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Core Network and Interoperability Testing (INT);

Part #: Artificial Intelligence (AI) in Test Systems and Testing AI models;

Sub-part #: Testing of AI, with Definitions of Quality Metrics

Release # : Joint TC INT & TC MTS Work

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*Replace all <parameters> with the appropriate text.*

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If you choose this solution, the following text has to be mentioned in all of the other parts and sub-parts:

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# Modal verbs terminology *(style H1)*

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# Introduction *(style H1)*

*To Precise that this includes Components and Systems Networks*

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*The "Scope" clause defines without ambiguity the subject of the ETSI deliverable and the aspect(s) covered, thereby indicating the limits of applicability of the ETSI deliverable or particular parts of it.*

*Forms of expression such as the following should be used:*

The present document …

This present document presents a General Guide to the Industry on Testing AI Models in General, and the Definitions of Quality Metrics that can potentially become a basis for Measurements and Assessments in Testing and Certification of AI Models, AI Components and Systems. As illustration it provides definitions of Quality Metrics that could be standardized to become a basis for Certification of AI Models of Autonomic Components/Systems.

EXAMPLE: The present document provides the necessary adoptions to the endorsed document.

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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.

* Use the **EX** style, add the letter "i" (for informative) before the number (which shall be in square brackets) and separate this from the title with a tab (you may use sequence fields for automatically numbering references, see clause 6.9.2 of [EDRs](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)) (see example).

*EXAMPLE:*

[i.1]*[tab]* *<*Standard Organization acronym*> <*document number*> <*V#*>: "<*Title*>".* *(style EX)*

[i.2]*[tab]* ETSI TR 102 469: "Digital Video Broadcasting (DVB); IP Datacast over DVB-H: Architecture". *(style EX)*

# 3 Definition of terms, symbols and abbreviations *(style H1)*

*[ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)* [(](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*[EDRs)](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx), clause 2.11.*

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## 3.1 Terms *(style H2)*

*The terms list shall:*

* *not take the form of, or contain, a requirement.*
* *be presented in alphabetical order.*
* *have a definition that can replace the term in context. Additional information shall be given only in the form of examples or notes. I**f there are several notes or examples for the same term, the notes and examples shall be numbered. (See examples below).*

*The following text block applies.* If there are no terms to be listed, replace the text block by "Void".

For the purposes of the present document, the [following] terms [given in ... and the following] apply:

* Use the **Normal** style.
* The term shall be in **bold**, and shall start with a lower case letter (unless it is always rendered with a leading capital) followed by a colon, one space, and the definition of term starting with a lower case letter and no ending full‑stop.

<**term**>**:** <definition of term>

*EXAMPLE 1:*

**communal site:** location at which there is more than one fixed transmitter *(style Normal)*

NOTE: There are two types of communal site; one having separate equipment and antennas but housed in a common equipment room, and the other having an engineered system employing common antenna working where the isolation between equipment is determined by the filter system.  
At all communal sites equipment installed on the site meet the limits as specified in the relevant standards. *(style NO)*

*EXAMPLE 2:*

**fast channel:** channel with low latency but higher BER in comparison to the slow channel *(style Normal)*

EXAMPLE: In contrast to the slow channel, the fast channel is not interleaved. *(style EX)*

## 3.2 Symbols *(style H2)*

*The symbols list shall:*

* *contain the symbols and their corresponding explanations.*
* *be presented in alphabetical order.*
* *have entries not numbered.*

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* Use the **EW** style and separate this from the definition with a tab. Use the **EX** style for the last term.

*<*1st symbol*>* *[tab]<*1st Definition of symbol*>* *(style EW)*

*<*2nd symbol*>* *[tab]<*2nd Definition of symbol*>* *(style EX)*

*EXAMPLE:*

dB decibel *(style EW)*

DDI Direct Dialling-In, or direct dialling-in *(style EX)*

## 3.3 Abbreviations *(style H2)*

*The abbreviations list shall:*

* contain the abbreviations and their corresponding full form.
* be presented in alphabetical order.
* have entries not numbered.

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*<*1st ABBREVIATION*>* *[tab]<*Definition of abbreviation*>* *(style EW)*

*<*2nd ABBREVIATION*>* *[tab]<*Definition of abbreviation*>* *(style EX)*

*EXAMPLE:*

DPC Dynamic Power Control *(style EW)*

CCI Co-Channel Interference *(style EX)*

# 4 Taxonomy: Definitions of Key Concepts and Terms

**TODO: We will add definitions of key concepts and terms, covering the following:**

* **AI Model** to be defined precisely
* **AI Algorithm** to be defined precisely
* **AI Component** to be defined precisely
* **AI System** to be defined precisely
* Relationships between AI Model and AI Algorithm
* Relationships between AI Model and AI Component
* Relationships between AI Model and AI System
* **AI-embedding Communication Network**
* **Non AI-embedding Communication Network**

# 5 Stakeholders that should make use of this present document as a Guide

Xxxxxxxx Align with the Stakeholders we captured in TR1

# 6 Brief Overview of the Development Process and General Lifecycle (in scope of GANA)

Provide a brief overview how a system is developed from AI models over AI components and integrate components.

As described earlier, the ETSI TS 103 195-2 [2] defines the concept of Autonomic Manager element (called a “Decision-making-Element” (DE) in the GANA terminology) as a functional entity that drives a control-loop meant to configure and adapt (i.e. regulate) the behaviour or state of a Managed Entity (i.e. a resource)—usually multiple Managed Entities(MEs). The ETSI GANA Standardized Framework for AMC (ETSI TS 103 195-2) defines an Intelligent Management and Control Functional Block called GANA KP that is an integral part of AMC Systems that provides for the space to implement complex network analytics functions performed by interworking Modularized and specialized DEs. The KP DEs run as software in the Knowledge Plane and drive self-\* operations such as self-adaptation, self-optimization, self-monitoring objectives for the network and services by programmatically (re)-configuring Managed Entities (MEs) in the network infrastructure through various means possible: e.g. through the NorthBound Interfaces available at the OSS, Service Orchestrator, Domain Orchestrator, SDN controller, EMS/NMS, NFV Orchestrator, etc. While a Cognitive GANA DE is the concept that must be considered with respect to Testing AI Models in GANA as Component Under Test (CUT), this Chapter provides a Generic Test Framework for Testing ETSI GANA Model’s Multi-Layer Autonomics & AI Algorithms for Closed-Loop Network Automation. The general principles outlined earlier in chapter 6 (which include the principles outlined in ETSI EG 203 341 V1.1.1 (2016-10) [27]) should also be considered by testers as they also apply to testing Cognitive DEs. The Generic Test Framework for Testing GANA Autonomics is an elaboration of the early draft framework presented in Annex of ETSI EG 203 341 V1.1.1 (2016-10) [27] and has been extracted from ETSI EG 203 341 V1.1.1 (2016-10) and elaborated as illustrated in this Chapter. NOTE: This Generic Test Framework for GANA is expected to be further developed by one of the deliverables of the newly launched Work Item in ETSI TC INT [25] and readers are encouraged to follow the further developments on the framework by the Work Item. The Generic Test Framework is aimed at providing guidance on various aspects such as the following aspects:

• Conformance Testing and Interoperability Testing for GANA Functional Blocks (DEs, ONIX, MBTS) based on their Reference Points and Characteristic Information exchange expected on the Reference Points; i.e. Conformance Testing and Interoperability Testing is required on the Reference Points for Autonomics instantiated in a target architecture and environment

• Criteria for use in Verdicts passing when Testing Autonomic Functions (AFs), i.e. GANA DEs

• The role of a GANA Meta-Model in generation of Data Types for use in Test Suites Development

• Need for Specifications to be provided to Tester by a DE vendor, regarding "claims" on what the DE strives to achieve during its operations, with indications on the metrics (e.g. KPIs) that can be measured and monitored, appearance/manifestations of new instances of objects the DE causes to be created, or change in state of certain objects impacted by the DE’s autonomic operations

• Testing non-cognitive GANA DEs, taking into consideration the "Operating-Region" of a Control-Loop(s) associated with the DE

• Testing Cognitive GANA DEs as deployable AI Models, taking into consideration the "Operating-Region" of a Control-Loop(s) associated with the DE, while taking into considerations Training Data Repository for AI Models (i.e. the cognitive DEs), and AI Algorithms that can be employed by a DE logic, such as machine Learning(ML), Deep Learning (DL), Computational Intelligence, etc.

• Integrated self-testing within a DE (i.e. embedded testing using a test component embedded within the DE

• Validation, Trustworthiness-building, and then Certification of a DE (or collective bundle of interworking DEs)

• Testing a collective group/bundle of interworking DEs as a black box (applies especially to DEs within GANA nodes)

• Consideration of the various Components that need to interwork with a GANA DE Under Test in Automated Test Developments and Executions

• Testing GANA Knowledge Plane as an AI system of collaborating DEs (AI Components)

• Testing vertical interactions of DE stacks along the GANA Hierarchy of Decision-making-Elements (DEs)

• Test Data required for Testing DEs

• The Types of Testing and associated Test Systems and components that should be applied in Testing DEs during various phases of DE lifecycles and also phases of the lifecycle of the Network to be impacted by the DE’s operations (Validation Phase of a DE, Trustworthiness building phase for a DE, Certification Phase for a DE, Network Deployment Phase, DE deployment and activation Phase, Network Operation Phase, Network Optimization Phase)

• Where Passive Testing plays a role and where combined Active and Passive Testing plays a role in Testing DEs

• Integration and User Acceptance Testing of GANA DEs

There are various Types of Testing that need to be more detailed by the Generic Test Framework, and need to be considered by Test systems developers and testers for GANA autonomics, namely:

• Conformance Testing of the GANA Knowledge Plane (KP) DEs and their Reference Points, and Test Data

• Conformance Testing of the GANA Knowledge Plane (KP) ONIX system and its associated Reference Points, and Test Data

• Conformance Testing of the GANA Knowledge Plane (KP) MBTS and its associated Reference Points, and Test Data

• Conformance Testing of the GANA Levels 2 and 3 DEs and their Reference Points, and Test Data

• Integration Testing of GANA Functional Blocks (KP DEs, ONIX, MBTS, GANA Levels 2 and 3 DEs in NEs/NFs), and Test Data

• Performance Testing of individual GANA Functional Blocks (KP DEs, ONIX, MBTS, GANA Levels 2 and 3 DEs in NEs/NFs), and Test Data Gathering and the need to ensure Quality for the Test Data through appropriate Data Validation techniques and methods to improve the quality through generation of synthetic data where necessary to complement real data gathered from real network operation environments

# 7 A General Methodology for Testing AI Models, including Testing of AI Components and AI Systems

In general, Testing AI Systems involves the following aspects [22]:

* **Data Validation**: In general, Testing of AI systems, in contrast to the testing of traditional non-AI systems that normally involves the **validation of the conformance of the outputs** of the system against specific inputs, testing of AI system rather involves **validation of the inputs themselves** (i.e. **Data Validation**) in order to verify the robustness of the AI system in terms of its ability to make effective and appropriate decisions in its outputs. The reason is because the effectiveness of AI systems in their decision making capability mainly depends on the quality of the training data (and the training data has to also include aspects such as bias and variety/diversity) [22].
* **Algorithms Testing and Model Validation**: The core part of AI systems is built on various types of algorithms that process data and generate actionable insights from the data. Model validation, the ability to learn, efficiency of a particular algorithm and empathy belong to the various key features that have to be considered in testing AI systems. The ability of the AI system to learn is the ability of the system to learn and modify its behavior with time [22]. The broader picture of algorithms at the core of AI systems are called *cognitive algorithms* and as defined in ETSI TS 103 195-2, “cognition” involves “learning” and “reasoning”. The various algorithms and techniques for learning help build the AI Model that is at the core of an AI system, and is what needs to be subjected to validation by rigorously testing it under various inputs. Other algorithms that may be employed by an AI system include *optimization algorithms* aimed at optimizing some parameters that determine the AI system’s behavior and some corresponding actions the system has to take in order to enforce the parameters to attain the optimized values.
* **Non-functional Testing (e.g. Performance Testing and Security Testing)**: Performance Testing of the AI systems needs to be carried out in order to determine the effectiveness of the system in delivering its services and timeliness in its responses to changing inputs, as well as measuring the Key Performance Indicators (KPIs) of the system against various factors such as the resources required by the system. Security testing of the AI system is done in order to ensure that the system does not violate certain security requirements and also to determine the extent to which the system is vulnerable to attacks or can pose a security risk when put into operation.
* **Integration Testing:** The Integration Testing of the AI system involves testing the ability of the system to communicate with the various other systems and components the system is required to interact with during its operation, and it also involves ability of the system to accept any loadable components of which the system may be required to support the loading by the user such that the system uses the on-boarded components in its operation.

## 7.1 AI-Specific Quality Characteristics to Be Addressed

AU: see comment by Martin; it includes quality of data

7.2 General aspects of “Testing of AI Systems”

* + MARTIN: AI-specific quality characteristics, e.g. bias, fairness
  + Data validation: training + test data, data quality
  + Algorithm testing and AI model validation
  + Testing of non-functional qualities, e.g. performance, security
  + Integration testing of AI components in a system scope
  + Testing during operation and continuous testing

Testing kinds in the scope of AI systems – discussion of their particularities

* + Conformance testing
  + Interoperability testing
  + Certification

Test system design for AI systems to support certification

* + Test data validation
  + Adaptive black-box testing approaches
* Proposed approach: Testing of components and systems that comprise AI technology:

**a)** When considering certification (conformance, interoperability testing), the concrete AI technology used in the system might be not exposed.

**b)** Consider general system properties that are realized using AI and help define the test framework accordingly:

1. Test objective and test model specification

2. Test derivation and test execution

3. Test result analysis

**c)** Test Languages and Tools

**d)** Design-Time Testing and On-Line (Run-Time) Testing of AI Models, Components, Systems

7.3 Classes of AI-empowered systems to be considered:

**a)** Classification systems:

1. Data processing, similar to data-flow testing

2. E.g., separation of training data and test data

3. Quality characteristics of data

**b)** Self-adaptive systems (Autonomic Systems):

1. Testing resilience against failures, e.g. fault-tolerant and self-healing systems

2. Testing structural adaptation, e.g. adding/deleting nodes in a distributed system

3. Testing behavioral adaptation due to environment changes, e.g. system operation under uncertainties

AI Models in Autonomic/Autonomous Self-Adaptive Systems: as Example Class of AI Models

Characteristics of Autonomous, Self-Adaptive Systems

* + Class of AI systems being covered in this guide? YES
  + Characteristics of “intelligence” to be validated, e.g. GANA decision-making elements
  + Control loops in self-adaptive systems
    - Monitoring  Analysing  Planning  Execution

**NOTE:** Other Types may are to be considered in later release but this selected Classes of AI systems (e.g. Autonomic Systems) is initial scope of focus and later other types of systems would be considered

6.3 Discussion, covering the aspects of testing + certification of autonomic/autonomous, self-adaptive systems

* + Detailed on aspects of their control loop design
  + Test adequacy, i.e. when is testing done?
  + Special aspects
    - Testing the self-testing capabilities of AI components
    - Building trust in AI systems, explainable AI (XAI)
    - Testing network optimisation
    - Testing self-adaptation aspects, e.g. fault resilience, structural or behavioural adaptation
    - Repeatability of tests and confidence

6.4 Work or Standards outside ETSI that could be leveraged in this domain

**Work or Standards outside ETSI that could be leveraged in this domain**

* + ISO/IEC TR 29119-11 Software and systems engineering -- Software testing -- Testing AI-Based Systems
  + ISO/IEC TR24029 Assessment of the robustness of neural networks
  + Others?

Add Chapter: A General Methodology for Testing Networks AI Systems forming a Network

# 7 A General Methodology for Testing an AI-embedding(powered) Network or AI Systems that collectively form a Network

To be Considered as well: Integration “AI-embedding” Network with “Non AI-embedding” Network, from Use Case Perspective (RAN Use Case, X-Haul Transport Use Case, Core Network Use Case, E2E Scenario, etc

# 8 Definitions of Quality Metrics of specific classes of AI Models, Components and Systems

8.1 General Definitions of Quality Metrics of AI Models/Components/Systems

We describe General Quality Metrics xxxxx

* Confidence metrics for AI based systems
  + Quality metrics definition
    - To be compared with ISO/IEC 25010 “System and software quality models” and ISO/IEC 25012 “Data Quality model”
    - To be compared with DIN SPEC 92001 “AI Quality Metamodel and Robustness”
    - Other related standards
  + Measurement and metrics calculation
  + Input data quality for metrics

8.2 Definitions of Quality Metrics that could be standardized to become a basis for Certification of AI Models of Autonomic Components/Systems

So as to enable Test Systems communities to test the AI Models and to provide insights on what could be a basis for certification services (even though certification is out of scope).

# 9 Generic Test Framework for Testing AI Models, Components and Systems during their lifecycles

This clause aims to give a particular focus on selected classes of AI Models built on AI techniques e.g. Machine Learning (ML) and Deep Learning (DL))

9.1 Overview of Testing and Validation of an AI Model or a collective bundle of interworking AI Models, Component and System based on well-defined criteria for verdict passing

The Generic Test Framework identifies different types of test systems that could be employed to the problem space of testing AI models and are to be applied in phased testing starting at design time up to the point when a network consisting of trusted and certified AI Model is tested as a whole (for integration and user acceptance testing).

• What type of testing is performed for an AI Model during design time and who performs the testing and owns test components used?

• What role Testing plays in the following phases of an AI Model lifecycle?

- Validation of an AI Model (or collective interworking AI Model);

- Trustworthiness building on an AI Model (or collective bundle of interworking AI Models);

- Certification of an AI Model (or collective bundle of interworking AI Models).

• Where Conformance Testing comes into play, and where Interoperability Testing comes into play?

• Where Integration and User Acceptance Testing of an Adaptive Network comes into play?

• Criteria/basis for assigning verdicts in Test cases employed at various phases of Testing AI Models?

• The need for the Test Systems or Test Components that test AI Models to be intelligent (i.e. themselves being autonomic-like) as to mimic IA Models themselves?

• Where Passive Testing plays a role and where combined Active and Passive Testing plays a role?

1) Individual AI Models or their composition into AI Systems need to undergo the following processes in the lifecycle: Validation, Trustworthiness-building, and then Certification. Providers/suppliers of AI Models are responsible for performing these processes. Deployability of an AI Model should be based on the condition that the AI Model passed all the processes up to having been certified. Figure 27XX illustrates the processes.



Figure 27: Potential AI Model certification process before inclusion in ANs (Adaptive Networks)

3) AI Model may be designed as run-time loadable or replaceable software modules (better AI Models in terms of quality of decision-making capability may be used to replace low quality AI Models), and may be deactivated and activated during operation time.

4) The AI operational environment scope for which a supplier of AI Models should be clarified by the supplier of the AI Models. For example, the scope could be the whole network segment or an IT domain and its management and control systems.

5) The operational objective realized by a particular AI Model, as well as "Assertions(claims)" on what the AI Model strives to achieve during its operations, with indications on the metrics Key Performance Indicators (KPIs) that can be measured and monitored, appearance/manifestations of new instances of objects the AI Model causes to be created, or change in state of certain objects impacted parameters, should all be used to verify/test the claim (assertion) and should be described by the AI Model supplier and made known to the tester.

6) Testing of AI Models involves various techniques and approaches, ranging from:

a) Integrated self-testing within an AI Model (i.e. embedded testing using a test component embedded within the AI Model) as shown in Figure 28.

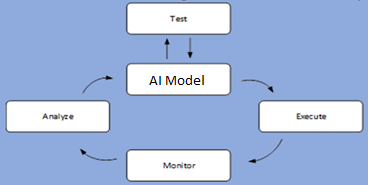


Figure 28xx: Self-Testing concept for AI Models

b) Testing a collective group/bundle of interworking AI Models as a black box (applies especially to AI Models within an AI System).

c) Testing system/component may intercept and observe actions of the AI Model under test that are performed in response to stimuli (mainly based on the operating region of the AI Model) and use the actions in inferring correctness of the AI Model results (depends on the intelligence and correctness of the test component's algorithms it employs in the testing). This applies to environment in which AI Models actions can be intercepted during active testing (with injection of stimuli data to the AI Model under test), e.g. in tests conducted by the AI Model owner. This could be considered as a foundation for establishing a “Qualified Automated Test Component(s) or System” that exhibit best quality AI capabilities for testing those AI Component(s)/System Under Test or simply a AI Model Under Test

d) Passive testing may be used by the test system to observe the metrics (KPIs) and the objects that may be instantiated or intentionally impacted by the AI Model, using monitoring techniques and inferring whether the changes are desirable for meeting the objectives of the AI Model impacted system and claims made about the AI Model's impact on the monitored metrics and/or objects instantiated or whose state gets modified intentionally by the AI Model's actions. The approach could be as follows: a set of metrics (e.g. KPIs) determined to be critical to be observed is derived based on impacts the AI Model is claimed to positively have on the metrics or observable objects (such as services or service nodes), and base acceptable values for the metrics or state of objects are first established, and then the test system passively monitors the metrics and objects over time while the environment and the workload around the AI Model is known to be changing over time, and then the test system/component keeps tracing if and how the KPIs or objects are impacted over an observation window. Verdicts are then assigned after the sampling. The test objective may seek to determine whether the measured values improve, remain close to acceptable values.

e) Combination of active and passive testing may be employed.

7) Test and Validation Verdicts for an AI Model or a bundle of AI Models (treated as black box) should be based on the following, depending on the testing approach used:

a) Verdict passing may be based on determining whether an intercepted action performed by an AI Model within a certain acceptable time that is measured relative to some event of interest to the test system/component, has significant impact on meeting the objectives required of the AI Model impacted system, depending on the claims (assertion) attached to the AI Model on what it does with respect to the objectives. The impact factor can be used in determining correctness of the action during validation of the AI Model. This applies to environment in which AI Model actions can be intercepted.

b) Verdict passing may be based on observing the impacts (metrics and/or objects instantiated or modified as a result of the adaptive behaviour of the AI Model under test) and assessing whether the impacts support the claims concerning what the AI Model is meant to achieve in its operation. This applies in environment and testing in which it may even not be possible to intercept AI Model actions.

c) Verdicts may be based on various criteria, such as a combination of actions, timing and impacts observed on metrics and objects of interest to the test case.

d) Because each AI Model may be designed to enable the AI impacted system as a whole to realise multiple features/objectives, such as auto-discovery and self-configuration, self-optimization, self-healing, etc. Verdicts may be defined that specifically target the individual objective/feature enabled by the AI Model.

8) Test Systems or Test Components that test AI Models should be intelligent as to mimic AI Models they are meant to test, meaning that confidence in the test system also needs to be built up over a certain time and application to various test scenarios. This could be considered as a foundation for establishing a “Qualified Automated Test Component(s) or System” that exhibit best quality AI capabilities for testing those of AI Component(s)/System Under Test or simply a AI Model Under Test.

9) Testing of AI Systems is to be considered as decomposed into various testing needs and associated test systems and components, from component level testing of an AI Model as individual software modules up to the highest level Integration and User Acceptance Testing of an AI System as a whole, which can only be done under the conditions that AI Models passed all testing phases and types of testing and validation to the point of having been certified. AI Models that are trusted and ideally certified should be the ones that can be made to participate in the overall Integration and User Acceptance Testing of an AI System as a whole, implying dependencies on the tests conducted in various phases of an AI Model lifecycle.

10) Integration and User Acceptance Testing of an AI System as a whole comes into play when individual AI Models have undergone as complete as possible the whole chain of Validation, Trustworthiness-building, and then Certification. At such a stage the Test system needs to access the system boundary that is defined by all the open interfaces for control and observation exposed mainly by the AI Models and their interfaces with other entities (i.e. a component that supply input required by the AI model for example policies that govern its behaviour) that enable the AI Model to operate. Some test cases on this higher level testing may depend on passive testing.

11) Input to deriving test cases for an AI Model should be based on the following items:

a) Reference Points that apply to the AI Models or bundled AI Models need to be tested. What needs to be considered with respect of the Reference Points of an AI Model in developing Test Cases is the Characteristic Information that needs to be exchanged on the Reference Point and the means by which the characteristic information is conveyed (e.g. by means of protocols or APIs methods). The Reference Points implementations (complete operational information exchange and protocols or APIs used in real-implementation) need to be obtained by Testers developing Test Cases.

b) The "Operating-Region" of an AI Model as defined by the training dataset that was used to train it. Validation dataset outside the operating region need to be considered.

c) The provider/supplier of an AI Model specifies what the AI Model is designed to achieve when running in the target operational environment (even without having to disclose the AI algorithms of the AI Model), specifying the AI Model metrics (e.g. KPIs) that get improved by the AI Model or kept to a certain threshold by virtue of optimizations operations by the AI Model.

12) Test System for an AI Model can evolve in its test capabilities along with the need to test evolved AI Model algorithms.

13) Test Data may be synthetic or include in-service data involving a real environment in which AI Models are being tested.

Table 2X categorizes the types of testing and associated test Systems and components that should be applied in Testing AI Models during their lifecycles.

Table 2X: Types of testing and associated deployment phases

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Type of Testing** | **Validation phase of an AI Model** | **Trustworthiness building phase** | **Certification Phase for the AI Model** | **Test System Deployment Phase** | **AI Model deployment and activation Phase** | **Test System Operation phase** | **Test System Optimization Phase** |
| AI Model Testing and Validation | x | x | x |  |  |  |  |
| Conformance Testing |  |  | x | x | x |  |  |
| Interoperability Testing |  |  | x | x | x |  |  |
| Integration and User Acceptance Testing of an AI System as a whole |  |  |  | x | x | x | x |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Testing**  **Phase**  **Type of Testing** | **Validation phase** | **Trustworthiness building phase** | **Certification Phase** | **Test Network Deployment Phase** | **AI Model Deployment and Activation Phase** | **Test Network Operation phase** |
| **Testing and Validation** | **x** | **x** | **x** |  |  |  |
| **Conformance Testing** |  |  | **x** | **x** | **x** |  |
| **Interoperability** |  |  | **x** | **x** | **x** |  |
| **Integration and User Acceptance** **Testing** |  |  |  | **x** | **x** | **x** |
| **Self-Testing** |  |  |  |  |  | **x** |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Testing**  **Phase**  **Type of Testing** | **Validation phase** | **Trustworthiness building phase** | **Certification Phase** | **Test Network Deployment Phase** | **AI Model Deployment and Activation Phase** | **Test Network Operation phase** | **Test Network Optimization Phase** |
| **Testing and Validation** | **x** | **x** | **x** |  |  |  |  |
| **Conformance Testing** |  |  | **x** | **x** | **x** |  |  |
| **Interoperability** |  |  | **x** | **x** | **x** |  |  |
| **Integration and User Acceptance** **Testing** |  |  |  | **x** | **x** | **x** | **x** |
| **Self-Testing** |  |  |  |  |  | **x** | **x** |

Table 1:  Generic Test Framework for Testing AI Models / Systems during their lifecycles



9.2 Conformance Testing (against a well-defined specification of behavioural and structural features expected of an AI Model)

xxxxx

9.3 Interoperability Testing of AI Models, Components, Systems

Based on what is expected to be communicated at Reference Points involving the AI Model (as a Component/ System) and other entities required to interact with it); and against what is expected of the AI model behaviour by the target integration and deployment environment

9.4 Integration and User Acceptance Testing of the AI Model

Here we consider an AI Model or Component or Systems that has been integrated to interwork with other AI Models, Component or System in the network that is also being tested as a whole

9.5 Self-Testing Capability of a AI Model embedded in Component or System

Xxxx

9.6 Validation phase of an AI Model (or collective bundle of interworking AI Models)

Xxxxxxxxx

9.7 Trustworthiness building phase of an AI Model (or collective bundle of interworking AI Models), Component or System

This is to include fuzzing approaches with domain-specific heuristics for generating adversarial samples to perform security and robustness testing of AI models

9.8 What a Certification Phase for the AI Model (or collective bundle of interworking AI Models) could involve

Even though Certification is out scope, we still need to give ideas on what certification of AI Models could involve

**a) NOTE 1:** For Certification, the various Definitions of Standardized Metrics for Measurements and Assessments in Testing and Certification of AI Models to be defined by this guide shall be the basis for Certification of AI Models by the Industry and relevant bodies.

**b)** **NOTE 2:** Certification is currently a research topic (several research project and research programs are currently active in this fields, e.g. for the aerospace sector a research project there is a project that will start this summer of 2020 and Fraunhofer is working on this, and the German Federal Office for Information Security is also working on a verification scheme for AI).

Xxxx

9.9 Test Network Deployment Phase (pertaining to a Test Network in which the AI Model(s) is being deployed)

Xxxxx

9.10 AI Model Deployment and Activation Phase

Xxxxxx

9.11 Test Network Operation phase (pertaining to a Test Network in which the AI Model(s) has been deployed)

Xxxxxxxx

9.12 Test Network Optimization Phase (pertaining to a Test Network in which the AI Model(s) has been deployed)

Xxxxxxxxx

# 10 Testing Offline AI Models which need a programmable configurable (re)-Training process in a CSPs’ Training environment

Testing Offline AI Models which need a programmable configurable (re)-Training process in the CSPs’ Training environment before being exposed to new data (real data) in the Production environment

# 11 Testing Online AI Models that are directly deployed in CSP’s Production Environment and are continuously exposed to real and new data

Testing Online AI Models that are directly deployed in the CSP’s Production environment, and are continuously exposed to real and new data and they have the ability to learn and modify their behavior continuously. They require a continuous testing, with faster response time.

# 12 Conclusion and Further Work

xxxxxxxx

xxxxxxx

# 15 User defined clause(s) from here onwards *(style H1)*

From clause 4 the technical content of the ETSI deliverable shall be inserted. Each clause **shall have a title** *For numbered clauses the title shall be placed after its number.*

A clause can have numbered subdivisions, e.g. 5.1, 5.2, 5.1.1, 5.1.2, etc. This process of subdivisions may be continued as far as the sixth heading level (e.g. 6.5.4.3.2.1).

For numbering issues, see clause 2.12.1 of the [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx).

* Use the **Heading** style appropriate to its level (see ETSI styles" table in [***editHelp!***](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles/Styleslistingtable.aspx)website).
* Separate the number of the heading and the text of the heading with a tab.
* Treat clause titles as normal text (i.e. **no additional capitalization**), **but** no full stop.

*Notes and examples*

*Notes and examples integrated in the text shall only be used for giving additional information intended to assist the understanding or use of the ETSI deliverable. Notes and examples shall not contain requirements. For more details see clauses 5.5 and 2.12.1 of the* [EDRs](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*).*

*A single note in a clause shall be preceded by "NOTE" in upper case. When several notes occur within the same element (e.g. clause, figure or table), they shall be designated "NOTE 1:", "NOTE 2:", "NOTE 3:", etc.*

Use the **NO** style.

Separate NOTE: from the text of the note with a tab.

*EXAMPLE:*

NOTE 1: Text formatted with the **NO** style will be formatted **with** a space after the paragraph. *(Style NO)*

NOTE 2: This is the second note contained in a clause. *(Style NO)*

*A single example in a clause shall be preceded by "EXAMPLE:" in upper case. When several examples occur within the same element (e.g. clause, figure or table), they shall be designated "EXAMPLE 1:", "EXAMPLE 2:", "EXAMPLE 3:", etc.*

*When there is a danger that it may not be clear where the example ends and the normal text continues, then the end of the example may be designated by "END of EXAMPLE".*

Use **EX** style.

Separate EXAMPLE: from the text of the example with a tab.

*EXAMPLE:*

EXAMPLE 1: This is the first example of the clause.(Style EX)

EXAMPLE 2: This is the second example of the clause. *(Style EX)*

END of EXAMPLE

*Figures*

Figures shall be prepared in accordance to clauses 5.1 and/or 7.2 of the [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx). Details concerning *"*[*Supported file formats*](https://portal.etsi.org/Services/editHelp!/Howtostart/Supportedfileformats.aspx)*" and "How to copy a figure"* are available *in* [*editHelp!*](https://portal.etsi.org/edithelp/Files/other/Graphics_editHelp!.pdf) *website.* *For an easy application of the ETSI styles download* *"The ETSI styles toolbar" from* [*editHelp!*](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles.aspx) *website.*

* The figure number and title shall be below the figure. An explicit figure title is optional.
* *Notes to figures* ***shall*** *be treated independently from notes integrated in the text, see clause 5.1.5 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx) *for more details.*
* *To generate a list of figures see clause 2.3.2 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*
* Use **TF** style for the figure number and title.
* Use **FL** style on the paragraph which contains the figure itself.
* Use **NF** style for the notes to figures. Separate "NOTE:" from the text of the note with a tab.
* If applicable, the figure number is followed by a colon, a space and the table title.
* Maximum width for figures is 17 cm and maximum height is 22 cm.
* For automatic figure numbering see clause 6.9.2 of the [EDRs](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx).

*Figure numbering*

*Figures may be numbered sequentially throughout the ETSI deliverable without regard to the clause numbering, e.g. first figure is figure 1 and the twentieth figure is figure 20.*

*Figures may also be numbered taking account of clause numbering.*

*EXAMPLE 1: First figure in clause 5 is figure 5.1, second figure in clause 5.1.1 is figure 5.2, third figure in clause 5.2.3 is figure 5.3.*

*EXAMPLE 2: First figure in clause 7.3.2 is figure 7.3.2.1, fifth figure in clause 7.3.2 is figure 7.3.2.5.*

*One level of subdivision only is permitted (e.g. table 1 may be subdivided as 1 a), 1 b), 1 c), etc.). See also clause 2.12.1.0 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*

*Figures of an annex shall be preceded by the letter designating that annex followed by a full-stop (e.g. figure B.1, figure C.4.1.1). The numbering shall start afresh with each annex.*

*Layout of a figure*

*EXAMPLE:*

**Figure** *(style FL)*

NOTE: This is a note to figure 1. *(style NF)*

**Figure 1: Details of apparatus** *(style TF)*

*Tables*

Tables shall be prepared in accordance to clause 5.2 of the [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx).*For an easy application of the ETSI styles download "the ETSI styles toolbar" from* [*editHelp!*](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles.aspx) *website.*

* *The figure number and title shall be above the table itself. An explicit table title is optional.*
* *If the table continues over more than one page, the column headings shall be repeated on all pages after the first.*
* *Notes to figures* ***shall*** *be treated independently from notes integrated in the text, see clause 5.1.5 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx) *for more details.*
* *To generate a list of figures see clause 2.3.2 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*
* *For numbering issues see clause 5.1.3 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*

|  |
| --- |
| * Use the following styles: * **TH** for the table number and title. * **TAH** for table headings * **TAL** for text left aligned * **TAC** for text centred * **TAR** for text right aligned * **TAN** for the note to table. Separate NOTE: from the text of the note with a "Ctrl" + "" (tab). Include notes to a table within its borders in one cell, at the bottom. * **TB1** for the list of level 1 * **TB2** for the list of level 2 * If applicable, the table number is followed by a colon, a space and the table title. * To repeat the column heading on all pages, use the table headings tool (**Table, Heading Rows Repeat**). * For automatic figure numbering see clause 6.9.2 of the [EDRs](http://portal.etsi.org/Help/editHelp!/Howtostart/ETSIDraftingRules.aspx)). |

Centre tables horizontally.

The "space between columns" is 0,1 pt or 0,05 cm (default cell margins Left 0,05 pt & Right 0,19 pt).

Maximum width for tables in portrait orientation: 17 cm and for landscape orientation: 22 cm.

Set table columns widths in centimetres (not inches).

Use borders to separate the rows and columns of tables, as appropriate; the precise format will depend on the structure of each table, but be consistent throughout a deliverable (or series of related deliverables). Borders should be ¾ pt single line.

Each table shall be followed by an empty "Normal" style paragraph ( "Enter" key).

*Table numbering*

*Tables may be numbered sequentially throughout the ETSI deliverable without regard to the clause numbering, e.g. the first table is table 1 and the twentieth table is table 20.*

*Tables may also be numbered taking account of clause numbering.*

*EXAMPLE 1: First table in clause 5 is table 5.1, second table in clause 5.1.1 is table 5.2, third table in clause 5.2.3 is table 5.3.*

*EXAMPLE 2: First table in clause 7.3.2 is table 7.3.2.1, fifth table in clause 7.3.2 is table 7.3.2.5.*

*One level of subdivision only is permitted (e.g. table 1 may be subdivided as 1 a), 1 b), 1 c), etc.). See also clause 2.12.1.0 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*

*Tables of an annex shall be preceded by the letter designating that annex followed by a full-stop (e.g. table B.1, table C.4.1.1). The numbering shall start afresh with each annex.*

*Layout of a table*

*The title shall be above the table. An explicit table title is optional. See the following examples. The first word in the heading of each column shall begin with a capital letter. The units used in a given column shall generally be indicated within the column heading.*

*EXAMPLE:*

**Table 1: Electrical properties** *(style TH****)***

|  |  |  |  |
| --- | --- | --- | --- |
| **Type** *(style TAH)* | **Linear density (kg/m)** *(style TAH)* | **Inside diameter (mm)** *(style TAH)* | **Outside diameter (mm)** *(style TAH)* |
| Text*(style TAL)* | Text *(style TAC)* | Text *(style TAR)* |  |
| NOTE 1: This is a note to table. *(style TAN)*  NOTE 2: This is a merged cell. *(style TAN)* | | | |

*Mathematical formulae*

Mathematical formulae shall be prepared in accordance to clause 5.3 of the *[EDRs](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx).* *Details concerning tools that shall be used for editing "Mathematical formulae" are available on* *[editHelp!](https://portal.etsi.org/Services/editHelp!/Tohelpyouinyourwork/Furtherresources/Mathematicalformulae.aspx) website.*

*For an easy application of the ETSI styles download "the ETSI styles toolbar" from* *[editHelp!](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles.aspx) website.*

* Use **EQ** style.
* Insert one tab before the equation to centre it.
* For automatic equation numbering see clause 6.9.2 of the [EDRs](http://portal.etsi.org/Help/editHelp!/Howtostart/ETSIDraftingRules.aspx).

*Equation numbering*

*If it is necessary to number some or all of the formulae in an ETSI deliverable in order to facilitate cross‑referencing, Arabic numbers in parentheses shall be used, beginning with 1:*

*EXAMPLE 1:*

*x2 + y2 < z2 (style EQ)* (1)

*Equations may be numbered sequentially throughout the ETSI deliverable without regard to the clause numbering, e.g. first equation is equation 1 and the twentieth equation is equation 20.*

*Equations may also be numbered taking account of clause numbering.*

*EXAMPLE 2: First equation in clause 5 is equation 5.1, second equation in clause 5.1.1 is equation 5.2, third equation in clause 5.2.3 is equation 5.3.*

*EXAMPLE 3: First equation in clause 7.3.2 is equation 7.3.2.1, fifth equation in clause 7.3.2 is equation 7.3.2.5.*

*Equations of an annex shall be preceded by the letter designating that annex followed by a full-stop (e.g. table B.1, table C.4.1.1). The numbering shall start afresh with each annex.*

*Supplementary files*

*If supplementary files accompany an ETSI deliverable, it is necessary to indicate where the files are made available. Here below, two example sentences:*

*EXAMPLE 1:*

The supplementary files, relating to the present document, are located at <https://forge.etsi.org/rep/mec/>gs012-rnis-api.

*EXAMPLE 2:*

The TTCN-3 code corresponding to the ATS is contained in archive ts\_10262403v010101p0.zip which accompanies the present document.

*More details are available at "News from edithelp!" on* [*editHelp!*](https://portal.etsi.org/Services/editHelp/How-to-start/ETSI-Drafting-News) *website.*

## 4.1 User defined subdivisions of clause(s) from here onwards *(style H2)*

<Text>.

Annexes

*Each annex* ***shall:***

* *start on a new page (insert a page break between annexes A and B, annexes B and C, etc.).*
* *be designated by a heading comprising the word "Annex" followed by a capital letter designating its serial order, beginning with "A".*
* *have its heading followed by the indication "(normative):" or "(informative):", and by the title on the next line.*

*[ETSI Drafting Rules (EDRs)](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx), clause 2.13.*

*Numbers given to the clauses, tables, figures and mathematical formulae of an annex shall be preceded by the letter designating that annex followed by a full-stop. The numbering* ***shall start afresh with each annex****. A single annex shall be designated "Annex A".*

*Clauses in annex A shall be designated "A.1", "A.2", "A.3", etc. (further details in clause 2.12.1 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*).*

* Use the **Heading 9** style. Insert a line break ("shift" +  "enter") between the colon and the title.
* For all annex clause headings use the appropriate Heading styles, starting from **Heading 1,** e.g. for clause A.1 use **Heading 1**, for clause A.1.1 use **Heading 2**. ("ETSI Styles" are available on the[*editHelp!*](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles/Styleslistingtable.aspx) website).

*EXAMPLE:*

<PAGE BREAK>

Annex A:  
Title of annex *(style H9)*

<Text>.

<PAGE BREAK>

Annex B:  
Title of annex *(style H9)*

# B.1 First clause of the annex *(style H1)*

## B.1.1 First subdivided clause of the annex *(style H2)*

<Text>.

<PAGE BREAK>

Annex <L>:  
Bibliography *(style H9)*

*The "Bibliography" annex identifies additional reading material not mentioned anywhere in an ETSI deliverable including annexes. These publications might or might not be publicly available (no check is made by the Secretariat).*

*The Bibliography* ***shall include*** *a list of standards, books, articles, or other sources on a particular subject which are not* *cited anywhere in an ETSI deliverable including annexes.*

*The Bibliography* ***shall not include****documents listed in clauses 2.1 and 2.2.*

*[ETSI Drafting Rules](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)* [(](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*[EDRs)](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx), clause 2.14.*

* Use **Heading 9** style for the "Bibliography" annex, see clause 2.13 for examples.
* For the listed material use the **Normal** style or bulleted lists (e.g. **B1+**), do not use numbered references.

*EXAMPLE 1:*

*<*Publication*>*:"*<*Title*>".<*Edition*>*. *<*Year*>*, *<*Issue designation*>*, *<*Page location*>*. *(style Normal)*

WEAVER, William. "Command performances". December 1985, vol. 42, n° 12, p. 126-133). *(style Normal)*

*EXAMPLE 2:*

* <Publication>: "<Title>". *(style B1+)*
* ETSI EN 300 066: "ElectroMagnetic Compatibility and Radio Spectrum Matters (ERM); Float-free maritime satellite Emergency Position Indicating Radio Beacons (EPIRBs) operating in the 406,0 MHz to 406,1 MHz frequency band; Technical characteristics and methods of measurement". *(style B1+)*

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Annex <L+1>:  
Change History *(style H9)*

*The "Change history/Change request (history)" is an optional informative element.*

*The "Change history/Change request (history)" annex, if present, describes the list of changes implemented in a new version of the ETSI deliverable. It shall be presented as a table.*

*"ETSI styles" for tables are available in* [*editHelp!*](https://portal.etsi.org/Services/editHelp!/Standardsdevelopment/Drafting/Styles/Styleslistingtable.aspx) *website.*

| Date | Version | Information about changes |
| --- | --- | --- |
| October 2011 | 1.1.1 | First publication of the TR after approval by TC SPAN at SPAN#19 (30 September - 2 October 2011; Prague) |
| February 2012 | 1.2.1 | Implemented Change Requests:  SPAN(12)20\_019 Error message information clarifications  SPAN(12)20\_033 Revised error message information  SPAN(12)20\_046 update of figure 3 clause 9.2  These CRs were approved by TC SPAN#20 (3 - 5 February 2012; Sophia)  Version 1.2.1 prepared by the Rapporteur |
| July 2013 | 1.3.1 | Implemented Changes:  Correction needed because the previously approved version did not contain the last version of the ASN.1 and XML attachments.  Version 1.3.1 prepared by the Rapporteur |

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# History *(style H1)*

*The "History" clause shall start on a new page and be the final unnumbered clause of an ETSI deliverable.*

*History shall be prepared in accordance to clause 2.16 of the* [*EDRs*](https://portal.etsi.org/Services/editHelp!/Howtostart/ETSIDraftingRules.aspx)*.*

Use **Heading 1** style for the title.

|  |  |  |
| --- | --- | --- |
| **Document history** | | |
| <Version> | <Date> | <Milestone> |
| 0.0.2 | 11/06/2020 | fusion AFI MTS |
|  |  |  |
|  |  |  |
|  |  |  |

A few examples:

|  |  |  |
| --- | --- | --- |
| **Document history** | | |
| V1.1.1 | April 2017 | Publication |
| V1.3.1 | June 2018 | Pre-Processing done before TB approval e-mail: <mailto:edithelp@etsi.org> |
| V2.0.0 | March 2018 | Clean-up done by ***editHelp!*** e-mail: <mailto:edithelp@etsi.org> |
|  |  |  |
|  |  |  |

*Last update 2019-11-14*