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Core Network and Interoperability Testing (INT);

Artificial Intelligence (AI) in Test Systems and
Testing of AI Models;

Use and Benefits of AI Technologies in Testing

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**TECHNICAL REPORT**

***ETSI***

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# Foreword

This Technical Report (TR) has been produced in collaboration by the ETSI Technical Committees Core Network and Interoperability Testing (INT) and Methods for Testing and Specification (MTS).

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*Main drivers to clauses and sub-clauses given in brackets below. Everyone works on his own document stored under Contributions folder on the website. Mature text will be integrated into the main document after discussion. Contributions are coordinated through the mailing list, triggered by the responsible persons.*

# 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](https://portal.etsi.org/Services/editHelp%21/Howtostart/ETSIDraftingRules.aspx) (Verbal forms for the expression of provisions).

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# Executive summary

*Why this TR? Covered area and relation to other activities outside ETSI.*

# Introduction

# 1 Scope

The present document …

# 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] <Standard Organization acronym> <document number><version number/date of publication>: "<Title>".

[i.2] etc.

# 3 Definition of terms, symbols and abbreviations

## 3.1 Terms

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

*AI… artificial intelligence*

*ML… supervised/unsupervised/semi-supervised machine learning, reinforcement learning*

*Testing, validation, verification, V&V…*

## 3.2 Symbols

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

## 3.3 Abbreviations

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

# 4 Benefits that AI/ML brings to stakeholders in testing [Tayeb, Muslim]

*Discussion of their business cases*

## 4.1 Test engineers [MTS: Andreas]

## 4.2 Test solution providers [MTS: György]

## 4.3 Communication Service Providers (CSPs) [INT: Tayeb, Muslim]

## 4.4 Network Infrastructure and Software Suppliers [INT: Ranganai, Benoit]

# 5 AI/ML technologies applied to software testing

*Reflects current (known) state of practice; discusses various AI/ML technologies and their known application for software testing types and testing activities.*

## 5.1 Test derivation in functional testing [Martin]

*AI for test derivation, e.g. evolutionary testing and further search-based testing techniques, intelligent concolic testing to reach code coverage*

## 5.2 Selection of regression test cases [Philip]

*AI enabled selection of regression test cases*

## 5.3 Test execution [Andreas]

*What is the benefit of AI with respect to e.g. GUI object recognition in automated GUI testing, shorten test execution time etc.*

## 5.4 Test result analysis and fault localisation [Tayeb, Benoit]

*AI applied here to faults from functional testing; , filtering false positives and true negatives via precision and recall*

## 5.5 Performance Testing [Ranganai]

*Load generation; QoS classification of test results*

## 5.6 Reliability testing [Benoit]

*Anomaly detection through neural networks (autoencoder) and other statistics;*

## 5.7 Security testing [Martin]

*Intelligent fuzzing*

## 5.8 Online testing and TestOps [Ranganai, Tayeb]

*Reinforcement learning; model inference and learning-based testing; predictive runtime verification through AI, e.g. predictions via Bayesian networks*

*Rhode&Schwarz and Spirent, Sigos (Shicheng Hu) reported on online testing in the AI Test White Paper.*

## 5.9 Test management [Andreas (1), Tayeb (2)]

*NLP processing of requirements and test case descriptions written in natural language; efforts estimation for automating tests; risks estimation of submitted code changes;
Two different aspects: (1) supporting the test manager selecting test cases and checking test execution results; (2) process-oriented management: who takes responsible for failed tests if AI in involved and other questions, discussion of trustworthiness of test results (trust, explainability, traceability)*

# 6 AI/ML empowered test technologies applied in test phases

*Discusses which AI technologies introduced in clause 5 can be applied best in which test phase. How could each test phase benefit from AI and with which AI technology?*

## 6.1 Unit testing [Philip]

*At source code level*

## 6.2 Integration testing [Finn]

*Includes testing of network slices, e.g. 5G PoC is running at INT*

## 6.3 System testing [Muslim]

*Could be also testing of a larger sub-system or even testing in context of a system of systems*

## 6.4 Certification testing [Tayeb]

*Includes conformance/interop testing*

# 7 Application cases of AI/ML in testing

*Considered application cases of AI test technologies (initial proposal, list can change depending on available content); each bullet point shall be evaluated in a sub-clause:*

* *Network protocols, Web services*
* *AI enabled components (e.g. image recogniser, optimiser, NLP component); if we want to have it here, otherwise covered in TR2*
* *Cyber-physical systems and real-time systems*
* *Autonomous and self-adaptive systems [INT]*
* *Multi-agent systems; maybe also better covered in TR2*
* *Systems of systems*
* *Business information systems*

*Kept open until clauses 5 and 6 are filled.*

## 7.1 Network protocols and Web services testing

*Discusses which AI empowered test technologies (introduced in the previous clause) can be applied to test network* *protocols or web services.*

## 7.2 Further sub-clauses according to the above list of application cases…

# 8 Landscape on the use of AI in testing [Tayeb]

*EU whitepaper, activities of other SDOs; overview only; relate above sections to other initiatives elsewhere*

# 9 Outlook [Andreas]

*Summary of recent trends and a look into the future*

Annex:
Bibliography

Annex:
Change History

| Date | Version | Information about changes |
| --- | --- | --- |
| <Month year> | <#> | <Changes made are listed in this cell> |
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