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TECHNICAL SPECIFICATION

**Intelligent Transport Systems (ITS);  
Facilities layer function;  
Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS);  
Release 2**

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**Reference**

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# Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

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# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**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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# Introduction

Multi-Channel Operation (MCO) is a cross-layer functionality that enables the use of multiple radio channels in Cooperative Intelligent Transportation Systems (C-ITS). The functional MCO architecture is specified in the ETSI TS 103 697 [i.1] describing the MCO functionalities at the different layers. The present document specifies the Facilities layer functionalities and its interfaces, ensuring backward compatibility with C-ITS Release 1, which were not present in the previous version of the present document.

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# 1 Scope

The present document specifies the Facilities layer MCO functionalities. It specifies the entities and its interfaces with protocols in relation with other MCO entities at other layers and with the applications and services at the Facilities and Application layers.

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## 2 References

### 2.1 Normative 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.

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The following referenced documents are necessary for the application of the present document.

- [1] ETSI TS 103 836-4-1 (V2.1.1): "Intelligent Transportation Systems (ITS); Vehicular Communications; GeoNetworking; Part 4: Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality; Release 2".

### 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 TS 103 697 (V2.1.1): "Intelligent Transport Systems (ITS); Architecture; Multi-Channel Operation (MCO) for Cooperative ITS (C-ITS); Release 2".
- [i.2] ETSI TS 103 696 (V2.1.1): "Intelligent Transport Systems (ITS); Communication Architecture for Multi-Channel Operation (MCO); Release 2".
- [i.3] ETSI TR 103 439 (V2.1.1): "Intelligent Transport Systems (ITS); Multi-Channel Operation study; Release 2".

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## 3 Definition of terms, symbols and abbreviations

### 3.1 Terms

For the purposes of the present document, the terms given in ETSI TS 103 697 [i.1] apply.

## 3.2 Symbols

Void.

## 3.3 Abbreviations

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

AER	Application Error
ASN	Abstract Syntax Notation
BME	Bandwidth Management Entity
CAM	Cooperative Awareness Message
C-ITS	Cooperative Intelligent Transport Systems
CLR	Channel Load Ratio
FCL	Functional Configuration Limits
FCP	Functional Configuration Profile
FcpID	Application Configuration Profile identifier
FER	Functional Error
ID	Identifyer
MCE	Message Collecting Entity
MCI	MCO Control Information
MCO	Multi-Channel Operation
MCO_APP_FAC_MMT	MCO Application Facilities Management interface
MCO_FAC	Multi-Channel Operation Facilities
MCO_FAC_MS_DATA	MCO Facilities Message Services interface
MCO_FAC_NET_DATA	MCO Facilities Networking Data interface
MCO_FAC_NET_MMT	MCO Facilities Networking Management interface
MGE	Message Generation Entity
MHE	Message Handling Entity
MRE	Message Receiving Entity
PCI	Protocol Control Information

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## 4 Facilities layer MCO functional operation

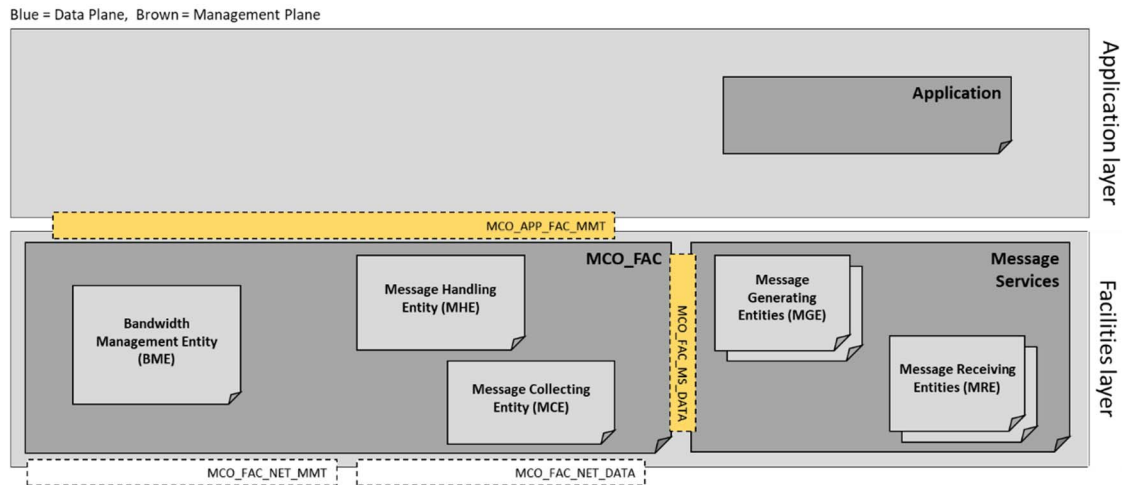
### 4.1 Introduction

The Facilities layer MCO functional architecture is part of the MCO architecture as specified in ETSI TS 103 697 [i.1] based on general C-ITS architectural aspects defined in ETSI TS 103 696 [i.2] from which functional and technical aspects have been identified in the ETSI TR 103 439 [i.3].

The ETSI TS 103 697 [i.1] introduces the MCO services at the different layers and identifies the Facilities layer functionalities as depicted in Figure 1. The 3 functionalities of the MCO\_FAC service is realized by 3 entities:

- **Bandwidth Management Entity (BME):** This entity is in charge of collecting ITS application requirements, capabilities of the available radio interfaces and channels, sending feedback to ITS applications to adapt the amount of information they generate based on collected information, errors and notifications, and configuring the lower layers to use the most adequate channels and radio access technologies taking into account the information collected.
- **Message Handling Entity (MHE):** This entity is in charge of the transmission of messages towards the Networking & Transport layer and configures their parameters on a per-message basis considering the capabilities of the available radio interfaces and channels.
- **Message Collecting Entity (MCE):** This entity is in charge of collecting received messages and forwarding them towards the corresponding message receiving entities.

The present document specifies the operation of these entities as well as their relation with other Application layer and Facilities layer entities and interfaces. The yellow marked interfaces in Figure 1 are the interfaces specified in the present document.



**Figure 1: MCO\_FAC and main related entities at Facilities and Application Layers**

## 4.2 Bandwidth Management entity operation

The Bandwidth Management Entity (BME) is responsible for the collection of the communication requirements of the ITS applications via the MCO\_APP\_FAC\_MMT interface specified in clause 5.2 and may collect IPv6 protocol requests from the Networking & Transport layer using the MCO\_FAC\_NET\_MMT interface as specified in ETSI TS 103 836-4-1 [1].

The BME collects the communication requirements of the ITS applications when these are activated and during the active state of the application when applicable. Alternatively, this information can be preconfigured for statically operating ITS applications. As depicted in Figure 2, the communication requirements are provided by means of Functional Configuration Profiles (FCPs) specified in clause 5.2, which are composed by the following parameters:

- Preferred settings (e.g. channel, technology, message priority, validity time, etc.)
- Alternative settings (e.g. channels, technologies, message priorities, validity time, etc.)
- Resource requests (e.g. bits per second)

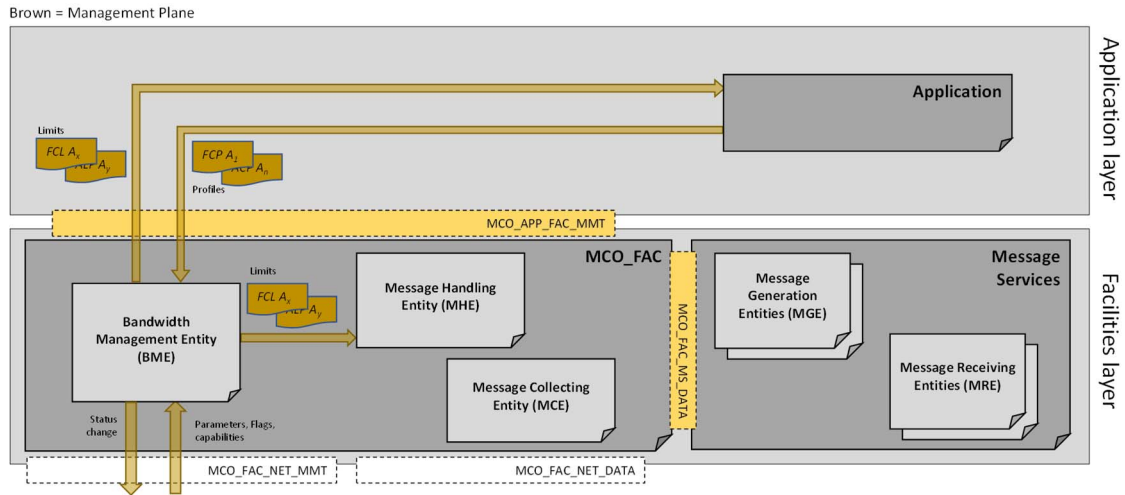
Each FCP is associated to a unique identifier, an FcpID.

**NOTE:** A preferred channel is a channel to which an application prefers to have its messages being disseminated. An alternative channel is a channel which can be used by MCO\_FAC in case certain conditions are reached (e.g. if the preferred channel is overloaded).

Additionally, as depicted in Figure 2, the BME is responsible for the collection of the lower layer communication capabilities and status notifications. It collects or receives this information through the MCO\_FAC\_NET\_MMT interface from the start of operation till the moment of deactivation of the C-ITS. This information may include information such as the CLR (Channel Load Ratio).

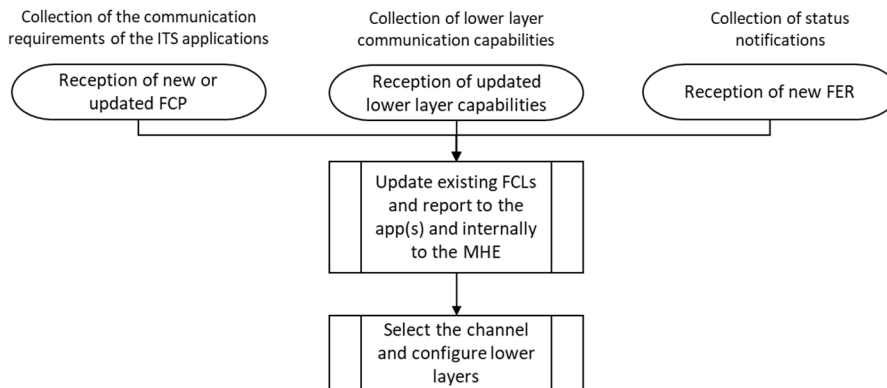
The BME estimates the Functional Configuration Limits (FCL) for each FCP. The FCL defines the limits of the FCP and is specified in clause 5.2. For example, the FCL associated to a given FCP may include the maximum number of kilobits per second that can be generated in its preferred and alternative channels. The BME informs the related ITS applications of the corresponding FCL of each FCP via the MCO\_APP\_FAC\_MMT interface and internally to the MCO Message Handling Entity (MHE), as specified in clause 5.2. This information is updated continuously.

Based on the FCPs requesting resources, and the collected lower layer capabilities, the BME shall select the channel and configure the lower layers by using the MCO\_FAC\_NET\_MMT interface specified in ETSI TS 103 836-4-1 [1]. The definition and specification of configuration policies is out of the scope of the present document.



**Figure 2: Bandwidth management**

Figure 3 illustrates the flow-chart of the main actions taken by the BME upon the reception of FCPs, of updated lower layer capabilities and status notifications, following the description provided in this clause.



**Figure 3: BME flow-chart**

### 4.3 Message Handling entity operation

All active ITS applications that make use of MCO send message generation requests by providing their application data to the applicable MGEs, which in turn generates message handling requests to the Message Handling Entity (MHE) for the dissemination of the messages. Each message handling request sent to the MHE is associated with an FcpID, as shown in Figure 4. The message handling request may have attached MCO Control Information (MCI) to override the default parameters of the FCP for the specific message (e.g. when the MGE wants that a specific message is transmitted in an alternate channel). The MHE is constantly updated with the latest information related to the FCLs by the BME as specified in clause 4.2 via the management plane.

When the MHE receives a message handling request from the MGE, the MHE shall verify whether it complies to the FCL provided by the BME. If this verification is positive, the MHE shall disseminate the message to the lower layer via the MCO\_FAC\_NET\_DATA interface specified in ETSI TS 103 836-4-1 [1] according to the current dissemination possibilities identified by the BME.



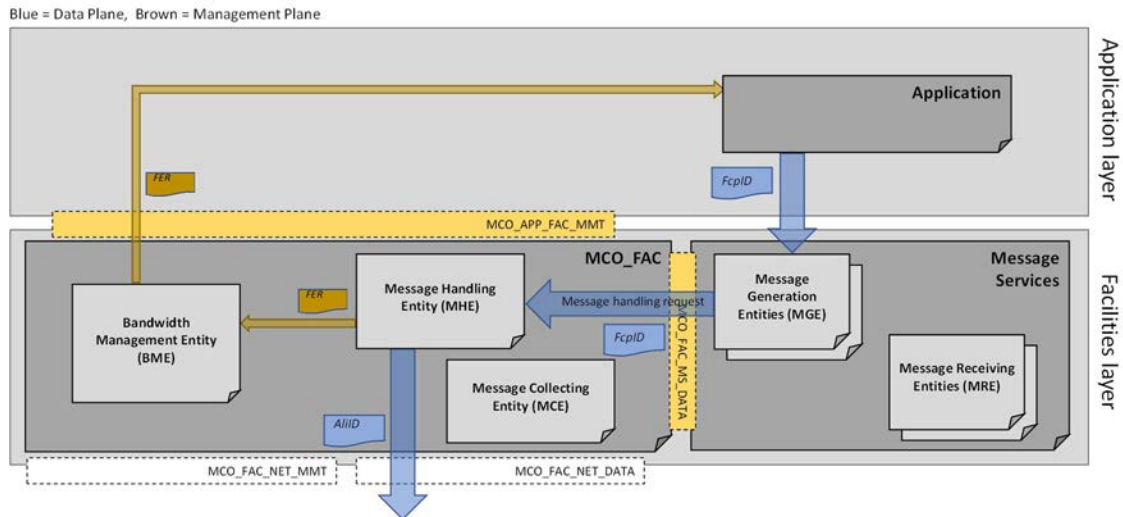


Figure 4: Message handling

If the message handling request received by the MHE from the MGE does not comply to the corresponding FCL, the MHE may send a Functional Error (FER) to the BME for evaluation, which may in turn provide this FER to the Application via the MCO\_APP\_FAC\_MMT interface, as shown in Figure 4. The MRE may still forward the message to the lower layers with an alternate parameter setting if allowed by the associated FCP.

In case an IPv6 data packet exchange is provided by the lower layer, an IPv6 routing request is sent by the lower layers via the MCO\_FAC\_NET\_MMT interface to the BME. The BME assess the situation and identifies whether this can be granted or not. In case this can be granted, the BME enables the IPv6 transfer by sending the appropriate parameter settings via MCO\_FAC\_NET\_MMT interface to the lower layers. The MHE is not involved in this process.

Figure 3 illustrates the flow-chart of the main actions taken by the MHE upon the reception of a message handling request, following the description provided in this clause.

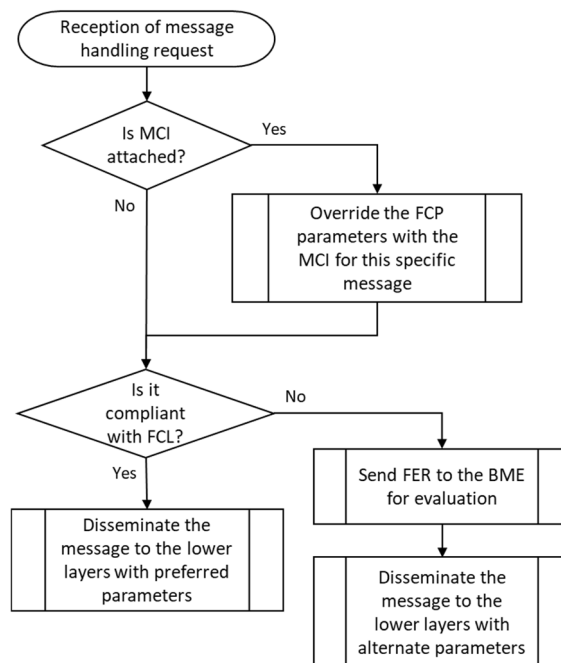


Figure 5: MHE flow-chart

## 4.4 Message Collecting entity operation

The Message Collecting Entity (MCE) collects the messages received from the lower layers through the MCO\_FAC\_NET\_DATA interface specified in ETSI TS 103 836-4-1 [1] and shall provide the messages to the appropriate Message Receiving Entity (MRE) through the MCO\_FAC\_MS\_DATA interface specified in clause 5.3 (see Figure 6).

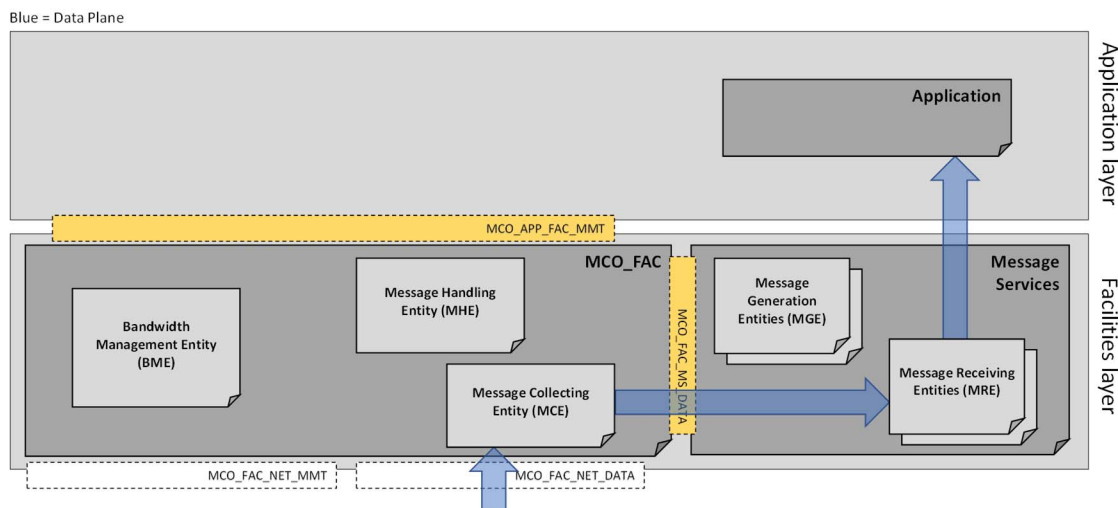


Figure 6: Message reception from lower layer

## 5 Interface Requirements

### 5.1 Introduction

As identified in the ETSI TS 103 697 [i.1] and in clause 4 and as illustrated in Figure 7, the MCO\_FAC has the following interfaces MCO\_APP\_FAC\_MMT, MCO\_FAC\_MS\_DATA, MCO\_FAC\_NET\_MMT and MCO\_FAC\_NET\_DATA. MCO\_APP\_FAC\_MMT and MCO\_FAC\_MS\_DATA interfaces are specified in the clauses below. The MCO\_FAC\_NET\_MMT and MCO\_FAC\_NET\_DATA interfaces are specified in ETSI TS 103 836-4-1 [1].

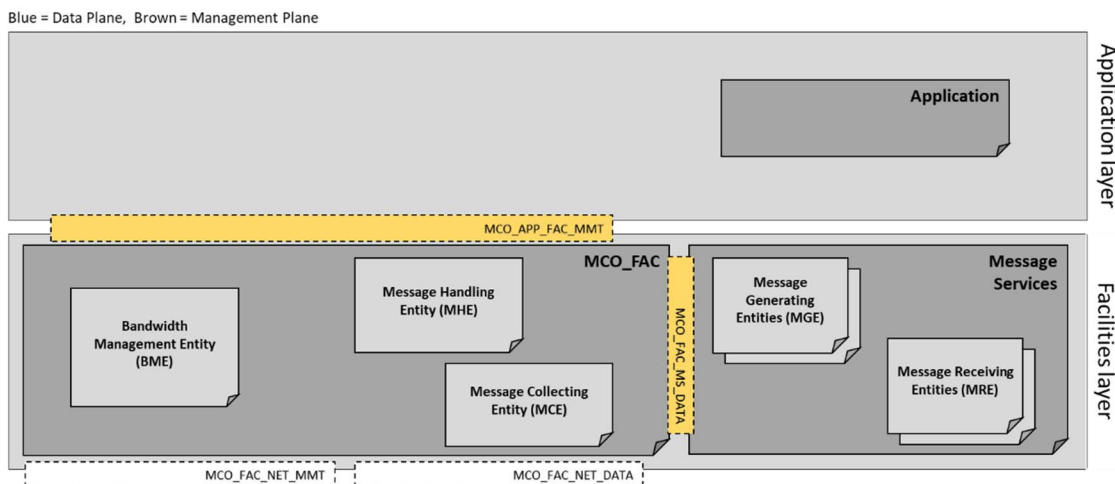


Figure 7: The MCO\_FAC interfaces

## 5.2 MCO\_APP\_FAC\_MMT

Before triggering the generation of messages, ITS applications send their communication requirements to the MCO\_FAC through an FCP using the parameters in Table 1. Each set of communication requirements corresponds to an FCP and is associated to an FcpID.

**Table 1: FCP parameters (input to MCO\_FAC)**

M-Param.No	Name of M-Param	Data type	Description	Status
0	FcpID	Number from 0 to 65 535	Identifier of the functional configuration profile. If FcpID is 0, the command defines the requirements of a new FCP. If FcpID is equal to the ID of an existing FCP, the command describes the new requirements of the FCP.	Mandatory
1	num_channels	Number from 1 to 127	Number of channels for which information is attached.	Mandatory
2	resources	Number from 1 to $2^{32}-1$	Indicates the amount of resources in kilobits per second that would be consumed at the Facilities layer by the FCP.	Optional
3	range	Number from 1 to 65 535	Intended minimum one-hop transmission range in meters.	Optional
4	packet_lifetime	Number from 1 to 65 535	Maximum packet lifetime in milliseconds.	Optional
5	flow_lifetime	Number from 0 to 65 535	Expected lifetime of the flow associated to the FCP in seconds. A time value of zero indicates "time unknow".	Optional
6	channel_list	List of length num_channels containing channel numbers	List of channel numbers in order of preference for the transmission of the messages. The first one is the preferred channel, and the rest are alternate channels.	Optional
7	technology_list	List of length num_channels containing radio access technology identifiers	List of radio access technologies in order of preference for the transmission of the messages. The first one is the preferred technology, and the rest are alternate ones.	Optional
8	priority_list	List of length num_channels containing priority indicators	List of priorities of the message when transmitted in each of the channels indicated in the channel_list; the priorities indicated in this field for each channel do not affect the order of preference of the channels.	Optional
9	criteria_list	List of length num_channels containing criteria identifiers	List of criteria by which MCO can decide to not use the specified channel for which the criteria is set for (e.g. congestion level reached). The specification of the criteria is out of the scope of the present document.	Optional

M-Param.No	Name of M-Param	Data type	Description	Status
10	saturation_indicator	1 bit 0 = discard 1 = use any other channel	Indicates if, in the case that a message cannot be sent through any of the channels in channel_list, that message should be dropped or can be sent through any of the other channels.	Optional

When an ITS application sends its communication requirements to the MCO\_FAC through an FCP, the MCO\_FAC shall inform it about the FCL using the MCO\_APP\_FAC\_MMT interface and the parameters in Table 2. This information shall be provided in response to the reception of an FCP, or independently when any of the parameters of the FCL changes (e.g. due to a change in the channel load and thus a change in the resources limit).

**Table 2: FCL parameters (output of MCO\_FAC)**

M-Param.No	Name of M-Param	Data type	Description	Status
0	FcpID	Number from 0 to 65 535	Identifier of the functional configuration profile	Mandatory
1	num_channels	Number from 1 to 127	Number of channels for which information is attached.	Mandatory
2	resources_limit	List of length num_channels containing resources from 1 to 2 <sup>32</sup> -1	Indicates the maximum amount of resources in kilobits per second that can be consumed at the Facilities layer by the FCP in each of the channels indicated in the channel_list.	Optional
3	range_limit	List of length num_channels containing ranges from 1 to 65 535	Indicates the maximum one-hop transmission range in meters that can be provided to the FCP in each of the channels indicated in the channel_list	Optional
4	packet_lifetime_limit	List of length num_channels containing packet lifetime values from 1 to 65 535	Indicates the maximum packet latency in milliseconds that can be provided to the FCP in each of the channels indicated in the channel_list	Optional
5	flow_lifetime_limit	List of length num_channels containing flow lifetime values from 0 to 65 535	Maximum allowed lifetime of the flow associated to the FCP in seconds in each of the channels indicated in the channel_list. A time value of zero indicates "flow not allowed".	Optional
6	channel_list	List of length num_channels containing channel numbers	List of channels in order of preference for the transmission of the messages.	Optional
7	technology_list	List of length num_channels containing radio access technology identifiers	List of radio access technologies in order of preference for the transmission of the messages.	Optional
8	priority_list	List of length num_channels containing priority indicators	List of priorities of the message when transmitted in each of the channels indicated in the channel_list; the priorities indicated in this field for each channel do not affect the order of preference of the channels.	Optional

The MCO\_FAC may also notify the corresponding ITS application that a given message handling request associated to a given FCP was not satisfied, using the parameters in Table 3.

**Table 3: Parameters of notifications (output of MCO\_FAC)**

M-Param.No	Name of M-Param	Format	Description	Status
0	FcplID	Number from 0 to 65 535	Identifier of the functional configuration profile.	Mandatory
1	FER (Functional Error)	INTEGER 0 = dropped 1 = sent through alternate channel 1 2 = sent to alternate channel 2 255 = sent using a different channel	Indicates that the requirements of a message handling request associated to the FCP could not be satisfied and the message was either dropped or sent through a channel different than the preferred channel.	Mandatory

### 5.3 MCO\_FAC\_MS\_DATA

MGEs shall send to MCO\_FAC a message handling request with the information in Table 4 for the transmission of each message. The message shall be embedded in a Facility-layer message together with the Protocol Control Information (PCI) required to be passed to the ITS Networking & Transport Layer. MGEs may attach MCI as shown in Table 4 and specified in Table 5, to override the default parameters of the FCP for the specific message handling request.

**Table 4: Message handling request**

Data	Data requirement	Status
Facility-layer message	As specified in the ASN.1 description of the corresponding Facility-layer message (e.g. CAM).	Mandatory
MCI	MCO control information used by MCO_FAC to handle the message.	Optional
PCI	Protocol control information that depends on the protocol stack applied in the networking and transport layer.	Mandatory

**Table 5: MCO control information (MCI) (input to MCO\_FAC)**

M-Param.No	Name of M-Param	Type	Description	Status
0	FcplID	Number from 0 to 65 535	Identifier of the functional configuration profile.	Mandatory
1	num_channels	Number from 1 to 127	Number of channels for which information is attached.	Mandatory
2	message_length	Number from 0 to 65 535	Message length in bytes.	Mandatory
3	packet_lifetime	Number from 1 to 65 535	Maximum packet lifetime in milliseconds.	Optional
4	flow_lifetime	Number from 0 to 65 535	Expected lifetime of the flow associated to the FCP in seconds. A time value of zero indicates "time unknown".	Optional
5	range	Number from 1 to 65 535	Intended minimum one-hop transmission range in meters.	Optional

<b>M-Param.No</b>	<b>Name of M-Param</b>	<b>Type</b>	<b>Description</b>	<b>Status</b>
6	channel_list	List of length num_channels containing channel numbers	List of channels in order of preference for the transmission of the message. The first one is the preferred channel, and the rest are alternate channels.	Optional
7	technology_list	List of length num_channels containing radio access technology identifiers	List of radio access technologies in order of preference for the transmission of the messages. The first one is the preferred technology, and the rest are alternate ones.	Optional
8	priority_list	List of length num_channels containing priority indicators	List of priorities of the message when transmitted in each of the channels indicated in the channel_list; the priorities indicated in this field for each channel do not affect the order of preference of the channels.	Optional
9	criteria_list	List of length num_channels containing criteria identifiers	List of criteria by which MCO can decide to not use the specified channel for which the criteria is set for (e.g. congestion level reached). The specification of the criteria is out of the scope of the present document.	Optional
10	saturation_indicator	1 bit 0 = discard 1 = use any other channel	Indicates if the message should be dropped or sent through any other channel if it is not possible to send it through any of the channels in channel_list.	Optional

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## Annex (informative): Change History

<b>Date</b>	<b>Version</b>	<b>Information about changes</b>
2021-06-28	0.0.1	Skeleton of the document
2022-01-15	0.0.2	Early draft with definition of MCO_FAC entity
2022-03-15	0.0.3	Stable draft with all clauses completed
2022-05-23	0.0.4	Final draft
2022-06-23	0.0.5	Updated after RC based on received comments
2022-07-11	0.0.6	Remaining comments removed
2022-09-01	0.0.7	Revision based on Remote Consensus comments received

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## History

<b>Document history</b>		
V2.1.1	November 2021	Publication
V2.2.1	November 2022	Publication