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Automotive Intelligence for/at Connected Shared Mobility

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1.0	2022-12-19	Erwin Schoitsch, Christoph Schmittner (Review)	Final Version, Bibliography added

Disclaimer

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1 Executive/ Publishable summary

This document gives an overview over the general automotive and the AI (Artificial Intelligence) standardization landscape in general as well as in context of safety critical systems. It follows the previous deliverable D1.8 which was intended to give an overview over the first part of the SC8 (Supply Chain 8, "***Impact Green Deal, Standardization, Certification, Ethical Aspects***") work with focus on the requirements of the other supply chains as collected in WP1 tasks T 1.X (X = SC-number) concerning ethical and environmental aspects ("Green Deal") and their relevance for the Use Cases. D1.8 reflected the collective results of the requirements elicitation of the other SCs (Supply Chains). D 7.7 complements this picture with respect to the very large standardization landscape and shows the large number of sub-teams and subgroups in many standardization groups covering all the relevant aspects of the fields of interest.

To demonstrate the complexity of theses standardization tasks, a short overview is provided over the processes to be performed from placement of an idea for a "New Work Item Proposal" (NWIP) to a final International Standard (IS), or a Technical Specification (TS), a "Public Available Specification" (PAS) or just a Technical Report (TR) giving some recommendations, guidelines or just considerations on a particular potential standardization area, e.g., in Ad-hoc Groups or Advisory Groups or Standardization Boards. The standardization landscape evolving is using all these different categories of standards documents depending on how mature a topic of interest is to be managed by a standard, TS, PAS or TR.

The other Supply Chains are either "Output Enablers" (SC 1 – SC3) or cover technology fields (SC4 – SC7). SC 8 is a "Value Enabler" (European Values) and has a horizontal function, collaborating across all of the Supply Chains and Work packages on impact towards the "Green Deal" and standardization; with respect to the "Green Deal" (environmental aspects) and ethical concerns the task of SC8 is an evaluating one, with respect to standardization it is supporting the use of existing or in some cases evolving standards (role of "early adopters") to make developments "future-fit", and on the other hand trying to influence standardization primarily by contributing via active participation in committees and working groups with transfer of project experiences and results to evolving and newly introduced standards and standardization initiatives. Most of this work will have its focus towards the end of the project, when results are visible, or when "Windows of Opportunity" are arising in the standardization landscape.

Since standardization schedules can vary from two to many years, depending on the type of document to be developed, activities cannot stop with the end of the project, as in case of any exploitation of project results – long term commitment of key partners is necessary – as is in case of AI4CSM. My longest experience was de facto more than ten years, with a long preliminary study phase before an official development stage could be started: it was the basic international functional safety standard IEC 61508, now in its CD-stage of Edition 3.

2 Non publishable information

All the information of this document is publishable, this document is categorized as PUBLIC.

3 Introduction & Scope

3.1 Role of Supply Chain 8 in context of the project AI4CSM

The work in AI4CSM is thematically organized in "Supply Chains", the organisational structure is organized in work packages and tasks in each work package (see Figure 1). As a result, several work packages have tasks and deliverables in connection with the SCs. Supply Chain 8, "***Impact Green Deal, Standardization, Certification, Ethical Aspects***" is evaluating the impact of the project work with respect to "European values", that means towards the "Green Deal", ethical and societal concerns (which is a key issue for the EC and their AI act and other safety, security environmental regulations and directives), and as long-term exploitation and impact on the ecosystems through standardization; it is supporting the use of existing or in some cases evolving standards and recommendations/regulations to make developments "future-fit" (e.g., in the role of "early adopters"). This chapter is a slightly adapted version of D1.8; the rest of the document focusses on the standardization aspect (which also covers partially ethical concerns and good governance, see chapter on "AI Standardization", see 4.1).

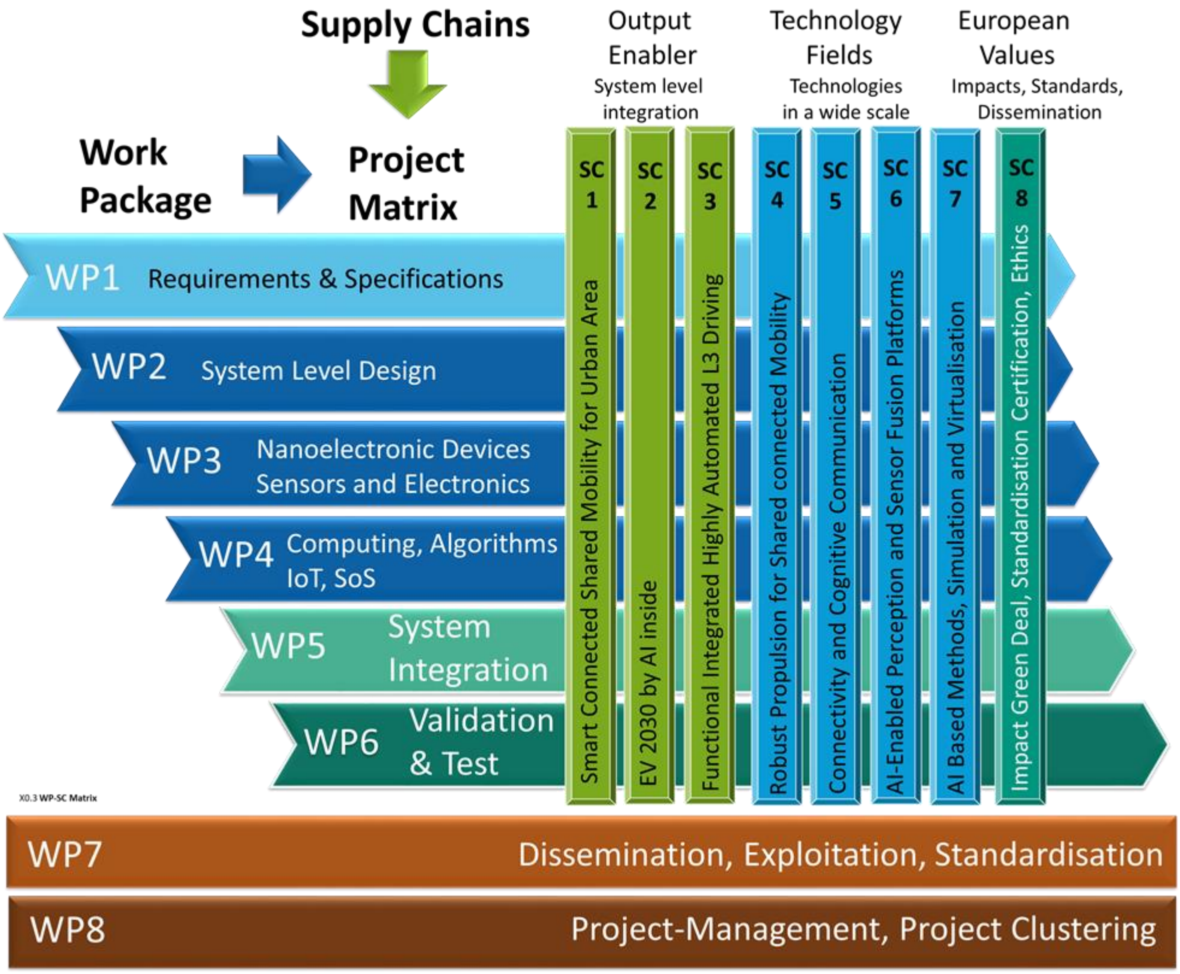

FIGURE 1: SUPPLY CHAIN AND WORK PACKAGE STRUCTURE OF AI4CSM

The other Supply Chains are either "Output Enablers" (SC 1 – SC3) or cover technology fields (SC4 – SC7). SC8 and the correlated tasks in WPs therefore perform a "horizontal" functional over all the SCs.

Thus, the activities are not focused on "activities per partner" only, but on collaborative activities and contribution from the tasks performed for the SCs.

3.2 SC8 Vision

According to the objectives, there are two key goals in the vision of SC8:

Related to the Green Deal, Ethical and Legal Aspects

Support and implement Europe's vision of climate neutrality by 2050 for the automotive and the semi-conductor sector. Starting the rapid transition today to gain a competitive advantage for our economy. The contributions described in D1.8 with respect to the derived requirements are based on the deliverables T1.X and the use case descriptions, and joint (web) meetings with the SCs and WPs.

Support the partners of AI4CSM to make sure that their R&D is conform with current and upcoming standards as well as to support their activates in driving new knowledge into the standards. This covers also the ethical and societal aspects, as e.g., addressed by the EC HLEG Experts Group on "Trustworthy AI", German Ethics Commission for Automated and Connected Driving, and other related recommendations as issued by Informatics and Computer Societies (Informatics Europe with ACM Europe, IEEE Ethically aligned design) and the standards of ISO/IEC JTC1 TR 24368 ("AI - Overview of ethical and societal concerns") and on IT Governance (see Figure 2).

Figure 2: Recommendations on Ethics and Societal concerns wrt. AI-driven and highly automated systems

The latest one is "UNESCO Recommendations on the Ethics of Artificial Intelligence" (see Figure 2). Very relevant is "Policy Area 1: Ethical Impact Assessment" as a guidance how to assess the ethical properties.

Related to Standardization, Certification, (covering partially also Ethical and Legal Aspects)

- SC8 follows the **AI4CSM VISION** related to **Standardization**, including **Certification, Ethical and Human Centred Aspects consideration (public acceptance)** to

„… support the partners of AI4CSM ensuring conformance of R&D work results with current and upcoming standards as well as influencing standardization by driving new knowledge into the standards"

This includes particularly in context of AI4CSM Supply Chains 1 to 7

- Contributing to ISO automotive standards, ITS and trustworthy AI and IoT standards (ISO TC 22 SC32 WG08 (Functional safety, SotiF) and WG14 (Safety & AI))
- Contributing to automotive Cybersecurity engineering standards (ISO TC22 SC32 WG11)
- Contributing to evolving ISO "Automated Driving" (AD) related standardization activities (ISO TC22 SC32 WG13, Automated Driving Systems (ADS))

The most relevant standardization committees and groups in this context are shown in (Figure 3)

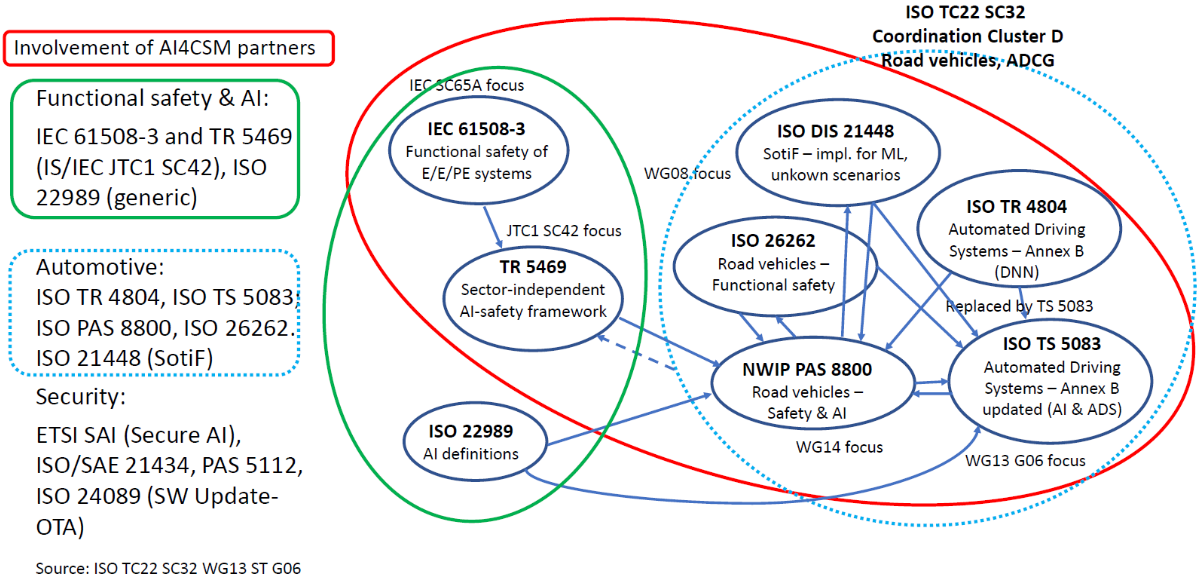

FIGURE 3: INTERRELATIONSHIPS BETWEEN THE CONVENTIONAL ISO SAFETY STANDARDS, AD STANDARDS AND AI-SAFETY STANDARDS

In the field of standardization "Green and Sustainable AI" has become an issue on international level too, e.g., CEN/CENELEC JTC21 Ad-Hoc Group Report "Green & Sustainable AI", which will be the basis for a new Work Item on Reducing AI Carbon Footprint, energy and water consumption etc. (both 2021, 2022).

European Regulations and Directives have also to be observed, which refer to so-called "Harmonized Standards" in their field, the lists of which are published by the Commission. The EC Machinery Directive, the new AI-Regulation (AI-Act), the NIS (Cybersecurity) and the RED (Radio Equipment) Directive are examples.

3.3 Objectives

Objectives *Related to the Green Deal*

The EU is working on the so called "Green Deal" to restructure the way we live, consume and produce in a sustainable way. Climate neutrality is only achievable by a combination of many activities which need to interact. The partners of AI4CSM see sustainable and smart mobility as one of the core elements of the European Green Deal as presented by the EC. According to the EC "transport accounts for a quarter of the EU's greenhouse gas emissions" and "to achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050".

These goals are addressed by four pillars (Figure 4). The details of the four pillars are described below.

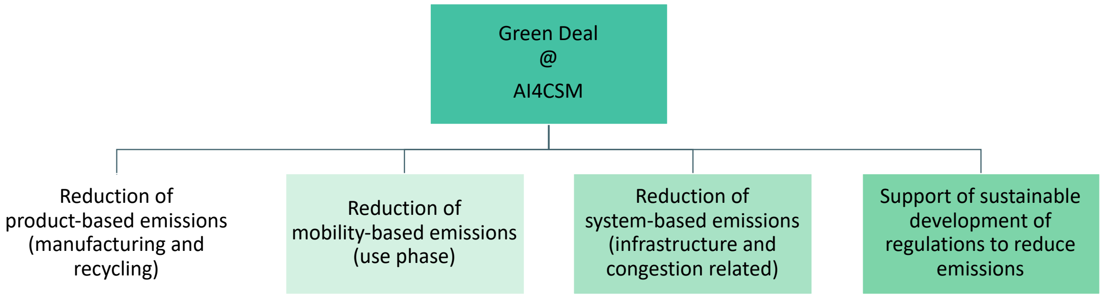

FIGURE 4: *THE FOUR PILLARS THE AI4CSM TEAM WILL WORK ON TO IMPLEMENT THE EUS GREEN DEAL*

Reduction of product-based emissions

Product based emissions are related to the efforts which are made to manufacture, maintain and recycle (or dispose) products. It is estimated that a modern EV has a 3x higher environmental footprint in the production than a comparable combustion engine car. Since every percent point efficiency increase helps to reduce the battery size it also helps to reduce the manufacturing related emissions. Thus, SC4 to SC7 will help to lower the needed amount of battery capacity. Moreover, the AI4CSM partners plan to exchange their individual approaches to achieve climate neutrality in the product design and manufacturing as well as recycling phase.

Reduction of mobility-based emissions

To achieve the 90% reduction of transport emissions the usage of conventional fossil-based technologies, like combustion engines, is not an option. AI4CSM only considers XEV transport means. XEV in combination with green energy sources is the key to a sustainable mobility. That's why we research new ways of route scheduling (SC1), new inverter technologies (SC4), advanced battery state estimation technologies (SC4) as well as more power efficient sensors and computing platforms (SC6) as well as new AI techniques that require less computational resources (SC6&7).

Reduction of system-based emissions

System based emissions are hard to tackle in comparison to mobility or product-based emissions since they rely on a multitude of factors. The position of the EC on this issue is quite clear "multimodal transport needs a strong boost" to increase the transport efficiency. AI4CSM clearly addresses this topic with its output enabler SCs (SC1-SC3) as well as with its methodology driven SC7. By enabling connected shared and automated mobility through the technologies derived in SC4-SC6 a significant reduction of the overall system related emissions can be made since cars will be used, maintained and shared more efficiently so that multimodality approaches can be fostered.

Support of sustainable development of regulations to reduce emissions

Another aspect of the view on how the Green Deal needs to be implemented are the regulations itself. The **transport system policies need to be upgraded as well since new technologies alone won't improve the situation.** These aspects strongly effect the transition to a modern and low-carbon mobility, which is a main objective of AI4CSM, but the necessary mass deployment and implementation has to be supported together with increasingly regulations for CO_2 and pollutant emission. Working groups are engaged by the EC to find new approaches to certifying EVs and AVs. The partners with their strong network inside the EU want to support with their expert view the policy making in order to make mobility climate neutral. This will be achieved mainly via dissemination and propagation of results and experiences resulting from the work in AI4CSM. SC8 has here the role of evaluation and motivation respectively monitoring the progress.

Objectives *Related to Standardization, Certification, Ethical and human-centered Aspects*

The increased use of automated support functions led to a substantial increase in standardization in related areas for road vehicles. ISO and other standardization groups like SAE (US), ETSI ITS, CEN/CENELEC, and standardizing automotive and automation industrial alliances (ASAM, Automotive Innovation, Connectivity Standards Alliance, and many others) are all working in parallel. UNECE WP29 (UNECE (United Nations Economic Commission for Europe) Regulations) takes up certain standards as reference how to fulfill their regulations. The following picture gives an overview on the automotive standardization landscape (Figure 5) (not including the industrial (automotive, automation) alliances, they are too many).

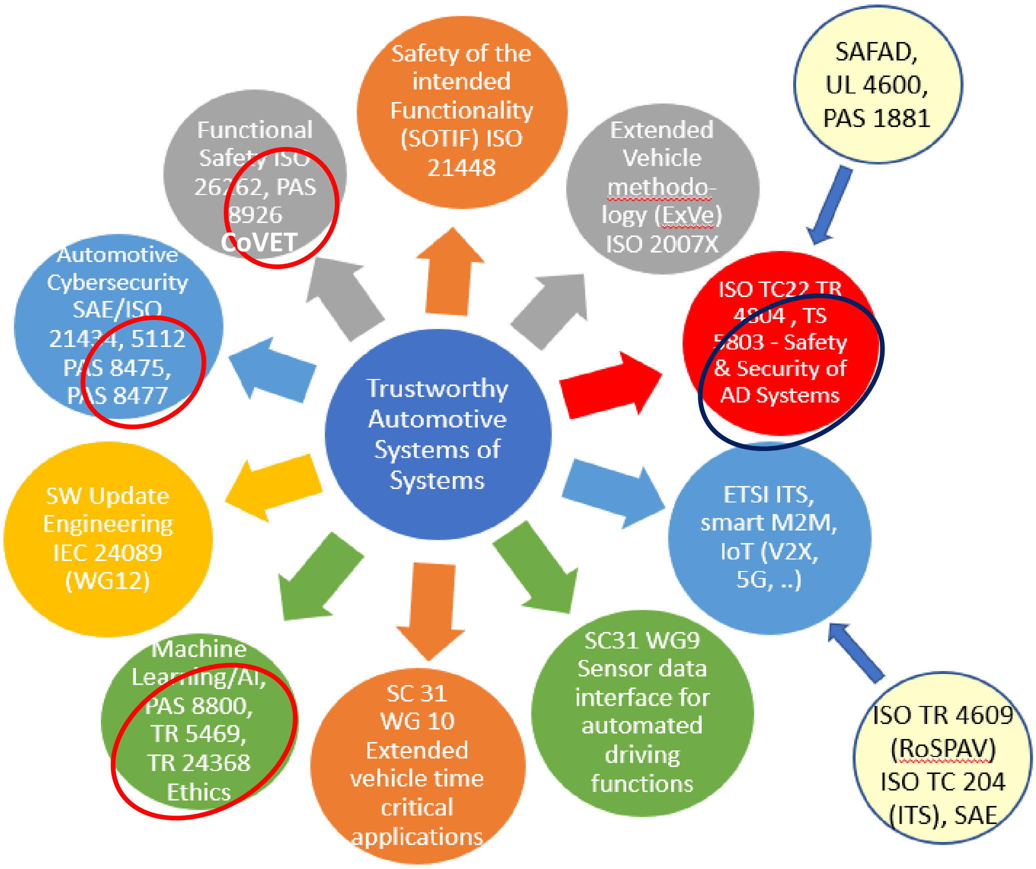

FIGURE 5: *EXTENDED VIEW OF THE AUTOMOTIVE STANDARDIZATION LANDSCAPE (ENCIRCLED: MOST RELEVANT)*

- ***Raising awareness among AI4CSM partners on existing and evolving standards in their field of experience (from "early adopters" to "users")***
- ***Bring forward AI4CSM concepts to standards – potential opportunities in "Automated Driving" and "Functional Safety" standardization, considering Cybersecurity engineering***
- ***Contributing to ITS (Intelligent Transport Systems), trustworthy AI and IoT standards, including consideration of Ethical aspects***

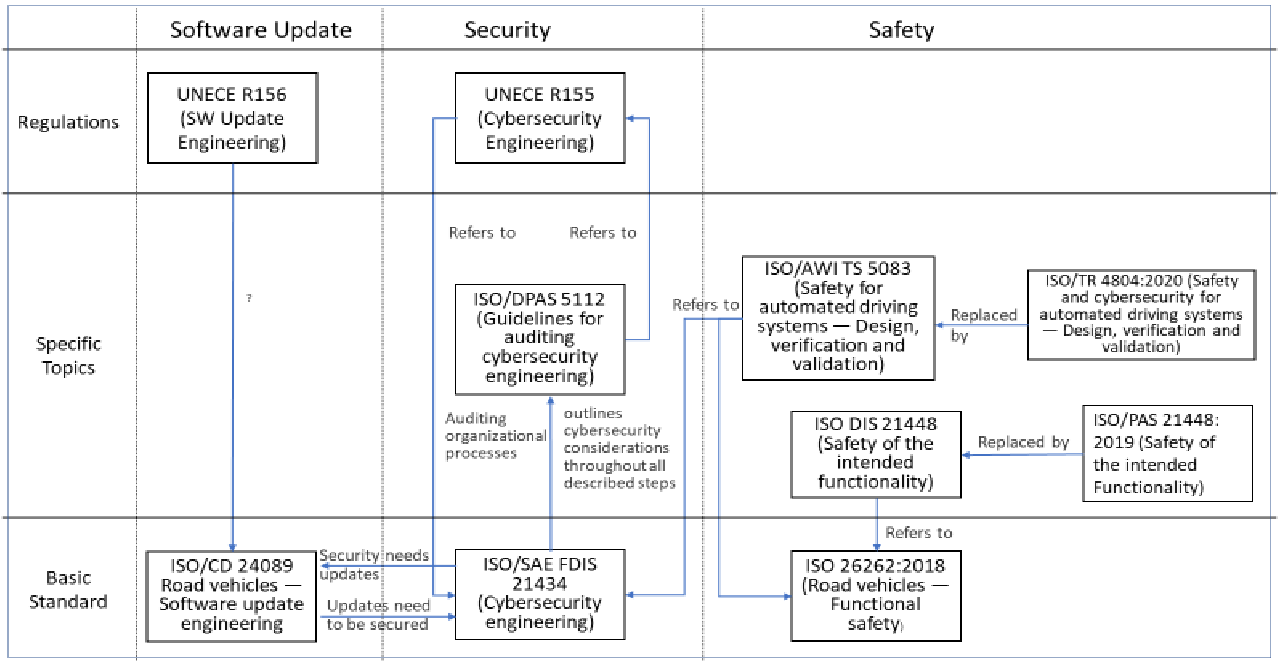

FIGURE 6: FUNCTIONAL SAFETY, CYBERSECURITY AND SOFTWARE UPDATE STANDARDS AND UNECE SECURITY REGULATIONS

The interdependencies between Automotive Safety, Cybersecurity and Software Update standards and the connection to the UNECE Cybersecurity Regulations are depicted in Figure 6. The key issue is that UNECE R155 and R156 require a Security Management System covering the whole supply chain. Therefore, the ISO/PAS 5112 for Auditing had to be developed in parallel to ISO 21434, the convenor was an AI4CSM partner (Christoph Schmittner from AIT). In the meantime, ISO 24089, PAS 5112 and ISO/SAE 21434 have been published as standards or PAS.

For AI for Automated Driving Systems as well as for highly advanced ADAS, and in conjunction with decision making with AI, ethical and safety concerns became evident too. Additional to WG13, the conventional safety and cybersecurity standards want to bridge the gap to new technologies and to WG 13 and ISO TC22 SC31 (Extended Vehicle standards) for their next edition, the cycle started just now. These interrelationships are already shown in Figure 3.

3.4 Further evolution of the main automotive functional safety and cybersecurity standards

The 2nd edition of ISO 26262 – Road vehicles – Functional safety, was published in 2018 in 12 parts. The 2nd edition of ISO/SAE 21434 – Road vehicles – Cybersecurity engineering was published 2021. In the meantime, the topic of "Safety of Automated Driving Systems" (ISO TC22 SC32 WG13) and use of AI systems in safety related applications, besides other new technologies, became virulent. This will be handled in Section 4 further, but it triggered also maintenance cycles in ISO 26262 and ISO/SAE 21434.

A main concern of us was to avoid duplication of work or even contradiction in evolving standards, but it could be successfully avoided to have critical overlap of the work in the different groups.

3.4.1 Updating ISO 26262:2018 for Ed 3 – preparatory work: ISO TC22 SC32 WG08

In initial discussions different sub-topics were created that were considered to be important. They should in the end expand the validity of ISO 26262 application on new challenges in technology and methodology without compromising safety or security. Many of the topics were selected to start a separate TR or PAS as predecessor of future inclusion in ISO 26262. These are:

- ISO PAS 8800 Safety and artificial intelligence (now a separate WG14 in ISO TC22 SC32)
- ISO PAS 8926 - Pre-Existing Software (PreExSW)
- TR 9839 - Application of predictive maintenance to hardware with ISO 26262-5
- TR 9968 Road vehicles — Functional safety — The application to generic rechargeable energy storage systems for new energy vehicle
- CoVETES – Connected Vehicles End-To-End Safety (RExVeS, ExVe TC22 SC31) (only on Working Draft basis at the moment, TR or PAS to decide)
- NEV – New Energy Vehicles

Additionally, there are "Part-Teams" for Part 1 – Part 11 (not for Part 12, Motorcycles, which are excluded at the moment from upgrading). A Task Group for the link to SotiF is lead by Nicolas Becker, the convenor of ISO 21448, they are contributing to all other groups where necessary (overlapping topic). SotiF principles are applied partially in all new technologies which cannot be assessed for functional safety in a traditional manner (e.g., AI).

AI4CSM partners are involved in most of these sub-teams; to participate and contribute is very demanding, since some groups act on weekly basis or at least bi-weekly basis, with timings not always convenient for Europe (or Japan or Western Pacific) (05:00 in morning or 23:00 – 03:00 night, etc., depending on the location of the leader or the meeting if hybrid – the world is 24 hours round!). All these documents are under development (stage 20.00 or 30.00, see next chapter on the International Standardization Process).

3.4.2 Updating ISO/SAE 21434:2021 for Ed. 3 (Preparation), ISO TC22 SC32 WG11

A similar process started now with ISO/SAE 21434 – Road vehicles – Cybersecurity engineering. Because the standard had to be finished in time for the UNECE R155 regulation as a reference, not only the Audit-PAS 5112 had to be developed in parallel, but also a few specific topics kept out in detail, like TAF (Target Attack Feasibility) and CAL (Cybersecurity Assurance Levels). Additionally, there does exist the "Software Update" Standard, including "OTA – Over the Air", ISO 24089, ISO TC22 SC32 WG12, which is also a Cybersecurity-related standard and addressed by UNECE R 156 (see Figure 6).

The resulting activities started with two PAS and were just recently complemented by additional Task Forces respectively liaisons.

- ISO/SAE PAS 8475 Cybersecurity Assurance Levels (CAL) and Target Attack Feasibility (TAF)
- ISO/SAE PAS 8477 Cybersecurity verification and validation
- ISO TC22 SC32 Harmonization Task Force (TF) (Cybersecurity is also a topic in SC31, Extended vehicles, Software Update, and other ISO TC22 WGs, therefore the TF Harmonization was created)
- ISO/IEC AWI 5888 – Information security, cybersecurity, and privacy protection – Security requirements and evaluation activities for connected vehicle devices; this is a work item of ISO/IEC JTC1 SC27 (Security), but ISO TC22 SC32 WG11 (Cybersecurity engineering) from the automotive standards was invited for official liaison (e.g., Christoph Schmittner from AIT as AI4CSM partner is registered already).

Since Cybersecurity is an issue in several SCs, it is also important to keep track and contribute to this group of standards. The general comment on the complexity of holistic standardization and contribution with so many groups as addressed in 3.4.1 is the same here.

3.5 The International Standardization Process

To understand better the complexity and schedules to be expected (beyond the duration of a research project like AI4CSM), some remarks will be provided here.

The standardization process and the editing rules (including use of certain keywords only in a specific context, like “shall” only for requirements, “should” for recommendations, and other drafting rules) are described in ISO/IEC Directives. An International Standard (IS), Technical Specification (TS), Publicly Available Specification (PAS) or Technical Report (TR) are developed in several stages. The stages reflect the level of progress and maturity of the documents which are developed. They also reflect the chances to influence the standards development – first via active membership and participation in the respective Committee, Subcommittee, Working Group or Sub-team, depending on how far the work on the document was split into smaller part and assigned to dedicated (sub-) groups. After key phases, the document is distributed to the “National Committees” (NC), which have as P-Member voting rights (if they do not delegate experts, then after some time a NC may become O-member (observer) – they have restricted access only to final documents, not to working documents which are only for working group members). In this “commenting phases” each NC can send a collection of comments which have to be discussed and resolved by the working groups. In some cases, we had more than 500 pages of comments! It is very important to know, that the process is consensus based – the convenor of a group has to find solutions which achieve consensus among the members. This is first priority – but does not mean that in the end all decisions have to be unanimously. Among NCs, each NC (China or Luxembourg) have one vote. A working group can have more members from the same NC, and one has to be nominated as “Head of Delegation” who casts the vote for his members; but in case that a committee meeting would become too large, the number of delegates per NC may be restricted; this happened in the past e.g., at ISO 26262 meetings already. The following list provides an overview over this process and the stages:

- **00.00 – 00.99 <Preliminary>** – From proposal sent to ISO by NC up to approval for a ballot (NCs) 00.99 (or: negative outcome: 00.98 abandoned – e.g., IoT Swarms intelligence) – AI4CSM topics: unlikely (examples: ISO PAS 5112, ITS station SECREDAS)
- **10.00 – 10.99 <Proposal>** – From registration of a new project (NP), via ballot & voting to new project approval (or negative outcome: 10.98 – NP rejected, needs e.g., 5 NCs delegating experts) (examples, e.g., Cybersecurity Asset Administration Shell; TS 63069 Framework for safety and security) → 1st chance to support by participating as NC.
- **20.00 – 20.99 <Preparatory>** – NP registered in TC/SC work programme (WG assigned), Working Draft (WD) commented, (or negative outcome: deletion (20.98) (IEC 62879 Human Factors and functional safety, but: input to other stds.) else approval as CD (Committee Draft) (20.99); → 2nd chance to contribute/influence in WG (E10, Safetrans recommendation submitted for guidance in Deployment phase of ADS)
- **30.00 – 30.99 <Committee>** – CD registered, commenting & voting, can be referred back to WG, that means, there can be several CDs before consensus is reached; outcome 30.98 deleted or 30.99 approved as DIS → via NCs, comments resolution some influence → early adopter in project as role possible

- **40.00 – 40.99 <Enquiry>** – DIS registered, ballot within 12 weeks, full report circulated/back to TC/SC, deleted (40.98) or approved for FDIS → via NCs, comments resolution some influence, → early adopter role possible
- **50.00 – 50.99 <Approval>** - Proof to Secretariate (formal check), Voting (only editorial comments allowed, no new technical input), can be referred back to TC/SC/WG, deleted (50.98) or 50.99 approved for publication; **FDIS = de facto THE Standard**
- **60.00 <Publication>** - 60.60 publication done **(now you have to pay for a standard document; for Users)**
- **90.00 <Review>** after ca. 5 years – result can be: revise (e.g., towards next edition, as for ISO 26262 ED 3), confirm (stability phase extended) or withdrawal (if obsolete or outdated).

A typical time schedule for a TS like TS 5083 (ADS – Automated Driving Systems, based on the already published TR 4804) is 3 years: 2021 was the alignment phase after the TR (4 plenary meetings), 2022 was the integration phase (4 plenary meetings), 2023 will be the CD ballot, review and conclusion of comments; as it looks like, the final TS could be published 2024.

3.6 EU Regulation 2022/1426 for type-approval of ADS implemented

As published in the official Journal of the European Union on 2022-08-26, the European Commission has implemented and published Regulation (EU) 2022/1426 of 5 August 2022 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles (citation).

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32022R1426&from=EN

This document describes not only the general principles but includes extensive Annexes.

Its scope covers fully automated vehicles category M or N for the following use cases:

- Fully automated vehicles, including dual mode vehicles, designed and constructed for the carriage of passengers or carriage of goods on a predefined area.
- ‘Hub-to-hub’: fully automated vehicles, including dual mode vehicles, designed and constructed for the carriage of passengers or carriage of goods on a predefined route with fixed start and end points of a journey/trip.
- Automated valet parking

Annex I is the form to be filled out by the applicant for type approval to provide the necessary basic information about the **fully automated vehicles with regard to their automated driving system.** **T**echnical specifications are set out in Annex II concerning performance requirements within the ODD (Operational Design Domain) for which the vehicles are designed for operation and its “Dynamic Driving Task” (DDT) **under critical traffic scenarios (emergency operation).** Other chapters cover DDT under failure scenarios, **Minimal risk manoeuvre (MRM) and Minimal risk Condition (MRC), human-machine interaction, functional and operational safety, cybersecurity and software updates. For legal purposes (liability issues, transparency in case of an accident), ADS data requirements and specific data elements for event data recorder for fully automated vehicles are defined. A manual driving mode, if allowed, (maximum 6 km/h if the driver is not staying in the vehicle) is also defined to take over after a critical risk manoeuvre, or for maintenance purposes. The ADS should then still support the driver by actively identifying obstacles etc.**

If we study the TR 4804 (predecessor of TS 5083) and the evolving documents of TS 5083 (**Safety for automated driving systems – Design, verification and validation methods),** we find that this regulation covers all important topics that have been raised by the OEMs and the standardization people in ISO TC22 SC32 WG13, ADS, and the preceding working group.

Other requirements are the provision of an operating Manual. Periodic roadworthiness tests shall verify important features of the ADS on a regular basis. Those specifications shall be assessed by the approval authorities or their technical services in accordance with Annex III (Compliance Assessment). Part I includes traffic scenarios, behavior competences for given events etc., Part 2 the assessment of the ADS safety concept and audit of the manufacturers safety management system.

In further appendices, a model for the safety assessment report and A model of the ADS assessment results to be annexed to the type-approval certificate are provided. It includes e.g., if the Cybersecurity and Software Update certificates are covering the ADS. Further templates ("models" are for the **Manufacturer's Declaration of Compliance for SMS, for certificates etc.**

Part 3 is dedicated to tests and test tools, Part 4 on Principles for Credibility Assessment for using virtual toolchain in ADS validation, models and simulation management etc. Part 5 covers a very important topic: In-service reporting, i.e., reporting of critical incidents from the field.

> *"The manufacturer shall notify without delay any safety critical occurrences to the type-approval authorities, market surveillance authorities and the Commission" (citation)*
>
> *"The manufacturer shall report every year to the type-approval authority that granted the approval on the occurrences listed in Appendix 1." (citation)*

Appendix 1 provides a list of occurrences and the requirements on reporting: short term reporting (1 month) and/or annual reporting. A particular situation has to be managed in case of "Occurrences related to the identification of new safety-relevant scenarios" (including modifications by the manufacturer).

In Annex IV, the **EU Type-Approval Certificate (Vehicle System) is described (template).**

4 Artificial Intelligence Standardization

IEC, founded in 1906, is responsible for international standardization in the field of electrotechnical standards. In many European countries, the regional standardization groups have been founded even earlier (e.g., in Austria 1883). ISO, founded 1946, is responsible for most of the areas of standardization, except telecommunications, for which the ITU (International Telecommunications Union) is the primary standardization organization (SDO). Besides these there are many standardization organizations driven by industrial associations or regional standards groups.

With the uprise of Information Technology (IT), many areas of mutual interest of both, IEC and ISO, became most relevant. ISO and IEC created a Joint Technical Committee (JTC1) managing standardization in the IT-sector, some committees hosted by IEC (e.g., ISO/IEC JTC1 SC41, Internet of Things (IoT) and Digital twin, is hosted by IEC, ISO/IEC JTC1 SC42 Artificial Intelligence (AI) is hosted by ISO).

4.1 General AI standardization in ISO/IEC JTC1 SC42

The scope of ISO/IEC JTC1 SC42 is standardization in the area of Artificial Intelligence (AI). It

- Serves as the focus and proponent for JTC 1's standardization program on AI (General AI standardization)
- Provides guidance to JTC 1, IEC, and ISO committees developing Artificial Intelligence applications (because other standardization groups, particularly for domains like automotive, machinery, medical devices and health services, industrial and home robotics etc., standardize their specific AI application aspects additionally)

ISO/IEC JTC1 SC42 has several Ad-hoc Groups and Working groups.

- AG 3 AI standardization roadmapping
- AHG 4 Liaison with SC 27
- AHG 6 Comment resolutions - CD/DIS ballots
- AHG 7 JTC21 joint development review
- JWG 2 Joint Working Group ISO/IEC JTC1/SC 42 - ISO/IEC JTC1/SC 7: Testing of AI-based systems
- JWG 3 Joint Working Group ISO/IEC JTC1/SC42 - ISO/TC 215 WG: AI enabled health informatics
- WG 1 Foundational standards
- WG 2 Data
- WG 3 Trustworthiness
- WG 4 Use cases and applications
- WG 5 Computational approaches and computational characteristics of AI systems

The AHGs and JWGs (Joint Working Groups) demonstrate, in which important areas of interest joint activities with other standardization groups are necessary because of overlapping topics (domain, field of interest). Most important are the evolving standards of WG 1 (Foundational) and WG 3 (Trustworthiness, covers all relevant stakeholders' interests, and include safety, security, dependability, performance etc., depending on the application).

SC42 has published already 16 ISO/IEC standards under its own responsibility and is developing (in different stages of development) 25 standards.

The most relevant published standards in context of AI4CSM are (Big Data Standards not considered here):

Foundational, concepts, Use cases:

- ISO/IEC 22989:2022 (published)
  Information technology — Artificial intelligence — Artificial intelligence concepts and terminology
- ISO/IEC DIS 42001 (under development)
  Information technology — Artificial intelligence — Management system
- ISO/IEC DIS 5338 (under development)
  Information technology — Artificial intelligence — AI system life cycle processes
- ISO/IEC TR 24030:2021 (published) (currently under revision as NWIP!)
  Information technology — Artificial intelligence (AI) — Use cases
- ISO/IEC DIS 5392 (under development)
  Information technology — Artificial intelligence — Reference architecture of knowledge engineering
- ISO/IEC CD 5339 (under development)
  Information Technology — Artificial Intelligence — Guidelines for AI applications
- ISO/IEC 24668:2022 (published)
  Information technology — Artificial intelligence — Process management framework for big data analytic

Trustworthiness, Decision making, Bias, Robustness:

- ISO/IEC CD TR 5469 (under development)
  Artificial intelligence — Functional safety and AI systems
- ISO/IEC TR 24027:2021 (published)
  Information technology — Artificial intelligence (AI) — Bias in AI systems and AI aided decision making
- ISO/IEC TR 24028:2020 (published)
  Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence
- ISO/IEC TR 24029-1:2021 (published)
  Artificial Intelligence (AI) — Assessment of the robustness of neural networks — Part 1: Overview
- ISO/IEC AWI 42005 (under development)
  Information technology — Artificial intelligence — AI system impact assessment
- ISO/IEC DIS 24029-2 (under development)
  Artificial intelligence (AI) — Assessment of the robustness of neural networks — Part 2: Methodology for the use of formal methods
- ISO/IEC 23894 (under development)
  Information technology — Artificial intelligence — Guidance on risk management
- ISO/IEC AWI TS 12791 (under development)
  Information technology — Artificial intelligence — Treatment of unwanted bias in classification and regression machine learning tasks

- ISO/IEC AWI TS 8200 (under development)
  Information technology — Artificial intelligence — Controllability of automated artificial intelligence systems

Computational approaches:

- ISO/IEC TR 24372:2021 (published)
  Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems
- ISO/IEC AWI TR 17903 (under development)
  Information technology — Artificial intelligence — Overview of machine learning computing devices

Machine Learning:

- ISO/IEC 23053:2022 (published)
  Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML)
- ISO/IEC TS 4213:2022 (published)
  Information technology — Artificial intelligence — Assessment of machine learning classification performance
- ISO/IEC DIS 8183 (under development)
  Information technology — Artificial intelligence — Data life cycle framework
- ISO/IEC AWI TS 6254 (under development)
  Information technology — Artificial intelligence — Objectives and approaches for explainability of ML models and AI systems
- ISO/IEC AWI 5259-5 (under development)
  Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 5: Data quality governance
- ISO/IEC CD 5259-4 (under development)
  Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 4: Data quality process framework
- ISO/IEC CD 5259-3 (under development)
  Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 3: Data quality management requirements and guidelines
- ISO/IEC CD 5259-2 (under development)
  Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 2: Data quality measures
- ISO/IEC CD 5259-1 (under development)
  Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 1: Overview, terminology, and examples

Software Quality, testing, V&V:

- ISO/IEC AWI TS 29119-11 (under development)
  Software and systems engineering — Software testing — Part 11: Testing of AI systems
- ISO/IEC AWI TS 17847 (under development)
  Information technology — Artificial intelligence — Verification and validation analysis of AI systems
- ISO/IEC DIS 25059 (under development)
  Software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Quality model for AI systems
- ISO/IEC AWI TS 25058 (under development)
  Software and systems engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guidance for quality evaluation of AI systems

Ethical aspects, governance, "Green Deal":

- ISO/IEC TR 24368:2022 (published)
  Information technology — Artificial intelligence — Overview of ethical and societal concern
- ISO/IEC 38507:2022 (published)
  Information technology — Governance of IT — Governance implications of the use of artificial intelligence by organizations
- ISO/IEC AWI TR 20226 (under development)
  Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems
- ISO/IEC AWI 12792 (under development)
  Information technology — Artificial intelligence — Transparency taxonomy of AI systems

The structuring should support identification of the relevant standard or evolving standard of interest for each SC (Supply Chain). The Link behind the standards ID number leads to the official abstract on the ISO websites for further information. Active members from SC8 may in many cases provide further information about ongoing work and trends.

4.2 Sector-independent Standard on "Functional Safety and AI systems"

Existing functional safety standards like IEC 61508 require rigid assessment and risk/hazard analysis of parts of the systems which may have impact on system safety. Since AI components at the moment (particularly DNN- and ML-based ones) cannot be evaluated and evidence for safety being derived by well accepted methods in the functional safety community it has to be given specific guidance under which circumstances which type of AI driven functions can be used in safety-critical systems.

Since AI is software-dependent (may it be implemented in hardware directly or just in software), ISO/IEC JTC1 SC42, WG03, "Trustworthiness", started together in cooperation with the maintenance team of IEC 61508-3, the basic functional safety standard, SW part, to develop a TR 5469 "Functional safety and AI systems". The approach taken, in short, was to classify AI technology classes and usage classes. The following figure tries to map these and provide recommendations:

AI Technology Classes

Class I developed and reviewed using existing functional safety methods and standards,

Class II cannot be fully developed and reviewed using existing functional safety methods and standards, but it is still possible to identify a set of available methods and techniques satisfying the properties (e.g., additional V&V).

Class III cannot be developed and reviewed using existing functional safety methods and standards and it is also not possible to identify a set of available methods and techniques satisfying the functional safety properties.

AI Application and Usage Classes

A1: Used in safety relevant E/E/PE system and automated decision making possible.

A2: Used in safety relevant E/E/PE system and no automated decision making (e.g., for uncritical diagnostics).

B1: Used to develop safety relevant E/E/PE systems (offline support tool). Automated decision making of developed function is possible.

B2: Used to develop safety relevant E/E/PE systems (offline support tool). No automated decision making of the developed function is possible.

C: AI technology is not part of a safety function in the E/E/PE system. Has potential indirect impact on safety (e.g., increase demand placed on a safety system)

D: AI technology is not part of a safety function in the E/E/PE system. No impact on safety due to sufficient segregation and behavior control.

<table>
<tr><th>AI Technology Class => AI application and usage level</th><th>AI technology Class I</th><th>AI technology Class II</th><th>AI technology Class III</th></tr>
<tr><td>Usage Level A1 (1)</td><td rowspan="5">Application of risk reduction concepts of existing functional safety International Standards possible</td><td>Appropriate set of requirements (5)</td><td rowspan="5">Not recommended</td></tr>
<tr><td>Usage Level A2 (1)</td><td>Appropriate set of requirements (5)</td></tr>
<tr><td>Usage Level B1 (1)</td><td>Appropriate set of requirements (5)</td></tr>
<tr><td>Usage Level B2 (1)</td><td>Appropriate set of requirements (5)</td></tr>
<tr><td>Usage Level C (1,3)</td><td>Appropriate set of requirements (5)</td></tr>
<tr><td>Usage Level D (2)</td><td colspan="3">No specific functional safety requirements for AI technology,
but application of risk reduction concepts of existing functional safety International Standards (4)</td></tr>
<tr><td colspan="4">1 Static (offline) (during development) teaching or learning only
2 Dynamic (online) teaching or learning possible
3 AI techniques clearly providing additional risk reduction and whose failure is not critical to the level of acceptable risk.
4 Additionally, other safety aspects (not being addressed with functional safety methods) can possibly be adversely affected by AI usage.
5 The appropriate set of requirements for each usage level can be established in consideration of Clauses 8, 9, 10 and 11. Examples are provided in Annex B.</td></tr>
</table>

Figure 7: Recommendations for usage of AI Technology Classes in certain Usage Levels

This DTR 5469 is already in an advanced stage, but still not a published TR, so this is just information for research.

4.3 Safety and Artificial Intelligence in the Automotive Domain

4.3.1 Automated Driving Systems (ADS)

Being aware of the risk that competing standards in particular (sub-) areas might arise, ISO TC22 SAG (Strategic Advisory Group) initiated an Ad-hoc Group for Automated Driving (ADAG). This resulted in a report ISO /CD TR 4609 “Road vehicles – Report on standardization prospective for automated vehicles (RoSPAV)” [17]. It provides an overview over all relevant standards and recommends coordination between the TC 22 Subcommittees and WGs as well as with TC 204 (ITS Intelligent Transport systems) and TC 241 (Road safety).

Automated Driving Systems (ADS) are the key topic in ISO TC22 SC32 WG13. Based on two earlier documents, the *Whitepaper "Safety first for Automated Driving", 2019, published by an industrial group with APTIV, AUDI, BAIDU, BMW, CONTINENTAL, DAIMLER, FCA, HERE, INFINEON, INTEL and VOLKSWAGEN,* and the resulting ISO TR 4804 *"Safety and cybersecurity for automated driving systems — Design, verification and validation"* led to further developments towards a TS 5083 *"Safety for automated driving systems – design, verification and validation*", which is now after an editing and intensive commenting phase. It covers all road vehicles except motorcycles (but which are included in ISO 26262, Part 12). This preparatory work was already presented by the convenor at (UNECE WP.29/GRVA) Working Party on Automated/Autonomous and Connected Vehicles (11th session), Sept. 27 – Oct. 01, 2021. One part, Annex B of TS 5083, is dedicated to the AI and safety recommendations for automated driving systems (proposed title: Annex B "Safety and cybersecurity for AI – application to automated driving systems").

For AI for Automated Driving Systems as well as for highly advanced ADAS, and in conjunction with decision making with AI, ethical and safety concerns became evident too. Additional to WG13, the conventional safety and cybersecurity standards want to bridge the gap to new technologies and to WG 13 and ISO TC22 SC31 (Extended Vehicle standards) for their next edition, the cycle started just now. These inter-relationships are shown in Figure 8.

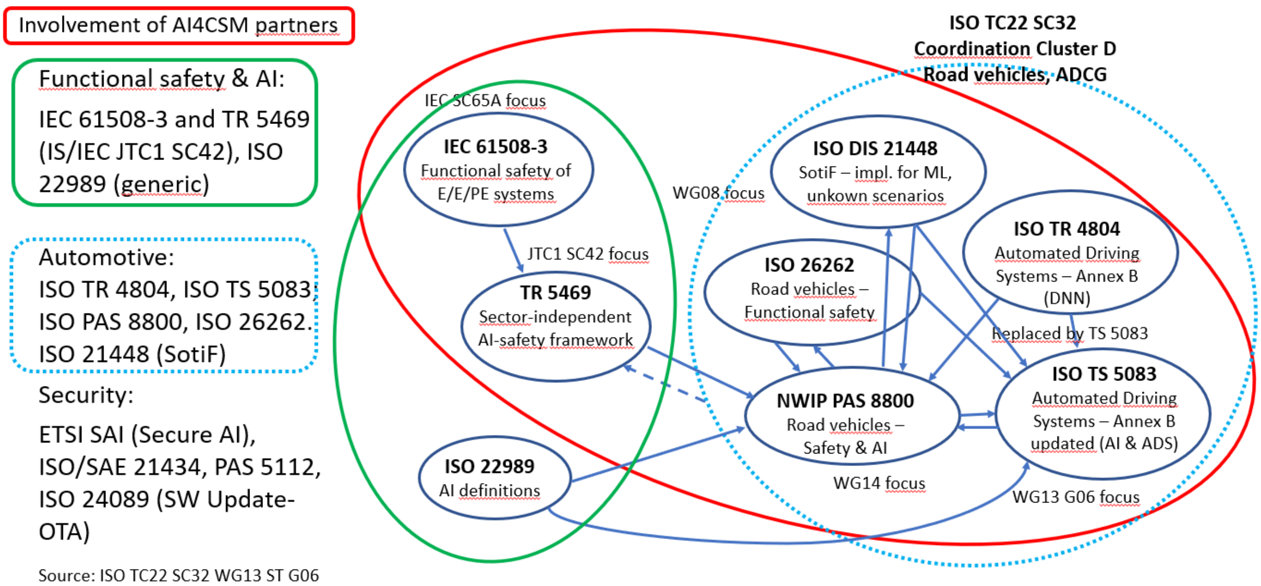

FIGURE 8: INTERRELATIONSHIPS BETWEEN THE CONVENTIONAL ISO SAFETY STANDARDS, AD STANDARDS AND AI-SAFETY STANDARDS (FIGURE 3 REPEATED FOR BETTER READABILITY OF THE SECTION)

To speed up the process of developing TS 5083 on basis of TR 4804 with the necessary extensions and requirements (which are not allowed in a TR), the work was split up into several Sub-groups which later became "Editorial Teams" after some alignment of topics. This process is visualized in Figure 9.

Some of these groups have almost finished their part, but a few topics remained and overlapped between the Editor-Teams. Therefore, three Task Forces started between Editor Teams:

- TF "V&V" (Verification & Validation – handle topics separately or together?)
- TF Harmonization (necessary to clarify overlapping topics and align different clauses)

- TF Cybersecurity: It was decided that Cybersecurity is a cross-cutting issue and has to be handled in each clause where relevant and not in a chapter on its own; the TF should align these efforts) – this is particularly relevant in case of ADS with external connections.

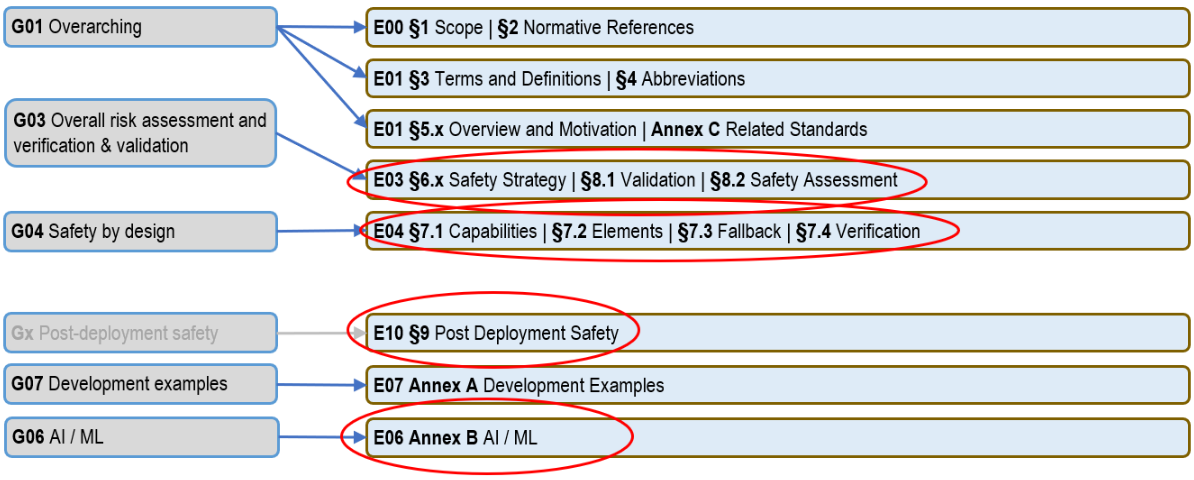

FIGURE 9: SUB-GROUPS AND EDITOR TEAMS FOR TS 5083 DEVELOPMENT (RED: OF MAJOR AI4CSM INTEREST)

The Post-Deployment Safety is an essential contribution and differs from the functional safety standards for conventional vehicles – we have to learn also from experiences in the field, from incidents of all kinds. This is also very well expressed in the EU Regulation 2022/1426 (see 3.6).

4.3.2 Safety and AI for Automation of (conventional) Road Vehicles

In the course of further development of the ISO 26262-series (Edition 2, 2018) towards Edition 3, several subgroups have been created, standardizing particular aspects of functional safety including new technology and automation of road vehicles. For AI application in most types of motorized road vehicles (except mopeds) ISO 26262 is the basis for functional safety (ISO TC22 SC32 WG08). For the additional AI aspects, which have not been treated in ISO 26262, a WG 14 was founded for the AWI (Approved Work Item) PAS 8800 "Safety and AI", covering all aspects of AI in automated vehicles, except particular aspects of Automated Driving Systems, which are tackled in ISO TS 5083.

Similar to TS 5083, the topics have been split between different Sub-Teams. The resulting sub-teams, after an initial discussion phase, are now:

- ST01 – Concepts and Definitions (PAS 8800 first meeting December 07, 2021)
- ST02 – Scoping
- ✓ ST03 – Functional Safety and SOTIF
- ✓ ST04 - Safety Lifecycle
- ✓ ST05 – Definition of safety-related properties of AI *(Kick-off June 10, 2022!!)*
- ✓ ST06 – Selection of AI techniques and design-related considerations *(Kick-off June 8, 2022!!)*
- ✓ ST07 – Data related considerations
- ✓ ST08 – Verification, Validation and Safety Analysis *(Kick-off July 7, 2022!!)*
- ✓ ST09 – Measures during operation and continuous assurance *(Kick-off June 14, 2022!!)*

The Sub-Teams (ST) where AI4CSM are participating and contributing, are marked (ST03 – ST09). AI4CM partners have taken part in most of the Sub-Teams from the very beginning, under the conditions already explained before for TS 5083.

5 Interrelationship of Supply Chain and Use Case Requirements with SC8

The following subsections collect the information derived from Supply Chain and use case contributions and requirement documents.

Three of the eight Supply-Chain Teams of AI4CSM are innovating different, AI enhanced, key subsystems to enable not only next levels of automotive automation but also new traffic optimization aspects:

- SC4 (Robust Propulsion System for Shared Connected Mobility)
- SC5 (Connectivity and Cognitive Communication)
- SC6 (AI-Enabled Perception and Sensor Fusion)

In the course of three further Supply Chains, subsystems will be integrated into higher system levels:

- SC1 (Smart Connected Shared Mobility for Urban Area)
- SC2 (EV5.0 car with AI based functions)
- SC3 (highly automated L3 driving) activities, those

SC7 (AI-Based Methods, Simulation and Virtualization) covers as enabler the complete technology field around AI-based methods, processes and tools (digital twins, learning, scene interpretation and manipulation, data analysis, AI at the edge).

SC8 is the "European Value enabler", evaluating AI4CSM work and results against the "Green Deal", Ethical and Societal concerns and guidelines, and the use of, contribution to and involvement in standardization.

5.1 List of Supply Chains and Use cases

SC1 - *Smart Connected Shared Mobility for Urban Area*

- ***SCD 1.1: Lessons-learned based (critical scenario) update of ADAS/AD Controller (lead: AVL)***
- ***SCD 1.2: Robo-taxi (lead: ViF)***
- ***SCD 1.3: Virtual city routing (lead: OTH)***

SC2 – *Electric Vehicle EV 2030 by AI inside*

- ***SCD 2.1: EV5.0 vehicle with real-time AI-based fault detection, analysis and mitigation (lead: MBAG)***

SC3 – *Functional integrated highly automated L3 driving*

- ***SCD 3.1: Demo vehicle to demonstrate L3 automated with a Driver's Monitoring System (lead: UNIMORE)***
- ***SCD 3.2: L1e vehicle with natively integrated telematics (lead: FEDDZ)***

SC4 – *Robust Propulsion System for Shared Connected Mobility*

- ***SCD 4.1: AI controlled redundant powertrain (lead: ZF)***
- ***SCD 4.2: AI accelerated powertrain control (lead: IFAG)***
- ***SCD 4.3: Intelligent battery by AI (lead: FHG)***
- ***SCD 4.4: Safety power management IC (lead: IFI)***
- ***SCD 4.5: Wireless Charging Enhanced by AI (lead: TUD)***

SC5 – *Connectivity and Cognitive Communication*

- ***SCD 5.1: Proof-of-concept communication platform (lead: TTTAuto)***

- ***SCD 5.2: Proof-of-concept demonstrator novel wireless data transmission (edge/cloud) (lead: IFAG)***

SC6 – ***AI-Enabled Perception and Sensor Fusion Platforms***

- ***SCD 6.1: Perception and vehicle intelligence platform (lead: NXPN)***
- ***SCD 6.2: Neuromorphic sensor fusion (lead: IMEC)***
- ***SCD 6.3: Affordable AI-enabled perception (lead: SINTEF)***
- ***SCD 6.4: Localization and 3D mapping (lead: BUT)***
- ***SCD 6.5: 3D Time of Flight with Aurix PPU (lead: IFAG)***

SC7 – ***AI-Based Methods, Simulation and Virtualization***

- ***SCD 7.1: Enriched virtual models based on standardized real-world data (lead: AVL)***
- ***SCD 7.2: Virtualized time and latency critical AI processes on the in-car computing platform (lead: TTTech)***
- ***SCD 7.3: AI based simulation and virtualization for multimodal mobility for virtual Smart Cities (lead: AIDG)***
- ***SCD 7.4: Reinforced virtual learning for real world driving (lead: EDI)***

SC8 – ***Impact Green Deal, Standardization, Certification, Ethical Aspects*** **(European values creation and evaluation)**

- ***SCD 8.1: Green Deal (AIT & TUD, all)***
- ***SCD 8.2: Standards (AIT, all)***

5.2 Detailed information on visions and objectives with respect to Green Deal, Ethical Concerns and Standards/Standardization Activities

This section contains detailed considerations on the relationship of Supply Chains and Use cases to SC8 (Green Deal and Ethical concerns) and to standardization. Most of it was already identified in Year 1, D1.8. A few new aspects are added became visible during the last 6 months since the review in June 2022.

5.2.1 SC1 – Smart Connected Shared Mobility for Urban Area

5.2.1.1 Vision

Enable a safe, efficient and green autonomous mobility in urban areas trough connected mobility.

- ***Safe***: safety enhancement via cooperative integration of cloud knowledge into edge perception and vehicle intelligence solutions
- ***Efficient***: maximize traffic throughput with minimum latency time together with minimizing active cars in urban environments
- ***Green***: consideration of shared resources for minimizing energy consumption

5.2.1.2 Key Objectives with respect to SC8 interrelationship:

- ***Trustworthy AI & Connected Services*** *(Link to SC7)*
    - Edge and cloud trustworthy AI technologies, application of new verification and validation technologies
- ***Perception and vehicle intelligence*** *(*Link to SC6)
    - <u>Edge:</u> semantic occupancy grid, static & dynamic objects, lane markings, traffic monitoring, charging station monitoring, local decision making and motion planning
    - <u>Cloud:</u> fusion of edge perception results → digital twin, city routing based on Digital Twin → minimize latency & maximize traffic flow considering shared resources (e.g. charging points)

- ***Sustainability & Green Deal*** *(Link to SC8)*
    - Explore technologies to reduce the carbon footprint and to make mobility as a service available to everyone. City routing for large numbers of vehicles reduces the CO2 emission of every single vehicle, digital twin of the traffic environment enables a better understanding of the traffic flow reducing the energy consumption of city cars

5.2.1.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 1.1: Lessons-learned based (critical scenario) update of ADAS/AD Controller (lead: AVL)***
- ***SCD 1.2: Robo-taxi (lead: ViF)***
- ***SCD 1.3: Virtual city routing (lead: OTH)***

With demonstrator SCD1.3 **"Virtual City Routing"** Supply Chain 1 features a demonstrator, which is directly dedicated to EU Green Deal objectives.

- A cloud-based routing service is developed, which provides efficiency-optimized routes considering on the one hand classical routing parameters like velocities, height profiles, curves and on the other hand dynamic changes of the environment (based on digital twins) and electric vehicle specific parameters like range, charging times and charger positions. Providing energy optimized routes, this service directly addresses **"Pillar Two" of the AI4CSM work implementing EU Green Deal: "Reduction of mobility-based emissions (use phase)".** Beyond the scope of classical routing, the developed service provides cooperative routing for fleets of electric vehicles based on geofencing and smart charging in in urban areas with a limited number of chargers. The technology optimizes the overall traffic throughput, addressing directly **"Pillar Three" of the AI4CSM work implementing EU Green Deal: "Reduction of system-based emissions (infrastructure and congestion related)".**
- A promising application of the virtual routing service is the **"Robo-taxi demonstrator"** (SCD1.2). The demonstrator at his own is intended to boost shared urban mobility by increased availability and efficiency based on the advantages of autonomous operation. Shared mobility features huge potential, especially in urban areas, to reduce the number of cars, both parking and driving. A significant reduction of the number of cars enables either revitalization of sealed surfaces, or utilization of additional areas for pushing zero-emission mobility like bicycles, or further maximize traffic throughput, for public and shared electric transportation, addressing again **"Pillar Three"**.
- Beside this aspect the combination of fleet-based energy optimized routing and shared mobility, further pushes the attractiveness of shared mobility, enabling a cloud-based efficiency- and throughput optimized operation, which reduces the latency of shared mobility.
- The requirements of SC1 defined in Task 1.1 and documented in Deliverable D1.1, focus on a technological level of the defined systems, modules and components (SCD1.1). The requirements mark the way towards substantial and valuable results of the demonstrators on technological level. However, as shown above, the overall motivation of the defined use cases, is strongly driven by Green Deal Objectives. As the success with respect to the Green Deal Objectives directly depends on the success on technological level, the compliance of the developed systems with the defined requirements consequently indirectly marks the way towards the successful implementation of the Green Deal Objectives within Supply Chain 1.

- From the standardization perspective, the Automotive Standards worked on in ISO TC22 SC32 WG 08 (Functional safety), WG 14 (AI and safety) and WG 11 (Cybersecurity engineering) are preconditions on single, human-controlled vehicle level. Their fulfillment is assumed by the work in WG 13, ADS (Automated Driving Standards, TS 5083), which concentrate on the connected and automated driving functions for the high SAE levels. Of particular interest are the sub-groups on AI & ML (ET06), Post-deployment (ET10, covering the operational, maintenance and disposal phases), and the risk-based considerations (ET04, ET03). Here some input to the potential application of evolving standards, and feedback for the standardization process, is expected (note: several AI4CSM partners are active in these groups).
- For the resource-saving implementation concerning traffic optimization, routing, and shared mobility in urban areas, ISO TC 204 (ITS) and "Smart City"-Standards (ISO/IEC JTC1 WG 11) are considered as relevant and will be observed.
- Ethical guidelines and concerns are relevant in context of AI-based decision making, particularly for protection of VRUs, freedom of choice of driving mode for humans, privacy, and fair scheduling in case of fleet management. How far this becomes relevant for the selected demonstrators has to be studied.
- **Digital Twin standards** are managed in ISO TC184 ("Industrial data, SC4") and ISO/IEC JTC1 SC41 "Internet of Things and Digital Twin", and "Smart Manufacturing Standards" (IEC TC65). The standardization landscape on "Digital Twin" and "IoT" is depicted in Figure 10. An overview on IoT and Digital Twin standards in ISO, IEC. ISO/IEC JTC1 SC41 is provided in **"AIOTI - High Priority Edge Computing Standardisation Gaps and Relevant SDOs"** (see References)

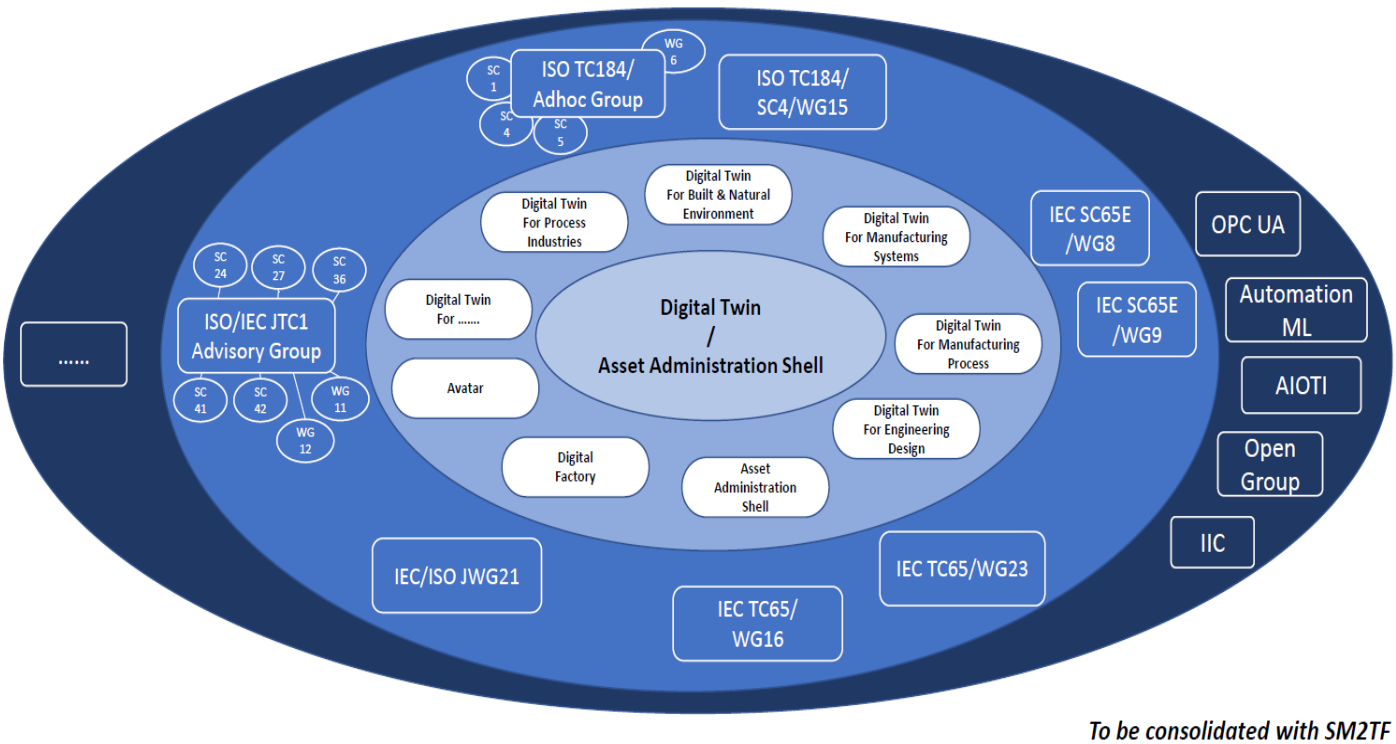

FIGURE 10: DIGITAL TWIN ECOSYSTEM (FOR ALL INDUSTRIES) (TASK FORCE SMART MANUFACTURING STANDARDS MAPPING)

- SC1 is applying and testing tools on **ASAM Standard "OpenDRIVE"**. ASAM (Association for Standardization of Automation and Measuring Systems) is one of the industrial associations mentioned at the beginning of this documents who contribute with particular standards to the automotive standardization landscape. OpenStreetMap has a lot of useful street information, but this has to be converted to the OpenDRIVE format. Three converters have been studied (Osm2xodr, Osm2opendrive, Carla). Each of them has Pro's and Contra's (deficiencies). The OpenDRIVE file format 1.7 misses also important variables. Conclusions and solutions will be published in SC1 deliverables.

5.2.2 SC2 – Electric Vehicle EV 2030 by AI inside

5.2.2.1 Vision

SC2 vision of this SC is the development of an EV5.0 car with AI based fault- detection, analysis and mitigation for the powertrain in real time operation, making use of 5G and cloud capabilities and integrating available sensor fusion/perception by utilizing the next generation AURIX platform that is based on multicore processors and PPUs/GPUs for cognitive and AI systems implementation.

The intelligent edge will provide a better decision basis for operability, efficiency, availability as well as it increases the system safety. Health monitoring is pivotal to ensure highest availability of all components in the powertrain. This will be supported by intelligent cloud data to achieve preventive maintenance, detection of generic abnormalities, ruleset for 24/7 availability. The real time powertrain operation data is the basis for intelligent data fusion, clustering and reduction of the data to feed the cloud with a condensed basis for learning and decision making.

5.2.2.2 Key Objectives with respect to SC8 interrelationship:

SC2 is targeting the integration of an improved intelligent electric propulsion systems for 24/7 use with less power consumption and with predictive (and remote) diagnosis and demonstration in an electric vehicle:

- A highly efficient powertrain, affordable due to new semiconductor material, will save energy needed for mobility and transport.
- Higher reliability and availability of an electric powertrain will increase consumer´s acceptance.
- AI-enabled predictive diagnosis will allow for 24/7 operation and for trustworthy green mobility.
- Adaptive/connected powertrain control strategies will enable novel HAD functionalities like platooning and inter-traffic mobility optimization.
- AI enhanced battery management system will reduce the stress on the battery and increase its durability.

5.2.2.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use case:

- ***SCD 2.1: EV5.0 vehicle with real-time AI-based fault detection, analysis and mitigation (lead: MBAG)***

The targets of the technology developments are addressing safety, maintainability and trustworthy green mobility by energy saving, battery management and transport optimization (platooning, inter-traffic optimization). Ethical aspects ad privacy issues may become of interest in context of highly automated driving functionalities (platooning, inter-traffic optimization, where data related to driver behavior may be collected). Positive with respect to societal concerns is the expected increase of consumer's (public in general) acceptance. These aspects have to be studied and monitored for evaluation.

From the standardization point-of-view, ITS standards (ISO TC 204) like ISO DIS 4272 (under development) "Intelligent transport systems — Truck platooning systems (TPS) — Functional and operational requirements" are of interest to be observed. This is a pre-autonomous truck ADS standard. This issue is also handled as part of ISO TS 5083, Autonomous Driving Systems, in ET07 (Development examples, including the "Trucks and busses" topic) and ET10 (post-deployment). Additionally, new working groups in the ISO 26262 group (WG08, see 3.4.1) on "**TR 9839 Road vehicles — Application of predictive maintenance** to hardware with ISO 26262-5" and "**For New Energy Vehicles**" may have or need contributions. From the AI-Standardization scenario, quality and robustness aspects (see 4.1) may have some importance to look at.

5.2.3 SC3 – Functional integrated highly automated L3 driving

5.2.3.1 Vision

The proposed SC is aligned with the Major Challenge 3 (e.g., managing interaction between humans and vehicles) described in the Transport and Mobility Chapter of the ECSEL JU MASP. In particular, the focus is on the **coexistence** of humans, "traditionally" operated vehicles, (partially) autonomous systems, and the **dynamic interaction** between them as well as with assistance/infotainment/communication systems and infrastructures. The very **innovative** aspect of SC3 **is the attempt to get, process and provide reliable information to the vehicle well before the driver either sees or perceives the presence of any critical situation.**

Furthermore, autonomous vehicles have to know, in a non-invasive manner, the current status of the "driver" in order to notify adequately if any manual driving action needs to be done. The integration of human feedback in the control loop of the AI-based electronic systems, will enable a so-called "Behavioral Planning" of the vehicle. Hence, the recognition of intentions, cognitive states and emotions of the driver can also bring to a more efficient transition of vehicle control in all those situations where the human intervention is requested (in terms of take-over or shared control). This starts from e.g., the exact seating position and extends to monitoring the vital signs in order to be able to do emergency driving manoeuvres in case of e.g., a sudden sleep attack or a heart attack. Here the new generation of wearable sensing devices can play a role, being interconnected with the vehicle network.

5.2.3.2 Key Objectives with respect to SC8 interrelationship:

This SC targets vehicle demonstrations in the field of multimodal Connected Shared Mobility (CSM) operating in the Modena Automotive Smart Area (MASA) in accordance to the above stated vision with a SAE level 3 passenger car and L1e type. In particular, the passenger car demonstrator will functionally integrate results from technology enabler supply chains (SC4-SC7), thus reaching Autonomous Driving according to SAE Level 3.

Therefor the following objects will be pursued:

- Development of a demo vehicle to demonstrate L3 automated driving on defined use cases and assessed in the real conditions available at the MASA

- Develop an innovative on-board Driver Monitoring System (DMS), including human behavioral aspects, driver style analysis, state of stress analysis and the adaption of the automated driving style relying on wearable devices, RGB/IR/NIR cameras and other sensors (pressure sensitive seat)
- Use of a high-performance embedded computing board to provide enough computational power to fuse data from multiple sensors/sources (enhanced perception) and to run AI/ML to process this data
- Development and validation of a wide range of electronic control systems: telematic on board unit, integrated body motor controller, sensor data fusion platform based on AI-born technologies
- Perform cognitive decisions for vehicle control (potentially AI based)
- Explore 5G connectivity to increase awareness of environment, e.g., in a smart city scenario (e.g., MASA),

5.2.3.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 3.1: Demo vehicle to demonstrate L3 automated with a Driver's Monitoring System (lead: UNIMORE)***
- ***SCD 3.2: L1e vehicle with natively integrated telematics (lead: FEDDZ)***

Highly Automated Driving at SAE Level 3 is not the primary level targeted at by the EC and German Ethical Guidelines on AI, which have been mentioned before, because autonomous decisions are rather punctual at component and lower functional level than in a fully autonomous vehicle.

However, the high level of ADAS support and the Driver Monitoring System raise ethical concerns with respect to privacy and human factors/ergonomics, including appropriateness of visualization and signaling to the driver, and the driver's distraction aspect, which can be a severe issue for safety also if information flow is to high or unstructured. In ISO TC22 SC39, standards have been developed for conventional applications, and the TC is also working now in cooperation with the other ADS groups in the ISO ADCG (Automated Driving Coordination Group) on HAV (Highly Automated Vehicles) requirements. The same is valid, e.g., for PAS 8235 in SC39, "PAS 8235 - Taxonomy and definitions for terms related to adaptive in-vehicle information systems" and other related standards. For sensor integration for automated driving, ISO TC22 SC31 WG09 "Sensor data interface for automated driving functions" is developing specifications, besides other groups already mentioned in the Section on Standardization of this document. A short review is planned on the possible impact of this standardization areas on SC 3 work. The AI standards of ISO/IEC JTC1 SC42, WG03, are in any case relevant to fulfill for safety, security and trustworthiness of the functions provided, e.g., in case of ML to avoid unwanted bias, to achieve robustness, controllability and to fulfill the UNECE Regulations on cybersecurity.

5.2.4 SC4 – Robust Propulsion System for Shared Connected Mobility

5.2.4.1 Vision

EVs will be an important part of future mobility concepts. They share data with the cloud and use off-board services for route planning, traction control and traffic optimization, ref. to SC1.

Through the **use of new AI-based approaches in the propulsion and power supply system**, AI4CSM will realize systems that can **continually adapt their operating envelope just as a human driver would**. Furthermore, upcoming **failures or safety hazards can be detected and avoided** before critical situations occur.

The partners of **SC4 will integrate cognition into the propulsion and power supply system** as a mean of delivering greater efficiency, reducing battery size, weight, and environmental impact, increasing driving comfort, and control safety as well as to use AI supported sensing technologies to increase the safety of wireless charging in public spaces.

Both the developed AI techniques for the battery system and AI controlled powertrain will be provided to SC2 for implementation and demonstration in a demonstrator vehicle.

5.2.4.2 Key Objectives with respect to SC8 interrelationship:

Objectives

In order to pursue the stated vision, the partners of SC4 are working on HV- and LV-components of the EV power train. For each of the components specific research targets in form of objectives are defined.

The **first objective** is the **development of a fail-operational powertrain architecture to elaborate a powertrain with inherent redundant elements and high efficiency**. This will be realized by researching a GaN powered 3-level inverter and evaluating it against state-of-the-art Si-/SiC-inverters with 3- or 6-phase configurations. The electric motor will be equipped with additional sensors like vibration sensors. The power distribution system will be enhanced to integrate additional information sources for health monitoring.

The **second objective** is to develop **in-situ diagnosis concepts** for failure detection and ageing of the **powertrain components**, either by novel sensors (high accurate and fast angle sensors and current sensors for di/dt extraction) or by sophisticated signal processing (e.g., switching time measurement) supported by new high-speed sensor interfaces enabling to switch into de-rated driving modes before failure occur or to prevent secondary damage after sudden events like arcing.

The **third objective** is the development of **a Cognitive Diagnostic** is to equip the vehicle propulsion with a system which deals with faults or upcoming **faults** which are **hardly recognizable** by classical approaches. This will lead to improved failure diagnosis and more reliable control strategy and reduce the number of additional sensors. It will be enabled by high-speed sensors equipped with high-speed interfaces providing low latency and sufficient data in a short timeframe for following processing. AI approaches like e.g., particle swarm optimization (PSO), ant-colony optimization (ACO) will be used to train an ANN for the correct detection of the faults which are hard to distinguish with conventional analytical approaches, but which require the different treatment. The off-line trained ANN will by validated in real-time on a test bench.

The **fourth objective** of this SC is to develop **Nonlinear model predictive control (NMPC-)algorithms** for the energy efficient propulsion system control. The power efficiency and control performance will be compared with the vector control algorithms which are nowadays commonly used in motor control applications. Cognitive diagnostics and anomaly detection will also be covered with regard to the electrical energy storage system as vital part of any fail-operational drive train. Integrating technical background of the battery system (e.g., cell chemistry, system design) as a priori knowledge into AI based anomaly detection and fault diagnostic functionality of a BMS will be a key aspect of the work in SC1.

The **fifth objective** is to **research** the necessary changes on the **powertrain control strategies for HAD functionalities** like platooning. For this the information flow within the vehicle and the chain of vehicles needs to be analyzed. Therefore, a Software in the Loop environment will be developed to tests the effects of different power train control strategies (including AI based strategies) on the different interaction levels.

The **sixth objective** is to develop **AI diagnosis solutions** for monitoring, state estimation and anomaly detection in battery systems. This will lead to improved safety by online detection inside the BMS of safety-critical cell/system failures. A mayor research topic concerns detection capabilities for untrained critical failures. The AI diagnosis functionality will be implemented in a battery demonstrator.

The **seventh objective** is to increase the availability and safety of **wireless chargers** for automated vehicles in public spaces. Therefore, **novel sensor** principles and **AI based** signal interpretation algorithms for the **Foreign Object detection (FOD)** of wireless chargers will be researched. This becomes necessary since none of the currently used FOD systems is capable to full all the stated requirements of the public and manufacture specific standards for fully automated vehicles. Therefore, new sensors based on Time Domain Reflectometry (TDR) principle will be build and corresponding AI based interpretation algorism will be trained and tested. An additional benefit of using the TDR principle is the capability to detect nonmagnetic objects, thus offering the potential to detect living objects.

5.2.4.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 4.1: AI controlled redundant powertrain (lead: ZF)***
- ***SCD 4.2: AI accelerated powertrain control (lead: IFAG)***
- ***SCD 4.3: Intelligent battery by AI (lead: FHG)***
- ***SCD 4.4: Safety power management IC (lead: IFI)***
- ***SCD 4.5: Wireless Charging Enhanced by AI (lead: TUD)***

The following parts of the objectives mentioned above are particularly important in connection with the “Green Deal” and Ethical requirements:

The activities from Supply Chain 4 are leveraging the benefits from new semiconductor technologies and artificial intelligence to improve efficiency and availability of the drive train and so contribute to resource savings. The Gallium-Nitride technology allows for minimal switching losses, comparable to state-of-the-art Silicon Carbide devices, thus allowing saving battery capacity. Furthermore, fabrication of GaN-devices can take place on already established Si-semiconductor production processes, thus potentially reducing the resource consumption of new production lines **(Pillar 1of the “Green Deal” Objectives !!).**

Using methods of artificial intelligence on operational parameters of the electric power train, it is expected to detect anomalies and degradation in an early stage. This creates the opportunity of reacting, e.g., by predictive maintenance, to avoid the occurrence of otherwise unavoidable failures. This will eventually lead to higher lifetimes of components and vehicles. AI in battery management will enhance lifetime and safe resources as well.

Concerning the Societal aspects, the considered technologies will contribute to the attractiveness of electric vehicles to the end customer, helping to promote emission-free mobility itself. Ethical aspects are of minor importance in SC4, since AI is mainly used for technical controls, where safety, cybersecurity, reliability, maintainability, availability and performance are in focus, not ethical aspects of decisions on system level.

Standardization aspects are, besides the generally valid standards for AI trustworthiness and safety, control and diagnostic functions and automotive standards for vehicles as in the other SCs, in particular:

- Advanced Mission Profile Model:
    - In general, it enables to build products closer to their usage. With this, we avoid redundancy, reduce costs, and generate less material that might not be needed.
    - Specifically, IEC 63142 - ELECTRIC COMPONENTS AND ASSEMBLIES RELIABILITY – FAILURE RATE PREDICTION is based on FIDES. This standard considers mission profiles for FIT-rate calculations as well. Because we develop an advanced mission profile model, this can have a potential impact to this standard as well.

Reliability standards / mission profile standards help to avoid overdesign and saves resources.

In the area of ISO 26262 WG08 work, it should be noted that **TR 9968** "Road vehicles — Functional safety — The **application to generic rechargeable energy storage systems for new energy vehicle**" is developed and could provide some insight or contribution (see 3.4.1). Furthermore, there are standards on battery control and monitoring as well as the TR on "New Energy Vehicles" in this group. The most accepted wireless charging standards for vehicles are **SAE (Society of Automotive Engineers) J2954, IEC (International Electrotechnical Commission) 61980 and ISO (International Organization for Standardization) 19363.**

5.2.5 SC5 – Connectivity and Cognitive Communication

5.2.5.1 Vision

SC5 will provide the communication techniques that enable AI-enabled methods to access data from the edge (e.g., cars, infrastructure) and the cloud (e.g., city-model) and fulfil fast, reliable, low-latency data connection. SC1 as output enabler will showcase the results of SC5 apart from the two demonstrators that will be built in this supply chain.

SC5 will follow an end-to-end approach that integrates independent hard- & software elements into a comprehensive platform to improve functionality and to decrease complexity, with focus on:

- **Safe and Secure communication, high data rates and bandwidth** for edge perception and in-car computing power.
- **Novel functionality** for merging of edge perception results with cloud data sources w.r.t. high and secure data connectivity and low latency.
- **Robust and low latency communication** methods for wireless connectivity based on 28 GHz mmW beam forming.
- OEM identity manager for personalized cloud services enabling an improved end-to-end security for **car sharing management**.
- **Edge computing with optimized provisioning** and mapping from tasks to compute resources.

The technologies developed in this SC will based on open interfaces and standards for the respective area and interoperable interfaces when it comes to cloud-based car sharing services.

5.2.5.2 Key Objectives with respect to SC8 interrelationship:

SC05 will evaluate and provide solutions to develop a novel intelligent and efficient V2X communication modular system incorporating the C-V2X as well as novel wireless 5G 28GHz mmW and 5G 3.7GHz radio link communication channels to the edge network. Concepts and methods for virtualized functions will be developed and integrated with the in-vehicle computing, cognition, control, connectivity platforms, to ensure safe, secure and reliable connectivity and interoperability for autonomous vehicle applications.

The V2X architectures will incorporate both on-board and edge infrastructure components to support end-to-end security and include learning capabilities at the edge.

SC05 will integrate the hardware platform with software and methods to demonstrate the capabilities of future communication channels (e.g., in-car, to the edge, to the cloud services) for smart mobility services. A mobile device-based identification reader with V2I connectivity will utilize the OEM identity server. Identity management supported with AI algorithms will aim at personalized secure cloud services for car sharing platforms.

5.2.5.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 5.1: Proof-of-concept communication platform (lead: TTTAuto)***
- ***SCD 5.2: Proof-of-concept demonstrator novel wireless data transmission (edge/cloud) (lead: IFAG)***

The main SC8 related challenges are focused on safety and cybersecurity, with privacy as potential ethical/societal impact. Automotive standards of ISO TC22 SC32 WG11, Cybersecurity engineering and SW-Update, cover this aspect, where there is strong involvement of AI4CSM partners. Particular aspects of V2X communication are covered in a set of ISO/TC204 standards (ITS) and ISO TC22 SC31, "Extended vehicle" (the latter including all information from outside the vehicle to the vehicle), which e.g., have been studied and been contributed to e.g., by some partners which have already been active in the ECSEL project SECREDAS. A new standard is developed by ISO/IEC JTC1 SC27 (Security) and ISO TC22 SC32 WG11 on "Information security, cybersecurity and privacy protection — Security requirements and evaluation activities for connected vehicle devices" (ISO/IEC 5888). A good overview on Cloud and Edge Standards is provided by ISO/IEC TR 23188:2020. Information technology — Cloud computing — Edge computing landscape, besides other standards of ISO/IEC JTC1 SC38 in this area. Partners active in ISO/IEC JTC1 or national mirror committees (e.g., in Austria ASI K001.42) have access to the standards on both groups (AI, Cloud, Security) and are active in these groups, at least observing/monitoring, which should be sufficient for SC8 evaluation.

5.2.6 SC6 – AI-Enabled Perception and Sensor Fusion Platforms

5.2.6.1 Vision

Develop **new scalable AI-enabled platforms and components** for autonomous mobility interconnected with **secure communication** architectures and systems with **perception and sensor fusion building blocks**. The platforms shall provide a new hybrid processing approach to perception, localization, interaction, and data fusion based on cognitive sensors in combination with a scalable hybrid platform architecture concept. Such concepts will enable functional integration, optimization and virtualization while utilizing AI based-processing accelerators such as GPUs, FPGAs, XNNs and CPUs for compute, security and safety tasks while being able to achieve ISO 26262 ASIL-D.

5.2.6.2 Key Objectives with respect to SC8 interrelationship:

The objectives on system level are:

- Develop a platform framework to address scalability, functional integration, virtualization, optimization, software-defined functions by sharing computing resources and connectivity through the fusion of information. Enable load specific and optimized sharing of computing resources composed of a mixture of single- or multi-core CPUs, accelerators, GPUs, FPGAs, NNs, neuromorphic processors, etc.
- The platform framework approach involves distributing intelligence to the perception sensors to facilitate local processing of raw sensor data and implementing a hybrid distributed system architecture that optimizes latency, share the computing resources at the deep edge where data is pre-processed reducing bandwidth requirements, power consumption, expensive cooling systems etc.
- Define the interfaces and communications protocols and topology for optimally and efficiently share data and information in a distributed automotive functional domains environment to achieve improved acquisition and perception capabilities for harsh weather and challenging environmental conditions as well as dynamic situations including unexpected objects.
- Standardization:
  - addressing the standardization activities targeting autonomous vehicles and the perception, sensor fusion AI and safety (e.g., ISO/PAS 21448 (SOTIF))
  - addressing the safety of the intended functionality, ISO 26262 aiming at mitigating risk due to system failure, IEEE P2846
  - addressing the formal model for safety consideration in automated vehicle decision-making as AI adds complexity to autonomous vehicle safety analysis, IEEE P2851
  - addressing data format for safety verifications of IP, SoC and mixed-signal ICs, IEEE P1228
  - address autonomous vehicle software safety throughout the vehicle's life cycle, ISO 12813
  - addressing compliance check communication for autonomous systems, ISO 13141
  - addressing localization augmentation communication for autonomous systems, ISO 22377
  - addressing functional safety for V2V cooperative functions, etc.) (ISO TC204 standards group)
  - Standards in ISO TC22 SC31 WG9, "**Sensor data interface for automated driving functions**", e.g., ISO 23150:2021 - Road vehicles -- Data communication between sensors and data fusion unit for automated driving functions.

5.2.6.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 6.1: Perception and vehicle intelligence platform (lead: NXPN)***
- ***SCD 6.2: Neuromorphic sensor fusion (lead: IMEC)***
- ***SCD 6.3: Affordable AI-enabled perception (lead: SINTEF)***
- ***SCD 6.4: Localisation and 3D mapping (lead: BUT)***
- ***SCD 6.5: 3D Time of Flight with Aurix PPU (lead: IFAG)***

Perception as basis for decision making is critical with respect to some Ethical aspects, depending on how far decision making becomes part of a use case. Therefore, this issue has to be studied separately in context of the details of the implementation of the use cases.

Relevant standardization is already very well described under the SC6 objectives mentioned above; including, some of the referenced standards of SC5, SC1 or SC2, e.g., ISO TC204 (ITS), ISO TC22 SC31 "Extended vehicle" and "Sensor data interface for automated vehicles", evolving TS 5083 (ADS, one group includes, e.g., High-Definition Maps issues) and the AI Trustworthiness standards, may be relevant for SC6 as well. This will be further discussed in the follow-up and during development.

5.2.7 SC7 – AI-Based Methods, Simulation and Virtualization

5.2.7.1 Vision

This SC is the central enabler for AI methods, tools and processes to make AI accountable, available, collaborative, explainable, fair, inclusive, reliable, resilient, safe, secure, trustworthy, and transparent and maintains privacy.

5.2.7.2 Key Objectives with respect to SC8 interrelationship:

The aim of this SC is to use AI for digital twins, learning, scene interpretation and manipulation, data analysis as well to push today's limits while running AI at the edge. We want to reduce the amount of programming through visualization and simulation that is necessary today to automate and test automated driving vehicles. We want to use digital twins based on real world data as well as digitally enhanced real-world data to enable a more software orientated training of automated driving functions. We want to be able to build whole systems and systems of systems that are standardized or open source to exchange data for testing ne AI algorithms and methods, respectively. And we also want to be able to simulate the effects of multimodality on the traffic systems with a very precise representation of individual cities.

- **Development of interoperability as well as standardization between the different systems:** This aspect contains the details for a standardized data transfer incl. the necessary file formats to transfer data from real world driving to the cloud and to enable a subsequent data processing. This real-world data should be suitable to formats like OpenDRIVE (see also SC1).
- **Development of virtualization tools for AI processing at the edge:** The benefits of virtualization are progressing more and more from today's servers, PCs and smartphones into the car. With more powerful in car processing capabilities the use and application of virtualized AI based functions with timing and latency constrains are clearly shall be explored.
- **Development of AI supported real world data virtualization (digital twins):** Build automated and AI enhanced virtualized models of the surrounding that a vehicle passes to use the real-world data for cloud-based training as well as cloud based optimization strategies (multi-modal traffic solutions and improve traffic flow).
- **Develop AI tools with multiple agents with observer elements for improved cooperation:** Intensify the cooperation between multiple traffic partners through novel multiple agent AI techniques in order to improve the possibilities of connected automated driving as well as to improve the applicability of online learning.

5.2.7.3 Relevance for Green Deal, Ethical Requirements and Standardization

Use cases:

- ***SCD 7.1: Enriched virtual models based on standardized real-world data (lead: AVL)***
- ***SCD 7.2: Virtualized time and latency critical AI processes on the in-car computing platform (lead: TTTech)***
- ***SCD 7.3: AI based simulation and virtualization for multimodal mobility for virtual Smart Cities (lead: AIDG)***
- ***SCD 7.4: Reinforced virtual learning for real world driving (lead: EDI)***

One of the most important targets for SC7 was to bring significant contribution to the Green Deal. For that reason, the demonstrators of SC7 were focused to implement the Reduction of product-based emissions (**SC8 Objectives Pillar 1**) and the Reduction of mobility-based emissions (**SC8 Objectives**

Pillar 2). Another reason was to apply methods on virtual visualisation and simulation have been developed to elaborate the CO2 emission in the so called Well to Wheel and Tank to Wheel analysis. Furthermore, different Multimodal Mobility concepts like Busses, Electric-Vehicle, or even Trains, and also UAV have been applied on a virtual simulation platform to calculate the CO2 Footprints. The term Tank-to-Wheel (TTW) refers to a subrange in the energy chain of a vehicle that extends from the point at which energy is absorbed (charging point; fuel pump) to discharge (being on the move). TTW thus describes the use of fuel in the vehicle and emissions during driving, while the term Well-to-Tank (WTT) describes the subrange of fuel supply – from production of the energy source (petrol, diesel, electricity, natural gas) to fuel supply (transport to the charging point or fuel pump). On the other hand, in the era of e-mobility and decarbonization, a comprehensive approach is increasingly favoured which covers the entire energy consumption and all greenhouse gas emissions of a fuel caused by production, supply and use. The generic term that subsumes Tank-to-Wheel and Well-to-Tank is Well-to-Wheel (WTW). New AI based Methods like the Green Munich Agile Concept have been implemented and applied. This new AI based methods helps to have a more exact consideration of the CO2 Footprint of different Multi Modal Mobility concept.

Ethical aspects can be relevant for AI-ML, reinforced learning, if ethically critical decisions could be triggered – an aspect, that should be looked at if relevant in this context.

Standardization complements these considerations: Besides the AI standards already mentioned in other context (AI & ML, Automotive ISO TC22 various WGs on AI application, as well as ISO/IEC JTC1 SC42 on safety and trustworthiness) it is interesting if there could be some input to the new CEN/CLC initiative CEN/CENELEC JTC21 Ad-Hoc Group Report "Green & Sustainable AI" and a potential follow-up as standard. For "Digital Twin" are standards evolving in ISO/IEC JTC1 SC41 (IoT), publications in AIOTI (Alliance for Internet of Things Innovation) and in ISO TC 184 SC4 "Industrial data". For "Smart Cities", the ISO/IEC JTC1 WG11 is the responsible international standardization group.

6 Conclusion

The vision, objectives and the potential impact of all supply chains' works with respect to the SC8 objectives and evaluation topics was analysed. These objectives cover "Green deal" issues (Pillar 1 – 4), Ethical and societal concerns particularly connected with trustworthy AI, and standardization particularly on safety and security (use, involvement, contribution to standards as result of AI4CSM work).

The key requirement is that shared, connected, and highly automated mobility shall not harm ethical, environmental, or social aspects, and not endanger technical safety, security and privacy. Both aspects are essential for public acceptance. The main existing guidelines and recommendations concerning Ethics and Green Deal are identified and referenced already in D1.8. Additionally, (technical) standardization aspects have now been added: on trustworthiness in the general meaning, and particularly with respect to safety and cybersecurity. This analysis, having observed the defined aspects, will not be final -– it is a parallel process to be executed even after the project had been ended. The evaluation of the results has to be done under the same way of understanding risks and limitations. Therefore, some issues have been identified, but their validity to handle them in course of the project, will in some cases be goal of further study and follow-up monitoring the developments in AI4CSM.

Basic standardization activities are common to almost all SCs: ISO/IEC JTC1 SC42 WG3 AI (Trustworthiness, includes one TR on Ethical aspects too), ISO TC22 SC32 (Road vehicles, Safety and cybersecurity standards, Automated Driving Systems TS 5083, including the many subtopics mentioned in the document), ISO TC 22 SC31 ("Extended vehicle" and "Data interfaces for AD"), ISO TC204 (ITS – Intelligent Transport Systems). Additionally, in specific cases, other standards are relevant as well. An overview over the automotive standardization landscape is provided, from different view- points, and with markings where already in the past, now and near future partners are involved. This is prerequisite to be able to capture evolving developments and consider respectively contribute.

SC8 as "European Value Enabler" for the work and results of AI4CSM, depends on contributions from all SCs and partners – the work on the objectives to fulfill cannot be done within SC8 and WP 7.5 (and a few tasks in other WPs), it requires a joint effort to achieve the best results for exploitation. Standardization is a medium-to-long term activity, with schedules beyond the duration of AI4CSM and similar research projects – it needs long term commitment of key partners. Fortunately, in the areas of standardization addressed in AI4CSM, key partners are already active in many of the referenced standardization groups for considerable time and are committed to continue.

7 Annex A – Requirements and Risk Analysis

7.1 Requirements

ID	AI4CSM_WP7_SCD8.1
Name	**"Green Deal" Validation and Evaluation**
Description	Validation and evaluation of the AI4CSM results according to the four-pillar schema
Rationale	Essential for managing development in terms of the goals of the Green Deal (four pillars: reduction of emissions caused by manufacturing, mobility in use, infrastructure & congestion, regulations)
Metrics	Depending on SC targets
Owner	AIT
Reference UC	SCD 8.1
Dependencies	On results of all SCs
Conflicts	none

ID	AI4CSM_WP7_SCD8.2
Name	**Standardization involvement**
Description	Bring forward AI4CSM concepts to standards (ISO TC22 Automotive, Automated Driving, ISO/IEC SC42 (AI, Trustworthiness) and others
Rationale	Essential for managing development in terms of the goals of standardization involvement: awareness raising, use/implementation of standards, influencing standardization, exploiting results of AI4CSM
Metrics	Participation in at least 10 relevant TCs/WGs
Owner	AIT
Reference UC	SCD 8.2
Dependencies	on contributions from all SCs/WPs and partners
Conflicts	none

7.2 Risk Analysis (FMEA)

Requirement	**Validation and evaluation of the AI4CSM results according to the four-pillar schema (SCD 8.1)**
Potential Failure Mode (Risk)	Insufficient/delayed inputs and collaboration by other SCs
Potential Effect of FM	High
Risk Cause	Lack of awareness of impact of results on "Green Deal" objectives (4 pillars)
Risk detection	Monitoring and active participation in other SC and WP meetings
Risk severity	7
Risk occurrence probability	3
Risk detectability	3
Risk Priority number (RPN)	63
Risk mitigation measures	Participation of SC8 lead & partners in SC/WP meetings for collection of required information, starting individual requests as backup
Relevant WPs	all
Risk Caretaker	SC 8
Comments/Risk manifestation examples	

Requirement	**Bring forward AI4CSM concepts to standards (ISO TC22 Automotive, Automated Driving, ISO/IEC SC42 (AI, Trustworthiness) (SCD 8.2)**
Potential Failure Mode (Risk)	Insufficient/delayed inputs and collaboration by other SCs
Potential Effect of FM	Moderate
Risk Cause	Lack of awareness of impact of standardization
Risk detection	Monitoring and active participation in other SC and WP meetings
Risk severity	5
Risk occurrence probability	4
Risk detectability	3
Risk Priority number (RPN)	60
Risk mitigation measures	Early assessment of standardization involvement and interests, Participation of SC8 lead & partners in SC/WP meetings for collection of required information, raising awareness and starting individual requests as backup
Relevant WPs	all
Risk Caretaker	SC 8
Comments/Risk manifestation examples	

7.3 Scoring:

Severity Level	Risk Priority Number	Mitigation Possibility
Disastrous	513 - 1000	Very High
Severe	217 - 512	High
Moderate	65 - 216	Medium
Slight	64 - 9	Low
Insignificant	0 - 8	Improbable

Risk Priority Number (RPN): S x O x D (Severity x Occurrence x Detectability)

Risk Severity:

9 – 10 DISASTROUS The most serious effect of the failure mode would result in Project failure.

7 – 8 SEVERE The most serious effect of the failure mode would result in disruption of one or more of the items in terms of the Project's scope/time/resource definition and require serious reorganization.

5 – 6 MODERATE Failure would result in considerable delays, reworking or reorganization. Some changes to roles and responsibilities may be required.

3 – 4 SLIGHT Failure would cause some minor delays or reorganization.

1 – 2 IRRELEVANT There would be no discernable effect in terms of the Project's end goal.

Risk Occurrence:

9 – 10 HIGH This failure mode is almost certain to occur.

7 – 8 MODERATE There is a moderate possibility for the failure mode to occur.

5 – 6 OCCASIONAL There is a possibility of occasional occurrence of the failure mode.

3 – 4 REMOTE There is a slight probability that the fault will occur.

1 – 2 IMPROBABLE It is unlikely that a fault will occur.

Risk Detectability:

9 – 10 LOW It is impossible or improbable that the technical/organizational failure will be detected.

7 – 8 FAIR The issue is detected only in particular cases.

5 – 6 MODERATE It is probable that the technical/organisational issue will be detected.

3 – 4 GOOD It is highly likely that the technical/organisational issue will be detected.

1 – 2 HIGH It is certain that the risk outcome will be detected.

8 Abbreviations

TABLE 1: ABBREVIATIONS

Abbreviation	Explanation
ADS	Automated Driving System
AI4CSM	Automotive Intelligence for Connected Shared Mobility
AI	Artificial Intelligence
AIOTI	Alliance for Internet of Things Innovation
CD	Committee Draft
CEN	European Committee for Standardisation
CENELEC (CLC)	European Committee for Electrotechnical Standardization
DIS	Draft International Standard
DMS	Driver Monitoring System
DPAS	Draft Publicly Available Specification
DTR	Draft Technical Report
E/E/PE	Electric/Electronic/Programmable Electronics
ETSI	European Telecommunications Standards Institute
ExVe	Extended Vehicle
FDIS	Final Draft International Standard
HAV	Highly Automated Vehicle
HDM	High Definition Map
IACS	Industrial Automation and Control Systems
IEC	International Electrotechnical Commission
IoT	Internet of Things
ISO	International Organisation for Standardisation
ITS	Intelligent Transport System
JTC1	Joint Technical Committee 1 (joint between ISO and IEC on IT)
ML	Machine Learning
NHTSA	National Highway Traffic Safety Administration
NN	Neural Network
ODD	Operational Design Domain (of automated vehicle)
ODT	Dynamic Driving Task (of automated vehicle)
PAS	Publicly Available Specification (Supporting Standards)
RExVe	Time-constrained Road and ExVe Safety
SC	Supply Chain (in AI4CSM)
SC	Subcommittee (in ISO, IEC)
TC	Technical Committee
TDR	Time Domain Reflectrometry
TR	Technical Report (informativ)
TS	Technical Specification (can contain requirements)
UNECE	United Nations Economic Commission for Europe (Road Traffic Regulator)
UNESCO	United Nations Educational, Scientific and Cultural Organization
VRU	Vulnerable Road User
WG	Working Group
WP	Work Package

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