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PowerizeD

Digitalization of Power Electronic Applications within Key Technology Value Chains

Deliverable	**Summary Report on Qualification and Standardization**		
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1.0	Dec 31, 2025		Final Version

Table of contents

1 Publishable summary

Project Acronym	***PowerizeD***
Project Logo	
Project full title	Digitalisation of Power Electronic Applications within Key Technology Value Chains
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Coordinating Entity	Infineon Technologies AG

This document is an update of D4.6.2 (public version of D4.6.1) and provides a general overview about the huge standardization landscape for the manufacturing industry, which is relevant for the various areas of interest of the Use Cases and CDTs (Cross Domain Topics). The update includes the result of a second standardization assessment with focus on the standardization landscape of PowerizeD use cases/CDTs rather than on the partners individual activities and involvements. It broadened the awareness of existing and upcoming standards and facilitates support of partners by information and motivation.

The Standardization Task is a support task for the partners working on Use Cases and Cross Domain topics in the Work Packages. The objectives and methodology applied are explained. Therefore, the first joint activity was to distribute a questionnaire to all partners, and particular to the work package and use case leads, to assess the interest and involvement of partners and their companies/organizations. The result was presented. Only the confidential version D4.7.1 contains a detailed overview of the data provided besides the summary (Annex 2, which is missing in D4.7.2). Further some concrete activities, contacts to standardization committees, dissemination activities with respect to the standardization activities and of internal support are summarized. The next steps as result of the survey was to focus on a second round of questionnaires on Use Cases and CDTs-relevant standards. The result is presented here showing how many activities have been identified. However, standardization is an ongoing activity beyond the duration of a project which lifetime is shorter than standardization life cycles are. The utilization of results in standardization or of standards for the project is indicated in this document.

2 Introduction & Scope

2.1 Handling the Standardization Landscape

The standardization landscape is built and managed by different types of SDOs (Standardization Organizations) and Industrial Alliances. In international standardization of ISO and IEC (and the Joint Committees of ISO/IEC, mainly JTC1 for all IT and ICT-related issues). An overview to provide some impression is given in Figure 1, already ordered by application domains, several of them relevant for PowerizeD:

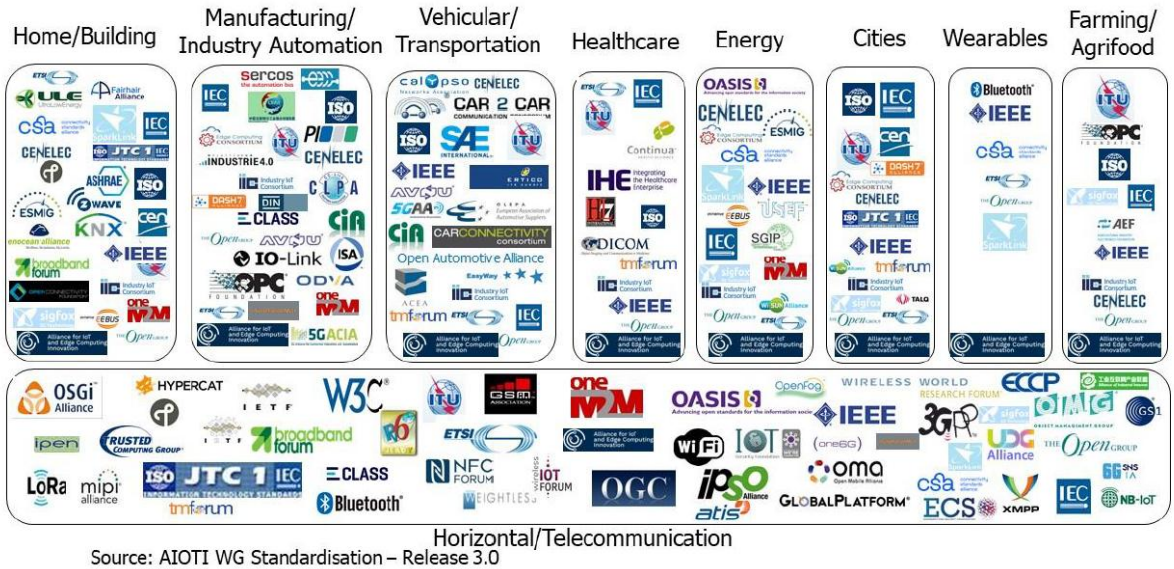

FIGURE 1: INTERNATIONAL STANDARDIZATION ORGANIZATIONS (SDOS) AND INDUSTRIAL/BUSINESS/DOMAIN ALLIANCES

Another approach, particularly important for PowerizeD, is the identification of standardization groups/SDOs according to the application layers:

TABLE 1: APPLICATION LAYERS, CROSS DOMAIN TOPICS AND GROUPS OF STANDARDS

Application Layer	Cross Domain Topic	Groups of Standards
Materials	Substrates, Metallization and Packaging, Intelligent Control, Reliability, Modelling, Artificial Intelligence and software (SW) & hardware (HW) Tools for simulations	Mainly Industrial Alliances, SEMI, OMG,, „de facto standards“ (tools)
Components	Artificial Intelligence, Modelling, and SW & HW Tools for simulations and measurements for components optimization.	AI-Standards ISO/IEC JTC1 SC42, OMG, Industrial Alliances
System	Modelling, Digital Twins, Intelligent Control and SW & HW Tools for simulations and measurements for converters.	ISO, IEC, ISO/IEC JTC1 SC7, ISO/IEC JTC1 SC41
System of Systems	Modelling, Digital Twins, Intelligent Control and SW & HW Tools for simulations and measurements for complex system operation.	ISO, IEC, ISO/IEC JTC1 SC7, ISO/IEC JTC1 SC41

Groups of Standards from different sources are building in some cases clusters and eco-systems and are becoming relevant in complex systems and systems-of-systems applications as a whole, because they are interacting and influencing (impacting) each other. Therefore, a broader view will be more efficient. Examples are:

1) Dependability (see section 4.1)
2) IoT and Digital Twin Eco-System (see following figure):

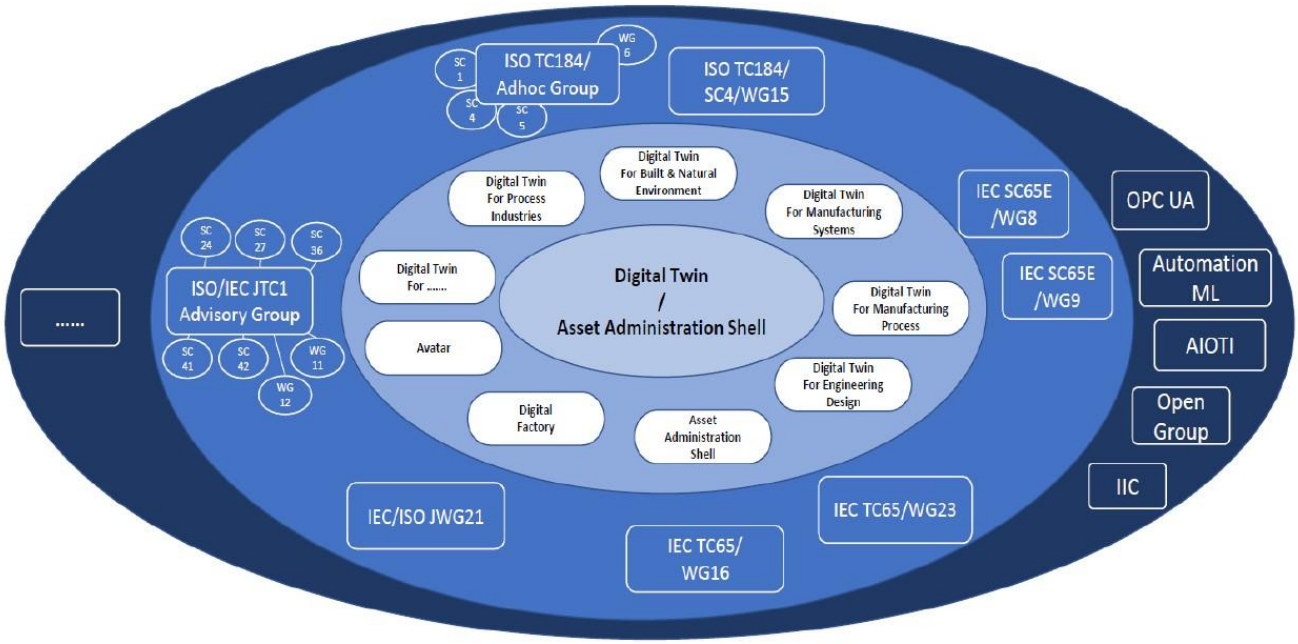

FIGURE 2: IOT AND DIGITAL TWIN ECO-SYSTEM

3) Automotive safety and AI

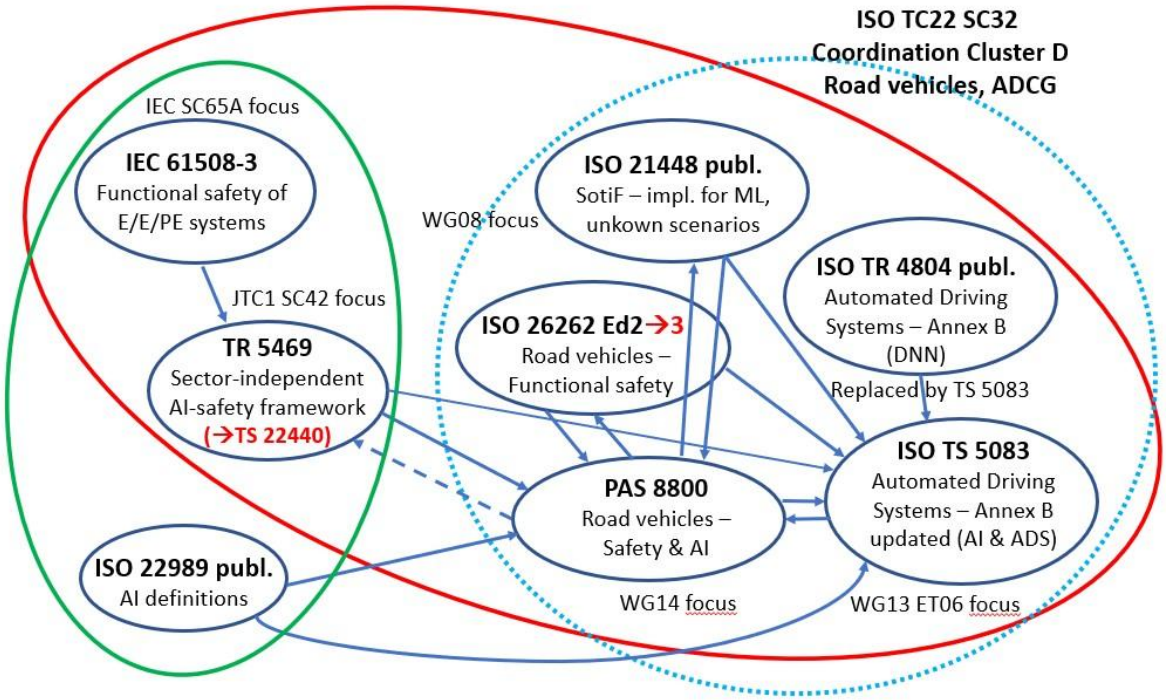

FIGURE 3: CLUSTER AUTOMOTIVE SAFETY AND AI

4) Industrial Standards cluster – many domains and topics to be covered:

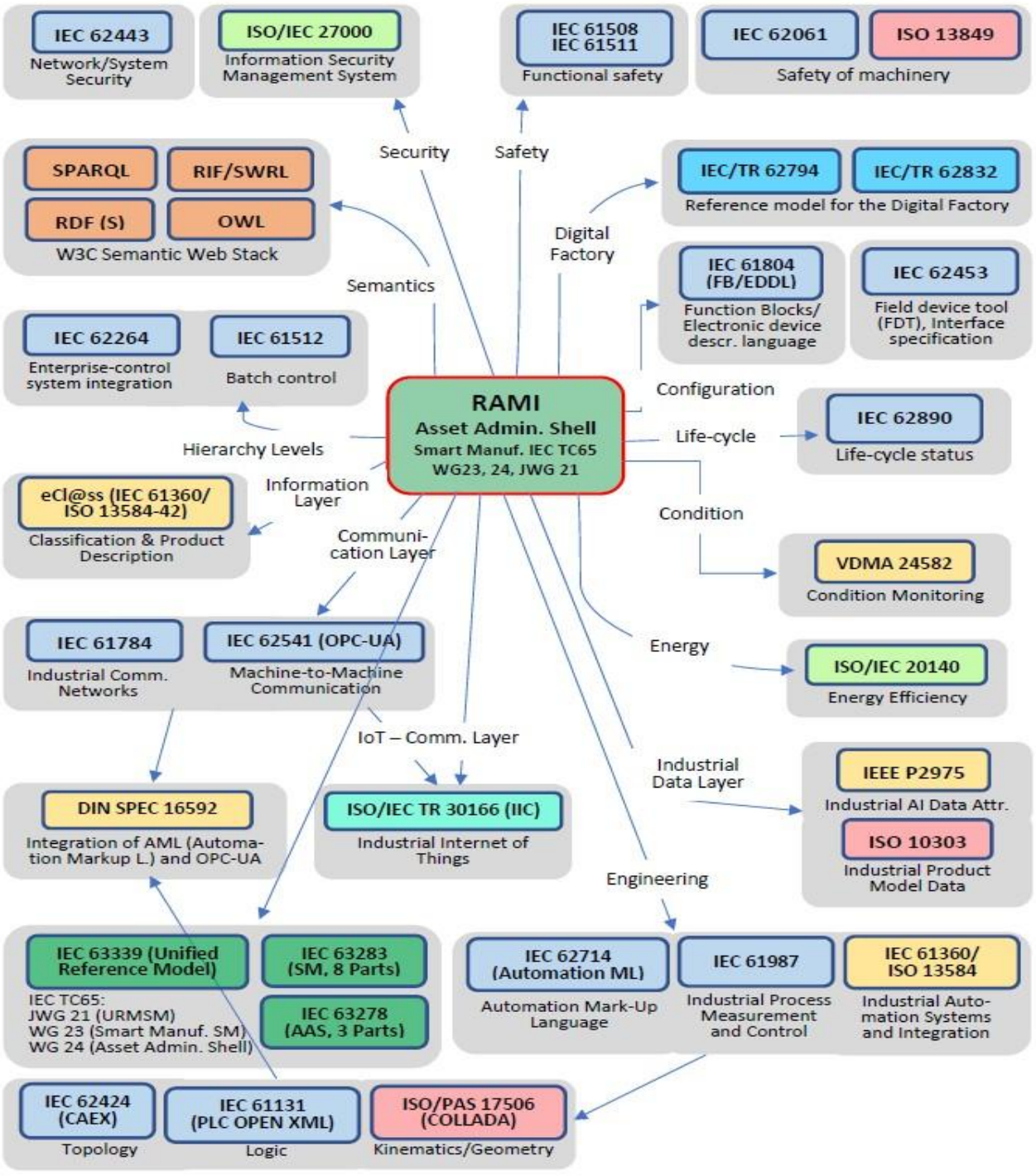

FIGURE 4: CLUSTER OF INDUSTRIAL STANDARDS

5) AI standardization-progressing (too?) fast, AI-Act standardization requests of the EC to CEN/CLC further speeds up activities (CEN/CLC JTC 21):

Note: since Figure 5 was presented in 2025/01, the AI landscape is exploded again: End or the year we have now 41 published standards and 47 under development in ISO/IEC JTC1 SC42 vs. 33/36, and there are others evolving in domain-specific standards in other ISO and IEC committees!!

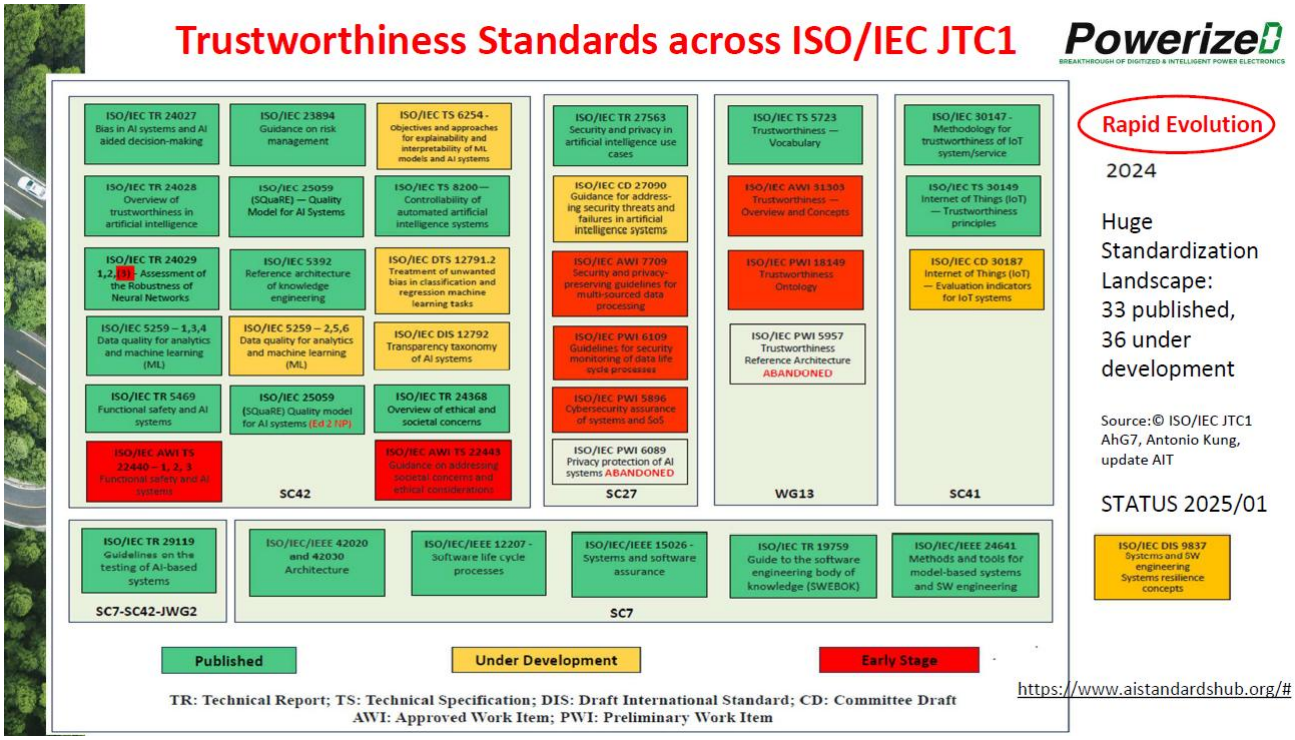

FIGURE 5: AI TRUSTWORTHINESS STANDARDS ACROSS ISO/IEC JTC1 (2025-01)

2.2 The PowerizeD Standardization Task

2.2.1 Objectives:

- **Facilitating the uptake** of the PowerizeD technologies through regulatory alignment and standardization efforts
- Preserving the **public stakeholders' interests** in quality, safety, security, dependability, performance and ethically aligned design, following European Recommendations, Directives and Regulations
- **Raising awareness** for existing and emerging standards and provide information and support in implementation (facilitating “future-proof” developments
- **Support transfer of results** to standardization (project-driven contributions)

2.2.2 Methodology

- Holistic approach to meet major **standardization challenges of the Technology WPs & Use Cases**

- **Analysis of standardization needs of CDTs and UCs vs. involvement of partners in Standardization**
- **Selection** of the proper subsets from the huge **standardization landscape** (Standardization Organizations (SDOs) and (Industrial) Alliances)
- Taking into account **„Windows of Opportunity“** – Standards under development or maintenance
- **Motivating use of standards or pre-standards**
- **Motivating active involvement & transfer of results/experiences to standardization groups**

KPI: ***Contribution to ≥ 5 Standards groups – ACHIEVED, activities in more than 20 committees and working groups on international and national level.***

The Standardization task aims at a holistic view on all standardization challenges in context of PowerizeD (Overview section 2.3). The first activity will be a survey over the WPs and Use cases to get a full picture of standards of interest, maybe used or being interested in their development, and to extend these landscapes where appropriate with specific standards on more detailed topics (section 3.1).

The second task is to motivate use of standards, raise awareness and identify gaps, particularly where project-driven contributions are to be expected (information on request by partners, presentations at project meetings).

The third task is to monitor standardization evolution, support participation and contribution to current standardization activities and to check for adaption of qualification/certification processes and methods concerning the new technologies developed (active participation in standardization Committees and working groups, section 4). However, it should be noted that certification or qualification as concrete activity are NOT part of a research project.

2.3 Standardization Challenges

Standardization is key for a fair, competitive economy, by preserving the public stakeholders' interests in safety, security, dependability, performance and ethical aligned design, following European recommendations, Directives and Regulations (some at the moment still under (further) development).

Increasing usage of AI technologies for development, monitoring, predictive health and maintenance, digital twins, self- and environmental awareness and highly automated/autonomous decision making raise many concerns which are already now considered in evolving generic as well as domain/application specific standardization work.

Key topics addressed in standardization cover a large landscape of standards organizations and industrial associations. Derived from the project principles mentioned above, the standardization landscape, that is already monitored and actively participated by partner companies on national and international level, includes:

- Generic functional safety and cybersecurity standards (IEC MT 61508, preparing Ed. 3, covering more than before new hardware, software and system technologies, e.g., AI and safety, object-oriented programming, hardware architectural and dependability considerations) and IEC 62443 IACS (Industrial automation and control systems security, developing towards a generic technical security standard),
- Generic and specific Dependability (Reliability) standards in IEC TC56, covering all sorts of

reliability models and calculations for hardware and systems,

- Automotive, (ISO TC22 SC32, Functional safety, Safety of the intended Functionality (considering limitations of sensor/HW also), Automated Driving systems (TS 5083, including AI decision making in Editor Team 06), update of ISO 26262 for next edition (including PAS 8800, AI and safety, ISO 26262 part 11 (semiconductor part)), standards for electric vehicles (TC 22 SC37) and connected vehicles (TC 22 SC31, including "vehicle to grid" standards, Extended vehicles, Remote diagnosis etc.),
- Railway standards on safety, cybersecurity, RAMS engineering, communications and signalling: Mainly done in CEN/CENELEC TC9X (later on transferred to IEC getting an IEC number as well), many developments on European level particularly on signalling (ETCS system).
- Machinery standards related to safety, dependability and security, in IEC TC44 and ISO TC 184 ("Machinery Safety, E/E/PE aspects", and "Automation systems and integration")
- AI standards related to safety, dependability and security: ISO/IEC JTC1 SC42, covering in many standards, reports and technical specifications all aspects of trustworthiness (including bias, controllability of automated AI systems, robustness of DNN, Explainability, Transparency, Ethics and societal aspects, etc.); functional safety (TR 5469) is developed together with IEC SC65A 61508-3, Validation and security together with the Systems and SW Engineering Group ISO/IEC SC7 resp. SC27,
- Thermal testing standards of semiconductor device packages developed and maintained by the JEDEC JC15 technical committee. Currently there is one single standard that deals with thermal testing of power semiconductor devices packages (JEDEC JESD51-14) that was published 10 years ago as a result of cooperation between IFAG and BME. Also, IFAG and BME commonly published a concept of a new standard on thermal characteristics of multi heat-source packages/modules. Recent trends, especially in case power semiconductor device packages require revision/scope extension, especially that of JEDEC standard JESD51-14. This process was initiated by a recent publication and to process needs to be further continued. The JC15 committee is also responsible for developing concepts and standards for compact thermal models of packages (digital twins in the thermal domain) and all thermal aspects covered by the JEDEC JEP30 standard's XML schema of parts definitions. These activities need to be harmonized with the new results of PowerizeD, through the JC15 committee memberships of partners' personnel from the PowerizeD project.
- Standards of the AEC council (Automotive Electronics Council) (Standards for qualification of reliable, high quality electronic components),
- ECPE (European Center for Power Electronics) guideline AQG324 (for power electronic devices qualification).
- IoT and Digital Twin standards (ISO/IEC JTC1 SC41): semantic and syntactic interoperability, Digital twin under different aspects from architecture to security, trustworthiness, etc.

3 Assessment and Evaluation of Partners' Involvement in Standardization

3.1 First Standardization Questionnaire (Annex 1)

The questionnaire was developed during the first reporting period, thus fulfilling the first part of the standardization task 4.1.3) and issued afterwards. Collection took some time and resulted in 25 replies from 61 partners (a few en-bloc, e.g., Infineon Technologies for all Infineon partners, or via direct communications). The questionnaire addressed two issues:

- Areas of interest, role of "Intelligence" (including reference to WP, CDT (Cross Domain Topic) and UC (Use Case), or comments)
- Standards Involvement Assessment Table (also with reference to reference to WP, CDT (Cross Domain Topic) and UC (Use Case))

It included explanations and an example (part from AIT), see Annex 1.

Note: Now we have 36 replies and many more relevant standards and activities identified after the second round with another, more focused questionnaire – see section 5!

3.2 Updated Result of the assessment of the "Areas of Interest":

The last round of questionnaires led to many additional inputs for the assessment of the standardization landscape and information on standards relevant and to be known in the areas of interest. The update is shown in the following (re-ordered by updated number of choices)

- **(18)** **Dependability/Reliability** (IEC TC56, for HW and Systems)
- **(17)** **Mobility:** Automotive (ISO TC22), Railways (CEN/CLC TC9X), ARP
- **(13)** **Artificial Intelligence** ISO/IEC JTC1 SC42 (trustworthiness, ethical concerns, robustness, bias, safety (with IEC SC65A), security (with JTC1 SC27) and Testing (withSC7)), **AI Act**
- **(13)** **Machinery Safety** (IEC TC44, ISO TC 184), **Machinery Directive**
- **(11)** **Functional Safety, Cybersecurity** (Generic & Industrial domain(IEC TC65)), **RED Directive, Cyber Resilience Act**
- **(10)** **JEDEC Standards, IEC TC56 (**Accelerated/Environmental Stress Testing)
- **(10)** **Power Electronics Standards (ECPE, DKE, and others)**
- **(9)** **Other Semiconductor/System Standards (e.g., IEC TC47) (added)**
- **(8)** **EMC Standards** (IEC, ISO, CENELEC, CEN, FCC, etc.) for process control and measurement, various domain standards, **EMC Directive**
- **(8)** **Digital Twin** (ISO/IEC JTC1 SC41 (IoT and DTw) and ISO TC184)
- **(6)** **AEC Standards**(Automotive Electronics Council) (Reliable Electronics)
- **(2)** **Modelling, Simulation and Prediction** (ASAM, XML, AML, ISO, IEC,…)**(area added by partners)**
- **(2)** **Intelligent control (area added by partners)**
- **(2)** **Eco-Design, environmental test, environmental management issus**
- **(1)** **Industry 4.0/5.0, Robotics, Autonomous Systems (various Stds.)**

In the last period, a second questionnaire was distributed to focus more on standardization relevant to Use Cases/CDTs; the results have also been integrated in the "Areas of Interest" and "Standardization Involvement" evaluation updates (see section 5).

3.3 Result of the Assessment of Standardization Committees and Groups

The questionnaire allowed to identify the role of the partner with respect to standards and standardization, either to groups of standards or individual standards. Roles are

- I (interested), M (monitoring) (there was no clear distinction, so "I" stands for both)
- U (using),
- A (active in Std. group),
- C (chairing a group)

Most positions in the tables referr to "I" (includes "M") or "U".
Partners chairing a standardization committee are:

- SIGN – IEC TC64 SC64A WG4 (LED light sources, lamps and modules), standards IEC 62560, IEC 62031, etc
- AIT – ÖVE EG56, Austrian Mirror of IEC TC56 (Dependability)
- IFAT - ÖVE EG56, Austrian Mirror of IEC TC56 (co-chair) (Dependability)
- UNIBO – IEC 61851-1 (Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests)
- SIGN – IEC TC77 (EMC standardization), IEC 61000 series (chairing some working groups)

Partners are actively participating in a series of international or national standardization groups (besides those already mentioned as "chairing"):

- AIT is active in many standards of IEC TC56 "Dependability" and IEC T65 (Industrial-process measurement, control and automation, particularly in the functional safety and cybersecurity area of interest, and the smart manufacturing standards), both in international and national level. The same applies to AI standards (ISO/IEC JTC1 SC42 and CEN/CLC JTC21, on national and partial on international level (Functional safety and AI – TS 22440, Human-machine teaming ISO/IEC AWI TR 42109, Cybersecurity and AI - CEN/CLC JTC21 WG5), in robotics and safety of machinery. IoT and Digital Twin is covered on national level.
  Automotive standards around ISO TC22 SC32 are ell covered as well on both levels: WG08 functional safety (ISO 26262 Ed3, ISO 21448 SotiF, WG 11 Cybersecurity engineering (partial as "ISO/SAE"), WG 12 SW Update, WG 13 from the beginning (Automated Driving Systems (ADS), already in TR 4804, now TS 5083).
- Infineon Technologies (IFAG, IFAT, IFD, IFI) are active in IEC TC56, JEDEC, IEC TC47 and standards like IEC 63492-1, 60747-xx, IEC TC109 IEC 60664 and other semiconductor standards, besides other standardization activities. IFAT (Austria) as co-chair of the national EG56 Committee (for IEC TC56) is involved in starting a discussion about a possible standard for remaining useful life (RUL) and attended the Plenary meeting November 2025 in Tokyo in person.

- Fraunhofer ENAS (FhG) is convenor of ISO/IEC SC42 AI-Management system standards group and contributing to several other AI standards (Trustworthiness, WG 03), partially with PowerizeD staff, others with related Chips-JU project staff. Regular contributions are to IEC TC56 Dependability management (IEC 60300 parts and IEC 60812 FMEA). Another topic concerns functional safety for Road vehicles (ISO 26262) and RAMS for Railways (EN 50126, EN TC9X, partially with PowerizeD staff). Digital twin standards activities cover ISO 23247 (Digital Twin for manufacturing, ISO TC 184/SC 4) and IEC 62541 (IEC TC65, Interoperability standards used for Digital Twin data exchange). Regular contributions are to JEDEC JESD 47 (JC14, Stress test qualification for ICs) and several standards of the 22-series in JC14.1. In AEC, FhG is active contributor to AEC-Q100 (IC Qualification) and AEC-Q101 (Discrete semiconductor qualification). In ECPE, FhG is active in Task Forces for SiC/GaN reliability Guidelines, Power Module Packaging & Robustness Validation Guidelines and (particularly with PowerizeD focussed staff) in AQG324, the Automotive Qualification Guideline.
- CSIC is active in several ISO/IEC JTC1 SC42 standards.
- SIGN is, besides its chairing position in IEC SC34A WG4, active also in SC34 B, C and D, and KDE 221.6.x on national level. For EMC standards, they are active in IEC TC77 and CISPR.
- UNIBO, besides its chairmanship, is active also in ARP 7374, 7375. UNIBO is leader of CDT 2.1, where JESD 51-14 is used and work prepared on suggestions to extend its scope to thermal testing of IGBTs as reported in the last PowerizeD questionnaire (Task 2.2.1, Substrates).
- AALTO participates with an expert in IEC TC 91/WG3 (IEC 63215 series - Endurance test methods for die attach materials) and TC91/ WG6 (IEC 62878-2-603 - Guideline for stacked electronic module – Test method of intra-module electrical connectivity).
- VIF participates in Automotive functional safety standards groups (NC Austria, ISO TC22 SC32).
- NANO-JOIN (NANOJ) is working on sintering and works for an ISO Committee for sintering, since there are no direct standards available. PowerizeD gives valuable input for the sintering committee. Other standards that are relevant are various ISO Quality management standards and IATF 16949 for Automotive.

This list was also updated by the second standardization assessment.

In total, there are more than 200 standards or standardization involvements indicated by partners, with focus on some specific areas (see section 3.2, including well established and well-known generic and basic standards) and some with very specialized ones, e.g.,

IEC TC47: To prepare international standards for the design, manufacture, use and reuse of discrete semiconductor devices, integrated circuits, display devices, sensors, electronic component assemblies, interface requirements, and microelectromechanical devices, using environmentally sound practices.

IEC 63492-1: Semiconductor devices - Isolation for semiconductor devices – Part 1: Failure mechanisms and measurement methods to evaluate solid insulation for semiconductor devices.

IEC 60747-xx Semiconductor standards: The IEC 60747 series of semiconductor standards covers discrete devices, integrated circuits, semiconductor sensors, microwave integrated circuits, and others as part of its 28 part series.

IEC TC109 (IEC 60664): To prepare International Standards on the principles of insulation coordination applicable to all low-voltage equipment (up to and including 1 000 V a.c. and 1 500V d.c.).

IEC TC34 Lighting: To prepare, review and maintain international standards and related IEC deliverables regarding safety, performance and compatibility specifications for lighting systems.

EN 62377-1: Safety requirements for power electronic converter systems and equipment

ISO/IEC DTR 20226: Information technology — Artificial intelligence — Environmental sustainability aspects of AI system.

IEC 61851-1: Electric vehicle conductive charging system, Part 1: General requirements

IEC 60034-18-41: Rotating electrical machines - Part 18-41: Partial discharge free electrical insulation systems (Type I) used in rotating electrical machines fed from voltage converters - Qualification and quality control tests.

Because there were many partners that did not reply or claimed to have no standardization activities, awareness raising was a major activity during the last months, trying to query the positions of those partners and to support analysis of the UC and CDTs (in the tables of the questionnaires often abridged to “CT” instead of CDT) with respect to provide a more complete picture of relevant standards, the approach indicated in section 5.1 (Figure 11) was chosen. This was the basis for final steps to consideration of (evolving and existing) standards during work in progress and identification of a few potential contributions to standards. Standardization is an ongoing process which takes longer than a research project like PowerizeD, and results that can be transferred to standardization work are to be expected towards the end of the project. This activity had a positive result, the number of replies with data increased from 25 to 36, and several more activities of partners and relevant standards for Use Cases/CDTs could be identified (section 5, updated tables).

NOTE: Detailed evaluation tables are in ANNEX 2 (<SEN> resp. <confidential> version only, i.e. only in D 4.7.1).

4 Standardization Activities and Established Contacts to Committees

4.1 PowerizeD and Reliability Standards: Revival of Austrian Mirror Group by the PowerizeD Standardization Team

Reliability is a key factor in application of semiconductors and hardware in critical systems. The long-established IEC TC 56 Committee develops and manages the standards around reliability and related topics as relevant for long-term deployed systems, like availability, maintainability and supportability. Therefore, the TC was renamed to "Dependability", to demonstrate the overarching topics on system level.

Dependability includes reliability, availability, maintainability, and supportability, as shown in Figure 6. It is fundamental for the performance of systems and services and impacts both all types of organizations and society in general. Particularly reliability is essential in the context of hardware and semiconductors and upwards to system level. Many targets of PowerizeD are covered by dependability standards, as shown in Figure 6 below, such as contributions to European goals of sustainability, resilience, circular economy, and public interest in trustworthiness of autonomous systems, and asset management in context of industrial supply chains.

The importance of dependability standards for the partners is well proven by the fact, that in the "areas of interest" table of the questionnaire it received by far the highest score!

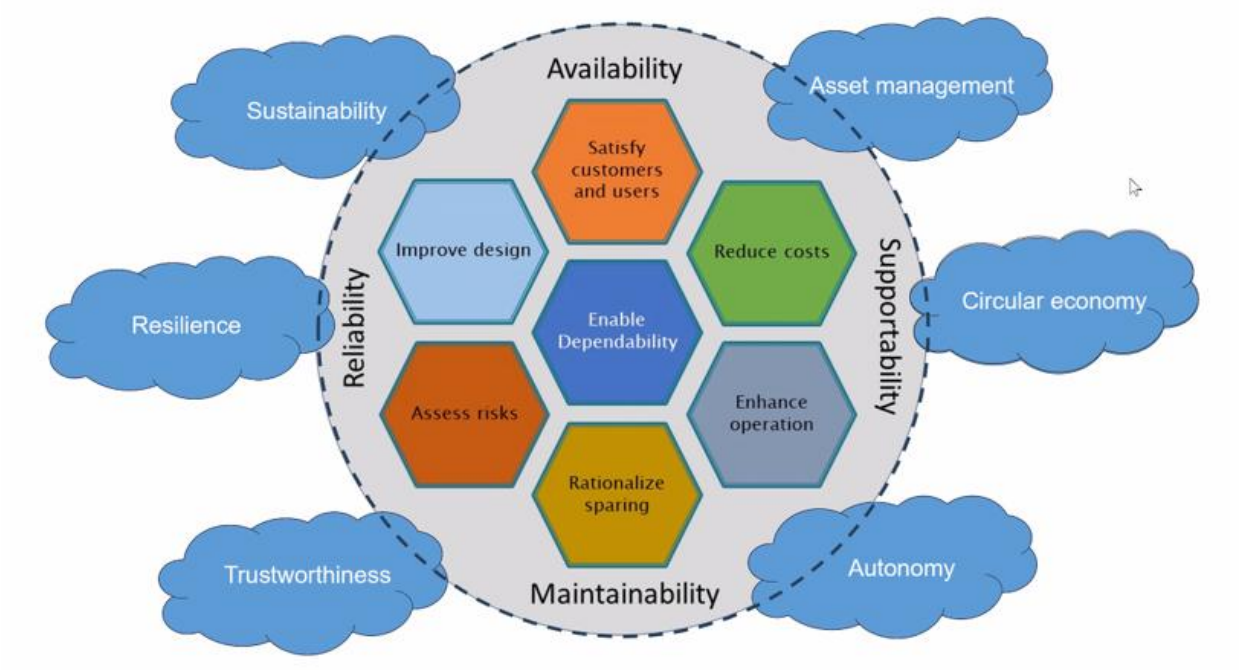

FIGURE 6: IEC TC56 DEPENDABILITY STANDARDIZATION (SOURCE: HTTPS://TC56.IEC.CH/)

The Austrian mirror group EG56 was endangered to be downgraded from P-member (Participating Member, who are voting members) to O-member (Observing member, who cannot vote) or even to be shut down after retirement of the long-term chairman. Representation on IEC level would have been just performed by ÖVE (Austrian Electrotechnical Association) at management level of the umbrella TK EG. The start of PowerizeD motivated the Austrian Team (Erwin Schoitsch and Horst Lewitschnig) to

revive and lead the national group to be able to actively perform the PowerizeD standardization task, in both directions: transfer of dependability standards information to work packages, Supply Chains (SCs) and CDTs (Use Cases and Cross-Domain Topics) and to facilitate to influence standardization where appropriate (transfer experiences and results to standardization groups).

This included active participation in IEC TC56 international Plenary meetings and participation in the work of working groups. Participation was initiated in WG 3 (Management and systems), and WG 4 (Information systems).

WG 3 covers:

- management of dependability; (foundational standards)
- maintainability, supportability and maintenance;
- technological risk assessment;
- systems engineering and human aspects.

WG 4 covers the important challenges of dependability of critical distributed systems and systems-of-systems:

- Dependability of information systems including open systems, Internet of Things (IoT), Systems of Systems (SoS).
- Dependability of IT security.

There are additional project groups in connection with the working groups, working on new topics. Projects of interest, particularly for RUL-based estimations relevant in PowerizeD, project teams like PT2.25 (Reliability data prediction) and PT 2.26 (Reliability – Reference failure rates at reference conditions) are working on these topics. PT 3.27 (Dependability management – Application guide – Availability) is of general interest in extending the existing, established basic standards of TC56 on Dependability management. A first approach to establish a standardization project on RUL-based estimations was started November 2025 at the Plenary in Tokyo by Horst Lewitschnig from IFAT (Austria) to find out how such a standard could be initiated.

4.2 PowerizeD Standardization Team at International IEC TC56 (Dependability) Plenary Meeting in Vienna, December 2-6, 2024

The Plenary meeting of IEC TC56 (Dependability) (Figure 8) took place in Vienna from December 2-6, 2024. It was hosted by ÖVE (Austrian Electrotechnical Association) and supported by the Austrian Mirror Committee EG56, led by Erwin Schoitsch (AIT Austrian Institute of Technology) and Horst Lewitschnig (Infineon Austria), both also the leaders of the PowerizeD Standardization Task. We had the opportunity to present the Standardization Synergies Roll-up Poster (Figure 7) and give a short overview on the importance of standardization in ECSEL and Chip-JU industry-driven projects, funded by the EC (Horizon Europe, Joint Undertakings ECSEL JU and Chips-JU) and national funding Authorities of the partners in the Plenary and during the seminar.

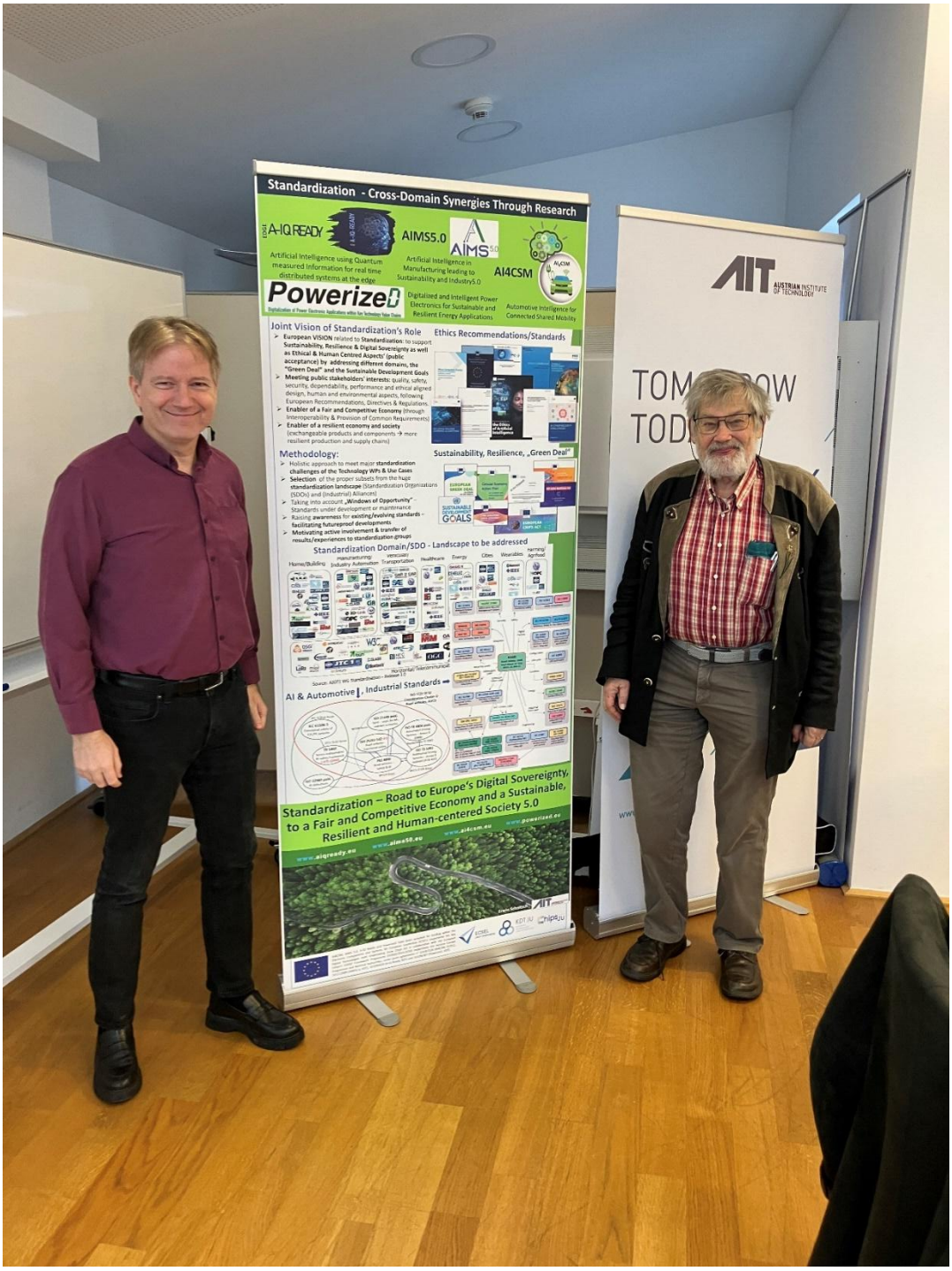

FIGURE 7: POWERIZED STANDARDIZATION TEAM, ERWIN SCHOITSCH AND HORST LEWITSCHNIG, AT THE ROLL-UP POSTER

FIGURE 8: FULL PLENARY OF IEC TC56 IN VIENNA, ALSO INCLUDING A SEMINAR AND MANY MEMBERS ONLINE.

4.3 JEDEC Standardization update

BME and IFAG were both members of JEDEC JC15 and planned to work together to provide inputs for the revision of the JEDEC JESD51-14 thermal testing standard with a focus on extending the scope of the standard from TO **(Transistor Outlines)** type packages to packages of high-power semiconductor devices. BME wanted also to prepare proposals for extending the series of JEDEC's thermal modelling guidelines (JESD 15-x series). They had a few items in mind that could be revised in this standard related to e.g., IGBTs (insulated-gate bipolar transistors). **Unfortunately, BME left JEDEC, so there was no longer a basis for this work. The related task was removed in the last Amendment 2024. Nevertheless, in Task 2.2.1 JESD 51-14 is addressed, and there is work on suggestions to extend its scope to thermal testing of IGBTs as reported in the last PowerizeD questionnaire (Task 2.2.1, Substrates).**

4.4 Standardization Support (examples)

Some examples are e.g., the CT on "Federated Learning", where AI and Machine Learning are covered in detail already by published or developing standards, but particularities of "Federated Learning" are not covered at the moment.

Other issues concern dependability/reliability standards, one very specific example question was raised on which standard(s) apply today and tomorrow for harmonic currents in a practicable usable form. EN 61000-3-12 is rather old – this could be answered insofar as exactly this standard is now coming under maintenance in IEC TC56, progress will be reported to the interested partner.

Standards for RUL-based estimations are now proposed to IEC TC56 (see report above) and summary report in the following section.

An internal support was initiated in investigating and facilitating contacts between partners on Wafer-test data exchange, standardized formats, etc., and on the upcoming EU Product Passport (vs. ISO TC 184, SC 4, Industrial data). Some other ideas are mentioned in section 5.

4.5 Synergies in Standardization Work with other ECSEL/ChipsJU projects

Since many aspects to be considered and handled in PowerizeD are partially shared with related ECSEL/ChipsJU project where key partners of PowerizeD are also involved (e.g., AIT as task leader in PowerizeD, AI4CSM, AIMS5.0 and A-IQ Ready; Infineon AG, Infineon Dresden and Infineon Austria, OTH, MBAG, VIF, BME, HUA, and others in two or more of them, just to name a few), there are some synergy effects as demonstrated in the Roll-Up (Poster) which was already presented at several project meetings, Conferences, Workshops and standardization meetings (see, e.g., section 4.2, and figure Figure 9).

FIGURE 9: PRESENTATION OF STANDARDIZATION RESEARCH AT CONFERENCES AND WORKSHOPS SYNERGIES THROUGH

Examples have been (besides project-internal workshops of the referenced projects):

- **Society 5.0 – Sustainable Technology Trends and Society** presentation on ""Society 5.0 – Sustainability as a Key Challenge for Society and Technology – Technology driven, but human-centred", Vienna, Jan. 30, 2024.
- **MESS24,** Vienna, June 6-7, 2024
- **SAFECOMP 2024 (DECSoS WS),** Florence, Sept. 17-20, 2024
- **ARROWHEAD fPVN/AIMS5.0,** Joint Workshop in Budapest, Hungary, November 12-14th, 2024
- **SAFECOMP 2025 (DECSoS Workshop),** Stockholm, KTH, Sept. 22-25, 2025
- **AIMS5.0/ARROWHEAD fPVN/SC4EU Joint Deep-Tech Dive WS**, Lisbon, Oct. 29-30, 2025

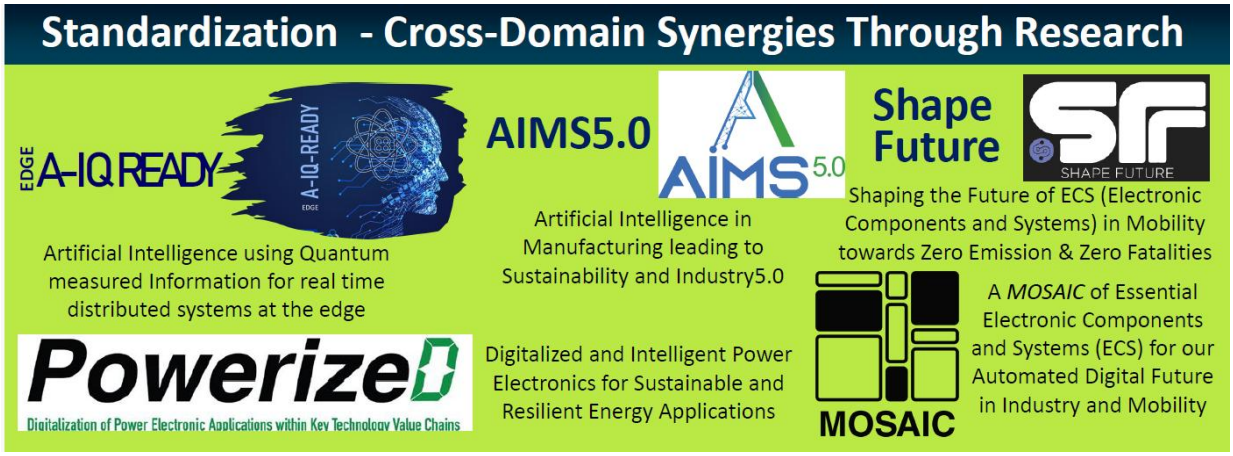

FIGURE 10: UPDATED PRESENTATION OF STANDARDIZATION OF CHIPSJU PROJECTS AT CONFERENCES AND WORKSHOPS

4.6 Establishing links to other standardization organizations

Besides this specific activity in IEC TC56, the involvement in the established areas and committees in ISO, IEC and ISO/IEC JTC1 of functional safety, cybersecurity, smart manufacturing, digital twin, IoT, Artificial Intelligence, Automated vehicles and robotics, EMC, Lighting, semiconductor standardization as indicated in the evaluation (JEDEC, IEC TC47, AEC and ECPE) are ongoing and includes more than 20 committees and working groups. Since standardization is a mid- to long term activity and commitment beyond the duration of PowerizeD, the major activities of key partners will continue, so that experiences and results will flow into future standardization contributions as well.

5 Use Case/CDT oriented Standardization Summary and Overview

5.1 Second Questionnaire for UC/CDT-oriented Standardization Landscape Assessment:

The last step was to query the replies to the questionnaire and complete on a "per CDT/UC/WP" level the identification and association of relevant standards to support partners to consider evolving standards and collect potential contributions to the standardization landscape.

USE CASE/CDT oriented Standards Assessment and Involvement

USE CASE #/CDT #	IFAT; UC1.3, UC1.5
Title:	Power Electronic Building Blocks for Traction Converters / DCDC Converters
Standardization Focus:	Power Electronics
Description (Goals/Claims from FPP/DoW)	

Standards: Topic, Committee	**UC 1.3, UC 1.5**	**Status**	**fair know-ledge**	**used**	**moni-tored**	**active**	**impact from PowerizeD**
IEC TC 56	IEC 63142 - FIT-Rated based on FIDES	under development	yes	no	yes	yes	Active involvement in standard development
	Plenary Meeting Tokyo 10. - 14. Nov. 2025	under development	yes			yes	Discussion started about a possible standard for remaining useful life (RUL)
IEC	IEC 60721-3-5 - Classification of environmental conditions	published	yes				
JEDEC	JEP195: Guideline for Evaluating Gate Switching Instability of Silicon Carbide Metal-Oxide-Semiconductor Devices for Power Electronic Conversion	published	yes				
ECPE	Guidelines PSRRA 02 - Railway Applications	published	yes	yes			

FIGURE 11: EXAMPLE OF QUESTIONNAIRE FOR ASSOCIATION OF RELEVANT STANDARDS TO USE CASES AND CDTS

A detailed assessment overview is in ANNEX 2, split for better readability over 4 pages. A short summary of particular results (beyond the generic safety and security standards) is in the following section, considering some particular domain- and use case specific ones. This detailed Annex is only available in the sensible version of the deliverable D4.7.1; in the public version is only the following summary.

5.2 Summary of some specific UC/CDT-oriented Standardization Landscape Assessment Results

Use Case 1.1 Rail Propulsion System (RISE, ALSTOM)

- IEC 62830 series – Semiconductors for energy harvesting (sensors)
- IEC 62391, IEC 60086, IEC 61960: Standards for batteries and Supercapacitors, relevant when pairing with an energy harvester.

Use Case 1.3, 1.5: Power Electronics Building Blocks for Traction Converters, DC/DC Converters (IFAG)

- IEC TC56 - IEC 63142 - FIT-Rated based on FIDES
- IEC TC56 – Proposal started for a possible standard for remaining useful life (RUL), Plenary Tokyo, Nov. 2025)
- JEDEC - JEP195: Guideline for Evaluating Gate Switching Instability of Silicon Carbide Metal-Oxide-Semiconductor Devices for Power Electronic Conversion
- ECPE - Guidelines PSRRA 02 - Railway Applications

Use Case 1.5, 3.1a (CDT 2.2 Interconnection materials (Substrats))(NANO Join (NANOJ))

- NANO JOIN (NANOJ) works with an ISO Committee to prepare standards for sintering, still to come (valuable input from PowerizeD work).

UC 1.6a Mobile in-line charger (MILCA)(AIXControl (XC))

Relevant standards used (Power electronics and Charging Infrastructure):

- DIN EN 62477-1: Sicherheitsanforderungen an Leistungshalbleiter - Umrichtersysteme und -betriebsmittel - Teil 1: Allgemeines
- DIN EN 55011: Industrielle, wissenschaftliche und medizinische Geräte - Funkstörungen - Grenzwerte und Messverfahren
- DIN EN IEC 61851-1: Konduktive Ladesysteme für Elektrofahrzeuge - Teil 1: Allgemeine Anforderungen
- ISO 15118-2: Road vehicles - Vehicle-to-Grid Communication Interface – Network and application protocol requirements

UC 1.7 Intelligent Energy for Mobility (OTH, EDI)

- IEEE - IEEE Recommended Practice for Privacy and Security for Federated Machine Learning
- ISO/IEC JTC1 SC27 - ISO/IEC 27701:2025, Information security, cybersecurity and privacy protection — Privacy information management systems — Requirements and guidance
- ISO/IEC JTC1 SC42 – ISO/IEC TS 8200 Information technology — Artificial intelligence — Controllability of automated artificial intelligence systems
- ISO/IEC JTC1 SC42 – ISO/IEC TR 20226 Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems
- ISO/IEC JTC1 SC42 - ISO/IEC AWI TS 22440-1 Artificial intelligence — Functional safety and AI systems

Use Case 2.3 LED Driver and LV DC Distribution Grid (Signify)
(CDT 4.4 EMC Prediction and Design optimization)

Standardization focus **IEC TC34 (Lighting):**

- SC34A WG 4 IEC62560, IEC62031: LED light source (lamps and modules) – Chair
- SC34B IEC60061: Lamp caps and holders (active)
- SC34C IEC61347: Control gear (active, used in PowerizeD: Analyze impact switching frequency on minimum creepage distance)
- SC34D IEC60598: Luminaires (active)

Others (all used in PowerizeD):

- IEC TC77A: IEC 61000 series: EMC (Chair) (Within PowerizeD models used to simulate if equipment will meet standards)
- CISPR: CISPR15: EMC (Chair, active) (Within PowerizeD models used to simulate if equipment will meet standards)
- DKE: IEC 63317 SRD: Low-voltage DC industry applications

Use Case 2.4: Home and mobile PV with storage (Finepower (FPG))

- EMC – IEC TC77, IEC 61000-3-2: limits for currents harmonics (used)
- EMC - IEC 61000-3-3: limits for conducted electromagnetic emissions on AC public grids for devices with nominal current <16A (used)
- Safety - IEC TC109 - IEC 60664-1: isolation coordination for electronics devices in low-voltage systems (used)
- Reliability – IEC TC56, IEC 60300-3 - got awareness on the standard, previously used methods for calculating FIT rates
- AI Security, AI Standards ISO/IEC SC42 - got awareness on the committee and standards, company starting with AI
- Relevant standards identified for product certification: IEC 62898, IEC 62040, IEC 60335-2-29, IEC 61853, IEC 62109, IEC 62257, IEC 62817, IEC 62920, IEC 63513, maybe IEC 62933-5-4.

Use Case 3.1: Industrial Drives

- NANO JOIN (NANOJ) works with an ISO Committee to prepare standards for sintering, still to come (valuable input from PowerizeD work).

Use Case 3.2: Hyper-Sensorized digital Drive (FAGOR)

- Low-Voltage Directive: IEC 60204-1 – Safety of machinery- Electrical equipment of machines – Part 1: General requirements
- Electromagnetic Compatibility Directive: IEC 61800-3:2017 Category C3. Adjustable speed electrical power drive systems. Part 3: EMC requirements and specific test methods.
- Machinery Directive: IEC 61800 series - Adjustable speed electrical power drive systems – various parts of safety requirements, IEC 61508 (SIL 2), EN ISO 13849 (Functional safety in machinery, certification possible).IEC 62137-1-1 -

CDT 1.1, 2.1, 2.2 (Electronic assembly standards) and 5.1 (Environmental management and eco-design):

Active participation (AALTO):

- IEC TC 91/WG3 - IEC 63215 series - Endurance test methods for die attach materials (PowerizeD know-how from novel interconnection solutions (Ag/Cu sintering and SLID/Diffusion soldering)) to be considered when preparing new standards
- TC91/ WG6 - IEC 62878-2-603 - Guideline for stacked electronic module – Test method of intra-module electrical connectivity (provides background information)
- IEC62137-1-1: Surface mount technology – Endurance test methods for lead-free solder joints. Part 1-1 & Part 1-2 (provides important background information)
- IEC 6309 series: Measurement method used in thermal design for electronics assemblies - Parts 1,2 and 3 (provides important background information)

Monitoring (AALTO) (Monitoring standards development and EU directives/standards for eco design):

- IEC TC91/ WG10 - IEC 61189-2-801 - Test methods for electrical materials, printed board and other interconnection structures and assemblies - Thermal Conductivity Test for Base Materials (and several others from TC91)

- IEC 62430 - Environmentally conscious design (ECD), Principles, requirements and guidance

Using (AALTO) for calculating environmental impact in Life Cycle assessment:

- ISO 14040 - Environmental management, Life cycle assessment - Principles and framework
- ISO 14044 - Environmental management, Life cycle assessment - Requirements and guidelines
- Several standards on Thermal cycling (IEC 60068-2-14), 85/85 tests (IEC 68-2-67), HAST (IEC 60068-2-66), FMG (IEC 68-2-60) and environmental tests used by CDT partners to qualify interconnection solutions development

CDT 2.1 UNIBO, Substrates (UC 1.6c)

- CDT2.1 addresses JESD 51-14, and is working on suggestions to extend its scope to thermal testing of IGBTs as reported in the last PowerizeD questionnaire (Task 2.2.1, Substrates).

6 Conclusions and Outlook

The standardization activities and involvement assessments have demonstrated that there is a good coverage of almost all related standardization areas. The standardization team could raise awareness, increase general knowledge and provide support in several cases on considering existing and evolving standards and inform partners on what to expect from the maintenance and update of (almost) outdated standards which no longer reflect technology progress in their area. The established contacts to the various international, national and industrial standardization organization as reflected in this document will continue beyond the project. Influencing standards needs long term commitment of key partners, which is the case in key standardization areas where partners are already involved or tried just in this last period to work on new topics or updates (e.g. in energy harvesting, sintering standards, dependability standards in IEC TC56, trying to close the gap in Federated learning AI standards, etc.). Several partners have indicated, that PowerizeD also provided valuable input for ongoing standardization work.

7 References

Links validated 2025-12-20.

AIOTI – Alliance for AI, IoT and Edge Continuum Innovation – https://aioti.eu

AIOTI Standardization WG - WG Standardisation Deliverables – AIOTI

ISO Standards https://www.iso.org (International Standards Organization)

IEC standards https://www.iec.ch (International Electrotechnical Commission)

ISO/IEC JTC1 About - JTC 1 (ISO/IEC Joint Technical Committee 1)

Schoitsch, E. (2020). "Towards a Resilient Society – Technology 5.0, Risks and Ethics", IDIMT 2020, Digitalized Economy, Society and Information Management, Proceedings, Trauner Verlag, Linz, Austria, Schriftenreihe Informatik 49, (ISBN 978-3-99062-958-1), p. 403-412.

UNESCO (2021, Nov. 23). Recommendation on the Ethics of Artificial Intelligence, https://unesdoc.unesco.org/ark:/48223/pf0000381137?3=null&queryId=c5dd8ced-9647-452b-b4d6-92723006496c

United Nations, Transforming our World - The 2030 Agenda for Sustainable Development (2015), https://sustainabledevelopment.un.org/post2015/transformingourworld

Von der Leyen, U. (2019). "A Union that strives for more – My agenda for Europe".
https://www.europarl.europa.eu/resources/library/media/20190716RES57231/20190716RES57231.pdf

8 List of figures

9 List of Tables

10 Annex 1: Standardization Involvement Questionnaire (Template)

Partner XXXX Involvement in Standardization & AI (Intelligence) issues

Please fill in XXXX and add this acronym to the filename replacing XXXX.

Please fill in as soon as possible, latest until January 10, 2024, to allow evaluation in time before the review.

Partner XXXX – < Full affiliation name>

Standardization Contact: <name, email> (one name required for each partner)

1. **Part 1:**
   a) **Comment in free text where in your work in PowerizeD AI/Intelligence plays a role, and which one (tools, product development, final product, …):**

   …….

   b) **List of areas addressed by standards – your interests, relevance in your CDT#, UC#, WP x.y.z (Table 1):**

Areas addressed	**Interest (Y/N, key standard (s)?)**	**CDT#, UC#, WP x.y.z or comment**
Functional Safety, Cybersecurity		
Dependability/Reliability		
Mobility: Automotive, Railways		
Machinery Safety		
Artificial Intelligence		
Digital Twin		
JEDEC Standards		
AEC (Automotive Electronics Council)		
ECPE (European Center for Power Electronics)		
EMC Standards		
<please add any other area you think may be relevant, in the following lines>		

2. Standards Involvement Assessment (Table 2)

General Remarks:

Note: "Involvement" does not address only you as person, but also your department or site (colleagues you may have contact to).

"PwD staff Y(es)" means personal involvement of persons working in PowerizeD (PwD), "N(o)" means "Partner XXX involved, but not PwD persons themselves"

SDO = Standardization Organization, TC Technical Committee, SC Subcommittee, WG Working Group, TF Task Force, etc. (use appropriate abbreviation depending on SDO or Alliance rules).

Roles of partners: I (interested), U (using), M (monitoring), A (active in Std. group), C (chairing a group)

Relevance: Please include your **UCs, CTs, WPs (Tasks)** where these standards are relevant.

Examples (marked yellow, NOT exhaustive) are from AIT involvement – please delete in your submission!

SDO	TC/WG	Stan-dard(s)	Title of Standard	Role	PwD staff	Comments on involvement	Relevant for UC#/ CDT#/WP x.y.z
IEC	SC 65A	IEC 61508	IEC 61508 Functional safety of E/E/PE systems, maintenance teams	A	Y	Regular contributions, IEC 61508-3 and IEC 61508-1 and 2;	CDT 1.x, 3.1, 3.2, 4.3, 4.4; UC 1.1, 1.7; WP 4.1.3:
IEC	TC65	IEC 62443 series	IEC 62443 Security of Industrial Process Measurement and Control – network and system security	A, U	N	Active via other AIT staff, AD staff: User with respect to Safety & Cybersecurity topics in other IEC Standards; Roadmap and Horizontality TF	CDT 1.3; UC 1.1, 1.6b, c, 1.7; WP 4.1.3
ISO	TC22 SC32 WG 8	ISO 26262	Road vehicles - Functional safety	A	Y	Regular contributions, initiator of ISO 26262:2018 cyber-security task force	UC 1.2, 1.7; WP 4.1.3
ISO	ISO/SAE JWG1	ISO 21434	Road vehicles – Cybersecurity engineering	A, U	Y	Active from the very beginning in several "Part Groups", in Ed3 in several TR, TS, PAS	CDT 1.3; UC 1.7; WP 4.1.3;
IEC	TC56	Several stds.	Dependability, Reliability, Maintainability, Supportability	C	Y	Convenor of the PAS from AIT - AI4CSM staff	CDT1.1, 2.1, 2.2, 2.3; UC 1, 2, 3, 5, 7; WP 4.1.3
ISO/ IEC JTC1	SC 42	Several AI Stds.	Artificial Intelligence – WG 3 "Trustworthiness"	A, U	Y/N	Plus several other AIT staff members, includes ethics, oversight and governance	CDT 1.4, 3.1a, 3.1b; WP 4.1.3

Extend tables if required!

The project has been accepted for funding within the Chips Joint Undertaking (Chips JU), a public-private partnership in collaboration with the Horizon Europe (HORIZONI Framework Programme and National Authorities under grant agreement number 101096387.

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