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From Principle to Process -Implementing Responsible AI Across National Borders

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ABSTRACT

The design of responsible AI systems in line with international requirements requires a holistic approach. Environmental and social aspects should be integrated as early as the design stage and throughout all phases of the life cycle in order to comply with the principles of trustworthiness for AI. European regulations, in particular the AI-Regulation (EU AI-Act), set clear requirements for transparency, security, and accountability. Supplemented by international standards and norms, the path is being paved for greater responsibility and sustainability in the development and use of AI. Business models are thus being realigned globally toward sustainability and the integration of ethical and social aspects through the use of trustworthy AI.

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Introduction

Responsible AI Fundamentals and Goals

A series of security incidents, instances of discrimination, the production of deepfakes, and hallucination phenomena, including results that can be classified as "false," require more attention to be paid to the risks to humans and the environment when using AI technology. The principles for trustworthy AI set out in Recital 27 of the EU AI-Actcan serve as guidance for implementing greater responsibility. These seven principles are based on the European Commission's Ethics Guidelines for Trustworthy AI (EU Commission, 2019) and, when implemented proactively, contribute to the objectives of the AI-Regulation [1].

The European Union's Ethics Guidelines for Trustworthy AI were developed to ensure that AI is used in an ethically responsible manner [1]. The seven principles of these ethics guidelines are integrated into the EU AI-Actand form the foundation for the alignment of AI technology for responsible development and use. According to Recital 27 of the AI-Regulation (EU AI-Act), these principles include: "human agency and supervision, technical robustness and security, privacy and data governance, transparency, diversity, non-discrimination and fairness, social and environmental well- being, and accountability" (cf. Recital 27 EU AI-Act).

According to Recital 27, sentence 5 of the EU AI-Act, ***"human agency and oversight"*** means "that an AI system is developed and used as a tool that serves people, respects human dignity and personal autonomy, and functions in a way that allows for appropriate human control and oversight. (cf. Recital 27 EU AI-Act)" AI systems should therefore empower people, enable them to make informed decisions, and strengthen their fundamental rights. At the same time, appropriate control mechanisms must be ensured, which can be achieved through human-in-the-loop, human-on-the-loop, and human-in- command approaches. These requirements are specified in Art. 14 EU AI-Act, "Human oversight."

According to recital 27, sentence 6 of the EU AI-Act, ***"technical robustness and security"*** means that AI systems must "be designed and used in such a way that they are robust in the event of difficulties and resistant to attempts to alter the use or performance of the AI system in such a way that it enables unlawful use by third parties, and that unintended damage is minimized" (cf. Recital 27 EU AI-Act) [2,3]. This principle promotes the reduction of risks and damage, as well as resulting claims for damages in terms of product liability, which in its new version fully integrates providers and manufacturers of digital products and services. According to Art. 7(1) of Directive 2024/2853 on liability for defective products and repealing Council Directive 85/374/EEC, a product is "defective" if it does not offer the safety that a person may expect or that is required by Union or national law. According to Article 7(2)(f) Directive 2024/2853 on liability for defective products and repealing Council Directive 85/374/EEC, this assessment must be made taking into account "the relevant product safety requirements, including cybersecurity requirements relevant to safety." (cf. Article 7(2)(f) of Directive 2024/2853). This requirement is specified in Article 15 of the EU AI-Act, "Accuracy, robustness, and cybersecurity [4].

In addition to security aspects, data protection and privacy play a major role in the use of AI. This principle combines the requirements of trade secret protection and the GDPR. The principle of ***'Privacy and Data Governance'*** means "that AI systems are developed and used in accordance with applicable privacy and data protection regulations, processing data that meets

high standards of quality and integrity." (cf. Recital 27 EU AI-Act) Data management mechanisms and data quality requirements can provide operational support here and promote the quality of the AI system. More detailed requirements relating to this principle are regulated by Art. 10 EU AI-Act 'Data and Data Governance' and Art. 17 of the EU AI-Act, 'Quality Management', as well as the requirements of the Trade Secrets Protection Act and the GDPR. When selecting training data, particular attention should be paid to ensuring that there are no violations of the GDPR, Trade Secrets Protection Act, copyright law, and that written confirmation of the use of the data is available.

Transparency creates trust, because it is particularly important in AI-based decision-making, such as in lending or personnel decisions, in order to be able to understand how the AI-based decision was made and how the derivation process works. According to the EU AI-Act, **"*transparency*"** means "that AI systems are developed and used in a way that is reasonably understandable and explainable, whereby people must be made aware that they are communicating or interacting with an AI system, and operators must provide proper information about the capabilities and limitations of the AI system and inform the persons concerned about their rights" (cf. Recital 27 EU AI-Act). Providers are therefore required to create transparency for AI operators (users) and to provide further information, such as details on energy consumption or instructions for use (see Articles 13, 23, 24, 26, 50, 53, 55, Annex V, XII of the EU AI- Act).

In addition to transparency, AI systems should prioritize "***diversity, non-discrimination, and fairness***." This means "that AI systems are developed and used in a way that involves different stakeholders and promotes equal access, gender equality, and cultural diversity, while preventing discriminatory effects and unfair biases that are prohibited under Union or national law" (cf. Recital 27 EU AI-Act). Unfair bias should be avoided as it can have numerous negative effects, from the exclusion of vulnerable groups to the exacerbation of prejudice and discrimination. To promote diversity, AI systems should be accessible to all, regardless of any disabilities.

The first five principles address other important aspects of responsible AI use Principle six focuses on the topic of 'sustainability' and addresses environmental friendliness and sustainability in development. According to the EU AI-Act, '***social and environmental well-being***' means "that AI systems are developed and used in a sustainable and environmentally friendly manner and for the benefit of all people, with the long-term impact on individuals, society, and democracy being monitored and evaluated" (cf. Recital 27 EU AI-Act). AI systems should benefit all people, including future generations. It must therefore be ensured that they are sustainable and environmentally friendly. In future, manufacturers must disclose energy consumption in accordance with Art. 53 (1) a) EU AI-Act in conjunction with Annex XI. The standard 'VDE SPEC 90012 VCIO-based description of systems for AI trustworthiness *characterization'* provides a corresponding model template, which is described in more detail in the next chapter [5].

This label also supports the implementation of the seventh principle, '***Accountability***'. The term and principle of accountability is not explained in detail in the EU AI-Act itself and is derived more specifically from the requirements for technical documentation under Article 11 EU AI-Act, or recording obligations under Article 12 of the EU AI-Act, as well as conformity assessments including CE marking (Article 47, 48 EU AI-Act) and approval requirements for market participation. In addition, it may also result from the GDPR under Article 5(2) if the AI system has been trained with personal data or interacts with humans during operation.

Standards and Norms – Design and Process Integration for Greater Responsibility in AI

With the awareness that we use AI technology globally and that this data processing process with its own levels of autonomy and high-speed learning effects knows no national borders, it is important to develop a global understanding of responsible AI. Norms and standards are proven tools for achieving the necessary security in this digital development, including in AI. They serve to ensure quality, safety, compatibility, and interoperability, as well as to facilitate trade and cooperation.

The EU AI-Act also refers to harmonized standardization in various places (cf. Art. 40 EU AI-Act), although only part of it has been published at this point in time and the so-called "presumption of conformity with certain requirements" has not yet been conclusively clarified (cf. Art. 42 EU AI-Act). Regardless of this, it is worth taking a look at the standards for AI systems that have already been published, as these offer further guidance. On the other hand, they also integrate various sustainability issues and security aspects for trustworthy and responsible AI, as shown in the roadmap published in March 2025 under the title "European AI Standards – Technical Standardization and Implementation Challenges under the EU AI Act" [6].

One of the new guiding standards is ISO/IEC42001:2023 'Artificial Intelligence Management Systems' as an international standard that is certifiable. This management standard can be integrated into the process landscapes of organizations to derive and guide the requirements of the EU AI-Act and other legal areas, such as the GDPR. ISO/IEC42001:2023 addresses both organizations that develop AI and organizations that use AI (so-called operators according to Art. 3 No. 4 EU AI-Act). In addition to a strong focus on the 'risk management' of AI systems, it is the organization's task to deal with the 'external and internal problems' that may be associated with the use of AI systems. These include applicable legal requirements and agile risk management, including the use of prohibited AI systems, as well as ethical considerations in the development of AI systems. Furthermore, the needs and expectations of interested parties are addressed, such as evaluating these and their requirements that must be met, which include aspects of climate change, among other things [7]. The AI Impact Assessment reflects these aspects for each AI system, converts them into a risk score, and derives further measures.

The aim of ISO/IEC42001:2023 is to obtain certification as proof of responsible use of AI to stakeholders such as customers, employees, regulatory authorities, investors, etc.

The European Commission defines responsible AI as "AI that is human-centered, ethically sound, transparent, and accountable" [8]. In conclusion, responsible AI refers to the development, deployment, and use of AI systems that comply with ethical, legal, and social standards. The aim is to ensure that AI technologies contribute to the well-being of society, respect human rights, ensure transparency, and minimize risks. Responsible AI therefore encompasses aspects such as fairness, transparency, data protection, security, and traceability. It is therefore the responsibility of organizations to address the issue of 'responsible AI', which includes ethical and sustainability aspects (cf. principle

'Social and environmental well-being' according to Recital 27 of the EU AI-Act), with ISO/IEC42001:2023 being the appropriate reflection tool.

In addition to ISO/IEC 42001:2023 as the international standard, there are already other standards that support the aspects of 'responsible AI' and assist organizations in its implementation.

The following standards are particularly noteworthy in the context of AI and responsibility

Standard	Title
ISO/IEC TR 24368:2022 [9]	Information technology - Artificial intelligence - Overview of ethical and societal concerns
ISO/IEC 9241-210:2019 [10]	Ergonomics of human-system interaction Part 210: Human-centered design for interactive
	systems
ISO/IEC TR 20226:2025 [11]	AI Environmental sustainability
ISO/IEC 24018:2020 [12]	AI Overview of trustworthiness in AI

Table: Excerpt from Important Ethical Standards (Own Representation, 2025)

ISO/IEC TR 24368:2022 provides an overview of the ethical and societal aspects related to AI. The aim of this standard is to identify the most important ethical principles and societal challenges that should be considered in the development, implementation, and use of AI systems. It serves as a guide for developers, companies, regulatory authorities, and other stakeholders to promote responsible and socially acceptable AI solutions. This standard covers topics such as data protection, fairness, transparency, accountability, human control, and the social impact of AI on society and the world of work [9].

ISO/IEC 9241-210:2019 is an international standard that deals with the ergonomic design of human- centered interactive systems. It establishes fundamental principles and procedures to ensure that interactive systems are user-friendly, effective, and safe by placing the needs and abilities of users at the center of the design process. The focus is on human-centered design (HCD), which includes iterative processes, user participation, and close coordination between design and user requirements. The goal is to develop products, systems, and services that provide users with a positive experience and increase their productivity and satisfaction. Among other things, the standard describes the phases of the design process, such as understanding user requirements, specification, design, evaluation, and improvement, as well as the importance of user participation and feedback throughout the development cycle [10].

ISO/IEC TR 20226:2025 is a standard that deals with environmental sustainability in relation to AI. The goal of ISO/IEC TR 20226:2025 is to provide an overview of the environmental impact and sustainability aspects of AI systems. It analyzes challenges, opportunities, and best practices for reducing the environmental footprint of AI technologies and promoting sustainable development. It covers topics such as energy consumption, resource management, environmental impacts in the development and use of AI, and strategies for improving environmental sustainability. This standard is aimed at developers, companies, regulatory authorities, and other stakeholders who want to use AI as part of sustainable and environmentally friendly practices [11].

ISO/IEC 24018:2020 provides an overview of the trust and trustworthiness that an AI system should embody. This standard was developed to convey the fundamental concepts, principles, and requirements necessary for AI systems to be considered trustworthy. The aim of this standard is to create a common basis for assessing and promoting the trustworthiness of AI. It describes the most important aspects that contribute to AI systems being transparent, secure, fair, traceable, and responsible. These include topics such as data protection, security, ethical principles, accountability, and the ability to monitor and control the behavior of AI systems. ISO/IEC 24018:2020 is aimed at developers, users, regulatory authorities, and other stakeholders who are interested in strengthening trust in AI systems and promoting the acceptance of AI technologies in society [12].

Another important standard for AI systems themselves is the VDE 90012 'VCIO based description of systems for AI trustworthiness characterization'. VDE 90012 is a German standard that enables systematic evaluation and validation of the trustworthiness of AI systems in order to ensure safety, reliability, and transparency. This increases user confidence, supports compliance with legal requirements, and reduces risks in the use of critical applications. It is one of the VDE standards published by the Association for Electrical, Electronic and Information Technologies (VDE). The VDE SPEC 90012 V1.0 standard defines requirements and procedures for characterizing and evaluating trustworthiness in electrical and electronic systems, particularly in AI applications [5]. This standard is relevant for industries such as automation, medical technology, transportation, and manufacturing, where trustworthiness plays a central role and which, according to the risk classification under the EU AI-Act, fall under the category of "high-risk AI systems" (cf. Art. 6 in conjunction with Annexes 1 and 3 of the EU AI-Act).

The consortium that created the standard has "worked to make this standard compatible with the EU AI-Act being developed at the European level. For AI products, the goal is to create a description of the trustworthiness aspects that both demonstrate the product's compliance with the EU AI-Act and enable differentiation in the market [5]." This standard is based on the so-called VCIO model. It distinguishes and combines the four concepts of values, criteria, indicators, and observables for evaluating AI, which in the AI context is presented in the report "From Principles to Practice – An Interdisciplinary Framework for Operationalizing AI Ethics" by the AI Ethics Impact Group [13]. It checks the following values for AI systems and then aggregates them into a 'value score' for the corresponding AI system [5].

The following value sections are evaluated: transparency, accountability, data protection, fairness, and reliability. Each of the five value sections uses the categorization from A to G as an indicator (observables) for the fulfillment of the individual requirements. With regard to the issue of the sustainability of AI systems, the value section 'fairness' is particularly important, as it includes, among other things, section 'F.3 Ecological Sustainable Development' of AI systems [5].

Section (Criteria) F.3 emphasizes the importance of ecological sustainability in the development and operation of AI systems. The aim is to ensure that the technologies used are environmentally friendly, that resources are used efficiently, and that long-term

negative environmental impacts are minimized. In terms of the trustworthiness of AI systems, this means that the systems should be designed to be environmentally friendly and resource-efficient. This includes aspects such as energy efficiency, durability, and the minimization of waste or harmful emissions, addressing the following measures

- **Energy Efficiency:** AI systems should be developed in such a way that energy consumption during operation and training is minimized in order to reduce environmental impact.
- **Resource Conservation:** Use of sustainable materials and components that are recyclable or have a long service life, especially when AI is part of physical products.
- **Life Cycle Analysis:** Assessment of environmental impacts throughout the entire life cycle of the system, including manufacturing, operation, maintenance, and disposal.
- **Environmentally Friendly Innovations:** Promotion of technologies that offer environmental benefits, e.g., through lower resource consumption or sustainable energy sources.

An AI system that is designed to be environmentally sustainable strengthens the trust of users and stakeholders, as it is not only functional but also socially and environmentally responsible. Thus, the implementation of VDE SPEC 90012 can contribute to establishing AI systems in a sustainable and responsible manner and also play a part in fulfilling the EU AI-Act.

All standards work toward the integration of principles for responsible AI and promote this approach already within the concept phase and its integration into the digital design of AI systems.

Impact on International Cooperation in AI

AI is not a rigid thing, but a constantly changing and learning data processing process of autonomous systems based on the idea of mechanically imitating human thinking and behavior. Through automation and integration into digital and physical products of all kinds, these data processing processes can hardly be distinguished from one another or assigned locally. Similar to other forms of energy, data flows through its so-called 'conductors', neurons and digital assets. This requires a common understanding of responsibility for autonomous systems that have been trained using our data, as well as interoperability – especially when different AI systems interact with each other and automated decisions build on each other. In addition, differing views on AI ethics and security make it difficult to share AI systems. Furthermore, the threat of sanctions in the form of fines and claims for damages hinders innovation and creates uncertainty. However, if we want to harness the power of autonomous systems, we must protect values and human well-being globally.

A global basic understanding of what is meant by, responsible AI‘ will become the central compass guiding developments. This primarily requires the development of AI competence, an indispensable skill set that organizations will need for the future. To this end, the Centre for Finance, Technology and Entrepreneurship (CFTE) published a groundbreaking white paper in May 2025 entitled "AI Literacy isn't the endpoint; it's the launchpad" [15]. Furthermore, the OECD, together with the EU Commission, published an "AI Literacy Framework for Primary and Secondary Education," which is aimed at students to help them understand AI [15,16]. Both publications clearly show how important AI literacy is for everyone, regardless of status and role. In order to develop and market responsible AI, knowledge of the ethical guidelines for 'responsible AI' and knowledge of the implementation standards are indispensable. Otherwise, there is a risk of being fined up to 7% or €35 million pursuant to Art. 99 EU AI-Act due to a misguided development, for example as a result of ignorance of prohibited AI practices pursuant to Art. 5 EU AI-Act, or of having to deal with liability issues under the new Product Liability Directive.

The development of responsible AI systems therefore requires the conscious integration of regulatory requirements, ethical principles, and technical standards throughout the entire life cycle. Responsible AI should therefore begin in the design process, in the concept phase, and take all phases of development into account. Ethical and ecological objectives can be anchored in this, e.g., through the selection of resource-efficient hardware or data management and algorithm design that supports non-discrimination and social justice. Since AI is not a finished product but a data processing process that is constantly changing through learning effects and levels of autonomy, continuous monitoring is required throughout the entire life cycle of an AI system. This includes, above all, ongoing risk assessments, such as checking whether the system still poses risks or whether risks are changing and intensifying, including appropriate documentation [17-53].

These measures are essential to ensure responsible AI, especially on a global scale, in order to guarantee the social acceptance of the systems. An integrative approach is crucial to realizing responsibly developed AI solutions that are economically, ecologically, and socially compatible and, above all, usable worldwide.

Conclusion and Outlook

The integration of ethical guidelines for ‚responsible AI‘ offers enormous opportunities for social and sustainable change, particularly with regard to environmental, social, and economic aspects. By using responsible and sustainable AI systems that take environmental and social criteria into account at the design stage, companies can not only increase their competitiveness but also assume social responsibility. Implementation via globally applicable norms and standards on AI offers companies and organizations the opportunity to cooperate and interact with each other. They set clear framework conditions for promoting transparency, security, and accountability. The interaction of regulatory requirements and complementary norms and standards, including conformity tests and certifications, orchestrates the further development of AI systems toward ‚responsible AI‘. At the same time, challenges such as high energy consumption, data ethics, and social implications highlight the need for a responsible and holistic approach to the development and use of AI. Only through continuous monitoring, auditing, and compliance with regulatory requirements can the transformative power of AI be steered in a sustainable and trustworthy direction. Overall, it is expected that sustainable AI will become a key driver worldwide for responsible digitalization and sustainable social change that serves to preserve the Earth.

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