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Table of Contents

1 Scope of Document 6

2 Conventions to be used 7

3 Acronyms and abbreviations 8

4 Use Cases 9

5 Requirements Specification 10

5.1 Functional Requirements . . . 10
5.1.1 Configuration . . . 10
5.1.2 Initialization . . . 11
5.1.3 Normal Operation . . . 12
5.1.4 Fault Operation . . . 19
5.1.5 Nm Coordination . . . 20
5.1.6 Partial Networking . . . 22
5.2 Non-Functional Requirements . . . 30
5.2.1 Layout Requirements . . . 30
5.2.2 Timing Requirements . . . 31
5.2.3 Resource Usage . . . 31
5.2.4 Hardware independency . . . 33

6 References 34

A Change history of AUTOSAR traceable items 35

A.1 Traceable item history of this document according to AUTOSAR Release R22-11 . . . 35
A.1.1 Added Requirements in R22-11 . . . 35
A.1.2 Changed Requirements in R22-11 . . . 35
A.1.3 Deleted Requirements in R22-11 . . . 37
A.1.4 Added Constraints in R22-11 . . . 37
A.1.5 Changed Constraints in R22-11 . . . 37
A.1.6 Deleted Constraints in R22-11 . . . 38
A.2 Traceable item history of this document according to AUTOSAR Release R23-11 . . . 38
A.2.1 Added Requirements in R23-11 . . . 38
A.2.2 Changed Requirements in R23-11 . . . 38
A.2.3 Deleted Requirements in R23-11 . . . 38
A.2.4 Added Constraints in R23-11 . . . 38
A.2.5 Changed Constraints in R23-11 . . . 38
A.2.6 Deleted Constraints in R23-11 . . . 38
A.3 Traceable item history of this document according to AUTOSAR Release R24-11 . . . 38

A.3.1 Added Requirements in R24-11 38
A.3.2 Changed Requirements in R24-11 39
A.3.3 Deleted Requirements in R24-11 39
A.4 Traceable item history of this document according to AUTOSAR Release R25-11 39
A.4.1 Added Requirements in R25-11 39
A.4.2 Changed Requirements in R25-11 39
A.4.3 Deleted Requirements in R25-11 39

1 Scope of Document

This document specifies requirements on the AUTOSAR Network Management.

The requirements apply on following functional entities:

- Network Management coordinating a particular Nm-cluster.
- Network Management bus specifics for a particular bus.
- Gateway and Interoperability of Network Management between Nm-clusters.

The communication system where Nm is applicable has to support a “bus sleep” mode. That means that the transceiver of the communication system can switch to a low power mode and can be switched again to full power mode by (specific) bus traffic and/or application.

2 Conventions to be used

The representation of requirements in AUTOSAR documents follows the table specified in [TPS_STDT_00078], see [1, Standardization Template].

The verbal forms for the expression of obligation specified in [TPS_STDT_00053] shall be used to indicate requirements, see [1, Standardization Template].

3 Acronyms and abbreviations

Abbreviation / Acronym	Description
Nm	Network Management
PN	Partial Network
PNI	Partial Network Information

Term	Description
Nm Message	Refers to the payload transmitted on the bus. It contains the User Data as well as the Control Bit Vector and may contain the Source Node Identifier.
Nm Node	A ECU (electornic controll unit) which is connected to one or more Nm clusters
Nm cluster	Set of Nm nodes coordinated with the use of the Nm algorithm.
Nm instance	A Nm instance represents the current status of one Nm cluster inside one Nm node

The acronyms/abbreviations and terms not provided in tables above are included in the AUTOSAR Glossary [2].

4 Use Cases

ID	Name	Description
0001	Synchronous Shutdown	If there is no communication need in a Nm cluster, the Nm protocol ensures that all Nm nodes synchronously enter sleep mode.
0002	Sub-networks Synchronous Shutdown	Support the coordinated shutdown of multiple sub-networks. This can be considered as an extension of the synchronous shutdown use case with the objective of synchronously shutting down multiple Nm clusters.
0003	Keep Nm Cluster Awake	If at least one Nm node in a Nm cluster needs communication, the Nm protocol ensures that all required Nm nodes remain awake.
0004	Partial Network	Support of partial network by defining communication/function domains to allow for turning off network communication across multiple ECUs in case their provided functions are not required under certain conditions. Other ECUs can continue to communicate on the same bus channels. Additionally use Nm messages to communicate the request/release information of a partial network cluster between the participating ECUs.
0005	Passive Mode	Nm node configured as Passive node is not able to initiate a start-up of a Nm cluster, however is able to be woken up if any other node initiates a start-up. This eliminates unnecessary communication and reduces bus and buffer overhead. Allowing shutdown to be controlled by a subset of the cluster's nodes enables the possibility that only fault tolerant nodes control shutdown.
0006	Partial Network Gateway	Since partial networks span over multiple buses, the network management protocol defines how the partial network information shall be gateway-ed between these buses, i.e. it shall be possible to forward request/release information to sub-networks thereby allowing gateway ECUs to act "on-behalf" of the original partial network requestor ECU.
0007	FlexRay Nm	Support the specific characteristics of the FlexRay bus and its HW Nm vector support. The network management protocol shall support alternatives for the FlexRay bus where the Network Management Vector of the FlexRay protocol specification can be used.

Table 4.1: Use Cases of Network Management

The acronyms/abbreviations and terms not provided in tables above are included in the AUTOSAR Glossary [2].

5 Requirements Specification

5.1 Functional Requirements

5.1.1 Configuration

[RS_Nm_00150] Specific features of the Network Management shall be configurable ⌈

Description:	The following features of the Network Management shall be configurable: • Detection of present nodes – [RS_Nm_00153] • Notification that all other ECUs are (no more) ready to sleep (i.e. Remote Sleep Indication (Cancellation)) – [RS_Nm_00052], [RS_Nm_02509] • Nm Coordination support – [RS_Nm_02514] • User data support – [RS_Nm_02503], [RS_Nm_02504] • Bus load reduction – [RS_Nm_00142] • Sending node identifier – [RS_Nm_02505] • Receiving node identifier – [RS_Nm_02506] • Immediate Transmission Confirmation • Configurable Role In Cluster Shutdown – [RS_Nm_02511] • Bus Keep Awake Services – [RS_Nm_00047] • Partial Networking extensions – [RS_Nm_02517] • Dynamic PNC Mapping – [RS_Nm_02547] • Synchronized PNC shutdown – [RS_Nm_02548]
Rationale:	Scalability
Dependencies:	–
Use Case:	Configuration of ECU SW
AppliesTo:	AP, CP
Supporting Material:	–

⌋

5.1.2 Initialization

[RS_Nm_00151] The Network Management algorithm shall allow any node to integrate into an already running Nm cluster ⌈

Description:	The Network Management algorithm shall allow any node to integrate into an already running Nm cluster.
Rationale:	Integration of • Late nodes • Nodes that have recovered from fault state • Nodes that have been connected to a running vehicle network (e.g. by service)
Dependencies:	–
Use Case:	See rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00043] Nm shall not prohibit bus traffic with Nm not being initialized ⌈

Description:	It shall be possible that software modules are enabled to access the communication system, independent of the presence of Nm (Nm initialized or not).
Rationale:	Initialization delays or errors of Nm shall not prohibit the communication of application software.
Dependencies:	–
Use Case:	ECU without Nm or Nm starts later (see rationale)
AppliesTo:	AP, CP
Supporting Material:	–

⌋

5.1.3 Normal Operation

[RS_Nm_00044] The Nm shall be applicable to different types of communication systems which are in the scope of AUTOSAR and support a bus sleep mode. ⌈

Description:	Network management mechanisms for each supported protocol shall be realized using a limited number of predefined Nm states and Nm transitions. The events triggering the transitions between states and the actions taken on these transitions may be protocol specific. A bus sleep mode shall be supported for each protocol. Nm shall be executable on asynchronous communication systems (e.g. CAN) as well as on synchronous communication systems (e.g. FlexRay), and also on any other types of communication systems which are in the scope of AUTOSAR.
Rationale:	In today's cars, multiple different communication systems are implemented. For energy consumption, all ECUs have to be able to switch into a low power mode. Therefore, network management is necessary for all communication systems. To facilitate understanding, Nm shall be constructed from a common set of state definitions.
Dependencies:	–
Use Case:	ECU with CAN and FlexRay, Ethernet
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_02515] Nm shall offer a generic possibility to run other Nms than the AUTOSAR-Nms ⌈

Description:	Support for managing a non AUTOSAR-Nm based network shall be done either by extending/modifying an existing bus-specific Nm or by introducing a Complex Device Driver (CDD) which uses the generic interfaces of the Nm. Support for running both one of the AUTOSAR-Nm and a non AUTOSAR-Nm on a single network shall be done the same way. The actual extensions for bus-specific Nms or CDDs are not specified by AUTOSAR.
Rationale:	–
Dependencies:	–
Use Case:	Running ISO 17356-5: Nm Specification or another Legacy-Nm on one of the networks.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_00045] Nm shall provide services to coordinate shutdown of Nm-clusters independently of each other ⌈

Description:	Nm has to provide services to coordinate shutdown of Nm-clusters independently of each other.
Rationale:	In today's cars, multiple different communication systems are implemented. Therefore, ECUs might be connected to multiple communication channels (e.g. 2 CAN clusters, 1 FlexRay cluster, etc.). Not in all cases all channels have to be in full power mode. Because of that, each channel has to be able to be started up or shut down separately.
Dependencies:	–
Use Case:	Gateways with more than one bus
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_02513] Nm shall provide functionality which enables upper layers to control the sleep mode. ⌈

Description:	Nm shall provide an interface which enable upper layers to coordinate the different Nm modes (especially sleep and wake-up/keep awake).
Rationale:	Enable control of Nm from the upper layers. Enable the Nm Coordinator to control multiple bus-specific Nms.
Dependencies:	–
Use Case:	Control of Nm Nm Coordinator
AppliesTo:	AP, CP
Supporting Material:	Related requirement [RS_Nm_02512]

⌋

[RS_Nm_00046] It shall be possible to trigger the startup of all Nodes at any Point in Time ⌈

Description:	At a specific point in time all nodes connected to Nm-cluster have to be started-up (e.g. if the car is started). Because of that Nm has to provide services to start up Nm of all nodes connected to a Nm-cluster at any point in time. The point in time can not be calculated offline, therefore this service has to be accessible at any time. Note regarding FlexRay networks: Under certain circumstances, a shutdown may be required before a startup can occur. In this situation substantial delays may occur.

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Rationale:	All nodes means all nodes connected to clamp 30 (nodes permanently connected to power supply). ECUs connected to clamp 15 (nodes power supplied through some power relay) have to be treated separately, due to the fact that they cannot be started-up at any point in time. Note: "Passive Nodes" are not able to initiate a start-up of a Nm-cluster, but they are able to be woken up if any other node initiates a start-up. Please refer [RS_Nm_02511]
Dependencies:	–
Use Case:	Driver enters the car and wants to start the engine.
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00047] Nm shall provide a service to request to keep the bus awake and a service to cancel this request. ⌈

Description:	The application implemented on one ECU must be enabled to signal at any point in time after the Nm has been initialized, that it requests to keep the bus awake and at any other point in time want to cancel this request. These bus keep awake services shall not be available for nodes configured to not contribute to the cluster shutdown decision, refer [RS_Nm_02511]
Rationale:	Basic Nm functionality
Dependencies:	–
Use Case:	See Rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00048] Nm shall put the communication controller into sleep mode if there is no bus communication ⌈

Description:	If no Application/ECU connected to a Nm-cluster requires bus communication, Nm shall indicate to put the communication controller into sleep mode.
Rationale:	Basic Nm functionality
Dependencies:	[RS_Nm_00047]
Use Case:	See Rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00050] The Nm shall provide the current state of Nm ⌈

Description:	The Nm shall provide an interface to retrieve information about the current state of Nm.
Rationale:	The application shall be able to get Nm state information by accessing specific interfaces of Nm. The Nm state reflects the state of the bus.
Dependencies:	–
Use Case:	See Rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00051] Nm shall inform application when Nm state changes occur. ⌈

Description:	Nm shall provide an interface, which can be used by applications to get informed when specific Nm state changes occur.
Rationale:	Applications shall be enabled to react on state changes.
Dependencies:	–
Use Case:	Especially the transition to sleep state to switch off transceiver is interesting.
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00052] The Nm interface shall signal to the application that all other ECUs are ready to sleep. ⌈

Description:	Nm shall provide an interface, which signals to an application that all other applications/ECUs are ready for sleep.
Rationale:	Prohibition of unintentional keep awake.
Dependencies:	[RS_Nm_02509]
Use Case:	Internal check in the application if ECU unintentionally keeps the bus awake. External network management coordination.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02509] The Nm interface shall signal to the application that at least one ECU is not ready to sleep anymore. ⌈

Description:	Nm shall provide an interface, which signals to an application that at least one other applications/ECUs is not ready for sleep anymore.
Rationale:	Notification that a bus is kept awake if necessary.

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Dependencies:	[RS_Nm_00052]
Use Case:	Identification of the last node that keeps the bus awake. External network management gateway coordination.
AppliesTo:	CP
Supporting Material:	–

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[RS_Nm_02503] The Nm API shall optionally give the possibility to send user data ⌈

Description:	The Nm API shall optionally give the possibility to set the user data that may be attached to every Nm message sent on the bus. Nm shall guarantee data consistency for the write operation.
Rationale:	Exchange of system relevant information within the network.
Dependencies:	–
Use Case:	Distribution of wakeup-reason in the network.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02504] The Nm API shall optionally give the possibility to get user data ⌈

Description:	The Nm API shall optionally give the possibility to get the user data that may be included in a received Nm message. Nm shall guarantee data consistency for the read operation.
Rationale:	Exchange of system relevant information within the network.
Dependencies:	–
Use Case:	Distribution of wakeup-reason in the network.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_00153] The Network Management shall optionally provide a possibility to detect present nodes ⌈

Description:	The Network Management shall optionally provide a possibility to detect nodes that are currently present on the bus. It shall be possible that nodes, on request, send their Nm-related data. This feature is statically configurable(available or not)(see [RS_Nm_00150]). Comment: This function is only needed in master ECUs (e.g. head unit, central body controller, ...)

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Rationale:	For diagnostics purposes and configuration checks.
Dependencies:	–
Use Case:	The Vehicle State Management can use this information to check the completeness of the network.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02508] Every node shall have a node identifier associated with it that is unique in the Nm-cluster. ⌈

Description:	Every node shall have associated with it a node identifier that is unique in the Nm-cluster.
Rationale:	Avoidance of node misidentification.
Dependencies:	–
Use Case:	Identification of the last node that keeps the bus awake. Detection of present nodes.
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_02505] The Nm shall optionally set the local node identifier to the Nm-message ⌈

Description:	The Nm shall optionally set the local node identifier to the Nm-message. See also [RS_Nm_00150].
Rationale:	Exchange of system relevant information within the network.
Dependencies:	–
Use Case:	Identification of the last node that keeps the bus awake. Detection of present nodes.
AppliesTo:	AP, CP
Supporting Material:	–

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[RS_Nm_02506] The Nm API shall give the possibility to read the source node identifier of the sender ⌈

Description:	The Nm API shall give the possibility to read the source node identifier of the sender from the most recently received Nm message. Nm shall guarantee data consistency for the read operation. Note: This Nm API is optional, since it is optional to send the source node identifier. See also [RS_Nm_00150].

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Rationale:	Exchange of system relevant information within the network.
Dependencies:	–
Use Case:	Identification of the last node that keeps the bus awake. Detection of present nodes.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02511] It shall be possible to configure the Network Management of a node so that it does not contribute to the cluster shutdown decision. ⌈

Description:	It shall be possible to configure the Network Management of a node so that it does not contribute to the cluster shutdown decision. Specifically, it shall be possible to configure some nodes of a cluster so that they are not able to broadcast the information used by other nodes to trigger shutdown, i.e., they have no Nm-related communication defined for the node. Such nodes shall not be capable of keeping the bus awake, but they are required to shut down in a manner consistent with the others. See also [RS_Nm_00150].
Rationale:	Eliminating unnecessary communication reduces bus and buffer overhead. Allowing shutdown to be controlled by a subset of the cluster's nodes enables the possibility that only fault tolerant nodes control shutdown. However, these nodes shall be otherwise capable of normal communication.
Dependencies:	–
Use Case:	In a dual channel FlexRay cluster with some single channel nodes, the cluster can be configured so that only dual channel nodes influence the shutdown. This ensures that all shutdown votes are replicated on across channels even though some nodes are only connected to one channel, thus making the decision process robust against the loss of a channel.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02536] Nm shall provide functionality to start-up without requesting the network. ⌈

Description:	Nm shall provide an interface which triggers the transition to the Network Mode without keeping the network awake.
Rationale:	A node has to participate to the network management without actively requesting communication.
Dependencies:	–
Use Case:	A bus wake-up occurs.
AppliesTo:	CP

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Supporting Material:	–

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[RS_Nm_02512] The Nm shall give the possibility to enable or disable the network management related communication configured for an active Nm node ⌈

Description:	The Nm shall give the possibility to enable or disable the network management related communication configured for an active Nm node. By default network management related communication shall be enabled.
Rationale:	Conformance to ISO 14229 CommunicationControl (28 hex) service
Dependencies:	[RS_Nm_02511]
Use Case:	Diagnostics
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02573] <Bus>Nm shall handle retransmission of NM-PDUs ⌈

Description:	<Bus>Nm has to perform a retry transmission handling for NM-PDU in the context of the main function calls, if transmission of this NM-PDU was not accepted or not confirmed by the lower layer.
Rationale:	Retry transmission requests of the <Bus>Nm should cover error cases, where the lower layer cannot transmit the Nm messages.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Cover error cases if the lower layer is not able to transmit NM-PDUs.
AppliesTo:	CP
Supporting Material:	–

⌋

5.1.4 Fault Operation

[RS_Nm_00137] Nm shall perform communication system error handling for errors that have impact on the Nm behavior. ⌈

Description:	If bus errors of a specific bus on which Nm is running have impact on the Nm behavior, the error handling must be performed by Nm. Focus: bus errors, not protocol errors. Example: loss of Nm message is handled.
Rationale:	Error handling

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Dependencies:	–
Use Case:	Communication loss
AppliesTo:	CP
Supporting Material:	–

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5.1.5 Nm Coordination

[RS_Nm_02514] It shall be possible to group networks into *Nm Coordination Clusters* ⌈

Description:	It shall be possible to group networks into *Nm Coordination Clusters*.Each bus specific Nm shall, by configuration, be part of 0 or 1 *Nm Coordination Cluster*. Nm shall provide functionality (*Nm Coordination*) to coordinate the different Nm modes (especially sleep and keep awake) on all networks in an *Nm Coordination Cluster*, by performing a synchronized shutdown on all included networks. The level of synchronization is determined by the configuration of the shutdown synchronization algorithm. Specifically, it shall be possible to perform *Nm Coordination* for each *Nm Coordination Cluster* separately and independently.
Rationale:	It shall be possible to perform coordinated and/or synchronized shutdown of multiple Nm clusters independently.
Dependencies:	–
Use Case:	Nm Coordinator
AppliesTo:	CP
Supporting Material:	–

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Note:
The definitions of *Nm Coordination Cluster, Nm Coordinator, Synchronize* and *Coordinate* are available in [2].

[RS_Nm_02516] All AUTOSAR Nm instances shall support the Nm Coordinator functionality including Bus synchronization on demand ⌈

Description:	All AUTOSAR Nm instances shall support the Nm Coordinator functionality of the Generic Nm Interface including Bus synchronization on demand. Bus Synchronization on demand allows for synchronization of an Nm-cluster at an arbitrary point in time, meaning the Nm-Timeout Timers in all nodes of the Nm-cluster are restarted simultaneously.

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Rationale:	Bus synchronization on demand allows synchronization of a Nm-cluster for an arbitrary point of time; in result, Nm-Timeout Timers in all nodes of the Nm-cluster are restarted.
Dependencies:	–
Use Case:	Nm Coordinator
AppliesTo:	CP
Supporting Material:	–

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[RS_Nm_02535] The Nm coordination shall support the coordination of nested sub-buses ⌈

Description:	The Nm coordination algorithm shall support coordination of a second level of bus hierarchy, when shutting down coordinated buses. There is no limitation of hierarchy levels.
Rationale:	The network management stack allows to have a coordinated shutdown of more than one bus if an ECU exists which is connected to the buses which are to be coordinated. The functionality is included in the NmIf module. However, there are currently two limitations 1. If a sub-bus exists on a coordinated bus, which is connected by a gateway, this sub-bus can currently not be added to the list of coordinated buses, because the algorithm only handles one level. As a result, a coordinated bus may shut down, but connected sub buses may still be active. 2. The functionality is not reliable, because, if the coordinating ECU fails, the buses will no longer be coordinated and act on their own; that is, they will – if no node is active – shut down independently. This concept intent to fix these shortcomings.
Dependencies:	–
Use Case:	Nested Gateways
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02537] The Nm Coordinator shall be able to abort the coordinated shutdown ⌈

Description:	As long as the coordinated shutdown is not completed, a network request on one of the coordinated buses shall be forwarded to other buses of this Coordination cluster.
Rationale:	The state of all coordinated buses shall be the same
Dependencies:	–
Use Case:	Internal or external communication request during coordinated shutdown of buses.

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AppliesTo:	CP
Supporting Material:	–

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5.1.6 Partial Networking

Note:
The definitions of *Partial Networking* is available in more details in [3].

[RS_Nm_02549] Nm Interfaces for Repeat Message Request ⌈

Description:	The Nm shall use one bit in the Nm Control Bit Vector to signal receiving nodes to enter NmRepeatMessage state. Additional Information: There must be an interface to set the value of this bit in the <Bus>Nm and the Repeat Message Request bit and one to indicate the change of this bit during reception. This feature must be statically configurable (available or not).
Rationale:	–
Dependencies:	[RS_Nm_00153], [RS_Nm_02547]
Use Case:	Node detection, Dynamic PNC Mapping
AppliesTo:	CP
Supporting Material:	–

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[RS_Nm_02517] CanNm shall support Partial Networking on CAN ⌈

Description:	CanNm shall support Partial Networking on CAN.
Rationale:	It is necessary to implement complete partial network support on the bus protocol CAN, to reduce the power consumption of CAN communication domains.
Dependencies:	–
Use Case:	The power consumption can be reduced by e.g • Shutting down of seat control functions • Shutting down of park assistant functions • Hazard flashers • Shutting down of Electric Park Brake (EPB)
AppliesTo:	CP
Supporting Material:	–

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[RS_Nm_02550] FrNm shall support Partial Networking on FlexRay ⌈

Description:	FrNm shall support Partial Networking on FlexRay.
Rationale:	It is necessary to implement complete partial network support on the bus protocol FlexRay, to reduce the power consumption of FlexRay communication domains.
Dependencies:	–
Use Case:	The power consumption can be reduced by e.g • Shutting down of seat control functions • Shutting down of park assistant functions • Hazard flashers • Shutting down of Electric Park Brake (EPB)
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02546] UdpNm shall support Partial Networking on Ethernet ⌈

Description:	UdpNm shall support Partial Networking on Ethernet.
Rationale:	It is necessary to implement complete partial network support on the bus protocol Ethernet, to reduce the power consumption of Ethernet communication domains.
Dependencies:	–
Use Case:	The power consumption can be reduced by e.g • Shutting down of seat control functions • Shutting down of park assistant functions • Hazard flashers • Shutting down of Electric Park Brake (EPB)
AppliesTo:	AP, CP
Supporting Material:	–

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[RS_Nm_02519] The Nm Control Bit Vector shall contain a PNI (Partial Network Information) bit. ⌈

Description:	The Nm Control Bit Vector shall contain a PNI (Partial Network Information) bit with the following meaning: 0: Nm message does not contain PN request information 1: Nm message contains PN request information (PNI)
Rationale:	This is required to assure the compatibility between carry over parts from current vehicle platforms and valid ECUs with Partial Networking. Current ECUs may not send Nm messages with PN request information.
Dependencies:	[RS_Nm_02517]

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Use Case:	–
AppliesTo:	AP, CP
Supporting Material:	–

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[RS_Nm_02527] Nm shall implement a filter algorithm dropping all Nm messages that are not relevant for the ECU ⌈

Description:	Nm shall implement a filter algorithm dropping all Nm messages that are not relevant for the ECU. The algorithm uses the Partial Network request information included with Nm and <Bus>Nm.
Rationale:	–
Dependencies:	[RS_Nm_02517]
Use Case:	–
AppliesTo:	AP, CP
Supporting Material:	–

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[RS_Nm_02528] Nm shall provide a service which allows for instantaneous sending of Nm messages. ⌈

Description:	In case of a change of requested PNs Nm Message(s) shall be sent spontaneously.
Rationale:	A PN request originating from the ECU needs to be sent out as fast as possible to avoid long latency
Dependencies:	[RS_Nm_02517]
Use Case:	–
AppliesTo:	AP, CP
Supporting Material:	–

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[RS_Nm_02547] <Bus>Nm Propagation and Evaluation for Partial Networking Learning ⌈

Description:	The Nm shall use one bit in the Nm Control Bit Vector to propagate the need for Partial Networking Learning. Additional Information: There must be an interface to set the value of this bit in the <Bus>Nm and the Repeat Message Request bit and one to indicate the change of this bit during reception. This feature must be statically configurable (available or not) (see [RS_Nm_00150]).

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Rationale:	–
Dependencies:	–
Use Case:	Dynamic PNC Mapping
AppliesTo:	CP
Supporting Material:	Partial Network learning differs between: • request Nm PDU, where the bit for partial networking learning and Repeat Message Request bit are both set, • response Nm PDU, where only the bit for partial networking learning is set (but Repeat Message Request bit stays unset). • response Nm PDU, where only the bit for partial networking learning is set (but Repeat Message Request bit stays unset).

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[RS_Nm_02548] <Bus>Nm PNC shutdown Propagation and Evaluation ⌈

Description:	The Nm shall use one bit in the Nm Control Bit Vector to propagate the synchronized PNC shutdown. Additional Information: There must be an interface to set the value of this bit in the <Bus>Nm and one to indicate the set bit during reception. This feature must be statically configurable (available or not)(see [RS_Nm_00150]).
Rationale:	This bit is used to indicate that a top-level PNC coordinator released at least one PNC. This bit is evaluated only by an intermediate PNC coordinator. A PNC leaf node ignores this bit.
Dependencies:	[RS_Nm_02517]
Use Case:	Synchronized PNC shutdown of the PNC within the network, to reduce the propagation time to release the PNC across all affected ECUs.
AppliesTo:	CP
Supporting Material:	Synchronized PNC shutdown differs between: • request Nm PDU, where the bit for partial networking and PN shutdown request bit are both set as ECU in role of an top-level PNC coordinator, • forward Nm PDU, where the bit for partial networking and PN shutdown request bit are both set as ECU in role of an intermediate PNC coordinator.

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[RS_Nm_02540] Nm Control Bit Vector Containing PN Shutdown Request ⌈

Description:	The Nm Control Bit Vector shall contain a PN shutdown request bit with the following meaning: • 0: Nm message does not contain synchronized Partial Network shutdown request • 1: Nm message does contain synchronized Partial Network shutdown request for at least one PNC

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Rationale:	This bit is used to indicate that a top-level PNC coordinator release at least one PNC. This bit is evaluated only by an intermediate PNC coordinator. A PNC leaf node ignore this bit.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Synchronized PNC shutdown of the PNC within the network
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02542] The <Bus>Nm of the top-level PNC coordinator shall set the PN shutdown request bit if a least one PNC is released

Status: DRAFT

⌈

Description:	The <Bus>Nm of a top-level PNC coordinator shall transmit a PN shutdown message if at least one PNC was released. A PN shutdown message set the PN shutdown request bit and the PNC bit of the released PNCs to 1. Thus, only the released PNCs are considered in the PN shutdown message. The remaining PNC bits are set to 0.
Rationale:	The PN shutdown request bit is used to indicate that a top-level PNC coordinator release at least one PNC. Therefore, a top-level PNC coordinator transmit a PN shutdown message by setting the PN shutdown bit and all PNC bits of the released PNCs to 1. Additionally, the top-level PNC coordinator reset the according PN reset timer of the released PNCs once more. The receiving nodes shall react immediately in dependency of the PNC network role either intermediate PNC coordinator or PNC leaf node.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Synchronized PNC shutdown of the PNC within the network
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02571] Nm shall handle requests for synchronized PNC shutdown ⌈

Description:	The Nm of an ECU in role a top-level PNC coordinator or intermediate PNC coordinator shall handle requests for a synchronized PNC shutdown indicated by ComM. Therefore, all information of indicated PNCs which has to be released shall be stored per NM-Channel. The stored request for a synchronized PNC shutdown are transformed to a byte array, where each bit represents a particular PNC (PNC bit vector). This PNC bit vector shall be provided per NM-Channel, if the <Bus>Nm indicate to fetch and transmit the NM-PDU as PN shutdown message on the corresponding Nm-Channel.

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Rationale:	Requests for synchronized PNC shutdown shall be aggregated and provided as PNC bit vector to all affected NM-Channels, if the <Bus>Nm indicate to transmit a NM-PDU.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Synchronized PNC shutdown of the PNC within the network.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02544] Nm Forwarding PN Shutdown Message Indication ⌈

Description:	The Nm of an ECU in role of an intermediate PNC coordinator shall immediately forward an indication of a received PN shutdown messages to ComM.
Rationale:	Requests for synchronized PNC shutdown must be immediately forwarded to the ComM, to minimize the delay for propagation of PN shutdown messages within the PNC network.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Forwarding of a synchronized PNC shutdown request to support a PNC shutdown almost in the same point in time
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02572] <Bus>Nm shall transmit requests for synchronized PNC shutdown as NM-PDU ⌈

Description:	The Nm of an ECU in role a top-level PNC coordinator or intermediate PNC coordinator handle requests for a synchronized PNC shutdown. Therefore NM indicate to start or stop a PNC shutdown process. If a PNC shutdown process has been started for a particular NM-Channel, then the <Bus>Nm fetch the aggregated requests for a synchronized PNC shutdown as PNC bit vector and transmit the NM-PDU as PN shutdown message on the corresponding NM-Channel. The <Bus>Nm indicate a successfully transmission to the Nm. Otherwise a re-transmission shall be performed if configured.
Rationale:	<Bus>Nm shall handle the transmission of NM-PDUs as PN shutdown message as fast as possible, to minimize the delay for propagation of PN shutdown messages across the PN topology.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Synchronized PNC shutdown of the PNC within the network.
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02561] Nm shall support Partial Networking

Status: DRAFT

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Description:	Nm shall support Partial Networking
Rationale:	Nm maintain the PNC timer handling and indicate changes regarding internal and external PNC request to the upper layer
Dependencies:	–
Use Case:	The power consumption reduction
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02562] Nm shall support channel-specific storage of IRA ⌈

Description:	Nm shall support channel-specific storage of IRA
Rationale:	Nm stores the latest IRA (internal request array) which represents the internal PNC requests as PNC bit vector. The IRA is stored per given Nm-channel and provided to <Bus>Nm to be transmitted within the Nm message.
Dependencies:	[RS_Nm_02517]
Use Case:	–
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02563] Nm shall calculate the combined partial network request status EIRA ⌈

Description:	Nm shall calculate the combined partial network request status EIRA (External and Internal Requests Aggregated) for each partial network relevant to the ECU. The calculation shall use a configurable time constant for resetting EIRA requests.
Rationale:	–
Dependencies:	[RS_Nm_02517], [RS_Nm_02561]
Use Case:	–
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02564] Nm shall calculate the status of the external partial network requests ERA ⌈

Description:	Nm shall calculate the status of the external partial network requests ERA (External Requests Aggregated) for each partial network relevant to the ECU. The calculation shall use a configurable time constant for resetting ERA requests.
Rationale:	–
Dependencies:	[RS_Nm_02517], [RS_Nm_02561]
Use Case:	–
AppliesTo:	CP
Supporting Material:	–

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[RS_Nm_02565] <Bus>Nm shall communicate EIRA and ERA requests to the upper layers using dedicated APIs ⌈

Description:	Nm shall communicate EIRA and ERA requests to the upper layers using dedicated APIs (not contained in the System Description but generated during Ecu configuration)
Rationale:	–
Dependencies:	[RS_Nm_02517], [RS_Nm_02561]
Use Case:	–
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02566] Nm shall support channel-specific configuration for ERA ⌈

Description:	Nm shall support channel-specific configuration for ERA
Rationale:	–
Dependencies:	[RS_Nm_02517], [RS_Nm_02561]
Use Case:	–
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02567] Nm shall support a global configuration for EIRA over all channels ⌈

Description:	Nm shall support a global configuration for EIRA over all channels
Rationale:	–
Dependencies:	[RS_Nm_02517], [RS_Nm_02561]

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Use Case:	–
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_02574] Nm shall provide a confirmation API to indicate the transmission state PNC bit vector ⌈

Description:	The Nm shall provide a confirmation API to indicated the transmission state of a PNC bit vector per NM-Channel.
Rationale:	The confirmation indicate is needed to update the internal PNC processing.
Dependencies:	[RS_Nm_02517], [RS_Nm_02550], [RS_Nm_02546]
Use Case:	Synchronized PNC shutdown of the PNC within the network, re-start of PN reset timer.
AppliesTo:	CP
Supporting Material:	–

⌋

5.2 Non-Functional Requirements

5.2.1 Layout Requirements

[RS_Nm_02541] Nm shall define a common layout of Nm messages. ⌈

Description:	Nm protocol specifies the Nm message format to have a common understanding of the protocol, independently of the underlying physical layer of the communication system used.
Rationale:	Compatibility, interoperability, interpretation and creation of Nm messages.
Dependencies:	–
Use Case:	–
AppliesTo:	AP, CP
Supporting Material:	–

⌋

5.2.2 Timing Requirements

[RS_Nm_00054] There shall be a deterministic time from the point where all nodes agree to go to bus sleep to the point where bus is switched off. ⌈

Description:	The time required from the point in time when the Nm of each ECU agree on shutting down a communication system and the point in time when the communication system is really shutting down, has to be deterministic (guarantee of min time and max time). This time must be statically configurable per cluster.
Rationale:	Determinism of network behavior, guarantee of synchronized sleep-mode.
Dependencies:	–
Use Case:	See Rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

5.2.3 Resource Usage

[RS_Nm_00142] Nm shall provide a mechanism to limit its bus load. ⌈

Description:	Nm shall not exceed a specified upper limit of bus load. This bus load has to be specified. Example: 3% in normal operation, 6% Bus load peak.
Rationale:	Determinism
Dependencies:	–
Use Case:	Avoid solution like in ISO 17356-5: Nm Specification: alive messages after bus wakeup
AppliesTo:	CP
Supporting Material:	–

⌋

[RS_Nm_00144] Nm shall support communication clusters of up to 64 ECUs ⌈

Description:	Communication clusters of up to 64 ECUs / controllers shall be supported by Nm.
Rationale:	Flexibility
Dependencies:	–
Use Case:	See Rationale
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00145] On a properly configured node, Nm shall tolerate a loss of a predefined number of Nm messages ⌈

Description:	On a properly configured node, Nm shall tolerate a loss of a predefined number of Nm messages. The limitations of the number of message losses have to be described in the specification.
Rationale:	Robustness: There shall be no need for Nm to receive every Nm message. A loss of one message (in case of bursts) shall have no impact on the Nm behaviour.
Dependencies:	–
Use Case:	Loss of Nm-message(s) must be tolerated
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00146] The Nm shall tolerate a time jitter of Nm messages in one or more ECUs ⌈

Description:	The Nm shall tolerate a time jitter of Nm messages in one or more ECUs. The limitations of the jitter have to be described in the specification.
Rationale:	Robustness
Dependencies:	–
Use Case:	Jitter of Nm-message(s) must be tolerated
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00152] The specification and implementation shall be split-up into a communication system independent and communication system dependent parts. ⌈

Description:	The specification and implementation shall be split-up into a communication system independent and communication system dependent parts (the communication system dependent parts shall be based on the communication system abstraction).
Rationale:	Re-use
Dependencies:	–
Use Case:	Usage of different bus systems (e.g. CAN, FlexRay, Ethernet) without implementing common logic more than once.
AppliesTo:	AP, CP
Supporting Material:	–

⌋

[RS_Nm_00149] The timing of Nm shall be configurable. ⌈

Description:	All timing parameters of the Nm shall be configurable. This includes timings defining sending of Nm messages, minimum send repetitions, staying awake until common shutdown etc.
Rationale:	Flexibility
Dependencies:	–
Use Case:	• Time until network is shut down after all nodes have indicated that they are ready to sleep. • Time interval between two consecutive status indications of a node, whether it is ready to sleep or not. • Determination of timing depending on the configurable number of nodes.
AppliesTo:	AP, CP
Supporting Material:	–

⌋

5.2.4 Hardware independency

[RS_Nm_00154] The Network Management API shall be independent from the communication bus ⌈

Description:	The Network Management API shall be independent from the communication bus i.e. equal for CAN and FlexRay.
Rationale:	Common, standardized interface to upper layers.
Dependencies:	–
Use Case:	Usage of Nm on different types of bus; only one interface independent of the underlying bus architecture.
AppliesTo:	AP, CP
Supporting Material:	–

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6 References

[1] Standardization Template
AUTOSAR_FO_TPS_StandardizationTemplate

[2] Glossary
AUTOSAR_FO_TR_Glossary

[3] Layered Software Architecture
AUTOSAR_CP_EXP_LayeredSoftwareArchitecture

A Change history of AUTOSAR traceable items

Please note that the lists in this chapter also include traceable items that have been removed from the specification in a later version. These items do not appear as hyperlinks in the document.

A.1 Traceable item history of this document according to AUTOSAR Release R22-11

A.1.1 Added Requirements in R22-11

Number	Heading
[RS_Nm_02571]	Nm shall handle requests for synchronized PNC shutdown
[RS_Nm_02572]	<Bus>Nm shall transmit requests for synchronized PNC shutdown as NM-PDU
[RS_Nm_02573]	<Bus>Nm shall handle retransmission of NM-PDUs
[RS_Nm_02574]	Nm shall provide a confirmation API to indicate the transmission state PNC bit vector

Table A.1: Added Requirements in R22-11

A.1.2 Changed Requirements in R22-11

Number	Heading
[RS_Nm_00043]	Nm shall not prohibit bus traffic with Nm not being initialized
[RS_Nm_00044]	The Nm shall be applicable to different types of communication systems which are in the scope of Autosar and support a bus sleep mode.
[RS_Nm_00045]	Nm shall provide services to coordinate shutdown of Nm-clusters independently of each other
[RS_Nm_00046]	It shall be possible to trigger the startup of all Nodes at any Point in Time
[RS_Nm_00047]	Nm shall provide a service to request to keep the bus awake and a service to cancel this request.
[RS_Nm_00048]	Nm shall put the communication controller into sleep mode if there is no bus communication
[RS_Nm_00050]	The Nm shall provide the current state of Nm
[RS_Nm_00051]	Nm shall inform application when Nm state changes occur.
[RS_Nm_00052]	The Nm interface shall signal to the application that all other ECUs are ready to sleep.
[RS_Nm_00054]	There shall be a deterministic time from the point where all nodes agree to go to bus sleep to the point where bus is switched off.

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Number	Heading
[RS_Nm_00137]	Nm shall perform communication system error handling for errors that have impact on the Nm behavior.
[RS_Nm_00142]	Nm shall provide a mechanism to limit its bus load.
[RS_Nm_00144]	Nm shall support communication clusters of up to 64 ECUs
[RS_Nm_00145]	On a properly configured node, Nm shall tolerate a loss of a predefined number of Nm messages
[RS_Nm_00146]	The Nm shall tolerate a time jitter of Nm messages in one or more ECUs
[RS_Nm_00149]	The timing of Nm shall be configurable.
[RS_Nm_00150]	Specific features of the Network Management shall be configurable
[RS_Nm_00151]	The Network Management algorithm shall allow any node to integrate into an already running Nm cluster
[RS_Nm_00153]	The Network Management shall optionally provide a possibility to detect present nodes
[RS_Nm_00154]	The Network Management API shall be independent from the communication bus
[RS_Nm_02503]	The Nm API shall optionally give the possibility to send user data
[RS_Nm_02504]	The Nm API shall optionally give the possibility to get user data
[RS_Nm_02505]	The Nm shall optionally set the local node identifier to the Nm-message
[RS_Nm_02506]	The Nm API shall give the possibility to read the source node identifier of the sender
[RS_Nm_02508]	Every node shall have a node identifier associated with it that is unique in the Nm-cluster.
[RS_Nm_02509]	The Nm interface shall signal to the application that at least one ECU is not ready to sleep anymore.
[RS_Nm_02511]	It shall be possible to configure the Network Management of a node so that it does not contribute to the cluster shutdown decision.
[RS_Nm_02512]	The Nm shall give the possibility to enable or disable the network management related communication configured for an active Nm node
[RS_Nm_02513]	Nm shall provide functionality which enables upper layers to control the sleep mode.
[RS_Nm_02514]	It shall be possible to group networks into *Nm Coordination Clusters*
[RS_Nm_02515]	Nm shall offer a generic possibility to run other Nms than the AUTOSAR-Nms
[RS_Nm_02516]	All AUTOSAR Nm instances shall support the Nm Coordinator functionality including Bus synchronization on demand
[RS_Nm_02519]	The Nm Control Bit Vector shall contain a PNI (Partial Network Information) bit.
[RS_Nm_02527]	Nm shall implement a filter algorithm dropping all Nm messages that are not relevant for the ECU
[RS_Nm_02528]	Nm shall provide a service which allows for instantaneous sending of Nm messages.
[RS_Nm_02535]	The Nm coordination shall support the coordination of nested sub-buses
[RS_Nm_02536]	Nm shall provide functionality to start-up without requesting the network.

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Number	Heading
[RS_Nm_02537]	The Nm Coordinator shall be able to abort the coordinated shutdown
[RS_Nm_02540]	The Nm Control Bit Vector shall contain a PN shutdown request bit.
[RS_Nm_02541]	Nm shall define a common layout of Nm messages.
[RS_Nm_02542]	The <Bus>Nm of the top-level PNC coordinator shall set the PN shutdown request bit if a least one PNC is released
[RS_Nm_02544]	Nm shall forward the indication of a PN shutdown message
[RS_Nm_02547]	<Bus>Nm shall be able to propagate and evaluate the need for Partial Networking Learning (optional)
[RS_Nm_02548]	<Bus>Nm shall be able to propagate and evaluate the need for synchronized PNC shutdown in the role of a top-level PNC coordinator or intermediate PNC coordinator (optional)
[RS_Nm_02549]	Nm shall offer interfaces to Request and indicate Repeat Message Request (optional)
[RS_Nm_02562]	Nm shall support channel-specific storage of IRA
[RS_Nm_02563]	Nm shall calculate the combined partial network request status EIRA
[RS_Nm_02564]	Nm shall calculate the status of the external partial network requests ERA
[RS_Nm_02565]	<Bus>Nm shall communicate EIRA and ERA requests to the upper layers using dedicated APIs
[RS_Nm_02566]	Nm shall support channel-specific configuration for ERA
[RS_Nm_02567]	Nm shall support a global configuration for EIRA over all channels

Table A.2: Changed Requirements in R22-11

A.1.3 Deleted Requirements in R22-11

Number	Heading
[RS_Nm_02543]	NM shall forward requests for synchronized PNC shutdown
[RS_Nm_02545]	<Bus>NM shall handle requests for synchronized PNC shutdown

Table A.3: Deleted Requirements in R22-11

A.1.4 Added Constraints in R22-11

none

A.1.5 Changed Constraints in R22-11

none

A.1.6 Deleted Constraints in R22-11

none

A.2 Traceable item history of this document according to AUTOSAR Release R23-11

A.2.1 Added Requirements in R23-11

none

A.2.2 Changed Requirements in R23-11

none

A.2.3 Deleted Requirements in R23-11

none

A.2.4 Added Constraints in R23-11

none

A.2.5 Changed Constraints in R23-11

none

A.2.6 Deleted Constraints in R23-11

none

A.3 Traceable item history of this document according to AUTOSAR Release R24-11

A.3.1 Added Requirements in R24-11

none

A.3.2 Changed Requirements in R24-11

none

A.3.3 Deleted Requirements in R24-11

none

A.4 Traceable item history of this document according to AUTOSAR Release R25-11

A.4.1 Added Requirements in R25-11

none

A.4.2 Changed Requirements in R25-11

Number	Heading
[RS_Nm_02540]	Nm Control Bit Vector Containing PN Shutdown Request
[RS_Nm_02544]	Nm Forwarding PN Shutdown Message Indication
[RS_Nm_02547]	<Bus>Nm Propagation and Evaluation for Partial Networking Learning
[RS_Nm_02548]	<Bus>Nm PNC shutdown Propagation and Evaluation
[RS_Nm_02549]	Nm Interfaces for Repeat Message Request

Table A.4: Changed Requirements in R25-11

A.4.3 Deleted Requirements in R25-11

none