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Securing Artificial Intelligence (SAI); Explicability and transparency of AI processing

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Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Securing Artificial Intelligence (SAI).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document identifies steps to be taken by designers and implementers of AI platforms that give assurance of the explicability and transparency of AI processing. AI processing includes AI decision making and AI data processing. The present document identifies its target audience as designers and implementers who are making assurances to a lay person.

NOTE: The present document uses the term explicability but recognizes that many other publications use the term explainability. The terms are interchangeable with the proviso that the latter term is not a commonly accepted UK English word.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI GR SAI 004: "Securing Artificial Intelligence (SAI); Problem Statement".

[i.2] ETSI GR SAI 002: "Securing Artificial Intelligence (SAI); Data Supply Chain Security".

[i.3] ETSI GR NFV-SEC 003: "Network Functions Virtualisation (NFV); NFV Security; Security and Trust Guidance".

[i.4] Auguste Kerckhoffs: "La cryptographie militaire" Journal des sciences militaires, vol. IX, pp. 5-83, January 1883, pp. 161-191, February 1883.

[i.5] ETSI GR SAI 001: "Securing Artificial Intelligence (SAI); AI Threat Ontology".

[i.6] COM/2021/206 final: "Proposal for a Regulation of the European Parliament and of the Council laying down harmonised rules on Artificial Intelligence (Artificial Intelligence Act) and amending certain union legislative acts".

[i.7] DARPA eXplainable AI project summary.

[i.8] Margaret Mitchell, Simone Wu, Andrew Zaldivar, Parker Barnes, Lucy Vasserman, Ben Hutchinson, Elena Spitzer, Inioluwa Deborah Raji, Timnit Gebru. Conference on Fairness, Accountability, and Transparency: "Model Cards for Model Reporting", January 29-31, 2019, Atlanta, GA, USA. ACM, New York, NY, USA, 10 pages.

[i.9] Samek, W., Montavon, G., Vedaldi, A., Hansen, L. K., and Müller, K. R. (eds.) (2019): "Explainable AI: Interpreting, Explaining and Visualizing Deep Learning". Cham, Springer.

[i.10] Timnit Gebru, Jamie Morgenstern, Briana Vecchione, Jennifer Wortman Vaughan, Hanna Wallach, Hal Daumé III, and Kate Crawford: "Datasheets for Datasets" (Commun. ACM 64, 12 (December 2021), 86-92.

[i.11] Lapuschkin, S., Wäldchen, S., Binder, A., Montavon, G., Samek, W., and Müller, K. R. (2019): "Unmasking Clever Hans predictors and assessing what machines really learn". Nat. Commun. 10, 1-8. doi: 10.1038/s41467-019-08987-4.

[i.12] Molnar, C. (2022): "Interpretable Machine Learning-A Guide for Making Black Box Models Explainable".

[i.13] Samek, W., Montavon, G., Binder, A., Lapuschkin, S., and Müller, K. R. (2016): "Interpreting the predictions of complex ML models by layer-wise relevance propagation", arXiv abs/1611.08191.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the terms given in ETSI GR SAI 004 [i.1] and the following apply:

explicability: property of an action to be able to be accounted for or understood

transparency: property of an action to be open to inspection with no hidden properties

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AI	Artificial Intelligence
BTT	Build-Train-Test
DARPA	Defence Advanced Research Projects Agency
LRP	Layer-wise Relevance Propagation
ML	Machine Learning
OECD	Organisation for Economic Cooperation and Development
RTE	Run Time Explicability
TA	Trust Association
XAI	eXplainable AI

4 Explicability and transparency

The SAI problem statement [i.1] identifies explicability as being a contributor in establishing trust in AI systems as one element of achieving transparency. However, in computer science the concept of transparency is somewhat at odds with explicability and can be interpreted as "*functioning without the user being aware of its presence*" when referring to a process. The term transparent (and its associated noun form, transparency) when applied to AI is, for the purposes of the present document, the core concept of being open to examination, or having no part hidden.

The term explicability is, in very crude terms, being able to show how any result was achieved ("*show your working*"), which when combined with transparency gives assurance that nothing is hidden.

NOTE 1: In ETSI GR SAI 004 [i.1] the term explainability is used whereas in the present document the more common term in UK English, explicability, is used.

NOTE 2: It is recognized that many processes are protected from disclosure by mechanisms that protect the intellectual property that the processes contain and such protections are not intended to be impacted by the requirement to maintain attributes of transparency and explicability.

The outcome of applying constraints of explicability and transparency to systems is that trust can be conferred as a system attribute that is open to examination and verification by 3rd parties.

It is recognized that in many systems, such as in telecommunications, the role of AI is often at a component level. The role of most applications is not to explicitly design or develop intelligence as a primary goal.

One purpose of transparency and, particularly, explicability is to prevent the AI components of a system from denying that they took part in an action, and to prevent the AI component denying they were the recipient of the output of an action from any other part of the system.

NOTE 3: The description above is very close to the common definition of non-repudiation but there is a subtly different intent in the scope of explicability and transparency, hence for the present document this is not referred to as non-repudiation.

In ETSI GR SAI 001 [i.5], it is stated that there are a number of characteristics associated to intelligence the key elements of which are given below, and in the context of transparency and explicability it is expected that each of these characteristics, if they are present in the AI component or system, is described.

- **reasoning:** the application of learned strategies in order to solve puzzles, and make judgments where there is uncertainty in either the input or the expected outcome;
- **learning:** the means by which reasoning and other behaviour evolves over time to address new input;
- **communicating:** in natural language (to human third parties), in particular when within the bounds of the system it is unable to process data to a known state.

In terms of explicability it should be clear where reasoning takes place, and on what data and algorithm, such reasoning is based. Similarly the scope of explicability and transparency addresses the means by which the system learns. Finally, in the context of the key characteristics above, the means by which the system's purpose is communicated should be in natural language where the intended recipient should be considered as a lay person (i.e. having no knowledge of any specialized language of AI/ML or of the programming techniques of AI/ML).

Many concerns raised regarding AI/ML (see ETSI GR SAI 004 [i.1]) and addressed as "Design challenges and unintentional factors" can be made visible through the application of specific explicability techniques. An example is the concern of bias (confirmation bias and selection bias in particular) where, by the application of simple checklists (see clauses 5 and 6) the system deployment should be able to answer questions of the form "why was this data source selected?".

EXAMPLE: An AI can be biased by design if the purpose of the AI is to filter candidates for a job based on some personal characteristic (i.e. as opposed to a meritocratic selection engine, the AI acts as a characteristic selection engine). In such a case the explicability and transparency requirements will be able to identify that negative, or trait-based, filtering is at the root of the reasoning engine of the AI.

It is reasonable to suggest that bias in inputs will be reinforced in the output, hence in clause 5 it is stressed that explicability addresses the purpose of data. If data is preselected to achieve a particular result that could be seen to be consistent with selection bias and that would need to be explained as part of the system purpose (as in the example) or removed by design.

5 Static explicability analysis

5.1 Summary of the role of static explicability analysis

The role of static explicability is closely related to giving detailed system documentation. The purpose of explicability is to allow a lay person (i.e. not a professional programmer or system analyst) to gain a reasonable understanding of the main data flows and processing steps in the program.

EXAMPLE: A data set of images is used as training data and routinely classified as images of, say, "Cat", "Dog", "Fox", "Badger" where the purpose is to enable a camera observing a suburban garden to record movements of particular animals at night, thus being able to say that a badger crossed the garden lawn at a particular time of the night.

In a simple scenario such as in the example above the purpose is clear (identify which animal is in the capture range of the camera), it is clear where the training data comes from (the set of images), and it is reasonable to expect a layperson to understand the purpose, the role of data and components in the system, and to make reasonable attempts to verify the veracity of the system (e.g. by getting a dog to pass in front of the camera and be recognized as a dog, or for a deer to pass in front of the camera and not to be recognized as one of the animals it has been trained to recognize).

As more components are added to the system to improve the system's ability in recognition, say by adding gait analysis (dogs and cats move quite differently) static explicability should be maintained.

The components identified in table 1 should be clearly identifiable in the system documentation.

Table 1: System documentation elements in static explicability analysis

Documentation Element	Element	Short description
1	Statement of system purpose	This element of the system documentation is intended to allow a layperson to clearly understand the purpose of the system and to explicitly identify the role of AI in achieving that purpose.
2a	Identification of data source(s)	Where the data comes from and how the authenticity of the data source is verified.
2b	Purpose of data source(s) (in support of system purpose)	The role of the particular data source in the system (e.g. training data containing images of dogs to train the system in recognizing a dog from an image)
2c	Method(s) used to determine data quality	Methods and processes used in determining if the input data is a fair and accurate representation of the desired input. This should address how bias or preference is identified and corrected in the data input.
3	Identity of liable party	For each processing or data element a means to identify liability for correction of errors or for maintenance of the element.

5.2 Advice on documenting the statement of system purpose

The statement of system purpose is critical in allowing a layperson to clearly understand the intent of the system and the role of AI in achieving that purpose or intent.

EXAMPLE 1: AI used in a voice-recognition personal assistant. The purpose of the system is to allow the user to issue spoken commands in natural language and to translate those into machine commands for purposes including machine control, and internet-based information search and retrieval. The AI in the system provides a number of functions in order to achieve its purpose including: AI to enable speech recognition; AI to assist in parsing of recognized speech to commands; AI to drive voice responses to spoken commands; AI to parse and relay the results of search commands into natural language.

EXAMPLE 2: AI used in adaptive cruise control in road vehicles. The primary purpose is to ensure that whilst the driver can set a target speed to be maintained it is recognized that strict adherence to the target speed can be unsafe. The role of the AI in this system is to maintain a safe distance between vehicles whilst maximizing the time spent at the target speed. The system therefore adaptively modifies the vehicle speed (not exceeding the target speed) by maintaining a "safe" distance from other vehicles through selective braking and acceleration where data on the presence and actions of other vehicles are obtained from system sensors and driver input.

The statement of system purpose should be written in natural language and be concise as well as precise (i.e. not open to variations in interpretation).

5.3 Methods in documenting the identification, purpose and quality of data sources

As outlined in table 1 where data is used in AI the liable party should ensure that answers are documented for the following questions:

- Where does the data come from?
  - As the purpose of data has been indicated earlier this clarifies explicitly the source of the data. This can include statements such as the following for the example of adaptive cruise control: "the range-data indicating the distance to surrounding vehicles and environmental objects is sourced from a radar array positioned at the front left, centre and right of the vehicle".
- How is the authenticity of the data source verified?
  - The aim here is to ensure that only trusted data (data sources) are used in the system
- What is the role of the particular data source in the system? (e.g. training data containing images of dogs to train the system in recognizing a dog from an image)
- What methods and processes are used in determining if the input data is a fair and accurate representation of the desired input?
- What steps have been taken to determine if the input data has bias?
  - It can be argued that all data is biased and that all designers will have some degree of selection bias in the data chosen to train and run their systems. However it is essential that designers be as objective as possible when documenting their sources. If similar data sources were available it may be necessary for the designer to show why one source was selected over any alternatives (e.g. for reasons of cost, or trust in the source as opposed to the content).
- What steps have been taken to compensate for any bias in the input?
  - As has been noted bias can be a design decision. In many instances it may not. Bias can be compensated in a number of ways including modification of data ranking or direct modification of the source to remove inherent bias. Any steps taken to compensate for bias should be documented in clear, concise, and precise natural language.

The use of Model Cards outlined in [i.8] performs much of the above role and where in [i.8] it is stated that there are no standardized documentation procedures to communicate the performance characteristics of trained Machine Learning (ML) and Artificial Intelligence (AI) models the approaches outlined in the present document and those in [i.8] are part of closing that gap in standardization. In addition, the use of datasheets as outlined in [i.10] provides a means to facilitate communication between dataset creators and consumers that is consistent with the intentions of the present document.

5.4 Identifying who is the liable party

In undertaking analysis and in providing the necessary documentation it should be made clear who is responsible for the AI system, and the system of which it forms a component. This should be consistent with any other obligations when placing products on the market.

6 Run time explicability

6.1 Summary of service

When an AI system is running it applies its AI to data to achieve its purpose. The goal of run time explicability is to ensure that the system developer, and other stakeholders in the supply chain, can identify the role of active processes, and data, in achieving the system purpose.

Static explicability is a pre-requisite to run-time explicability. Run Time Explicability (RTE) is defined in the present document as an explicit service of a running system.

The goal of the explicability service is to collect, maintain, make available and validate irrefutable evidence concerning the purpose of, and data contributing to, an action of the machine in order to assist in determining the validity of the action at the time it was taken.

NOTE: The explicability service is closely related to conventional non-repudiation services but with the intent of explaining actions rather than for solving disputes (see also clause 4).

6.2 Abstraction of AI system

An abstract model of an AI processing system is given in ETSI GR SAI 004 [i.1] from which figure 1 is taken to represent stages in the ML lifecycle.

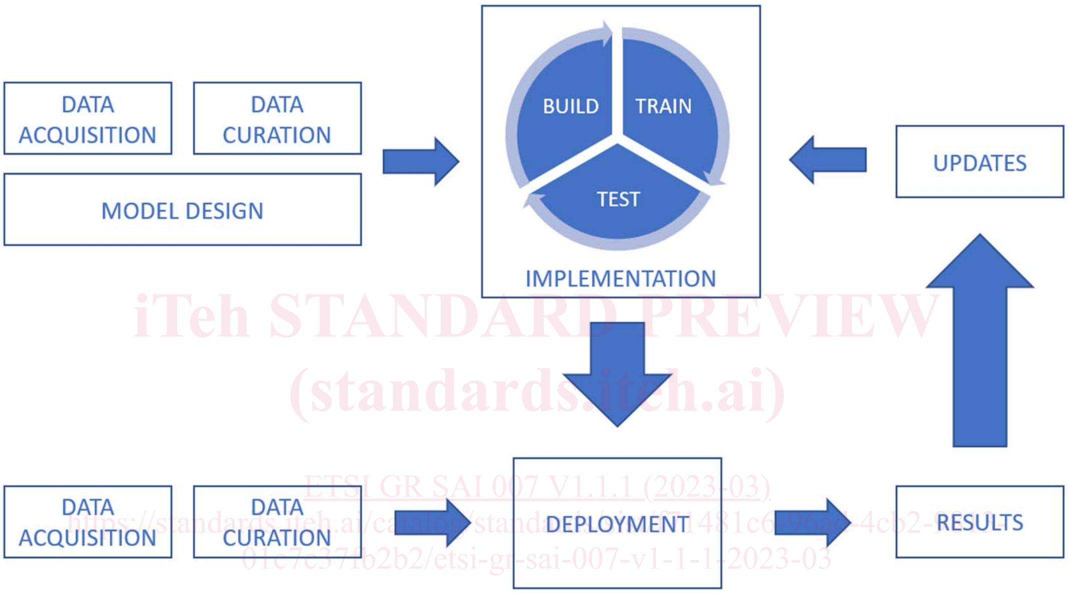

Figure 1: Typical machine learning lifecycle (from [i.1])

Explicability applies to the Build-Train-Test (BTT) cycle during model design, and to the role of the update cycle during deployment that supplements the BTT cycle.

6.3 Evidence requirements for explicability

The requirements for static explicability, outlined in clause 5, apply as a pre-requisite to providing evidence for run-time explicability.

As indicated above, explicability (and transparency as a pre-requisite) aims to prevent the AI components of a system from denying that they took part in an action, and to prevent the AI component denying they were the recipient of the output of an action from any other part of the system. The RTE service expands on the set of questions outlined in clause 5.3 and summarized below:

- What process does data undergo between acquisition and curation?
  - The lifecycle shown in figure 1 identifies data acquisition and curation used in development of the model that is used in implementation (following a BTT cycle), and also in the active deployment phase where results are used in feedback to refine the implemented model. It is reasonable to filter data between acquisition (say where multiple data sources are used) and its curation (say by removing fields from data sources where those fields are not relevant to the model).