



## **Network Functions Virtualisation (NFV) Release 3; Management and Orchestration; Report on management of NFV-MANO and automated deployment of EM and other OSS functions**

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## Foreword

This Group Report (GR) has been produced by ETSI Industry Specification Group (ISG) Network Functions Virtualisation (NFV).

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## Modal verbs terminology

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

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# 1 Scope

The present document reports on:

- management aspects (update, configuration, etc.) of NFV-MANO functions, and
- the automated deployment of Element Management (EM) and Operations Support Systems (OSS) functions specific for managing certain VNF or NS.

Recommendations for the normative work to support the framework and potential solutions are also provided in the present document.

The basis for the report is the NFV Architectural Framework from ETSI GS NFV 002 [i.1] and NFV-MANO Architectural Framework from ETSI GS NFV-MAN 001 [i.2].

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## 2 References

### 2.1 Normative references

Normative references are not applicable in the present document.

### 2.2 Informative references

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

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

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

- [i.1] ETSI GS NFV 002 (V1.2.1): "Network Functions Virtualisation (NFV); Architectural Framework".
- [i.2] ETSI GS NFV-MAN 001 (V1.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration".
- [i.3] ETSI GS NFV 003 (V1.2.1): "Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV".
- [i.4] ETSI GS NFV-IFA 010 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Functional requirements specification".
- [i.5] Recommendation ITU-T X.733: "Information technology - Open Systems Interconnection - Systems management: alarm reporting function".
- [i.6] ETSI GS NFV-IFA 011 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; VNF Packaging Specification".
- [i.7] ETSI GS NFV-IFA 007 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vnfm reference point - Interface and Information Model Specification".
- [i.8] ETSI GS NFV-IFA 005 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Or-Vi reference point - Interface and Information Model Specification".
- [i.9] ETSI GS NFV-IFA 006 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Vi-Vnfm reference point - Interface and Information Model Specification".

- [i.10] ETSI GS NFV-IFA 008 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Ve-Vnfm reference point - Interface and Information Model Specification".
- [i.11] ETSI GS NFV-IFA 013 (V2.1.1): "Network Functions Virtualisation (NFV); Management and Orchestration; Os-Ma-nfvo reference point - Interface and Information Model Specification".
- [i.12] ETSI GS NFV-SEC 012 (V3.1.1): "Network Functions Virtualisation (NFV) Release 3; Security; System architecture specification for execution of sensitive NFV components".
- [i.13] ETSI GS NFV-SEC 006 (V1.1.1): "Network Functions Virtualisation (NFV); Security Guide; Report on Security Aspects and Regulatory Concerns".
- [i.14] ETSI GS NFV-SEC 004 (V1.1.1): "Network Functions Virtualisation (NFV); NFV Security; Privacy and Regulation; Report on Lawful Interception Implications".
- [i.15] ETSI GS NFV-SEC 010 (V1.1.1): "Network Functions Virtualisation (NFV); NFV Security; Report on Retained Data problem statement and requirements".
- [i.16] ETSI GS NFV-REL 006 (V3.1.1): "Network Functions Virtualisation (NFV) Release 3; Reliability; Maintaining Service Availability and Continuity Upon Software Modification".

## 3 Definitions and abbreviations

### 3.1 Definitions

For the purposes of the present document, the terms and definitions given in ETSI GS NFV 003 [i.3] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in [i.3].

**NFV-MANO functional entity application:** program designed to perform a function or a set of functions providing NFV-MANO services

**NFV-MANO management service:** one or more capabilities for the support of operations, administration and maintenance of the NFV-MANO functional entity being managed

**NFV-MANO service:** one or more capabilities offered via NFV-MANO functional blocks (i.e. NFVO, VNFM, VIM) invoked using a defined interface

NOTE: This definition has been specialized from the term "NFV-MANO service" as defined in ETSI GS NFV 003 [i.3].

EXAMPLE: The VNFM offers a NFV-MANO service for VNF lifecycle management to the NFVO. The NFVO offers an NFV-MANO service for Network Service lifecycle management to OSS/BSS functions and uses the NFV-MANO service provided by the VNFM.

### 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in [i.3] and the following apply:

EM	Element Management
FCAPS	Fault, Configuration, Accounting, Performance and Security
IFA	Interfaces and Architecture
MANO	Management and Orchestration
OSS	Operations Support Systems
PM	Performance Management
TOSCA	Topology and Orchestration Specification for Cloud Applications
VR	Virtualised Resource

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## 4 Overview of management functions

### 4.1 Introduction

Network Functions Virtualisation (NFV) introduces a new set of management and orchestration functions in addition to existing Element Management (EM) and Operations Support Systems (OSS) functions. This new set of functions is needed in order to manage and orchestrate:

- The relationship between the Virtualised Network Functions (VNFs) and the NFV Infrastructure (NFVI).
- The interconnection of VNFs and/or other Physical Network Functions (PNFs) and/or nested Network Service (NS) to realize a NS.

As a whole, the Network Functions Virtualisation Management and Orchestration (NFV-MANO) functions have the role to manage the NFVI and orchestrate the allocation of resources needed by the NSs and VNFs.

NFV-MANO interworks with EM and OSS functions at references points identified in ETSI GS NFV-MAN 001 [i.2].

The present document considers the following type of management functions:

- NFV-MANO functions, which are further described in clause 4.2.
- EM and OSS functions for managing specific VNF or NS, which are further described in clause 4.3.

NOTE: "specific VNF or NS" means a type or class of VNF or NS.

### 4.2 Overview of NFV-MANO functions

The NFV-MANO architectural framework in ETSI GS NFV-MAN 001 [i.2] identifies and describes the following functional blocks:

- NFV Orchestrator (NFVO),
- VNF Manager (VNFM), and
- Virtualised Infrastructure Manager (VIM).

The NFVO has two main responsibilities:

- the orchestration of NFVI resources across multiple VIM instances, fulfilling the Resource Orchestration functions, and
- the lifecycle management of NS, fulfilling the Network Service Orchestration functions.

The VNFM is responsible for the lifecycle management of VNF instances.

The VIM is responsible for controlling and managing NFVI compute, storage and network resources. The VIM manages the association of the virtualised resources to the physical compute, storage and networking resources.

Functional requirements for the NFVO, VNFM and VIM are specified in ETSI GS NFV-IFA 010 [i.4].

### 4.3 Overview of EM and OSS functions for managing specific VNF or NS

In an NFV context, EM is responsible for Fault, Configuration, Accounting, Performance and Security (FCAPS) management functionality of the service functions provided by a VNF, and it supports an abstraction of these service functions. The EM interworks with the VNFM to perform the functions that require exchanges of information regarding the virtualised resources associated with the VNF, and the VNF lifecycle management.

The OSS is a combination of a network operator operations support functions. OSS functions typically provide management and orchestration functionality of a network and may have full end-to-end visibility of services provided by network functions in an operator's network. In an NFV context, OSS interworks with the NFVO to perform the functions that require exchange of information associated with an NS, and the NS lifecycle management.

EM and OSS encompass a variety of management functions. As such, some of the functions can be specific for managing certain types of VNF instances or NS instances, and thus their deployment and usage only be required when corresponding types of VNF or NS instances are also deployed.

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## 5 Use case

### 5.1 Use cases with focus on management of NFV-MANO functions

#### 5.1.1 Monitoring of NFV-MANO functional entity failures

##### 5.1.1.1 Introduction and goal

As any network functional entity in a real network deployment, an NFV-MANO functional entity can fail. If an NFV-MANO functional entity fails, it can impact the operations performed by other entities. For example, if a VIM entity fails due to a crash on the underlying hardware or software systems supporting the VIM, this can impact handling the requests from a VNFM, e.g. the VNFM might need to request certain operations on virtualised resources being used by a managed VNF instance.

An important step to recover from a failure is first to verify that such a failure has occurred.

The goal of this use case is to enable the monitoring of failures of NFV-MANO functional entities, so that when a failure occurs, the monitoring entity knows about it.

**NOTE:** The present use case does not cover all the phases of an end-to-end failure recovery, which may be covered in other use cases.

It is assumed in the present use case that the monitoring and failure detection is performed at two levels:

- Failures detected by an external entity, e.g. the external entity determines some failure is happening due to the NFV-MANO functional entity being unresponsive to some health check messages.
- Failures detected by the NFV-MANO functional entity itself that can still be notified by the NFV-MANO entity to another external entity.

It is also assumed in the present use case that the monitoring and failure detection can take place at different levels. For instance, the detected failure can be related to the malfunctioning of:

- at the functional entity level, e.g. the whole or part of the NFV-MANO functional entity,
- at the reference point level, e.g. communication in between NFV-MANO functional entities or between other entities and NFV-MANO functional entities,
- at the interface level, e.g. a specific interface produced by an NFV-MANO functional entity, or
- at the resource level for resources supporting the execution of an NFV-MANO functional entity, e.g. CPU, memory, etc., as event type relevant to resources being reported (see also Recommendation ITU-T X.733 [i.5]).

This would allow the monitoring entity to determine at a more granular level the specific aspect/functionality of an NFV-MANO functional entity that is failing.

### 5.1.1.2 Actors and roles

Table 5.1.1.2-1 describes the use case actors and roles.

**Table 5.1.1.2-1: Monitoring of NFV-MANO functional entity failures actors and roles**

#	Role	Description
1	NFV-MANO functional entity	The entity that is being monitored.
2	MANO Monitor	The entity that monitors. See note.
NOTE: The "MANO Monitor" is used for the purpose to describe the use case and help understand the functionality that is described herein. The use case does not make any assumption what entity can play such a role.		

### 5.1.1.3 Pre-conditions

Table 5.1.1.3-1 describes the use case pre-conditions.

**Table 5.1.1.3-1: Monitoring of NFV-MANO functional entity failures pre-conditions**

#	Pre-condition	Additional description
1	The NFV-MANO functional entity is running.	N/A

### 5.1.1.4 Post-conditions

Table 5.1.1.4-1 describes the use case post-conditions.

**Table 5.1.1.4-1: Monitoring of NFV-MANO functional entity failures post-conditions**

#	Post-condition	Additional description
1	The MANO Monitor has detected the failure(s) during the monitoring period.	N/A

### 5.1.1.5 Flow description

Table 5.1.1.5-1 describes the use case flow.

**Table 5.1.1.5-1: Monitoring of NFV-MANO functional entity failures flow description**

#	Actor/Role	Action/Description
Begins when	MANO Monitor	The MANO Monitor determines that a specific NFV-MANO functional entity needs to be monitored against failures. The source of the determination can be an automatic action based on a specific configuration or come from an explicit request, e.g. from the network operator.
Step 1	MANO Monitor -> NFV-MANO functional entity	The MANO Monitor requests the NFV-MANO functional entity to set-up the failure monitoring conditions and notify about failures detected by the entity itself (see note).
Step 2	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity informs about the successful setup of the failure monitoring mechanism (see note).
Step 3	MANO Monitor	The MANO Monitor adds the NFV-MANO functional entity as a monitored entity. The MANO Monitor also starts monitoring the NFV-MANO functional entity (e.g. by sending health check requests at regular intervals).
Step 4	NFV-MANO functional entity -> MANO Monitor or MANO Monitor	Whenever a failure occurs and is detected by the NFV-MANO functional entity, the NFV-MANO functional entity informs to the MANO Monitor about such a failure (see note), or Whenever the MANO Monitor detects the NFV-MANO functional entity is unresponsive, the MANO Monitor determines itself that the NFV-MANO functional entity is faulty.

#	Actor/Role	Action/Description
Ends when	MANO Monitor	The MANO Monitor requests the NFV-MANO functional entity to stop the failure monitoring mechanism (see note). The MANO Monitor stops monitoring the NFV-MANO functional entity.
NOTE:	This behaviour applies only to the case of enabling the notification of failures detected by the NFV-MANO functional entity itself.	

## 5.1.2 Collection of performance data from NFV-MANO functional entity

### 5.1.2.1 Introduction and goal

An NFV-MANO functional entity runs on supporting hardware/software, and, therefore, it makes use of compute, storage and network resources. As part of the tasks performed by the NFV-MANO functional entity, reporting on the usage of resources is a useful feature for the network operator to determine the proper functioning of the entity. In addition, from an NFV-MANO service perspective, the NFV-MANO functional entity handles management service requests, workflows, managed objects, etc. which count toward determining the performance of the NFV-MANO functional entity. Collecting performance data can be used for simple monitoring purposes or even for root cause analysis.

The goal of this use case is to enable the collection of performance data from NFV-MANO functional entities, so that the Service Provider or some monitoring entity can use such data for monitoring and root cause analysis purposes.

It is assumed in the present use case that the performance monitoring is performed at different levels, including more granular metrics related to interfaces exposed by the NFV-MANO functional entity:

- Metrics related to resources supporting the execution of an NFV-MANO functional entity, e.g. CPU load, memory consumption, etc.
- Metrics related to the NFV-MANO functional entity from an NFV-MANO functional entity application perspective, e.g. number of requests per second, number of managed objects (e.g. VMs by a VIM, VNF instances by a VNFM, etc.), number of workflows under execution by a VNFM and NFVO, operation latency, etc.
- Metrics related to the NFV-MANO functional entity at the interface level, e.g. number of requests per second per interface exposed by the entity, etc.

### 5.1.2.2 Actors and roles

Table 5.1.2.2-1 describes the use case actors and roles.

**Table 5.1.2.2-1: Collection of performance data from NFV-MANO functional entity actors and roles**

#	Role	Description
1	NFV-MANO functional entity	The entity from which the performance data is collected.
2	MANO Monitor	The entity that collects performance data. See note in table 5.1.1.2-1.

### 5.1.2.3 Pre-conditions

Table 5.1.2.3-1 describes the use case pre-conditions.

**Table 5.1.2.3-1: Collection of performance data from NFV-MANO functional entity pre-conditions**

#	Pre-condition	Additional description
1	The NFV-MANO functional entity is running.	N/A

### 5.1.2.4 Post-conditions

Table 5.1.2.4-1 describes the use case post-conditions.

**Table 5.1.2.4-1: Collection of performance data from NFV-MANO functional entity post-conditions**

#	Post-condition	Additional description
1	The MANO Monitor has performance data collected from the NFV-MANO functional entity during the monitoring period.	N/A

### 5.1.2.5 Flow description

Table 5.1.2.5-1 describes the use case flow.

**Table 5.1.2.5-1: Collection of performance data from NFV-MANO functional entity flow description**

#	Actor/Role	Action/Description
Begins when	MANO Monitor	The MANO Monitor determines that performance data needs to be collected from a specific NFV-MANO functional entity. The source of the determination can be an automatic action based on a specific operator configuration or come from an explicit request, e.g. from the network operator.
Step 1	MANO Monitor -> NFV-MANO functional entity	The MANO Monitor requests the NFV-MANO functional entity to start collecting performance data on certain performance metrics and at which interval the collected data should be reported.
Step 2	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity informs about the successful setup of the performance data collection task.
Step 3	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity starts collecting performance data according to the performance collection task set in the previous step, and it periodically informs the MANO Monitor about the performance measurement values or the availability of performance data.
Ends when	MANO Monitor	The MANO Monitor requests the NFV-MANO functional entity to delete the performance data collection task.

## 5.1.3 Performance alarm monitoring from NFV-MANO functional entity

### 5.1.3.1 Introduction and goal

NFV-MANO functional entities deployed in production environments can potentially need to process a great number of operations and requests from other management functions or other NFV-MANO functional entities. As any other function, an NFV-MANO functional entity can experience performance issues such as an overload situation. If an NFV-MANO functional entity has a performance issue, it can impact the operations performed by other entities. For instance, a high number of virtualised resource performance data collection jobs can overload a VIM's underlying CPU and memory resources. Another example is an NFVO entity that has to handle multiple workflows to update virtualised resources capacity information from several VIM entities, yet at the same time having to handle NS LCM requests and issuing VNF LCM requests to VNFM entities. All these tasks can also overload the NFVO entity's capacity.

Monitoring the performance of NFV-MANO functional entity resources and getting alarms once certain thresholds are reached will allow Service Providers to determine an overload situation in NFV-MANO and set the proper action(s).

The goal of this use case is to enable the monitoring of performance issues of NFV-MANO functional entities, so that when a performance issue occurs, a monitoring entity can be informed about it.

It is assumed in the present use case that the performance alarms can be set at different levels, including:

- Metrics related to resources supporting the execution of an NFV-MANO functional entity, e.g. CPU load, memory consumption, etc.

- Metrics related to the NFV-MANO functional entity from an NFV-MANO functional entity application perspective, e.g. number of requests per second, number of managed objects (e.g. VMs by a VIM, VNF instances by a VNFM, etc.), number of workflows under execution by a VNFM and NFVO, operation latency, etc.
- Metrics related to the NFV-MANO functional entity at the interface level, e.g. number of requests per second per interface exposed by the entity, etc.

### 5.1.3.2 Actors and roles

Table 5.1.3.2-1 describes the use case actors and roles.

**Table 5.1.3.2-1: Performance alarm monitoring of NFV-MANO functional entity actors and roles**

#	Role	Description
1	NFV-MANO functional entity	The entity that is being monitored.
2	MANO Monitor	The entity that monitors performance alarms. See note in table 5.1.1.2-1.

### 5.1.3.3 Pre-conditions

Table 5.1.3.3-1 describes the use case pre-conditions.

**Table 5.1.3.3-1: Performance alarm monitoring of NFV-MANO functional entity pre-conditions**

#	Pre-condition	Additional description
1	The NFV-MANO functional entity is running.	N/A

### 5.1.3.4 Post-conditions

Table 5.1.3.4-1 describes the use case post-conditions.

**Table 5.1.3.4-1: Performance alarm monitoring of NFV-MANO functional entity post-conditions**

#	Post-condition	Additional description
1	The MANO Monitor is aware of any performance alarm in the NFV-MANO functional entity during the monitoring period.	N/A

### 5.1.3.5 Flow description

Table 5.1.3.5-1 describes the use case flow.

**Table 5.1.3.5-1: Performance alarm monitoring of NFV-MANO functional entity flow description**

#	Actor/Role	Action/Description
Begins when	MANO Monitor	The MANO Monitor determines that a specific NFV-MANO functional entity needs to be monitored with regards to performance. The source of the determination can be an automatic action based on a specific operator configuration or come from an explicit request with specific monitoring requirements, e.g. from the network operator.
Step 1	MANO Monitor -> NFV-MANO functional entity	The MANO Monitor requests the NFV-MANO functional entity to set the performance threshold based on the monitoring requirements for the alarm to be raised.
Step 2	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity informs about the successful setup of the performance alarm threshold.
Step 3	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity periodically checks its own performance and immediately informs the MANO Monitor about a performance alarm detected by the entity itself when certain threshold is reached.

#	Actor/Role	Action/Description
Ends when	MANO Monitor	The MANO Monitor requests the NFV-MANO functional entity to delete the performance alarm threshold.

## 5.1.4 Informing about NFV-MANO functional entity maintenance

### 5.1.4.1 Introduction and goal

An NFV-MANO functional entity can require a maintenance action such as a reboot, a software upgrade, or a fix of a failure in the underlying hardware. In order to prepare for such maintenance action, other NFV-MANO functional entities making use of services provided by the affected NFV-MANO functional entity have to be informed in order to prepare for the expected downtime of the affected NFV-MANO functional entity.

NOTE 1: For maintaining availability of the service provided by an NFV-MANO functional entity during its software modification, ETSI GS NFV-REL 006 [i.16] specifies the case for a redundant deployment of this NFV-MANO functional entity. The present use case does not consider such a redundant deployment.

For example, if a VIM entity has to go into maintenance mode, the VNFM and NFVO entities are informed, so that the VNFM and NFVO entities can disable scheduling new virtualised resources from the affected VIM entity, and perform additional actions, e.g. re-instantiation of VNF instances using virtualised resources managed by the affected VIM to other VIM entity(s) in order to release virtualised resources managed by the affected VIM entity. Once the above actions have completed, maintenance on the NFV-MANO functional entity can be further performed.

The goal of this use case is to enable informing to related NFV-MANO functional entities about a certain NFV-MANO functional entity going into/out of maintenance mode, so that the first NFV-MANO functional entities can disable/enable scheduling new actions towards the affected NFV-MANO functional entity and perform appropriate actions before the maintenance starts or after the maintenance has been completed.

NOTE 2: The present use case does not detail the procedure by which informed NFV-MANO functional entities realize the appropriate actions previous to/after the actual maintenance procedure steps.

Performing maintenance actions is not assumed to be only applicable on a per NFV-MANO functional entity. Considering the complexity of functions to be realized by an NFV-MANO functional entity, maintenance actions are also relevant on a more granular level. However, in these cases it is assumed that specific interfaces are handled by corresponding internal NFV-MANO functional entity application components whose level of interaction would rather base on controlling the start/stop of the actual provided NFV-MANO service. These cases are not considered in the present use case.

### 5.1.4.2 Actors and roles

Table 5.1.4.2-1 describes the use case actors and roles.

**Table 5.1.4.2-1: Informing about NFV-MANO functional entity maintenance actors and roles**

#	Role	Description
1	Maintained NFV-MANO functional entity	The NFV-MANO functional entity that goes into/out of maintenance mode.
2	Other NFV-MANO functional entity(s)	The NFV-MANO functional entity(s) that is (are) not put under maintenance mode but can make use of NFV-MANO services provided by the Maintained NFV-MANO functional entity.
3	MANO Monitor	The entity that informs about the status change of the NFV-MANO functional entity. See note in table 5.1.1.2-1.

### 5.1.4.3 Pre-conditions

Table 5.1.4.3-1 describes the use case pre-conditions.

**Table 5.1.4.3-1: Informing about NFV-MANO functional entity maintenance pre-conditions**

#	Pre-condition	Additional description
1	The Maintained NFV-MANO functional entity and the Other NFV-MANO functional entity(s) are operational.	N/A

### 5.1.4.4 Post-conditions

Table 5.1.4.4-1 describes the use case post-conditions.

**Table 5.1.4.4-1: Informing about NFV-MANO functional entity maintenance post-conditions**

#	Post-condition	Additional description
1	The NFV-MANO functional entity(s) has (have) been informed about the maintenance status of the Maintained NFV-MANO functional entity.	N/A

### 5.1.4.5 Flow description

Table 5.1.4.5-1 describes the use case flow.

**Table 5.1.4.5-1: Informing about NFV-MANO functional entity maintenance flow description**

#	Actor/Role	Action/Description
Begins when	MANO Monitor	The MANO Monitor determines that a specific NFV-MANO functional entity needs to go into/out of maintenance mode. The source of the determination can be an automatic action based on a specific operator configuration or come from an explicit request, e.g. from the network operator.
Step 1	MANO Monitor -> Maintained NFV-MANO functional entity	The MANO Monitor updates the state of the Maintained NFV-MANO functional entity to "going into maintenance" or "going out of maintenance" and informs the maintenance mode to the Maintained NFV-MANO functional entity.
Step 2	MANO Monitor -> Other NFV-MANO functional entity	The MANO Monitor informs about the status change of the Maintained NFV-MANO functional entity to the Other NFV-MANO functional entity(s).
Ends when	MANO Monitor	The MANO Monitor has informed about the status change to "into maintenance mode" or "out of maintenance mode" of the Maintained NFV-MANO functional entity.

## 5.1.5 Adding an NFV-MANO functional entity

### 5.1.5.1 Introduction and goal

The goal of this use case is to add an NFV-MANO functional entity, e.g. adding a new VNFM to the list of VNFMs known to the NFVO, so that the NFVO may be able to use the new VNFM for VNF LCM.

The present use case assumes that the addition action can apply to different levels. Instead of adding the whole NFV-MANO functional entity to a second NFV-MANO functional entity, the addition can also concern to a particular interface being used in between the first and second NFV-MANO functional entity. For instance, assuming the possible interaction between a VIM and an NFVO and the case that the NFVO does need to make use of virtualised network resource management capabilities of the VIM, it could be determined to add into the NFVO the VIM concerning a specific interface such as the Virtualised Resource Management interface, while at the same time consumption for other interfaces may not be added.

### 5.1.5.2 Actors and roles

Table 5.1.5.2-1 describes the use case actors and roles.

**Table 5.1.5.2-1: Adding an NFV-MANO functional entity actors and roles**

#	Role	Description
1	MANO Monitor	The entity that requests the addition of the whole set or a subset of the services of the NFV-MANO functional entity.
2	Added NFV-MANO functional entity	The NFV-MANO functional entity whose whole set or a subset of the services that has been added.
3	Other NFV-MANO functional entity(s)	The NFV-MANO entity(s) which can make use of NFV-MANO services provided by the Added NFV-MANO functional entity.

### 5.1.5.3 Pre-conditions

Table 5.1.5.3-1 describes the use case pre-conditions.

**Table 5.1.5.3-1: Adding an NFV-MANO functional entity pre-conditions**

#	Pre-condition	Additional description
1	The MANO Monitor is deployed and running in the virtualised network.	N/A
2	The Added NFV-MANO functional entity is deployed and running.	N/A

### 5.1.5.4 Post-conditions

Table 5.1.5.4-1 describes the use case post-conditions.

**Table 5.1.5.4-1: Adding an NFV-MANO functional entity post-conditions**

#	Post-condition	Additional description
1	The whole or a subset of services of the Added NFV-MANO functional entity is known to Other NFV-MANO functional entity(s).	N/A

### 5.1.5.5 Flow description

Table 5.1.5.5-1 describes the use case flow.

**Table 5.1.5.5-1: Adding an NFV-MANO functional entity flow description**

#	Actor/Role	Action/Description
Begins when	MANO Monitor	The MANO Monitor determines that a specific Added NFV-MANO functional entity or a subset of the services needs to be added to Other NFV-MANO functional entity(s).
Step 1	MANO Monitor -> Other NFV-MANO functional entity(s)	The MANO Monitor requests the Other NFV-MANO functional entity(s) to add the Added NFV-MANO functional entity as a known entity, or a subset of the services provided by the Added NFV-MANO functional entity. The request includes necessary information for the Other NFV-MANO functional entity(s) to proceed with the addition action, e.g. identification of the Added NFV-MANO functional entity, interface reachability, subset of the services, etc.
Step 2	Other NFV-MANO functional entity(s)	The Other NFV-MANO functional entity(s) proceed(s) with the addition of the Added NFV-MANO functional entity or the subset of the services. This may require interaction between the entities e.g. discovery of capacity, establishment of reachability, etc.
Step 3	Other NFV-MANO functional entity(s) -> MANO Monitor	The Other NFV-MANO functional entity(s) confirm(s) to the MANO Monitor the addition of the Added NFV-MANO functional entity or the subset of the services.

#	Actor/Role	Action/Description
Ends when	MANO Monitor	The MANO Monitor has been informed about the results of the addition of the Added NFV-MANO functional entity or the subset of the services by the Other NFV-MANO functional entity(s).

## 5.1.6 Removing an NFV-MANO functional entity

### 5.1.6.1 Introduction and goal

The number of NFV-MANO functional entities in a real network deployment can depend on many factors, e.g. geographical coverage of the network deployment, types and amount of virtualised resources to be managed, number of Network Functions and Network Services to be managed, etc. Also, the number of NFV-MANO functional entities will not be fixed throughout the time, with some entities being added and removed according to the network operator needs and service conditions.

During the lifetime of the NFV-MANO, the removal of an NFV-MANO functional entity from the consumer list of another entity could be executed for different reasons:

- to ease the execution of maintenance tasks, or
- as a preparation for decommissioning completely the NFV-MANO functional entity.

In both cases, the network operations are easier if there is the guarantee that the consumer(s) of the NFV-MANO functional entities have stopped using NFV-MANO services from the NFV-MANO functional entity that is being removed.

The goal of the present use case is to enable a Service Provider removing the consumption of NFV-MANO services of a first NFV-MANO functional entity from a second NFV-MANO functional entity, so that further operations (e.g. maintenance on the first NFV-MANO functional entity) can be executed minimizing any service impacts.

The present use case assumes that the removal action can apply to different levels. Instead of removing the whole NFV-MANO functional entity from a second NFV-MANO functional entity, the removal can also concern to a particular interface being used in between the first and second NFV-MANO functional entity. For instance, assuming the possible interaction between a VIM and an NFVO and the case that the NFVO does not need to make use of virtualised resource management capabilities of the VIM, it could be determined to remove from the NFVO the VIM concerning a specific interface such as the Virtualised Resource Management interface, yet at the same time still being able to consume other interfaces such as Virtualised Resource Capacity Management interface.

### 5.1.6.2 Actors and roles

Table 5.1.6.2-1 describes the use case actors and roles.

**Table 5.1.6.2-1: Removing an NFV-MANO functional entity actors and roles**

#	Role	Description
1	Removed NFV-MANO functional entity	The entity whose all or subset of services is being removed from the Consumer NFV-MANO functional entity.
2	Consumer NFV-MANO functional entity(s)	The entity(s) from which the Removed NFV-MANO functional entity is removed.
3	Operator	The entity that informs about the removal of the NFV-MANO functional entity.

### 5.1.6.3 Pre-conditions

Table 5.1.6.3-1 describes the use case pre-conditions.

**Table 5.1.6.3-1: Removing an NFV-MANO functional entity pre-conditions**

#	Pre-condition	Additional description
1	The Removed NFV-MANO functional entity and the Consumer NFV-MANO functional entity(s) are running.	N/A

### 5.1.6.4 Post-conditions

Table 5.1.6.4-1 describes the use case post-conditions.

**Table 5.1.6.4-1: Removing an NFV-MANO functional entity post-conditions**

#	Post-condition	Additional description
1	The Consumer NFV-MANO functional entity(s) do(es) not use the whole set or a subset of the services of the Removed NFV-MANO functional entity.	The Consumer NFV-MANO functional entity is not making use of all or a subset of NFV-MANO services provided originally by the Removed NFV-MANO functional entity.

### 5.1.6.5 Flow description

Table 5.1.6.5-1 describes the use case flow.

**Table 5.1.6.5-1: Removing an NFV-MANO functional entity flow description**

#	Actor/Role	Action/Description
Begins when	Operator	The Operator determines that a first (the Removed) NFV-MANO functional entity or subset of services needs to be removed from a second (the Consumer) NFV-MANO functional entity(s).
Step 1	Operator -> Consumer NFV-MANO functional entity(s)	The Operator requests to the Consumer NFV-MANO functional entity(s) to remove the Removed NFV-MANO functional entity or subset of services from the Consumer NFV-MANO functional entity(s).
Step 2	Consumer NFV-MANO functional entity(s) -> Removed NFV-MANO functional entity	The Consumer NFV-MANO functional entity(s) perform(s) the necessary procedures to stop using NFV-MANO services provided by the Removed NFV-MANO functional entity, including those NFV-MANO services re-exposed indirectly to other NFV-MANO functional entities (e.g. VNF related virtualised resource management in indirect-mode). For instance, if the removal concerns to a VIM in a consuming NFVO, this step can involve (among others) requesting by the NFVO the deletion of software images from the VIM's repositories, requesting the termination of virtualised resources managed by the VIM, and unsubscribing from notifications from the VIM.
Step 3	Consumer NFV-MANO functional entity(s) -> Operator	The Consumer NFV-MANO functional entity(s) confirm(s) to the Operator the result of the removal of the Removed NFV-MANO functional entity or subset of services. In the case that the removal is not completed/successful, e.g. because NFV-MANO services have not been fully discharged, the Consumer NFV-MANO functional entity(s) return(s) necessary error information.
Ends when	Operator	The Operator has been informed by the Consumer NFV-MANO functional entity(s) about the results of the removal of the Removed NFV-MANO functional entity or subset of services.

## 5.1.7 Information retrieval and capability discovery from NFV-MANO functional entity

### 5.1.7.1 Introduction and goal

In a production network deployment, the number and capabilities of NFV-MANO functional entities may vary depending on the type of the NFV-MANO function. For instance, the number of VNFM entities may be due to different factors like the number of VNF instances to be managed, the distribution of VNFM entities according to certain services, the use of specific vs. generic VNFM, etc.

As the multiplicity of NFV-MANO functional entities and their capabilities can be diverse, and since the NFV-MANO functional entities make use of NFV-MANO services offered by other NFV-MANO functional entities, discovering the capabilities offered by the functional entities is a necessary step in order to maximize the usage of a deployed NFV-MANO system. An example with multiple VNFMs where the NFVO selects the VNFM that is responsible for managing the lifecycle of a specific VNF during the NS, VNF and resource orchestration is introduced for the purpose of illustrating the present use case. In order for the NFVO to appropriately select the right VNFM, the NFVO needs to possess information about the capabilities and capacity of the different VNFM entities. Some of the relevant information to be discovered by the NFVO can include (not an exhaustive list):

- the kinds of VNF instances that can be managed, i.e. to determine the compatibility of a VNF with certain VNFM according to the `vnfmInfo` attribute in the VNFD (see attribute `vnfmInfo` in table 7.1.2.2-1 in ETSI GS NFV-IFA 011 [i.6]),
- VNF-related resource management support for indirect mode, direct mode, or both,
- management capacity, e.g. maximum number of VNF instances that the VNFM can manage,
- version of the standard the interface is compliant to,
- API exposed endpoints, and
- version of the VNFM.

Furthermore, newer versions of the software of a NFV-MANO functional entity may enhance current functional capabilities, add new capabilities, support for additional versions of the standard that an interface is compliant to, change of API exposed endpoints, etc. In such a case, to fully leverage the whole capabilities of the network, it is necessary that the network operator and the consuming NFV-MANO functional entities gather the necessary information and discover the supported capabilities once the new software version is running.

The goal of the present use case is to enable the network operator and an existing first NFV-MANO functional entity to acquire information about an existing second NFV-MANO functional entity, including the supported capabilities and capacity, so that the network operator and the first NFV-MANO functional entity have the necessary information to realize its management and orchestration tasks.

### 5.1.7.2 Actors and roles

Table 5.1.7.2-1 describes the use case actors and roles.

**Table 5.1.7.2-1: Information retrieval and capability discovery from NFV-MANO functional entity actors and roles**

#	Role	Description
1	Operator and/or Consumer NFV-MANO entity	The entity that queries the information, including the supported capabilities and capacity.
2	Producer NFV-MANO entity	The entity that provides its own information, including the supported capabilities and capacity.

### 5.1.7.3 Pre-conditions

Table 5.1.7.3-1 describes the use case pre-conditions.

**Table 5.1.7.3-1: Information retrieval and capability discovery from NFV-MANO functional entity pre-conditions**

#	Pre-condition	Additional description
1	The existence of the Producer NFV-MANO functional entity is known to the Operator and/or Consumer NFV-MANO functional entity.	For the case of a Consumer NFV-MANO functional entity, this pre-condition can be achieved by the addition/starting of the Producer NFV-MANO functional entity into the Consumer NFV-MANO functional entity (see use cases in clauses 5.1.5 and 5.1.9).

### 5.1.7.4 Post-conditions

Table 5.1.7.4-1 describes the use case post-conditions.

**Table 5.1.7.4-1: Information retrieval and capability discovery from NFV-MANO functional entity post-conditions**

#	Post-condition	Additional description
1	The Operator and/or Consumer NFV-MANO functional entity possesses information about the Producer NFV-MANO functional entity.	N/A

### 5.1.7.5 Flow description

Table 5.1.7.5-1 describes the use case flow.

**Table 5.1.7.5-1: Information retrieval and capability discovery from NFV-MANO functional entity flow description**

#	Actor/Role	Action/Description
Begins when	Operator and/or Consumer NFV-MANO functional entity	The Operator and/or Consumer NFV-MANO functional entity determines the need to retrieve or update local information about a specific Producer NFV-MANO functional entity. The source of the determination can be an automatic action based on a specific operator configuration (e.g. period timer), or be a result of an explicit request or notification from an external entity.
Step 1	Operator and/or Consumer NFV-MANO functional entity -> Producer NFV-MANO functional entity	The Operator and/or Consumer NFV-MANO functional entity requests to the Producer NFV-MANO functional entity information about the Producer NFV-MANO functional entity. The query can include input data for selecting the required information, e.g. the supported capabilities, API exposed endpoints, and/or capacity of the Producer NFV-MANO functional entity.
Step 2	Producer NFV-MANO functional entity -> Operator and/or Consumer NFV-MANO functional entity	The Producer NFV-MANO functional entity provides the requested information to the Operator and/or Consumer NFV-MANO functional entity.
Ends when	Operator and/or Consumer NFV-MANO functional entity	The Operator and/or Consumer NFV-MANO functional entity has received the requested information from the Producer NFV-MANO functional entity.

## 5.1.8 Notifying about changes of an NFV-MANO functional entity capabilities

### 5.1.8.1 Introduction and goal

The capabilities of an NFV-MANO functional entity could evolve throughout time, e.g. as a result of upgrading the software, adding new features and/or capabilities, etc.

The goal of the use case is to enable the network operator to be informed about the set of capabilities of an NFV-MANO functional entity, e.g. after its software has changed. Such a notification/information is needed by the network operator, so that additional actions can be performed such as:

- request on-demand re-synchronization between NFV-MANO functional entities to perform the information retrieval and capability discovery (see use case in clause 5.1.7),
- add or remove the NFV-MANO functional entity (see use case in clauses 5.1.5 and 5.1.6), and
- put the NFV-MANO functional entity out of maintenance (see use case in clause 5.1.4), assuming that the NFV-MANO functional entity is under maintenance at the time of receiving the notification.

### 5.1.8.2 Actors and roles

Table 5.1.8.2-1 describes the use case actors and roles.

**Table 5.1.8.2-1: Notifying about changes of an NFV-MANO functional entity capabilities actors and roles**

#	Role	Description
1	NFV-MANO functional entity	The entity whose capabilities have changed.
2	MANO Monitor	The entity that is notified about the capabilities changes of the NFV-MANO functional entity. See note in table 5.1.1.2-1.

### 5.1.8.3 Pre-conditions

Table 5.1.8.3-1 describes the use case pre-conditions.

**Table 5.1.8.3-1: Notifying about changes of an NFV-MANO functional entity capabilities pre-conditions**

#	Pre-condition	Additional description
1	The MANO Monitor has subscribed to notifications about changes to the capabilities of the NFV-MANO functional entity.	The NFV-MANO functional entity has a subscription for notifications related to changed capabilities.

### 5.1.8.4 Post-conditions

Table 5.1.8.4-1 describes the use case post-conditions.

**Table 5.1.8.4-1: Notifying about changes of an NFV-MANO functional entity capabilities post-conditions**

#	Post-condition	Additional description
1	The MANO Monitor knows about the changed capabilities of the NFV-MANO functional entity.	N/A

### 5.1.8.5 Flow description

Table 5.1.8.5-1 describes the use case flow.

**Table 5.1.8.5-1: Notifying about changes of an NFV-MANO functional entity capabilities flow description**

#	Actor/Role	Action/Description
Begins when	NFV-MANO functional entity	The capabilities of the NFV-MANO functional entity have changed.
Step 1	NFV-MANO functional entity -> MANO Monitor	The NFV-MANO functional entity notifies to the MANO Monitor the changes of its capabilities.
Ends when	MANO Monitor	The MANO Monitor has received the notification about the changed capabilities.

## 5.1.9 Operating an NFV-MANO functional entity and notification of state changes

### 5.1.9.1 Introduction and goal

As part of regular and critical operations, an entity in an operator's network needs to respond to some basic actions such as starting and stopping the entity. This type of actions also applies to NFV-MANO functional entities.

For instance, in case of an NFV-MANO functional entity that does not perform its functions as expected or runs under certain erroneous behaviour, the network operator may try to recover the entity by stopping and starting the NFV-MANO functional entity application, hopefully bringing it back into operation. This stopping/starting action can be applicable, not only to the whole NFV-MANO functional entity application, but also to certain specific NFV-MANO services provided by the NFV-MANO functional entity. For instance, the NFV-MANO services related to a specific interface functionality produced by the NFV-MANO functional entity are started/stopped.

Furthermore, if there is any change in the state of the NFV-MANO functional entity due operating it, the network operator or other entities will be interested on being notified of such a state change.

The goal of the present use case is to enable the network operator to operate an NFV-MANO functional entity, such as start/stop the NFV-MANO functional entity application and/or specific provided NFV-MANO services, as well as being notified about the state change, so that the network operator can further execute necessary management procedures such as root cause analysis, service recovery, updates, etc.

### 5.1.9.2 Actors and roles

Table 5.1.9.2-1 describes the use case actors and roles.

**Table 5.1.9.2-1: Operating an NFV-MANO functional entity and notification of state changes actors and roles**

#	Role	Description
1	Operator	The entity that requests the action on the NFV-MANO functional entity.
2	Operated NFV-MANO functional entity	The entity whose NFV-MANO functional entity application and/or provided NFV-MANO service is being operated.
3	MANO Monitor	The entity that is notified about the state change. This can also be the role of the entity playing the Operator role. See note in table 5.1.1.2-1.

### 5.1.9.3 Pre-conditions

Table 5.1.9.3-1 describes the use case pre-conditions.

**Table 5.1.9.3-1: Operating an NFV-MANO functional entity and notification of state changes pre-conditions**

#	Pre-condition	Additional description
1	The Operated NFV-MANO functional entity is operational.	The Operated NFV-MANO functional entity needs to be in a state able to process the operation request.
2	The MANO Monitor has subscribed to notifications about state changes on the Operated NFV-MANO functional entity.	The Operated NFV-MANO functional entity has a subscription for notifications related to state changes.

### 5.1.9.4 Post-conditions

Table 5.1.9.4-1 describes the use case post-conditions.

**Table 5.1.9.4-1: Operating an NFV-MANO functional entity and notification of state changes post-conditions**

#	Post-condition	Additional description
1	The Operated NFV-MANO functional entity's application and/or provided NFV-MANO service are/is in the state according to the input action.	For example, if the input action was "stop", as a result of the flow, the Operated NFV-MANO functional entity's application and/or provided NFV-MANO service are/is stopped.
2	The MANO Monitor knows about the state change.	N/A

### 5.1.9.5 Flow description

Table 5.1.9.5-1 describes the use case flow.

**Table 5.1.9.5-1: Operating an NFV-MANO functional entity and notification of state changes flow description**

#	Actor/Role	Action/Description
Begins when	Operator	The Operator determines that a certain NFV-MANO functional entity application and/or provided NFV-MANO service action on the Operated NFV-MANO functional entity is needed.
Step 1	Operator -> Operated NFV-MANO functional entity	The Operator requests to the Operated NFV-MANO functional entity to perform an application and/or provided NFV-MANO service (start/stop) action on the entity.
Step 2	Operated NFV-MANO functional entity -> Operator	The Operated NFV-MANO functional entity confirms the requested action and the change of the NFV-MANO functional entity application and/or provided NFV-MANO service status.
#	Actor/Role	Action/Description
Step 3	Operated NFV-MANO functional entity -> MANO Monitor	The Operated NFV-MANO functional entity notifies to the MANO Monitor about the state change.
Ends when	N/A	All steps identified above are successfully completed.

## 5.1.10 Logging in NFV-MANO to support root-cause analysis

### 5.1.10.1 Introduction and goal

The present use case introduces logging and data analytics in the context of NFV-MANO. The goal of the use case is to enable with a common manner the management of logging of NFV management and orchestration tasks and performance across different NFV-MANO functional entities. The support of logging in NFV-MANO would enable sufficient information to be provisioned and processed by the network operator to maximize and enhance over time the usage of the NFV-MANO.

A more concrete example follows where the network operator needs data to identify the possible causes of certain recurring silent failures. Silent failures do not raise any alarm. For instance the network operator identifies that a specific VNF is not operating as expected, e.g. it underperforms always after certain period of time, but without raising any alarm, neither by the VNF instance, nor by any of the NFV-MANO entities. By logging management and orchestration actions and making available these logs to the network operator, the network operator can execute some data analytics on such logs, potentially resulting in the identification of a silent failure, e.g. an undocumented incompatibility of executing the VNF on certain type of NFVI resources, where the decision of using those resources has always been determined by a specific VIM. Thanks to the information acquired through logs, follow-up actions can be performed by the network operator, e.g. setting up some resource usage policies in the VIM, or executing certain NFVI-PoP selection on the NFVO, in order to minimize the occurrence of such silent failure in the future.

The present use case considers two types of logs to be accessed with a common manner:

- Logs of messages exchanged between NFV-MANO functional entities, and between NFV-MANO functional entities and external entities. This includes logging of the input and output message parameters of interfaces exposed by the functional entities, e.g. input and output messages when an NFVO entity queries the `InstantiateVnf` operation of the VNF LCM interface (see clause 7.2.3 in ETSI GS NFV-IFA 007 [i.7]).
- NFV-MANO functional entity provider specific logs. In this case, it is assumed that such logs may have security restrictions in place, e.g. be encrypted, so that only a certain organization can have access to the content in the log. On this aspect, the present use case focuses on the notification of the availability of these logs, so that the operator can make them available later to the appropriate organization (i.e. NFV-MANO functional entity provider).

The base flow in the present use case describes the steps needed for the configuration of the logging requested by the network operator and the notification of the availability of the logs, so that the network operator can later retrieve the logs. The retrieval of the logs is not described in the present use case, and common manners for file transferring are assumed to be used.

### 5.1.10.2 Actors and roles

Table 5.1.10.2-1 describes the use case actors and roles.

**Table 5.1.10.2-1: Logging in NFV-MANO to support root-cause analysis actors and roles**

#	Role	Description
1	NFV-MANO functional entity	The entity that provides logs and exposes interfaces.
2	Operator	The entity that requests management of the logging feature provided by the NFV-MANO functional entity and makes use of them.

### 5.1.10.3 Pre-conditions

Table 5.1.10.3-1 describes the use case pre-conditions.

**Table 5.1.10.3-1: Logging in NFV-MANO to support root-cause analysis pre-conditions**

#	Pre-condition	Additional description
1	The NFV-MANO functional entity has a subscription for notifying to the Operator about the availability of logs.	N/A

### 5.1.10.4 Post-conditions

Table 5.1.10.4-1 describes the use case post-conditions.

**Table 5.1.10.4-1: Logging in NFV-MANO to support root-cause analysis post-conditions**

#	Post-condition	Additional description
1	The Operator has the information acquired through the logging request operation.	Through the "logging notification base flow", the Operator is notified about the availability of the logs provided by the NFV-MANO functional entity that had been requested to be compiled.

### 5.1.10.5 Flow description

Table 5.1.10.5-1 describes the use case flow for the "logging notification base flow".

**Table 5.1.10.5-1: Logging in NFV-MANO to support root-cause analysis flow description – "logging notification base flow"**

#	Actor/Role	Action/Description
Begins when	Operator	The Operator determines that logging from a specific NFV-MANO functional entity is needed.
Step 1	Operator -> NFV-MANO functional entity	The Operator requests to the NFV-MANO functional entity the setup of logging, e.g. to prepare and start the logging. The query can include input filter data for selecting the needed logging, e.g. vendor specific logs, or logs produced with messages on a specific interface.
Step 2	NFV-MANO functional entity -> Operator	The NFV-MANO functional entity acknowledges the setup request.
Step 3	NFV-MANO functional entity -> Operator	When the log is ready, the NFV-MANO functional entity notifies to the Operator the availability of the log.
Ends when	Operator -> NFV-MANO functional entity	The Operator requests to the NFV-MANO functional entity to stop the collection of the logs.

## 5.2 Use cases with focus on automated deployment of EM and OSS functions specific for managing certain VNF or NS

### 5.2.1 Automated EM deployment

#### 5.2.1.1 Introduction and goal

Some network functions require specific Element Management (EM) functions to be fully operational. End-to-end automation of the deployment of network services can only be achieved if the deployment of such EM functions is automated as well. The use case describes automated instantiation of a network service which includes at least one VNF that requires an EM delivered by the VNF provider.

#### 5.2.1.2 Actors and roles

Table 5.2.1.2-1 describes the use case actors and roles.

**Table 5.2.1.2-1: Automated EM deployment actors and roles**

#	Role	Description
1	Service Acceptance Manager	Service provider function responsible to validate, certificate and on-board VNFs.
2	Service Deployment Manager	Service provider function responsible for managing the deployment (e.g. instantiation, update) of the NSs based VNFs validated by the Service Acceptance Manager.
3	NFV-MANO	The three NFV Management and Orchestration functional blocks (NFVO, VNFM and VIM) described in ETSI GS NFV 002 [i.1].
4	OSS	The Operations Support System used by the Service Deployment Manager.

### 5.2.1.3 Pre-conditions

Table 5.2.1.3-1 describes the use case pre-conditions.

**Table 5.2.1.3-1: Automated EM deployment pre-conditions**

#	Pre-condition	Additional description
1	All required VNF packages are on-boarded.	N/A
2	The EM functionality is made available by the VNF vendor as software (i.e. not as a hardware appliance).	Whether EM software is embedded in the VNF package or not depends on the solution and is therefore not indicated in the use case description.
3	The NSD is on-boarded.	N/A

### 5.2.1.4 Post-conditions

Table 5.2.1.4-1 describes the use case post-conditions.

**Table 5.2.1.4-1: Automated EM deployment post-conditions**

#	Post-condition	Additional description
1	All required VNF instances and the associated EM functionality are instantiated.	N/A

### 5.2.1.5 Flow description

Table 5.2.1.5-1 describes the use case flow.

**Table 5.2.1.5-1: Automated EM deployment flow description**

#	Actor/Role	Action/Description
Begins when	OSS	The OSS determines to instantiate an NS which includes at least one VNF which requires an EM function that is not already deployed.
Step 1	OSS -> NFV-MANO	The OSS requests to the NFV-MANO to instantiate a NS which includes at least one VNF which requires an EM function that is not already deployed.
Step 2	NFV-MANO	The NFV-MANO deploys the NS, including the required EM functionalities.
Step 3	NFV-MANO -> OSS	The OSS and the instances of this VNF receive from the NFV-MANO the address to reach the software entity providing the EM functionality (see note 1).
Ends when	OSS	The OSS and the EM functions can communicate with each other. The EM functions and the associated VNF instances can communicate with each other (see note 2).
NOTE 1: Depending on implementation this step may be subdivided.		
NOTE 2: VNFM is a part of NFV-MANO, so it can communicate with the EM functions as well.		

## 5.2.2 Deployment of virtualised EM as a VNF

### 5.2.2.1 Introduction and goal

In the NFV context, EM is regarded as an entity responsible for the application level management of the VNFs. The application level management of the VNFs including the application level management of virtualised EM is out of scope of the present document. In order to facilitate the automated deployment of a network service, the deployment of the EM may have several possibilities including to be virtualised as a special VNF dedicated for application management of the other VNF instances in a NS.

The goal of this use case is to show how to deploy the virtualised EM when the EM is a VNF and this EM is part of the same NS as the VNFs it manages.

### 5.2.2.2 Actors and roles

Table 5.2.2.2-1 describes the use case actors and roles.

**Table 5.2.2.2-1: Deployment of virtualised EM as a VNF actors and roles**

#	Role	Description
1	OSS	The entity that requests the instantiation of a new NS.
2	vEM	Virtualised EM.
3	NFVO	The entity that initiates the instantiation of the vEM and the Managed VNF(s) the vEM manages.
4	VNFM	The entity that executes the instantiation of the vEM and the Managed VNF(s) the vEM manages.
5	Managed VNF	The entity that can be managed by EM (including vEM).

### 5.2.2.3 Pre-conditions

Table 5.2.2.3-1 describes the use case pre-conditions.

**Table 5.2.2.3-1: Deployment of virtualised EM as a VNF pre-conditions**

#	Pre-condition	Additional description
1	The VNFDs of VNFs (corresponding to vEM and the Managed VNF) are referenced in the NSD.	The nature of a VNF application (e.g. vEM or the Managed VNF) is not known to the NFV-MANO.

### 5.2.2.4 Post-conditions

Table 5.2.2.4-1 describes the use case post-conditions.

**Table 5.2.2.4-1: Deployment of virtualised EM as a VNF post-conditions**

#	Post-condition	Additional description
1	The Managed VNF instances can be managed by the vEM.	N/A

### 5.2.2.5 Flow description

Table 5.2.2.5-1 describes the use case flow.

**Table 5.2.2.5-1: Deployment of virtualised EM as a VNF flow description**

#	Actor/Role	Action/Description
Begins when	OSS	The OSS determines to create a new NS instance.
Step 1	OSS -> NFVO	OSS sends a request to NFVO to instantiate a new NS instance.
Step 2	NFVO -> VNFM	NFVO sends a request to VNFM to instantiate the vEM and the Managed VNF according to the NSD. See note.
Step 3	VNFM -> NFVO	VNFM executes the instantiation of the vEM and the Managed VNF, and notifies NFVO the completion of the instantiation of the vEM and the Managed VNF.
Step 4	NFVO -> OSS	NFVO notifies OSS the results of the NS instantiation.
Step 5	OSS -> NFVO	OSS sends NFVO a request to query the information of the vEM or the Managed VNF in the NS.
Step 6	NFVO -> OSS	NFVO returns the information of the vEM or the Managed VNF to OSS.
Step 7	OSS -> NFVO	OSS sends an updating NS request to NFVO to modify the configuration data of the Managed VNF with the vEM related information contained in the new configuration data or sends a request to NFVO to modify the configuration data of the vEM with the Managed VNF related information contained in the new configuration data.
Step 8	NFVO -> VNFM	NFVO sends a request to VNFM to modify the configuration data of the vEM or the Managed VNF according to the request received from OSS.
Step 9	VNFM -> Managed VNF	VNFM configures the Managed VNF with the vEM related information or configures the vEM with the Managed VNF information according to the request received from NFVO.

#	Actor/Role	Action/Description
Ends when	Managed VNF(s), vEM	The Managed VNF(s) can be managed by the vEM.
NOTE: For simplicity, this use case assumes a single VNFM, but more complex cases are possible.		

## 5.2.3 Deployment of EM internal to the VNF

### 5.2.3.1 Introduction and goal

In the NFV context, EM is regarded as an entity responsible for the FCAPS management of the network applications implemented as VNFs. The application level management of the VNFs including the application level management of EM is out of scope of the present document. In order to facilitate the automated deployment of a network service, several options of EM deployment can be considered.

The goal of this use case is to show how to automatically deploy the EM internal to the VNF, e.g. in the form of a VNFC. An EM that is internal to the VNF is deployed at VNF instantiation time. From the perspective of this use case, EM manages the VNF in which it is internal. There is at least one VNF instance (which has internal EM functionality) in the NS. Such VNF instance is considered as "Self-managed VNF". NFV-MANO deploys the "Self-managed VNF" based on the contents of VNF Package, which may indicate compliancy with a particular protocol needed by OSS to interface with EM of this "Self-managed VNF".

### 5.2.3.2 Actors and roles

Table 5.2.3.2-1 describes the use case actors and roles.

**Table 5.2.3.2-1: Deployment of EM internal to the VNF actors and roles**

#	Role	Description
1	OSS	The entity that requests the instantiation of a new NS.
2	NFVO	The entity that initiates the instantiation of the VNF(s). See note 1.
3	Self-managed VNF	The VNF entity that has internal EM functionality. See note 2.
4	VNFM	The entity that executes the instantiation of the VNF(s). See note 3.
5	EM	EM functionality internal to VNF.
NOTE 1: According to NSD at least one of the instantiated VNFs has internal EM functionality.		
NOTE 2: EM manages the VNF, in which it is internal.		
NOTE 3: At least one of the instantiated VNFs is Self-managed VNF, but VNFM does not distinguish it from other VNFs.		

### 5.2.3.3 Pre-conditions

Table 5.2.3.3-1 describes the use case pre-conditions.

**Table 5.2.3.3-1: Deployment of EM internal to the VNF pre-conditions**

#	Pre-condition	Additional description
1	The VNF Package(s) of VNF(s) and Self-managed VNF(s) referenced in the NSD are on-boarded.	The nature of a Self-managed VNF application is not known to the NFVO.

### 5.2.3.4 Post-conditions

Table 5.2.3.4-1 describes the use case post-conditions.

**Table 5.2.3.4-1: Deployment of EM internal to the VNF post-conditions**

#	Post-condition	Additional description
1	The Self-managed VNF instance(s) are operational.	N/A

### 5.2.3.5 Flow description

Table 5.2.3.5-1 describes the use case flow.

**Table 5.2.3.5-1: Deployment of EM internal to the VNF flow description**

#	Actor/Role	Action/Description
Begins when	OSS	The OSS determines to create a new NS instance.
Step 1	OSS -> NFVO	OSS sends a request to NFVO to instantiate a new NS instance.
Step 2	NFVO -> VNFM	NFVO sends a request to VNFM to instantiate the VNF(s) according to NSD. At least one of instantiated VNF(s) is Self-managed VNF. See note 1.
Step 3	VNFM -> NFVO	VNFM executes the instantiation of the VNF(s). At least one of instantiated VNF(s) is Self-managed VNF (see note 2). VNFM notifies NFVO the completion of the instantiation.
Step 4	NFVO -> OSS	NFVO notifies OSS the results of the NS instantiation.
Step 5	OSS -> NFVO	OSS sends NFVO a request to query the connectivity information for the new Self-managed VNF(s), which was(were) instantiated. See note 1.
Step 6	NFVO -> VNFM	NFVO sends to VNFM a request to query the connectivity information for the new Self-managed VNF(s), which was(were) instantiated. See note 2.
Step 7	VNFM -> NFVO	VNFM returns to NFVO the connectivity information for the new Self-managed VNF(s), which was(were) instantiated. See note 2.
Step 8	NFVO -> OSS	NFVO returns the connectivity information for the new Self-managed VNF(s) to OSS. See note 1.
Ends when	Self-managed VNF, OSS, EM	OSS can manage the Self-managed VNF(s) directly. See note 3.
NOTE 1: NFVO does not distinguish Self-managed VNF from other VNF(s).		
NOTE 2: VNFM does not distinguish Self-managed VNF from other VNF(s).		
NOTE 3: The communication between OSS and EM is out of scope of ETSI NFV.		

## 6 Use Case analysis and derivation of patterns

### 6.1 Introduction

The following clauses provide a summary of functionality identified in the use cases and identifies any pattern from such use cases. Clause 6.2 addresses the analysis of use cases with a focus on management of NFV-MANO functions. Clause 6.3 addresses the analysis of use cases with a focus on automated deployment of EM and OSS functions specific for managing certain VNF or NS.

### 6.2 Analysis of use cases with a focus on management of NFV-MANO functions

#### 6.2.1 Types of management functionality

Some of the use cases relate to different NFV-MANO management services:

- Fault management: it is concerned with the monitoring of NFV-MANO functional entity failures. Failures can be detected by an external entity, or detected by the NFV-MANO functional entity itself and be notified to another external entity. To realize this, there needs to be means for:
  - An external entity to configure, start, and stop the fault monitoring of the NFV-MANO functional entity. See use case in clause 5.1.1.
  - An external entity to check the responsiveness of the NFV-MANO functional entity. See use case in clause 5.1.1.
  - The NFV-MANO functional entity to report about failures of the functional entity itself to an external entity. See use case in clause 5.1.1.

- Performance management: it is concerned with the collection of performance data from an NFV-MANO functional entity and the monitoring of alarms regarding performance. To realize this, there needs to be means for:
  - An external entity to configure, create, and delete tasks for collecting performance data. See use case in clause 5.1.2.
  - The NFV-MANO functional entity to notify about the availability of collected performance data to the external entity. See use case in clause 5.1.2.
  - An external entity to create, configure, and delete performance thresholds on an NFV-MANO functional entity. See use case in clause 5.1.3.
  - The NFV-MANO functional entity to report alarms to an external entity about a performance threshold crossing. See use case in clause 5.1.3.
- Configuration and information management: it is concerned with the configuration of the NFV-MANO functional entity for determining certain behaviour of the functional entity itself, as well as the status of other NFV-MANO functional entities. It is also concerned with the retrieval of information and capability discovery from an NFV-MANO functional entity. To realize this, there needs to be means for:
  - An external entity to add/remove a first NFV-MANO functional entity from a second NFV-MANO functional entity. See use cases in clauses 5.1.5 and 5.1.6.
  - An external entity to inform to a second NFV-MANO functional entity about a state change of a first NFV-MANO functional entity related to maintenance. See use case in clause 5.1.4.
  - A first NFV-MANO functional entity to query information and capabilities of a second NFV-MANO functional entity. See use case in clause 5.1.7.
  - The NFV-MANO functional entity to notify to subscribers about changes of the NFV-MANO functional entity's capabilities and information. See use case in clause 5.1.8.
- State management: it is concerned with the state of the NFV-MANO functional entity. To realize this, there needs to be means for:
  - An external entity to change the state of an NFV-MANO functional entity related to maintenance. See use case in clause 5.1.4.
  - An external entity to operate the state of an NFV-MANO functional entity application and/or provided NFV-MANO service. See use case in clause 5.1.9.
  - An NFV-MANO functional entity to notify to subscribers about changes of the state of the NFV-MANO functional entity's application and/or provided NFV-MANO service. See use case in clause 5.1.9.
- Log management: it is concerned with the management of logging mechanisms of the NFV-MANO functional entity and corresponding log reporting. To realize this, there needs to be means for:
  - An external entity to activate/de-activate (or start/stop) the logging in an NFV-MANO functional entity, including filtering for selecting the needed logging. See use case in clause 5.1.10.
  - An NFV-MANO functional entity to notify the availability of the log report(s). See use case in clause 5.1.10.
  - An external entity to retrieve the log reports from where they have been stored. Support of common file transfer functions are assumed. See use case in clause 5.1.10.

## 6.2.2 Granularity of fault and performance monitoring

Use cases in clauses 5.1.1, 5.1.2 and 5.1.3 deal with fault and performance monitoring functionality. The use cases describe some examples of the types of failures and performance measurements to monitor. As described in the use cases, different granularity of failures and performance measurements are needed.

For fault monitoring, the granularity of failures ranges from detecting that the whole NFV-MANO functional entity is unresponsive to identifying malfunctioning of the NFV-MANO functional entity due to failures on the resources supporting its execution.

For performance monitoring, the granularity of measurements range from reporting aggregate resource-related usage metrics, such as CPU usage (%), memory consumption usage, to measuring metrics related to an NFV-MANO functional entity's management functionality.

## 6.3 Analysis of use cases with a focus on automated deployment of EM and OSS functions specific for managing certain VNF or NS

### 6.3.1 Analysis of use cases with a focus on automated deployment of EM

Use case in clause 5.2.1 provides the general, business oriented perspective for automated deployment of EM. It considers service provider roles relevant in the process of NS design and inclusion of EM function, which is then automatically deployed by the NFV-MANO system and connected to the OSS.

The following use cases describe detailed technical approaches to EM deployment:

- 1) Deployment of virtualised EM as a VNF (see clause 5.2.2): the service provider decides during NS design to include a VNF, which realizes the EM functionality. The NFV-MANO system is not aware about the nature of this VNF (as EM). The VNF package can additionally indicate compliancy with a particular management protocol needed by OSS to interface with this VNF (as EM). As described in the use case, the deployment of virtualised EM as a VNF can be realized by using the existing interface operations.
- 2) Deployment of EM internal to the VNF (see clause 5.2.3): the service provider decides during NS design to include a Self-managed VNF, which has internal EM functionality. The information relevant for automated deployment of the Self-managed VNF is included in the VNFD. The NFV-MANO system is not aware about the nature of this VNF. The VNF package can additionally indicate compliancy with a particular management protocol needed by OSS to interface with this VNF.

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## 7 Framework and potential solutions

### 7.1 Potential solutions

#### 7.1.1 Solution A: NFV-MANO functional entity capabilities and information modelling

##### 7.1.1.1 Introduction

Use cases in clauses 5.1.5, 5.1.7 and 5.1.8 describe functionality related to configuration and information management. The use cases indicate the types of information and configuration that characterize the behaviour and capabilities of an NFV-MANO functional entity (see clause 6.2.1).

### 7.1.1.2 Types of information about an NFV-MANO functional entity

Regarding the capabilities and information about an NFV-MANO functional entity, the following data is needed:

- Identification information.
- Provider information, e.g. NFV-MANO functional entity provider name.
- Software version.
- List of supported interfaces, including information about:
  - version of the standard the interface is compliant to,
  - provider-specific software API version,
  - API exposed endpoints (i.e. connectivity information of the API endpoints for other NFV-MANO functional entities or other external entities to connect to),
  - list of supported operations per interface,
  - maximum number of concurrent operations per interface or per operation, and
  - security related information (e.g. list of supported encryption algorithm).
- Current values of configurable parameters that are set via the NFV-MANO Configuration and Information Management interface (see clause 7.1.6.5).
- State of the NFV-MANO functional entity application and individually provided NFV-MANO service(s).
- NFV-MANO functional entity specific data, i.e. specific to a VIM, VNFM or NFVO type of NFV-MANO functional entity.

For the NFV-MANO functional entity specific data, the types of information for specific NFV-MANO functional entities are provided in table 7.1.1.2-1.

**Table 7.1.1.2-1: NFV-MANO functional entity specific information**

NFV-MANO functional entity	Specific information
VIM	- Maximum number of Virtualised Resources that the VIM can manage (see note).
VNFM	- Support for indirect or direct mode of VNF-related resource management, or both. - The kinds of VNF instances that can be managed, e.g. to determine the compatibility of a VNF with certain VNFM according to the <code>vnfmInfo</code> attribute in the VNFD (see table 7.1.2.2-1 in ETSI GS NFV-IFA 011 [i.6]). - Maximum number of VNF instances that the VNFM can manage (see note). - Supported VNFD data format (e.g. TOSCA and/or YANG).
NFVO	- Maximum number of NSDs that can be on-boarded on the NFVO. - Maximum number of VNF Packages that can be on-boarded on the NFVO. - Maximum number of NS instances that the NFVO can manage (see note). - Supported VNFD/NSD data format (e.g. TOSCA and/or YANG).
NOTE:	This type of information (i.e. maximum number of VR, VNF and NS instances) may be more complex than a simple value due to the fact that the related managed object may also be of different sub-types, complexity, size, etc. For instance, with respect to Virtualised Resources, there are different types of resources (i.e. compute, storage and network) which can influence the maximum management capacity.

### 7.1.1.3 NFV-MANO functional entity information modelling

The information of an NFV-MANO functional entity needs to be structured so that specific attributes of information can be properly identified by an external entity when either querying or modifying the attribute values via the NFV-MANO Configuration and Information Management interface (see clause 7.1.6.5).

The types of information about an NFV-MANO functional entity is introduced in clause 7.1.1.2. Table 7.1.1.3-1 provides a description of attributes that are part of the NFV-MANO functional entity information element.

**Table 7.1.1.3-1: Attributes of NFV-MANO functional entity information element**

Attribute	Description
manoEntityType	The type of NFV-MANO functional entity.
manoEntityId	Information to identify this specific NFV-MANO functional entity.
manoEntityName	Human-readable name given to this specific NFV-MANO functional entity. See note.
manoEntityDescription	Human-readable description of this specific NFV-MANO functional entity. See note.
manoEntityProvider	Information about the provider of this entity. It typically includes the name of the provider.
manoEntitySoftwareVersion	The version of the software of this specific NFV-MANO functional entity.
manoEntityInterfaces	Information about the supported interfaces. The attribute's content is a complex content type providing information about: <ul style="list-style-type: none"> <li>- version of the standard the interface is compliant to,</li> <li>- provider-specific software API version,</li> <li>- API exposed endpoints (i.e. connectivity information of the API endpoints),</li> <li>- list of supported operations per interface,</li> <li>- maximum number of concurrent operations per interface or per operation, and</li> <li>- security related information.</li> </ul>
manoConfigurableParams	Information and current values of the configurable parameters. The attribute's content is a complex content type providing information about: <ul style="list-style-type: none"> <li>- List of NFV-MANO functional entity peers, including for each peer information about: <ul style="list-style-type: none"> <li>- type of NFV-MANO functional entity,</li> <li>- current state,</li> <li>- API exposed endpoints,</li> <li>- list of enabled management interfaces and operations, and</li> <li>- active subscriptions to notifications for monitoring.</li> </ul> </li> <li>- List of links to NFV-MANO functional entity peers, indicating reference point type and NFV-MANO functional entity peer.</li> </ul> See note.
manoApplicationState	Information and current values of the NFV-MANO functional entity's application and individual NFV-MANO service(s) state. This attribute's content is a complex type in order to cover the possibility of informing about the state of multiple individual NFV-MANO services.
manoEntitySpecificData	The information specific to this type of NFV-MANO functional entity. The attribute's content is a complex content type collecting the information as described in table 7.1.1.2-1.
NOTE:	The attribute's value should be writable through the corresponding NFV-MANO Configuration and Information Management interface (see clause 7.1.6.5).

## 7.1.2 Solution B: Types of failure and alarm modelling for NFV-MANO functional entity fault monitoring

### 7.1.2.1 Types of failure for NFV-MANO functional entity fault monitoring

The use case in clause 5.1.1 deals with fault monitoring functionality. It introduces some examples of the types of failures that are of interest to be monitored.

Regarding fault monitoring (see also clause 6.2.1), the granularity of failures include:

- Failure of the whole NFV-MANO functional entity.
- Communication failures with other peering NFV-MANO functional entities.
- Failures affecting a specific interface produced by the NFV-MANO functional entity, e.g. VNF lifecycle management interface produced by a VNFM.
- Malfunctioning of the NFV-MANO functional entity due to failures on resources supporting the execution of the entity, e.g. CPU, memory, reported as event type relevant to resources (see Recommendation ITU-T X.733 [i.5]).

### 7.1.2.2 Fault reporting information modelling

The fault information reported to a consumer needs to include information to identify the object on which the fault occurred, the type of fault that was identified, the cause of the fault, the timestamp information about when the event causing the fault was observed, as well as timing information about the alarm that is raised.

Table 7.1.2.2-1 provides a description of the attributes that compose an alarm entry for reporting failures.

NOTE: It is recommended reusing the format of alarm entry available as defined in other ETSI NFV-IFA deliverables.

**Table 7.1.2.2-1: Attributes of fault alarm**

Attribute	Description
alarmId	Identifier of the alarm.
objectType	The object type, which in this case is the NFV-MANO functional entity.
objectInstanceId	The information to identify this specific NFV-MANO functional entity.
alarmRaisedTime	Timestamp indicating when the alarm is raised by the managed object.
alarmChangedTime	Timestamp indicating when the alarm was last changed.
alarmClearedTime	Timestamp indicating when the alarm was cleared.
ackState	State of the alarm, e.g. acknowledged, unacknowledged.
faultType	The type of fault. It typically includes the name or identifier of the fault type.
eventType	Type of the event, as defined in Recommendation ITU-T X.733 [i.5].
eventTime	Timestamp indicating when the fault was observed.
perceivedSeverity	Information about the perceived severity of the fault.
probableCause	Information about the probable cause of the fault.
isRootCause	Information indicating if this fault is the root cause of other correlated alarms.
correlatedAlarmId	List of identifiers of other alarms correlated to this fault.
faultDetails	Additional information about the fault.
rootCauseFaultyResource	Information about the resource that is causing the fault, if any.

### 7.1.3 Solution C: Performance metrics definition for NFV-MANO functional entity performance monitoring

#### 7.1.3.1 Types of performance metrics for NFV-MANO functional entity performance monitoring

Use cases in clauses 5.1.2 and 5.1.3 deal with performance monitoring functionality. The use cases describe some examples of the types of performance information that are of interest to be monitored.

Regarding performance monitoring (see clause 6.2.1), the granularity of performance measurements that need to be reported/acquired include:

- Aggregate metrics related to the performance of resources supporting the execution of the NFV-MANO functional entity. These metrics are mainly related to usage (%), including aggregate CPU usage, memory consumption usage, in/out bytes per network interface, etc.
- Metrics related to the performance of the NFV-MANO functional entity's management functionality, including:
  - Metrics about number of managed objects, e.g. virtualised containers by a VIM, or VNF instances by a VNFM.
  - Number of workflows under execution, e.g. number and type of VNF lifecycle management operations under execution by the VNFM.
- Metrics related to the performance of the NFV-MANO functional entity at the interface level, including:
  - Number of requests per second per interface produced/consumed by the entity.
  - Number of failed requests per second per interface produced/consumed by the entity.
  - Accumulated number of requests per interface produced/consumed by the entity.

- Accumulated number of failed requests per interface produced/consumed by the entity.

### 7.1.3.2 Performance reporting information modelling

The performance information reported to a consumer needs to include information to identify the object on which the measurement is reported, the performance metric and its value.

Table 7.1.3.2-1 provides a description of the attributes that compose a performance report entry.

NOTE: It is recommended to reuse the format of performance report entry available as defined in other ETSI NFV-IFA deliverables.

**Table 7.1.3.2-1: Attributes of performance report entry**

Attribute	Description
objectType	The object type for which the performance is being reported, which in this case is the NFV-MANO functional entity.
objectInstanceId	The information to identify this specific NFV-MANO functional entity.
performanceMetric	The metric that is being collected and reported. It typically includes the name or identifier of the metric.
performanceValue	The value of the metric that has been collected.
timestamp	The timestamp indicating when the data has been collected.

## 7.1.4 Solution D: External entity consuming interfaces for management of an NFV-MANO functional entity

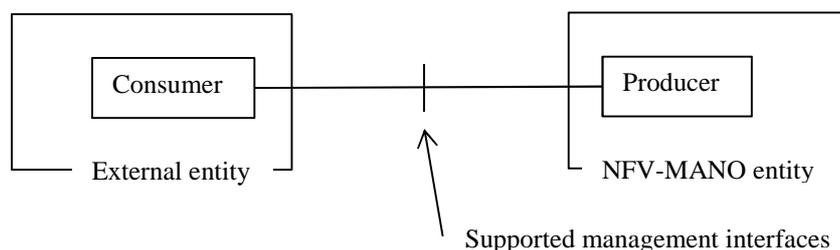
### 7.1.4.1 Introduction and objective

The related types of management functionality are described in clause 6.2.1. For fault, performance, configuration and information, state and log management types of functionality, an external entity is described.

This solution addresses the cases where an external entity needs to perform management actions on an NFV-MANO functional entity, and, thus, the NFV-MANO functional entity exposes interfaces for such management.

### 7.1.4.2 Framework

The framework of Solution D is illustrated in figure 7.1.4.2-1. The NFV-MANO functional entity exposes a set of management interfaces to an external entity through a Producer.



**Figure 7.1.4.2-1: Framework of external entity consuming interfaces for management of an NFV-MANO functional entity**

The Producer implements and supports a set of management interfaces that can be consumed by a Consumer within an external entity. The set of management interfaces is described in Solution F in clause 7.1.6.

In use cases where the role of "MANO Monitor" and/or "Operator" is introduced, in Solution D, this role is played by the same entity as the one playing the role of the Consumer.

## 7.1.5 Solution E: NFV-MANO functional entity consuming interfaces for management of another NFV-MANO functional entity

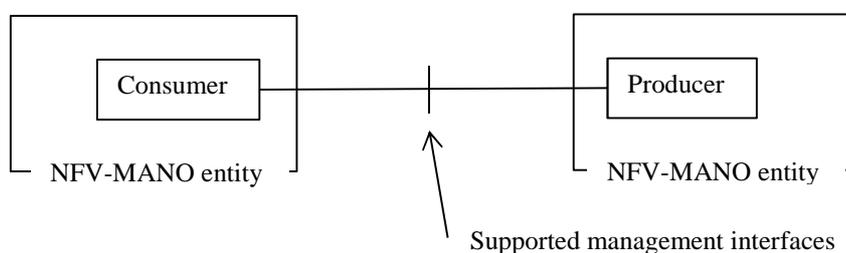
### 7.1.5.1 Introduction and objective

The types of management functionality are described in clause 6.2.1. For fault, performance, configuration and information, state, and log management types of functionality, certain operations are described to potentially be consumed by other NFV-MANO functional entity(s).

This solution addresses the cases where a consumer NFV-MANO functional entity needs to perform management actions on a producer NFV-MANO functional entity, and, thus, the NFV-MANO functional entity exposes interfaces for such management.

### 7.1.5.2 Framework

The framework of Solution E is illustrated in figure 7.1.5.2-1. The NFV-MANO functional entity exposes a set of management interfaces to another NFV-MANO functional entity through a Producer.



**Figure 7.1.5.2-1: Framework of NFV-MANO functional entity consuming interfaces for management of another NFV-MANO functional entity**

The Producer implements and supports a set of management interfaces that can be consumed by a Consumer within another NFV-MANO functional entity. The set of management interfaces is described in Solution F in clause 7.1.6.

The interaction between the Consumer and the Producer being part of two different NFV-MANO functional entities may be supported over existing reference points in the NFV-MANO Architectural Framework. Table 7.1.5.2-1 lists the relevant reference points and maps the Producer and Consumer to the respective NFV-MANO functional entities for the purpose of enabling the management of all kinds of NFV-MANO functional entities by at least another peering management entity.

**NOTE:** The scope of this solution is on enabling the management of NFV-MANO functional entities; therefore, the applicability of the management to other management entities outside of NFV-MANO is out of scope.

**Table 7.1.5.2-1: Solution E mapping to existing NFV-MANO Architectural Framework reference points**

Entity that is being monitored	Reference Point	Producer	Consumer
VIM	Or-Vi Vnfm-Vi	VIM	NFVO VNFM
VNFM	Or-Vnfm Ve-Vnfm-em,	VNFM	NFVO EM (see note)
NFVO	Os-Ma-nfvo Or-Vnfm	NFVO	VNFM OSS/BSS (see note)
<b>NOTE:</b> In this case, the Consumer is not an NFV-MANO functional entity.			

In use cases where the role of "MANO Monitor" is introduced, this role is played by the same entity as the one playing the role of the Consumer. However, not all interfaces/operations are consumed in this case, as clause 7.1.5.3 further details.

### 7.1.5.3 Interfaces consumption

When enabling the consumption of interfaces by a peering NFV-MANO functional entity, consumption per interface and per operation needs to be properly authorized. Therefore, only specific operations should be exposed to and be consumable by the Consumer within the peering NFV-MANO functional entity (refer to figure 7.1.5.2-1) (see example 1). This should also be considered in the case that certain interfaces are consumable by the Consumer within only specific NFV-MANO functional entities (see example 2).

- EXAMPLE 1:** Though the consumption of a specific interface may be needed by the NFVO to receive notifications on VIM state changes, the NFVO should not be able to request changing the state of the VIM through an operation of that same specific interface.
- EXAMPLE 2:** In order not to overload a VIM, VNFMs are authorized and configured to monitor faults of VIMs that are being used for managing the resources of managed VNF instances, but not authorized to monitor the performance of these same VIMs.

Table 7.1.5.3-1 describes the list of interfaces and operations described in clause 7.1.6 of Solution F that are consumable by the Consumer within the peering NFV-MANO functional entity as supported in this solution.

**Table 7.1.5.3-1: Solution E interfaces consumption**

Interface	Consumable operations
NFV-MANO Fault Management interface	Subscribe Unsubscribe Notify ForceHeartbeat
NFV-MANO Performance Management interface	CreatePmJob DeletePmJobs QueryPmJob CreateThreshold DeleteThreshold QueryThreshold Subscribe Unsubscribe Notify
NFV-MANO Configuration and Information Management interface	QueryConfigInfo Subscribe Unsubscribe Notify
NFV-MANO State Management interface	Subscribe Unsubscribe Notify
NFV-MANO Log Management interface	StartLogging (only interface message logging) StopLogging (only interface message logging) Subscribe Unsubscribe Notify

## 7.1.6 Solution F: Interfaces for management of NFV-MANO functional entity

### 7.1.6.1 Introduction and objective

This solution addresses the description of the interfaces and operations for enabling the management of an NFV-MANO functional entity covering the NFV-MANO management services as specified in clause 6.2.1.

- NOTE:** The set of interfaces defined in clause 7.1.6.2 are interfaces defined for the purpose of management of an NFV-MANO functional entity and are not the same interfaces that are available in other interfaces defined in [i.8], [i.9], [i.7], [i.10] and [i.11]. This is also clarified by tagging the different interface names with "NFV-MANO".

## 7.1.6.2 Set of interfaces

The set of management interfaces include:

- NFV-MANO Fault Management interface,
- NFV-MANO Performance Management interface,
- NFV-MANO Configuration and Information Management interface,
- NFV-MANO State Management interface, and
- NFV-MANO Log Management interface.

## 7.1.6.3 NFV-MANO Fault Management interface

### 7.1.6.3.1 Description

The NFV-MANO Fault Management interface provides the capability for a consumer to monitor the faults in an NFV-MANO functional entity and receive information through notifications when a fault is detected.

### 7.1.6.3.2 Operations

The list of operations of the NFV-MANO Fault Management interface is described in table 7.1.6.3.2-1.

**Table 7.1.6.3.2-1: NFV-MANO Fault Management interface operations**

Operation	Description
ConfigureMonitoring	This operation enables providing configuration parameters for the fault monitoring mechanisms.
QueryMonitoring	This operation enables a consumer to query the current fault monitoring configuration.
Subscribe	This operation enables a consumer to subscribe with a filter for the notifications related to fault monitoring which can be sent through the Notify operation.
Unsubscribe	This operation enables a consumer to unsubscribe receiving notifications issued through the Notify operation.
Notify	This operation distributes notifications to subscribers. In order to receive a notification, the consumer needs to have a subscription. The following types of notifications can be sent by this operation: <ul style="list-style-type: none"> <li>- HeartbeatNotification,</li> <li>- AlarmNotification,</li> <li>- AlarmClearedNotification, and</li> <li>- AlarmListRebuiltNotification.</li> </ul>
GetAlarmList	This operation enables a consumer to query the list of active alarms on the producer NFV-MANO functional entity.
ForceHeartbeat	This operation enables a consumer to force the producer NFV-MANO functional entity to send a heartbeat notification.

## 7.1.6.4 NFV-MANO Performance Management interface

### 7.1.6.4.1 Description

The NFV-MANO Performance Management interface provides the capability for a consumer to monitor the performance of an NFV-MANO functional entity and receive information through notifications when performance reports/data is available or when performance thresholds are crossed.

### 7.1.6.4.2 Operations

The list of operations of the NFV-MANO Performance Management interface is described in table 7.1.6.4.2-1.

**Table 7.1.6.4.2-1: NFV-MANO Performance Management interface operations**

Operation	Description
CreatePmJob	This operation enables a consumer to create a PM job on the producer NFV-MANO functional entity for collecting performance data.
DeletePmJobs	This operation enables a consumer to delete one or more PM jobs on the producer NFV-MANO functional entity.
QueryPmJob	This operation enables a consumer to query information about an existing PM job on the producer NFV-MANO functional entity.
CreateThreshold	This operation enables a consumer to create a threshold to specify threshold levels on a specified performance metric.
DeleteThresholds	This operation enables a consumer to delete one or more existing thresholds.
QueryThreshold	This operation enables a consumer to query the details of an existing threshold.
Subscribe	This operation enables a consumer to subscribe with a filter for the notifications related to performance monitoring which can be sent through the Notify operation.
Unsubscribe	This operation enables a consumer to unsubscribe receiving notifications issued through the Notify operation.
Notify	This operation distributes notifications to subscribers. In order to receive a notification, the consumer needs to have a subscription. The following types of notifications can be sent by this operation: <ul style="list-style-type: none"> <li>- PerformanceReportAvailableNotification, and</li> <li>- ThresholdCrossedNotification.</li> </ul>

### 7.1.6.5 NFV-MANO Configuration and Information Management interface

#### 7.1.6.5.1 Description

The NFV-MANO Configuration and Information Management interface provides the capability for a consumer to configure an NFV-MANO functional entity for determining the behaviour of the entity as well as the status of other entities according to the supported NFV-MANO functional entity's resource model. The interface also provides the capability to query configuration and information from the NFV-MANO functional entity. Finally, the interface also provides the mechanism to notify to subscribers when configuration and information data changes.

#### 7.1.6.5.2 Operations

The list of operations of the NFV-MANO Configuration and Information Management interface is described in table 7.1.6.5.2-1.

**Table 7.1.6.5.2-1: NFV-MANO Configuration and Information Management interface operations**

Operation	Description
ModifyConfig	This operation enables a consumer to modify the value of configuration and information parameters.
QueryConfigInfo	This operation enables a consumer to query for current values of NFV-MANO functional entity's configuration and information.
Subscribe	This operation enables a consumer to subscribe with a filter to notifications related to configuration changes which can be sent through the Notify operation.
Unsubscribe	This operation enables a consumer to unsubscribe receiving notifications issued through the Notify operation.
Notify	This operation distributes notifications to subscribers. In order to receive a notification, the consumer needs to have a subscription. The following type of notification can be sent by this operation: <ul style="list-style-type: none"> <li>- InformationChangedNotification.</li> </ul>

## 7.1.6.6 NFV-MANO State Management interface

### 7.1.6.6.1 Description

The NFV-MANO State Management interface provides the capability for a consumer to change the state of an NFV-MANO functional entity. The present solution includes changing the state for "maintenance" and back to "normal", as well as operating the state (i.e. "start" and "stop") of the NFV-MANO functional entity application and provided NFV-MANO service(s).

### 7.1.6.6.2 Operations

The list of operations of the NFV-MANO State Management interface is described in table 7.1.6.6.2-1.

**Table 7.1.6.6.2-1: NFV-MANO State Management interface operations**

Operation	Description
SetMaintenance	This operation enables a consumer to change the state to "maintenance".
UnsetMaintenance	This operation enables a consumer to change the state to "normal". Pre-condition is that the NFV-MANO functional entity is in "maintenance" state.
StartService	This operation enables a consumer to start the NFV-MANO functional entity application and/or specific NFV-MANO service.
StopService	This operation enables a consumer to stop the NFV-MANO functional entity application and/or specific NFV-MANO service.
Subscribe	This operation enables a consumer to subscribe with a filter for notifications related to state changes which can be sent through the Notify operation.
Unsubscribe	This operation enables a consumer to unsubscribe receiving notifications issued through the Notify operation.
Notify	This operation distributes notifications to subscribers. In order to receive a notification, the consumer needs to have a subscription. The following type of notification can be sent by this operation: - StateChangedNotification.

## 7.1.6.7 NFV-MANO Log Management interface

### 7.1.6.7.1 Description

The NFV-MANO Log Management interface provides the capability to manage logging jobs on an NFV-MANO functional entity and enable corresponding log reporting. Two types of logs can be collected:

- Logs of messages exchanged on interfaces between NFV-MANO functional entities (i.e. on reference points Or-Vi, Vi-Vnfm and Or-Vnfm), and between NFV-MANO functional entities and external entities (e.g. on reference points Os-Ma-nfvo and Ve-Vnfm-em/vnf).
- NFV-MANO functional entity provider specific logs. In this case, it is assumed that such logs are secured, e.g. be encrypted, and that specific filtering for start/stop logging is provider-defined. Notification on the availability of these logs is also applicable.

### 7.1.6.7.2 Operations

The list of operations of the NFV-MANO Log Management interface is described in table 7.1.6.7.2-1.

**Table 7.1.6.7.2-1: NFV-MANO Log Management interface operations**

Operation	Description
StartLogging	This operation enables a consumer to start a logging job according to a specified filter, so that the NFV-MANO functional entity starts the logging activity and creates the associated log.
StopLogging	This operation enables a consumer to stop the logging activity of an existing logging job.
Subscribe	This operation enables a consumer to subscribe with a filter for the notifications related to log management which can be sent through the Notify operation.
Unsubscribe	This operation enables a consumer to unsubscribe receiving notifications issued through the Notify operation.

Operation	Description
Notify	This operation distributes notifications to subscribers. In order to receive a notification, the consumer needs to have a subscription. The following type of notification can be sent by this operation: - LogReportAvailabilityNotification.

## 7.1.7 Solution G: Deployment of EM generic for VNF instances

### 7.1.7.1 Introduction

This clause describes the solution enabling automated EM deployment, where EM is external to VNF instances and is generic for VNFs. In this solution, the EM is deployed as a VNF.

The service provider during the design of an NS decides to reference the VNFD of an "EM generic for VNF instances" in the NSD. NFV-MANO deploys NS as defined in the NSD and is not aware of any specific functionalities of the deployed elements. The service provider designs the NS in a way, which allows OSS to communicate with the automatically deployed EM.

The solution is developed on the basis of use cases described in clauses 5.2.1 and 5.2.2.

### 7.1.7.2 Description

The service provider designs an NS. The NSD includes a reference to a VNFD that represents an EM to be deployed as VNF. Such an EM is used for managing some of the constituent VNF instance(s) of the NS that are instantiated from this NSD. The VNF selected for realization of EM functionalities is deployed based on a VNF package.

**NOTE:** The VNF package for the EM is different from the VNF Package(s) of the managed VNF(s) used in the NS.

The EM functionality is deployed no later than the first VNF it manages. Thanks to information available in the VNF package of the VNF hosting the generic EM functionality, the OSS can determine automatically how to communicate with the deployed EM.

Thanks to information available in the VNF packages of the managed VNFs, the EM can determine automatically how to communicate with the VNFs to be managed.

This approach is illustrated on figure 7.1.7.2-1.

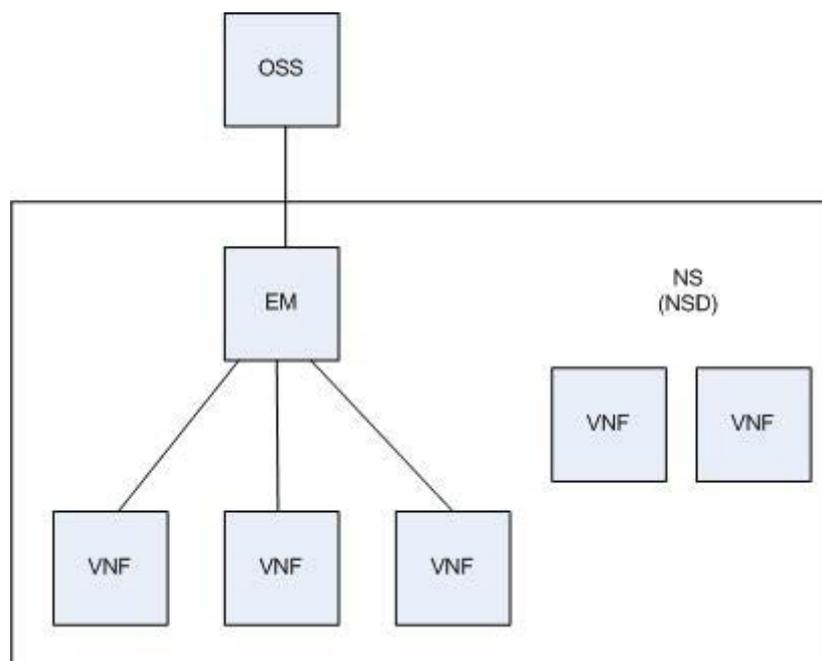


Figure 7.1.7.2-1: Illustration for contents of NSD for the NS

### 7.1.7.3 Extensions

The above solution assumes that information of interest to the OSS to setup communication with the deployed generic EM and of interest to the generic EM to setup communication with the VNFs to be managed can be included in the VNF Package.

## 7.1.8 Solution H: Deployment of EM internal to VNF

### 7.1.8.1 Introduction

This clause describes the solution enabling automated EM deployment, where EM is internal to VNF. Such VNF is considered as self-managed VNF. For the purpose of this solution it is assumed that EM manages only the VNF to which it is internal.

EM is automatically deployed during VNF instantiation, without NFV-MANO being aware of it. The service provider designs the NS in a way which allows the OSS to communicate with the automatically deployed EM.

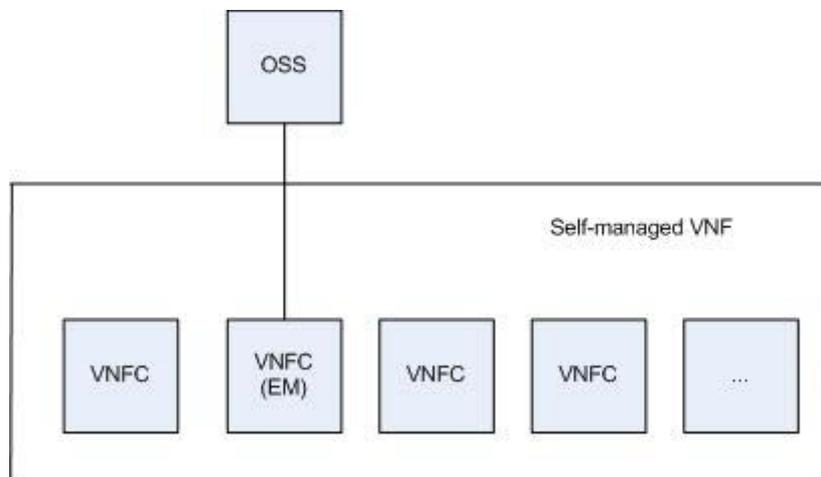
The solution is developed on the basis of use cases described in clauses 5.2.1 and 5.2.3.

### 7.1.8.2 EM deployed as VNFC

#### 7.1.8.2.1 Description

The service provider designs an NS. Service provider includes the VNFD of a self-managed VNF in the corresponding NSD. This solution considers as an example the self-managed VNF that has a VNFC dedicated to realize EM functionality for this VNF. Information about this VNFC (hereafter named EM) is provided in the VNFD. EM is deployed based on the content of VNFD. Thanks to information available in the VNF package, the OSS can determine automatically how to communicate with the deployed EM.

This approach is illustrated on figure 7.1.8.2.1-1.



**Figure 7.1.8.2.1-1: Illustration of an example of self-managed VNF for the NS**

#### 7.1.8.2.2 Extensions

The above solution assumes that information of interest to the OSS to setup communication with the deployed EM can be included in the VNF package.

## 7.1.9 Solution I: Deployment of EM specific for VNF instances

### 7.1.9.1 Introduction

This clause describes the solution enabling automated EM deployment, where the EM is external to the VNF(s) and is specific to VNF instance(s) it manages. In this solution EM is deployed as a VNF and it is assumed that the EM and the VNF instances it manages can communicate with each other through pre-agreed protocols and data models.

The service provider during the design of an NS decides to include the "EM specific for VNF(s)" in the NSD. NFV-MANO deploys the NS as defined in the NSD and is not aware of any specific functionalities of deployed elements. The service provider designs the NS in a way, which allows OSS to communicate with the automatically deployed EM.

The solution is developed on the basis of use cases described in clauses 5.2.1 and 5.2.2.

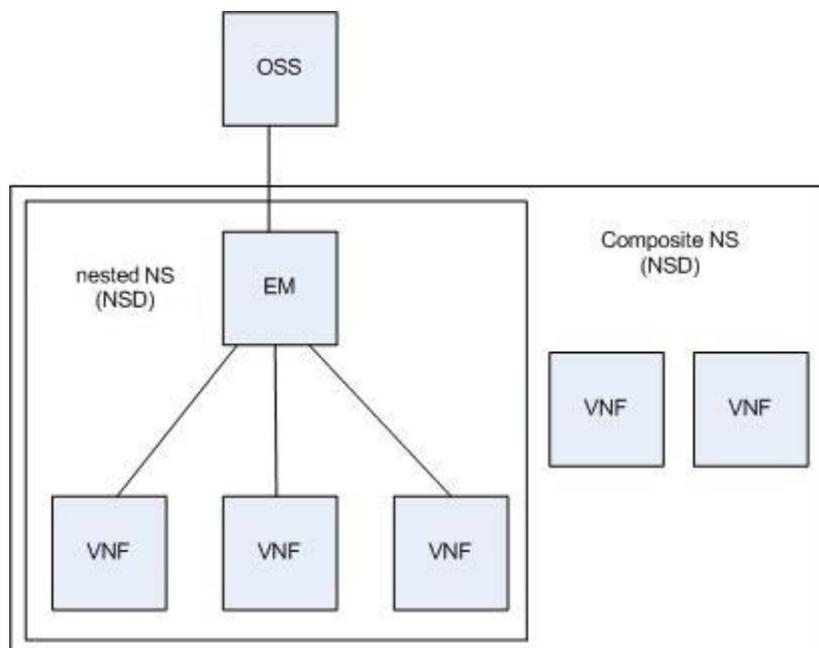
### 7.1.9.2 Description

The service provider designs an NS. The NSD includes a reference to a VNFD that represents an EM to be deployed as a VNF. Such an EM is used for managing some of the constituent VNF(s) of the NS that are instantiated from this NSD. The VNF selected for realization of EM functionalities is deployed based on a VNF package.

**NOTE:** The VNF package of the EM is different from the VNF Package(s) of the managed VNF(s) used in the NS.

The VNF hosting the EM functionality is deployed no later than the first VNF it manages. Thanks to information available in the VNF Package of the VNF hosting the EM functionality, the OSS can determine automatically how to communicate with the deployed EM.

The VNFD representing the EM can be grouped together with the VNFDs representing the VNFs it manages into a nested NSD, or a flat NSD structure can be used. Those approaches are illustrated on figure 7.1.9.2-1 for the nested NSD case, and on figure 7.1.9.2-2 for the flat NSD structure case.



**Figure 7.1.9.2-1: Using NSD of a nested NS for the composite NS**

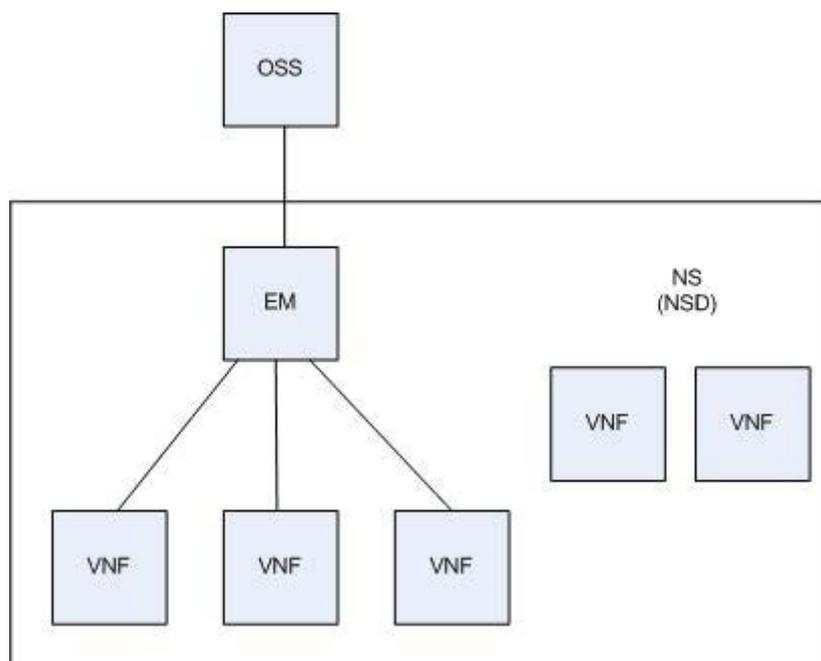


Figure 7.1.9.2-2: Using NSD of a flat NS structure

### 7.1.9.3 Extensions

The above solution assumes that information of interest to the OSS to setup communication with the deployed EM can be included in the VNF package.

## 8 Recommendations

### 8.1 Overview

Clause 8 provides recommendations resulting from the analysis performed on the use cases, and the potential solutions derived in clause 7. Recommendations encompass the identification of potential new requirements, i.e. to describe that a requirement is needed to cover certain aspect or required functionality.

Recommendations are categorized and elaborated as follows:

- architecture and framework aspects (refer to clause 8.2),
- functional aspects (refer to clause 8.3),
- reference points and/or interfaces (refer to clause 8.4),
- descriptors and other information/data model artefacts (refer to clause 8.5), and
- VNF Packages (refer to clause 8.6).

### 8.2 Recommendations related to architecture and framework aspects

The present clause provides recommendations focusing on higher-level architectural and framework aspects.

Table 8.2-1 provides the recommendations related to architectural aspects of management of NFV-MANO functional entities.

**Table 8.2-1: Recommendations related to architectural aspects of management of NFV-MANO functional entities**

Identifier	Recommendation description	Comments and/or traceability
Arch.Oam.001	It is recommended that a high-level requirement be specified for the NFV Architectural Framework to support the management of NFV-MANO functional entities.	Refer to analysis in clause 6.2.1.

### 8.3 Recommendations related to functional aspects

The present clause provides recommendations focusing on functional aspects of functional blocks identified in the NFV Architectural Framework.

Table 8.3-1 provides the recommendations related to functional aspects of management of NFVO as a managed entity.

**Table 8.3-1: Recommendations related to functional aspects of management of NFVO as a managed entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFVO as a managed entity to support:		
Nfvo.Oam.001	NFV-MANO fault management by a managing entity.	Refer to analysis in clause 6.2.1.
Nfvo.Oam.002	NFV-MANO performance management by a managing entity.	Refer to analysis in clause 6.2.1.
Identifier	Recommendation description	Comments and/or traceability
Nfvo.Oam.003	NFV-MANO configuration and information management by a managing entity.	Refer to analysis in clause 6.2.1.
Nfvo.Oam.004	NFV-MANO state management by a managing entity.	Refer to analysis in clause 6.2.1.
Nfvo.Oam.005	NFV-MANO log management by a managing entity.	Refer to analysis in clause 6.2.1.

Table 8.3-2 provides the recommendations related to functional aspects of management of VNFM as a managed entity.

**Table 8.3-2: Recommendations related to functional aspects of management of VNFM as a managed entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the VNFM as a managed entity to support:		
Vnfm.Oam.001	NFV-MANO fault management by a managing entity.	Refer to analysis in clause 6.2.1.
Vnfm.Oam.002	NFV-MANO performance management by a managing entity.	Refer to analysis in clause 6.2.1.
Vnfm.Oam.003	NFV-MANO configuration and information management by a managing entity.	Refer to analysis in clause 6.2.1.
Vnfm.Oam.004	NFV-MANO state management by a managing entity.	Refer to analysis in clause 6.2.1.
Vnfm.Oam.005	NFV-MANO log management by a managing entity.	Refer to analysis in clause 6.2.1.

Table 8.3-3 provides the recommendations related to functional aspects of management of VIM as a managed entity.

**Table 8.3-3: Recommendations related to functional aspects of management of VIM as a managed entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the VIM as a managed entity to support:		
Vim.Oam.001	NFV-MANO fault management by a managing entity.	Refer to analysis in clause 6.2.1.
Vim.Oam.002	NFV-MANO performance management by a managing entity.	Refer to analysis in clause 6.2.1.
Vim.Oam.003	NFV-MANO configuration and information management by a managing entity.	Refer to analysis in clause 6.2.1.
Vim.Oam.004	NFV-MANO state management by a managing entity.	Refer to analysis in clause 6.2.1.
Vim.Oam.005	NFV-MANO log management by a managing entity.	Refer to analysis in clause 6.2.1.

## 8.4 Recommendations related to reference points and/or interfaces

The present clause provides recommendations focusing on the definition and specification of interfaces related to management of an NFV-MANO functional entity.

Table 8.4-1 provides the recommendations related to interface aspects of management of NFV-MANO functional entities.

**Table 8.4-1: Recommendations related to interface aspects of management of NFV-MANO functional entities**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the support of a:		
Nfvmanoif.001	NFV-MANO fault management interface produced by the NFV-MANO functional entity.	See note. Refer to clause 7.1.6.3. See also table 8.4-2.
Nfvmanoif.002	NFV-MANO performance management interface produced by the NFV-MANO functional entity.	See note. Refer to clause 7.1.6.4. See also table 8.4-3.
Nfvmanoif.003	NFV-MANO configuration and information management interface produced by the NFV-MANO functional entity.	See note. Refer to clause 7.1.6.5. See also table 8.4-4.
Nfvmanoif.004	NFV-MANO state management interface produced by the NFV-MANO functional entity.	See note. Refer to clause 7.1.6.6. See also table 8.4-5.
Nfvmanoif.005	NFV-MANO log management interface produced by the NFV-MANO functional entity.	See note. Refer to clause 7.1.6.7. See also table 8.4-6.
NOTE: The NFV-MANO functional entity producer is: NFVO, VNFM, or VIM.		

Table 8.4-2 provides the recommendations related to the interface for fault management of an NFV-MANO functional entity.

**Table 8.4-2: Recommendations related to interface for fault management of an NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFV-MANO fault management interface to support:		
Nfvmanoif.Fm.001	Configuration of fault monitoring.	Refer to clause 7.1.6.3.2
Nfvmanoif.Fm.002	Query of current fault monitoring configuration.	Refer to clause 7.1.6.3.2
Nfvmanoif.Fm.003	Notifications related to fault monitoring, and the corresponding subscription and un-subscription operations for such notifications.	Refer to clause 7.1.6.3.2
Nfvmanoif.Fm.004	Query the list of active alarms by a consumer.	Refer to clause 7.1.6.3.2
Nfvmanoif.Fm.005	Forcing the creation of heartbeat notifications by a consumer.	Refer to clause 7.1.6.3.2

Table 8.4-3 provides the recommendations related to the interface for performance management of an NFV-MANO functional entity.

**Table 8.4-3: Recommendations related to interface for performance management of an NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFV-MANO performance management interface to support:		
Nfvmanoif.Pm.001	Creation, deletion, and query of PM jobs for performance monitoring.	Refer to clause 7.1.6.4.2
Nfvmanoif.Pm.002	Creation, deletion, and query of thresholds for performance monitoring.	Refer to clause 7.1.6.4.2
Nfvmanoif.Pm.003	Notifications related to performance monitoring, and the corresponding subscription and un-subscription operations for such notifications.	Refer to clause 7.1.6.4.2

Table 8.4-4 provides the recommendations related to the interface for configuration and information management of an NFV-MANO functional entity.

**Table 8.4-4: Recommendations related to interface for configuration and information management of an NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFV-MANO configuration and information management interface to support:		
Nfvmanoif.Cim.001	Modification of configuration and information parameters.	Refer to clause 7.1.6.5.2
Nfvmanoif.Cim.002	Query of current configuration and information parameters.	Refer to clause 7.1.6.5.2
Nfvmanoif.Cim.003	Notifications related to changes in configuration and information, and the corresponding subscription and un-subscription operations for such notifications.	Refer to clause 7.1.6.5.2

Table 8.4-5 provides the recommendations related to the interface for state management of an NFV-MANO functional entity.

**Table 8.4-5: Recommendations related to interface for state management of an NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFV-MANO state management interface to support:		
Nfvmanoif.Sm.001	Change the state of the NFV-MANO functional entity.	Refer to clause 7.1.6.6.2
Nfvmanoif.Sm.002	Start and stop of the NFV-MANO functional entity application and/or specific NFV-MANO services.	Refer to clause 7.1.6.6.2
Nfvmanoif.Sm.003	Notifications related to state changes of the NFV-MANO functional entity application and/or specific NFV-MANO services, and the corresponding subscription and un-subscription operations for such notifications.	Refer to clause 7.1.6.6.2

Table 8.4-6 provides the recommendations related to the interface for log management of an NFV-MANO functional entity.

**Table 8.4-6: Recommendations related to interface for log management of NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
It is recommended that a requirement set be specified for the NFV-MANO log management interface to support:		
Nfvmanoif.Logm.001	Start and stop the logging jobs according to a specified filter.	Refer to clause 7.1.6.7.2
Nfvmanoif.Logm.002	Notifications related to log management of the NFV-MANO functional entity, and the corresponding subscription and un-subscription operations for such notifications.	Refer to clause 7.1.6.7.2

## 8.5 Recommendations related to descriptors and other information/data model artifacts

The present clause provides recommendations focusing on the definition and specification of descriptors and information model elements related to management of an NFV-MANO functional entity.

Table 8.5-1 provides the recommendations related to descriptors and information model aspects related to management of NFV-MANO functional entity.

**Table 8.5-1: Recommendations related to descriptors and information model aspects related to management of NFV-MANO functional entity**

Identifier	Recommendation description	Comments and/or traceability
Nfvmanoim.001	It is recommended that a set of information elements be specified that describe and contain information of an NFV-MANO functional entity.	See note 1, note 2. Refer to clause 7.1.1.2. The attributes of the NFV-MANO functional entity information elements are defined in clause 7.1.1.3.
Nfvmanoim.002	It is recommended that a set of information elements be specified to describe and contain information about fault alarms of an NFV-MANO functional entity.	See note 1, note 2. Refer to clause 7.1.2.1. The attributes of the fault alarm are defined in clause 7.1.2.2.
Nfvmanoim.003	It is recommended that a set of performance metrics and information elements be specified for the reporting of performance information of an NFV-MANO functional entity.	See note 1, note 2. The attributes of the performance report entry are defined in clause 7.1.3.2.
NOTE 1: The NFV-MANO functional entity is: NFVO, VNFM, or VIM.		
NOTE 2: The "a set of information elements" may result in just one information element. The set of information elements will depend on the final set of classes and required information model structure.		

## 8.6 Recommendations related to VNF Packages

The present clause provides recommendations focusing on the extensions to VNF packages.

Table 8.6-1 provides the recommendations for VNF packages.

**Table 8.6-1: Recommendations related to VNF packages**

Identifier	Recommendation description	Comments and/or traceability
Vnfpack.001	It is recommended that a requirement be defined for a VNF Package to provide generic extension mechanism that allows to store in the VNF Package information for use by functional blocks beyond NFV-MANO, and to identify that information in an SDO-independent and vendor-independent manner.	Refer to clauses 7.1.7, 7.1.8 and 7.1.9. See note 1, note 2.
NOTE 1: Functional blocks using this information could include the OSS and external EMs.		
NOTE 2: It is expected that other uses cases beyond those described in the present document will benefit from a mechanism fulfilling this requirement.		

## 8.7 Recommendations related to Security

ETSI GS NFV-SEC 012 [i.12] defines requirements for host system elements on which sensitive workloads are to be run. It also defines requirements to ensure isolation of sensitive workloads from non-sensitive workloads sharing a platform. Moreover, it discusses a wide range of different technologies which aim to increase the security of a host system for the workloads which will be executing on it.

The present clause provides recommendations focusing on security aspects in alignment with Annex A of the present document. Table 8.7-1 provides the recommendations related to security. The present clause on recommendations related to security assumes that all entities are within one administrative domain.

**Table 8.7-1: Recommendations related to Security**

Identifier	Recommendation description	Comments and/or traceability
Sec.001	It is recommended that a requirement be defined for the system to provide means to prove the authenticity and to ensure data integrity of any performance report, notification, and NFV-MANO functional provider-specific log.	Refer to clauses 7.1.3 and 7.1.6.7.
Sec.002	It is recommended that a requirement be defined for the system to provide means to verify the identity and authenticity of the source of any performance report, notification, and NFV-MANO functional provider-specific log.	
Sec.003	It is recommended that a requirement be defined for the system to provide means to ensure the confidentiality of any performance report, notification, and NFV-MANO functional provider-specific log, i.e. to ensure it is not made available or disclosed to unauthorized individuals, entities, or processes. This includes that the system is to provide means to ensure that only authorized entities can subscribe to receive notifications.	
Sec.004	It is recommended that a requirement be defined for the system to provide means to ensure non-repudiation for any logs, notifications, and performance reports.	
Sec.005	It is recommended that a requirement be defined for the system to provide means to prevent replay of any notification.	
Sec.006	It is recommended that a requirement be defined for timestamps to be issued by a trusted source of time.	Refer to clauses 7.1.2 and 7.1.3.
Sec.007	It is recommended that a requirement be defined for the identifiers of entities or other identification information to be secured by an identity management system.	
Sec.008	It is recommended that a requirement be defined for the interfaces that they can only be accessed by authorized entities.	

Identifier	Recommendation description	Comments and/or traceability
Sec.009	It is recommended that a requirement be defined for the system to have a mitigation process in place.	
Sec.010	It is recommended that a requirement be defined for security best practice to be followed for matters not specifically identified in this table. These includes such topics such as denial-of-service mitigation.	

## 9 Conclusion

The present document studies use cases and potential solutions and provides recommendations relevant to the scope of the present document, which is:

- management aspects of NFV-MANO functional entities, and
- the automated deployment of EM and OSS functions specific for managing certain VNF or NS.

With respect to management aspects of NFV-MANO functional entities, a set of recommendations are derived based on the use cases identified and the potential solutions. The set of recommendations indicate the need to perform additional normative specification work to address the NFV-MANO management feature. The aspects that require normative work are:

- Recommendations related to architectural aspects of management of NFV-MANO functional entities (refer to table 8.2-1).
- Recommendations related to functional aspects of management of NFVO, VNFM and VIM as a managed entity (refer to tables 8.3-1, 8.3-2 and 8.3-3).
- Recommendations related to interface aspects of management of NFV-MANO functional entities (refer to table 8.4-1), as well as specific types of functionality related to fault management (refer to table 8.4-2), performance management (refer to table 8.4-3), configuration and information management (refer to table 8.4-4), state management (refer to table 8.4-5), and log management (refer to table 8.4-6).
- Recommendations related to descriptors and information model aspects for the management of NFV-MANO functional entities (refer to table 8.5-1).

With respect to the aspects of automated deployment of EM and OSS functions specific for managing certain VNF or NS, several use cases and potential solutions are described. Considering the fact that the application level management of the VNFs including the application level management of EM is out of scope of NFV-MANO, the present document analyses the need of automated establishing of the communication between OSS and EM or EM and VNF. The aspects that require normative work include the recommendation related to the generic extension mechanism that allows to store in the VNF Package information for use by 3rd party functional blocks outside of NFV-MANO e.g. OSS or EM (refer to table 8.6-1).

Finally, a set of recommendations related to security aspects, for the scope of the present document, were derived from the analysis included in Annex A.

# Annex A: Security and Regulatory Concerns

## A.1 Risk analysis and assessment

Table A.1-1 is the output of the Threat, Risk, Vulnerability Analysis according to ETSI GS NFV-SEC 006 [i.13].

**Table A.1-1: Threat, Risk, Vulnerability Analysis**

<b>A Security Environment</b>		
<b>a.1 Assumptions</b>		
a.1.1	A new set of management and orchestration functions in addition to existing Element Management (EM) and Operations Support Systems (OSS) functions is introduced by NFV. Such NFV-MANO functions have the role to manage the NFVI and orchestrate the allocation of resources needed by the NSs and VNFs.	See clause 4.1
a.1.2	An NFV-MANO functional entity application is a program designed to perform a function or a set of functions providing NFV-MANO services.	See clause 3.1
a.1.3	An NFV-MANO service is one or more capabilities offered via NFV-MANO functional blocks (i.e. NFVO, VNFM, VIM) invoked using a defined interface.	See clause 3.1
a.1.4	An NFV-MANO management service is one or more capabilities for the support of operations, administration and maintenance of the NFV-MANO functional entity being managed.	See clause 3.1
a.1.5	NFV-MANO management functions include fault management, performance management, configuration and information management, state management, as well as log management. More details about these management functionalities is summarized in clause 6.2.1 and the related interfaces are described in the corresponding clause 7.	See clause 6.2.1 and clause 7
a.1.6	EM and OSS functions for managing specific VNF or NS, including deployment of virtualised EM as a VNF and deployment of EM internal to the VNF.	
<b>a.2 Assets</b>		
a.2.1	NFVO: it has two main responsibilities: <ul style="list-style-type: none"> <li>- the orchestration of NFVI resources across multiple VIM instances, fulfilling the Resource Orchestration functions, and</li> <li>- the lifecycle management of NS, fulfilling the Network Service Orchestration functions.</li> </ul>	See clause 4.2
a.2.2	VNFM: it is responsible for the lifecycle management of VNF instances.	See clause 4.2
a.2.3	VIM: it is responsible for controlling and managing NFVI compute, storage and network resources. The VIM manages the association of the virtualised resources to the physical compute, storage and networking resources.	See clause 4.2
a.2.4	NFV-MANO functional entity: it is the NFVO, VNFM, or VIM. An NFV-MANO functional entity is associated with data describing the capabilities and holding information about it.	See clause 7.1.1
a.2.5	External entity consuming interfaces for management of an NFV-MANO functional entity: it is an external entity that needs to perform management actions on an NFV-MANO functional entity, and, thus, the NFV-MANO functional entity exposes interfaces for such management.	See clause 7.1.4
a.2.6	Management interfaces: For fault, performance, configuration and information, state, and log management types of functionality, certain operations are described to potentially be consumed by other NFV-MANO functional entity(s).	See clause 6.2.1 and clause 7.1.5
a.2.7	Interfaces for management of an NFV-MANO functional entity.	See clause 7.1.6
a.2.8	Fault alarm: fault information reported to a consumer including information to identify the object on which the fault occurred, the type of fault that was identified, the cause of the fault, the timestamp information about when the event causing the fault was observed, as well as timing information about the alarm that is raised.	See clause 7.1.2
a.2.9	Performance metrics: performance measurements that need to be reported/acquired.	See clause 7.1.3

<b>A Security Environment</b>		
<b>a.3 Threat agents</b>		
a.3.1	Unauthorized user of assets (e.g. reports, notifications, log)	
a.3.2	(Industrial) espionage agent	
a.3.3	Sabotage agent	
a.3.4	Internal threat agent, e.g. corrupt employee	
<b>a.4 Threats</b>		
a.4.1	Unauthorized viewing/copying of data	Refer to threat agents a.3.1, a.3.2 and a.3.4. Refer to all assets in a.2.
a.4.2	Manipulation	Refer to threat agents a.3.3 and a.3.4. Refer to all assets in a.2.
a.4.2.1	- Unauthorized access	
a.4.2.2	- Masquerade ("spoofing")	
a.4.2.3	- Forgery	
a.4.2.4	- Loss or corruption of information	
a.4.3	Repudiation	Refer to threat agent a.3.4. Refer to assets a.2.6 to a.2.9.
a.4.4	Denial of service	Refer to threat agents a.3.3 and a.3.4. Refer to assets a.2.1 to a.2.7.
<b>B Security Objectives</b>		
<b>b.1 Security objectives for the asset</b>		
b.1.1	The assets should ensure that only authorized and authenticated entities can access (read or write) the provided interfaces and that data is exchanged in a confidential manner. Therefore, requirements for access controls and communications security (see clauses 8.5 and 8.6 in [i.12]) should be followed.	
b.1.2	The assets should ensure the authenticity and integrity of all data exchanged on the interfaces and should prevent replay of any data. Therefore, requirements for authentications controls (see clause 8.4 in [i.12]) should be followed.	
b.1.3	The assets should ensure the availability of data to be provided on the interfaces.	
b.1.4	The assets should be accountable for the data provided, that is why the assets should ensure collected data (e.g. fault or performance data, timestamps) and its sources can be trusted.	
b.1.5	The assets should ensure that interception is possible where required to support regulatory requirements (such as Lawful Interception [i.14] and Retained Data [i.15]) and not possible otherwise.	
b.1.6	The assets should ensure that denial of service (e.g. by message storms) is not possible.	
b.1.7	The system should ensure secure logging as described in clause 8.1 in [i.12].	

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## Annex B: Authors & contributors

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## Annex C: Change history

Date	Version	Information about changes
June 2016	0.0.1	Initial version of ToC (approved contribution NFVIFA(16)000668r1).
June 2016	0.1.0	Implementation approved contributions from EA: NFVIFA(16)000669r2. Implementation approved contribution from IFA#33: NFVIFA(16)000993r1, and NFVIFA(16)000994r1. Implementation of rapporteur actions from NFVIFA(16)0001015r3. Editorials: Clause 2.2: added NFVIFA010 reference. Clause 3.2: added FCAPS abbreviation.
September 2016	0.2.0	Implementation approved contributions from IFA#38: NFVIFA(16)0001254r3, NFVIFA(16)0001255r3, NFVIFA(16)0001256r2, and NFVIFA(16)0001257r2.
November 2016	0.3.0	Implementation of approved contributions from EA and IFA#40: NFVIFA(16)0001280r3, NFVIFA(16)0001356r2, and NFVIFA(16)0001358r1. Editorials: Clause 2.2: added NFV-IFA011 reference and corrected a few typos.
December 2016	0.4.0	Implementation of approved contributions from e-mail approval: NFVIFA(16)0001352r4, and NFVIFA(16)0001435. Implementation of approved contributions from IFA#43: NFVIFA(16)0001279r7, NFVIFA(16)0001477, NFVIFA(16)0001357r2, NFVIFA(16)0001354r3, NFVIFA(16)0001480r1, NFVIFA(16)0001481, NFVIFA(16)0001483r1, and NFVIFA(16)0001482r1. Implementation of rapporteur actions from NFVIFA(16)0001498. Editorials: Table 5.2.2.5-1: In step 2, move the NOTE to bottom of the table according to EDR.
February 2017	0.5.0	Implementation of approved contributions from IFA#46: NFVIFA(17)000119, NFVIFA(17)000120r2, NFVIFA(17)000121r2, NFVIFA(17)000122r1, NFVIFA(17)000123r1, NFVIFA(17)000124r3, NFVIFA(17)000125r2, and NFVIFA(17)000126r1. Rapporteur actions: Added references for IFA006, IFA008 and IFA013 used in clause 7.1.6.1. Editorials: Formatted the "editor's note" with correct EDR Word style. Corrected some formatting with bullet list in clauses 4.1, 4.2, 5.1.1.1, 5.1.2.1, 5.1.3.1, 5.1.6.1, 5.1.7.1, 5.1.8.1, 5.1.10.1, 6.2.1.
March 2017	0.6.0	Implementation of approved contributions from IFA#48: NFVIFA(17)000213, NFVIFA(17)000214r1, NFVIFA(17)000215, NFVIFA(17)000216, NFVIFA(17)000217, NFVIFA(17)000218, NFVIFA(17)000219r1, NFVIFA(17)000220r1, NFVIFA(17)000221r1, NFVIFA(17)000222. Editorials: Several clauses in 7: corrected some formatting of text to use "Normal" template. Clause 6.2.1: corrected misspelled /s/stage/state. Clause 7.1.5.2: corrected references to figures and tables.
May 2017	0.7.0	Implementation of approved contributions from IFA#52: NFVIFA(17)000410, NFVIFA(17)000419r1, NFVIFA(17)000244r6. Editorials: None.
June 2017	0.8.0	Implementation of approved contribution from IFA#55 and IFA#56: NFVIFA(17)000245r6, NFVIFA(17)000444r4, NFVIFA(17)000418r1. Editorials: Added "clause" wording while implementing 245r6.
September 2017	0.9.0 (Stable Draft)	Implementation of approved contributions from IFA#67 NFVIFA(17)000806, NFVIFA(17)807r1, NFVIFA(17)000552r9, NFVIFA(17)000553r7, NFVIFA(17)000554r6, NFVIFA(17)000556r8 Editorials: Corrected formatting of text to use "Normal" template. Correction of "Consumer NFV-MANO functional entity" to "Consumer NFV-MANO functional entity(s)" in clause 5.1.6.5 in alignment with 807r1.

Date	Version	Information about changes
October 2017	0.10.0	Final review and consistency performed to the Stable Draft. Implementation of approved contributions during the review: NFVIFA(17)000889, NFVIFA(17)000890, NFVIFA(17)000891r1, NFVIFA(17)000892, NFVIFA(17)000893, NFVIFA(17)000894r1, NFVIFA(17)000946. Rapporteur actions following the guidelines in contribution NFVIFA(17)000888. Additional actions taken are: Removed the editor's note in clause 9, as content is complete with approval of contribution NFVIFA(17)000894r1.
December 2017	0.11.0	Final review with security and reliability analysis. Implementation of approved contributions: NFVIFA(17)000938r5, NFVIFA(17)0001112, NFVIFA(17)0001138r2. Rapporteur action: added final conclusions statement in the clause 9 Conclusion based on the implementation of contribution NFVIFA(17)000938r5 as new clause 8.7.

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## History

<b>Document history</b>		
V3.1.1	January 2018	Publication