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| 3GPP TR 38.843 V0.0.0 (2022-05) |
| Technical Report |
| 3rd Generation Partnership Project;Technical Specification Group Radio Access Networks;Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR air interface(Release 18) |
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For definitive guidance on drafting 3GPP TSs and TRs, see [3GPP TS 21.801](http://www.3gpp.org/DynaReport/21801.htm) supplemented by the 3GPP web page <http://www.3gpp.org/specifications-groups/delegates-corner/writing-a-new-spec>.

Ensure all blue guidance text is removed before submitting the TS/TR to the TSG for approval.

# Foreword

This clause is mandatory; do not alter the text in any way other than to choose between "Specification" and "Report".

This Technical Specification|Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In drafting the TS/TR, pay particular attention to the use of modal auxiliary verbs! TRs shall not contain any normative provisions.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# Introduction

This clause is optional. If it exists, it shall be the second unnumbered clause.

# 1 Scope

This clause shall start on a new page.

The present document …

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] RP-213599: “New SI: Study on Artificial Intelligence (AI)/Machine Learning (ML) for NR Air Interface”, Qualcomm (Moderator).

…

[x] <doctype> <#>[ ([up to and including]{yyyy[-mm]|V<a[.b[.c]]>}[onwards])]: "<Title>".

It is preferred that the reference to 21.905 be the first in the list.

# 3 Definitions of terms, symbols and abbreviations

This clause and its three subclauses are mandatory. The contents shall be shown as "void" if the TS/TR does not define any terms, symbols, or abbreviations.

## 3.1 Terms

For the purposes of the present document, the terms given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

Definition format (Normal)

**<defined term>:** <definition>.

**example:** text used to clarify abstract rules by applying them literally.

## 3.2 Symbols

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

Symbol format (EW)

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

AI Artificial Intelligence

BM Beam Management

CSI Channel State Information

KPI Key Performance Indicator

LCM Life Cycle Management

ML Machine Learning

# 4 General AI/ML Framework

The purpose of this section is to identify common notation and terminology for AI/ML related functions, procedures and interfaces.

Note: the work done for FS\_NR\_ENDC\_data\_collect is considered when appropriate.

## 4.1 Description of the stages of Machine Learning

In this section, the defining stages of AI/ML related algorithms and associated complexity are characterized, namely:

* Model generation, e.g., model training (including input/output, pre-/post-process, online/offline as applicable), model validation, model testing, as applicable
* Inference operation, e.g., input/output, pre-/post-process, as applicable

In addition, the treatment of dataset(s) for training, validation, testing, and inference is documented.

## 4.2 Collaboration levels

In this section, various levels of collaboration between UE and gNB are identified as found pertinent to the selected use cases, e.g.,

* No collaboration: implementation-based only AI/ML algorithms without information exchange [for comparison purposes]
* Various levels of UE/gNB collaboration targeting at separate or joint ML operation

## 4.3 ML model Life Cycle Management

In this section, the lifecycle management of AI/ML model is characterized, e.g., model training, model deployment, model inference, model monitoring, model updating.

# 5 Use cases

Initial set of use cases includes:

* CSI feedback enhancement, e.g., overhead reduction, improved accuracy, prediction [RAN1]
* Beam management, e.g., beam prediction in time, and/or spatial domain for overhead and latency reduction, beam selection accuracy improvement [RAN1]
* Positioning accuracy enhancements for different scenarios including, e.g., those with heavy NLOS conditions [RAN1]

Finalize representative sub use cases for each use case for characterization and baseline performance evaluations by RAN#98

* The AI/ML approaches for the selected sub use cases need to be diverse enough to support various requirements on the gNB-UE collaboration levels

Note: the selection of use cases for this study solely targets the formulation of a framework to apply AI/ML to the air-interface for these and other use cases. The selection itself does not intend to provide any indication of the prospects of any future normative project.

## 5.1 CSI feedback enhancement

### ~~5.1.1 Description~~

### ~~5.1.2 KPIs~~

## 5.2 Beam Management

### ~~5.2.1 Description~~

### ~~5.2.2 KPIs~~

## 5.3 Positioning accuracy enhancements

### ~~5.3.1 Description~~

### ~~5.3.2 KPIs~~

# 6 Evaluations

In this section, performance benefits of AI/ML based algorithms for the agreed use cases in the final representative set are evaluated:

The evaluation methodology is based on statistical models (from TR 38.901 and TR 38.857 [positioning]), for link and system level simulations.

* Extensions of 3GPP evaluation methodology for better suitability to AI/ML based techniques should be considered as needed.
* Whether field data are optionally needed to further assess the performance and robustness in real-world environments should be discussed as part of the study.
* Need for common assumptions in dataset construction for training, validation and test for the selected use cases.
* Consider adequate model training strategy, collaboration levels and associated implications
* Consider agreed-upon base AI model(s) for calibration
* AI model description and training methodology used for evaluation should be reported for information and cross-checking purposes

Common KPIs and corresponding requirements for the AI/ML operations are to be determined. Also, use-case specific KPIs and benchmarks of the selected use-cases are to be determined.

* Performance, inference latency and computational complexity of AI/ML based algorithms should be compared to that of a state-of-the-art baseline
* Overhead, power consumption (including computational), memory storage, and hardware requirements (including for given processing delays) associated with enabling respective AI/ML scheme, as well as generalization capability should be considered.

## 6.1 Common evaluation methodology and KPIs

## 6.2 CSI feedback enhancement

### 6.2.1 Evaluation assumptions, methodology and KPIs

### 6.2.2 Performance results

## 6.3 Beam Management

### 6.3.1 Evaluation assumptions, methodology and KPIs

### 6.3.2 Performance results

## 6.4 Positioning accuracy enhancements

### 6.4.1 Evaluation assumptions, methodology and KPIs

### 6.4.2 Performance results

# 7 Potential Specification Impact Assessment

## 7.1 General observations

[Editor’s note: this section is meant to capture general observations on specification impact considering possibly, different timelines (e.g, short-term vs. long-term)]

## 7.2 Physical layer aspects

In this section, aspects related to, e.g., the potential specification of the AI Model lifecycle management, and dataset construction for training, validation and test for the selected use cases are considered.

In addition, use case and collaboration level specific specification impact is documented, such as new signalling, means for training and validation data assistance, assistance information, measurement, and feedback.

### 7.2.1 Common framework

### 7.2.2 CSI feedback enhancement

### 7.2.3 Beam management

### 7.2.4 Positioning accuracy enhancements

## 7.3 Protocol aspects

In this section, aspects related to, e.g., capability indication, configuration and control procedures (training/inference), and management of data and AI/ML model, per RAN1 input, are considered.

In addition, collaboration level specific specification impact per use case is documented.

### 7.3.1 Common framework

### 7.3.2 CSI feedback enhancement

### 7.3.3 Beam management

### 7.3.4 Positioning accuracy enhancements

## 7.4 Interoperability and testability aspects

In this section, requirements and testing frameworks to validate AI/ML based performance enhancements and ensuring that UE and gNB with AI/ML meet or exceed the existing minimum requirements, if applicable, are documented.

The need and implications for AI/ML processing capabilities definition is considered.

### 7.4.1 Common framework

### 7.4.2 CSI feedback enhancement

### 7.4.3 Beam management

### 7.4.4 Positioning accuracy enhancements

# 8 Conclusions

[Editor’s note: conclusions may include recommendations for subsequent WI(s).]

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Annex <X> :
Change history

Use style "Heading 8" in TSs and "Heading 9" in TRs. Do not use "informative" in the title in TRs.

This is the last annex for TS/TSs which details the change history using the following table.
This table is to be used for recording progress during the WG drafting process till TSG approval of this TS/TR.
For TRs under change control, use one line per approved Change Request
Date: use format YYYY-MM
CR: four digits, leading zeros as necessary
Rev: blank, or number (max two digits)
Cat: use one of the letters A, B, C, D, F
Subject/Comment: for TSs under change control, include full text of the subject field of the Change Request cover
New vers: use format [n]n.[n]n.[n]n

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| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-05 | RAN1#109e |  |  |  |  | TR skeleton | 0.0.0 |