both human and financial resources.

There are seven membership levels as defined in the Membership Agreement: Junior, Academic Partner, Base, Core, Core Partner, Strategic and Strategic Partner. The membership levels determine initial and annual membership fees, membership services eligibility and roles the member is allowed in the governance structure.

Membership Level based benefits are as described in the table below:

Membership Level	Constraints & Opportunities
Junior	Can be an official service provider after registration and approval. No reserved voting rights except as determined by committee.
Academic Partner	Can be an official service provider after registration and approval. No reserved voting rights except as determined by committee.
Base	Can be an official service provider after registration and approval. Eligible for service discounts. No reserved voting rights except as determined by committee.
Core	Can be an official service provider after registration and approval. Eligible for service discounts. Eligible for committee and project leadership positions. Eligible for IAMTS Technical Leadership Committee. One vote for general ballots and ballots to determine project and committee leadership.
Strategic	Can be an official service provider after registration and approval. Eligible for service discounts. Eligible for committee and project leadership positions. Eligible for Technical Leadership Committee. Eligible for IAMTS Board upon approval. Two votes for general ballots and ballots to determine project and committee leadership.
Core and Strategic Partner	Equivalent to Core and Strategic Level.

See in **Addendum A** a matrix organization structure chart which provides a more detailed description of the membership categories and membership levels.

An important aspect of the membership model is to provide opportunities to members to become a service provider as well as to provide incentives to corporate members to utilize services through the Alliance. Below is an overview about the membership services that will be provided by IAMTS:

Membership Service	**Offering**
Training	• AV verification & validation methods • Mobility related rules & regulations
Consulting	• Design of smart mobility testbeds • Optimization of testbed operation • Development of AV test programs
Data Analytics	• Access to smart mobility testbed database • Access to testbed digital twin data pool • Specific data queries • User/Operator matchmaking
Testing	• Access to test facilities with specified capabilities at preferred conditions
Certification	• Access to auditors that can certify vehicles, infrastructure or testbeds
Projects	• Involvement in pre-competitive R&D projects through IAMTS partnerships
Conference and technology demonstration events	• Conference sponsoring • Customized technology demonstration events

The governance structure of IAMTS (Rules of Procedure) is composed of one board, a managing director level (IAMTS Management) and a committee:

IAMTS Rules of Procedure	
Body	**Purpose and Overview**
IAMTS Board	● Supervises all operations of the association taking into consideration existing rules & regulations, bylaws and decisions of the General Assembly; ● Supervises the management of the financial assets of the association; ● Supervises the fulfillment of the purpose of the association and the financial uses of resources; ● Reviews all reports provided by the Managing Directors including financials; ● Defines the strategic alignment of the association's activities including a long term plan; ● Provides guidance and steers the development of IAMTS roadmaps and additional (annual) plans as needed in collaboration with the Managing Directors; ● Implements committees and working groups and its governance in collaboration with the Managing Directors; ● Defines tasks for Managing Directors and appoints Managing Directors; ● Initially comprised of Founding Members; ● Develops, updates and approves the IAMTS Charter.
IAMTS Management	● The Managing Directors operate IAMTS ● The Managing Directors ensure that decisions of the General Assembly and directions set by the Board are being implemented; ● The Managing Directors decide which projects according to the annual plan can be implemented and funded and are also responsible for project reporting and project accounting; ● The Managing Directors are responsible for producing the annual report, managing the finances and assets, hiring and terminating staff, and signing contracts with external service providers.
IAMTS Technical Leadership Committee (TLC)	● The TLC is responsible for the implementation of the work program as defined in the Activities Roadmap; ● Technical implementation of testbed database, the testbed big data pool and the testbed certification program; ● The TLC is responsible for R&D project partnerships; ● The TLC is responsible for technical training programs;

	• The TLC is responsible for technical programs of IAMTS conferences or conferences with IAMTS involvement; • The TLC implements technical committees to support activities for which it is responsible, including Working Groups and Study Groups.

See **Addendum B** for details of the IAMTS Overall Organizational Structure.

ADDENDUM A:

	IAMTS Membership Level*				
	Strategic Member	Core Member	Base Member	Academic Partner	Junior
Regulation, Standards and Certification Providers	• SDO • CTO	• SDO • CTO • Government	• SDO • CTO • Government		
Testing Service Providers	• Test Facility • Operator • Simulator • RECS • ICT • Academic	• Test Facility • Operator • Simulator • RECS • ICT • Academic • Government	• Test Facility • Operator • Simulator • RECS • SmB • Academic • Government	• Academic	• SmB
Testing Service Consumers	• Manufacturer • Insurer • MaaS • RECS • ICT	• Manufacturer • Insurer • MaaS • RECS • ICT • Academic • Government	• Manufacturer • Insurer • MaaS • RECS • ICT • SmB • Government	• Academic	• SmB
Other	• Other	• Other	• Other		

SDO =Standards Development Organization
CTO = Certification & Testing Organization
RECS = Research, Engineering and Consulting Services firm
ICT = Information and Communications Technology firm
MaaS = Mobility as a Service Provider
SmB = Small Business
Manufacturer = OEM or Tier 1-2 Supplier
Academic = Non-Profit Academic or Academic-Affiliated Research Institution
Operator = Testbed Operator or Test Operator
Government = Local, National, Regional and Regulatory
Other = Other organization whose products, services or interests are relevant to the IAMTS mission, vision and scope

*Approved Membership Level is at the discretion of the IAMTS Board.

ADDENDUM B:
IAMTS Overall Organizational Structure