D2.1

AI Success criteria by national standards and ISO regulatory bodies

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FORSEE

Forging Successful AI Applications for European Economy and Society

D2.1. Success criteria by national standards and ISO regulatory bodies

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Executive Summary

This document focuses on analysing AI specific documents issued by international, European and national standards bodies between 2018 and 2025.

Standards are selected from the international AI standards committee of ISO/IEC JTC 1/ SC 42 and a smaller convenience sample of national standards on AI are selected from the German standards body (DIN). In both cases, standards are selected based on their normative dependence on other standards and their scope in relation to AI development and deployment. These standards have the status of voluntary standards.

A corpus of AI standards (n=36) were analysed using a combination of thematic analysis and topic modelling. Given the number and length of standards available, emphasis was placed on using unsupervised topic analysis using BERTopic for the full corpus, supplemented by manual thematic analysis of a subset of the more normatively significant

standards (n=5).

Key findings include:

1. The themes that emerged in this study align well to the meta-themes developed in the parallel study of supranational AI policy documents (D2.2) i.e. AI technology, uses, risks/harms and governance of AI. This suggests that terminological alignment is occurring across supranational bodies and formal documents.
2. Consistent with the type of standards in the corpus, which primarily address organisations developing and deploying AI and provide high-level technical and governance frameworks, the themes identified show a strong expectation that organisations should and can attend in a consistent manner to technical issues, risk management and AI governance processes. Failures are conceptualised as something that can be managed.
3. The analysis found that though organisations need to consider a wide range of harms, risk management factors and AI governance factors, there is an expectation that the definitions and setting of thresholds for acceptable levels of risks, as well as for the adequacy of risk management and governance measures, remains a topic that is attended to by other organisations and institutions at the meso and macro level, rather than organisations alone. This signals the emergence of a multiscalar AI governance system with procedures and metrics operationalised at the micro level, and the normative values etc. set at regional or national levels.
4. Fragmentation is observable in relation to ethical, social and environmental concerns which are contained in specific technical reports. Values and ethics are conceptualised as the purview of regional and national bodies.

Acronyms

AI	Artificial Intelligence
CEN	Comité Européen de Normalisation (European Committee for Standardization)
CENELEC	Comité Européen de Normalisation Électrotechnique (English: European Committee for Electrotechnical Standardization)
ESO	European Standards Organisation
EU	European Union
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
JTC	Joint Technical Committee
ISO	International Organization for Standardisation
SC	SubCommittee
SDO	Standards Developing Organisation

Terminology

The following provides the definitions of the key concepts in this deliverable.

Code	A concept that is manually identified in the thematic analysis process as being both present and important within the document.
Document	A formally issued textual artefact, as a whole, issued by supranational bodies, technical standardisation organisations, academic institutions, or professional bodies, and intended to articulate principles, requirements, or procedures relevant to the governance, development, or deployment of artificial intelligence.
Thematic Analysis	A popular method of manual qualitative data analysis that systematically analyses datasets and identifies patterns of meaning.
Theme	A broad interpretable semantic concept derived through expert interpretation, either from the topics generated by a topic modeller or from the codes generated during the thematic analysis process.
Topic Modelling	A statistical method used to identify prevalent topics in large corpora of text using unsupervised machine learning techniques.
Topic	A concept that has been identified by a computational model (e.g., LDA or BERTopic) as a latent concept associated with a subset of documents (in our work a subset of sentences within a document). Topic is typically summarised by salient words that tend to appear when that concept is present.

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1. Introduction

This deliverable (D2.1) is part of a four-part study in Work Package 2 (WP2) of the FORSEE project, that aims to map social expectations present in institutional and formal approaches to asserting success criteria for Artificial Intelligence (AI). Together, these studies investigate the viewpoints and criteria set forth by a range of supranational bodies, technical organisations, academic institutions, and professional bodies in defining successful AI applications. Supranational bodies, technical organisations, academic institutions, and professional bodies collectively play a pivotal role in shaping perceptions of success in AI by establishing standards, guidelines, and ethical frameworks that influence the development, deployment, and evaluation of AI applications. These bodies serve as crucial actors therefore in shaping formal approaches, criteria and social expectations as to AI success.

This deliverable (D2.1) is focussed on the expression of AI success criteria offered in documents developed by **technical standards bodies** *representing international and national bodies developing technical and process standards for AI*.

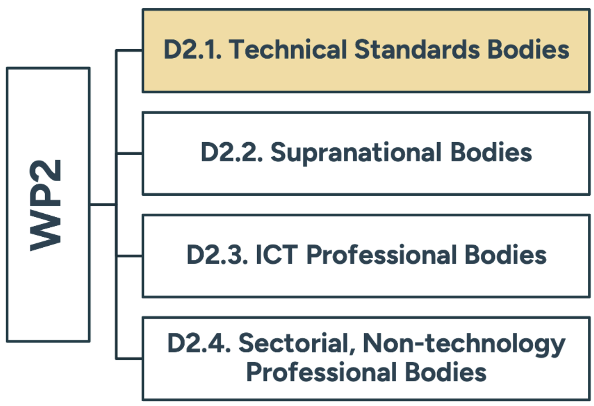

Figure 1. The structure of work package 2 deliverables

For context, as shown in Figure 1, the other three parts of the study address respectively AI governance outputs from:

- **Supranational Institutions**: representing supranational organisations involved in policymaking in the context of AI governance.
- **ICT Professional Bodies**: Bodies representing ICT professionals internationally that have engaged in guidelines or rules addressing AI governance.
- **Sectorial, Non-technology Professional Bodies**: Bodies representing professionals internationally in sectors that are not primarily ICT-based but which are sufficiently impacted by AI technology to engage in sector-specific AI governance.

Overall, WP2 aims to discern the set of baseline criteria for AI success produced by these different classes of international institutions. This study does not aim to draw any comparison between individual countries. Perspectives are presented from institutions that can claim some wide international representation as well as bodies representing states within Europe.

At the international level, the **International Organization for Standardisation (ISO)** stands out as the most influential body in shaping standards in the area of AI, with the ISO/IEC Joint Technical Committee 1 / Subcommittee 42 (JTC 1/SC 42) committee on AI, established in 2017 leading AI standardisation activities. As of January 2026, JTC 1/SC 42 has published 42 AI-related ISO standards, with an additional 47 standards under development. In selecting technical standards bodies that represent European perspectives, the broad consensus views on AI under development jointly by Comité Européen de Normalisation (CEN, in English European Committee for Standardization) and Comité Européen de Normalisation Électrotechnique (CENELEC, in English: European Committee for Electrotechnical Standardization) under Joint Technical Committee 21 (JTC21) were still in preparation at the time of writing. Therefore, a European national perspective was included via AI technical standards developed by the German Institute for Standardization (DIN[9]).

This deliverable specifically aims to establish common topics and themes, both shared and divergent, within **technical standards relevant to AI issued by the International Organization for Standardisation (ISO) and DIN, as the selected national technical standards body**. The research question this report explores is: ***What are the prevalent themes in existing technical AI standards published by ISO/IEC JTC 1/SC 42 and DIN between 2018 and 2025 and who has responsibility for addressing them?***

Addressing the research question, we first create a corpus of relevant standards. We then employ a mixed method approach that integrates thematic analysis, originating from social

[9] Deutsches Institut für Normung

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sciences, and unsupervised topic modelling algorithms to identify key themes that signal success criteria for AI within the corpus. Combining thematic analysis and topic modelling ensures that the nuanced concepts within documents are captured through human-based analysis, while enabling discovery of new patterns across our large and diverse document set through an unsupervised machine learning algorithm. We consolidate the results from thematic analysis and topic modelling and analyse them to identify and categorise recurring themes, priorities, and nuanced dimensions of success criteria outlined in technical AI standards through the lens of sociology of expectations. Thereby, this work sheds light on the evolving perspectives and priorities that shape institutional discourse on the responsible development and deployment of AI.

The remainder of this report is structured as follows. In section 2, we provide essential background information regarding AI standards development. In the absence of prior work using thematic analysis and topic modelling for analysing AI standards, in section 3, we review the relevant literature surveying the role of standards and some unresolved uncertainties related to AI policies. Section 4 describes our methodology to identify prevalent themes within AI documents through combination of unsupervised topic modelling and thematic analysis approaches. Section 5 provides our corpus of AI standards. We present the results of our manual thematic analysis and automated machine learning-based algorithms in section 6. In section 7, we provide an interpretation of the results through the Sociology of Expectations framework and we conclude the report in section 8 where we also suggest further work in this area.

2. AI Standards Development Landscape

Technical standards are a subset of standards more generally – but all standards aim to have an 'ordering effect' (Busch, 2013; Star & Lampland, 2009; Timmermans & Berg, 2003) to shape social action. They are not neutral, but "Each standard and each category valorizes a point of view, and silences another" as Bowker and Star (Bowker & Star, 1999) point out.

The literature on standards distinguishes between de facto, de jure and voluntary consensus (White, 2019). De facto standards refer to practices or products that become accepted through use or market dominance (e.g. the QWERTY keyboard or VHS video). De jure standards are based on regulations and laws which are mandated by national, regional or international bodies. De jure standards must be complied with and are often monitored using audits and documentation. De jure standards are more 'performative' and must be actioned in the world. Finally, voluntary consensus standards are narrower in scope and are developed by industry associations, unions and other bodies such as the International Standards Association (ISO), which is one of the bodies examined in this report. The latter are developed via a deliberative process of consensus making by experts and interested parties. They can be both normative and performative.

Voluntary technical standards focus on developing a shared terminology/vocabulary, design specifications, procedures and performance metrics. As (White, 2019, 2021) points out, standards are often nested (overlapping, interacting with existing standards), interlinked and integrated, distributed unevenly and an embodiment of ethics and values. Standards aim to guide multiple actors in a process of standardisation and accordingly once embedded and adopted can be difficult to reverse or change. This leads to what social scientists have referred to as 'path-dependency' (David, 2001) and others as technological momentum (Hughes, n.d.). This is not to say that standards are technologically determinist, but rather to point to the fact that considerable effort, time and resources must be expended to develop de jure and voluntary standards and once developed the actions of a network of documents, people and organisations are crucial to ensuring they are enacted and that they become instruments of governance (Thévenot, 2009; White, 2021, p. 20).

There are a wide range of Standards Developing Organisations (SDOs) worldwide and they vary in their membership schemes, constitutions, standards development and approval processes and areas of competencies. There is no overall authority that is able to coordinate the development of standards, so it is not uncommon for multiple standards bodies to develop outputs with overlapping objectives and scope[10].

Standardisation activities within SDOs are typically structured to reflect the need for some degree of consensus for an activity of economic and/or societal importance. The importance of standardisation is reflected in the fact that many nation states designate and often fund a National Body responsible for representing national interests in standards development, e.g. the National Standards Authority of Ireland (NSAI) or the British Standards Institute (BSI). This importance of standards is further reflected in the ability of an SDO to mobilise experts to convene and follow a structured process of development and consensus building. Typically such experts are supported by their employers to contribute their time to standards development projects at SDOs, and as a result the collective expert contributions underpinning the consensus represented in standards can be weighted toward the view of organisations with the resources and motivation to support expert contributions. The economic and societal importance of Information and Communication Technology (ICT) means that many SDO have this as a major or a primary area of activity.

[10] As open source software pioneer, Andrew S. Tanenbaum once quipped: "The nice thing about standards is that you have so many to choose from." Computer Networks, 2nd ed., p. 254.

Some types of standards play a role in national, regional or international legislation or treaties, where the relevant standards outputs are referred to as **de jure standards**. Within the EU a process exists for adopting standards from specific SDO as harmonised European Norms that support the implementation of EU legislation and therefore are considered part of the EU legislative *acquis* and recorded in the official journal of the EU. For example, the EU AI Act relies on "***harmonised standards***" to provide concrete technical details for implementation of its requirements. Under the presumption of conformity (Art. 40, Regulation (EU) 2024/1689, 2024), compliance with provisions of the AI Act can be demonstrated through conformity with harmonised standards listed in the Official Journal of EU.

Figure 2 depicts some of the major SDOs active in the ICT domain. They can be broadly categorised as those whose members are primarily national bodies and those whose members are fee paying individuals or organisations. The primary source of de jure ICT standards is the Joint Technical Committee 1 (JTC1), which was established by the International Standardization Organization (ISO) and the International Electro-technical Commission (IEC) in 1987 to develop, maintain and promote standards in the fields of Information Technology (IT) and Information and Communications Technology (ICT). Expert contributions are made via national standards bodies and documents are often used as technical interoperability and process guideline standards in national policies, international treaties as well as being widely adopted by companies worldwide. Within Europe, the equivalent national body membership organisations are CEN (the European Committee for Standardisation) and CENELEC (European Electrotechnical Committee for Standardization). The primary international SDO in the telecommunication sector is the ITU (International Telecommunication Union) which is a United Nations Agency that operates via fee paying membership. ETSI (European Telecommunications Standards Institute) performs a similar fee-paying member-driven standardisation function within Europe.

CEN, CENELEC and ETSI are officially recognised by the EU and by the European Free Trade Association (EFTA) as being responsible for developing and defining **voluntary standards** at European level and are enabled to develop standards that can be admitted as harmonised European Norms.

The IEEE (Institute of Electrical and Electronics Engineers) is a professional fee paying organisation that also operates as an SDO through its standards association, where participation is open to IEEE individual members as well as to corporations, academic institutions, associations, nonprofits, government agencies. In the context of the broader FORSEE study IEEE activities are examined therefore in FORSEE Deliverable D2.3 on ICT professional bodies. Other relevant member-driven SDO are W3C (World Wide Web

Consortium), which addresses standards for the WWW stack, and OASIS, which focuses on market driven digital interoperability standards.

Figure 2. High level landscape of ICT-related Standards Developing Organisations

Regarding ISO outputs, there are multiple types of documents developed by ISO, including:

- International Standards (IS): are fully mature, consensus-based normative documents developed through the complete ISO approval process. According to ISO, an International Standard "provides rules, guidelines, or characteristics for activities or their results, with the objective of achieving an optimum degree of order within a given context." It may take multiple forms, including product standards, test methods, codes of practice, guideline standards, and management system standards.
- Technical Specification (TS): are normative documents that address work still under technical development or areas where there is an expected, but not immediate, possibility of consensus on an International Standard. A Technical Specification is published for immediate use while providing a mechanism to gather feedback from stakeholders, with the aim that it may eventually be transformed and republished as an International Standard.
- Technical Report (TR) are informative documents that are less mature than the previously mentioned ISO document types. They provide data obtained from

surveys, informative reports, best practices, use cases, or information that is perceived as state-of-the-art.

3. Prior Work on AI Standards

Artificial Intelligence is a rapidly growing topic within existing ICT standards development activities and has been the subject of AI related literature surveys (Schmittner & Shaaban, 2023), including for specific issues of AI governance (Cihon, 2019), responsible AI (Gadekallu et al., 2025), values in AI development (Gonzales Torres & Ali-Vehmas, 2024) and quality in AI engineering (Oviedo et al., 2024).

Existing literature on AI standards has primarily examined their role as policy documents and instruments of technical coordination, regulatory compliance, and risk management and predictions (Brunsson et al., 2012; Miller & Rose, 2013; Timmermans & Epstein, 2010). From a social science perspective the development of AI, ISO standards specify technical requirements while actively shaping how AI systems are imagined, governed, and assessed. These standards translate macro-level political and ethical objectives into operational measurements and technical documentations, thereby, they aim to mediate between laws, technologies, and organisational practices.

Compliance with technical standards often emphasises demonstrable procedures such as documentation, lifecycle management, and internal and external auditability. While formally ISO standards are not legal documents, therefore the compliance of which is technically voluntary, they are also used in a way acting in place as regulatory instruments for both organisations and state institutions (Veale & Borgesius, 2021). Existing literature has shown some ambiguity in relation to the status and action of compliance with AI standards (Yazici, 2025). Unlike statutory regulation, standards do not impose legally binding obligations on organisations. However, in practice, compliance with standards often functions as a de facto requirement through their integration into regulatory, market, and organisational governance mechanisms.

In the context of the EU AI Act, adherence to harmonised standards is explicitly linked to a presumption of conformity, making standards a central pathway for demonstrating regulatory compliance without being legally mandated (Mazzini & Scalzo, 2022).

To the best of our knowledge, the existing body of work on AI standards has not attempted to conduct thematic analysis or employ topic modelling approaches to analyse emerging AI standards. Therefore, in this section we provide further organisational context on the process of standards development and highlight some of the current uncertainties in the adoption of standards in implementing AI policies and regulations, in particular the EU's AI Act.

The widespread concern with the ethical and societal impact of AI technology means that SDO often need to consider issues of ethical or trustworthy characteristics of AI standards in parallel to the market driven needs for standardisation. Different standards bodies vary in their approach to balancing such considerations however. ISO and IEC are formally grounded in the principles of the World Trade Organization (WTO) to reduce barriers to international trade. However, they are expected to take an ethical stance where it can be affected by standardisation. For example, all new work item requirements must declare their relevance to the UN framework of Sustainable Development Goals. Some specific standards development activities within JTC 1 include the work of subcommittee (SC) 39 on ecological sustainability of IT and through IT, and of SC 40 on IT Governance. Standards are therefore a mixed common good that is expected to have positive ethical impact on business and industry practice as well as reducing interoperability barriers to commerce and shared best practice.

The EU Act takes a risk-based approach modelled on the existing EU scheme, known as the New Legislative Framework (NLF), for harmonising product health and safety legislation across the EU internal market (Mazzini & Scalzo, 2022). Thus, the AI Act benefits from established rules and practices for product regulation laid out in the so-called "Blue Guide" (*Commission Notice The 'Blue Guide' on the Implementation of EU Product Rules 2022 - C:2022:247:TOC*, 2022).

The ability to unambiguously verify that a high-risk AI system employs appropriate technical measures to mitigate risks to health, safety and fundamental rights relies on investigation of technical documentation, testing and instructions, which therefore are central to the consistent and effective implementation of the Act, and where efficiency is vital to minimising the regulatory burden of complying with the Act (Golpayegani et al., 2024). However, the Act is limited to essential high-level requirements for technical measures and how they should be undertaken is stated in horizontal terms independent of sectoral context. Instead, in common with some other regulations under the NLF, the Act allows compliance with requirements to be demonstrated by AI providers in terms of a presumption of conformity gained by adherence to separate technical standards. These technical standards can be either "Harmonised Standards" developed by European

Standards Organisations (ESOs) or if that is not possible or insufficient then via "Common Specification" to be developed by the European Commission (EC) (Tartaro, 2023). The EC has already issued a request for harmonised standards in 10 areas to the ESOs, addressing different aspects of the required technical measures (*C(2023)3215 – Standardisation request M/593*, 2023). A Joint Technical Committee of the ESO's CEN and CENELEC (JTC21) has been chartered in response to the need to develop European Standards for AI.

Despite the link in EU legislation between the implementation of AI regulation and the adoption of AI standards, the literature has already raised several concerns or uncertainties about this approach as listed below.

Limited representation in standards development: Standards development is a meticulous, lengthy and highly technical process. Therefore, the bulk of participation comes from large multinational companies that sustain teams of suitably-experienced experts, whereas other less well-resourced experts from NGOs, SMEs or academia struggle to maintain effective levels of contribution (Cuccuru, 2019). This raises concerns that the resulting AI harmonised standards from CEN/CENELEC JTC21 may not sufficiently represent the interests of citizens and SMEs in favour of the large companies that the Act must also regulate (Veale & Borgesius, 2021). Further, JTC21 is able to adopt standards directly from ISO/IEC, where the subcommittee on AI (JTC1 /SC 42) has been developing AI standards since 2018, many of which align to topics in the EC's harmonised standards request, e.g. ISO/IEC 23894 on AI risk management (ISO/IEC 2023a) and ISO/IEC 24029-2 on AI robustness (ISO/IEC 2023b). However, as these are developed by experts from a global membership of national standards bodies rather than just the European-based ones, the representation of less well resourced European actors, such as CSOs, may be further diluted.

Lack of free access to harmonised standards: Standards bodies such as ISO/IEC and CEN/CENELEC rely on charging for access as a means of funding to maintain their convening and quality assurance functions, and harmonised standards are typically high-demand items. However, as harmonised standards essentially enter EU law and are key to enforcing important consumer protections, paywall access became untenable and resulted in court actions (Kamara, 2022). The European Court of Justice delivered a judgment in Case C-588/21 P (*PublicResourceOrg, Inc and Right to Know CLG v European Commission*, 2024) that there was an overriding public interest in free access to harmonised standards, and in response ISO/IEC have asked to annul this decision (Case T-631/24, pending), thereby casting uncertainty regarding the sustainability of the current model for harmonised standards.

***Developing standards with reference to legal requirements and ethical norms**:* ISO/IEC and CEN/CENELEC guidelines prohibit addressing legal compliance so as to avoid introducing barriers to trade in these specifications. Harmonised standards address this by including a specific annex to map provisions in the standard to specific legislative requirements. This arms-length treatment and the perceived lack of democratic legitimacy in standards development means that issues of fundamental rights and ethics are limited to non-normative technical reports (ISO/IEC 2022).

***Integrating horizontal and vertical standards development**:* A key benefit of grounding harmonised standards in international ISO/IEC standards is the support offered for regulatory certification regimes, where conformity assessment is based on the ISO 17000 series of standards. This allows for use of standardised certification assessments from authorised bodies that certify against a given regulation and its harmonised standards through "notification" (i.e. competent authorities assess certification providers and "notify" them if deemed qualified). Complementing this scheme is the harmonised management system standard (MSS) template defined by ISO/IEC (ISO/IEC 2024). This common template facilitates organisations combining adoption of MSSs from different standards committees into a unified organisational management system, e.g. ISO/IEC 27001 for information security and ISO 42001 which is the MSS developed by JTC 1/SC 42 for AI from the harmonised management system. This however offers no guarantee that similar concepts or control measures included from different ISO/IEC standards committees are not in conflict, as they are often developed at different times and as committees addressing horizontal technologies such as AI are typically chartered separately to those addressing sectorial standards, such as ISO/TC 210 on health related products. The ideal solution for a Joint Committee to be formed between separate committees is tricky as there are two sets of consensus forming and voting communities involved which makes it typically slower to establish. and complete standards project. To date, the harmonised standards request to JTC21 has only sought horizontal harmonised standards from JTC21, so the development of harmonised standards specific to AI use in a vertical domain such as medical devices may introduce uncertainties in the timeliness and consistency of liaison between these committees on joint specifications.

The institutional context and SDO procedures followed have a bearing on the role of these themes in realising these expectations. Different documents have different normative standing in the ISO process. Standards contain normative statements in terms of requirements and recommendations, that an organisation can claim compliance against. A standard can contain normative dependencies on other standards, indicating the compliance to a given standard requires compliance with such normative references. Standards will focus on operational measures, while Technical Standards offer a more technology-specific set of normative requirements. Technical Reports (TR) are non-normative documents intended to provide consensus views on the state of the art of a topic without offering requirements or recommendations against which compliance claims can be made. The coordination and consistency of terms and concepts used across a family of standards project undertaken by a specific sub committee such as JTC 1/SC 42 is given special attentions, as can be seen in the normative reference made in many of the standards examined to foundational standards on terms on concepts, includes ISO/IEC 22989 for AI overall, ISO/IEC 23053 for machine learning specific terms and ISO/IEC 5259-1 for Data quality in Machine Learning. Further, JTC 1/SC 42 standards make extensive reference and use of concepts from more general purpose Standards and Technical Standards, such as those for Risk Management, System and Software System lifecycle, quality engineering and evaluation, IT Governance, Compliance systems and Management System Standards.

4. Methodology

In this section, we introduce how we selected our corpus of documents and how our methodology for analysing these documents combines manual thematic analysis and automated topic modelling.

4.1. Selecting Documents and Compiling the Corpus

Documents to be examined in this deliverable are selected based on the following criteria:

- Scope: Technical standards related to AI
- Timeline: Standards published during the period of 2018 - 2025, corresponding to the period in which AI standardisation activities have emerged. Notably, the ISO/IEC technical committee for AI standardisation, ISO/IEC JTC 1/SC 42, was created in 2017, with its first standards published in 2018.
- Issuing body: AI standardisation committees in ISO/IEC, CEN-CENELEC, and DIN.
- Type of standard: No restrictions were applied in regard to the type of standard, therefore from the ISO/IEC set of **published** standards, international and national standards, technical reports (TR), and technical specifications (TS) are included in the corpus.
- Length of document: No restrictions were applied in respect to the length documents. Note that the length of standards, in terms of page number, can vary. For example, ISO/IEC 5259-5:2025 is 22 pages long (including title page, bibliography, and intentionally blank pages) and ISO/IEC 42001:2023 is 62 pages long.

The corpus of technical standards is detailed in section 5.

4.2 Combining Thematic Analysis and Topic Modelling

The terms "**code", "topic**", **"theme"** are used extensively throughout this deliverable. Although they may appear as synonyms, they are treated as distinct concepts and are not used interchangeably. To clarify this distinction, in the following, we provide background information about how we combine **thematic analysis** and **topic modelling** in this deliverable.

In this deliverable, we consider a **document** as an individual text issued regarding AI by a technical standardisation body. These documents, or in more accurate wording standards, are included within a corpus (see section 5).

In our methodology, we first apply **thematic analysis,** which is a popular method of qualitative data analysis that systematically organises datasets, helps to identify patterns of meaning commonly referred to as themes (Squires, 2023). First described in the 1970s by Houlton – albeit the term itself had been in use even earlier – it became more prominent in the late 1990s with researchers like Boyatzis and Hayes (Braun & Clarke, 2021; Terry et al., 2017). In recent times, thematic analysis has been understood as an umbrella term for different approaches. While popular in qualitative interview data analysis, computer-assisted expert thematic analysis of legal texts and technical standards appears to be less commonly employed.

In our work, we use manual thematic analysis to create codes from a small subset of standards (5 out of 36 international and national standards under investigation). The output of this process is a set of codes**. Code** refers to a concept that is manually identified as being both present and important within the domain. **Thematic analysis can then be conducted across these codes.** By its nature, thematic analysis is subjective and relies on the individual's judgements and expertise. In addition, it is a time-consuming and resource-intensive process which makes it difficult to conduct thematic analysis of a large corpus of documents.

Addressing these limitations, we also employ **topic modelling,** which is a statistical method used to identify prevalent topics in large corpora of text. Topic modelling uses unsupervised machine learning techniques for uncovering topics within large sets of documents. There are different unsupervised topic models (see Churchill & Singh, 2022) for evolution of such models). Currently, BERTopic (Grootendorst, 2022) and Latent Dirichlet Allocation (LDA) (Blei et al., 2003) are the most popular topic models. The output of these models are topics.

Topic is a concept that has been identified by a computational model (e.g., LDA or BERTopic) as being present in the corpus consisting of multiple documents. In both LDA and BERTopic, a topic can be understood as a latent concept associated with a subset of documents and typically summarised by salient words that tend to appear when that concept is present. It should, however, be noted that the underlying mathematical object defining a topic differs across LDA and BERTopic (a probability distribution over words in LDA versus a cluster of document embeddings in BERTopic). On the basis of our initial work to identify a suitable topic modelling approach for documents issued by supranational bodies, as described in detail in FORSEE Deliverable D2.2[11], and also published in (Golpayegani et al., 2025), we use BERTopic as the suitable topic modeller for quantitative analysis of the standards examined in this deliverable. Though BERTopic, and in general topic modelling approaches, are usually applied to a set of documents, we apply it to each document separately to gain insights into each single document (each standard document in this deliverable). Therefore, in this work topics are associated with a subset of sentences within a document.

Finally, to gain insights, we interpret the codes and topics through the lens of sociology of expectation to identify **themes. A theme** is a broad interpretable semantic concept derived through expert interpretation, either from the topics generated by a topic modeller or directly from the codes generated during the thematic analysis process. By illustrating the overall methodology wherein thematic analysis and topic modelling are integrated, Figure 3 shows the key concepts in the methodology and how they are related to each other.

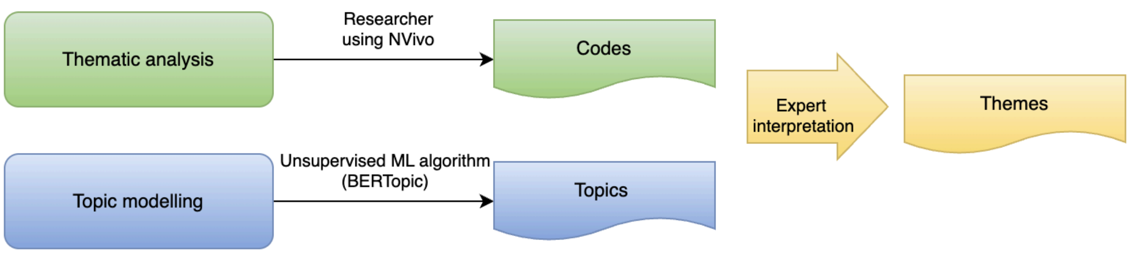

Figure 3. Overall methodology that combines thematic analysis and topic modelling to identify themes

4.2.1. Thematic Analysis

[11] https://zenodo.org/records/18352574

The qualitative analysis of a set of ISO standards was conducted using NVivo software (see section 6 for the findings). As explained by (Dhakal, 2022), NVivo is a CAQDAS (Computer-assisted qualitative data analysis software) programme that assists, rather than replaces, a human researcher. NVivo analysis is, thus, expert-led and in this project it was performed by a legal researcher (Researcher #1 as mentioned in the positionality statement). The documents were imported into NVivo and coding was performed by selecting a section of text and then tagging it with a code. The codes were assigned inductively by the human researcher. These codes were subsequently used to inform the development of higher level themes.

Given the volume of potentially relevant documents and the fact that the majority of them are highly structured and technical, we decided to conduct NVivo-supported manual thematic analysis on a sample of 5 standards, which are:

- **ISO/IEC 22989:2022** Information technology — Artificial intelligence — Artificial intelligence concepts and terminology
- **ISO/IEC 42001:2023** Information technology — Artificial intelligence — Management system
- **ISO/IEC TR 24028:2020** Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence
- **ISO/IEC TR 24368:2022** Information technology — Artificial intelligence — Overview of ethical and societal concerns
- **ISO/IEC TR 20226:2025** Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems

We chose these specific standards employing purposive sampling, beginning with **ISO/IEC 22989:2022** which provides the key concepts and terminology identified as relevant to AI standardisation in ISO/IEC. We also included **ISO/IEC 42001:2023** which offers a structured framework for AI governance that is well aligned with the EU AI Act, despite not being selected as a harmonised standard. These are respectively the conceptual and procedural foundational standards for the normative standards developed by SC42, i.e. they underpin any future claims to standards compliance by individual organisations.

The other three documents were technical reports (TR). These do not offer any normative weight for future compliance claims but they can be referred to representing consensus **on the state of the art** on issues seen as relevant to AI deployment, but not yet addressed in normative standards that can support compliance. These three TR were selected as they directly address issues that are common to AI public policy concerns, namely trustworthiness, ethical and societal issues and environmental issues, and therefore closely linked to the socio-technical success factors analysis of the FORSEE project. **ISO/IEC TR**

24028, Overview of trustworthiness in artificial intelligence, is selected as an early and influential ISO document on AI trustworthiness, published in 2020. This ISO Technical Report establishes criteria for AI trustworthiness, by recognising key concerns associated with AI systems and providing risk mitigation measures and techniques to address such concerns. **ISO/IEC TR 24368,** provides a high-level overview of ethical and societal concerns. Addressing a wide range of stakeholders, from organisations developing AI to researchers to policymakers, this technical report identifies 14 AI principles and provides guidelines for *building ethical and socially acceptable AI.*

Finally, **ISO/IEC TR 20226** is a recent, and to the best of our knowledge, the only ISO document that focuses on environmental impacts of AI. This Technical Report focuses on environmental sustainability aspects of AI, including energy consumption, carbon footprint, and waste of AI systems. As evident, these three documents are published as Technical Reports, rather than International Standards. This reflects, first, the relative immaturity of guidelines, approaches, and metrology concerning ethical, societal, and environmental aspects of AI. It further can be an indicator of the complexity of these issues and the fact that ethical values and environmental and social considerations are not uniformly prioritised across different jurisdictions and societies, which together makes consensus building a challenging and lengthy process. This selection of standards therefore allow manual thematic analysis supported by the NVivo tool to be efficiently concentrated on documents with the most relevance to the broader study, while automated topic analysis with BERTopic is used to analyse the remaining set of relevant documents from international ISO/IEC AI standardisation and a smaller set from the German SDO DIN, representing national AI standardisation activities.

4.2.2. Topic Modelling

Building upon our work on FORSEE Deliverable D2.2 (also described in (Golpayegani et al., 2024)), we use BERTopic for quantitative analysis of our corpus of AI standards. For determining topics from the standards we follow these steps:

1. **Document preparation**: from each document, repeated standard title and licence statements as well as bibliography are removed. To enable application of BERTopic on a single document, we treated each document as a set of sentences. We extracted the text from the PDF file and then split the text into sentences using the `PyMuPDF` library in Python.

2. **Text preprocessing**: Before application of BERTopic, we employed common NLP

approaches to apply minimal preprocessing using the `nltk` library for:

- Lowercasing,
- Removing non-alphabetic tokens (e.g. punctuation marks),
- Removing tokens shorter than two characters.

Note that we did not remove tokens that consist solely of numbers since they represent useful information about the other standards mentioned in the standard. Further, we did not remove stop words or perform lemmatisation prior to embedding, given that BERTopic uses transformer-based embeddings, which require the text to be persevered for better accuracy. We removed the stop words, after generating embeddings, using the `CountVectorizer` when initialising BERTopic.

3. **Applying BERTopic**: Since this work uses BERTopic at the sentence-level, the description of how BERTopic works is made consistent with the wording used throughout this deliverable. The following describes how BERTopic generates topics:
    - Each sentence is converted to its embedding representation (numerical representation) using a pre-trained language model. We used `all-MiniLM-L6-v2`[12] which is a pre-trained mode that converts sentences and paragraphs into vector-based representations.

```python
embedding_model = SentenceTransformer("all-MiniLM-L6-v2")
```

    - To group sentences into semantically similar clusters, the dimensionality of the resulting embeddings is reduced using UMAP (Uniform Manifold Approximation and Projection) and HBDSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise). Since applying BERTopic default parameters on short documents did not generate any coherent topics, we identified two hyperparameter configurations: one for longer texts and another for shorter documents. These configurations only differ in the `HDBSCAN` clustering model**,** with a lower minimum number of samples per word cluster is set for shorter documents. These hyperparameter configurations were used uniformly (based on the length of document) to ensure consistency and reproducibility of results.

[12] https://huggingface.co/sentence-transformers/all-MiniLM-L6-v2

```python
map_model = umap.UMAP(n_neighbors=15, n_components=5, min_dist=0.0, metric='cosine', random_state=42)
hdbscan_model = HDBSCAN(min_cluster_size=10, min_samples=5)
```

- For topic representations, we used `CountVectorizer` to enable frequency analysis, without down-weighting the common words in the document. Instead, we removed some common words, such as “AI”, “Artificial Intelligence", and latin numerals in this step.

```python
vectorizer_model = CountVectorizer(ngram_range=(1, 1), stop_words= stop_words)
```

The snippets used for preprocessing and topic modelling are available on GitHub under the MIT licence at https://github.com/DelaramGlp/forsee_topicmodelling. The source code and the results are available in an archived release with a persistent digital object identifier (DOI): https://doi.org/10.5281/zenodo.18303112.

4. **Topic labelling**: An example of BERTopic output for ISO/IEC 42001 on AI management system is shown in Figure 4. In this, “topic” demotes a unique numeric identifier for each topic generated by the model. -1 topic denotes outliers (sentences) not assigned to any meaningful topic. The “Count” column shows the frequency of each topic, i.e. the number of sentences assigned to the topic. “Name” shows a short topic label, however, as shown in the figure, BERTopic does not automatically assign a semantic label and only shows top keywords. “Representation” provides a list of keywords representing the topic and “Representative Sentences” is a set of sentences that are associated with the topic.

   As noted earlier, the *Names* generated by BERTopic do not constitute meaningful semantic labels for topics. Consequently, assigning interpretable labels as topics requires to be conducted manually. In this work, a researcher involved in WP2 (Researcher #1, see positionality statement) independently topics based on the keywords. The proposed labels were reviewed by an expert in AI standardisation (Researcher #4). An example of label assignments is shown in Figure 5, with the

Topic Label demonstrating the agreed-upon topic label.

Topic	Count	Name	Representation	Representative_Sentences
0	43	0_impacts_groups_assessments_societal	['impacts', 'groups', 'assessments', 'societal', 'assessing', 'sustainability', 'environmental', 'greenhouse', 'emissions', 'documentation']	['6.1.4 ai system impact assessment the organization shall define process for assessing the potential consequences for individuals or groups of individuals or both and societies that can result from the development provision or use of ai systems', 'b.5.2 ai system impact assessment process control the organization should establish process to assess the potential consequences for individuals or groups of individuals or both and societies that can result from the ai system throughout its life cycle', 'b.5.4 assessing ai system impact on individuals or groups of individuals control the organization should assess and document the potential impacts of ai systems to individuals or groups of individuals throughout the system life cycle']
1	42	1_risk_risks_management_options	['risk', 'risks', 'management', 'options', 'objectives', 'controls', 'assessments', 'process', 'actions', 'services']	['6.1.2 ai risk assessment the organization shall define and establish an ai risk assessment process that is informed by and aligned with the ai policy see 5.2 and ai objectives see 6.2 note when assessing the consequences as part of 6.1.2 the organization can utilize an ai system impact assessment as indicated in 6.1.4. is designed such that repeated ai risk assessments can produce consistent valid and comparable results identifies risks that aid or prevent achieving its ai objectives analyses the ai risks to assess the potential consequences to the organization individuals and societies that would result if the identified risks were to materialize assess where applicable the realistic likelihood of the identified risks determine the levels of risk evaluates the ai risks to compare the results of the risk analysis with the risk criteria see 6.1.1 prioritize the assessed risks for risk treatment', '6.1.3 ai risk treatment taking the risk assessment results into account the organization shall define an ai risk treatment process to select appropriate ai risk treatment options determine all controls that are necessary to implement the ai risk treatment options chosen and compare the controls with those in annex to verify that no necessary controls have been omitted note annex provides reference controls for meeting organizational objectives and addressing risks related to the design and use of ai systems', 'when risk assessments identify new risks that require treatment risk treatment process in accordance with 6.1.3 shall be performed for these risks']

Figure 4. An excerpt of the output generated by BERTopic for ISO/IEC 42001 on AI management system

Topic	Count	Representation	Topic Label
0	22	['data', 'pii', 'users', 'application', 'downstream', 'originators', 'requirements', 'rights', 'decommissioning', 'benefit']	data protection
1	20	['guidance', 'organizations', 'quality', 'methods', 'analytics', 'edition', 'references', 'tools', 'requirements', 'ml']	data governance, organizatior
2	19	['ml', 'performance', 'results', 'training', 'models', 'trained', 'analytical', 'experience', 'techniques', 'transparency']	data training, transparency
3	16	['quality', 'characteristics', 'measures', 'dataset', 'requirements', 'figure', 'assessment', 'framework', 'degree', 'refers']	data quality, lifecycle
4	13	['ml', 'training', 'testing', 'validation', 'supervised', 'labelling', 'data', 'process', 'technologies', 'annotation']	training, testing, validation
5	13	['step', 'engineer', 'data', 'quality', 'service', 'requirements', 'pipeline', 'managing', 'purpose', 'warehouse']	data quality, data managemen
6	12	['provenance', 'information', 'governance', 'records', 'origin', 'dataset', 'manipulated', 'gather', 'proof', 'authenticity']	data governance, data quality
7	10	['analytics', 'dlc', 'stages', 'project', 'model', 'arrows', 'pathway', 'development', 'processes', 'progression']	data analytics, lifecycle
8	9	['analytics', 'ml', 'projects', 'quality', 'scenarios', 'objectives', 'models', 'requirements', '02_5259_1_modified', 'aspect']	data quality, data analytics
9	9	['visualization', 'values', 'data', 'measures', 'features', 'attributes', 'heart', 'outliers', 'volumetric', 'tumour']	data quality, stakeholders
10	9	['stage', 'preparation', 'project', 'planning', 'provisioning', 'analytics', 'acquisition', 'batches', 'requirements', 'goals']	data management

Figure 5. An example of assigning of labels to the outputs generated by BERTopic by experts (Expert #1 as described in the positionality statement) for ISO/IEC 5259-1 on the terminology and examples of data quality for analytics and machine learning

4.2.3. Interpreting Codes and Topics to Identify Themes

Following inductive manual coding and automated topic analysis the research team went through a process of iterative interpretation aimed at generating, refining and naming themes. This process of meaning making involved both colour coding of topics and codes, clustering, referring back to the original texts and a structured analysis. In line with prior work on the Sociology of Expectations, we also categorised the themes according to whether the themes primarily referred to actions that might be taken by actors at a micro, meso and macro levels. The multidisciplinary team then reviewed, discussed and refined the themes and clustered them into meta-themes guided by the overall research question, our disciplinary backgrounds and our grounding in the data and the prior literature.

5. Corpus of Technical Standards Issued by ISO/IEC JTC 1/SC 42 and the German National Standards Body (DIN)

Our study focuses on technical standards issued between January 2018 and August 2025, covering the period when AI governance in Europe was shifting from early trustworthy AI guidelines to the recent regulation setting efforts. As noted earlier, the standards selected were from two sources:

- Firstly, ISO/IEC JTC 1/SC 42 Standards published in the time window and which had relevance to the AI Act (including the topics covered in the AI Act harmonised standards request) and those addressing socio-technical aspects of AI, or technical aspects on which they rely, consistent with the scope of the border focus of the study on success factors. These were accessed under a research license in place between the National Standards Authority of Ireland and Trinity College Dublin (n=30). The lists of ISO/IEC standards included in our corpus are provided in Table 1 and shown in Figure 6.
- Secondly, to offer a perspective from a relevant European national standardisation activity, AI standards with technical compliance or socio-technical scope made available by the German Institute for Standardisation (DIN) and the German Commission for Electrotechnical, Electronic & Information Technologies (DKE) free of charge under their Publicly Available Specification (PAS) scheme (n=6) were included. The DIN standards included in the corpus are listed in Table 2.

Standards developed by CEN-CENELEC JTC 21 were also considered as these would include standards specifically developed to address the EC harmonised standards request for the AI Act, however none of these had been finalised within the time window. For an additional national standards perspective, AI standards published by the British Standards Institute (BSI) were also consulted, however, the relevant BSI AI standards were found to be either adoptions of existing ISO/IEC JTC 1/SC 42 standards, that were already included in the selected corpus, or were national domain specific standards and behind a paywall.

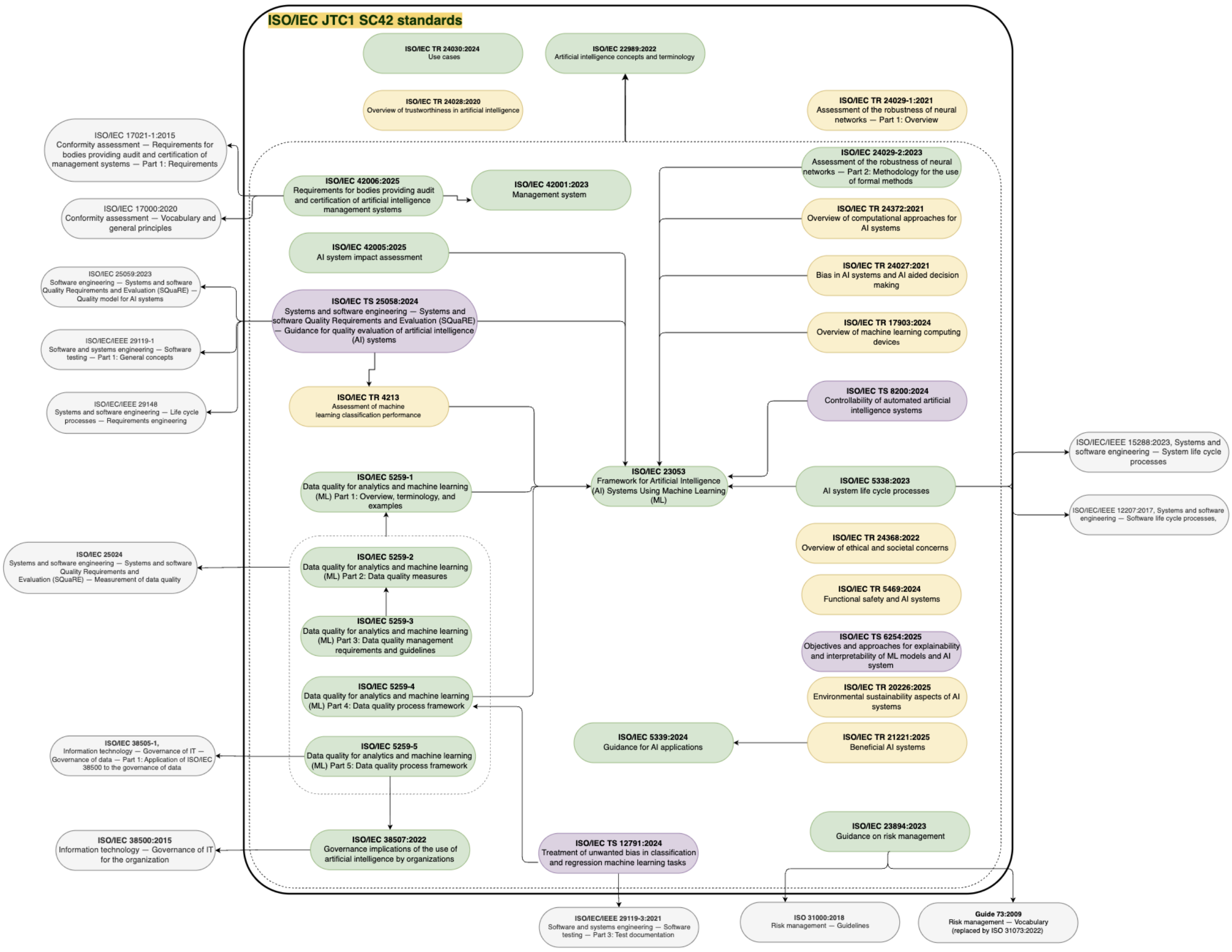

Figure 6. Depiction of the classes of selected ISO/IEC JTC 1/SC 42 Standards (in green), Technical Standards (in purple) and Technical Reports (in yellow), together with their normative dependencies and dependencies on standards from other committees and subcommittees within ISO (shown in grey).

Table 1. ISO/IEC JTC 1/ SC 42 AI standards included in the corpus

ID	Document	Issuer	Type
ISO_01	**ISO/IEC TS 4213:2022** - Information technology — Artificial intelligence — Assessment of machine learning classification performance (*ISO/IEC TS 4213*, 2022)	ISO/IEC	International Standard
ISO_02	**ISO/IEC *5259-1:2024*** - Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 1: Overview, terminology, and examples (*ISO/IEC 5259-1*, 2024)	ISO/IEC	International Standard
ISO_03	**ISO/IEC 5259-2:2024** -Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 2: Data quality measures (*ISO/IEC 5259-2*, 2024)	ISO/IEC	International Standard
ISO_04	**ISO/IEC 5259-3:2024** - Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 3: Data quality management requirements and guidelines (ISO/IEC 5259-3, 2024)	ISO/IEC	International Standard
ISO_05	**ISO/IEC 5259-4: 2024** - Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 4: Data quality process framework (*ISO/IEC 5259-4*, 2024)	ISO/IEC	International Standard
ISO_06	**ISO/IEC 5259-5: 2025** - Artificial intelligence — Data quality for analytics and machine learning (ML) — Part 5: Data quality governance framework (*ISO/IEC 5259-5*, 2025)	ISO/IEC	International Standard
ISO_07	**ISO/IEC 5338:2023** - Information technology — Artificial intelligence — AI system life cycle processes (*ISO/IEC 5338*, 2023)	ISO/IEC	International Standard
ISO_08	**ISO/IEC 5339: 2024** - Information technology — Artificial intelligence — Guidance for AI applications (*ISO/IEC 5339*, 2024)	ISO/IEC	International Standard
ISO_09	**ISO/IEC TR 5469: 2024** - Artificial intelligence — Functional safety and AI systems (*ISO/IEC TR 5469*, 2024)	ISO/IEC	Technical Report (TR)
ISO_10	**ISO/IEC TS 6254: 2025** - Information technology — Artificial intelligence — Objectives and approaches for explainability and interpretability of machine learning (ML) models and artificial intelligence (AI) systems (*ISO/IEC TS 6254*, 2025)	ISO/IEC	Technical Specification (TS)
ISO_11	**ISO/IEC TS 8200: 2024** - Information technology — Artificial intelligence — Controllability of automated artificial intelligence systems (*ISO/IEC TS 8200*, 2024)	ISO/IEC	Technical Specification (TS)
ISO_12	**ISO/IEC TS 12791: 2024** - Information technology — Artificial intelligence — Treatment of unwanted bias in classification and regression machine learning tasks (*ISO/IEC TS 12791*, 2024)	ISO/IEC	Technical Specification (TS)

ID	Document	Issuer	Type
ISO_13	**ISO/IEC TR 17903: 2024** - Information technology — Artificial intelligence — Overview of machine learning computing devices (ISO/IEC TR 17903, 2024)	ISO/IEC	Technical Report (TR)
ISO_14	**ISO/IEC TR 20226: 2025** - Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems (*ISO/IEC TR 20226*, 2025)	ISO/IEC	Technical Report (TR)
ISO_15	**ISO/IEC TR 21221: 2025** - Information technology — Artificial intelligence — Beneficial AI systems (*ISO/IEC TR 21221*, 2025)	ISO/IEC	Technical Report (TR)
ISO_16	**ISO/IEC 22989: 2022** - Information technology — Artificial intelligence — Artificial intelligence concepts and terminology (*ISO/IEC 22989*, 2022)	ISO/IEC	International Standard
ISO_17	**ISO/IEC 23053: 2022** - Framework for Artificial Intelligence (AI) Systems Using Machine Learning (ML) (*ISO/IEC 23053*, 2022)	ISO/IEC	International Standard
ISO_18	**ISO/IEC 23894: 2023** - Information technology — Artificial intelligence — Guidance on risk management (*ISO/IEC 23894*, 2023)	ISO/IEC	International Standard
ISO_19	**ISO/IEC TR 24027: 2021** - Information technology — Artificial intelligence (AI) — Bias in AI systems and AI aided decision making (ISO/IEC TR 24027, 2021)	ISO/IEC	Technical Report (TR)
ISO_20	**ISO/IEC TR 24028, 2020** - Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence (*ISO/IEC TR 24028*, 2020)	ISO/IEC	Technical Report (TR)
ISO_21	**ISO/IEC TR 24029-1: 2021** - Artificial Intelligence (AI) — Assessment of the robustness of neural networks — Part 1: Overview (*ISO/IEC TR 24029-1*, 2021)	ISO/IEC	Technical Report (TR)
ISO_22	**ISO/IEC 24029-2, 2023** - Artificial intelligence (AI) — Assessment of the robustness of neural networks — Part 2: Methodology for the use of formal methods (*ISO/IEC 24029-2*, 2023)	ISO/IEC	International Standard
ISO_23	**ISO/IEC TR 24030, 2024** - Information technology — Artificial intelligence (AI) — Use cases (*ISO/IEC TR 24030*, 2024)	ISO/IEC	Technical Report (TR)
ISO_24	**ISO/IEC TR 24368, 2022** - Information technology — Artificial intelligence — Overview of ethical and societal concerns (*ISO/IEC TR 24368*, 2022)	ISO/IEC	Technical Report (TR)
ISO_25	**ISO/IEC TR 24372: 2021** - Information technology — Artificial intelligence (AI) — Overview of computational approaches for AI systems (*ISO/IEC TR 24372*, 2021)	ISO/IEC	Technical Report (TR)

ID	Document	Issuer	Type
ISO_26	**ISO/IEC TS 25058: 2024** - Systems and software engineering — Systems and software Quality Requirements and Evaluation (SQuaRE) — Guidance for quality evaluation of artificial intelligence (AI) systems (*ISO/IEC TS 25058*, 2024)	ISO/IEC	Technical Specification (TS)
ISO_27	**ISO/IEC 38507: 2022** - Information technology — Governance of IT — Governance implications of the use of artificial intelligence by organizations (*ISO/IEC 38507*, 2022)	ISO/IEC	International Standard
ISO_28	**ISO/IEC 42001: 2023** - Information technology — Artificial intelligence — Management system (*ISO/IEC 42001*, 2023)	ISO/IEC	International Standard
ISO_29	**ISO/IEC 42005: 2025** - Information technology — Artificial intelligence (AI) — AI system impact assessment (*ISO/IEC 42005*, 2025)	ISO/IEC	International Standard
ISO_30	**ISO/IEC 42006, 2025** - Information technology — Artificial intelligence — Requirements for bodies providing audit and certification of artificial intelligence management systems (ISO/IEC 42006, 2025)	ISO/IEC	International Standard

Table 2. DIN AI standards included in the corpus

ID	Document	Issuer	Type
DIN_01	**DIN 305203- DIN SPEC 92001-1:2019-04**: AI Life Cycle Processes and Quality Requirements - Part 1 Quality Meta-model (DIN SPEC 92001-1, n.d.)	DIN	DIN SPEC (PAS)
DIN_02	**DIN 3205018- DIN SPEC 92001-2:2020-12**: AI Lifecycle Process and Quality Requirements - Part 1: Robustness (*DIN SPEC 92001-1*, n.d.)	DIN	DIN SPEC (PAS)
DIN_03	**DIN 3338834- DIN DKE SPEC 99001:2022-05**: Definition of success methods for labelling data for AI training (*DIN DKE SPEC 99001*, n.d.)	DIN	DIN DKE SPEC (PAS)
DIN_04	**DIN 3439886- DIN SPEC 32792:2023-07**: Semantic definitions to support AI-enabled data processing (*DIN SPEC 32792*, n.d.)	DIN	DIN SPEC (PAS)
DIN_05	**DIN 3521675- DIN SPEC 92005:2024-03**: AI - Uncertainty Quantification for Machine Learning (*DIN SPEC 92005*, n.d.)	DIN	DIN SPEC (PAS)
DIN_06	**DIN 3610747- DIN SPEC 91526:2025-05**: Knowledge graphs for language models and language models for knowledge graphs ((*DIN SPEC 91526*, n.d.))	DIN	DIN SPEC (PAS)

6. Findings

6.1. Codes Identified from a Subset of ISO/IEC Standards in NVivo-supported Thematic Analysis

The NVivo-supported thematic analysis of the selected sample of ISO/IEC AI standards provides insight into the current governance priorities embedded within the international standardisation landscape. While the sample is partial and cannot be taken as a comprehensive representation of all AI-related standards under development within ISO/IEC JTC 1/SC 42, the results nevertheless illuminate several consistent patterns.

Across the standards examined, risk consistently emerges as one of the most frequently referenced concepts. Similarly, the concept of the AI system life-cycle constitutes a recurring code across the standards. This suggests an understanding of AI systems as requiring continuous governance and monitoring. This life-cycle framing is further reinforced by the substantial attention given to technical documentation which is positioned as both an accountability mechanism and evidence for demonstrating conformity. Furthermore, nearly all the analysed standards incorporate references to stakeholders, suggesting an acknowledgment that AI systems require collaborative governance.

Codes associated with the widely referenced principles of "trustworthy AI", such as explainability, transparency, privacy, fairness, and accountability, appear across the standards, though with varying degrees of emphasis. This suggests that while high-level principles are present across the documents, their depth and specificity may depend on each standard's scope.

Notably, environmental considerations feature prominently in ISO/IEC TR 20226 and appear, **albeit to a lesser extent**, in other standards. Codes such as carbon footprint, energy consumption, waste, and sustainable development signal an emerging integration of ecological concerns as a part of the operational dimensions alongside more established ethical and technical principles.

Conversely, compared to risk, documentation, and technical considerations, codes such **as human rights, employment impacts, future of work, and bias/discrimination appear less frequently** and with lower percentage coverage. This suggests that while these issues are acknowledged in certain documents (notably TR 24368), they are not yet uniformly embedded across the standards ecosystem. This may also be characteristic of the restrictions under which projects at SDOs such as ISO/IEC operate under, which limits reference to legal requirements (see section 2).

Overall, the NVivo analysis of the 5 standards indicates that the current ISO/IEC AI standards framework is predominantly shaped by risk-based governance, life-cycle management, technical documentation, and the operational dimensions of trustworthiness. Ethical, societal, human-centric and environmental considerations are mentioned in specific technical reports, but they tend to receive less consistent emphasis across the documents, and thus are more siloed.

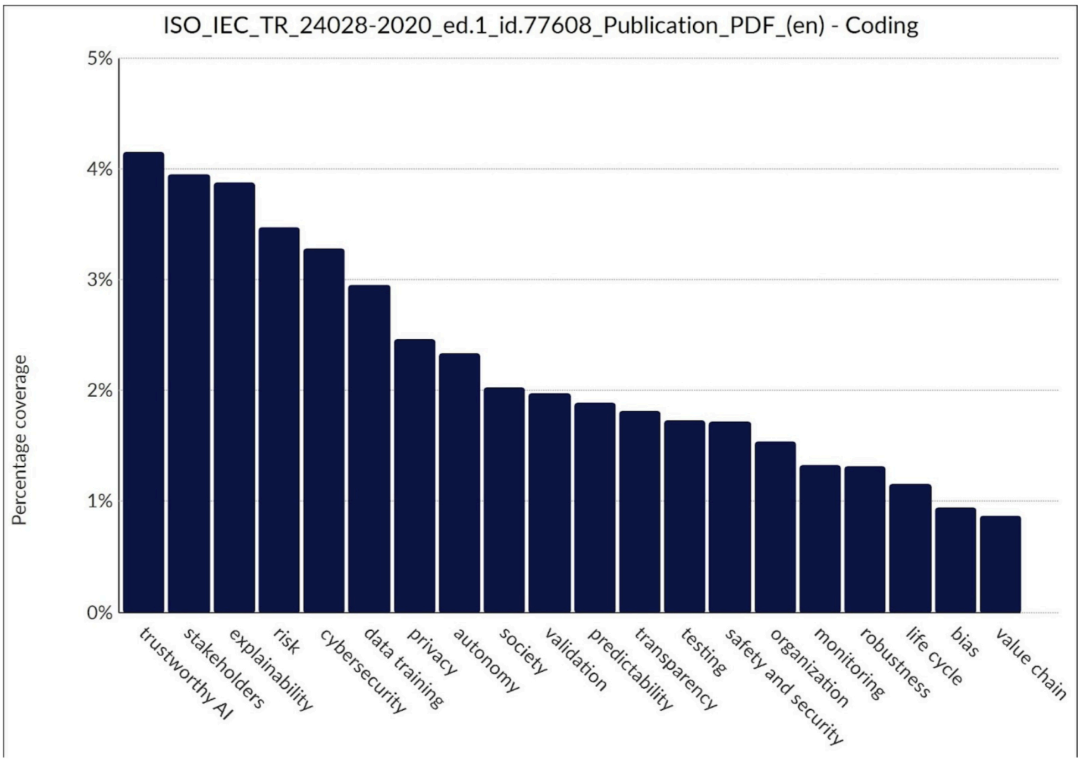

Figure 7. Results (codes) from manual thematic analysis of ISO/IEC TR 24028:2020 Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence

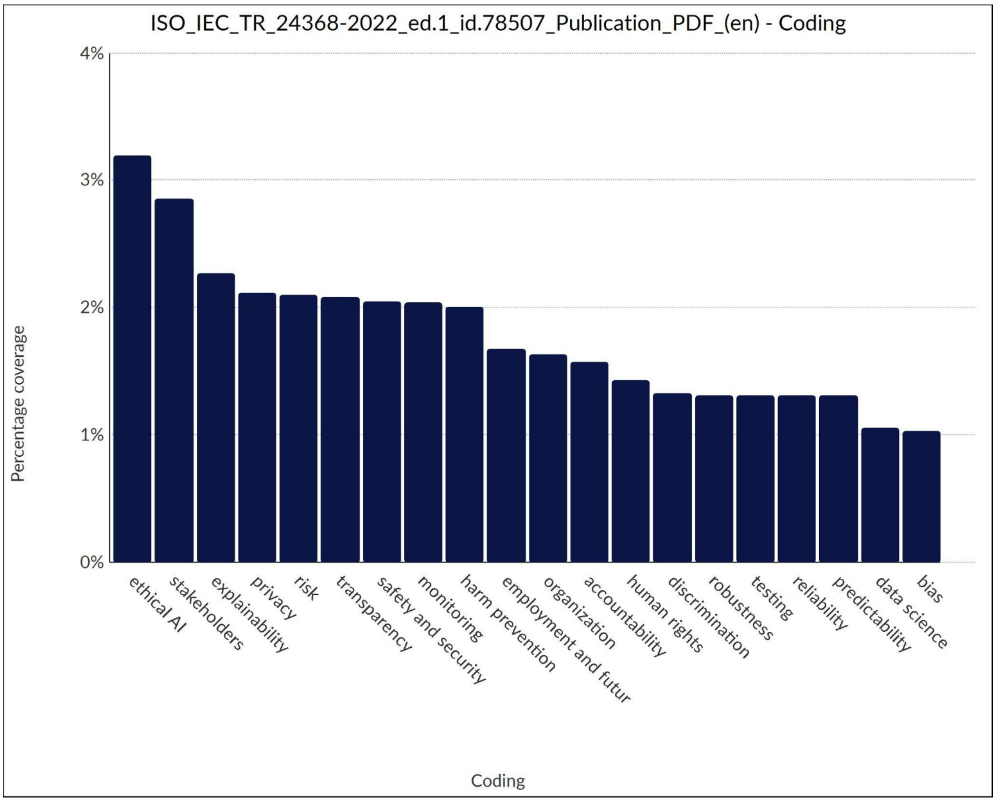

Figure 8. Results (codes) from manual thematic analysis of ISO/IEC TR 24368:2022 Information technology — Artificial intelligence — Overview of ethical and societal concerns

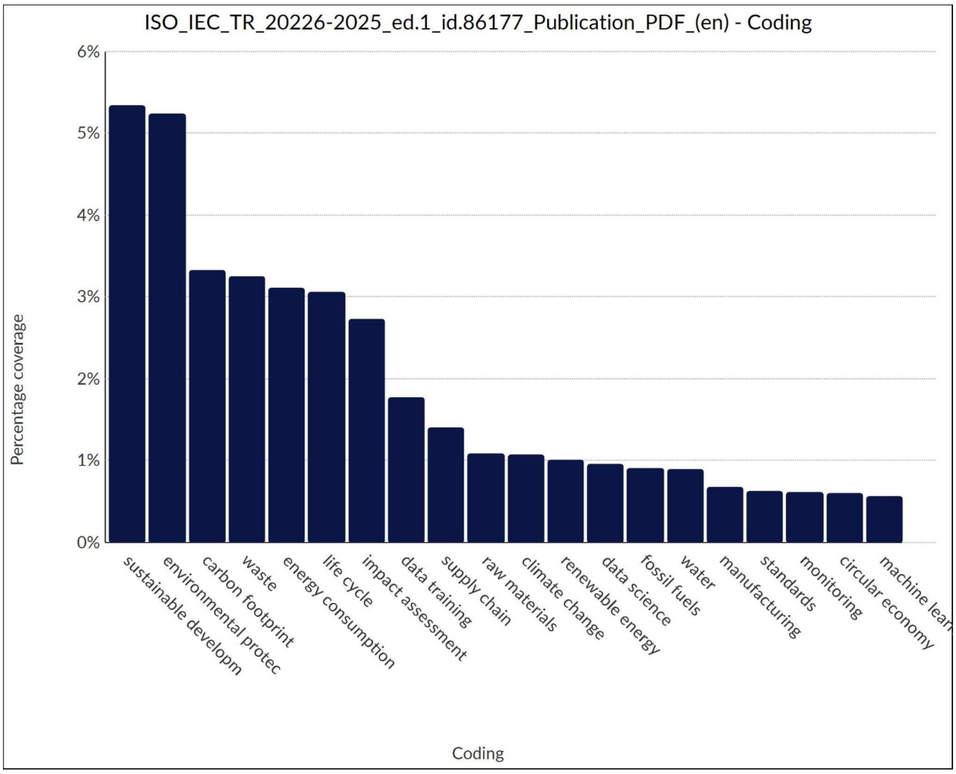

Figure 9. Results (codes) from manual thematic analysis of ISO/IEC TR 20226:2025 Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems

Table 3. Overview of the key codes identified in NVivo-supported manual thematic analysis

ID	Document	No. of codes	Key codes identified through NVivo-supported manual thematic analysis
ISO_14	ISO/IEC TR 20226:2025 Information technology — Artificial intelligence — Environmental sustainability aspects of AI systems	35	Sustainable Development, Environmental Protection, Carbon Footprint, Waste, Energy Consumption, Life Cycle, Impact Assessment, Data Training, Supply Chain, Raw Materials
ISO_16	ISO/IEC 22989:2022 Information technology — Artificial intelligence — Artificial intelligence concepts and terminology	23	Data Science, Stakeholders, Life Cycle, Knowledge, Autonomy, Trustworthy AI, Explainability, Risk, Transparency, Robustness
ISO_20	ISO/IEC TR 24028:2020 Information technology — Artificial intelligence — Overview of trustworthiness in artificial intelligence	33	Trustworthy AI, Stakeholders, Explainability, Risk, Cybersecurity, Data Training, Privacy, Autonomy, Society, Validation
ISO_24	ISO/IEC TR 24368:2022 Information technology — Artificial intelligence — Overview of ethical and societal concerns	49	Ethical AI, Stakeholders, Explainability, Privacy, Risk, Transparency, Safety and Security, Monitoring, Harm Prevention, Employment and the Future of Work
ISO_28	ISO/IEC 42001:2023 Information technology — Artificial intelligence — Management system	45	Technical Documentation, Risk, Monitoring, Impact Assessment, AI Management, Data Science, Safety and Security, Life Cycle, Society, Explainability

6.2. Topics Identified from ISO/IEC and DIN Standards Using BERTopic

In this section, we provide the topics identified from BERTopic, following the topic modelling part of our methodology. As a reminder, in this step, BERTopic is applied to a pre-processed text of each standard. The output of BERTopic is stored in a tabular format (CSV), and top keywords related to each topic are visualised using a bar chart as well as a word cloud. The use of multiple visualisations enhanced assignment of meaningful semantic topic labels to BERTopic-generated topics. An example bar chart illustrating the key topics identified from ISO/IEC 42001 AI management system is shown in Figure 10. Figure 11 illustrates the word cloud of top topics identified from ISO/IEC 42005 on AI impact assessment. Note that in the word cloud, Topic -1 represents the noisy topic cluster.

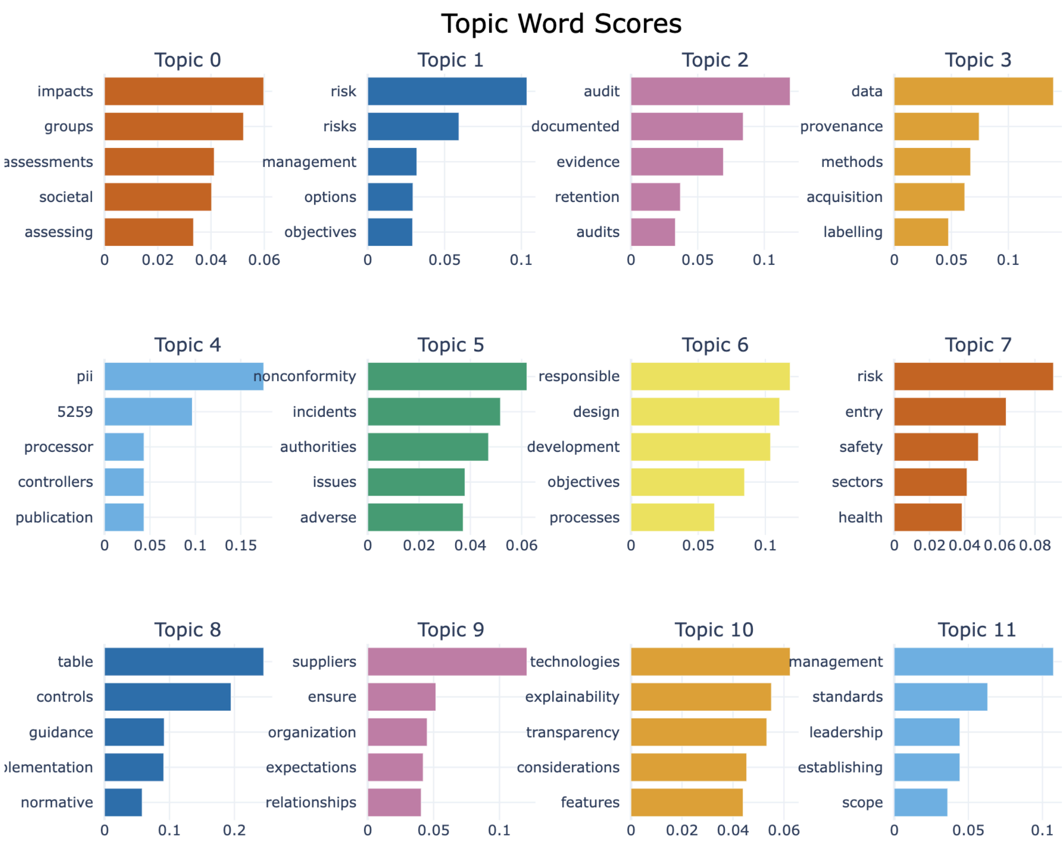

Figure 10. Bar charts representing top topics identified by BERTopic for ISO/IEC 42001 on AI management system

Figure 11. Word clouds demonstrating the topics identified by BERTopic for ISO/IEC 42005 on AI impact assessment

Researcher #1 (refer to the positionality statement for the profile of the experts involved) independently analysed the BERTopic outputs and assigned labels to keywords indicating topics. Despite text pre-processing and hyperparameter optimisation of BERTopic, some of the keywords exhibited insufficient coherence (sufficient noise) to allow meaningful interpretation to assign meaningful topic labels.

Additionally, while some keywords representing a topic were coherent, multiple topic labels could be assigned to them. We adopted a minimalistic approach when assigning topics, i.e. attributing the smallest set of labels to each topic identified by BERTopic. In cases where comprehensive representation required multiple labels, we established a constraint of assigning a maximum of 3 labels to each topic. The results of label assignment were then reviewed jointly in a consensus-building session, with involvement of Researcher #4, during which discrepancies were discussed and resolved.

It is worth observing that *failure* and *misuse* appear in Figure 11 analysis of ISO/IEC 42005 AI impact assessment (topic 7). When we examine this in more detail this refers to system failures and is framed as 'failure to meet performance requirements' with potential impacts on human rights, or potential physical or psychological harms. It may also refer to when a system is compromised by unauthorised users. While only identified in one standard document, this framing of failure provides us with some insights into the emerging terminology around success and failure.

Figure 12 provides a word cloud of topics identified from ISO/IEC JTC 1/SC 42 standards, highlighting the most prevalent themes across the corpus. Figure 13 shows the prevalent topics identified from DIN standards through analysis of BERTopic results, using word cloud visualisation.

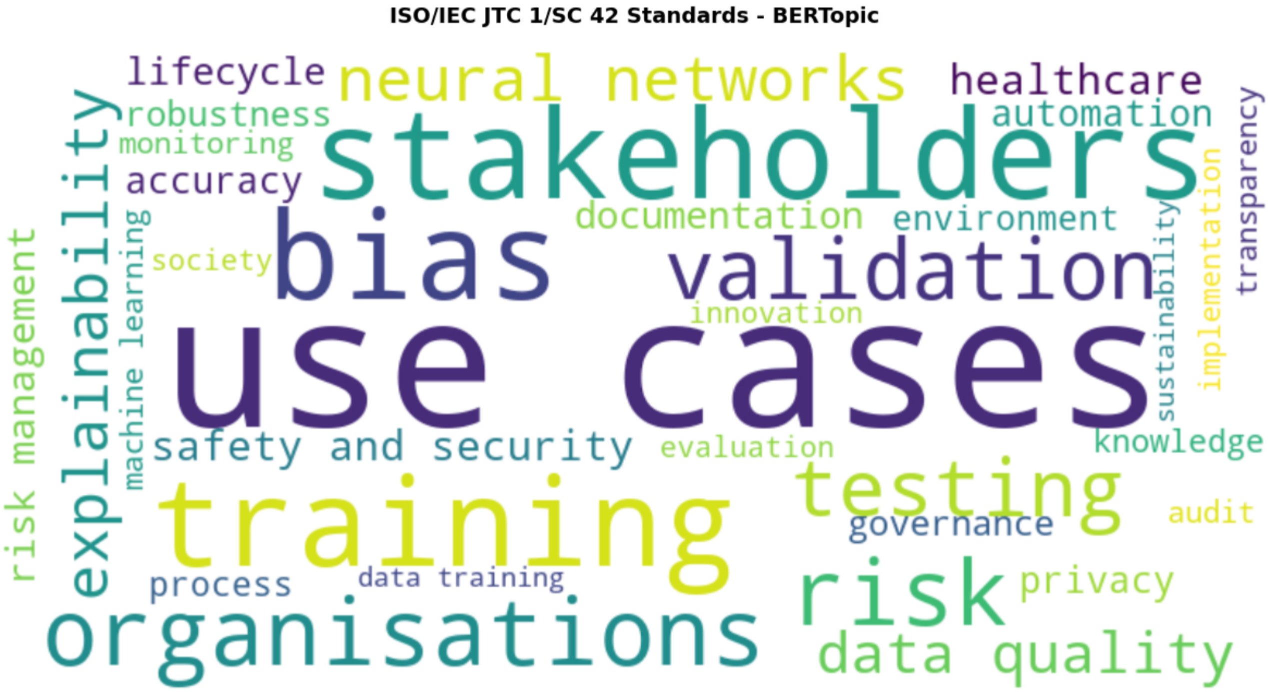

Figure 12. Word Cloud of the identified topics from ISO/IEC JTC 1/SC 42 standards

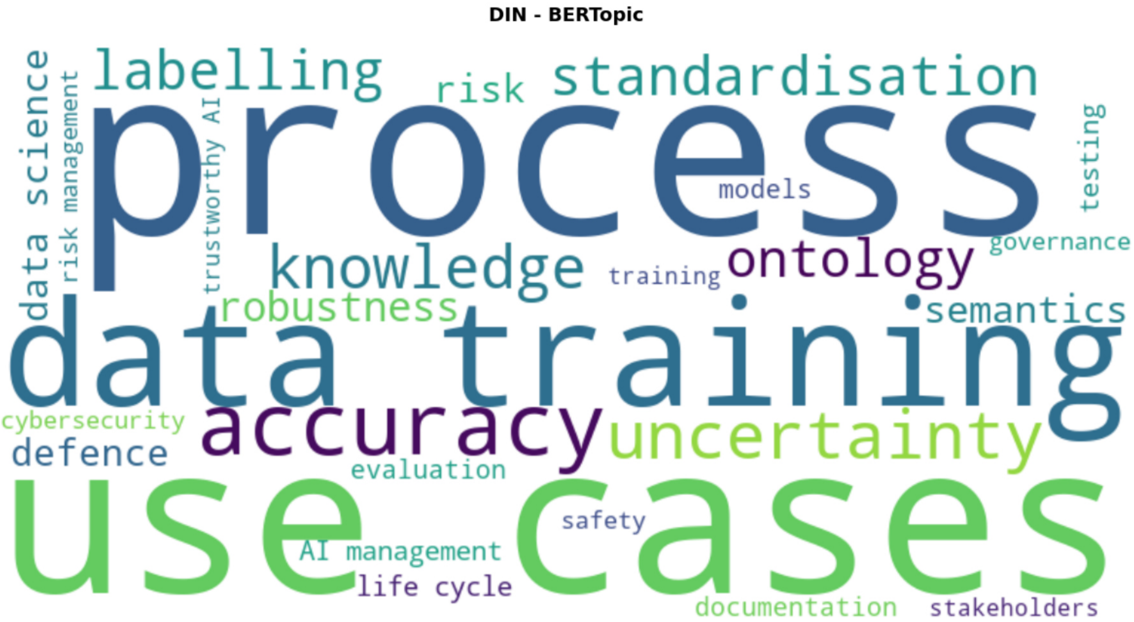

Figure 13. Word Cloud of the identified topics from DIN standards

As illustrated across the heatmaps shown in Figures 14 and 15, some topics are used across many ISO/IEC JTC 1/SC 42 documents, while other topics are siloed into particular standards documents, or rarely used at all. Policy and governance process and procedures, including *stakeholders, use cases*, *training*, *organisations*, *risk*, and *testing*, feature heavily while more sociotechnical concepts do not emerge with only *bias* and *safety and security* appearing across a number of documents. Meanwhile, *explainability* is the key technical principle that appears regularly.

We need to examine the technical reports (analysed above in section 6.1) for specific discussion of the ethical, social and environmental issues related to AI. As noted above, technical reports have a different status compared to the full technical standards documents.

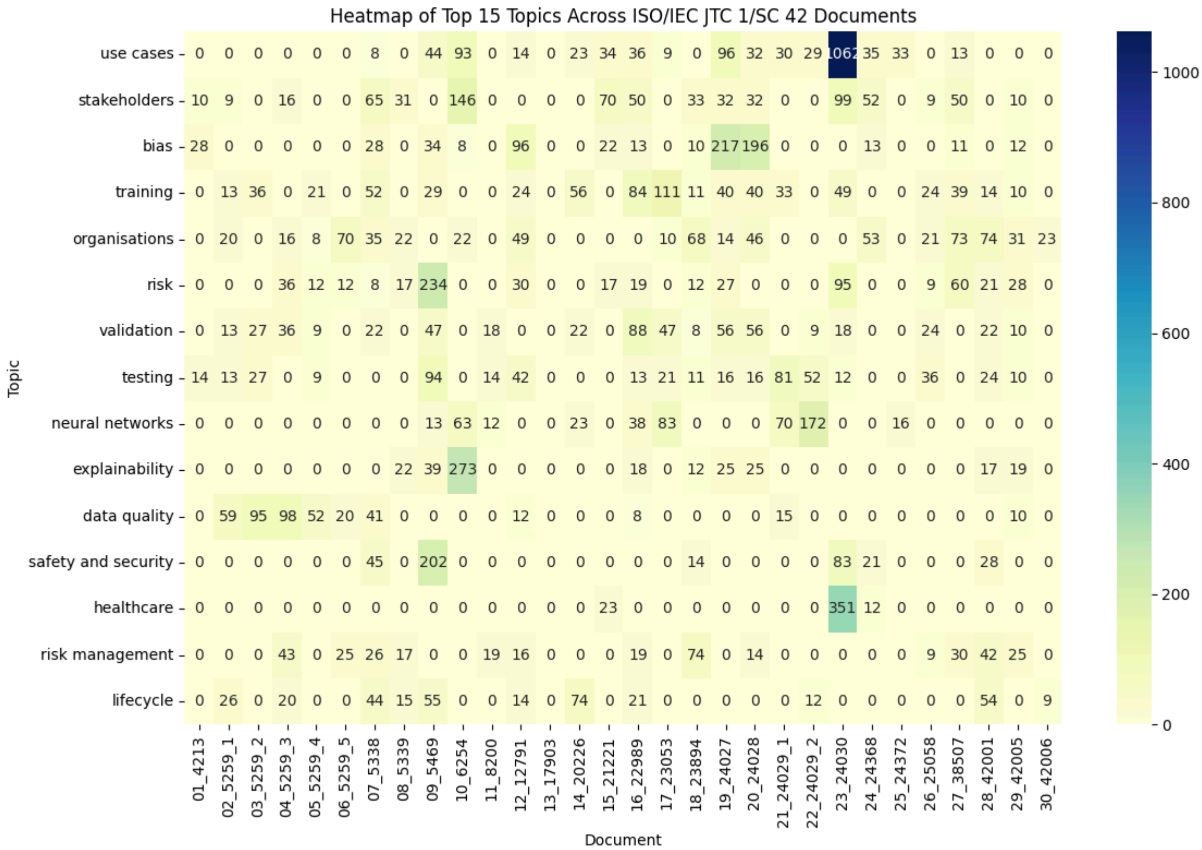

Figure 14. Heatmap of top 15 topics identified from ISO/IEC JTC 1/SC 42 standards

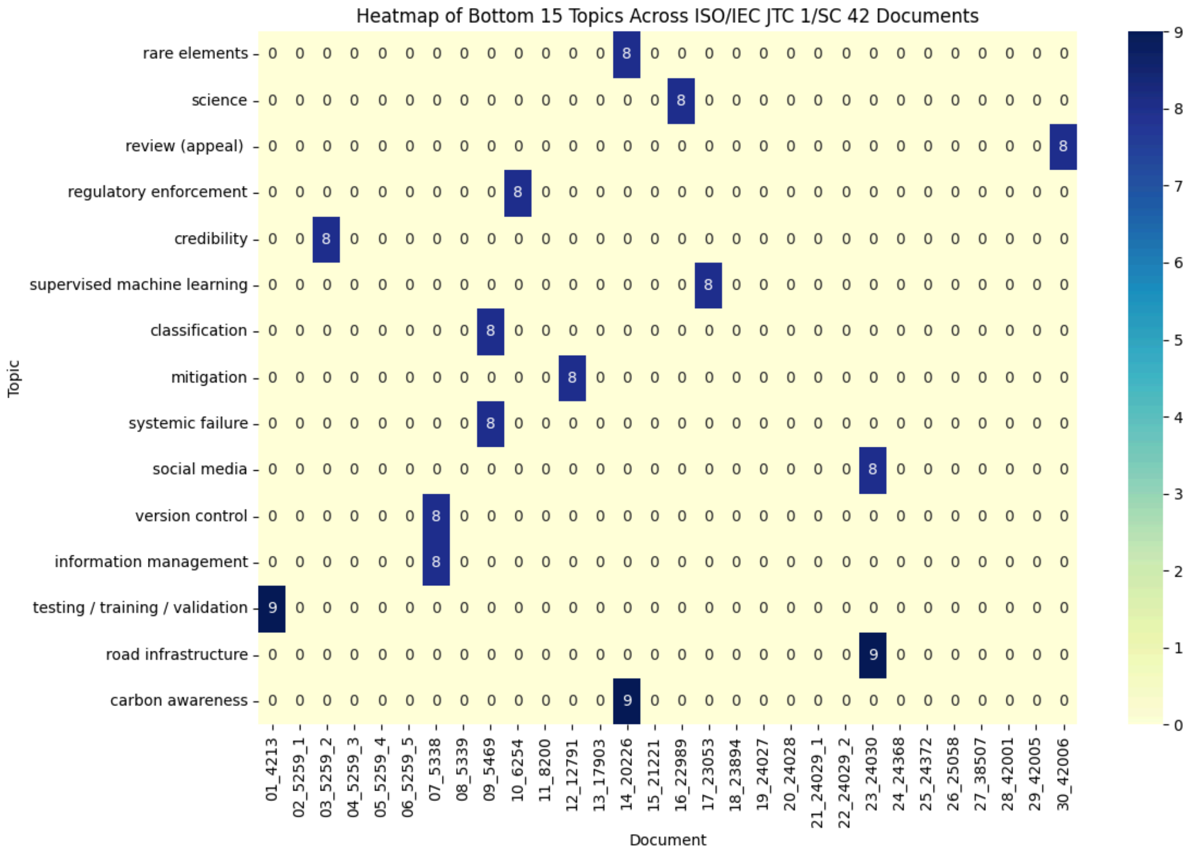

Figure 15. Heatmap of bottom 15 topics identified from ISO/IEC JTC 1/SC 42 standards

7. Key Themes, Insights, and Discussion

The topics and codes from this selected set of ISO/IEC JTC 1/SC 42 and DIN standards reflect the intention of such documents to support consistent practice by organisations in developing, using and assessing AI systems. These standards offer both operational (i.e. organisational) and technical (i.e. technology-based) measures that can be used to achieve consistent practice. As such these documents attempt to provide co-ordination across diverse organisations, a shared terminology and some assurance to those deploying or developing such systems.

The selected standards are voluntary, in that they are not mandated as a requirement for regulatory conformance for an organisation's involvement in AI, but they may be adopted in support of: satisfying regulatory requirements, of broader societal goals or of related goals pursued by value-chain partners (customers and suppliers) or other stakeholders (consumers, rights holders, investors, CSOs, non-normative oversight). In adopting standards that embody consistent practices, organisations may: improve society's confidence that they are following widely agreed responsible practices; facilitate third party auditing of those practices; and enable comparison of their practice against those of other standards-following practitioners, including competitors.

A thematic analysis was undertaken based on an assessment of the concepts represented by the combined NVivo-supported codes and topics identified from BERTopic-generated outputs. To facilitate comparison with the thematic analysis conducted for supranational AI policy documents in FORSEE deliverable D2.2, this analysis adopted the same meta-themes identified in the thematic analysis of supranational AI policy document, namely: **AI Technical Issues**; **AI Uses**; **AI Risks and Harms**; and **AI Governance**.

Themes are then categorised within these four meta-themes, using the micro-meso-macro framing already used in the analysis of the supranational document set in FORSEE Deliverable 2.2[13]. This framing aims to offer a sense of the expectations of the ICT standards bodies as to where and by whom each theme would be best addressed. The **micro** categorisation indicates that the concepts would be best addressed by individual organisations, but with some degree of freedom in how they do so and therefore accommodating of diversity and innovation in approaches taken. A majority of the concepts and themes addressed the micro or organisational level. There is clearly an expectation that organisations who adopt these voluntary standards will be able to deploy the technology, manage the risks and address any failures.

The **meso** categorisation indicates that concepts would be best addressed at the level of specific sectors or within a particular government policy area or at a national level. Similarly this would accommodate different approaches as appropriate between sectors or areas. The **macro** categorisation indicates that concepts would be best addressed at a level that spans approaches taken by organisations, sectors and policy areas. Indeed the international standards and technical reports recognise that regional variations in approaches are appropriate and will emerge.

The number of concepts arising from the NVivo codes and BERTopic topic analyses was n=371. The reflect the high number and length of documents in the set selected from ICT

[13] https://zenodo.org/records/18352574

standardisation bodies. This is also reflected in the structure of the set of selected standards documents, with risk, governance, use cases and numerous technical issues being evident in the titles of separate documents.

To simplify the process of identifying themes across this large number of codes and topics, a first pass was conducted to allocate concepts to one of the four meta-themes. Themes were then identified within these four groupings of concepts, resulting in eleven themes mapped out against the common framing in Table 4. During the identification of these themes, 3 concepts were moved between meta-themes. This indicated that the distinction between the meta-themes identified for the supranational body document were highly robust when applied to uniquely categorising concepts from the selected standardisation documents. An initial set of themes was proposed by researcher #4 and then reviewed by researchers #4, #2 and #5 to revise theme titles, to allocate a small number of concepts between themes and categorise themes against the micro-meso-macro structure.

The concepts in the **AI Technical Issues meta-theme** (n=109) were grouped into four themes. *Theme 1, AI/ML Engineering* (n=55), assembled concepts specific to the engineering of AI and in particular machine learning systems, reflecting the AI specific focus of the selected documents. *Theme 2, Data Engineering* (n=20), consisted of concepts involved in data engineering, indicating the centrality of data to AI training, validation and testing and the focus on data quality in the 5-part ISO/IEC 5259 standard. *Theme 3, Knowledge Engineering* (n=11), reflected the role of symbolic (as opposed to statistical) knowledge in AI beyond purely machine learning techniques, though this is also magnified by a standard on this specific topic in the DIN standards selection. *Theme 4, Software/System Engineering* (n=23), reflect concepts that are common to software engineering but not specific to Theme 1, 2 or 3. This reflects the standardisation process in ISO/IEC which prefers the reuse of concepts that are already standardised in other areas unless new concepts are needed, e.g. AI in this case. This is present in the ISO/IEC JTC 1/SC 42 specification related to AI lifecycle and AI Systems and software Quality Requirements and Evaluation which draw on similar standards for software systems. Theme 1, 2, 3 and 4 represent expectations on actors in the micro category, reflecting their technical engineering nature and the intention that these standards are primarily used by organisations developing or deploying AI systems.

The concepts in the **AI Uses meta-theme** (n=54) were grouped into two themes. *Theme 5, Sectoral AI Uses* (n=36), grouped concepts that related to a potential use of AI in a specific industrial sector, such as agriculture, childcare, education and finance. This theme therefore represented expectations on issues best addressed at the meso level. Theme 6, Horizontal AI Uses (n=18), group use of AI described in terms of a system capability or function, rather than being positioned in a specific sector. Examples include image recognition, machine translation and text summarisation. Within the standards these are referenced as examples of AI application rather than being the subject of the standardised specification or requirements, therefore the expectations they represent issues best addressed across the meso and macro categories rather than representing issues intended to be attended to at the micro (organisational) level by those implementing the standards.

The concepts in the **AI Risks and Harms meta-theme** (n=75) were grouped into three themes. *Theme 7, AI Risk Sources* (n=21), collected concepts such as black box, data corruptions and model attack that represent either technical phenomenon or external factors that affect the behaviour of AI systems. In either case, there is a clear expectation that the sources of AI risks must be identified and where possible addressed as part of risk mitigation processes (made explicit in ISO/IEC 23894 - Guidance on AI Risk Management) so this theme is placed in the micro category. *Theme 8, Harms from AI Risks* (n=40), represents harms that may occur or state of affairs negatively impacted by a risk being materialised, e.g. human autonomy, health and safety, global warming and employment. While there is an explicit expectation that organisations should identify and work to mitigate such harms, there are limited definitions of assessment techniques or acceptable risk thresholds, with the implicit expectation that these are determined externally, i.e. at a meso or macro level. Therefore theme 8 is categorised across the micro, meso and macro levels. A small set of concepts in theme 8 were also placed in theme 7 since they could represent both a source of risk and of harm when risks are realised, specifically: bias, corruption, cybersecurity, failure and supply chain. Theme 9, AI Risk Management Techniques and Factors (n=14), contains concepts that would be employed or should be considered when undertaking risk management processes, such as risk mitigation, control process, cost, innovation and health benefits. As risk management processes are intended to be undertaken at an organisational level, but some of these factors may need to be determined in policies set at a meso and macro level, then this theme spans all three levels. This theme reflects ISO's conceptualisation of *risk* as the effect of uncertainty, which can be both negative and positive.

The concepts in the **AI Governance meta-theme** (n=78) were grouped into two themes. *Theme 10, AI Governance Mechanisms* (n=45), collects concepts such as certification, audit, benchmarking, compliance, that organisations are expected to implement as part of their AI government processes. Therefore this theme is placed in the micro category. *Theme 11, AI Governance Factor* (n=33), collects concepts such as gender, environmental sustainability, fairness and uncertainty that should be considered in undertaking AI governance. While the expectation is that these factors need to be considered by organisations at the micro level, the broad scope of many of them indicate an expectation that these will be elaborated upon and specified at the meso or macro levels. Therefore this theme is placed across all three levels.

Table 4. Meta-themes and themes identified from ISO/IEC JTC 1/SC 42 and DIN Standards

<table>
<tr><td>High level (meta) Themes:</td><td>Micro themes where expectations are attended to by individual organisations, but they may do so in ways different to other organisations</td><td>Meso themes where expectations are attended to at a specific sectoral or national policy level</td><td>Macro themes where expectations are attended to at a societal level, and are expected to span sectoral or policy domains</td></tr>
<tr><td>AI Technical Issues</td><td>Theme 1: AI/ML Engineering (n=55)

Theme 2: Data Engineering (n=20)

Theme 3: Knowledge Engineering (n=11)

Theme 4: Software/System Engineering (n=23)</td><td>-</td><td>-</td></tr>
<tr><td rowspan="2">AI Uses</td><td>-</td><td>Theme 5: Sectoral AI Uses (n=36)</td><td>-</td></tr>
<tr><td>-</td><td colspan="2">Theme 6: Horizontal AI Uses (n=18)</td></tr>
<tr><td rowspan="2">AI Risks and Harms</td><td>Theme 7: AI Risk Sources (n=21)</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Theme 8: Harms from AI Risks (n=40)

Theme 9: AI Risk Management Techniques and Factors (n=14)</td></tr>
<tr><td rowspan="2">AI Governance</td><td>Theme 10: AI Governance Mechanism (n=45)</td><td>-</td><td>-</td></tr>
<tr><td colspan="3">Theme 11: AI Governance Factors (n=33)</td></tr>
</table>

8. Conclusion

This deliverable (D2.1) examined how success in AI is articulated by key international and national AI standardisation bodies through an analysis of 30 standards published by ISO/IEC's technical committee working on AI, JTC 1/ SC 42 and DIN, the German Standards body, between 2018 to 2025.

Utilising a mix-method approach that combined thematic analysis and topic modelling, we identified prevalent codes and topics within documents and further interpreted them to define "successful AI" through the lens of sociology of expectations.

Across the corpus, the four meta-themes which emerged in FORSEE Deliverable D2.2 were used to guide the categorisation of the findings: AI Technical Issues, AI Uses, AI Risks and Harms and AI Governance, set against a micro-meso-macro framing to locate where institutional responsibility for themes falls.

The concepts **extracted** from these selected standards (i.e. identified codes and topics) readily formed themes within the proposed meta-theme structure, with 11 distinct themes identified therein. This revealed a distinct placement of some themes (related to technical engineering issues, risk sources and governance mechanisms) into the micro level. This is consistent with their intended use to support consistent practice by organisations developing or deploying AI, and indicates an expectation that these issues can be sufficiently addressed by organisational compliance with these standards without reliance on further meso or macro level guidance. Success therefore is framed as complying with the standard requirements and failure is framed as managing both anticipated and unanticipated risks.

Conversely, it also reveals areas of risk and harm and of governance factors, where the avoidance of specific normative guidance indicates an expectation that further meso or macro level guidance or norm setting is required. Such meso or macro level initiatives could include encouraging further standardisation in these areas by SDOs. The current CEN CENELEC JTC21 effort to develop harmonised standards to support the implementation of the AI Act represents the realisation of such meso/macro level call for standardisation. Future analysis of these JTC21 standards once finalised would be required however to determine if they also address the specific themes highlighted here or if other, non-SDO instruments will be required. ISO/IEC SC42 is also undertaking current projects that aim to add more specific technical standardisation to ethical and societal issues, including projects on guidance on addressing societal concerns and ethical considerations[14] and on an example template for documenting ethical issues of an AI system[15].

Given the emphasis on consistent terminology and use of concepts in standards documents this analysis could also be used to explore the degree of semantic alignment between ISO/IEC concepts and concepts identified in other types of documents in other deliverables. This may provide insight into the relative degree of conceptual certainty that underpins the expectations identified between different classes of bodies via the document outputs analysed, and thereby the relative levels of institutional commitment expressed to realising those expectations.

In terms of methodological approach, this deliverable has demonstrated the possibility of employing BERTopic, to identify topics in a large corpus of highly structured documents that exhibited consistent use of terminology. By using a combination of topic modelling and thematic analysis, this study provides a scalable yet human-centric approach to analyse the evolving and growing body of AI standards documents. A limitation of the approach is that we were not able to consider who were the experts developing these standards and the relative power of nation states, companies and other participants to shape them .

Future work will involve a more detailed comparison of themes identified in these standards with those identified in the parallel analyses conducted in FORSEE WP2, namely the studies on supranational AI policies and regulations and documents from ICT and non-ICT professional bodies, with an exploration of how expectations that require consensus at the meso and macro level will be addressed.

Positionality Statement

The experts directly involved with identification of codes, topics, and themes are:

1. Researcher #1: Holds a PhD in EU law and has 3 years of postdoc experience,
2. Researcher #2: Holds a PhD in computer science, has experience in AI risk modelling, EU AI policies and standards, and has 1 year of postdoc experience.
3. Researcher #3: Holds a PhD in Communication Studies, a Full Professor of Digital Media & Communication with 25 years experience.
4. Researcher #4: Holds a PhD in Computer Science, a Full Professor of Computer Science, with 35 years of research experience.
5. Researcher #5: Is a PhD candidate and holds a MSc in computer science.

[14] https://www.iso.org/standard/87119.html
[15] https://www.iso.org/standard/90760.html

- The thematic analysis to produce codes was conducted by Researcher#1
- The expert analysis of the BERTopic outputs was conducted by Researcher #1 and was reviewed by Researcher #4.
- Analysis of codes and topics through the lens of sociology of expectation to identify themes were conducted by Researchers #4, #2 and #5, using the framing provided by Researcher #3.
- Researcher #2 and Researcher #4 have both participated as contributing experts to ISO/IEC JTC 1/SC 42 projects, including ones resulting in some of the standards analysed.

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References

Bowker, G. C., & Star, S. L. (1999). *Sorting Things Out: Classification and Its Consequences*. The MIT Press. https://doi.org/10.7551/mitpress/6352.001.0001

Braun, V., & Clarke, V. (2021). *Thematic Analysis: A Practical Guide*. SAGE.

Brunsson, N., Rasche, A., & Seidl, D. (2012). The Dynamics of Standardization: Three Perspectives on Standards in Organization Studies. *Organization Studies*, *33*(5–6), 613–632. https://doi.org/10.1177/0170840612450120

Busch, L. (2013). *Standards: Recipes for reality* (First MIT paperback edition). MIT Press.

C(2023)3215 – Standardisation Request M/593 (2023). https://ec.europa.eu/growth/tools-databases/enorm/mandate/593_en

Churchill, R., & Singh, L. (2022). The Evolution of Topic Modeling. *ACM Computing Surveys*, *54*(10s), 1–35. https://doi.org/10.1145/3507900

Cihon, P. (2019). Standards for AI governance: International standards to enable global coordination in AI research & development. *Future of Humanity Institute. University of Oxford*, *40*(3), 340–342.

Commission notice The 'Blue Guide' on the implementation of EU product rules 2022—C:2022:247:TOC. (2022). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=oj:JOC_2022_247_R_TOC

Cuccuru, P. (2019). *Interest Representation in European Standardisation: The Case of CEN and CENELEC* (SSRN Scholarly Paper No. 3505290). Social Science Research Network. https://doi.org/10.2139/ssrn.3505290

David, P. A. (2001). Path dependence, its critics, and the quest for "historical economics." In P. Garrouste & S. Ioannides (Eds.), *Evolution and Path Dependence in Economic Ideas* (pp. 15–40). Edward Elgar Publishing. https://doi.org/10.4337/9781781950227.00006

Dhakal, K. (2022). NVivo. *Journal of the Medical Library Association: JMLA*, *110*(2), 270.

DIN DKE SPEC 99001:2022-05, Definition einer Erfolgsmethode zum Labelling von Daten zum Training künstlicher Intelligenz_- Anwendungsfokus: Question-Answering; Text Englisch. (n.d.). DIN Media GmbH. https://doi.org/10.31030/3338834

DIN SPEC 32792:2023-07, Semantische Daten-Annotationen zur Unterstützung KI-gestützter Datenverarbeitung; Text Englisch. (n.d.). DIN Media GmbH. https://doi.org/10.31030/3439886

DIN SPEC 91526:2025-05, Wissensgraphen für Sprachmodelle und Sprachmodelle für

Wissensgraphen_- Hybride Anwendungen symbolischer und subsymbolischer KI; Text Englisch. (n.d.). DIN Media GmbH. https://doi.org/10.31030/3610747

DIN SPEC 92001-1:2019-04, Künstliche Intelligenz_- Life Cycle Prozesse und Qualitätsanforderungen_- Teil_1: Qualitäts-Meta-Modell; Text Englisch. (n.d.). DIN Media GmbH. https://doi.org/10.31030/3050203

DIN SPEC 92005:2024-03, Künstliche Intelligenz_- Quantifizierung von Unsicherheiten im Maschinellen Lernen; Text Englisch. (n.d.). DIN Media GmbH. https://doi.org/10.31030/3521675

Gadekallu, T. R., Dev, K., Khowaja, S. A., Wang, Weizheng, Feng, H., Fang, K., Pandya, S., & Wang, Wei. (2025). *Framework, Standards, Applications and Best practices of Responsible AI: A Comprehensive Survey* (arXiv:2504.13979). arXiv. https://doi.org/10.48550/arXiv.2504.13979

Golpayegani, D., Hupont, I., Panigutti, C., Pandit, H. J., Schade, S., O'Sullivan, D., & Lewis, D. (2024). AI Cards: Towards an Applied Framework for Machine-Readable AI and Risk Documentation Inspired by the EU AI Act. *Privacy Technologies and Policy: 12th Annual Privacy Forum, APF 2024, Karlstad, Sweden, September 4–5, 2024, Proceedings*, 48–72. https://doi.org/10.1007/978-3-031-68024-3_3

Golpayegani, D., Lasek-Markey, M., Younus, A., Kerr, A., & Lewis, D. (2025). Uncovering AI Governance Themes in EU Policies Using BERTopic and Thematic Analysis. In R. Markovich, L. Di Caro, A. Rapp, & C. Schifanella (Eds.), *Frontiers in Artificial Intelligence and Applications*. IOS Press. https://doi.org/10.3233/FAIA251621

Gonzales Torres, A. P., & Ali-Vehmas, T. (2024). *Governing Through Standards: Artificial Intelligence and Values*. https://easychair.org/publications/preprint/xklW

Hughes, T. P. (n.d.). Technological Momentum. In *Does Technology Drive History?: The Dilemma of Technlogical Determinism* (pp. 101–114). (Original work published 1994, The MIT Press, Cambridge)

ISO/IEC 5259-1:2024. (2024). https://www.iso.org/standard/81088.html

ISO/IEC 5259-2:2024. (2024). https://www.iso.org/standard/81860.html

ISO/IEC 5259-3:2024. (2024). https://www.iso.org/standard/81092.html

ISO/IEC 5259-4:2024. (2024). https://www.iso.org/standard/81093.html

ISO/IEC 5259-5:2025. (2025). https://www.iso.org/standard/84150.html

ISO/IEC 5338:2023. (2023). https://www.iso.org/standard/81118.html

ISO/IEC 5339:2024. (2024). ISO. https://www.iso.org/standard/81120.html

ISO/IEC 23053:2022. (2022). https://www.iso.org/standard/74438.html

ISO/IEC 23894:2023. (2023). https://www.iso.org/standard/77304.html

ISO/IEC 24029-2:2023. (2023). https://www.iso.org/standard/79804.html

ISO/IEC 38507:2022. (2022). https://www.iso.org/standard/56641.html

ISO/IEC 42001:2023. (2023). https://www.iso.org/standard/42001

ISO/IEC 42005:2025. (2025). https://www.iso.org/standard/42005

ISO/IEC 42006:2025. (2025). https://www.iso.org/standard/42006

ISO/IEC TR 5469:2024. (2024). https://www.iso.org/standard/81283.html

ISO/IEC TR 17903:2024. (2024). https://www.iso.org/standard/85078.html

ISO/IEC TR 21221:2025. (2025). https://www.iso.org/standard/86690.html

ISO/IEC TR 24027:2021. (2021). https://www.iso.org/standard/77607.html

ISO/IEC TR 24028:2020. (2020). https://www.iso.org/standard/77608.html

ISO/IEC TR 24029-1:2021. (2021). https://www.iso.org/standard/77609.html

ISO/IEC TR 24030:2024. (2024). https://www.iso.org/standard/84144.html

ISO/IEC TR 24368:2022. (2022). https://www.iso.org/standard/78507.html

ISO/IEC TR 24372:2021. (2021). https://www.iso.org/standard/78508.html

ISO/IEC TS 4213:2022. (2022). https://www.iso.org/standard/79799.html

ISO/IEC TS 6254:2025. (2025). https://www.iso.org/standard/82148.html

ISO/IEC TS 8200:2024. (2024). https://www.iso.org/standard/83012.html

ISO/IEC TS 12791:2024. (2024). https://www.iso.org/standard/84110.html

ISO/IEC TS 25058:2024. (2024). https://www.iso.org/standard/82570.html

Kamara, I. (2022). General Court EU: Commercial interests block the right to access European harmonised standards. *Journal of Standardisation*, *1*. https://doi.org/10.18757/jos.2022.6397

Mazzini, G., & Scalzo, S. (2022). *The Proposal for the Artificial Intelligence Act: Considerations around Some Key Concepts* (SSRN Scholarly Paper No. 4098809). Social Science Research Network. https://doi.org/10.2139/ssrn.4098809

Miller, P., & Rose, N. S. (2013). *Governing the present: Administering economic, social and personal life* (Nachdr.). Polity Press.

Oviedo, J., Rodriguez, M., Trenta, A., Cannas, D., Natale, D., & Piattini, M. (2024). ISO/IEC quality standards for AI engineering. *Computer Science Review*, *54*, 100681. https://doi.org/10.1016/j.cosrev.2024.100681

PublicResourceOrg, Inc and Right to Know CLG v European Commission, Case C-588/21 P

(ECJ March 5, 2024). https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:62021CJ0588

Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 Laying down Harmonised Rules on Artificial Intelligence and Amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act) (Text with EEA Relevance) (2024). https://eur-lex.europa.eu/eli/reg/2024/1689/oj/eng

Schmittner, C., & Shaaban, A. M. (2023). Overview of AI Standardization. *IDIMT-2023 : New Challenges for ICT and Management*. http://epub.jku.at/obvulioa/9026586

Squires, V. (2023). Thematic Analysis. In J. M. Okoko, S. Tunison, & K. D. Walker (Eds.), *Varieties of Qualitative Research Methods* (pp. 463–468). Springer International Publishing. https://doi.org/10.1007/978-3-031-04394-9_72

Star, S. L., & Lampland, M. (2009). Reckoning with standards. *Classifying and Formalizing Practices Shape Everyday Life*, 2–25.

Tartaro, A. (2023). *Towards European Standards Supporting the AI Act: Alignment Challenges on the Path to Trustworthy AI* (SSRN Scholarly Paper No. 4470766). Social Science Research Network. https://papers.ssrn.com/abstract=4470766

Terry, G., Hayfield, N., Clarke, V., & Braun, V. (2017). Thematic analysis. *The SAGE Handbook of Qualitative Research in Psychology*, *2*(17–37), 25.

Thévenot, L. (2009). Postscript to the Special Issue: Governing Life by Standards: A View from Engagements. *Social Studies of Science*, *39*(5), 793–813. https://doi.org/10.1177/0306312709338767

Timmermans, S., & Berg, M. (2003). *The Gold Standard: The Challenge Of Evidence-Based Medicine*. Temple University Press.

Timmermans, S., & Epstein, S. (2010). A World of Standards but not a Standard World: Toward a Sociology of Standards and Standardization. *Annual Review of Sociology*, *36*(1), 69–89. https://doi.org/10.1146/annurev.soc.012809.102629

Veale, M., & Borgesius, F. Z. (n.d.). *Demystifying the Draft EU Artificial Intelligence Act*.

Veale, M., & Borgesius, F. Z. (2021). Demystifying the Draft EU Artificial Intelligence Act. *Computer Law Review International*, *22*(4), 97–112. https://doi.org/10.9785/cri-2021-220402

White, J. M. (2019). *Standardising the city: A material-discursive genealogy of CPA-I_001, ISO 37120 and BSI PAS 181* [PhD Thesis]. National University of Ireland Maynooth.

White, J. M. (2021). Standardising the city as an object of comparison: The promise, limits and perceived benefits of ISO 37120. *Telematics and Informatics*, *57*, 101515. https://doi.org/10.1016/j.tele.2020.101515

Yazici, T. (2025). Toward a global standard for ethical AI regulation: Addressing gaps in AI-driven biometric and high-resolution satellite imaging in the EU AI Act. *Law, Innovation and Technology*, *17*(1), 366–394. https://doi.org/10.1080/17579961.2025.2470589 961.2025.2470589