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**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.

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# 1 Scope

The present document specifies the MDA capabilities with corresponding analytics inputs and analytics outputs (reports), as well as processes and requirements for MDAS (Management Data Analytics Service), historical data handling for MDA, and ML support for MDA.

The present document also describes the MDA functionality and service framework, and MDA role in the management loop.

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# 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] Void
- [3] 3GPP TS 28.535: "Management and orchestration; Management services for communication service assurance; Requirements".
- [4] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".
- [5] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".
- [6] 3GPP TS 32.422: "Telecommunication management; Subscriber and equipment trace; Trace control and configuration management".
- [7] 3GPP TS 32.423: "Telecommunication management; Subscriber and equipment trace; Trace data definition and management".
- [8] 3GPP TS 28.405: "Telecommunication management; Quality of Experience (QoE) measurement collection; Control and configuration".
- [9] 3GPP TS 28.406: "Telecommunication management; Quality of Experience (QoE) measurement collection; Information definition and transport".
- [10] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".
- [11] 3GPP TS 28.532: "Management and orchestration; Generic management services".
- [12] 3GPP TS 32.425: "Telecommunication management; Performance Management (PM); Performance measurements Evolved Universal Terrestrial Radio Access Network (E-UTRAN)".
- [13] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification".
- [14] 3GPP TS 23.273: "5G System (5GS) Location Services (LCS); Stage 2".
- [15] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

- [16] 3GPP TS 28.658: "Telecommunication management; Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [17] 3GPP TS 28.662: "Telecommunication management; Generic Radio Access Network (RAN) Network Resource Model (NRM); Information Service (IS)".
- [18] 3GPP TS 32.156: "Telecommunication management; Fixed Mobile Convergence (FMC) Model Repertoire".
- [19] 3GPP TS 28.622: "Telecommunication management; Generic Network Resource Model (NRM) Integration Reference Point (IRP); Information Service (IS)".
- [20] 3GPP TS 28.511: "Telecommunication management; Configuration Management (CM) for mobile networks that include virtualized network functions; Procedures".
- [21] 3GPP TS 28.531: "Management and orchestration; Provisioning".
- [22] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".
- [23] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".
- [24] 3GPP TS 28.105: "Management and orchestration; Artificial Intelligence/Machine Learning (AI/ML) management".
- [25] 3GPP TS 32.160: "Management and orchestration; Management service template".
- [26] ETSI GS NFV-IFA 011 (V3.3.1): "Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; VNF Descriptor and Packaging Specification".
- [27] Recommendation ITU-T X.733: "Information technology - Open Systems Interconnection - Systems Management: Alarm reporting function".

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## 3 Definitions of terms, symbols and abbreviations

### 3.1 Terms

For the purposes of the present document, the terms given in 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 TR 21.905 [1].

**MDA capability:** analytics capability corresponding to analytics of a set of analytics input data to provide analytics output data

**MDA Type:** type of analytics corresponding to specific MDA capability

### 3.2 Symbols

Void

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 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 TR 21.905 [1].

|         |                                    |
|---------|------------------------------------|
| AI      | Artificial Intelligence            |
| CHO     | Conditional Handover               |
| DAPS    | Dual Active Protocol Stack         |
| MDA MnS | MDA Management service             |
| MDA     | Management Data Analytics          |
| MDAF    | Management Data Analytics Function |
| MDAS    | Management Data Analytics Service  |
| ML      | Machine Learning                   |

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# 4 Concepts and overview

## 4.1 Overview

Management Data Analytics (MDA), as a key enabler of automation and intelligence, is considered a foundational capability for mobile networks and services management and orchestration.

The MDA provides a capability of processing and analysing data related to network and service events and status including e.g. performance measurements, KPIs, Trace/MDT/RLF/RCEF reports, QoE reports, alarms, configuration data, network analytics data, and service experience data from AFs, etc. to provide analytics output, i.e. statistics or predictions, root cause analysis issues, and may also include recommendations to enable necessary actions for network and service operations. The MDA output is provided by the MDAS (Management Data analytics Service) producer to the corresponding consumer(s) that requested the analytics.

The MDA can identify ongoing issues impacting the performance of the network and services, and help to identify in advance potential issues that may cause potential failure and/or performance degradation. The MDA can also assist to predict the network and service demand to enable the timely resource provisioning and deployments which would allow fast time-to-market network and service deployments.

Management Data Analytics Service (MDAS), the services exposed by the MDA, can be consumed by various consumers, including for instance MnFs (i.e. MnS producers/consumers for network and service management), NFs (e.g. NWDAF), SON functions, network and service optimization tools/functions, SLS assurance functions, human operators, and AFs, etc.

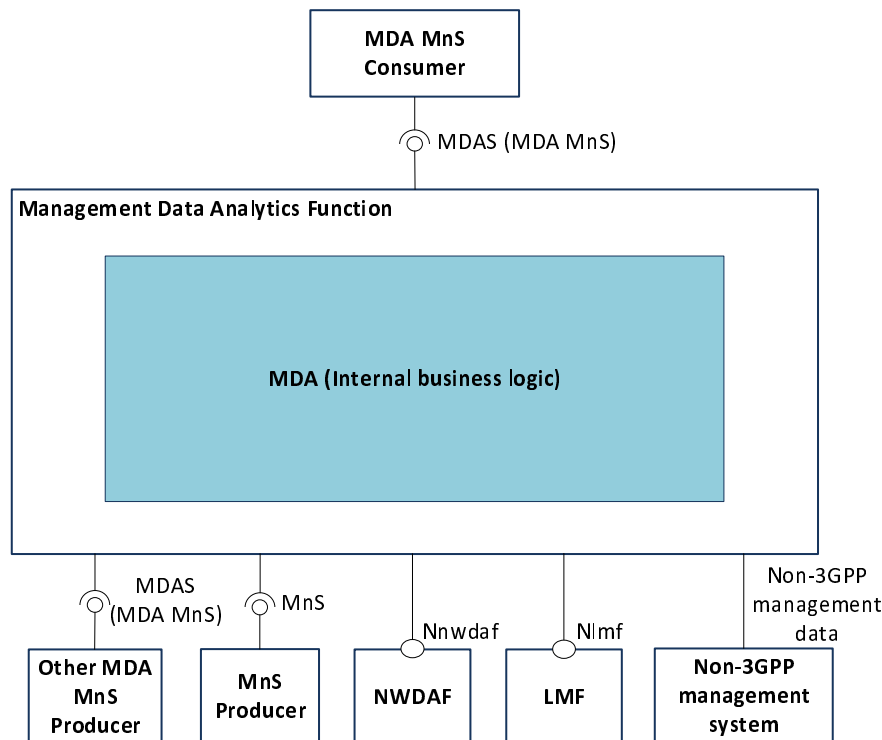
NOTE: Throughout the present document the terms, MDAS and MDA MnS are equivalent and may be used interchangeably.

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# 5 MDA functionality and service framework

## 5.1 General framework

MDA MnS (also referred to as MDAS) in the context of SBMA enables any authorized consumer to request and receive analytics as illustrated in Figure 5.1-1.



**Figure 5.1-1: MDA functional overview and service framework**

A management function (MDAF) may play the roles of MDA MnS producer, MDA MnS consumer, other MnS consumer, NWDAF consumer and LMF service consumer, and may also interact with other non-3GPP management systems.

The internal business logic related to MDA leverages the current and historical data related to:

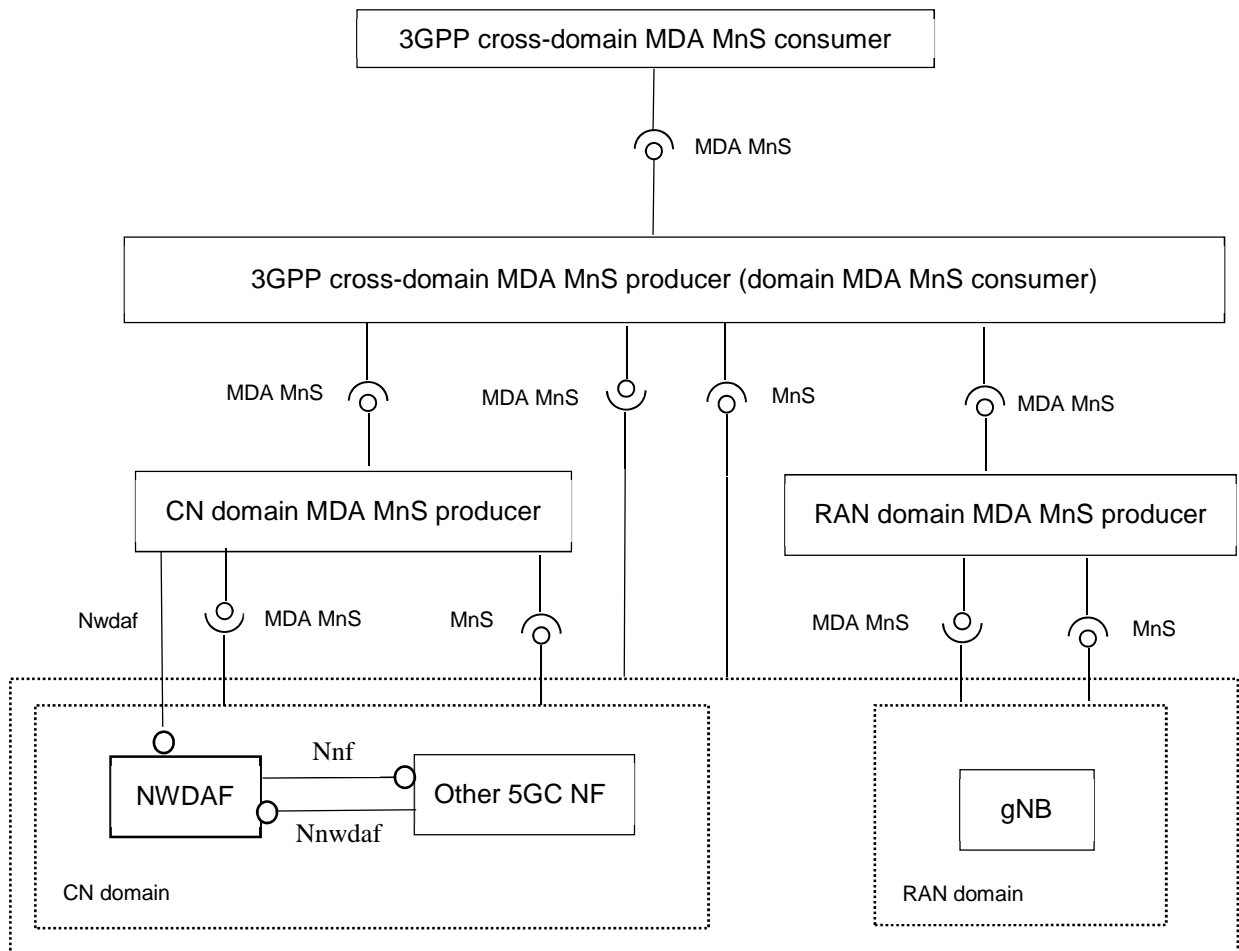
- Performance Measurements (PM) as per TS 28.552 [4] and Key Performance Indicators (KPIs) as per TS 28.554 [5].
- Trace data, including MDT/RLF/RCEF, as per TS 32.422 [6] and TS 32.423 [7].
- QoE and service experience data as per TS 28.405 [8] and TS 28.406 [9].
- Analytics data offered by NWDAF as per TS 23.288 [10] including 5GC data and external web/app-based information (e.g. web crawler that provides online news) from AF.
- Alarm information and notifications as per TS 28.532 [11].
- CM information and notifications.
- UE location information provided by LMF as per TS 23.273 [14].
- MDA reports from other MDA MnS producers.
- Management data from non-3GPP systems.

Analytics output from the MDA internal business logic are made available by the management functions (MDAFs) playing the role of MDA MnS producers to the authorized consumers, (including but not limited to other management functions, network functions/entities, NWDAF, SON functions, optimization tools and human operators).

## 5.2 Interaction with CN and RAN domains

The MDA MnS producer provides analytics data for management purposes based on input data related to different types of NFs or entities in the network, e.g. data reported from gNB and/or specific core network function(s). Depending on the use case and when needed, the MDA MnS producer may use the analytics results produced by NWDAF as input.

Management Data Analytics Function (MDAF) may act as 3GPP domain-specific (e.g. RAN or CN) or as 3GPP cross-domain MDA MnS producer. Figure 5.2-1 illustrates the example of coordination between NWDAF, gNB and MDA MnS producer(s) for data analytics purpose.



**Figure 5.2-1: Example of coordination between NWDAF, gNB and MDAS (MDA MnS) producer**

Any authorized MnS consumers get access to MDA reports by interacting with MDA MnS producers. These scenarios include but are not limited to the following:

- The NWDAF, leveraging MDA reports (e.g. for control purposes and other 5GC NFs), interacts with MDA MnS producers.
- The gNB may consume the MDA MnS for RAN control purpose.
- The 3GPP cross domain MDA MnS Producer may consume (acting as Domain MDA MnS consumer) MDA MnS provided by domain-specific (RAN and/or CN) MDA MnS producer(s) and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of domain MDA MnS producer may interact with 5GC and RAN MnSs and NFs to receive analytics inputs per MDA capability, including:

- The CN Domain MDA MnS producer may consume the service provided by NWDAF and other 5GC NFs for MDA purpose.
- The RAN Domain MDA MnS producer may consume the MnS provided by/for gNB for MDA purpose.

The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer consumes 5GC domain MDA, RAN domain MDA, 5GC MnS and RAN MnS to receive analytics inputs per each MDA use case/capability including:

- The cross domain MDA MnS producer may consume the MDA MnS provided by RAN and/or CN domains.



- The cross domain MDA MnS producer may consume MnS provided by RAN and/or CN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

### 5.3 Deployment of multiple MDAs

Multiple MDA instances may be deployed according to deployment needs.

The 3GPP cross domain management may consume MDA MnS provided by core network management as shown in Figure 5.3-1.

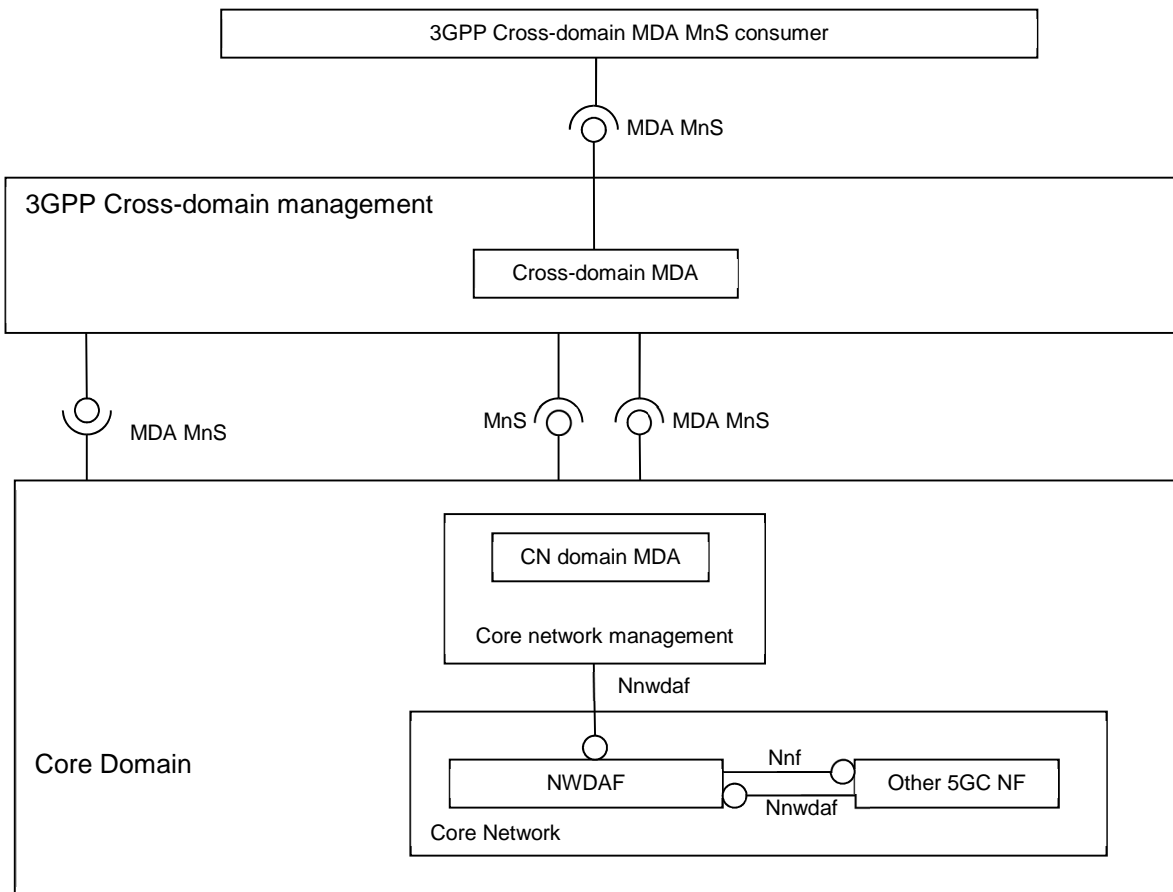


Figure 5.3-1

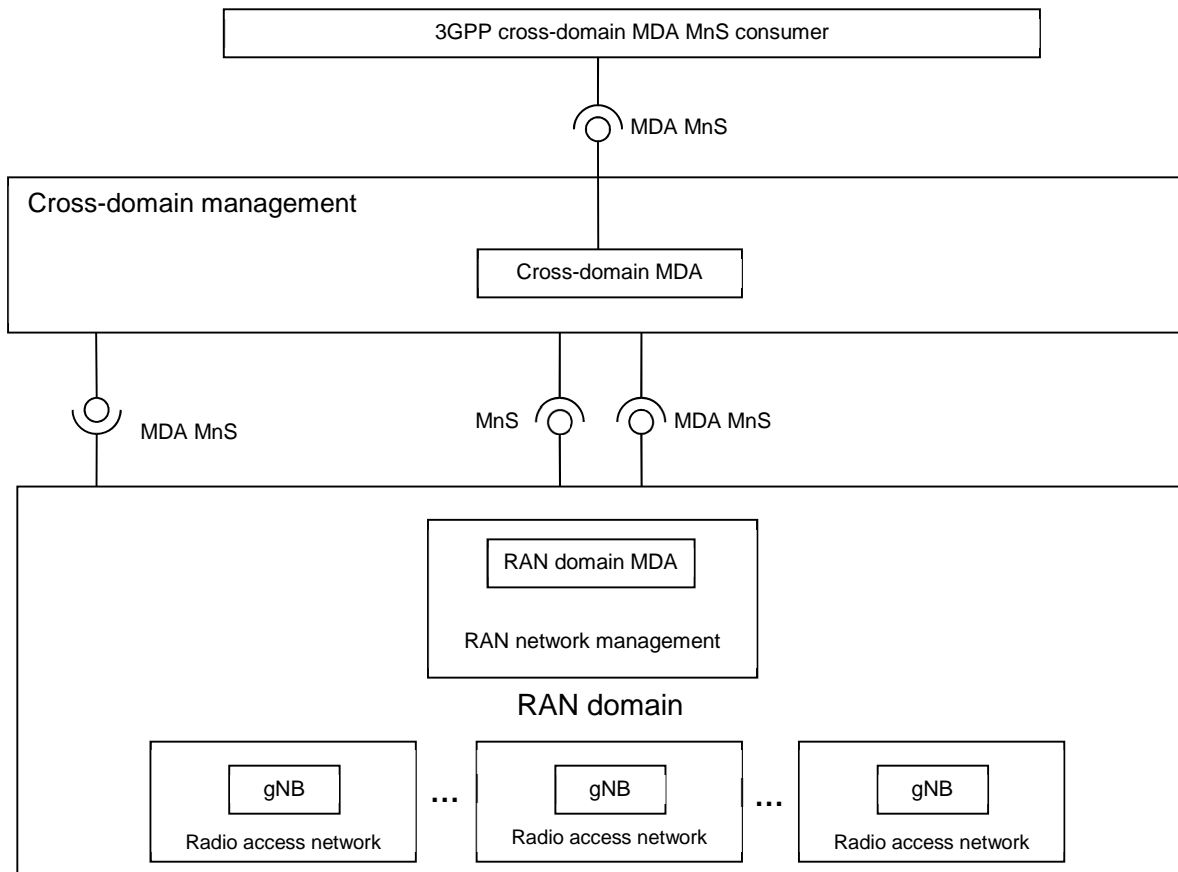
The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer interacts with CN domain MDA per each MDA use case/capability as follows:

- The cross-domain MDA MnS producer may consume the CN domain MDA MnS.
- The cross-domain MDA MnS producer may consume MnS provided by CN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of CN domain MDA MnS producer interacts with MnS producers per each use case/capability as follows:

- The CN domain MDA MnS producer may consume analytics results produced by NWDAF, MnS provided by CN domain management, other MDA MnS producers, management data derived by subnetwork management function(s), and management data derived by element management function(s).

The 3GPP cross domain management may consume MDA MnS provided by RAN management as shown in Figure 5.3-2.



**Figure 5.3-2: Example of coordination cross-domain MDA and RAN domain MDA**

The management function (MDAF) playing the role of 3GPP cross domain MDA MnS producer interacts with RAN domain MDA per each MDA use case/capability as follows:

- The cross domain MDA MnS producer may consume the RAN domain MDA MnS.
- The cross domain MDA MnS producer may consume MnS provided by RAN domains, and produce MDA MnS that may be consumed by 3GPP cross-domain MDA MnS consumer(s).

The management function (MDAF) playing the role of RAN domain MDA MnS producer interacts with MnS producers per each use case/capability as follows:

- The RAN domain MDA MnS producer may consume MnS provided by RAN domain management, other MDA MnS producers, management data derived by subnetwork management function(s), and management data derived by element management function(s).

## 5.4 Network Context

An MDA MnS producer provides analytics with respect to a particular network context, i.e. network status, under which data is collected to produce analytics. For example, a prediction of load in an area of interest may differ when all gNBs and potential additional RATs are operating compared to case where certain gNBs or other RATs are experiencing a fault or are powered off to save energy. The analytics conducted and produced by the MDA MnS producer for these two example scenarios would be different and directly affected by the specific status of network. Although the network status (context) affects the produced analytics conducted by the MDA producer, awareness of the network context would fall on the consumer side to complement the obtained analytics results. This network context, reflecting network status at the time of enabling data collection, is important for the MDA MnS consumer to understand the network conditions related to the obtained analytics and hence be able to use such analytics more efficiently.

The MDA MnS consumer cannot expect the MDA producer to provide the network context, because the network context interest of each MDA MnS consumer may differ depending on the usage and purpose of analytics. The usage can include a proprietary algorithm that assist a decision-making process. For example, a load balancing algorithm may require the load and mobility information among neighbouring gNB whereas other load balancing algorithms may also require load and mobility information from a greater geographical area.

In addition, the selection of the parameters and their combinations may prove to be impractical for the MDA MnS producer to prepare and provide. Hence, it is efficient for the MDA MnS producer to prepare only the MDA output without including any network context and allow the MDA MnS consumer to obtain the required network context, to complement the obtained analytics, using conventional configuration management procedures as described in TS 28.511 [20] and TS 28.531 [21].

## 5.5 Historical data handling for MDA

Historical analytics reports may be saved and retrieved for use at later times by a MDA MnS consumer, and historical analytics input (enabling) data (along with current analytics input data) may be used for analytics by MDA MnS producer. Such a historical data usage may be applicable to both or one of the MDA MnS producer and MDA MnS consumer side.

NOTE: Historical data refers to (a) historical analytics reports that have been produced in the past, and (b) historical analytics input (enabling) data that had been collected in the past.

## 5.6 AI/ML support for MDA

The MDA process may utilize AI/ML technologies. An MDA Function may optionally be deployed as one or more AI/ML-enabled function(s) in which the relevant models are used for inference per the corresponding MDA capability. Specifications for MDA AI/ML model training to enable AI/ML model deployments is given in TS 28.105 [24].

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# 6 MDA in management loop

## 6.1 MDA role in the management loop

Intelligence in Analytics, played by MDA, in the management loop which can be open loop (operator controlled) or closed loop (autonomous) [1] as shown in Figure 6.1-1, generates value by processing and analysis of management and network data, where AI and ML techniques may be utilized (see TS 28.105 [24]).

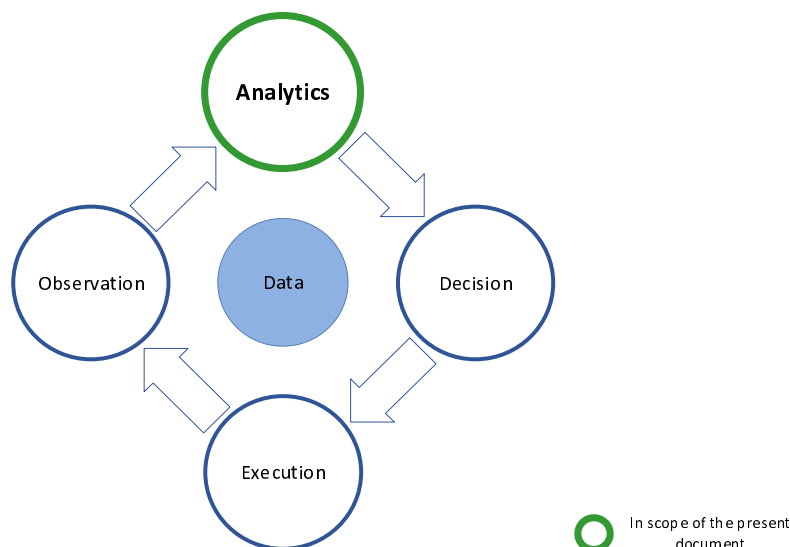


Figure 6.1-1: Analytics in management loop

The management loop constitutes number of elements including the analytics, and these are briefly described below:

**Observation:** The observation of the managed networks and services. It involves monitoring and collection of events, status and performance of the managed networks and services, and providing the observed/collected data.

**Analytics:** The data analytics for the managed networks and services. MDA plays the role of Analytics in the management loop. It prepares, processes and analyses the observed/collected data or time series of the observed/collected data related to the managed networks and services. MDA reports may contain root cause analysis of ongoing issues, predictions of potential issues and corresponding relevant causes and recommended actions for preventions, and/or prediction of network and/or service demands.

**Decision:** The decision making for the management actions for the managed networks and services. The management actions are decided based on the analytics reports (provided by MDA) and other management data (e.g. historical decisions made previously) if necessary. The decision may be made by the consumer of MDAS (in the closed management control loop), or by a human operator (in the case of open management loop). The decision may include e.g. what actions to take, and when to take the actions.

**Execution:** The execution of the management actions according to the decisions. During the execution step, the actions are carried out to the managed networks and services, and the reports (e.g. notifications, logs) of the executed actions are provided.

## 6.2 MDA role in the management loop for service assurance

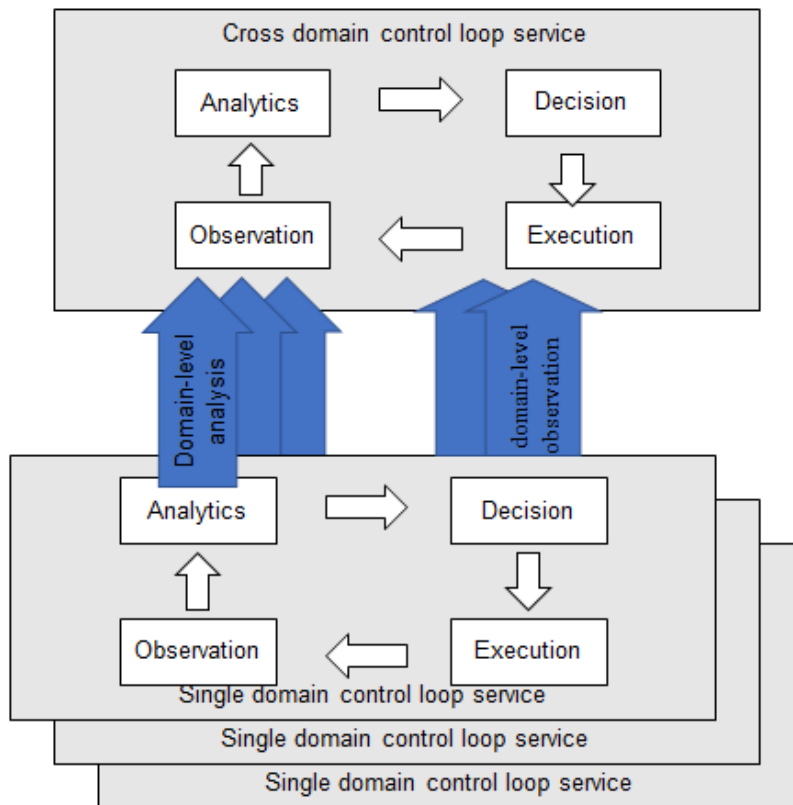
MDA represents Analytics roles in the management control loop for communications service assurance [3]. The management and control of resources used by a communication service and the assurance of this communication service level agreements (e.g. per SLS) is provided by the management control loop involving different management services produced by the management system, which includes management data analytics service (MDAS, or MDA MnS). The MDAS (MDA MnS) may be produced based on a combination of information including e.g. the user quality of service experience, network performance and network resource utilization analysis and the SLS.

The MDAS complements other services in the management loop in order to perform SLS communication service assurance. Prior to operation phase, the MDA role in the management control loop is to prepare, process and analyse the data related to the managed communication service, in order to provide the analytics output (analytics report) which may include prediction and feasibility checks of network resource requirements to meet the SLS.

During the operation phase, the MDA can identify ongoing issues impacting the performance of the communication service per the SLS and identify in advance potential risks that would cause potential failure and/or performance degradation. The MDA can also predict the network and service demand to maintain delivery of communication service per the contracted SLS.

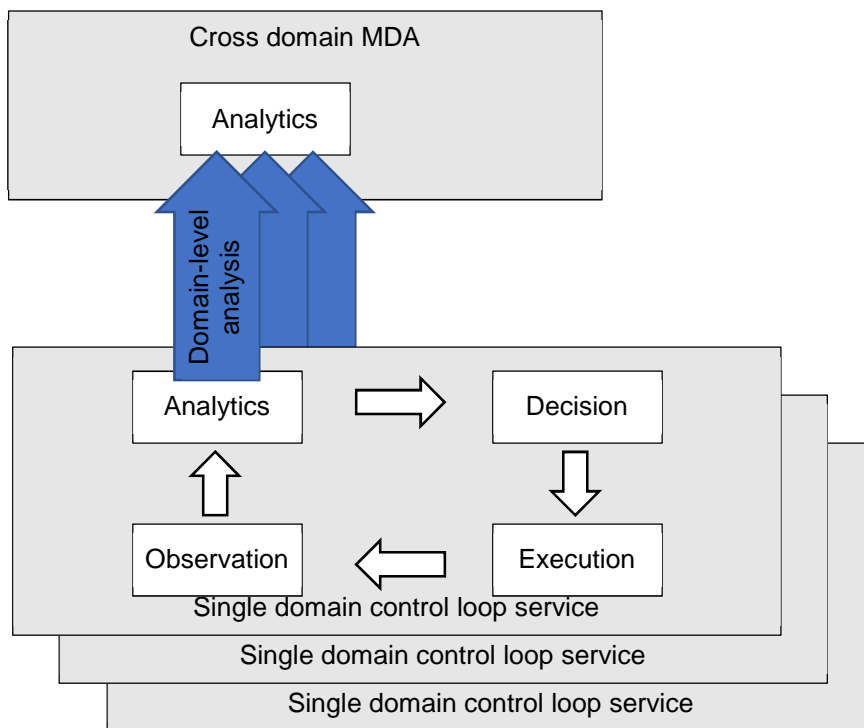
## 6.3 MDA role in cross-domain service assurance

Cross-domain MDA may base its analysis on the outputs from one or multiple single-domain MDA including analytics output and other input data (e.g. PM, alarm notifications, etc.). To facilitate service assurance the cross-domain MDA may adopt output from one or multiple single-domain MDA. Figure 6.3-1 shows the simplest case, where a cross-domain MDA incorporates the results of single-domain MDA(s).



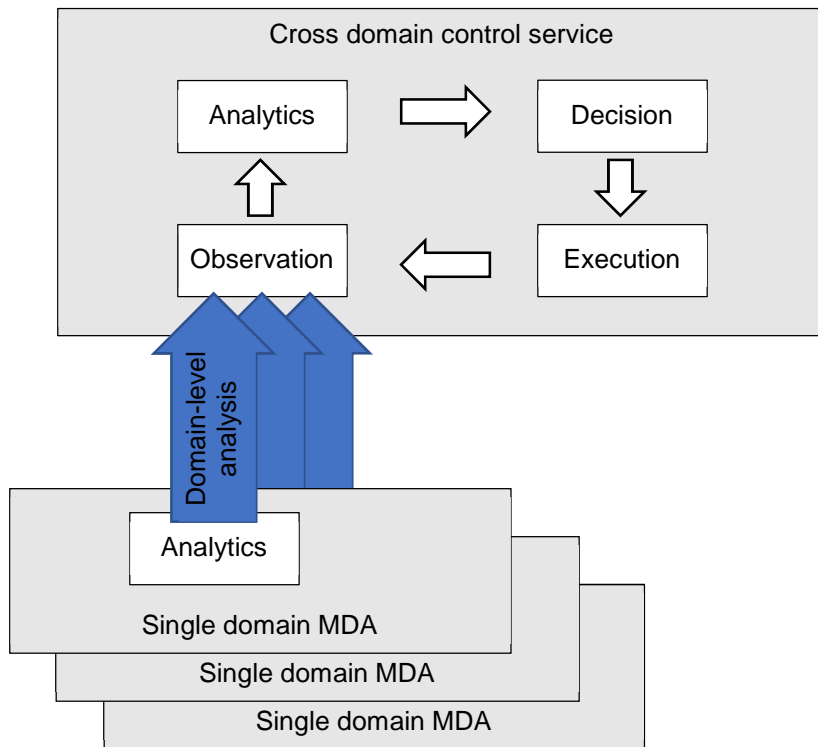
**Figure 6.3-1 Cross-domain MDA based on single-domain MDA**

Figure 6.3-2 shows the case where a cross-domain MDA incorporates the results of single-domain MDA(s) which are embedded within single-domain control loop service(s). Service assurance control loop may be conducted at single-domain bases where MDA role is assumed by analytics. The cross-domain MDA may further leverage the output from one or multiple single-domain control loops for its analytics for the e2e service assurance.



**Figure 6.3-2: Cross-domain MDA based on single-domain control loop service**

Figure 6.3-3 shows the case where a cross-domain MDA is part of a cross-domain control loop service. Also in this case, cross-domain MDA incorporates the results of single-domain MDA(s). Service assurance control loop may be conducted at the cross-domain level in which the MDA role is assumed by analytics. The cross-domain control loop may adopt output from one or multiple single-domain MDA(s) for the e2e service assurance.



**Figure 6.3-3: Cross-domain control loop service based on single-domain MDA(s)**

Figure 6.3-4 shows another case where a cross-domain MDA is part of a cross-domain control service. In this case, cross-domain MDA incorporates the results of single-domain MDA(s) which are embedded within single-domain control loop service(s). Service assurance control loop may be conducted at both levels where MDA role is assumed by analytics, i.e. at the cross-domain and single-domain. The cross-domain MDA may adopt output from one or multiple single-domain MDA(s) for the e2e service assurance.

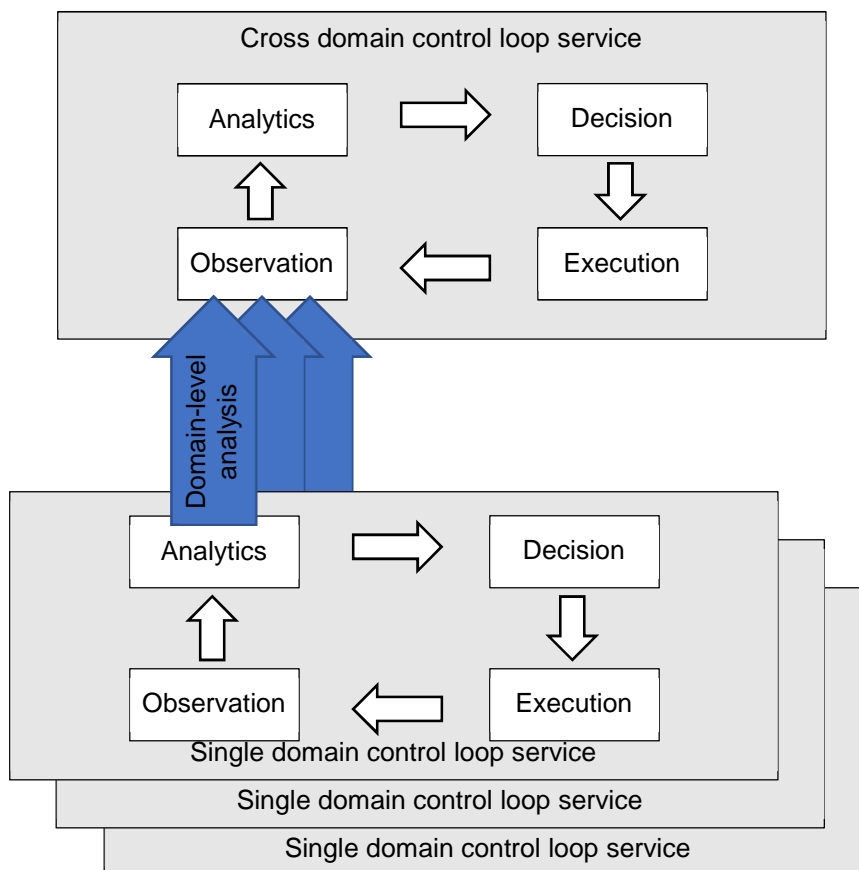


Figure 6.3-4: Cross-domain control loop service based on single-domain control loop service(s)

## 7 Use cases and requirements for MDA capabilities and services

### 7.1 General

The following clauses describe the use cases and requirements for MDA capabilities and MDA MnSs. The MDA capabilities are grouped under specific categories.

### 7.2 MDA capabilities

#### 7.2.1 Coverage related analytics

##### 7.2.1.1 Coverage problem analysis

###### 7.2.1.1.1 Description

This MDA capability is for analysis of coverage related problem.

###### 7.2.1.1.2 Use case

The RAN coverage problem may cause UEs to be out of service or result in a downgrade of network performance offered to the UEs, such as failure of random access, paging, RRC connection establishment or handover, low data throughput, abnormal releases of RRC connection or UE context, and dissatisfied QoE.

There are various types of coverage problems, e.g. weak coverage, a coverage hole, a pilot pollution, an overshoot coverage, or a DL and UL channel coverage mismatch, etc., caused by different sorts of reasons, such as insufficient or weak transmission power, blocked by constructions and/or restricted by terrain.

The 5G related coverage problem may exist in NR, in E-UTRA or both.

To unravel a coverage problem, it is necessary for MDAS consumer to determine the details about when and where the problem occurred or likely to occur, and the type and cause(s) of the problem. Therefore, it is desirable for MDA to correlate and analyze multifold data (such as performance measurements, MDT reports, RLF reports, RCEF reports, UE location reports, together with the geographical, terrain and configuration data of the RAN) to detect and describe the problem with detailed information.

The RAN coverage related problems can cause network performance degradation and in the extreme cases can result into service degradation. So besides identifying the problems after they have happened, it is also necessary to proactively avoid the RAN coverage related problems well before they occur.

To avoid coverage related problems or to proactively undertake actions to avoid their occurrence, the consumer of MDA MnS may wish to know the characteristics and quality of the coverage of the RAN. This may be expressed graphically on a Map, called a Radio Environment Map, that shows the coverage quality for a set of cells. Such a map may be constructed e.g. to show the RSRP or the SINR of the cells as derived from the observed UE performance and/or from radio configuration parameters of the cells including transmit powers, antenna gains, antenna tilts, etc. It is desirable that the MDAS producer can provide the Radio Environment Map in an appropriate graphical form.

Moreover, where a new RAN node is provisioned, the MDAS producer should be able to take into considerations the coverage of existing cells as defined by a Radio Environment Map and derive the configuration of the new cell(s) and the existing cells to optimize the coverage. Image analytics should help to identify the most optimized set of initial radio configurations that can be assigned to a new RAN NE.

To help MDAS consumer to solve the coverage problem as quickly as possible, MDA may also provide, along with the description of the problem, the recommended remedy actions (e.g. reconfigure or add cells, beams, antennas, etc.).

### 7.2.1.1.3 Requirements

**Table 7.2.1.1.3-1**

| Requirement label | Description   | Related use case(s)       |
|-------------------|---|---------------------------|
| REQ-COV_MDA-01    | MDA capability for coverage problem analysis shall be able to provide the analytics for issues including, weak coverage, coverage holes, pilot pollution, overshoot coverage, or DL and UL channel coverage mismatch.   | Coverage problem analysis |
| REQ-COV_MDA-02    | MDA capability for coverage problem analysis shall be able to provide the analytics for area specific coverage problem analysis.  | Coverage problem analysis |
| REQ-COV_MDA-03    | MDA capability for coverage problem analysis shall be able to provide a radio environment map that graphically describes the radio coverage characteristics (e.g. RSRP or SINR) of the selected cluster of cells.   | Coverage problem analysis |
| REQ-COV_MDA-04    | MDA capability for coverage problem analysis shall be able to provide the optimum configurations of a RAN node based on the radio environment map that graphically describes the radio coverage characteristics (e.g. RSRP or SINR) of a selected cluster of cells. | Coverage problem analysis |

### 7.2.1.2 Slice coverage analysis

#### 7.2.1.2.1 Description

This MDA capability is for the slice coverage analysis.



### 7.2.1.2.2 Use case

The slice coverage is one of the indicators when a 3<sup>rd</sup> party (i.e. slice tenant) issues a slice request and is mapped into the desired geographical coverage area with the available radio coverage which depends on the base station planning and deployment. In order to map the desired slice coverage perfectly, MDA can be used to optimize the slice coverage on the slice instantiation and runtime considering:

- i) slice-aware statistics, e.g. slice-UE distributions and mobility patterns;
- ii) slice SLA; and
- iii) access node capabilities.

In 5G the notion of coverage is represented by a set of one or more Tracking Areas (TAs), which are contained in a Registration Area (RA), which is assigned to a UE once it registers to the network. Depending on the MDA MnS producer output, TA and RA planning, i.e. grouping cells to form a TA and then TAs to an RA, can be optimized and the RAN parameters can be adjusted to shape the cell edges and load distribution. The main objective is to fulfill a given slice SLA involving as few cells as possible by leveraging the benefits of adjusting cell configurations for satisfying the desired coverage.

### 7.2.1.2.3 Requirements

**Table 7.2.1.2.3-1**

| Requirement label | Description  | Related use case(s)     |
|-------------------|--|-------------------------|
| REQ-NS_COV_MDA-01 | MDA capability for slice coverage analysis shall be able to provide the analytics output describing the slice coverage and slice availability.   | Slice coverage analysis |
| REQ-NS_COV_MDA-02 | MDA capability for slice coverage analysis shall be able to provide the analytics of the mapping between slice coverage and actual radio deployment.   | Slice coverage analysis |
| REQ-NS_COV_MDA-03 | MDA capability for slice coverage analysis shall be able to provide recommended actions that involve options to reconfigure TA and/or RAN attributes including HO parameters, cell reselection parameters, beam configuration, computing resource and slice support in a cell. | Slice coverage analysis |

### 7.2.1.3 Paging optimization analysis

#### 7.2.1.3.1 Description

This MDA capability is for enabling various functionalities related to paging optimization.

#### 7.2.1.3.2 Use Case

As per the current procedures, if the UE goes Out-Of-Coverage (OOC) the paging which was initiated by the network Access and Mobility Management Function (AMF) fails. The re-attempts continue to fail until UE enters the coverage and respond to the paging attempts. This repetitive paging attempts result in the wastage of network resources. As an example, the use case includes a user or a group of users getting into an area, with no cellular coverage on a regular basis for a considerably long duration, for e.g. the user gets into a shielded room for some testing purpose every day for a defined period. The Network initiated paging for such users will fail until they are back in the area with cellular coverage. This would result in in-efficient network resource usage.

It is desirable to use MDAS (Management data analytic service) to optimize the current paging procedures in 5G networks. MDAS producer provides an analytics output containing the user(s) paging analytics indicating the time window at which a group of users are OOC on a regular basis at the particular location. MDAS producer also provides the geographical map within which the UEs would experience paging issues and hence will not be able to respond on a network-initiated paging. Based on the provided MDA output, MDAS consumer (e.g. AMF, gNB) decides on whether, when and where to initiate or not to initiate the paging procedures, thereby ensuring the efficient paging procedures and optimal network resource utilization, as paging can be initiated only when there are more chances for it to be successful.

## 7.2.1.3.3 Requirements

Table 7.2.1.3.3-1

| Requirement label | Description   | Related use case(s)          |
|-------------------|---|------------------------------|
| REQ-PAG_MDA-01    | MDA capability for paging optimization analysis shall be able to provide analytics output describing paging result patterns for a group of users.   | Paging optimization analysis |
| REQ-PAG_MDA-02    | MDA capability for paging optimization analysis shall be able to provide analytics output describing paging result patterns based on geographical area.   | Paging optimization analysis |
| REQ-PAG_MDA-03    | MDA capability for paging optimization analysis shall be able to provide analytics output describing the paging result patterns based on successful and un-successful paging attempts at a particular time and duration based on geographical area.   | Paging optimization analysis |
| REQ-PAG_MDA-04    | MDA capability for paging optimization analysis shall be able to provide analytics output describing the paging result patterns to contain the following information: <ul style="list-style-type: none"> <li>- Identification of a group of users.</li> <li>- Identify the geographical area of concern.</li> <li>- Prediction of the time window during which UE is out-of-coverage periodically.</li> <li>- Prediction of the last known location before UE going out-of-coverage periodically.</li> <li>- The recommended action which may suggest stopping paging the UE for Daily-OOC-Duration at Daily-OOC-Location.</li> </ul> | Paging optimization analysis |

## 7.2.2 SLS analysis

## 7.2.2.1 Service experience analysis

## 7.2.2.1.1 Description

This MDA capability is for the service experience analysis.

## 7.2.2.1.2 Use case

Service experience of end user is key indicator that directly reflects the user satisfaction degree. In 5G system, the diversity of network services is expanding all the time and the requirements of different services especially from vertical users are being standardized. Considering these diverse requirements and expectation from end user perspective (e.g. priorities of SLA related attributes such as latency, throughput, maximum number of users or different required values of these attributes), the service experience as a comprehensive indicator need to be extensively analysed.

## 7.2.2.1.3 Requirements

Table 7.2.2.1.3-1

| Requirement label  | Description  | Related use case(s)         |
|--------------------|--|-----------------------------|
| REQ-SER_EXP_MDA-01 | MDA capability for service experience analysis shall be able to identify the source of service experience issue, e.g. RAN issue, CN issue, TN issue, UE issue, service provider issue.   | Service experience analysis |
| REQ-SER_EXP_MDA-02 | MDA capability for service experience analysis shall be able to provide the analytics output with following information describing the current service experience aspects and potentially future prediction: <ul style="list-style-type: none"> <li>- The predicted future service experience and/or observed service experience statistics.</li> <li>- Service experience degradation root cause analysis.</li> </ul> | Service experience analysis |
| REQ-SER_EXP_MDA-03 | MDA capability for service experience analysis shall be able to provide the level of service experience.   | Service experience analysis |
| REQ-SER_EXP_MDA-04 | MDA capability for service experience analysis shall be able to provide the recommendation for improving service experience.   | Service experience analysis |

## 7.2.2.2 Network slice throughput analysis

### 7.2.2.2.1 Description

This MDA capability is for the network slice throughput analysis.

### 7.2.2.2.2 Use case

Throughput is of great importance which represents the end users' experiences and also reflects the network problems, e.g. low UE throughput may be caused by resource shortage. In order to satisfy the requirements of  $dL/uIThptPerSlice$  in the ServiceProfile, MDAS may be utilized for throughput related analysis/predictions for network slice instance.

MDAS producer allows the consumer to request analytics of network slice throughput related issues and identify the corresponding root cause(s) to assist throughput assurance. Network slice throughput analysis can be for a specific domain and/or for cross-domain. The two level MDAS producers, i.e. domain-specific and cross-domain may work in coordination to assure the optimum throughput performance.

### 7.2.2.2.3 Requirements

**Table 7.2.2.2.3-1**

| Requirement label | Description   | Related use case(s)               |
|-------------------|---|-----------------------------------|
| REQ-THR_MDA-1     | MDA capability for network slice throughput analysis shall be able to identify the network slice throughput issues, including those RAN-related and CN-related issues.  | Network slice throughput analysis |
| REQ-THR_MDA -2    | MDA capability for network slice throughput analysis shall be able to provide the root cause analysis of the network slice throughput issue(s).   | Network slice throughput analysis |
| REQ-THR_MDA -3    | MDA capability for network slice throughput analysis shall be able to provide the analytics output of the network slice throughput which contain the following information: <ul style="list-style-type: none"> <li>- Network slice throughput statistics.</li> <li>- Network slice throughput predictions.</li> </ul> | Network slice throughput analysis |
| REQ-THR_MDA-04    | MDA capability for network slice throughput analysis shall be able to provide the prompt when the network slice throughput exceeds or falls below a certain threshold.  | Network slice throughput analysis |

## 7.2.2.3 Network slice traffic prediction

### 7.2.2.3.1 Description

This MDA capability is for the prediction of network slice traffic patterns.

### 7.2.2.3.2 Use case

It is desirable to use MDAS to get the network slice traffic predictions including individual traffic load predictions on each of the constituent network function instance present in the network slice. The traffic load predictions per constituent network function instances can be used for better resource provisioning of the network slice. For example, resources can be pre-configured considering the predicted traffic on the network slice.

### 7.2.2.3.3 Requirements

**Table 7.2.2.3.3-1**

| Requirement label | Description   | Related use case(s)              |
|-------------------|---|----------------------------------|
| REQ-TRA_MDA--01   | MDA capability for network slice traffic prediction shall be able to provide analytics output describing traffic load prediction of the network slice including traffic load prediction for each of its constituent network function instances.   | Network slice traffic prediction |
| REQ-TRA_MDA-02    | MDA capability for network slice traffic prediction shall be able to provide analytics output describing traffic load prediction for the network slice which include the following information: <ul style="list-style-type: none"> <li>- Predicted uplink and downlink throughput on each User Plane Function instance (UPF) in the network slice.</li> <li>- Predicted number of Packet Data Unit (PDU) session for each Session Management Function (SMF) instance in the network slice.</li> <li>- Predicted number of UE or Registered subscriptions for each AMF instance in the network slice.</li> <li>- Predicted maximum packet size for each UPF instance in the network slice.</li> <li>- Predicted UE uplink and downlink throughput on each gNodeB (gNB) instance in the network slice.</li> <li>- Predicted number of UE for each gNB/NR cell instance in the network slice.</li> </ul> | Network slice traffic prediction |

## 7.2.2.4 E2E latency analysis

### 7.2.2.4.1 Description

This MDA capability is for E2E latency related issue analysis.

### 7.2.2.4.2 Use case

E2E latency is an important parameter for URLLC services. User data packets should be successfully delivered within certain time constraints to satisfy the end users requirements. Latency could be impacted by the network capability and network configurations. These factors may be the root cause if the latency requirements cannot be achieved. Packet transmission latency may dynamically change if these factors change. The latency requirement should be assured even if some of the network conditions may degrade. It is important for the MDAS producer to analyze the latency related issues to support SLS assurance.

### 7.2.2.4.3 Requirements

**Table 7.2.2.4.3-1**

| Requirement label | Description  | Related use case(s)   |
|-------------------|--|-----------------------|
| REQ-LAT_MDA-01    | MDA capability for E2E latency analytics shall be able to identify the type of the E2E latency issue, including, RAN- related latency issue, CN-related latency issue, TN-related latency issue, UE-related latency issue and service provider originated latency issue. | E2E latency analytics |
| REQ-LAT_MDA-02    | MDA capability for E2E latency analytics shall be able to provide the root cause analysis of the E2E latency issue.  | E2E latency analytics |
| REQ-LAT_MDA-03    | MDA capability for E2E latency analytics shall be able to provide the recommended actions to solve the E2E latency issue.  | E2E latency analytics |

## 7.2.2.5 Network slice load analysis

### 7.2.2.5.1 Description

This MDA capability is for network slice load analysis.

### 7.2.2.5.2 Use cases

Network slice load may vary during different time periods. Therefore, network resources allocated initially could not always satisfy the traffic requirements, for example, the network slice may be overloaded or underutilized. Overload of signalling in control plane and/or user data congestion in user plane will lead to underperforming network. Besides, allocating excessive resources for network slice with light load will decrease resource efficiency.

The analysis of network slice load should consider the load of services with different characteristics (e.g. QoS information, service priority), load distribution to derive the corresponding resource requirements. Load distribution analytic result may be provided, e.g. load distribution for network slices, different locations and/or time periods etc.

Traffics and resources related performance measurements and UE measurements can be utilized by MDAS producer to identify degradation of the performance measurements and KPI documented in an SLS due to load issues, e.g. radio resource utilization. MDAS producer may further provide recommendations to the network slice load issue. This analytics results can be considered as an input to support SLA assurance to perform further evaluation.

### 7.2.2.5.3 Requirements

**Table 7.2.2.5.3-1**

| Requirement label  | Description  | Related use case(s)          |
|--------------------|--|------------------------------|
| REQ-NS_LOAD_MDA-01 | MDA capability for network slice load analytics shall be able to identify the domain of the network slice load issue, including, RAN issue, CN issue and TN-related issues.                  | network slice load analytics |
| REQ-NS_LOAD_MDA-02 | MDA capability for network slice load analytics shall be able to identify the phase of the network slice load issue, e.g. historic/ongoing/potential network slice load issue.               | network slice load analytics |
| REQ-NS_LOAD_MDA-03 | MDA capability for network slice load analytics shall be able to identify the state of the network slice load issue, e.g. overload/underutilized network slice load issue.                   | network slice load analytics |
| REQ-NS_LOAD_MDA-04 | MDA capability for network slice load analytics shall be able to identify the list of the network entities which are involved in the network slice load issue.                               | network slice load analytics |
| REQ-NS_LOAD_MDA-05 | MDA capability for network slice load analytics shall be able to provide analytics related to network slice load within specified time schedules and geographic locations or target objects. | network slice load analytics |
| REQ-NS_LOAD_MDA-06 | MDA capability for network slice load analytics shall be able to provide the root cause and recommended actions to the network slice load issue.   | network slice load analytics |

## 7.2.3 MDA assisted fault management

### 7.2.3.1 Failure prediction

#### 7.2.3.1.1 Description

This MDA capability is for failure prediction.

#### 7.2.3.1.2 Use case

There are multiple sources of faults which may cause the 5G system to fail to provide the expected service. These faults and the associated failures need extensive troubleshooting. In order to reduce network and service failure time and performance degradation, it is necessary to supervise the status of various network functions and resources, and predict the running trend of network and potential failures to intervene in advance. These predictions can be used by the management system to autonomously maintain the health of the network, e.g. speedy recovery actions on a network function related to the predicted potential failure.

Due to the fact that failure prediction could depend on the existing alarm incidents and relevant historical and real-time data (performance measurement information, configuration data, network topology information, etc.), there is a possibility for MDA to be used in conjunction with AI/ML technologies and model training to predict potential failures.

In order to avoid the occurrence of failures and abnormal network status, it is necessary for consumers of analytics to obtain the required details of potential failure and the corresponding degradation trend (abnormal KPI, performance measurement information, possible alarm type, fault root cause, etc.). Therefore, MDA, may in conjunction with AI/ML technology, be required to obtain basic health maintenance knowledge (e.g. the relationship between the failures or potential failures and the related maintenance actions) through predefined expertise or model training, so as to effectively predict potential failures. The basic health maintenance knowledge could be updated with feedback.

If necessary, MDA could also provide corresponding recommended actions for failure prevention.

### 7.2.3.1.3 Requirements

**Table 7.2.3.1.3-1**

| Requirement label       | Description  | Related use case(s) |
|-------------------------|--|---------------------|
| REQ-FAILURE_PRED_MDA-01 | MDA capability for failure prediction shall be able to collect, correlate, filter and analyse the required data (including, alarm information, historical and real-time data) as inputs for analytics and provide the analytics output.                        | Failure prediction  |
| REQ-FAILURE_PRED_MDA-02 | MDA capability for failure prediction shall be able to obtain basic health maintenance knowledges (including, the relationship between the failures or potential failures and the related maintenance actions) through predefined expertise or model training. | Failure prediction  |
| REQ-FAILURE_PRED_MDA-03 | MDA capability for failure prediction shall be able to provide the analytics output including predictions of potential service failures, as well as the possible recommendation actions to prevent failures.   | Failure Prediction  |

## 7.2.4 MDA assisted Energy Saving

### 7.2.4.1 Energy saving analysis

#### 7.2.4.1.1 Description

This MDA capability is for the energy saving analysis.

#### 7.2.4.1.2 Use cases

Operators are aiming at decreasing power consumption in 5G networks to lower their operational expense with energy saving management solutions. Energy saving is achieved by activating the energy saving mode of the NR capacity booster cell or 5GC NFs (e.g. UPF etc.). The energy saving decision making is typically based on the load information of the related cells/UPFs, the energy saving policies set by operators and the energy saving recommendations provided by MDAS producer. To achieve an optimized balance between the energy consumption and the network performance, MDA can be used to assist the MDAS consumer to make energy saving decisions.

To make the energy saving decision, it is necessary for MDAS consumer to determine where the energy efficiency issues (e.g. high energy consumption, low energy efficiency) exist, and the cause of the energy efficiency issues. Therefore, it is desirable for MDA to correlate and analyze the energy saving related performance measurements (e.g. PDCP data volume of cells, power consumption, etc.) and the network analysis data (e.g. observed service experience related network data analytics) to provide the analytics results which indicate current network energy efficiency. In some low-traffic scenarios, MDA MnS consumers may expect to reduce energy consumption to save energy. In this case, the MDA MnS consumer may request the MDAS producer to report only high energy consumption issue related analytics results. When the consumer expects to improve energy efficiency, although it may lead to high energy consumption in network or in certain parts of network, then the related issue is the low energy efficiency one. In that case, the consumer may request analytics results related to low energy efficiency issue. So, the target could be to enhance the performance of NF for a given energy consumption. This will result in higher Energy Efficiency of network.

To make the energy saving decision, it is necessary for MDAS consumer to determine which Energy Efficiency (EE) KPI related factor(s) (e.g. traffic load, end-to-end latency, active UE numbers, etc.) are affected or potentially affected. The MDAS producer can utilize historical data to predict the EE KPI related factors (e.g. load variation of cells at some future time, etc.). The prediction result of these information can then be used by operators to make energy-saving decision to guarantee the service experience.

The MDAS producer may also provide energy saving related recommendation with the energy saving state to the MDAS consumer. Under the energy saving state, the required network performance and network experience should be guaranteed. Therefore, it is important to formulate appropriate energy saving policies (start time, dynamic threshold setting, base station parameter configuration, etc.). The MDAS consumer may take the recommendations with the energy saving state into account for making analysis or making energy saving decisions. After the recommendations have been executed, the MDA producer may start evaluating and further analyzing network management data to optimize the recommendations.

### 7.2.4.1.3 Requirements

**Table 7.2.4.1.3-1**

| Requirement label | Description   | Related use case(s)    |
|-------------------|---|------------------------|
| REQ-ES_MDA-01     | MDA capability for energy saving analysis shall be able to identify the energy efficiency issue (including high energy consumption, low energy efficiency), and identify the cell/NFs or location area of where the indicated energy efficiency issue exists. | Energy saving analysis |
| REQ-ES_MDA-02     | MDA capability for energy saving analysis shall be able to identify the root cause of the energy efficiency issue when necessary.   | Energy saving analysis |
| REQ-ES_MDA-03     | MDA capability for energy saving analysis shall be able to utilize the network status analysis and predictions information of the energy efficiency KPI factors (including, traffic load trends) to assist achieving energy saving.                           | Energy saving analysis |
| REQ-ES_MDA-04     | MDA capability for energy saving analysis shall be able to provide the energy saving recommendation, including policies and configuration actions to guarantee the network performance and end user service experience.                                       | Energy saving analysis |

## 7.2.5 MDA assisted mobility management

### 7.2.5.1 Mobility performance analysis

#### 7.2.5.1.1 Description

This MDA capability is for the mobility performance analysis.

#### 7.2.5.1.2 Use case

The mobility performance related problems may result from too-early/too-late/ping-pong handovers due to inappropriate handover parameters. MDAS can be used to analyse service experience and network performance during handover period in different mobility scenarios. MDAS producer may also be capable to provide the recommendations of optimal handover parameters to MDAS consumer.

In different NSA and SA deployment architecture scenarios, handover mechanisms (e.g. DAPS, CHO or RACH-less handover) will have different impacts on the mobility performance. The analytics report to identify the most optimal handover mechanism may be provided by MDAS producer.

## 7.2.5.1.3 Requirements

Table 7.2.5.1.3-1

| Requirement label | Description  | Related use case(s)                 |
|-------------------|--|-------------------------------------|
| REQ-MRO_MDA-01    | MDA capability for mobility performance issue analysis shall be able to provide the mobility performance in NSA and SA deployment architectures.                                       | Mobility performance issue analysis |
| REQ-MRO_MDA-02    | MDA capability for mobility performance issue analysis shall be able to provide the mobility issue analysis including too-early handovers, too-late handovers and ping-pong handovers. | Mobility performance issue analysis |
| REQ-MRO_MDA-03    | MDA capability for mobility performance issue analysis shall be able to identify the most optimal handover mechanism including DAPS, CHO or RACH-less handover.                        | Mobility performance issue analysis |
| REQ-MRO_MDA-04    | MDA capability for mobility performance issue analysis shall be able to provide the area specific mobility performance analysis.   | Mobility performance issue analysis |

## 7.2.5.2 Handover optimization analysis

## 7.2.5.2.1 Description

This MDA capability is for the handover optimization analysis.

## 7.2.5.2.2 Use cases

## 7.2.5.2.2.1 Handover optimization

Current handover procedures are mainly based on radio conditions for selecting the target gNB upon a handover. The target gNB accepts or rejects the Handover (HO) request depending on various conditions. In virtualized environment, the HO may be rejected due to inadequate available resources within the target gNB. The notion of resources may include virtual resources (e.g. compute, memory) and/or radio resources (e.g. PRB, RRC connected users). If the HO request is rejected, a UE will try to connect to a different gNB until the request is successfully accepted. Several target gNBs can be tried until the request is successfully accepted. This process can result in wastage of UE and network resources, while it may also introduce service disruption due to increased latency and Radio Link Failures (RLFs). It also introduces inefficiency in the HO or other network procedures.

To address this handover optimization issue, it is desirable to use MDA (Management Data Analytics) to provision and/or select a particular target gNB for handover in order to reduce or even avoid HO rejections. The MDAS producer provides a HO optimization analytics output containing the current and future/predicted resource consumption, resources capabilities and other KPIs' status for the available target gNB(s). The analytics output also provides recommended actions to optimize the target gNB for handover. This may include resource re-configuration or the updated selection criteria for target gNB. Based on the output, the MDAS consumer adjusts (e.g. scale-out/up the virtual resource, re-schedule/optimize radio resource) the resources before continuing with the handover and/or adjusts the selection criteria of the target gNB by also considering the overlapping coverages of inter-frequency and inter-RAT deployments.

## 7.2.5.2.2.2 Handover optimization based on UE Load

The target node, eNB, may not have adequate resources to accept certain handover requests. In the context of network virtualization, these resources may include not only legacy radio resources, but also virtual resources such as processor and memory. Handover optimization can benefit from knowledge about the projected UE load on the target cell including additional radio and virtual resources.



## 7.2.5.2.3 Requirements

Table 7.2.5.2.3-1

| Requirement label | Description   | Related use case(s)                    |
|-------------------|---|--|
| REQ-MOB_MDA-01    | MDA capability for handover optimization shall be able to provide the analytics output related to current statistics and future predictions of virtual resource consumption of gNB.   | Handover optimization                  |
| REQ-MOB_MDA-02    | MDA capability for handover optimization shall be able to provide the analytics output related to current statistics and future predictions of radio resource consumption of gNB.   | Handover optimization                  |
| REQ-MOB_MDA-03    | MDA capability for handover optimization shall be able to provide an analytics output indicating a selection priority for the target cell, among a set of candidate inter-frequency cells.  | Handover optimization                  |
| REQ-MOB_MDA-04    | MDA capability for handover optimization shall be able to provide an analytics output indicating a list of target cells to spare, i.e. avoid, a handover for an indicated time period.  | Handover optimization                  |
| REQ-MOB_MDA-05    | MDA capability for handover optimization shall be able to provide the analytics output describing inter-frequency target cell selection for handover including information for provisioning or selecting a target gNB with respect to a specific service or slice, if the same Network Slice Instance (NSI) is available in both the current and target gNB.  | Handover optimization                  |
| REQ-MOB_MDA-06    | MDA capability for handover optimization shall be able to provide the analytics output describing inter-frequency target cell selection for handover including indication of current and expected QoE (for the UE) at the current and target gNB.   | Handover optimization                  |
| REQ-MOB_MDA-07    | MDA capability for handover optimization shall be able to provide the analytics output including the following information that can be used to optimize handover decisions: <ul style="list-style-type: none"> <li>- Indication on whether the target gNB is optimal for handover.</li> <li>- Recommended action to optimize the target gNB and/or the selection of the target gNB for handover.</li> </ul> | Handover optimization                  |
| REQ-MOB_MDA-08    | MDA capability for handover optimization shall be able to provide an analytics output indicating the projected UE load with respect to virtual resource and radio resource on the target cell.  | Handover optimization based on UE Load |

## 7.2.5.3 Inter-gNB beam selection optimization

## 7.2.5.3.1 Description

This MDA capability is for inter-gNB beam selection optimization.

## 7.2.5.3.2 Use case

With the deployment of 5G networks, Massive MIMO has been used on a large scale. Beamforming, as a key technology to reduce user interference, which can suppress interference signals in non-target directions and enhance sound signals in target directions, is always combined with Massive MIMO to further decrease interference. A cell can make use of multiple beams for serving residing users (SSB or CSI-RS) with each user served by a single beam at a time. The cell level quality can be represented as an aggregated metric over one or more beams. So, although handover is performed between two 5G cells, the granularity of handover can be further broken down to beam level.

The handover of beams could be performed if the network resource or the user's state have changed to obtain better network performance. Beam optimization includes the handover between different beams and configuration of beam parameters.

In order to avoid selecting the wrong beam to perform RACH on the target cell and causing RLF of the UE, MDA can be used to recommend a means to prioritize and/or select the beam in case of handover for a specific target cell. MDA can provide a beam level HO optimization analysis considering information on the handover performance of different beam combinations between the source and target cell pairs. Beams of the target cell with a successful handover are preferred in the selection.

MDA could also provide recommended actions and priority options for beam selection. Based on the recommended actions, the MDA MnS consumer adjusts the priorities for the beam selection at HO, i.e. the beam combinations that are likely to succeed are prioritized, less optimal beam combinations are down prioritized. The target cell may also obtain analytics to allocate RACH resources in a way that ensures HO success.

In order to optimize antenna and beam configuration, so as to reduce energy loss and enhance network performance, MDA can be used to analyze the current network status.

### 7.2.5.3.3 Requirements

**Table 7.2.5.3.3-1**

| Requirement label         | Description   | Related use case(s)                   |
|---------------------------|---|---------------------------------------|
| <b>REQ-HO_BEAM_OPT-01</b> | MDA capability for inter-gNB beam selection optimization shall be able to provide the analytics of the handover performance of beam pair combinations between cell pairs. | Inter-gNB beam selection optimization |
| <b>REQ-HO_BEAM_OPT-02</b> | MDA capability for inter-gNB beam selection optimization shall be able to provide an indication if a beam pair is to be prioritized or down prioritized.                  | Inter-gNB beam selection optimization |
| <b>REQ-HO_BEAM_OPT-03</b> | MDA capability for inter-gNB beam selection optimization shall be able to provide feasible antenna and beam configuration analysis.                                       | Inter-gNB beam selection optimization |

## 7.2.6 MDA assisted critical maintenance management

### 7.2.6.1 RAN Node Software Upgrade

#### 7.2.6.1.1 Description

This MDA capability is for network critical maintenance during RAN node software upgrade process.

#### 7.2.6.1.2 Use case

As per the current mechanism of software upgrade at RAN node results in service disruption or huge operational cost. Consider a scenario, when a RAN Node is required to shut down manually to undergo critical maintenance for a very short duration of time. Software upgrade can be one such critical maintenance scenario. In such cases, all the resources (bearer, security functions, mobility management) that are managed by this RAN Node need to be purged and reconfigured at another RAN Node (standby RAN Node) or if another RAN Node is not available then resources will be reconfigured again when former RAN Node comes up after software upgrade. Both the situations lead to additional operational expenses and data loss. Operational expense in terms of all the resources to be released/attached again and data loss for all GBR sessions/bearer.

It is expected to use MDAS to optimize the procedure of software upgrade at RAN Node by providing the right time to execute the required upgrade. The software upgrade should be automatically initiated by the OAM system, once configured, during the time frame when the expected impacts are minimum i.e. at the optimal time when there would be minimum expected operational cost and data loss. The Optimal Time (current or futuristic) can be derived by collecting and analysing the data related to DRBs including GBR/non-GBR, state, modification count, ongoing handover etc. MDAS can utilize historical data and AI/ML (e.g. time series based) algorithm to derive the future optimal time frame for software upgrade.

NOTE: RAN Node above refers to CU-CP in case of gNB split case.

## 7.2.6.1.3 Requirements

Table 7.2.6.1.3-1

| Requirement label | Description  | Related use case(s)       |
|-------------------|--|---------------------------|
| REQ-SWA_MDA-01    | MDA capability for RAN Node software upgrade shall be able to provide the DRB info analytics output describing the DRBs info at a particular RAN Node(s).  | RAN Node software upgrade |
| REQ-SWA_MDA-02    | MDA capability for RAN Node software upgrade shall be able to provide the DRB info analytics output describing the DRB info based on the following DRB characteristics; type (GBR/non-GBR), state (idle/active), modification count (indicating number of times, this bearer has gone for modification since its creation), handover in-progress (indicates whether the bearer is undergoing handover or not).   | RAN Node software upgrade |
| REQ-SWA_MDA-03    | MDA capability for RAN Node software upgrade shall be able to provide output describing the DRB info that contain the following information: <ul style="list-style-type: none"> <li>- Time frame/duration at which the output is generated.</li> <li>- Whether RAN Node is optimal for upgrade at present.</li> <li>- Whether RAN Node will be optimal for upgrade during a future time frame. This will also provide a future frame.</li> <li>- Total number of GBR and non-GBR DRBs at future point of time frame. This will also provide a future frame.</li> </ul> | RAN Node software upgrade |

## 7.3 MDA MnS

## 7.3.1 MDA request and control

## 7.3.1.1 Description

The MDA request and control allow any authorized MDA MnS consumer to request management data analytics.

## 7.3.1.2 Use case

The MDA MnS consumer can request the MDA MnS producer to provide MDA output for a list of specified MDA type of analytics, i.e. MDA type, which corresponds to an MDA capability, which is to support analytics for a set of data or analytics for a certain PM, KPI, trace or QoE data. The MDA MnS consumer may introduce control attributes related to the MDA output with respect to the geographical location (i.e. area scope) and/or the target objects, e.g. managed elements, time schedule for obtaining an MDA output, time conditions related to the preparation of MDA output (i.e. time schedule for start, end and duration of analytics, etc.), and potential filter conditions to be met before an MDA output is made available, e.g. load or delay threshold crossing related to a target object. The geographical location indicates an area of interest for obtaining MDA output and/or target objects include affected objects or objects of interest for obtaining MDA output.

The MDA MnS consumer may control the MDA output attributes related to, e.g. time schedule, geographical location, target objects, etc., and has the capability to modify them at any point in time. The MDA MnS consumer can request the MDA MnS producer to generate an MDA output that contains numeric output results, e.g. average, normal distribution, etc., recommendation options, e.g. potential handover target cells, or root cause analysis, e.g. alarm prediction.

The MDA MnS consumer can be informed with an acknowledgment if the request was successful. If the request was not successful, the consumer is informed about potential errors indicating the reasons. The MDA MnS consumer can also deactivate the MDA reporting control request once it is no longer needed.

### 7.3.1.3 Requirements

**Table 7.3.1.3-1**

| Requirement label      | Description   | Related use case(s)  |
|------------------------|---|----------------------|
| <b>REQ-MDA-CONT-01</b> | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the MDA type.  | <b>All use cases</b> |
| <b>REQ-MDA-CONT-02</b> | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the reporting time schedule.                                 | <b>All use cases</b> |
| <b>REQ-MDA-CONT-03</b> | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on geographic location and/or the target objects if applicable. | <b>All use cases</b> |
| <b>REQ-MDA-CONT-04</b> | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to request MDA output, while indicating its selection on the time schedule related to specific part of MDA results.   | <b>All use cases</b> |
| <b>REQ-MDA-CONT-05</b> | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to modify the attributes related to the requested MDA output.   | <b>All use cases</b> |
| <b>REQ-MDA-CONT-6</b>  | The MDA MnS producer shall have the capability to allow any authorized MDA MnS consumer to specify filter conditions on target objects based on threshold crossing for MDA output when this is applicable.    | <b>All use cases</b> |

## 7.3.2 Obtaining MDA Output

### 7.3.2.1 Description

Following a successful MDA request any authorized MDA MnS consumer can obtain management data analytics from the corresponding MDA MnS producer. The MDA MnS consumer can control the MDA output by modifying the attributes related to the MDA request at any point in time.

### 7.3.2.2 Use case

The MDA MnS producer allow consumers to obtain MDA output when the conditions indicated in the MDA request are met. The level of details and granularity of MDA output results would depend on the MDA request and nature of MDA capability. Therefore an MDA output can vary in complexity and may contain one or more MDA results, which may be:

- i) numeric, e.g. average, etc.;
- ii) recommendation options, e.g. potential handover target cells; or
- iii) root cause analysis, e.g. alarm prediction.

These results may be related to one or more MDA types, which correspond to MDA capabilities, and can also contain information regarding the time schedule or the validity time of the provided MDA output.

MDA MnS producer may allow consumers to request and obtain different MDA output results. The MDA MnS producer may also allow consumers to obtain information regarding the geographical location and/or the target objects, e.g. managed elements, related to the provided MDA result - from the corresponding element.

The MDA MnS producer may allow consumers options to obtain MDA output results either by pulling or pushing mechanisms. Any MDA output may be obtained once it is prepared or when the specified MDA request and control conditions are met.

### 7.3.2.3 Requirements

**Table 7.3.2.3-1**

| Requirement label | Description  | Related use case(s) |
|-------------------|--|---------------------|
| REQ-MDA_REP-01    | The MDA MnS producer shall have a capability allowing MDA MnS consumers to obtain analytics output per the MDA request.  | All use cases       |
| REQ-MDA_REP-02    | The MDA MnS producer shall have a capability allowing MDA MnS consumers to indicate if produced analytics output shall be pushed to the MDA MnS consumer or whether the MDA MnS consumer pulls the data. | All use cases       |
| REQ-MDA_REP-03    | The MDA MnS producer shall allow MDA MnS consumer to obtain the geographical location and/or the target objects related to the MDA output if applicable.   | All use cases       |
| REQ-MDA_REP-04    | The MDA MnS producer shall allow MDA MnS consumer to obtain time schedule information related to the MDA output.   | All use cases       |

## 8 Data definitions for MDA capabilities

### 8.1 Introduction

#### 8.1.1 MDA Types

The output of MDA can be related to a particular capability as described in clause 7, where an MDA type can indicate a specific MDA capability corresponding to a predefined use case(s).

The MDA capabilities may also support analytics of a set of data or analytics for certain PMs, KPIs, trace data, QoE or other type of data. Analytics related to the set of data relies on multiple raw, or already processed input data enabling an MDA MnS producer to provide more complex MDA output. Analytics related to certain set of data including PMs, KPIs, trace or QoE data may rely on these specific categories of data.

MDA MnS consumers may request and obtain output for MDA types related to analytics of a set of data or analytics for certain PMs, KPIs, trace or QoE data.

### 8.2 About analytics

#### 8.2.1 About enabling data

Analytics are capability-specific, and the present document provides the enabling data for each MDA capability in the respective tables. It is not restrictive or mandatory to use the analytics inputs exactly the same as the provided enabling data for implementation, and other (additional or different) data are also allowed in order to facilitate the production of analytics outputs.

#### 8.2.2 About analytics outputs

For analytics outputs, there are:

- 1) common information elements that can be generated by MDA and be applicable for all MDA capabilities;
- 2) capability-specific information elements; and
- 3) optionally, vendor specific extensions.

The common information elements are provided in clause 8.3, and the capability-specific information elements are provided per MDA capability in clause 8.4 of the present document.

## 8.3 Common information elements of analytics outputs

### 8.3.0 General

There are some information elements that are common for all analytics outputs and MDA capabilities, i.e. these common information elements form a subset of all analytics outputs of all MDA capabilities.

### 8.3.1 Common information element definitions

The common information elements of the analytics outputs are defined in Table 8.3.1-1.

**Table 8.3.1-1: Common information elements of analytics outputs**

| Information element           | Definition  | Support qualifier | Properties  |
|-------------------------------|---|-------------------|---|
| mDAType                       | It indicates the MDA type.<br><br>The allowed values are the MDA type names defined for each MDA capability respectively in clause 8.4. | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| analyticsId                   | The identifier of the analytics output.   | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False  |
| analyticsOutputGenerationTime | It indicates the time when the analytics output is generated.   | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.4 Data definitions per MDA capability

### 8.4.1 Coverage related analytics

#### 8.4.1.1 Coverage problem analysis

##### 8.4.1.1.1 MDA type

The MDA type for coverage problem analysis is: CoverageAnalytics.CoverageProblemAnalysis.

##### 8.4.1.1.2 Enabling data

The enabling data for CoverageAnalytics.CoverageProblemAnalysis MDA type are provided in table 8.4.1.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.1.1.2-1: Enabling data for coverage problem analysis

| Data category            | Description  | References   |   |
|--------------------------|--|--|---|
| Performance measurements | SS-RSRP distribution per SSB (beam) of serving NR cell   | SS-RSRP distribution per SSB (clause 5.1.1.22.1 of TS 28.552 [4]).                                     |   |
|                          | SS-RSRP distribution per SSB (beam) of neighbor NR cell  | SS-RSRP distribution per SSB of neighbor NR cell (clause 5.1.1.22.2 of TS 28.552 [4]).                 |   |
|                          | RSRP distribution of neighbor E-UTRA cell for an NR cell   | RSRP distribution per neighbor E-UTRAN cell (clause 5.1.1.22.3 of TS 28.552 [4]).                      |   |
|                          | Power headroom distribution for NR cell  | Type 1 power headroom distribution (clause 5.1.1.26.1 of TS 28.552 [4]).                               |   |
|                          | Wideband CQI distribution for NR cell  | Wideband CQI distribution (clause 5.1.1.11.1 of TS 28.552 [4]).  |   |
|                          | Timing Advance distribution for NR cell  | Timing Advance distribution for NR Cell (clause 5.1.1.33.1 of TS 28.552 [4]).                          |   |
|                          | Number of UE Context Release Request (gNB-DU initiated)  | Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]).           |   |
|                          | Number of UE Context Release Request per SSB (gNB-DU initiated)  | Number of UE Context Release Request (gNB-DU initiated) (clause 5.1.3.5.1 of TS 28.552 [4]).           |   |
|                          | Number of UE Context Release Requests (gNB-CU initiated)   | Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]).           |   |
|                          | Number of UE Context Release Requests per SSB (gNB-CU initiated)   | Number of UE Context Release Request (gNB-CU initiated) (clause 5.1.3.5.2 of TS 28.552 [4]).           |   |
|                          | RSRP related measurements for ng-eNB   | RSRP related measurements (clause 6.1 of TS 32.425 [12]).  |   |
|                          | UE power headroom related measurements for ng-eNB  | UE power headroom related measurements (clause 6.3 of TS 32.425 [12]).                                 |   |
|                          | Wideband CQI distribution for ng-eNB   | Wideband CQI distribution (clause 4.10.1.1 of TS 32.425 [12]).   |   |
|                          | Average sub-band CQI for ng-eNB  | Average sub-band CQI (clause 4.10.1.2 of TS 32.425 [12]).  |   |
|                          | UE Rx - Tx time difference related measurements for ng-eNB   | UE Rx - Tx time difference related measurements (clause 6.4 of TS 32.425 [12]).                        |   |
|                          | AOA related measurements for ng-eNB  | AOA related measurements (clause 6.5 of TS 32.425 [12]).   |   |
|                          | Timing Advance distribution for ng-eNB   | Timing Advance Distribution (clause 4.10.2 of TS 32.425 [12]).   |   |
|                          | Number of UE CONTEXT Release Request initiated by ng-eNodeB  | Number of UE CONTEXT Release Request initiated by eNodeB/RN (clause 4.1.5.1 of TS 32.425 [12]).        |   |
|                          | MDT reports  | MDT reports containing RSRPs of the serving cell and neighbour cells, and UE location.                 | RSRPs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7].           |
|                          | RLF reports  | RLF reports containing RSRPs of the last serving cell and neighbour cells, and UE location.            | RLF data collection and RLF reporting in TS 32.422 [6], and rlf-Report-r16 in TS 38.331 [13]. |
| RCEF reports             | RCEF reports containing RSRPs of NR cell where the RRC connection establishment failed and neighbour cells, and UE location. | RCEF data collection and RCEF reporting in TS 32.422 [6], and ConnEstFailReport-r16 in TS 38.331 [13]. |   |
| UE location reports      | UE location information provided by the LMF services which can be used to correlate with the MDT reports.                    | The UE location information provided by LMF via service-based interface (see TS 23.273 [14]).          |   |

| Data category      | Description  | References  |
|--------------------|--|---|
| Geographical data  | The geographical information (longitude, latitude, altitude) of the deployed RAN (NG-RAN and E-UTRAN). | The geographical information (longitude, latitude, altitude) information (see the <code>peeParametersList</code> attribute of the <code>ManagedFunction</code> IOC in TS 28.622 [19]).  |
| Configuration data | The NRMs containing the attributes affecting the coverage for (NG-RAN and E-UTRAN).                    | <code>NRCellDU</code> IOC, <code>NRSectorCarrier</code> IOC, <code>BWP</code> IOC, <code>CommonBeamFormingFunction</code> IOC, and <code>Beam</code> IOC in TS 28.541 [15]; <code>EUtranGenericCell</code> IOC in TS 28.658 [16]; <code>SectorEquipmentFunction</code> IOC, <code>AntennaFunction</code> IOC, and <code>TMAFunction</code> IOC in TS 28.662 [17]. |

### 8.4.1.1.3 Analytics output

The specific information elements of the analytics output for coverage problem analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.1.1.3-1.

**Table 8.4.1.1.3-1: Analytics output for coverage problem analysis**

| Information element               | Definition  | Support qualifier | Properties   |
|-----------------------------------|---|-------------------|--|
| <code>coverageProblemId</code>    | The identifier of the coverage problem.   | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False  |
| <code>coverageProblemType</code>  | Indication of type of the coverage Problem.<br><br>The allowed value is one of the enumerated values: <code>WeakCoverage</code> , <code>CoverageHole</code> , <code>PilotPollution</code> , <code>Overshoot coverage</code> , <code>DIUIChannelCoverageMismatch</code> , <code>Other</code> .                                     | M                 | type: enumeration<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| <code>coverageProblemAreas</code> | Geographical location areas where the coverage problem occurred.  | O                 | type: <code>GeoArea</code> (see TS 28.622, to be confirmed)<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| <code>problematicCells</code>     | The CGIs of cells where the coverage problem occurred.  | M                 | type: Integer<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| <code>recommendedActions</code>   | The recommended actions to solve the coverage problem.<br><br>The recommended action may be (but not limited to): <ul style="list-style-type: none"> <li>- creation of new beam(s), or cell(s);</li> <li>- change the transmission power of the NR sector carrier;</li> <li>- delete some unwanted beam(s) or cell(s).</li> </ul> | M                 | type: <code>RecommendedAction</code><br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                        |



| Information element | Definition   | Support qualifier | Properties   |
|---------------------|--|-------------------|--|
| radioEnvironmentMap | <p>The graphical description of the observed radio coverage characteristics. The graphic may be for the RSRP or SINR of the selected cluster of cells mapped against the physical geographical information (longitude, latitude, altitude) of the area where the RAN (NG-RAN and E-UTRAN) cells are deployed.</p> <p>It is a list of paired tuples of geographical information (longitude, latitude, altitude) and coverage (RSRP or SINR) values.</p> | O                 | <p>type: List<br/> multiplicity: *<br/> isOrdered: N/A<br/> isUnique: N/A<br/> defaultValue: None<br/> isNullable: False</p>   |
| cellConfigurations  | <p>The cell configurations for a new cell or reconfigurations of existing cells derived based on the characteristics in the radioEnvironmentMap.</p> <p>The cell configurations are the changes to the NRMs attributes affecting the cell coverage (NG-RAN and E-UTRAN).</p>   | O                 | <p>type: may differ as defined in NRCellDU IOC, NRSectorCarrier IOC, BWP IOC, CommonBeamformingFunction IOC, and Beam IOC in TS 28.541 [15]; EUTranGenericCell IOC in TS 28.658 [16]; SectorEquipmentFunction IOC, AntennaFunction IOC, and TMAFunction IOC in TS 28.662 [17].</p> <p>multiplicity: *<br/> isOrdered: N/A<br/> isUnique: True<br/> defaultValue: None<br/> isNullable: False</p> |

## 8.4.1.2 Paging Optimization

### 8.4.1.2.1 MDA type

The MDA type for Capability-Paging Optimization: SLSAnalysis.PagingOptimization.

### 8.4.1.2.2 Enabling data

The enabling data for paging optimization are provided in table 8.4.1.2.2-1.

**Table 8.4.1.2.2-1: Enabling data for Paging Optimization Analysis**

| Data category            | Description                                    | References                                 |
|--------------------------|--|--|
| MDT Data                 | MDT reports indicating UE location information | MDT measurements defined in TS 32.423 [7]. |
| Performance measurements | Measurement for 5G Paging from AMF             | See clause 5.2.5.2 in TS 28.552 [4].       |

### 8.4.1.2.3 Analytics output

The specific information elements of the analytics output for paging optimization, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.1.2.3-1.

**Table 8.4.1.2.3-1: Analytics output for paging optimization analysis**

| Information element | Definition  | Support qualifier | Properties   |
|---------------------|---|-------------------|--|
| oOCDuration         | This specify the time window during which UE is out-of-coverage.  | M                 | type: ProjectionDuration<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| oOCLocation         | This specifies the last known location of the UEs before it goes out-of-coverage. This would be within the area indicated by the "areaScope" of the MDA request.                        | CM                | type: GeoCoordinate<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| oOCMap              | This specifies the geographical region within which the paging issues are experienced by a group of UEs. This would be within the area indicated by the "areaScope" of the MDA request. | CM                | type: GeoCoordinate<br>multiplicity: 1..*<br>isOrdered: True<br>isUnique: True<br>defaultValue: None<br>isNullable: False  |

## 8.4.2 SLS analysis

### 8.4.2.1 Service experience analysis

#### 8.4.2.1.1 MDA type

The MDA type for Capability-Service experience analysis is: SLSAnalysis.ServiceExperienceAnalysis.

#### 8.4.2.1.2 Enabling data

The enabling data for SLSAnalysis.ServiceExperienceAnalysis MDA type are provided in table 8.4.2.1.2-1.

**Table 8.4.2.1.2-1: Enabling data for service experience analysis**

| Data category            | Description   | References   |
|--------------------------|---|--|
| Performance measurements | Average e2e uplink/downlink delay for a network slice   | Average e2e uplink/downlink delay for a network slice (in clause 6.3.1.8 in TS 28.554 [5]).  |
|                          | Integrated uplink/downlink delay in RAN                 | Integrated downlink delay in RAN (clause 6.3.1.2 in TS 28.554 [5]); Integrated uplink delay in RAN (clause 6.3.1.7 in TS 28.554 [5]).  |
|                          | Round-trip packet delay                                 | Round-trip packet delay between PSA UPF and NG-RAN (clause 5.4.8 in TS 28.552 [4]).  |
|                          | UL/DL throughput for network and Network Slice Instance | Upstream throughput for network and Network Slice Instance (clause 6.3.2 in TS 28.554 [5]); Downstream throughput for Single Network Slice Instance (clause 6.3.3 in TS 28.554 [5]). |
|                          | RAN UE Throughput                                       | RAN UE Throughput (clause 6.3.6 in TS 28.554 [5])  |
|                          | Throughput at N3 interface                              | Upstream Throughput at N3 interface (clause 6.3.4 in TS28.554 [5]); Downstream Throughput at N3 interface (clause 6.3.5 in TS28.554 [5]).  |
| QoE Data                 | The QoE data of the different services                  | QoE data (TS 26.247 [22] and TS 26.114 [23] can be acquired through the procedures defined in TS 28.405 [8]).  |

### 8.4.2.1.3 Analytics output

The specific information elements of the analytics output for service experience analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.1.3-1.

**Table 8.4.2.1.3-1: Analytics output for Service experience analysis**

| Information element          | Definition   | Support qualifier | Properties  |
|------------------------------|--|-------------------|---|
| serviceExperienceId          | The identifier indicates the analytics report is related with service experience analysis.   | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| serviceExperienceIssueType   | Indication of the service experience issue type.<br><br>The allowed value is one of the enumerated values:<br>- RAN issue;<br>- CN issue;<br>- both  | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| affectedObjects              | The managed object instances where the service experience is applicable, e.g. SubNetwork Instance, NetworkSlice Instance, S-NSSAI.   | O                 | type: DN<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| serviceExperienceStatistics  | The statistics of the level of service experience for a service in a certain time period, e.g. there are five levels which are represented by 1, 2, 3, 4, 5 where level 1 represents the users are enduring bad experience while level 5 represents the users' requirements are perfectly satisfied. | O                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| serviceExperiencePredictions | The predictions of the level of service experience for a service in a certain time period.   | O                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |

### 8.4.2.2 Network slice throughput analysis

#### 8.4.2.2.1 MDA type

The MDA type for Capability-Network slice throughput analysis is: SLSAnalysis.NetworkSliceThroughputAnalysis.

#### 8.4.2.2.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceThroughputAnalysis MDA type are provided in table 8.4.2.2.2-1.

**Table 8.4.2.2.2-1: Enabling data for network slice throughput analysis**

| Data category            | Description   | References  |
|--------------------------|---|---|
| Performance measurements | UL/DL throughput for network and Network Slice Instance | Upstream throughput for network and Network Slice Instance as defined in clause 6.3.2 in TS 28.554 [5];<br>Downstream throughput for Single Network Slice Instance as defined in clause 6.3.3 in TS 28.554 [5]. |
|                          | RAN UE Throughput                                       | RAN UE Throughput as defined in clause 6.3.6 in TS 28.554 [5].  |
|                          | Throughput at N3 interface                              | Upstream Throughput at N3 interface as defined in clause 6.3.4 in TS 28.554 [5];<br>Downstream Throughput at N3 interface as defined in clause 6.3.5 in TS 28.554 [5].  |

### 8.4.2.2.3 Analytics output

The specific information elements of the analytics output for network slice throughput analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.2.3-1.

**Table 8.4.2.2.3-1: Analytics output for network slice throughput analysis**

| Information element                   | Definition  | Support qualifier | Properties   |
|---------------------------------------|---|-------------------|--|
| networkSliceThroughputIssueId         | Network slice throughput issue identifier   | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False  |
| networkSliceThroughputIssueType       | Indication of the network slice throughput issue type<br><br>The allowed value is one of the enumerated values:<br>RAN issue, CN issue, both  | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False    |
| networkSliceThroughputUserStatistics  | The statistics of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of users, for which the required SLS throughput satisfies        | O                 | type: integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| networkSliceThroughputTimeStatistics  | The statistics of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of time, during which the required SLS throughput satisfies      | O                 | type: integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| networkSliceThroughputUserPredictions | The predictions of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of users, for which the required SLS throughput could be met    | O                 | type: integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| networkSliceThroughputTimePredictions | The predictions of the UL and/or DL network slice throughput in a certain time period. The value indicates the average percentage of time, during which the required SLS throughput could be met. | O                 | type: integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

### 8.4.2.3 Network slice traffic prediction

#### 8.4.2.3.1 MDA type

The MDA type for capability Network slice traffic prediction is: SLSAnalysis.NetworkSliceTrafficAnalysis.

#### 8.4.2.3.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceTrafficAnalysis MDA type are provided in table 8.4.2.3.2-1.

**Table 8.4.2.3.2-1: Enabling data for network slice traffic prediction analysis**

| Data category            | Description  | References   |
|--------------------------|--|--|
| Performance measurements | UL/DL throughput for network slice.                          | Upstream throughput for Network and Network Slice Instance (clause 6.3.3 in TS 28.554 [5]); Downstream throughput for Single Network Slice Instance (clause 6.3.4 in TS 28.554 [5]). |
|                          | Number of incoming and outgoing octets of GTP packet on N3   | See clauses 5.4.1.4 and 5.4.1.3 in TS 28.541 [5].  |
|                          | UL/DL UE throughput for network slice                        | RAN UE Throughput (clause 6.3.6 in TS 28.554 [5]).   |
|                          | Number of PDU sessions of network slice                      | Mean number of PDU sessions of network and network Slice Instance (clause 6.4.1 in TS 28.554 [5]).   |
|                          | Number of registered subscribers of a network slice instance | Mean registered subscribers of network and network slice through AMF (see clause 6.2.1 in TS 28.554 [5]).  |
|                          | Maximum packet size for a network slice                      | Maximum packet size for a network slice subnet (see clause 6.3.11 of TS 28.541 [5]).   |

### 8.4.2.3.3 Analytics output

The specific information elements of the analytics output for network slice traffic prediction analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.3.3-1.

**Table 8.4.2.3.3-1: Analytics output for network slice traffic prediction analysis**

| Information element | Definition  | Support qualifier | Properties   |
|---------------------|---|-------------------|--|
| trafficProjections  | This specifies the traffic projections for a slice. | M                 | type: TrafficProjections<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

### 8.4.2.4 E2E latency analysis

#### 8.4.2.4.1 MDA type

The MDA type for Capability-E2E latency analysis is: SLSAnalysis.E2ElatencyAnalysis.

#### 8.4.2.4.2 Enabling data

The enabling data for SLSAnalysis.E2ElatencyAnalysis MDA type are provided in table 8.4.2.4.2-1.

**Table 8.4.2.4.2-1: Enabling data for E2E latency analysis**

| Data category            | Description                                 | References  |
|--------------------------|---|---|
| Performance measurements | Average e2e UL/DL delay for a network slice | Average e2e uplink delay for a network (clause 6.3.1.8.1 in TS 28.554 [5]); Average e2e downlink delay for a network slice (clause 6.3.1.8.2 in TS 28.554 [5]). |
|                          | Integrated uplink/downlink delay in RAN     | Integrated downlink delay in RAN (clause 6.3.1.2 in TS 28.554 [5]); Integrated uplink delay in RAN (clause 6.3.1.7 in TS 28.554 [5]).                           |
|                          | Round-trip Packet Delay                     | Round-trip packet delay between PSA UPF and NG-RAN (clause 5.4.8 TS 28.552 [4]).  |

### 8.4.2.4.3 Analytics output

The specific information elements of the analytics output for E2E latency analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.4.3-1.

**Table 8.4.2.4.3-1: Analytics output for E2E latency analysis**

| Information element | Definition  | Support qualifier | Properties  |
|---------------------|---|-------------------|---|
| e2ELatencyIssued    | The identifier indicates the output is for E2E latency issue analysis   | M                 | type: String<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| e2ELatencyIssueType | Indication the type of the E2E latency issue.<br><br>The allowed value is one of the enumerated values: RAN latency issue, CN latency issue | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| affectedObjects     | The managed object instances of subnetwork, managed elements or network slices where the latency issue happens                              | O                 | type: DN<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

### 8.4.2.5 Network slice load analysis

#### 8.4.2.5.1 MDA type

The MDA type for Capability- Network slice load analysis is: SLSAnalysis.NetworkSliceLoadAnalysis.

#### 8.4.2.5.2 Enabling data

The enabling data for SLSAnalysis.NetworkSliceLoadAnalysis MDA type are provided in table 8.4.2.5.2-1.

**Table 8.4.2.5.2-1: Enabling data for network slice load analysis**

| Data category            | Description   | References   |
|--------------------------|---|--|
| Performance measurements | Number of PDU sessions of network slice                   | Mean number of PDU sessions of network and network Slice Instance (clause 6.4.1 in TS 28.554 [5]).   |
|                          | Number of PDU Sessions successfully setup                 | Number of PDU Sessions successfully setup (clause 5.1.1.5 in TS28.552 [4]).  |
|                          | Mean Number of PDU sessions                               | Number of PDU sessions(Mean) (clause 5.3.1.1 in TS 28.552 [4]).  |
| Network Data Analytics   | Analysis results from the control plane produced by NWDAF | Analytics data from NWDAF in TS 23.288 [10] including e.g. Slice load level related network data analytics clause 6.3, and the analytics for user plane performance (i.e. average/maximum traffic rate, average/maximum packet delay, average packet loss rate in clause 6.14. |
| Configuration data       | MOIs of the cells, NW slice/NW slice subnet, 5GC NFs      | NRM information TS 28.541 [15].  |

### 8.4.2.5.3 Analytics output

The specific information elements of the analytics output for network slice load analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.2.5.3-1.

**Table 8.4.2.5.3-1: Analytics output for network slice load analysis**

| Information element          | Definition   | Support qualifier | Properties  |
|------------------------------|--|-------------------|---|
| networkSliceLoadIssued       | The identifier indicates the output is for Network slice instance load analysis  | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| networkSliceLoadIssueDomain  | Indicates the domain of the network slice instance load issue<br><br>The allowed value is one of the enumerated values:<br>- RAN issue;<br>- CN issue  | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| networkSliceLoadIssuePhase   | Indicates the phase of the network slice instance load issue<br><br>The allowed value is one of the enumerated values: historic network slice load issue, ongoing network slice load issue, potential network slice load issue | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| networkSliceLoadIssueType    | Indicates the type of the network slice instance load issue<br><br>The allowed value is one of the enumerated values: overload network slice load issue, underutilized network slice load issue                                | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |
| affectedObjects              | The managed object instances involved in the network slice instance load problem   | O                 | type: DN<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| networkSliceLoadDistribution | Describes the detailed load distribution or predictive distribution, e.g. load distribution for a network slice instance at a certain location or in a certain time period   | O                 | type: list<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |

## 8.4.3 MDA assisted fault management

### 8.4.3.1 MDA assisted failure prediction

#### 8.4.3.1.1 MDA type

The MDA type for failure prediction analysis is: MDAAssistedFaultManagement.FailurePrediction.

#### 8.4.3.1.2 Enabling data

The enabling data for MDAAssistedFaultManagement.FailurePrediction MDA type are provided in table 8.4.3.1.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.3.1.2-1: Enabling data for fault predication analysis**

| Data category            | Description   | References  |
|--------------------------|---|---|
| Performance measurements | The deteriorated performance or the abnormal performance measurements based on certain performance monitoring threshold.<br>3GPP management system may monitor a set of performance measurements and their thresholds, so as to support the analytics of prediction of a network service failure. | The performance measurements as defined in TS 28.552 [4]  |
| Alarm notifications      | Alarm information, e.g. the alarm notification of network functions.  | Alarm information and notifications as per TS 28.532 [11] |
| Configuration data       | MOIs of the cells, UPFs and SMFs.   | TS 28.541 [15]  |
| Network analytics data   | The control plane analysis result from the NWDAF, e.g. observed service experience related network data analytics.  | TS 23.288 [10]  |

### 8.4.3.1.3 Analytics output

The specific information elements of the analytics output for failure prediction analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.3.1.3-1.

**Table 8.4.3.1.3-1: Analytics output for fault prediction analysis**

| Information element     | Definition  | Support qualifier | Properties  |
|-------------------------|---|-------------------|---|
| failurePredictionObject | Indication of NR cells or NFs where the failure related issues occurred or potentially occur.   | M                 | type: DN<br>multiplicity: 1..*<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False    |
| potentialFailureType    | Indication of type of issues that can cause the failures.<br><br>NOTE 1: The values can be defined as a list of example values: "Operational Violation", "Physical Violation" and "Time Domain Violation". See alarmType described in TS 28.532 [11]. | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| eventTime               | This field holds the time of potential failure predicted.<br><br>Examples: "20:15:00", "20:15:00-08:00" (for 8 hours behind UTC).   | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| issueID                 | This field holds the ID of this failure prediction which is reported.<br><br>When reports, this identifier can be used to provide the information to management system to maintain.   | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| perceivedSeverity       | This field holds the value to indicate relative level of urgency for operator attention.<br><br>NOTE 2: The value can be Critical, Major, Minor, Warning, Indeterminate, Cleared, see Recommendation ITU-T X.733 [27].                                | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |



## 8.4.4 MDA assisted energy saving

### 8.4.4.1 Energy saving analysis

#### 8.4.4.1.1 MDA type

The MDA type for energy saving analysis is: MDAAssistedEnergySaving.EnergySavingAnalysis.

#### 8.4.4.1.2 Enabling data

The enabling data for MDAAssistedEnergySaving.EnergySavingAnalysis MDA type are provided in table 8.4.4.1.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.4.1.2-1: Enabling data for energy saving analysis**

| Data category            | Description   | References   |
|--------------------------|---|--|
| Performance measurements | PNF Power Consumption: power consumed over the measurement period   | Clause 5.1.1.19.2 of TS 28.552 [4].                                |
|                          | PNF Energy consumption: energy consumed   | Clause 5.1.1.19.3 of TS 28.552 [4].                                |
|                          | SS-RSRP distribution per SSB (beam) of serving NR cell  | Clause 5.1.1.22.1 of TS 28.552 [4].                                |
|                          | SS-RSRP distribution per SSB (beam) of neighbor NR cell   | Clause 5.1.1.22.1 of TS 28.552 [4].                                |
|                          | PDCP Data Volume of NR cells: PDCP data volume delivered in the downlink and uplink   | Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4]                        |
|                          | Traffic load variation: <ul style="list-style-type: none"> <li>- PRB utilization rate;</li> <li>- RRC connection number;</li> <li>- etc.</li> </ul> | Clause 5.1.1.2 and 5.1.1.4 of TS 28.552 [4].                       |
|                          | UE throughput: <ul style="list-style-type: none"> <li>- UE throughput in downlink and uplink</li> </ul>   | Clause 5.1.1.3 of TS 28.552 [4].                                   |
|                          | Delay related measurements of UPF   | Clause 5.4 of TS 28.552 [4].                                       |
|                          | Data volume of UPF  | Clause 5.4 of TS 28.552 [4].                                       |
|                          | Virtual resource usage of NF: The virtual CPU usage, virtual memory usage, virtual disk usage of virtual network functions                          | Clause 5.7.1 of TS 28.552 [4].                                     |
| MDT reports              | The RSRPs of UE measurements  | RSRPs of M1 measurements in TS 32.422 [6] and TS 32.423 [7].       |
|                          | The RSRQs of UE measurements  | RSRQs of M1 measurements in TS 32.422 [6] and TS 32.423 [7].       |
|                          | The UE location information   | UE location of M1 measurements in TS 32.422 [6] and TS 32.423 [7]. |
| QoE Data                 | The measurements that are collected are DASH and MTSI measurements  | TS 28.406 [9].   |
| Configuration data       | MOIs of the cells, UPFs and SMFs  | TS 28.541 [15].  |
| Network analytics data   | The control plane analysis result from the NWDAF, e.g. observed service experience related network data analytics                                   | TS 23.288 [10].  |

#### 8.4.4.1.3 Analytics output

The specific information elements of the analytics output for energy saving analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.4.1.3-1.

Table 8.4.4.1.3-1: Analytics output for energy saving analysis

| Information element               | Definition  | Support qualifier | Properties  |
|-----------------------------------|---|-------------------|---|
| energyEfficiencyProblematicObject | Indication of NR cells or NFs where the energy efficiency issues occurred or potentially occur.   | M                 | type: DN<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False                     |
| energyEfficiencyProblemType       | Indication of type of the energy efficiency issues.<br><br>The allowed value is one of the enumerated values: HighEnergyConsumption, LowEnergyEfficiency, Other, Unknown.   | M                 | type: enumeration<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                  |
| trafficLoadTrends                 | The predictions of the trends of traffic load in a certain time period. The predictions include the traffic load of the issue cell(s) and neighboring cell(s).  | M                 | type: TrafficLoadTrend<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False       |
| energySavingRecommendations       | The recommendation shall contain the energy saving policy.<br>For ES on NR cells. It may contain a set of: <ul style="list-style-type: none"> <li>- Recommended NR Cell (ES-Cell) to enter energySaving state.</li> <li>- Recommended candidate cells with precedence for taking over the traffic of the ES-Cell.</li> <li>- The time to enter and terminate the energy saving state.</li> <li>- The load threshold to enter and terminate the energy saving state for the ES-Cell.</li> </ul> For ES on UPFs. It contains a set of: <ul style="list-style-type: none"> <li>- Recommended UPF (ES-UPF) to conduct energy saving.</li> <li>- Recommended candidate UPFs with precedence for taking over the traffic of the ES-UPF.</li> <li>- The time to conduct energy saving for the ES-UPF.</li> </ul> | M                 | type: EsRecommendation<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False       |
| statisticsOfCellsEsState          | The statistic result of current energy saving state of the cells at a certain time, which can be used by consumers to make analysis (e.g. observed service experience analysis made by NWDAF) or to make decision (e.g. enter/exit the energy saving state based on the current energy saving state).   | O                 | type: StatisticOfCellEsState<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

## 8.4.5 MDA assisted mobility management

### 8.4.5.1 Mobility performance analysis

#### 8.4.5.1.1 MDA type

The MDA type for mobility performance analysis is: MobilityManagementAnalytics.MobilityPerformanceAnalysis.

#### 8.4.5.1.2 Enabling data

The enabling data for MobilityManagementAnalytics.MobilityPerformanceAnalysis MDA type are provided in table 8.4.5.1.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.5.1.2-1: Enabling data for mobility performance analysis**

| Data category            | Description                     | References   |
|--------------------------|---------------------------------|--|
| Performance measurements | Inter-gNB handovers             | Inter-gNB handovers (clause 5.1.1.6.1 of TS 28.552 [4]). |
|                          | Intra-gNB handovers             | Inter-gNB handovers (clause 5.1.1.6.4 of TS 28.552 [4]). |
|                          | Inter-gNB DAPS handovers        | Inter-gNB handovers (clause 5.1.1.6.2 of TS 28.552 [4]). |
|                          | Intra-gNB DAPS handovers        | Inter-gNB handovers (clause 5.1.1.6.3 of TS 28.552 [4]). |
|                          | Inter-gNB conditional handovers | Inter-gNB handovers (clause 5.1.1.6.6 of TS 28.552 [4]). |
|                          | Intra-gNB conditional handovers | Inter-gNB handovers (clause 5.1.1.6.7 of TS 28.552 [4]). |

### 8.4.5.1.3 Analytics output

The specific information elements of the analytics output (MDA report) for mobility performance analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.5.1.3-1.

**Table 8.4.5.1.3-1: Analytics output for Mobility Performance analysis**

| Information element                | Definition  | Support qualifier | Properties   |
|------------------------------------|---|-------------------|--|
| mobilityPerformanceIssueIdentifier | The identifier of the mobility performance issue analysis;  | M                 | type: integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                                       |
| mobilityPerformanceIssueRootCause  | The root cause of mobility performance issues.<br><br>The allowed value is one of the enumerated values: too long mobility interruption time, poor coverage of the cell-edge, inappropriate handover parameters, other. | M                 | type: ENUM<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False  |
| mobilityPerformanceIssueLocation   | Geographical location areas where the mobility performance issue occurred.  | O                 | type: GeoArea (see TS 28.622 [19], to be confirmed)<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

### 8.4.5.2 Handover Optimization analysis

#### 8.4.5.2.1 MDA type

The MDA type for handover optimization is: MobilityManagementAnalytics.HandoverOptimization.

#### 8.4.5.2.2 Enabling data

The enabling data for handover optimization analysis are provided in table 8.4.5.2-1.

For general information about enabling data, see clause 8.2.1.

**Table 8.4.5.2.2-1: Enabling data for handover optimization analysis**

| Data category            | Description  | References  |
|--------------------------|--|---|
| Performance Measurements | Consumed virtual resources of target gNB   | Virtualised resource usage measurement (clause 6.2 of TS 28.552 [4])                        |
|                          | The physical radio resource utilization of each target cells   | Physical radio resource utilization of the target gNB, see clause 5.1.1.2 of TS 28.552 [4]; |
|                          | PDCP Data Volume of NR cells   | Clause 5.1.2.1 and 5.1.3.6 of TS 28.552 [4].  |
| MDT Data                 | UE measurements related to RSRP, RSRQ, SINR (serving cell and neighbour cells) and UE location information | RSRPs, RSRQs and UE location of M1 measurements for NR in TS 32.422 [6] and TS 32.423 [7].  |

### 8.4.5.2.3 Analytics output

The specific information elements of the analytics output for handover optimization analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.5.2.3-1.

**Table 8.4.5.2.3-1: Analytics output for handover optimization analysis**

| Information element | Definition   | Support qualifier | Properties  |
|---------------------|--|-------------------|---|
| hOTarget            | This provides analytics report for each target cell, of a target gNB, for handover optimization. | M                 | type: HOTargetType<br>multiplicity: 1..*<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

## 8.4.6 Maintenance management related analytics

### 8.4.6.1 Maintenance management analysis

#### 8.4.6.1.1 MDA type

The MDA type for maintenance management is: Maintenance.MaintenanceAnalytics.

#### 8.4.6.1.2 Enabling data

The enabling data for Maintenance.MaintenanceAnalytics MDA type are provided in table 8.4.6.1.2-1.

For general information about enabling data, see clause 8.2.1.

Table 8.4.6.1.2-1: Enabling data for maintenance analysis

| Data category            | Description  | References   |
|--------------------------|--|--|
| Performance Measurements | Number of Active DRB                                   | Mean number of DRBs being allocated (clause 5.1.1.10.9 of TS 28.552 [4]).  |
|                          | Number of bearers undergoing handover                  | Number of requested preparations for handovers from 5GS to EPS (clause 5.1.1.6.3.1 of TS 28.552 [4]).<br>Number of requested resource allocations for handovers from EPS to 5GS (clause 5.1.1.6.3.4 of TS 28.552 [4])<br>Number of requested preparations for EPS fallback handovers (clause 5.1.1.6.3.10 of TS 28.552 [4])<br>Number of successful executions for EPS fallback handovers (clause 5.1.1.6.3.13 of TS 28.552 [4]) |
|                          | Number of bearers being recovered from the error state | <b>Editors Note: to be defined in TS 28.552.</b>   |
|                          | Number of successful bearer modification               | Number of QoS flows attempted to modify (clause 5.1.1.13.4.1 of TS 28.552 [4])   |

### 8.4.6.1.3 Analytics output

The specific information elements of the analytics output for maintenance management analysis, in addition to the common information elements of the analytics outputs (see clause 8.3), are provided in table 8.4.6.1.3-1.

Table 8.4.6.1.3-1: Analytics output for maintenance analysis

| Information element   | Definition   | Support qualifier | Properties  |
|-----------------------|--|-------------------|---|
| currentUpgradeOptimal | This data type defines whether gNB can be upgrade at present             | M                 | type: CurrentUpgrade<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: none<br>isNullable: False |
| futureUpgradeOptimal  | This data type defines whether the gNB can be upgrade in future and when | M                 | type: FutureUpgrade<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: none<br>isNullable: False  |
| gNBID                 | This identifies the gNB  |                   | type: String<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: none<br>isNullable: False         |

## 8.5 Data type definitions

### 8.5.1 RecommendedAction <<dataType>>

#### 8.5.1.1 Definition

This data type specifies the type of recommended action in the analytics output.

## 8.5.1.2 Information elements

Table 8.5.1.2-1

| Name                            | Definition   | Support qualifier | Properties   |
|---------------------------------|--|-------------------|--|
| recommended3GPPActions          | It contains the recommendations actions concerning 3GPP defined operations on MOIs.  | O                 | type: Recommended3GPPAction<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| recommendedHumanReadableActions | It contains the recommendations on human readable actions.<br>NOTE: Further details of recommended human readable actions are not specified. | O                 | type: string<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                |

## 8.5.2 Recommended3GPPAction &lt;&lt;dataType&gt;&gt;

## 8.5.2.1 Definition

This data type specifies the data type of recommended 3GPP action.

## 8.5.2.2 Information elements

Table 8.5.2.2-1

| Name       | Definition   | Support qualifier | Properties  |
|------------|--|-------------------|---|
| mOInstance | Identifies the instance of a common ancestor object of the objects for which changes are recommended.  | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| path       | The "path" and "mOInstance" identify the object, attribute, attribute field or multi-value attribute element, that are recommended for creation, deletion or modification. | M                 | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

| Name           | Definition   | Support qualifier | Properties   |
|----------------|--|-------------------|--|
| op             | <p>It specifies the type of operation that is recommended for the MOI specified by the path.</p> <p>Allowed values: "add", "remove" and "replace".</p> <p>The operation describes what is recommended to do to the NRM.</p> <p>"add" shall be used for recommending the creation of an object, attribute, attribute field or multi-value attribute element.</p> <p>"remove" shall be used for recommending the deletion of an object, attribute, attribute field or multi-value attribute element.</p> <p>"replace" shall be used for recommending the replacement of an existing attribute value, attribute field value or multi-value attribute element.</p>   | M                 | <p>type: enumeration</p> <p>multiplicity: 1</p> <p>isOrdered: N/A</p> <p>isUnique: N/A</p> <p>defaultValue: None</p> <p>isNullable: False</p>                                |
| value          | <p>If an object creation is recommended with "add", the "value" shall carry a complete representation of the created object. If an object deletion is recommended with "remove", the "value" shall be absent. It may optionally carry a complete representation of the deleted object.</p> <p>If an attribute, attribute field or multi-value attribute element creation is recommended with "add", the "value" shall carry the value of the recommended attribute, attribute field or multi-value attribute element.</p> <p>If an attribute, attribute field or multi-value attribute element deletion is recommended with "remove", the "value" shall be absent.</p> <p>If the replacement of an attribute, attribute field or multi-value attribute element value is recommended with "replace", the "value" shall carry the new value of the attribute, attribute field or multi-value attribute element.</p> <p>If multiple objects are recommended for creation, the creation of parent objects shall be recommended before the child objects.</p> | CM                | <p>type: AttributeValuePair (see TS 32.156 [18])</p> <p>multiplicity: *</p> <p>isOrdered: False</p> <p>isUnique: True</p> <p>defaultValue: None</p> <p>isNullable: False</p> |
| additionalText | <p>It provides the additional text for the recommended change.</p>   | O                 | <p>type: string</p> <p>multiplicity: *</p> <p>isOrdered: False</p> <p>isUnique: False</p> <p>defaultValue: None</p> <p>isNullable: False</p>                                 |

### 8.5.2.3 Constraints

**Table 8.5.2.3-1**

| Name                    | Definition   |
|-------------------------|--|
| value Support Qualifier | Condition: value of op attribute is "add", or "replace". |

## 8.5.3 TrafficLoadTrend <<dataType>>

### 8.5.3.1 Definition

This data type specifies the type of TrafficLoadTrend.

### 8.5.3.2 Information elements

**Table 8.5.3.2-1**

| Name            | Definition  | Support qualifier | Properties  |
|-----------------|---|-------------------|---|
| cellId          | It indicates the cell for which the traffic load prediction is performed. | M                 | type: DN<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False         |
| startTime       | It indicates the start time that are used for traffic load prediction.    | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| endTime         | It indicates the end time that are used for traffic load prediction.      | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False   |
| trafficLoadList | It provides a list of PRB usage based on a specific granularity.          | M                 | type: Integer<br>multiplicity: 1..*<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.4 EsRecommendation <<dataType>>

### 8.5.4.1 Definition

This data type specifies the type of energy saving recommendations in the analytics output.

### 8.5.4.2 Information elements

**Table 8.5.4.2-1**

| Name                       | Definition   | Support qualifier | Properties   |
|----------------------------|--|-------------------|--|
| esRecommendationsOnNRcells | It contains the energy saving recommendations on NR cells. | M                 | type: EsRecommendationsOnNRcell<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| esRecommendationsOnUPFs    | It contains the energy saving recommendations on UPFs.     | M                 | type: EsRecommendationsOnUPF<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False    |



## 8.5.5 EsRecommendationsOnNRcell <<dataType>>

### 8.5.5.1 Definition

This data type specifies the type of energy saving recommendations on NR cells.

### 8.5.5.2 Information elements

**Table 8.5.5.2-1**

| Name              | Definition  | Support qualifier | Properties  |
|-------------------|---|-------------------|---|
| esNRcell          | It provides the DN of NR cell (ES-Cell) which is recommended to enter energySaving state.   | M                 | type: DN<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                                     |
| candidateNRcells  | It provides the DN of candidate NR cells which are recommended with precedence for taking over the traffic of ES-Cell.  | M                 | type: DN<br>multiplicity: *<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False                                  |
| enterTime         | It provides the recommended time to enter the energy saving state for the ES-Cell.  | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                               |
| endTime           | It provides the recommended time to terminate the energy saving state for the ES-Cell.  | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                               |
| trafficThresholds | It provides the recommended traffic threshold information. The ES-Cell can enter the energy saving state when the traffic is below the threshold value defined in the thresholdValue. | M                 | type: ThresholdInfo (see TS 28.622 [19])<br>multiplicity: *<br>isOrdered: False<br>isUnique: False<br>defaultValue: None<br>isNullable: False |

## 8.5.6 EsRecommendationsOnUPF <<dataType>>

### 8.5.6.1 Definition

This data type specifies the type of energy saving recommendations on UPFs.

## 8.5.6.2 Information elements

Table 8.5.6.2-1

| Name          | Definition  | Support qualifier | Properties  |
|---------------|---|-------------------|---|
| esUPF         | It provides the DN of UPF (ES-UPF) which is recommended to conduct energy saving.                                 | M                 | type: DN<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False       |
| candidateUPFs | It provides the DN of candidate UPFs which are recommended with precedence for taking over the traffic of ES-UPF. | O                 | type: DN<br>multiplicity: *<br>isOrdered: False<br>isUnique: True<br>defaultValue: None<br>isNullable: False    |
| conductTime   | It indicates the recommended time to conduct energy saving for the ES-UPF.  | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.7 StatisticOfCellEsState &lt;&lt;dataType&gt;&gt;

## 8.5.7.1 Definition

This data type specifies the type of statistics of cells energy saving state in the analytics output.

## 8.5.7.2 Information elements

Table 8.5.7.2-1

| Name               | Definition   | Support qualifier | Properties  |
|--------------------|--|-------------------|---|
| cellId             | It indicates the cell for which the statistics is performed.   | M                 | type: DN<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False       |
| startTime          | It indicates the start time that are used for statistics.  | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| endTime            | It indicates the end time that are used for statistics.  | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| ratioOfEsStateTime | It provides the ratio of the time when the cell is in the energy saving state to the total time between StartTime and EndTime. | M                 | type: Real<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False     |

## 8.5.8 CurrentUpgrade <<dataType>>

### 8.5.8.1 Definition

This data type specifies whether it is optimal to upgrade the gNB at present.

### 8.5.8.2 Information elements

**Table 8.5.8.2-1**

| Name                  | Definition   | Support qualifier | Properties   |
|-----------------------|--|-------------------|--|
| currentUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade at present. |                   | type: Boolean<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| numberOfGBRDRB        | This specifies the total number of GBR bearer at present.                |                   | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| numberOfNonGBRDRB     | This specifies the total number of non-GBR bearer at present.            |                   | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.9 FutureUpgrade <<dataType>>

### 8.5.9.1 Definition

This data type specifies whether it is optimal to upgrade the gNB at a future point of time.

### 8.5.9.2 Information elements

**Table 8.5.9.2-1**

| Name                 | Definition  | Support qualifier | Properties  |
|----------------------|---|-------------------|---|
| futureUpgradeOptimal | Boolean attribute indicating whether RAN Node can be upgrade at a future point of time.   | M                 | type: Boolean<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False  |
| optimalTime          | This specifies the future time at which the gNB can be upgraded optimally.<br><br>This shall be present only if the FutureUpgradeOptimal is TRUE.   | CM                | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| numberOfGBRDRB       | This specifies the total number of GBR bearer which will be present at the time stamp provided by the attribute OptimalTime.<br><br>This shall be present only if the FutureUpgradeOptimal is TRUE. | CM                | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False  |

| Name              | Definition  | Support qualifier | Properties   |
|-------------------|---|-------------------|--|
| numberOfNonGBRDRB | This specifies the total number of non-GBR bearer which will be present at the time stamp provided by the attribute OptimalTime.<br><br>This shall be present only if the FutureUpgradeOptimal is TRUE. | CM                | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.10 TrafficProjections <<dataType>>

### 8.5.10.1 Definition

This data type specifies the traffic projection for a slice.

### 8.5.10.2 Information elements

**Table 8.5.10.2-1**

| Name           | Definition  | Support qualifier | Properties  |
|----------------|---|-------------------|---|
| rojectionTime  | The time duration for which the projections are made.   | M                 | type: ProjectionDuration<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| uPFProjections | This specifies the traffic projection of a UPF in the slice.<br><br>It shall be present only if the analysis target contains CN part.                         | CM                | type: UPFProj<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False            |
| gNBProjections | This specifies the traffic projection of a gNB in the slice.<br><br>It shall be present only if the analysis target contains AN part.                         | CM                | type: gNBProj<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False            |
| SMFProjections | This specifies the projected number of PDU session of a SMF in the slice.<br><br>It shall be present only if the analysis target contains CN part.            | CM                | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False            |
| aMFProjections | This specifies the projected number of registered subscriber of an AMF in the slice.<br><br>It shall be present only if the analysis target contains CN part. | CM                | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False            |

## 8.5.11 UPFProj <<dataType>>

### 8.5.11.1 Definition

This data type specifies the traffic projection for a UPF.

## 8.5.11.2 Information elements

Table 8.5.11.2-1

| Name         | Definition  | Support qualifier | Properties  |
|--------------|---|-------------------|---|
| uLThroughput | The projected average UL throughput for a single UPF in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.<br><br>This is the projection of the Upstream Throughput at N3 interface KPI defined in TS 28.554 [5]    | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| dLThroughput | The projected average DL throughput for a single UPF in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.<br><br>This is the projection of the Downstream Throughput at N3 interface KPI defined in TS 28.554 [5]. | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| maxPktSize   | The projected average maximum packet size for a single UPF in the slice, over the time duration indicated by projectionTime attribute.  | O                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

## 8.5.12 gNBProj &lt;&lt;dataType&gt;&gt;

## 8.5.12.1 Definition

This data type specifies the traffic projection for a gNB.

## 8.5.12.2 Information elements

Table 8.5.12.2-1

| Name           | Definition   | Support qualifier | Properties  |
|----------------|--|-------------------|---|
| uLUEThroughput | The projected average UL UE throughput in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.<br><br>This is the projection of the UL RAN UE throughput KPI defined in TS 28.554 [5]. | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |
| dLUEThroughput | The projected average DL throughput in the slice, over the time duration indicated by projectionTime attribute. The unit is kbit/s.<br><br>This is the projection of the DL RAN UE throughput KPI defined in TS 28.554 [5].    | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: False |

## 8.5.13 HOTargetType <<dataType>>

### 8.5.13.1 Definition

This data type specifies the information about the target cell and gNB for handover.

The attribute `isOptimal` specify if the cell (served by gNB) is optimal for handover considering the current virtual, physical and radio resource consumption by the gNB and/or the cell. The value `TRUE` imply that the target is not resource deprived at present and can be selected for handover.

The attribute `futureOptimalInfo` specify if the cell (served by the gNB) will be optimal for handover at a future point of time considering the future virtual and radio resource consumption by the gNB and/or the cell . This will also provide projection of future virtual, and radio resource consumptions.

### 8.5.13.2 Information elements

**Table 8.5.13.2-1**

| Name                           | Definition  | Support qualifier | Properties   |
|--------------------------------|---|-------------------|--|
| <code>gNBId</code>             | See clause 4.4.1 of TS 28.541 [15].   | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                       |
| <code>cellLocalId</code>       | See clause 4.4.1 of TS 28.541 [15].   | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: TRUE<br>defaultValue: NULL<br>isNullable: False                      |
| <code>isOptimal</code>         | This specifies if the cell (served by the gNB) is optimal for handover with respect to the virtual and physical resource consumption of its gNB and its own radio resource consumption. The value <code>TRUE</code> indicates that the gNB is optimal at present.<br><br>Allowed Values: <code>TRUE</code> and <code>FALSE</code> . | M                 | type: Boolean<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: <code>TRUE</code><br>isNullable: False          |
| <code>futureOptimalInfo</code> | This specifies related information when the cell is optimal for handover in future.   | O                 | type: FutureOptimal<br>multiplicity: 1<br>isOrdered: False<br>isUnique: True<br>defaultValue: <code>TRUE</code><br>isNullable: False |

## 8.5.14 FutureOptimal <<dataType>>

### 8.5.14.1 Definition

This data type specifies the time duration for which the gNB is optimal for upgrade. This also provide virtual, physical and radio resource projections.

### 8.5.14.2 Information elements

Table 8.5.14.2-1

| Name              | Definition   | Support qualifier | Properties  |
|-------------------|--|-------------------|---|
| futureOptimalTime | This specifies the time duration during which the cell is optimal for handover.                                      | M                 | type: ProjectionDuration<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| projectedVResCon  | This specifies the projected virtual resource consumption of the gNB.<br><br>This exist only in case of virtual gNB. | CM                | type: VirRes<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False             |
| projectedRResCon  | This specifies the projected radio resource consumption of the cell.   | M                 | type: RadRes<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False             |

## 8.5.15 VirRes <<dataType>>

### 8.5.15.1 Definition

This data type specifies the virtual resource consumption.

### 8.5.15.2 Information elements

Table 8.5.15.2-1

| Name          | Definition  | Support qualifier | Properties   |
|---------------|---|-------------------|--|
| virtualCPU    | It indicates the average number of virtual CPU (see definition of numVirtualCpu in clause 7.1.9.2.3.2 of ETSI GS NFV-IFA 011 [26]) usage over the time duration indicated by FutureOptimalTime attribute. | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| virtualMemory | It indicates the average virtual memory size (see definition of virtualMemSize in clause 7.1.9.2.3.2 of ETSI GS NFV-IFA 011 [26]) usage over the time duration indicated by FutureOptimalTime attribute.  | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| virtualDisk   | It indicates the average virtual storage size (see definition of sizeOfStorage in clause 7.1.9.2.3.2 of ETSI GS NFV-IFA 011 [26]) usage over the time duration indicated by FutureOptimalTime attribute.  | M                 | type: Integer<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.16 RadRes <<dataType>>

### 8.5.16.1 Definition

This data type specifies the radio resource consumption.

### 8.5.16.2 Information elements

**Table 8.5.16.2-1**

| Name       | Definition   | Support qualifier | Properties  |
|------------|--|-------------------|---|
| dLPRBUsage | This specifies the average total usage (in percentage) of Physical Resource Blocks (PRBs) on the downlink for any purpose, over the time duration indicated by projectionTime attribute. | M                 | type: Real<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| uLPRBUsage | This specifies the average total usage (in percentage) of Physical Resource Blocks (PRBs) on the uplink for any purpose, over the time duration indicated by projectionTime attribute.   | M                 | type: Real<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |

## 8.5.17 ProjectionDuration <<dataType>>

### 8.5.17.1 Definition

This data type specifies the time duration for which the projections are made.

### 8.5.17.2 Information elements

**Table 8.5.17.2-1**

| Name     | Definition   | Support qualifier | Properties  |
|----------|--|-------------------|---|
| fromTime | This specifies the timestamp from when the projection are made | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |
| toTime   | This specifies the timestamp till when the projection are made | M                 | type: DateTime<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False |



## 9 Information model definitions for MDA

### 9.1 Imported and associated information entities

#### 9.1.1 Imported information entities and local labels

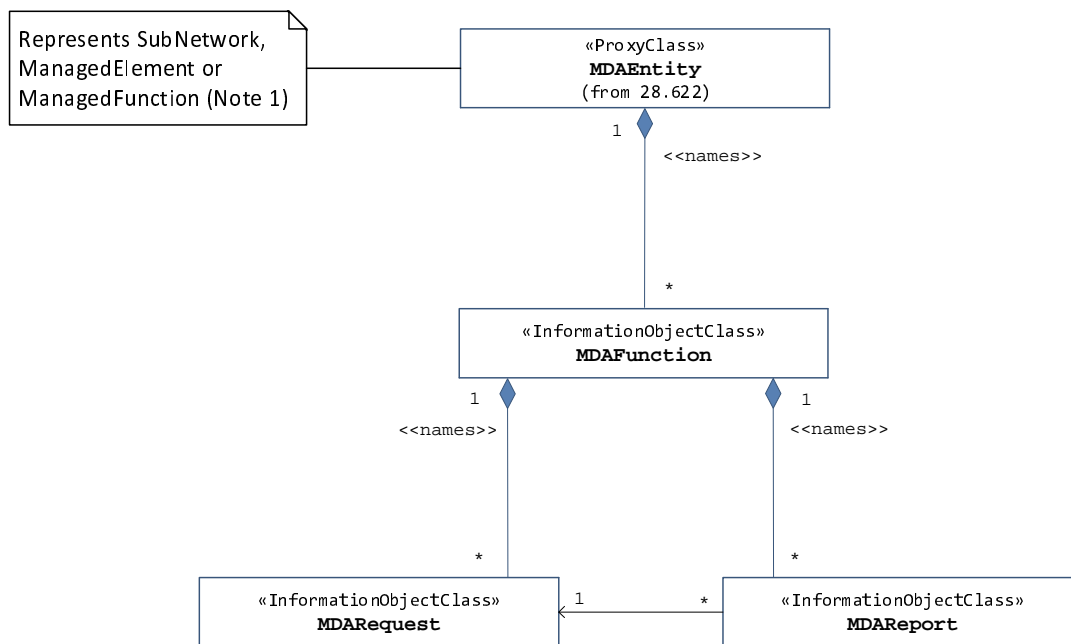
Table 9.1.1-1

| Label reference                      | Local label     |
|--------------------------------------|-----------------|
| TS 28.622 [19], IOC, Top             | Top             |
| TS 28.622 [19], IOC, SubNetwork      | SubNetwork      |
| TS 28.622 [19], IOC, ManagedElement  | ManagedElement  |
| TS 28.622 [19], IOC, ManagedFunction | ManagedFunction |

## 9.2 Class diagram

### 9.2.1 Relationships

This clause provides the relationships of relevant classes in UML.



NOTE: When the MDAEntity represents the ManagedElement or ManagedFunction, it means the MDAF is located in the NE/NF that the ManagedElement or ManagedFunction represents, but it does not mean the MDA is the feature of the NE/NF.

Figure 9.2.1-1: NRM fragment for MDA request and MDA report

## 9.2.2 Inheritance

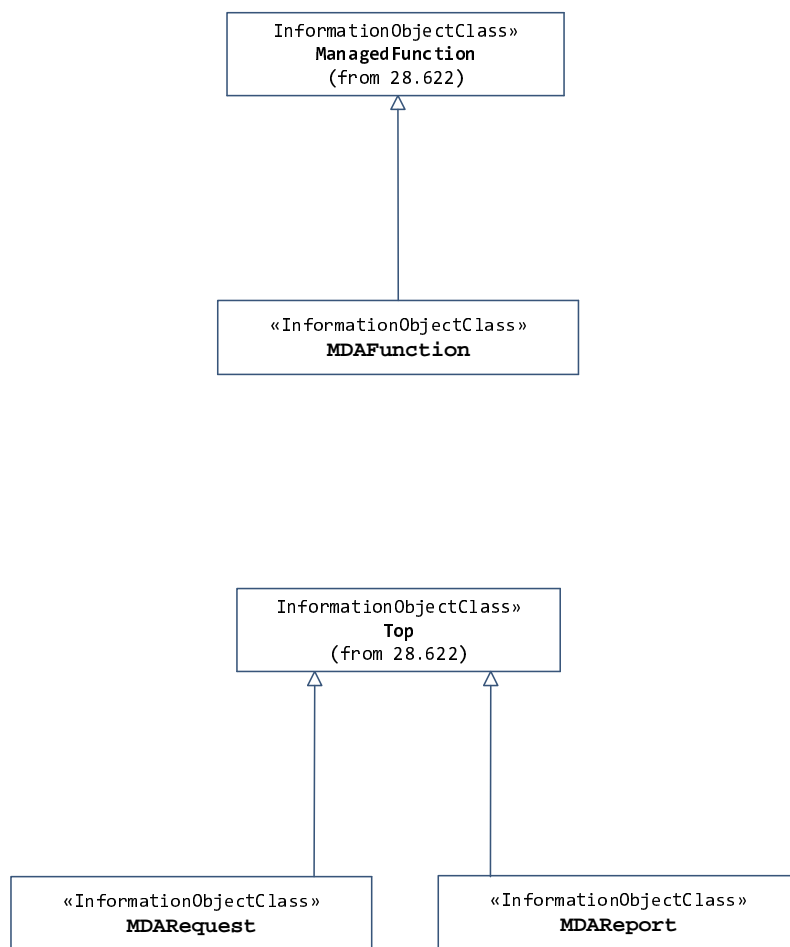


Figure 9.2.2-1: Inheritance Hierarchy

## 9.3 Class definitions

### 9.3.1 MDAFunction

#### 9.3.1.1 Definition

The IOC MDAFunction represents the MDA function which supports one or more MDA capabilities.

#### 9.3.1.2 Attributes

Table 9.3.1.2-1

| Attribute name           | S | isReadable | isWritable | isInvariant | isNotifiable |
|--------------------------|---|------------|------------|-------------|--------------|
| supportedMDACapabilities | M | T          | F          | F           | T            |

#### 9.3.1.3 Attribute constraints

None.

### 9.3.1.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

## 9.3.2 MDARequest

### 9.3.2.1 Definition

The IOC `MDARequest` represents the MDA output request created by an MnS consumer.

The attribute `requestedMDAOutputs` contains one or multiple `MDAOutputPerMDAType` elements, and each `MDAOutputPerMDAType` element supports filtering of MDA output for a certain MDA type.

### 9.3.2.2 Attributes

**Table 9.3.2.2-1**

| Attribute name                   | S | isReadable | isWritable | isInvariant | isNotifiable |
|----------------------------------|---|------------|------------|-------------|--------------|
| <code>requestedMDAOutputs</code> | M | T          | T          | F           | T            |
| <code>reportingMethod</code>     | M | T          | T          | F           | T            |
| <code>reportingTarget</code>     | M | T          | T          | F           | T            |
| <code>analyticsScope</code>      | M | T          | T          | F           | T            |
| <code>startTime</code>           | M | T          | T          | F           | T            |
| <code>stopTime</code>            | M | T          | T          | F           | T            |
| <code>analyticsWindow</code>     | M | T          | T          | F           | T            |

### 9.3.2.3 Attribute constraints

None.

### 9.3.2.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

## 9.3.3 MDAReport

### 9.3.3.1 Definition

The IOC `MDAReport` represents the report containing the outputs for one or more MDA types delivered to the MDA consumer.

### 9.3.3.2 Attributes

**Table 9.3.3.2-1**

| Attribute name           | S | isReadable | isWritable | isInvariant | isNotifiable |
|--------------------------|---|------------|------------|-------------|--------------|
| <code>mDAReportID</code> | M | T          | F          | T           | T            |
| <code>mDAOutputs</code>  | M | T          | F          | F           | T            |

NOTE: The content represented by this IOC can be reported by notification, file and streaming.

### 9.3.3.3 Attribute constraints

None.

### 9.3.3.4 Notifications

The common notifications defined in clause 9.6 are valid for this IOC, without exceptions or additions.

## 9.4 Data type definitions

### 9.4.1 MDAOutputPerMDAType <<dataType>>

#### 9.4.1.1 Definition

This <<dataType>> represents the analytics output filters for each MDA type for an MDA request.

If only `mDAType` element is present (i.e. `mDAOutputIEFilters` element is not present), then all of the MDA output information elements for this `mDAType` (see analytics output definitions per MDA capability in clause 8) are requested.

if `mDAOutputIEFilters` element is present, then only the listed analytics output information elements are requested and shall be reported according to the corresponding threshold.

#### 9.4.1.2 Attributes

**Table 9.4.1.2-1**

| Attribute name                  | S | isReadable | isWritable | isInvariant | isNotifyable |
|---------------------------------|---|------------|------------|-------------|--------------|
| <code>mDAType</code>            | M | T          | T          | F           | T            |
| <code>mDAOutputIEFilters</code> | O | T          | T          | F           | T            |

#### 9.4.1.3 Attribute constraints

None.

#### 9.4.1.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.2 MDAOutputIEFilter <<dataType>>

#### 9.4.2.1 Definition

This <<dataType>> represents the filter for an MDA output information element for an MDA request.

If only `mDAOutputIEName` element is present (i.e. `filterValue` and `threshold` elements are not present), then the MDA output information element indicated by the `mDAOutputIEName` is requested and reported without filter or threshold.

If `filterValue` element is present (only applicable when the MDA output information element indicated by `mDAOutputIEName` is non-numeric type (e.g. enum, string)), then the MDA output information element indicated by the `mDAOutputIEName` is only requested and reported when its value equals to the value of `filterValue`.

If `threshold` element is present (only applicable when the MDA output information element indicated by `mDAOutputIEName` is numeric type (e.g. integer, real)), then the MDA output information element indicated by the `mDAOutputIEName` is only requested and reported when its value reaches or crosses the threshold.

If `mDAOutputIEAnalyticsPeriod` element is present (only applicable when `mDAOutputIEFilterValue` and `mDAOutputIETHreshold` elements are not present), then the MDA output information element indicated by the `mDAOutputIENAME` is only requested and reported, at specified time or periodically, i.e. when time reaches the indicated time schedule.

`mDAOutputIETimeOut` element is present optionally when an MDA MnS consumer needs an `mDAOutputIENAME` element before a specified time only.

#### 9.4.2.2 Attributes

Table 9.4.2.2-1

| Attribute name               | Support Qualifier | isReadable | isWritable | isInvariant | isNotifiable |
|------------------------------|-------------------|------------|------------|-------------|--------------|
| <code>mDAOutputIENAME</code> | M                 | T          | T          | F           | T            |
| <code>filterValue</code>     | CO                | T          | T          | F           | T            |
| <code>threshold</code>       | CO                | T          | T          | F           | T            |
| <code>analyticsPeriod</code> | O                 | T          | T          | F           | T            |
| <code>timeOut</code>         | O                 | T          | T          | F           | T            |

#### 9.4.2.3 Attribute constraints

Table 9.4.2.3-1

| Name                     | Definition   |
|--------------------------|--|
| <code>filterValue</code> | Condition: the MDA output information element indicated by the <code>mDAOutputIENAME</code> element is non-numeric type (e.g. enum, string). |
| <code>threshold</code>   | Condition: the MDA output information element indicated by the <code>mDAOutputIENAME</code> element is numeric type (e.g. integer, real).    |

#### 9.4.2.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.3 AnalyticsScopeType <<choice>>

#### 9.4.3.1 Definition

This <<choice>> represents the scope of analytics.

When the `managedEntitiesScope` attribute is present, the MnS producer identify the analytics scope by the DNs of the managed entities.

When the `areaScope` attribute is present, the MnS producer identify the analytics scope by the geographical area information.

The `managedEntitiesScope` attribute and `areaScope` attribute shall not be present at the same time.

#### 9.4.3.2 Attributes

Table 9.4.3.2-1

| Attribute name                             | S  | isReadable | isWritable | isInvariant | isNotifiable |
|--|----|------------|------------|-------------|--------------|
| Choice_1 <code>managedEntitiesScope</code> | CM | T          | T          | F           | T            |
| Choice_2 <code>areaScope</code>            | CM | T          | T          | F           | T            |

### 9.4.3.3 Attribute constraints

**Table 9.4.3.3-1**

| Name                          | Definition   |
|-------------------------------|--|
| Choice_1 managedEntitiesScope | Condition: the MDA MnS producer supports to identify the scope by managed entities.          |
| Choice_2 areaScope            | Condition: MDA MnS producer supports to identify the scope by geographical area information. |

### 9.4.3.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

## 9.4.4 TimeWindow <<dataType>>

### 9.4.4.1 Definition

This <<dataType>> represents the time duration related to the MDA output towards the MDA MnS consumer.

### 9.4.4.2 Attributes

**Table 9.4.4.2-1**

| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
|----------------|---|------------|------------|-------------|--------------|
| startTime      | M | T          | T          | F           | T            |
| endTime        | M | T          | T          | F           | T            |

### 9.4.4.3 Attribute constraints

None.

### 9.4.4.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

## 9.4.5 MDAOutputs <<dataType>>

### 9.4.5.1 Definition

The IOC MDAOutputs represents the MDA outputs created by an MDA MnS producer for a specific MDA type.

### 9.4.5.2 Attributes

**Table 9.4.5.2-1**

| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
|----------------|---|------------|------------|-------------|--------------|
| mDType         | M | T          | T          | F           | T            |
| mdaOutputList  | M | T          | T          | F           | T            |
| mdaRequestRef  | M | T          | F          | F           | T            |

### 9.4.5.3 Attribute constraints

None.

#### 9.4.5.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.6 MDAOutputEntry <<dataType>>

#### 9.4.6.1 Definition

This data type specifies an MDA output.

#### 9.4.6.2 Attributes

**Table 9.4.6.2-1**

| Attribute name   | S | isReadable | isWritable | isInvariant | isNotifyable |
|------------------|---|------------|------------|-------------|--------------|
| mdaOutputIENName | M | T          | T          | F           | T            |
| mdaOutputIEValue | M | T          | T          | F           | T            |
| analyticsWindow  | M | T          | T          | F           | T            |
| confidenceDegree | M | T          | T          | F           | T            |

#### 9.4.6.3 Attribute constraints

None.

#### 9.4.6.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

### 9.4.7 TimeWindow <<dataType>>

#### 9.4.7.1 Definition

The <<dataType>> represents the time duration related to the MDA output towards the MDA MnS consumer.

#### 9.4.7.2 Attributes

**Table 9.4.7.2-1**

| Attribute name | S | isReadable | isWritable | isInvariant | isNotifyable |
|----------------|---|------------|------------|-------------|--------------|
| startTime      | M | T          | T          | F           | T            |
| endTime        | M | T          | T          | F           | T            |

#### 9.4.7.3 Attribute constraints

None.

#### 9.4.7.4 Notifications

The <<IOC>> using this <<dataType>> for one of its attributes, shall be applicable.

## 9.5 Attribute definitions

### 9.5.1 Attribute properties

Table 9.5.1-1

| Attribute Name      | Documentation and Allowed Values  | Properties  |
|---------------------|---|---|
| mDAType             | It indicates the type of MDA type (corresponding to the MDA capability).<br><br>AllowedValues: the value of MDA type defined for each MDA capability in clause 8.   | type: String<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                              |
| requestedMDAOutputs | It indicates the requested analytics outputs for an MDA request.  | type: MDAOutputPerMDAType<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False                |
| mDAOutputIEFilters  | It provides the filters for the analytics output information elements of an MDA type for an MDA request.  | type: MDAOutputIEFilter<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                   |
| mDAOutputIENAME     | It indicates the analytics output information element name of an MDA type for an MDA request.<br><br>AllowedValues: the analytics output information element names for each MDA type as specified in clause 8.  | type: string<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                              |
| filterValue         | It indicates the filter value for analytics output information element for an MDA request.<br><br>The MDA output information element is only requested and reported when its value equals to the value of this attribute.<br><br>allowedValues: depends on the definitions of the analytics output information element (see clause 8) indicated by mDAOutputIENAME attribute. | The type for the corresponding mdaOutputIENAME as defined in clause 8   |
| threshold           | It indicates the threshold for analytics output information element for an MDA request.   | type: ThresholdInfo (see TS 28.622 [19])<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: True |
| analyticsPeriod     | It indicates a list of times, which may determine a time-period related to a time schedule for analytics period.  | type: DateTime (see TS 32.156 [18])<br>multiplicity: 1..*<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: True   |
| timeOut             | It indicates a time until which an MDA MnS consumer needs to obtain an MDA output. Beyond this time the MDA output is no longer needed by the MDA MnS consumer.   | type: DateTime (see TS 32.156 [18])<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True       |



| Attribute Name       | Documentation and Allowed Values  | Properties  |
|----------------------|---|---|
| reportingMethod      | It indicates the reporting method of the analytics output selected by the MnS consumer.<br><br>allowedValues: File, Streaming, Notification.  | type: Enum<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                          |
| reportingTarget      | It indicates the reporting target of the MDA outputs.<br><br>Allowed values: URI.   | type: String<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                        |
| analyticsScope       | It indicates the scope of the analytics requested by the MnS consumer.  | type: AnalyticsScopeType<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True            |
| managedEntitiesScope | It indicates the scope of the analytics by the DNs of the managed entities.<br><br>It carries the DN(s) of SubNetwork MOI(s), ManagedElement MOI(s), and/or the MOI(s) of the derivative IOCs of ManagedFunction (see TS 28.622 [19]).<br><br>For each MOI provided by this attribute, the MOI itself and all of its subordinated MOIs are in the scope of analytics. | type: DN<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                            |
| areaScope            | It indicates the scope of the analytics by the geographical area information.   | type: GeoArea (see TS 28.622)<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True       |
| startTime            | It indicates the start time of the analytics requested by the MnS consumer.   | type: DateTime (see TS 32.156 [18])<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True |
| stopTime             | It indicates the stop time of the analytics requested by the MnS consumer.  | type: DateTime (see TS 32.156 [18])<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True |
| analyticsWindow      | It indicates the time duration related with the analytics output towards the MDA MnS consumer.  | type: TimeWindow<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                    |
| mDAReportID          | It indicates the identifier for the MDARreport.   | type: string<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True                        |

| Attribute Name           | Documentation and Allowed Values  | Properties   |
|--------------------------|---|--|
| mdaOutputList            | It indicates a list of output results related to particular MDA type.   | type: MDAOutputEntry<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True |
| analyticsWindow          | It indicates the time duration related to MDA output. It can be in the past, when the analytics is statistics, or in the future for a prediction.           | type: TimeWindow<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: True     |
| mdaOutputIEValue         | It indicates the MDA output result that can be numeric or non-numeric.  | The type for the corresponding mdaOutputIENAME as defined in clause 8  |
| confidenceDegree         | A probability range that contains the degree of accuracy of the analytics output statistics or prediction.  | type: Real<br>multiplicity: 1<br>isOrdered: N/A<br>isUnique: N/A<br>defaultValue: None<br>isNullable: False          |
| supportedMDACapabilities | It indicates the MDA capabilities supported by the MDA function.<br><br>AllowedValues: the value of MDA types defined for the MDA capabilities in clause 8. | type: String<br>multiplicity: *<br>isOrdered: N/A<br>isUnique: True<br>defaultValue: None<br>isNullable: True        |

## 9.6 Common notifications

### 9.6.1 Configuration notifications

This clause presents a list of notifications, defined in TS 28.532 [11], that an MnS consumer may receive. The notification header attribute `objectClass/objectInstance` shall capture the DN of an instance of a class defined in the present document.

**Table 9.6.1-1**

| Name                           | Qualifier | Notes |
|--------------------------------|-----------|-------|
| notifyMOICreation              | O         | --    |
| notifyMOIDeletion              | O         | --    |
| notifyMOIAttributeValueChanges | O         | --    |
| notifyEvent                    | O         | --    |

## 10 MDA related service components

### 10.1 MDA MnS Service components

#### 10.1.1 General

The MDA MnS service components are defined below for both MDA request and control and for MDA reporting taking into consideration the requirements defined in clause 7.3, the MDA capability data definitions in clause 8 and information models for MDA defined in clause 9

## 10.1.2 MDA report request and control

### 10.1.2.1 Service components

**Table 10.1.2.1-1: Components of MDA MnS for MDA request and control**

| Management service              | Management service component type A  | Management service component type B     |
|---------------------------------|--|---|
| MnS for MDA request and control | <p>The operations and notifications can be referred in TS 28.532 [11]. Which can be supported by all use cases.</p> <p>Operation:</p> <ul style="list-style-type: none"> <li>- createMOI</li> <li>- getMOIAttributes</li> <li>- modifyMOIAttributes</li> <li>- deleteMOI</li> </ul> <p>Notification:</p> <ul style="list-style-type: none"> <li>- notifyMOICreation</li> <li>- notifyMOIDeletion</li> <li>- notifyMOIAttributeValueChanges</li> <li>- notifyEvent</li> <li>- notifyMOIChanges</li> </ul> | MDARequest IOC defined in clause 9.3.2. |

## 10.1.3 MDA reporting

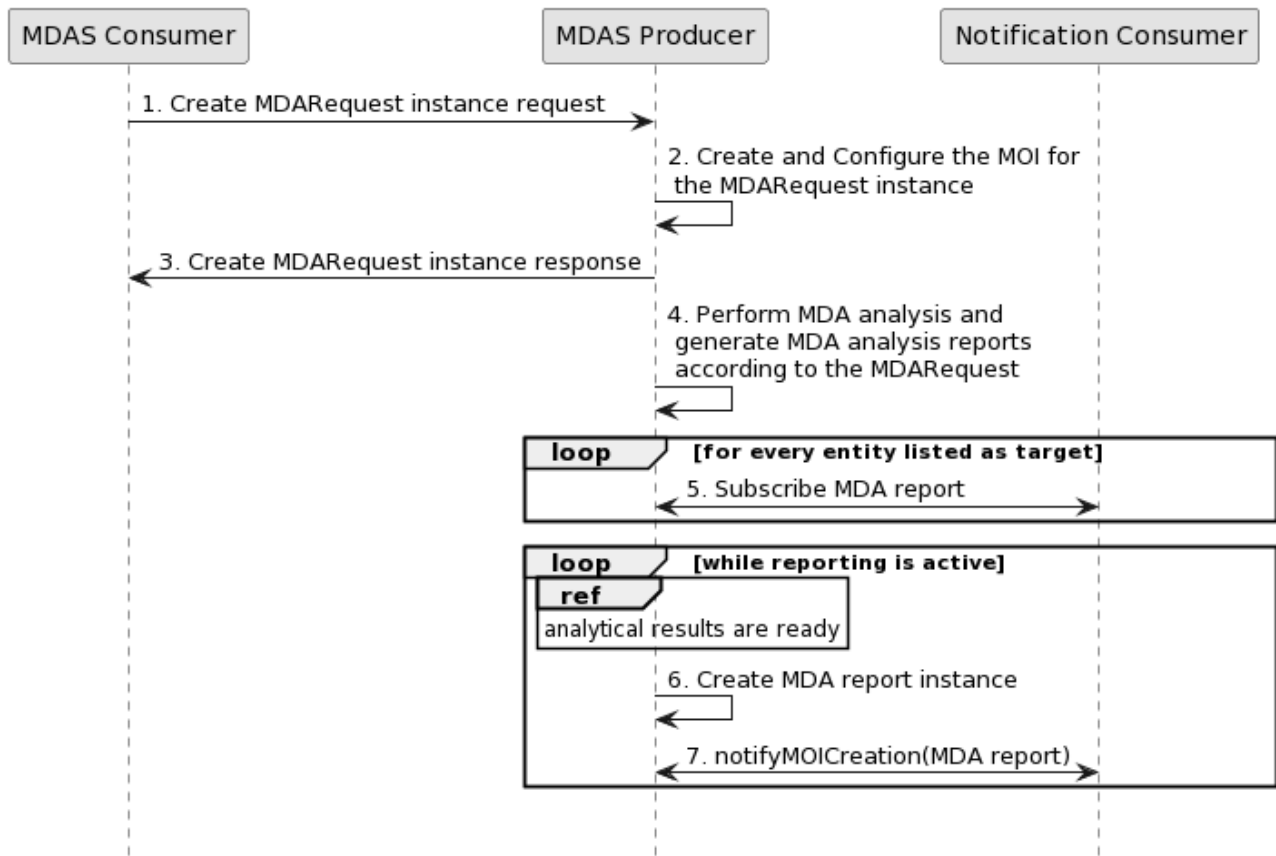
### 10.1.3.1 Service components

**Table 10.1.3.1-1: Components of MDA MnS for MDA reporting**

| Management service                                       | Management service component type A   | Management service component type B | Management service component type C  |
|--|---|-------------------------------------|--|
| MnS for MDA reporting - File based reporting             | <p>The operations and notifications in TS 28.532 [11], clause 11.6 are applicable and shall be supported for all MDA capabilities.</p> <p>Operations:</p> <ul style="list-style-type: none"> <li>- subscribe</li> <li>- unsubscribe</li> <li>- listAvailableFiles</li> </ul> <p>Notifications:</p> <ul style="list-style-type: none"> <li>- notifyFileReady</li> <li>- notifyFilePreparationError</li> </ul>      | MDAReport IOC defined in clause 9.  | The file containing the content defined by MDAReport IOC with the format specified in clause A.2.2.        |
| MnS for MDA reporting - Streaming based reporting        | <p>The operations and notifications in TS 28.532 [11], clause 11.5 are applicable and shall be supported for all MDA capabilities.</p> <p>Operations:</p> <ul style="list-style-type: none"> <li>- establishStreamingConnection</li> <li>- terminateStreamingConnection</li> <li>- reportStreamData</li> <li>- addStream</li> <li>- deleteStream</li> <li>- getConnectionInfo</li> <li>- getStreamInfo</li> </ul> | MDAReport IOC defined in clause 9.  | The stream data containing the content defined by MDAReport IOC with the format specified in clause A.2.2. |
| MnS for MDA reporting - NRM notification based reporting | <p>The following operations and notifications in TS 28.532 [11], clause 11.1 are applicable and shall be supported for all MDA capabilities.</p> <p>Operations:</p> <ul style="list-style-type: none"> <li>- getMOIAttributes</li> </ul> <p>Notifications:</p> <ul style="list-style-type: none"> <li>- notifyMOICreation</li> <li>- notifyMOIDeletion</li> <li>- notifyMOIChanges</li> </ul>                     | MDAReport IOC defined in clause 9.  |  |

# 11 Workflows for MDA management

## 11.1 MDA request and reporting workflow



**Figure 11.1-1: Generic MDA request/reporting workflow**

1 MDAS Producer receives a Create MDARequest MOI request (see createMOI operation defined in TS 28.532 [11]) from MDAS Consumer with MDA request related information.

NOTE: The MDA request related information see information model definition for MDA request NRM in clause 9.

2 The MDAS Producer creates the MOI for the MDARequest to be created.

3 The MDAS Producer sends the Create MDARequest MOI response (see createMOI operation defined in TS 28.532 [11]) to MDAS Consumer with identifier of MOI.

4 The MDAS Producer performs MDA analysis and generate MDA report (see the MDAReport IOC defined in clause 9) according to the MDA request.

5 The Notification consumer subscribes an MDA report by invoking the subscribe operation.

6 The MDAS producer creates an MDA report instance.

7 The MDAS producer sends the notification containing the MDA report to subscribed Notification consumers.

---

## 12 Solution Set (SS)

The present document defines the following NRM Solution Set definitions for MDA:

- YAML based Solution Set (Annex A).

---

# Annex A (normative): OpenAPI definitions of the MDA NRM and MDA report

## A.1 General

This annex contains the OpenAPI definitions of the MDA NRM and MDA report in YAML format.

The information models of the MDA NRM and MDA report are defined in clause 9.

Mapping rules to produce the OpenAPI definition based on the information model are defined in TS 32.160 [25].

---

## A.2 Solution Set (SS) definitions

### A.2.1 OpenAPI document "mdaNrm.yaml"

```

openapi: 3.0.1
info:
  title: MDA NRM
  version: 17.0.0
  description: >-
    OAS 3.0.1 specification of the MDA NRM
    © 2020, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).
    All rights reserved.
externalDocs:
  description: TS 28.104; MDA
  url: http://www.3gpp.org/ftp/Specs/archive/28_series/28.104/
paths: {}
components:
  schemas:

#----- Definition of types-----

MDATypes:
  type: array
  items:
    type: string

MDAOutputs:
  type: array
  items:
    $ref: '#/components/schemas/MDAOutputPerMDAType'

MDAOutputPerMDAType:
  type: object
  properties:
    mDAType:
      type: string
    mDAOutputIEFilters:
      type: array
      items:
        $ref: '#/components/schemas/MDAOutputIEFilter'

MDAOutputIEFilter:
  type: object
  properties:
    mDAOutputIENName:
      type: string
    filterValue:
      type: string
    threshold:
      $ref: 'genericNrm.yaml#/components/schemas/ThresholdInfo'
    analyticsPeriod:
      type: array
      items:
        $ref: 'comDefs.yaml#/components/schemas/DateTime'
    timeOut:
      $ref: 'comDefs.yaml#/components/schemas/DateTime'

```

```

ReportingMethod:
  type: string
  enum:
    - FILE
    - STREAMING
    - NOTIFICATION

ReportingTarget:
  $ref: 'comDefs.yaml#/components/schemas/Uri'

AnalyticsScope:
  oneOf:
    - type: object
      properties:
        managedEntitiesScope:
          $ref: 'comDefs.yaml#/components/schemas/DnList'
    - type: object
      properties:
        areaScope:
          $ref: '#/components/schemas/GeoAreaList'

GeoAreaList:
  type: array
  items:
    $ref: '#/components/schemas/GeoArea'

GeoArea:
  type: object
  properties:
    coordinates:
      type: array
      items:
        $ref: '#/components/schemas/Coordinate'
    altitude:
      type: number
      format: float

Coordinate:
  type: object
  properties:
    latitude:
      $ref: 'comDefs.yaml#/components/schemas/Latitude'
    longitude:
      $ref: 'comDefs.yaml#/components/schemas/Longitude'

#----- Definition of abstract IOCs -----

#----- Definition of concrete IOCs -----

SubNetwork-Single:
  allOf:
    - $ref: 'genericNrm.yaml#/components/schemas/Top'
    - type: object
      properties:
        attributes:
          $ref: 'genericNrm.yaml#/components/schemas/SubNetwork-Attr'
    - $ref: 'genericNrm.yaml#/components/schemas/SubNetwork-ncO'
    - type: object
      properties:
        SubNetwork:
          $ref: '#/components/schemas/SubNetwork-Multiple'
        ManagedElement:
          $ref: '#/components/schemas/ManagedElement-Multiple'
        MDFunction:
          $ref: '#/components/schemas/MDFunction-Multiple'
        MDAReport:
          $ref: '#/components/schemas/MDAReport-Multiple'

ManagedElement-Single:
  allOf:
    - $ref: 'genericNrm.yaml#/components/schemas/Top'
    - type: object
      properties:

```



```

    attributes:
      $ref: 'genericNrm.yaml#/components/schemas/ManagedElement-Attr'
  - $ref: 'genericNrm.yaml#/components/schemas/ManagedElement-ncO'
  - type: object
  properties:
    MDAFunction:
      $ref: '#/components/schemas/MDAFunction-Multiple'

```

```

MDAFunction-Single:
  allOf:
  - $ref: 'genericNrm.yaml#/components/schemas/Top'
  - type: object
  properties:
    attributes:
      allOf:
      - $ref: 'genericNrm.yaml#/components/schemas/ManagedFunction-Attr'
      - type: object
      properties:
        supportedMDACapabilities:
          $ref: '#/components/schemas/MDATypes'
  - $ref: 'genericNrm.yaml#/components/schemas/ManagedFunction-ncO'
  - type: object
  properties:
    MDAResult:
      $ref: '#/components/schemas/MDAResult-Multiple'

```

```

MDAResult-Single:
  allOf:
  - $ref: 'genericNrm.yaml#/components/schemas/Top'
  - type: object
  properties:
    attributes:
      allOf:
      - type: object
      properties:
        requestedMDAOutputs:
          $ref: '#/components/schemas/MDAOutputs'
        reportingMethod:
          $ref: '#/components/schemas/ReportingMethod'
        reportingTarget:
          $ref: '#/components/schemas/ReportingTarget'
        analyticsScope:
          $ref: '#/components/schemas/AnalyticsScope'
        startTime:
          $ref: 'comDefs.yaml#/components/schemas/DateTime'
        stopTime:
          $ref: 'comDefs.yaml#/components/schemas/DateTime'

```

```

MDAResult-Single:
  $ref: 'mdaReport.yaml#/components/schemas/MDAResult'

```

#----- Definition of JSON arrays for name-contained IOCs -----

```

SubNetwork-Multiple:
  type: array
  items:
    $ref: '#/components/schemas/SubNetwork-Single'
ManagedElement-Multiple:
  type: array
  items:
    $ref: '#/components/schemas/ManagedElement-Single'
MDAFunction-Multiple:
  type: array
  items:
    $ref: '#/components/schemas/MDAFunction-Single'
MDAResult-Multiple:
  type: array
  items:
    $ref: '#/components/schemas/MDAResult-Single'
MDAResult-Multiple:
  type: array
  items:
    $ref: '#/components/schemas/MDAResult-Single'

```

#----- Definitions in TS 28.104 for TS 28.532 -----

```

resources-mdaNrm:
  oneOf:
    - $ref: '#/components/schemas/SubNetwork-Single'
    - $ref: '#/components/schemas/ManagedElement-Single'

    - $ref: '#/components/schemas/MDAFunction-Single'
    - $ref: '#/components/schemas/MDARequest-Single'
    - $ref: '#/components/schemas/MDAReport-Single'

```

## A.2.2 OpenAPI document "mdaReport.yaml"

```

openapi: 3.0.1
info:
  title: MDA Report
  version: 17.0.0
  description: >-
    OAS 3.0.1 specification of the MDA Report
    © 2020, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).
    All rights reserved.
externalDocs:
  description: TS 28.104; MDA Report
  url: http://www.3gpp.org/ftp/Specs/archive/28_series/28.104/
paths: {}
components:
  schemas:

#----- Definition of types-----

MDAOutputs:
  type: object
  properties:
    mDAType:
      type: string
    mdaOutputList:
      type: array
      items:
        $ref: '#/components/schemas/MDAOutputEntry'
    mDARequestRef:
      $ref: 'comDefs.yaml#/components/schemas/Dn'

MDAOutputEntry:
  type: object
  properties:
    mDAOutputIENName:
      type: string
    mdaOutputIEValue: {}
    analyticsWindow:
      $ref: '#/components/schemas/TimeWindow'
    confidenceDegree:
      type: number
      format: float

TimeWindow:
  type: object
  properties:
    startTime:
      $ref: 'comDefs.yaml#/components/schemas/DateTime'
    endTime:
      $ref: 'comDefs.yaml#/components/schemas/DateTime'

#----- Definition of MDA Report -----

MDAReport:
  allOf:
    - $ref: 'genericNrm.yaml#/components/schemas/Top'
    - type: object
      properties:
        attributes:
          allOf:
            - type: object
              properties:
                mDAReportID:
                  type: string
                mDAOutputs:
                  $ref: '#/components/schemas/MDAOutputs'

```

## Annex B (informative): Change history

| Change history |          |           |    |     |     |  |             |
|----------------|----------|-----------|----|-----|-----|--|-------------|
| Date           | Meeting  | TDoc      | CR | Rev | Cat | Subject/Comment  | New version |
| 2021-04        | SA5#137e | n/a       | -  | -   | -   | Initial skeleton   | 0.0.0       |
| 2021-09        | SA5#138e | S5-214614 | -  | -   | -   | Add abbreviations and an overview clause   | 0.1.0       |
| 2021-09        | SA5#138e | S5-214615 | -  | -   | -   | Add text for the scope   | 0.1.0       |
| 2021-09        | SA5#138e | S5-214616 | -  | -   | -   | Add MDA role to the MDA in management loop   | 0.1.0       |
| 2021-09        | SA5#138e | S5-214617 | -  | -   | -   | Add text to MDA functionality and service framework clause   | 0.1.0       |
| 2021-10        | SA5#139e | S5-215657 | -  | -   | -   | Add structure for TS 28.104  | 0.2.0       |
| 2021-10        | SA5#139e | S5-215637 | -  | -   | -   | Add description of fault prediction analysis   | 0.2.0       |
| 2021-10        | SA5#139e | S5-215653 | -  | -   | -   | Add service experience analysis  | 0.2.0       |
| 2021-10        | SA5#139e | S5-215659 | -  | -   | -   | Add network slice throughput analysis  | 0.2.0       |
| 2021-10        | SA5#139e | S5-215561 | -  | -   | -   | Add traffic Projection use case and requirements   | 0.2.0       |
| 2021-10        | SA5#139e | S5-215206 | -  | -   | -   | Add mobility performance analysis use case requirements  | 0.2.0       |
| 2021-10        | SA5#139e | S5-215265 | -  | -   | -   | Add MDA role in cross-domain service assurance   | 0.2.0       |
| 2021-10        | SA5#139e | S5-215638 | -  | -   | -   | Add example of MDA producers and consumers   | 0.2.0       |
| 2021-10        | SA5#139e | S5-215658 | -  | -   | -   | Add ML support for MDA   | 0.2.0       |
| 2021-11        | SA5#140e | S5-216471 | -  | -   | -   | Replace alarm incident with alarm information  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216472 | -  | -   | -   | Add software management use case and requirements  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216473 | -  | -   | -   | Add paging optimization use case and requirements  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216474 | -  | -   | -   | Add HO optimization use case and requirements  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216475 | -  | -   | -   | Alignment of terminology   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216476 | -  | -   | -   | Add coverage analysis requirement  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216350 | -  | -   | -   | Add MDA capability for coverage problem analysis   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216556 | -  | -   | -   | Add stage 2 structure for TS 28.104  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216477 | -  | -   | -   | Add MDA assisted Energy Saving use case and requirements   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216479 | -  | -   | -   | Add MDA Request and Control  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216478 | -  | -   | -   | Add obtaining MDA output   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216480 | -  | -   | -   | Add E2E latency analysis use case and requirements   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216481 | -  | -   | -   | Add MDA related data, use case and requirements  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216552 | -  | -   | -   | Add network slice load analysis use case and requirements  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216470 | -  | -   | -   | Add inter-gNB beam selection optimization  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216553 | -  | -   | -   | Add slice coverage analysis  | 0.3.0       |
| 2021-11        | SA5#140e | S5-216554 | -  | -   | -   | Add requirements for ML model training   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216555 | -  | -   | -   | Add MnS producer initiated ML model training   | 0.3.0       |
| 2021-11        | SA5#140e | S5-216622 | -  | -   | -   | Add NRM for MDA request  | 0.3.0       |
| 2022-02        | SA5#141e | S5-221602 |    |     |     | Including individual PM, KPI, trace and QoE statistics and predictions as additional MDA types       | 0.4.0       |
| 2022-02        | SA5#141e | S5-221603 |    |     |     | Add MDA types  | 0.4.0       |
| 2022-02        | SA5#141e | S5-221606 |    |     |     | Add coverage issue analytics output area definition - stage2   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221607 |    |     |     | Update MDA service framework and data definitions for coverage problem analysis                      | 0.4.0       |
| 2022-02        | SA5#141e | S5-221609 |    |     |     | Add E2E latency analysis solution  | 0.4.0       |
| 2022-02        | SA5#141e | S5-221611 |    |     |     | Add network slice load analysis solution   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221250 |    |     |     | Update use case and requirement for MDA assisted energy saving analysis                              | 0.4.0       |
| 2022-02        | SA5#141e | S5-221613 |    |     |     | Update NRM for MDA request   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221271 |    |     |     | Rapporteur clean-up  | 0.4.0       |
| 2022-02        | SA5#141e | S5-221273 |    |     |     | Further clarifications and supporting text for clause 6.3 MDA role in cross-domain service assurance | 0.4.0       |
| 2022-02        | SA5#141e | S5-221615 |    |     |     | Add MDA context  | 0.4.0       |
| 2022-02        | SA5#141e | S5-221619 |    |     |     | Move out ML model training part to TS 28.105   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221712 |    |     |     | Add service experience analysis solution   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221610 |    |     |     | Add network slice throughput analysis solution   | 0.4.0       |
| 2022-02        | SA5#141e | S5-221612 |    |     |     | Add MDA capability for MDA assisted energy saving analysis   | 0.4.0       |
| 2022-03        | SA#95e   |           |    |     |     | Sent for information   | 1.0.0       |
| 2022-04        | SA5#142e | S5-222692 |    |     |     | Extend requirements for coverage analytics   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222693 |    |     |     | Critical Maintenance Management  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222695 |    |     |     | Network Slice Traffic Prediction   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222105 |    |     |     | Correct the referred clauses   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222697 |    |     |     | Add common information elements of MDA outputs   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222698 |    |     |     | Update NRM for MDA request   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222699 |    |     |     | Enhancing MDA request IOC  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222332 |    |     |     | Clarify MDA interactions   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222701 |    |     |     | Prediction of service failures   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222702 |    |     |     | Add stage 2 description of failure predication analytics   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222702 |    |     |     | Add stage 2 description of failure predication analytics   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222703 |    |     |     | Clarifications on MDA Context  | 1.1.0       |

| Change history |          |           |    |     |     |   |             |
|----------------|----------|-----------|----|-----|-----|---|-------------|
| Date           | Meeting  | TDoc      | CR | Rev | Cat | Subject/Comment   | New version |
| 2022-04        | SA5#142e | S5-222352 |    |     |     | Add an enumeration value in output for "Network slice throughput analysis"  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222705 |    |     |     | Add an enumeration value in output for "Network slice throughput analysis"  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222706 |    |     |     | Multiplicity change for "Affected Objects" IE in "NW slice load analysis"   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222707 |    |     |     | Multiplicity change for "Affected Objects" IE in "Service experience analysis"                                    | 1.1.0       |
| 2022-04        | SA5#142e | S5-222708 |    |     |     | Modify the paging requirements based on geographical area   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222364 |    |     |     | Update the analytics output of coverage analysis use case   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222709 |    |     |     | Add MDA capability for MDA assisted energy saving analysis  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222710 |    |     |     | Update use case description for MDA assisted energy saving analysis   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222641 |    |     |     | Define the data type of statistics of cells energy saving state   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222711 |    |     |     | Add MDA related service components  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222712 |    |     |     | Add mobility performance analysis solution  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222713 |    |     |     | Rapporteur clean-up   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222714 |    |     |     | Editorial, enhancements and modifications on MDA overview   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222715 |    |     |     | Editorial modifications on MDA functionality and service framework  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222481 |    |     |     | Add historical data handling for MDA  | 1.1.0       |
| 2022-04        | SA5#142e | S5-222716 |    |     |     | Clarifications on MDA Types   | 1.1.0       |
| 2022-04        | SA5#142e | S5-222717 |    |     |     | Adding domain observation data as input in cross-domain MDA   | 1.1.0       |
| 2022-05        | SA5#143e | S5-223635 |    |     |     | Update EsRecommendationsOnUPF and EsRecommendationsOnNRcell   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223636 |    |     |     | Add clause for energy saving analysis   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223637 |    |     |     | Editorial improvement   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223638 |    |     |     | Rapporteur clean-up   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223640 |    |     |     | Update TrafficProjections data type   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223641 |    |     |     | Adding MDA output IOC   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223642 |    |     |     | Add data type definitions   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223643 |    |     |     | Enhance MDA NRM   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223749 |    |     |     | Add reporting MnS components  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223645 |    |     |     | MDA output for proactive coverage analytics   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223350 |    |     |     | Update the paging use case description to indicate the geographical area-based and group of users based analytics | 1.2.0       |
| 2022-05        | SA5#143e | S5-223648 |    |     |     | Add AI/ML optional support for MDA  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223649 |    |     |     | Add MDA analysis request and report generic workflow  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223651 |    |     |     | Revisions to Network slice traffic prediction   | 1.2.0       |
| 2022-05        | SA5#143e | S5-223505 |    |     |     | Revisions to clause 7.3.2 obtaining MDA Output  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223750 |    |     |     | Add Paging Optimization Solution - Stage 2  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223748 |    |     |     | Add Handover Optimization Solution - Stage 2  | 1.2.0       |
| 2022-05        | SA5#143e | S5-223644 |    |     |     | Add stage 3 solution sets for MDA NRM   | 1.2.0       |
| 2022-06        | SA#96    | SP-220494 |    |     |     | Presented for approval  | 2.0.0       |
| 2022-06        | SA#96    |           |    |     |     | Upgrade to change control version   | 17.0.0      |
| 2022-06        | SA#96    |           |    |     |     | Removal of comments   | 17.0.1      |

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# History

| <b>Document history</b> |           |             |
|-------------------------|-----------|-------------|
| V17.0.1                 | July 2022 | Publication |
|                         |           |             |
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|                         |           |             |
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