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**Terrestrial Trunked Radio (TETRA);
Technical requirements for Direct Mode Operation (DMO);
Part 1: General network design**

Reference

REN/TETRA-08196

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Terrestrial Trunked Radio (TETRA).

The present document is part 1 of a multi-part deliverable covering the Technical requirements for Direct Mode Operation (DMO), as identified below:

Part 1: "General network design";

Part 2: "Radio aspects";

Part 3: "Mobile Station to Mobile Station (MS-MS) Air Interface (AI) protocol";

Part 4: "Type 1 repeater air interface";

Part 5: "Gateway air interface";

Part 6: "Security";

Part 7: "Type 2 repeater air interface"; (Historical)

Part 8: "Protocol Implementation Conformance Statement (PICS) proforma specification"; (Historical)

Part 10: "Managed Direct Mode Operation (M-DMO)". (Historical)

NOTE: Part 7, part 8 and part 10 of this multi-part deliverable are of status "historical" and will not be updated according to this version of the standard.

National transposition dates	
Date of adoption of this EN:	22 December 2011
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1 Scope

The multi-part deliverable EN 300 396 defines the Terrestrial Trunked Radio (TETRA) Direct Mode Operation (DMO). It specifies the basic air interface, the inter-working between Direct Mode (DM) groups via repeaters, and inter-working with the TETRA Voice plus Data (V+D) system via gateways. It also specifies the security aspects in TETRA DMO, and the intrinsic services that are supported in addition to the basic bearer services and teleservices.

The present document applies to the general network design of TETRA DMO as follows:

- it defines and specifies the circuit mode reference points for the Mobile Station (MS), repeater and gateway to the Switching and Management Infrastructure (SwMI);
- it defines and specifies models of the air interface protocol stack where the different functions of layers and sub-layers are listed;
- it defines and specifies the TETRA DMO addressing and identities and their organization in groups corresponding to the different functions;
- it defines and specifies the functions provided by the circuit mode teleservices used for speech and basic services used for data transfer;
- it defines and specifies the intrinsic services that extend the capabilities of the circuit mode bearer services and teleservices;
- it defines and specifies the functions related to the transport of short data messages.

NOTE: If a discrepancy occurs between the present document and any other part of the EN 300 396 multi-part deliverable, then the other part will take precedence. This part will be updated at a frequency consistent with maintaining the integrity of the present document as a whole.

2 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 reference document (including any amendments) applies.

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2.1 Normative references

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

- [1] ETSI EN 300 392-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".
- [2] ETSI EN 300 396-2: "Terrestrial Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 2: Radio aspects".
- [3] ETSI EN 300 396-3: "Terrestrial Trunked Radio (TETRA); Technical Requirements for Direct Mode Operation (DMO); Part 3: Mobile Station to Mobile Station (MS-MS) Air Interface (AI) Protocol".
- [4] ETSI EN 300 396-4: "Terrestrial Trunked Radio (TETRA); Technical Requirements for Direct Mode Operation (DMO); Part 4: Type 1 repeater air interface".

- [5] ETSI EN 300 396-5: "Terrestrial Trunked Radio (TETRA); Technical Requirements for Direct Mode Operation (DMO); Part 5: Gateway air interface".
- [6] ETSI EN 300 396-6: "Terrestrial Trunked Radio (TETRA); Technical Requirements for Direct Mode Operation (DMO); Part 6: Security".
- [7] ETSI EN 300 395-2: "Terrestrial Trunked Radio (TETRA); Speech codec for full-rate traffic channel; Part 2: TETRA codec".
- [8] ITU-T Recommendation E.218: "Management of the allocation of terrestrial trunk radio Mobile Country Codes".

2.2 Informative references

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 Directives: "ETSI Statutes; ETSI Rules of Procedure; ETSI Board Working Procedures; Powers and Functions of the Board; Terms of Reference of the Operational Co-ordination Group (OCG); ETSI Technical Working Procedures; ETSI Drafting rules".
- [i.2] ETSI EN 300 392-1: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 1: General network design".
- [i.3] Void.
- [i.4] ETSI TR 102 300-5: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Designers' guide; Part 5: Guidance on numbering and addressing".
- [i.5] ETSI EG 202 118: "Services and Protocols for Advanced Networks (SPAN); The structure of the TETRA numbering resource, interworking and high level policy for administration".
- [i.6] ITU-T Recommendation I.411 (1993): "ISDN user-network interfaces - Reference configurations".
- [i.7] ETSI EN 300 392-5: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D) and Direct Mode Operation (DMO); Part 5: Peripheral Equipment Interface (PEI)".
- [i.8] ETSI TS 100 392-18-1: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D) and Direct Mode Operation (DMO); Part 18: Air interface optimized applications; Sub-part 1: Location Information Protocol (LIP)".
- [i.9] ETSI EN 300 396-7: "Terrestrial Trunked Radio (TETRA); Technical Requirements for Direct Mode Operation (DMO); Part 7: Type 2 repeater air interface". (Historical).

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in the ETSI Directives [i.1] and the following apply:

Bit Error Ratio (BER): ratio of the bits wrongly received to all bits received in a given logical channel

call: complete sequence of related call transactions between DM-MSs

NOTE 1: There are two types of call, individual call or group call. An individual call is a complete sequence of related call transactions between two DM-MSs. A group call is a complete sequence of related call transactions involving two or more DM-MSs. The number of participants in a group call is not fixed. Participants may join (late entry) and leave an ongoing call.

NOTE 2: For calls without presence check there is no guaranty that anyone is listening.

call transaction: all of the functions associated with a complete unidirectional transmission of information

NOTE: A call is made up of one or more sequential call transactions.

called user application: user application which receives an incoming call

calling user application: user application which initiates an outgoing call

Direct Mode Call Control (DMCC): layer 3 entity responsible for setting up and maintaining a call in DMO

Direct Mode GATEway (DM-GATE): device that provides gateway connectivity between a DM-MS(s) and the TETRA TMO network

NOTE: The gateway provides the interface between TETRA DMO and TETRA TMO. A gateway may provide only the gateway function (DM-GATE) or may provide the functions of both a DM repeater and a DM gateway during a call (DM-REP/GATE).

Direct Mode Mobile Station (DM-MS): physical grouping that contains all of the mobile equipment that is used to obtain TETRA DM services

NOTE: A DM-MS may have one of three roles:

- **master:** if the DM-MS is either active in a call transaction transmitting traffic or control data, or is reserving the channel by means of channel reservation signalling;
- **slave:** if the DM-MS is receiving traffic and/or signalling in a call;
- **idle:** if the DM-MS is not in a call.

Direct Mode Operation (DMO): mode of simplex operation where mobile subscriber radio units may communicate using radio frequencies which may be monitored by, but which are outside the control of, the TETRA TMO network

NOTE: Direct Mode Operation is performed without intervention of any base station.

Direct Mode REPeater (DM-REP): device that operates in TETRA DM and provides a repeater function to enable two or more DM-MSs to extend their coverage range

NOTE: It may be either a type 1 DM-REP, capable of supporting only a single call on the air interface, or a type 2 DM-REP, capable of supporting two calls on the air interface. A type 1 DM-REP may operate on either a single RF carrier (type 1A DM-REP) or a pair of duplex-spaced RF carriers (type 1B DM-REP). A type 2 DM-REP [i.9] operates on a pair of duplex-spaced RF carriers.

DM channel: specific grouping of timeslots in the DM multiplex structure related to a particular DM RF carrier (i.e. DM frequency)

NOTE: The grouping may not always be fixed, but in DMO when operating in frequency efficient mode as an example, there are two DM channels, identified by the letters A and B.

Dual mode switchable Mobile Station (DU-MS): MS that is capable to operate in TETRA DMO or in TETRA TMO one mode at a time

NOTE: Only one mode can be selected at any given time and the MS is not capable of monitoring a DM RF carrier while in TMO or TMO channels while in DMO.

Dual Watch Mobile Station (DW-MS): MS that is either full dual watch MS (F-DW-MS) or idle dual watch MS (I-DW-MS)

NOTE: When idle, the MS periodically monitors both the DM RF carrier and the TMO control channel. If the MS is performing full dual watch, it is also capable of periodically monitoring the TMO control channel while in a DM call and a DM RF carrier while in a TMO call. Alternatively the MS may perform idle dual watch, in which case it need not be capable of monitoring the TMO control channel while involved in a DM activity (e.g. call) or a DM RF carrier while involved in a TMO activity (e.g. call).

Functional group: set of functions which may be needed in TETRA DMO access arrangements

NOTE 1: In a particular access arrangement, specific functions in a function group may but need not be present.

NOTE 2: Specific functions in a functional group may be performed in one or more pieces of equipment.

frequency efficient mode: mode of operation where two independent DM communications are supported on a single RF carrier

NOTE: In frequency efficient mode the two DM channels are identified as channel A and channel B.

Full Dual Watch Mobile Station (F-DW-MS): MS that is capable of both TETRA DMO and TETRA TMO and capable to monitor the DM RF carrier while in a TMO service and a TMO control channel while in a DM service

NOTE: When idle, the MS periodically monitors both the DM RF carrier and the TMO control channel. The MS is also capable of periodically monitoring the TMO control channel while in a DM call and a DM RF carrier while in a TMO call.

gateway: DM-GATE or DM-REP/GATE

NOTE: Generic term which describes either a pure DM-GATE or a combined implementation with a repeater (DM-REP/GATE).

Idle Dual Watch Mobile Station (I-DW-MS): MS that is capable of both TETRA DMO and TETRA TMO and when idle capable to periodically monitor both modes

NOTE: When idle, the MS periodically monitors both the DM RF carrier and the TMO control channel. The MS need not be capable of monitoring the TMO control channel while involved in a DM activity (e.g. call) or a DM RF carrier while involved in a TMO activity (e.g. call).

logical channel: any distinct data path

NOTE: Logical channels are considered to operate between logical endpoints.

Message Erasure Rate (MER): ratio of the messages detected as wrong by the receiver to all messages received in a given logical channel

normal mode: mode of operation where only one DM communication is supported on a RF carrier

occupation: time where a call transaction is in progress on a channel

Open MNI (O-MNI): open network address used for all DM networks on the selected frequency

NOTE: O-MNI consists of all binary ones ($11\dots11_2$). The O-MNI is used in combination with the O-SSI or the network specific SSI.

Open SSI (O-SSI): short subscriber identity used in order to obtain openness within a given MNI

NOTE: O-SSI consists of all binary ones ($11\dots11_2$). The O-SSI is used in combination with the O-MNI or the network specific MNI.

Open TSI (O-TSI): open TETRA subscriber identity, which is a combination of O-MNI + O-SSI

NOTE: O-TSI consists of all binary ones ($11\dots11_2$).

pre-emption: transfer of the master role to the requested DM-MS

NOTE: This process may occur within a call during occupation or to set-up a new call during either occupation or reservation.

Radio Frequency carrier (RF carrier): radio frequency channel

NOTE: This is a specified portion of the RF spectrum. In DMO, the RF carrier separation is 25 kHz.

random access: request permission from the current master to use the DM channel or to change the ongoing call timing

NOTE: The request of the DM channel usage may be issued by any DM-MS that wishes to transmit traffic or short data either during occupation or reservation period. The request of changing the ongoing call timing may be issued by any DW-MS involved in the call as a slave either during occupation or reservation period.

R0: reference point within the Mobile Terminating unit (MT) that corresponds to the top of the mobile radio not including the routing

NOTE: R0 acts as the network service boundary and exists in all MTs.

R1: reference point between Terminal Equipment (TE2) and the Mobile Termination (MT2)

NOTE: There may be several alternative interface protocols at R1, including existing standards.

R2: reference point at the TETRA air interface

recent user: DM-MS that was master of the call transaction immediately prior to the current master's call transaction in a call

recent user priority: service which gives the recent user a preferred access to request transmission when the current master is ceasing its call transaction in a group call

NOTE: This service is controlled by the current master.

reference configuration: conceptual configuration useful in identifying various possible physical access arrangements to TETRA DMO

NOTE 1: Two concepts are used in defining reference configurations:

- reference points; and
- functional groups.

NOTE 2: Physical interfaces that do not correspond to a reference point will not be described in the TETRA deliverables.

reference point: conceptual point dividing functional groups

NOTE: In a specific access arrangement, a reference point may correspond to a physical interface between pieces of equipment, or there need not be any physical interface corresponding to the reference point. Physical interfaces that do not correspond to a reference point will not be the subject of TETRA DMO interface recommendations.

reservation: time where a "channel reservation" signal is present on the channel

short data service: data service providing both user-defined short messages and predefined 16-bit messages

simplex: mode of working in which information can be transferred in both directions but not at the same time

Trunked Mode Operation (TMO): mode of operation where MSs communicate via the TETRA V+D air interface which is controlled by the TETRA Switching and Management Infrastructure (SwMI)

NOTE: This is also called V+D operation. The abbreviation "TMO" is used in the present document to pair with the abbreviation "DMO" instead of the abbreviation "V+D". "TMO" abbreviation is not used in EN 300 392-1 [i.2] and EN 300 392-2 [1].

Type 1 DM-REP: DM repeater that supports a single call on the air interface

NOTE: There are two varieties of type 1 DM-REP. A type 1A DM-REP operates on a single RF carrier. A type 1B DM-REP operates on a pair of duplex-spaced RF carriers, one used as the "uplink" from DM-MSs to the DM-REP and the other used as the "downlink" from the DM-REP to DM-MSs.

Type 2 DM-REP: DM repeater that is capable of supporting two simultaneous calls on the air interface

NOTE: A type 2 DM-REP operates on a pair of duplex-spaced RF carriers, one used as the "uplink" from DM-MSs to the DM-REP and the other used as the "downlink" from the DM-REP to DM-MSs.

V+D operation: mode of operation for communication via the TETRA V+D air interface which is controlled by the TETRA Switching and Management Infrastructure (SwMI)

NOTE: This is also called Trunked Mode Operation (TMO).

3.2 Symbols

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

>>	Possible physical interfaces
Ud	TETRA Direct Mode air interface access point
Um	TETRA Trunked Mode air interface access point

3.3 Abbreviations

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

AI	Air Interface
AP2	Access Point for Bearer Services at R reference point
AP3	Access Point for Teleservices
ASSI	Alias Short Subscriber Identity
BER	Bit Error Rate
C	Control plane
CRC	Cyclic Redundancy Check
DLL	Data Link Layer
DM	Direct Mode
DMCC	Direct Mode Call Control
DM-GATE	Direct Mode GATEway
DMMM	Direct Mode Mobility Management
DM-MS	Direct Mode Mobile Station
DMO	Direct Mode Operation
DM-REP	Direct Mode REPeater
DM-REP/GATE	Direct Mode REPeater/GATEway
DO-MS	Direct mode Only Mobile Station
DSB	Direct mode Synchronization Burst
DU-MS	Dual mode switchable Mobile Station
DW-MS	Dual Watch Mobile Station
ESN	Electronic Serial Number
FAC	Final Assembly Code
F-DW-MS	Full Dual Watch Mobile Station
FEC	Forward Error Correction
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
I-DW-MS	Idle Dual Watch - Mobile Station
ISSI	Individual Short Subscriber Identity
ITSI	Individual TETRA Subscriber Identity
LIP	Location Information Protocol
LS	Line connected Station
MCC	Mobile Country Code
MER	Message Erasure Rate
MMI	Man Machine Interface
MNC	Mobile Network Code
MNI	Mobile Network Identity
MS	Mobile Station
MT	Mobile Termination
MT0	Mobile Termination type 0
MT2	Mobile Termination type 2
NSAP	Network Service Access Point
O-MNI	Open MNI
O-SSI	Open SSI
O-TSI	Open TSI
PDU	Protocol Data Unit
PL	Physical Layer
RF	Radio Frequency
RSSI	Radio-Signal-Strength-Indicator
SCK	Static Cipher Key

SDS	Short Data Service
SDS-TL	SDS Transport Layer
SDU	Service Data Unit
SIM	Subscriber Identity Module
SS	Supplementary Services
SSI	Short Subscriber Identity
SwMI	Switching and Management Infrastructure
TAC	Type Approval Code
TE	Terminal Equipment
TE2	TE presenting a TETRA interface
TEI	TETRA Equipment Identity
TMI	TETRA Management Identity
TMO	Trunked Mode Operation
TPNI	Transmitting Party Number Identification
TSI	TETRA Subscriber Identity
TVP	Time Variant Parameter
U	User plane
USSI	Un-exchanged Short Subscriber Identity
WAP	Wireless Application Protocol

4 DMO reference points

Annex A gives information of the general reference configuration and reference points of TETRA DMO mobile stations, repeater and gateways used in TETRA DMO standardization.

5 Protocol architecture for DMO

Annex B describes the protocol architecture principles used in TETRA DMO standardization.

6 DM addressing and identities

6.1 Introduction

Clause 6 defines the DMO TETRA addresses and identities that shall be used by all TETRA DMO equipment.

The identities are organized into the following groups, corresponding to the different functions of the addresses and identities.

- Mobile Network Identity (MNI);
- TETRA Subscriber Identities (TSI);
- Short Subscriber Identities (SSI);
- TETRA Equipment Identities (TEI);
- DM repeater or gateway address.

TETRA addresses and identities are designed to support the following objectives:

- 1) to allow a large number of networks (and network operators) to co-exist, and for each network to support a large number of subscribers;
- 2) to be able to uniquely identify any subscriber in any TETRA DM channel;
- 3) to be able to identify the serving repeater or gateway in any TETRA DM channel.

The main TETRA identities are the subscriber identities. A key difference between TETRA and public mobile networks is the existence of group identities. As far as possible, group identities within TETRA shall be treated identically to individual identities, i.e. group and individual identities shall have the same structure and shall be allocated from the same TETRA identities space.

The individual subscriber identities shall have a special role to provide a unique identification of terminal users because an individual subscriber identity can only refer to one MT. By contrast, a group subscriber identity is intended to refer to several MTs.

TETRA DM uses the same addressing scheme for subscriber identities as TETRA TMO. As defined in EN 300 392-1 [i.2].

NOTE: The subscriber identities may be transferable, and may be removed from the equipment by the user.

The relationship between the different TETRA identities and the other addresses is shown in figure 6.1.

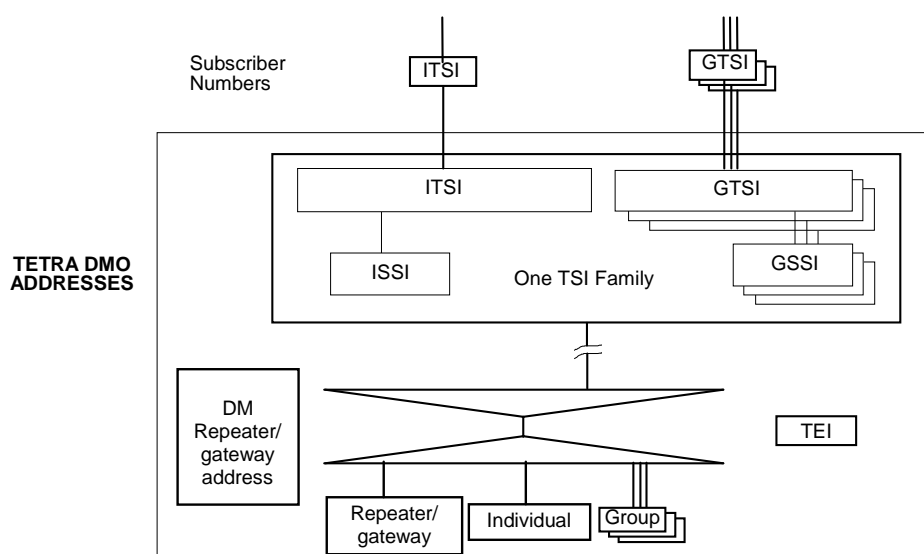


Figure 6.1: Relationship between TETRA DM addresses

6.2 Mobile Network Identity (MNI)

The MNI shall consist of two sub-parts as shown in figure 6.2.

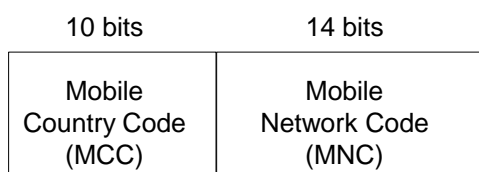


Figure 6.2: Contents of MNI

The coding for the MCC and MNC fields is defined as follows:

- The MCC shall use 10 bits to encode the 3 decimal digit value of the country code as defined in ITU-T Recommendation E.218 [8].

EXAMPLE: France has the country code 208 decimal
This is coded as 00 1101 0000 binary (0D0 hexadecimal).

The undefined binary codes of decimal values 1 000 to 1 022 are reserved and shall not be used.

- MNC shall be allocated by the National Administration for each country. A unique MNC shall be allocated to each operator. The MNC shall use 14 bits to encode a 4 decimal digit value of the network code. The maximum value is 9 999 decimal or 270F in hexadecimal format, refer to TR 102 300-5 [i.4], EG 202 118 [i.5] or ITU-T Recommendation E.218 [8].

The undefined binary codes of decimal values 10 000 to 16 382 are reserved and shall not be used.

- The MCC of decimal value 1 023 (10 bits binary ones) and the MNC of decimal value 16 383 (14 bits binary ones) shall be used only in combination for the Open MNI (O-MNI).

6.3 Subscriber identities

6.3.1 General

Subscriber identities (TSI or SSI) shall exist in two sizes:

- TETRA Subscriber Identity (TSI), 48 bits long;
- Short Subscriber Identity (SSI), 24 bits long.

The TSI shall consist of the MNI and the SSI combined as shown in figure 6.3.

The SSI shall be a truncation of the TSI.

10 bits	14 bits	24 bits
Mobile Country Code (MCC)	Mobile Network Code (MNC)	Network Specific Short Subscriber Identity (SSI)

Figure 6.3: Contents of TSI

TSI identities shall have a fixed length structure that has the same information elements as defined in ITU-T Recommendation E.218 [8].

Each TSI shall be unique across the complete TETRA domain, i.e. all TETRA networks, but each SSI shall only be unique in one TETRA sub-domain, i.e. one TETRA network.

6.3.2 TETRA Subscriber Identity (TSI)

Each DM-MS shall contain at least one family of TSIs. Each TSI family shall contain one Individual TETRA Subscriber Identity (ITSI) which provides a unique address to a particular TETRA Subscriber and may also have several Group TETRA Subscriber Identities (GTSIs), in which a number of particular individual TETRA subscribers may be members.

One TSI family:

- 1 x ITSI;
- N x GTSI.

The partitioning of the address space between ITSIs, and GTSIs shall only be known inside the relevant TETRA sub-domain. Outside of this sub-domain ITSI and GTSI cannot be distinguished. The partitioning rules are outside the scope of the present document.

The following will only consider the requirements for a single family. A single termination may contain more than one TSI family, and in this case each family shall meet these requirements independently of the other families.

TSIs shall be allocated by the network operators. A DM-MS shall possess at least one ITSI before it can be used.

A valid ITSI shall be required in order to support the air interface addressing procedures (refer to clauses 6.3.5 and 6.7).

To support group addressing, one (or more) GTSI shall be allocated in addition to the ITSI. There may be several GTSI per ITSI and the same GTSI may be associated to several ITSIs. The binding between the GTSI and the ITSI is outside the scope of the present document, and a given group subscriber is only known to other subscribers by his GTSI.

6.3.3 Short Subscriber Identity (SSI)

The SSI is the network specific part of the TSI. SSIs shall be unique within a given MNI. The same SSI value may be used with different MNIs.

An Individual Short Subscriber Identity (ISSI) shall be formed from an ITSI by removing the MCC and the MNC. Likewise, a Group Short Subscriber Identity (GSSI) shall be truncated from a GTSI by removing the MCC and the MNC.

Valid values for an SSI shall correspond to the valid types of TSI as follows:

- ISSI = SSI from ITSI;
- GSSI = SSI from GTSI.

6.3.3A Open identities

In addition to the DM-MS's allocated group addresses (GTSIs), the predefined "Open" SSI (O-SSI) defines a group to which all DM-MSs of a given MNI shall belong (see note 1). This allows calls to be made to all users of that MNI who have selected the same DM radio frequency carrier. The content of the 24 bits Open SSI shall comprise all binary ones (11...11₂).

To obtain network openness on the DM radio frequency carrier, the predefined "Open" MNI (O-MNI) shall be used (see note 2). The content of the 10 bits Open MNI shall comprise all binary ones (11...11₂).

To obtain complete openness on the DM radio frequency carrier, the predefined "Open" TSI (O-TSI) shall be used. The Open TSI is a combination of O-MNI + O-SSI and therefore consists of all binary ones (11...11₂).

NOTE 1: The O-SSI may be used in combination with the O-MNI or the network specific MNI.

NOTE 2: The O-MNI may be used in combination with the O-SSI or the network specific SSI.

6.3.4 Installation of TSIs

TSIs (ITSIs or GTSIs) may be installed by several alternative mechanisms as follows:

- by the network operator (i.e. not usually changed by the user);
- by inserting a Subscriber Identity Module (SIM) module or "smart card";
- by the user entering a login code via a local MS application.

NOTE: These mechanisms are only provided as examples. No methods of installation are defined by the present document.

6.3.5 Use of subscriber identities

Subscriber identities shall be used as a layer 2 address for the air interface as described in clause 6.6.

Subscriber identities shall be used by layer 3 for source (at receiving side) and destination addresses. The source address at receiving side is used for intrinsic service Transmitting Party Number Identification (TPNI).

The layer 3 destination address shall be an ITSI or GTSI.

The layer 3 source address at receiving side shall be an ITSI.

Subscriber identities shall be used within the security provisions for TETRA DMO. The ITSI is tied to a user and shall be used as the anchor point for the secret key K within the authentication and encryption processes.

6.4 DM repeater or gateway address

6.4.1 Contents of DM repeater or gateway address

A DM repeater or gateway address shall be a 10 bit address used to identify a particular repeater or gateway. A DM repeater or gateway address may not be unique across the complete TETRA domain.

NOTE: No methods of DM repeater or gateway address installation are defined by the present document.

6.4.2 Use of DM repeater or gateway address

The DM repeater or gateway address shall be used by the DM-MS to address a DM repeater or gateway.

The DM-MS is aware of the repeater or gateway address either:

- by subscription; or
- by the user application supplying it; or
- by receiving repeater or gateway signalling.

6.5 TETRA Equipment Identity (TEI)

The TEI uniquely identifies one piece of TETRA equipment (MT).

The TEI shall be allocated by the equipment manufacturer. One manufacturer may supply several networks, and therefore the TEI shall not be specific to one network.

6.5.1 Contents of TEI

Contents of TEI shall be as presented in figure 6.4.

24 bits or 6 hexa digits	8 bits or 2 hexa digits	6 hexa digits	1 hexa digit
Type Approval Code (TAC)	Final Assembly Code (FAC)	Electronic Serial Number (ESN)	Spare (SPR)

Figure 6.4: Contents of TEI

Type Approval Code and Final Assembly Code information elements shall be encoded as binary encoded information elements.

When those are presented for human reader e.g. printed on the equipment the values shall be presented using hexadecimal digits indicating the same value as the binary value.

TEI Electronic Serial Number digits shall use the hexadecimal digits.

The spare digit (equivalent to 4 bits) shall be set to "0" (0000₂) in a TEI conforming to the present document.

All the information elements shall contain leading zero bits in the information element. So the total length of the TEI shall be 60 bits or 15 hexadecimal digits.

6.5.2 Allocation principles for TEI

ETSI shall allocate individual Type Approval Codes (TACs) and keep register of the assigned codes. The allocation of individual TACs will remain private within ETSI. Refer to annex D for an application form or site

<http://portal.etsi.org/dvbandca/>.

NOTE 1: For the purpose of the present document the TAC means "presumption of conformity" to the relevant harmonized standards covering the product. Although use of an external type approval body is no more needed in Europe ETSI still allocates TACs. It is manufacturer's discretion, when a new TAC is needed for a TETRA equipment implementation.

NOTE 2: TAC is independent of any national type approval certification. Any national type approval identification is outside the scope of the present document.

Final Assembly Code (FAC) shall identify the manufacturer and may identify the place of final assembly. ETSI shall assign individual FACs and keep register of the assigned codes. ETSI may maintain a public Web page of allocation of FACs (see annex E). Refer to annex E for an application form or site <http://portal.etsi.org/dvbandca/>.

NOTE 3: Manufacturer may freely use one or multiple FACs in a single or multiple manufacturing sites. An economical use of FACs is encouraged.

Electronic Serial Number (ESN) shall be an individual serial number that uniquely identifies each equipment within each TAC + FAC. ESN shall be allocated by the manufacturer.

NOTE 4: In order to have compatibility with the previous version of the present document the ESN field may contain only binary coded decimal digits although the coding supports hexadecimal coding.

6.6 Layer 2 addresses and labels

In the lower layers of the air interface, the primary addressing function shall be based on the 48 bit TETRA subscriber addresses for source and destination MSs. This use of subscriber identities requires a subscriber identity to be allocated to all MTs before they can access TETRA DMO.

When repeaters and gateways are employed in a connection, they need to be explicitly addressed and for this purpose a shortened addressing scheme shall be used, see clause 6.4.

Labelling functions within DMO are restricted to the transmission of a colour code to be used in scrambling.

6.6.1 DM colour code

Colour codes are defined to ensure that transmissions on a given channel are only received by the intended endpoints. The colour code is used to prevent cross calls.

A colour code shall appear as part of every transmission event for both signalling and traffic. The colour code shall be used for all DMO normal burst transmissions. The colour code technique shall also be used for DMO synchronization burst, but with a code of all zeroes.

The colour code shall be a 30 bit sequence as defined in clause 8.2.4 of:

- EN 300 396-3 [3] for DM-MS (see note),
- EN 300 396-4 [4] for DM-REP (see note),
- EN 300 396-5 [5] for DM-GATE (see note).

This shall be used as the "seed" for the colour code scrambling function as specified in EN 300 396-2 [2], clause 8 with every transmission or reception.

NOTE: At the receiving MS, there is assumed to be no extraction of the scrambling label. An erroneous reception would only be detected by the normal channel coding as a decoding failure. This means that the receiver need not distinguish between different errors (e.g. errors due to noise, fading, Doppler or errors due to a co-channel interferer).

6.7 Use of TETRA addresses

6.7.1 Air interface addressing functions

The address functions for all layers are summarized in table 6.1.

Table 6.1: Addressing functions per layer

Layer	Protocol	Addresses used	Address function
3	Layer 3	Destination TSI	End-to-end routing
		Source TSI	Transmitting party identification
2	DLL	Destination TSI	burst addressing
		Source SSI	burst addressing
		DM repeater or gateway address	burst addressing
1	PL	DM Colour Code	Scrambling

The overview through all layers of the functions related to the addresses is illustrated in figure 6.5.

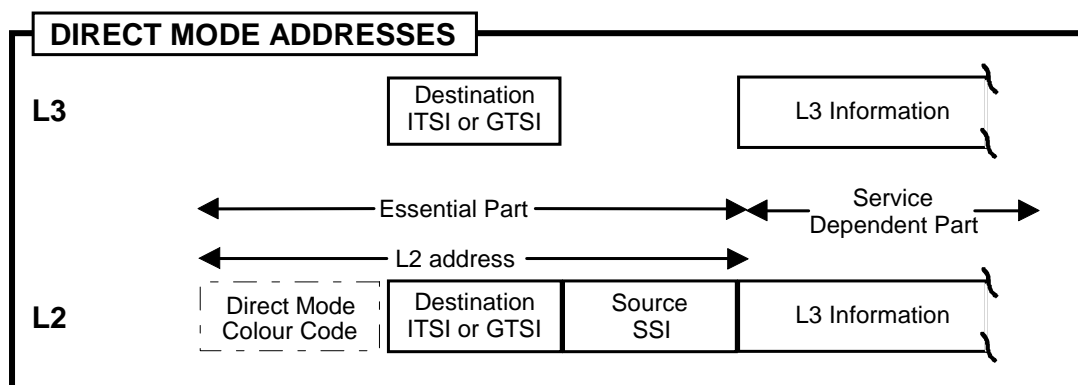


Figure 6.5: Message addressing

6.7.2 Address placement in primitives and PDUs

Figure 6.6 shows the inclusion of addresses within primitives and PDUs for direct MS-MS operation.

6.7.2.1 Use of addresses at layer 2 for direct MS-MS operation

The relevant destination TSI address shall be supplied to layer 2 by the DMCC. It shall appear in the layer 2 primitives as a separate parameter: i.e. it shall remain visible down to the DLL. This TSI address shall only be "invisible" at the PL.

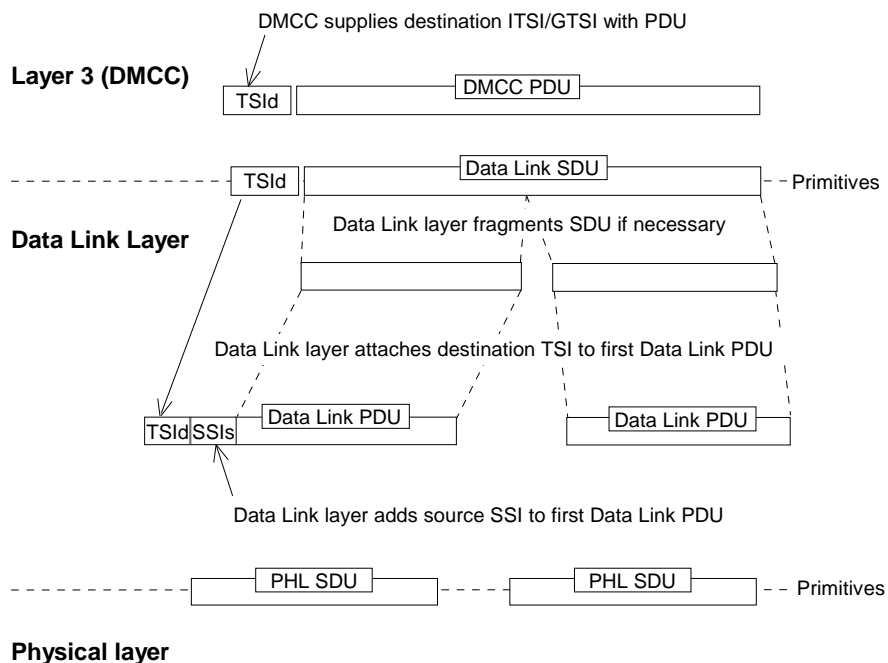
The source SSI is supplied by the DLL. The DLL may use a pseudo SSI instead of the true SSI as a source SSI. A pseudo SSI is a random 24 bit temporary address generated by the DLL.

At the sender, the DLL shall place the destination TSI and normally places the source SSI into PDUs. At the receiver the DLL receives the destination TSI and normally receives the source SSI.

6.7.2.2 Use of TSI at layer 3 for direct MS-MS operation

The ITSI or GTSI shall be used for all DM services (e.g. call) for destination addressing.

There shall not be an additional address field in the PDUs at layer 3, if full addressing information is already available at layer 2.



Key: TSId = Destination TSI, SSIs = Source SSI.

Figure 6.6: TETRA DMO air interface addressing

6.7.2.3 Use of addresses for DM repeater operation

The use of addresses for operation with a repeater is similar to direct MS-MS operation, except that all messages carried in DM synchronization bursts shall include the 10-bit repeater address.

6.7.2.4 Use of addresses for DM gateway operation

The use of addresses for operation with a gateway is similar to direct MS-MS operation, except that:

- 1) all messages carried in DM synchronization bursts shall include the 10-bit gateway address;
- 2) the gateway-specific messages include only the source or the destination address at layer 2: the source address in gateway-specific messages sent by DM-MSs or the destination address in gateway-specific messages sent by the gateway;
- 3) for a call set-up through a gateway, an external subscriber number may be included within the layer 3 destination addressing;
- 4) for a call set-up from TMO, the layer 2 source address element may contain the TMO calling party address.

6.7.3 Address and identity comparison

DMO and TMO addresses and identities are compared in table 6.2.

Table 6.2: Comparison of addresses and identities between DMO and TMO

DMO	TMO
ITSI/GTSI	ITSI/GTSI
ISSI/GSSI	ISSI/GSSI
-	ASSI
-	USSI
-	TMI
TEI	TEI
-	NSAP
DM repeater or gatewayaddress	-

7 DM circuit mode teleservices and bearer services

Annex C gives an overview of DM circuit mode teleservices and bearer services.

8 DM intrinsic services

Annex C gives an overview of DM intrinsic services.

9 DM Short Data Service (SDS)

Annex C gives an overview of DM Short Data Service.

Annex A (informative): DMO reference points

A.1 Introduction

This annex is based on the principle of reference configurations presented in ITU-T Recommendation I.411 [i.6] in order to specify conceptual reference points which are relevant to TETRA DMO. For consistency with the TETRA TMO standard, common terminology for the reference points highlighted here has been used.

A.2 Reference configuration

A TETRA DM configuration can offer various telecommunication services. The general TETRA DM network and the access for teleservice and bearer service is shown in figure A.1.

A DM-MS includes a Mobile Termination (MT) and may include a Terminal Equipment (TE).

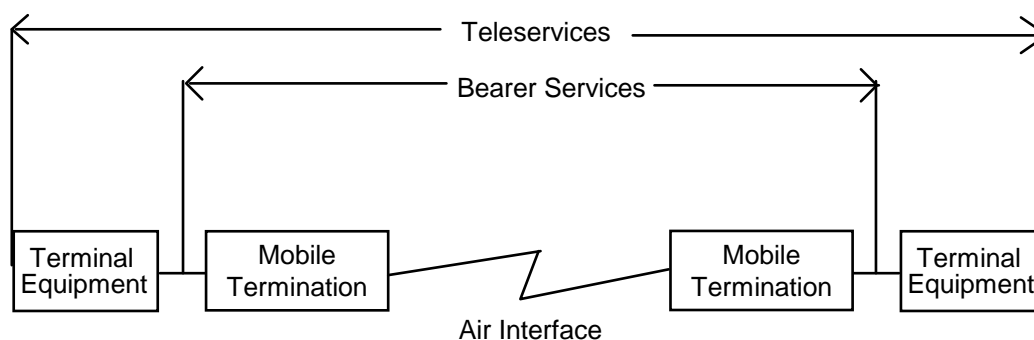


Figure A.1: Concept of bearer services and teleservices

A.2.1 Reference models

In this clause a number of reference models are identified which apply to TETRA DMO. The purpose behind these models is to assist in providing a definition of the interfaces which exist between various device types and, if relevant, to any other involved terminal or network entities.

The reference models cover all distinct operating possibilities and provide a framework for describing the technical requirements for the various interfaces.

The abbreviation DM-MS is used throughout the present document as a generalized term to include all MSs capable of working in DMO. The full capability of any particular DM-MS is not a standardized parameter but is an issue for implementation.

Some basic assumptions on the likely types of mobile are however useful in order to define specific operational issues and where this is appropriate in the present document, the following terminology is used:

- DM-MS: generalized term for any DMO capable MS;
- DO-MS: Direct mode Only MS;
- DU-MS: Dual mode switchable MS;
- DW-MS: Dual Watch MS;
- DM-REP: Direct Mode REPeater;

- DM-GATE: Direct Mode GATEway;
- DM-REP/GATE: Direct Mode REPeater/GATEway.

Implementations which combine dual functionality in a single unit, e.g. a DM-REP and MS equipment are not considered to be distinct and separate stations, but for the purposes of the present document are considered to be combinations of those listed above.

The general term DM-MS is used as applying to all DM-MSs, but the other terms listed above may be applied where specific differentiation is necessary.

A.2.1.1 Direct mode mobile station (DM-MS)

The basic reference model for DMO applies to a simple point-to-point or point-to-multipoint communication between DM-MSs using the DM air interface, U_{d1} . Figure A.2 shows the most basic configuration and is the most simple with which to define the range of services which are to be supported by DMO.

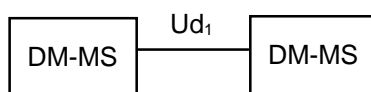


Figure A.2: DM-MS connected to DM-MS via DM air interface, U_{d1}

The basic U_{d1} air interface protocol is further described in subsequent parts of the present document. The full definition of the air interface protocol is in EN 300 396-3 [3]. In the definition of the air interface, differentiation is made between the current transmitting and the current receiving MSs at any point in a call.

The transmitting DM-MS providing the synchronization reference is defined as the "master" DM-MS. Any DM-MS which receives the traffic or signalling from a "master" DM-MS is defined as a "slave" DM-MS.

At the beginning of a call, during a call transaction or during channel reservation, the master DM-MS transmits synchronization bursts to enable any receiving DM-MS on the same channel to synchronize itself in terms of frequency and time, or to maintain synchronization.

The same U_{d1} air interface applies to a DO-MS, a DU-MS when set for DMO and the DM aspects of a DW-MS (either in active or monitoring mode). The U_{d1} air interface also applies to links between DM-MSs and DM-REPs, or to links between DM-MSs and DM-GATEs and DM-REP/GATEs, though in these latter cases there are slight differences within the protocol operating over the air interface in order to cater for additional functionality. The differences between the air interface protocols for each different type of direct mode operation is signified by the different subscripts following U_{d1} .

Air interface links to the TETRA TMO system from DW-MSs or from DM-GATEs are supported over the trunked mode air interface, U_m , as detailed in EN 300 392-1 [i.2].

A.2.1.2 Dual watch mobile station (DW-MS)

The dual watch capability of a DM-MS allows it to monitor activity on the trunked mode air interface and detect calls addressed to it. The inverse functionality can be supported in trunked mode terminals allowing them to monitor activity on the direct mode channel and detect DMO calls intended for them whilst they are operational in trunked mode. The individual model shown in figure A.3 applies to a DM-MS which is capable of dual watch. The full definition of the air interface protocol is detailed in EN 300 396-3 [3].

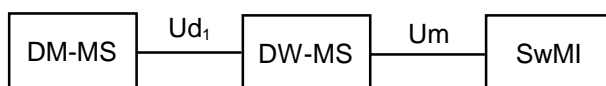


Figure A.3: Dual Watch reference model

There are two types of dual watch, full dual watch and idle dual watch.

In full dual watch the DW-MS can be in one of three states as follows:

- a) idle in both modes and periodically monitoring both the TMO control channel and a selected DM RF carrier; or
- b) communicating with another DM-MS via the Ud air interface and periodically monitoring the TMO control channel over the Um air interface without interrupting direct mode operation; or
- c) communicating with the TETRA Switching and Management Infrastructure (SwMI) in TMO via the Um air interface and periodically monitoring a selected DM RF carrier without interrupting trunked mode operation.

In idle dual watch the DW-MS can be in any one of three states as follows:

- a) idle in both modes and periodically monitoring both the TMO control channel and a selected DM RF carrier; or
- b) communicating with another DM-MS via the Ud air interface and not able to monitor the TMO control channel over the Um air interface; or
- c) communicating with the TETRA Switching and Management Infrastructure (SwMI) in TMO via the Um air interface and not able to monitor a selected DM RF carrier.

It is important to stress that simultaneous active communication over the two air interfaces is not supported by the DMO standard.

In order to operate with TMO a DW-MS first registers with the SwMI in the same manner as a normal TMO MS.

For Dual mode Mobile Stations (DU-MS), a similar reference model applies. The DU-MS is firmly in one mode or the other (TMO or DMO). There is no capability to monitor the inactive mode (as there would be for a DW-MS). With DU-MSs, either the TMO or the DMO reference model applies at any one time.

A.2.1.3 Direct mode repeater (DM-REP)

This reference model applies to operation using a direct mode individual (DM-REP) between the end MSs.

Figure A.4 shows the simplest form of link between DM-MS's using the Ud air interface via a DM-REP.

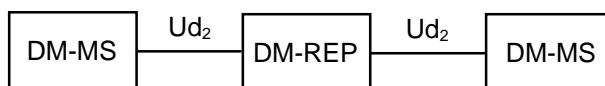


Figure A.4: DM-REP reference model

The DM-REP receives information from a transmitting mobile on an "uplink timeslot" and re-transmits this information to another mobile or group of mobiles on a "downlink timeslot". The DM-REP specified within the DMO standard is regenerative, i.e. it decodes and re-encodes received speech and signalling bursts which it receives (one slots-worth at a time), to improve the overall link performance.

The standard defines three different types of repeater:

- Type 1A: single call single frequency repeater.
- Type 1B: single call two frequency repeater.
- Type 2: two call two frequency repeater.

The full definition of the air interface protocol for Type 1A and Type 1B repeaters is in EN 300 396-4 [4]. The definition of the air interface protocol for Type 2 repeaters is in EN 300 396-7 [i.9] (see note).

NOTE: The Type 2 repeater standard EN 300 396-7 [i.9] has not been updated in line with the other parts of the DMO standard and is now considered historical.

A DM-MS transmitting to a repeater includes an appropriate repeater address to ensure that it keys up the correct repeater.

A.2.1.4 Direct mode gateway (DM-GATE)

This reference model applies to operation when using a DM-GATE into a TETRA TMO. In the present document, DM-GATE concerns only the link between TETRA DMO and TETRA TMO.

Figure A.5 shows the simplest form of link between a DM-MS and the TETRA TMO SwMI (and hence onward, e.g. to a TMO MS or Line connected Station (LS)) using the Ud air interface via a DM-GATE.

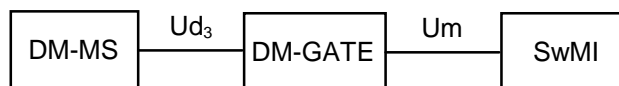


Figure A.5: Gateway into a TETRA SwMI

The DM-GATE caters for the differences in protocol between the Ud₃ and Um air interfaces and provides for the required inter-connectivity between DM and the TETRA TMO network.

In order to operate with TMO a gateway first registers itself with the SwMI in the same manner as a normal TMO MS.

All of the teleservices and bearer services available in DM are supported by operation through a gateway into the TMO.

The limitations are as follows:

- a DM-MS may obtain access to the services offered by TMO via a DM-GATE. The DM-MS is however limited to those TMO services it may use by the capability of the DM air interface;
- a DM-MS accessing TMO via a gateway is therefore only capable of utilizing those TMO services which are supported by the Ud₃ interface;
- a DM-MS transmitting to a gateway includes an appropriate gateway address to ensure that it keys up the correct gateway.

A.2.1.5 Direct mode repeater/gateway combination (DM-REP/GATE)

This is a special case of combined repeater/gateway functionality, e.g. perhaps in a single equipment where a vehicle based repeater serving a DM network is also required to have a link back to the TETRA TMO network over the Um air interface. Figure A.6 shows a DM-GATE combined with a Type 1 DM-REP.

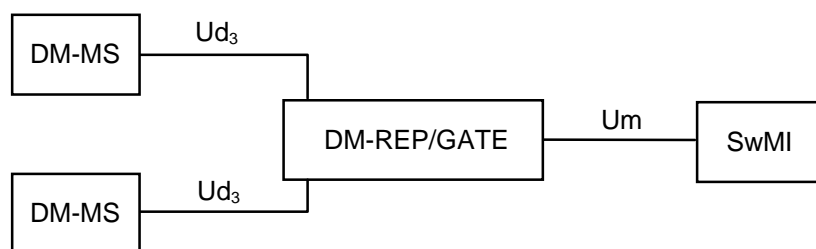


Figure A.6: Repeater/gateway into a TETRA SwMI

The Ud and Um air interfaces for the above reference model are no different from those in the previous examples. The TMO air interface is used for the link between the gateway and the TETRA SwMI and the DMO air interface is used for the links from the DM-MSs to the gateway (repeater included).

A.3 TETRA DM access

A.3.1 DM-MS access

A DM-MS includes a Mobile Termination (MT) and may include a Terminal Equipment (TE).

The DM-MS access to services supported by a TETRA network (DM, TM) is shown in figure A.7.

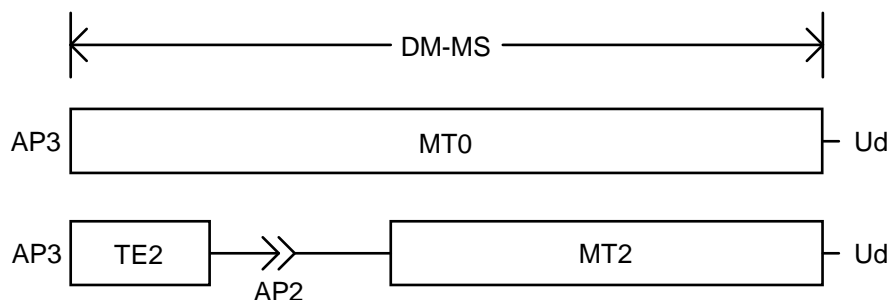


Figure A.7: MS access points

A.3.2 MS functional groups

The mobile termination functional group, MT, may support the following general functions:

- air interface termination (Ud / Um);
- radio channel management;
- speech and data encoding/decoding;
- error protection/correction for all information (speech, signalling, user data) sent across the radio path;
- mapping of signalling and user data;
- rate adaption between user data and radio channel rate;
- support of TE.

There are two types of MT defined:

- MT0 includes functions belonging to the functional group MT, with support of non-standard terminal interfaces that provide TE functionality;
- MT2 includes functions belonging to the functional group MT, with a terminal interface that complies with a TETRA recommended interface.

The TE functional group supports the Man Machine Interface (MMI) to the user (access point AP3) and supports a TETRA terminal interface to MT2 functional group (access point AP2).

There is one type of TE defined:

- TE2 represents an asynchronous (start/stop) serial TETRA specific interface as defined in EN 300 392-5 [i.7].

A.3.3 Reference points

To further clarify the locations of reference points and the MS functional groups, figure A.8 shows the generic protocol stack as applicable to a TETRA DM-MS of functional group MT0 (combined MT and TE) in communication over the Ud air interface.

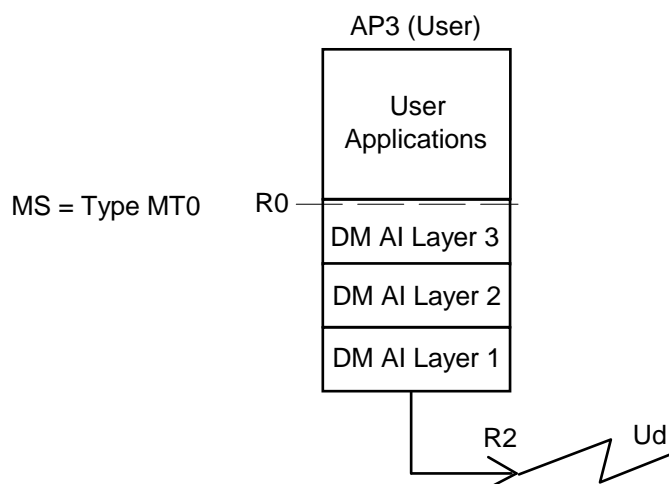


Figure A.8: MT0 protocol stack for DM air interface

This generic stack may apply for example with a DM-MS operating a TETRA teleservice which the MT0 supports right up to the user interface at AP3.

Figure A.9 shows another generic protocol stack as applicable to a TETRA DM-MS of functional group MT2 (separate MT and TE) in communication over the Ud air interface.

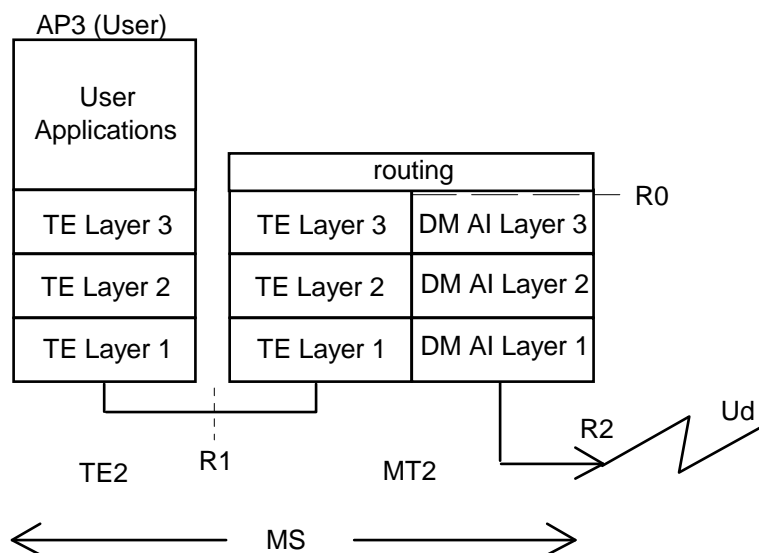


Figure A.9: MT2 protocol stack for DM air interface

Annex B (informative): Protocol architecture for DMO

B.1 Introduction

The purpose of this protocol architecture is to be a model where the different functions and processes are identified in the different layers in the DM protocol stacks.

NOTE: The protocol stacks are used to define the functionality of the TETRA protocols for interfaces. The protocol stacks in other parts of the standard are normative when used to describe functionality of the interfaces, but these stacks and sub-division of protocol layers does not imply or restrict any implementation.

B.2 DM-MS protocol architecture

B.2.1 Overview

The TETRA DM protocol architecture follows the generic OSI layering structure.

The DM MS-MS protocol stack for MS-MS operation and operation with a repeater is shown in figure B.1.

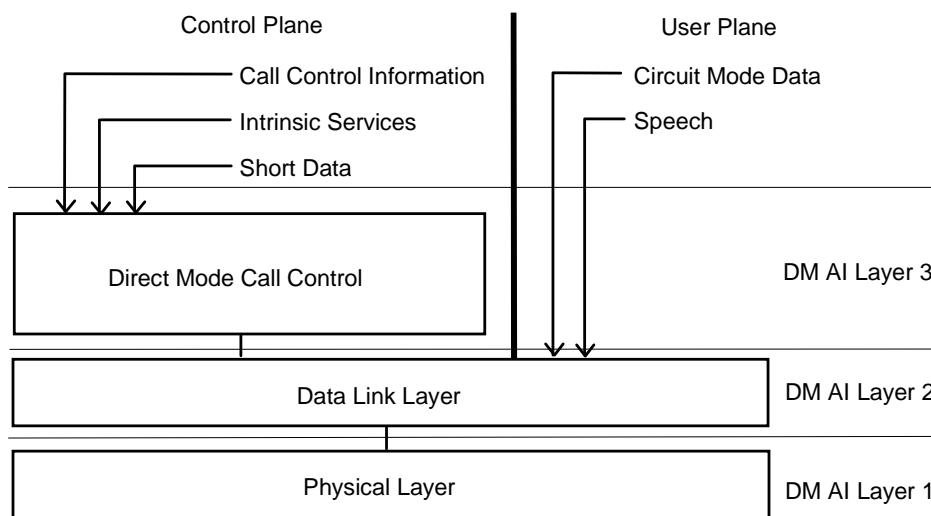


Figure B.1: DM-MS Protocol stack for basic operation and operation with a repeater

The base of the protocol stack rests on layer 1. The Physical Layer (PL).

Layer 2, the Data Link Layer (DLL), handles the problem of sharing the medium by a number of users. At the DLL, the protocol stack is divided vertically into two parts:

- the User plane (U-plane) for transporting voice or circuit mode data information without addressing capability, and
- the Control plane (C-plane) for signalling with addressing capability.

Layer 3, the Direct Mode Call Control (DMCC), lies in the C-plane and is responsible for control of the call, provides the intrinsic services supported in DM and supports the carriage of short data messages. U-plane access at layer 2 (the DLL) supports the speech teleservice and the circuit mode data bearer services which are available in TETRA DMO.

The protocol stack for operation with a DM-GATE is shown in figure B.2. It is the same as for MS-MS and repeater operation with the addition of a Direct Mode Mobility Management (DMMM) entity to support the additional optional procedure of registration.

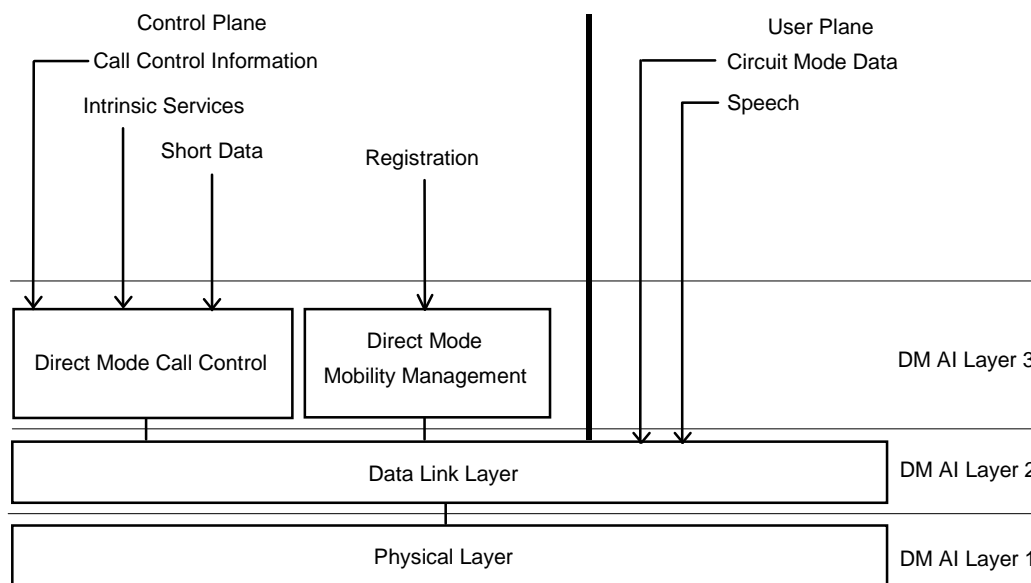


Figure B.2: DM-MS Protocol stack for operation with a gateway

B.2.2 Air interface layer 1

The air interface layer 1 is the physical interface. It deals with the physical burst, composed of bits and symbols (= association of 2 bits), which is to be sent and/or received.

The air interface layer 1 contains the following functions:

Radio oriented:

- modulation/demodulation as defined in EN 300 396-2 [2];
- transmitter/receiver switching as defined in EN 300 396 2 [2];
- RF characteristics as defined in EN 300 396-2 [2]:
 - frequency (or channel) setting;
 - Radio-Signal-Strength-Indicator (RSSI);
- fine adjustments of radio parameters:
 - frequency correction: synchronization may be achieved using a specific frequency correction sequence located inside the DM Synchronization Burst (DSB) as defined in EN 300 396-2 [2];
 - optional power control (for a DM-MS working with a repeater or a repeater/gateway).

Bits and symbol oriented:

- symbol synchronization: a specific training sequence, located inside the burst, precisely determines the occurrence of the symbols. The PL is then able to determine the burst boundaries (i.e. the beginning and the end).

Burst building:

- receiving/submitting data from and to the DLL: because the PL is able to determine the starting and ending points of the burst, at the emission, it maps the data link block onto the physical burst and adds its specific information (layer 1 only) at the correct place. At the reception, it extracts its specific information (layer 1 only) from the burst and rebuilds data link block(s), see EN 300 396-2 [2]. The data link block(s) are then passed to the DLL;
- slot flag coding/de-coding using two distinct training sequences, see EN 300 396-2 [2].

B.2.3 Air interface layer 2

The air interface layer 2 handles logical connections and hides the physical medium from the upper layers. An overview can be found in EN 300 396-3 [3], clause 7.

The main functions are as follows:

Channel coding and scrambling:

- scrambling/de-scrambling: Scrambling is done according to the colour code. So, the frame will be decoded correctly only by the receiving station having that colour code (de-scrambling). Refer to EN 300 396-2 [2], clause 8;
- interleaving, de-interleaving and re-ordering the protected bits over one block or two blocks to allow spreading the errors instead of having them grouped, see EN 300 396-2 [2], clause 8;
- in order to protect bits transmitted on the radio path, Forward Error Correction (FEC) using convolutional coding adds some redundancy (e.g. 2/3 coding, which encodes 2 bits of information into 3 transmitted bits) so that errors may be corrected afterwards;
- a Cyclic Redundancy Check (CRC) is performed on the incoming block of information so that errors may be detected up to a certain amount, depending on the size of the CRC. 16 bits CRC will ensure a protection against undetected errors. The receiving MS calculates the CRC on the received bit stream using the same algorithm and compares the result to the received CRC. The actions taken in case of error are described in EN 300 396-2 [2], clause 8.

Radio channel access control:

- frame synchronization: keeps track of the frame and slot number;
- DM channel access control: detecting DM channel states which are: free, reserved or occupied. Initiating signalling on DM channel taking account these DM channel states;
- random access control: during channel occupation and channel reservation, a simple random access protocol is employed to control colliding signalling by slave DM-MSs;
- fragmentation/re-association (optional): this splits the content of one single SDU into several PDUs. On the other side, parts are re-associated together in order to re-constitute the original SDU;
- multiplexing/de-multiplexing of the logical channels: creates all layer 2 parts of the burst, see EN 300 396-2 [2], clause 9.
- multiframe building and synchronization: the frames are assembled to form a multiframe of 18 frames which are cyclically numbered from 1 to 18, see EN 300 396-2 [2], clause 9. A synchronization block contains information about time slot, frame number and colour code information, see EN 300 396-2 [2], clause 9.

Radio resource management: this part will be unique to one MS. It enables powerful control of the radio resources to be available at any time without explicit involvement of layer 3:

- address management for individual and group calls;
- power control management (where option is supported): execution is in PL;
- radio link establishment;

- buffering of control information and traffic frames until transmitted;
- circuit mode applications: interface with DLL as represented in figure B.1 (U-plane);
- exchanging control and/or user data with the layer 3 entity.

Encryption:

- TETRA DMO provides, as an option, call confidentiality against eavesdropping by means of air interface encryption with the use of a transmitted Time Variant Parameter (TVP) to initialize and synchronize the encryption units. TVP may contain a time of day element to prevent replay. DM encryption uses Static Cipher Keys (SCKs). DM encryption is defined in EN 300 396-6 [6].

B.2.4 Air interface layer 3

B.2.4.1 Direct Mode Call Control (DMCC) entity

The DMCC sub-layer is applicable only to the C-plane, and is a platform for the services provided on top of the layer 2 functionality.

The DMCC may provide the following functions:

- establishing, maintaining and clearing basic service calls;
- addressing (destination, repeater and gateway as appropriate);
- support of intrinsic services;
- Short Data Service (SDS).

B.2.4.1.1 Intrinsic services control

Intrinsic services control handles the processes associated with the following services:

- recent user priority;
- transmitting party number identification;
- transmitting party identification restriction;
- pre-emption;
- late entry.

B.2.4.1.2 Short Data Service (SDS)

SDS offers connectionless data messages with the following capabilities:

- source and destination address associated with the short data;
- unacknowledged or acknowledged service point-to-point;
- unacknowledged service point-to-multipoint.

B.2.4.1.3 SDS-TL service

SDS Transport Layer (SDS-TL) is an additional protocol layer for the short data service - type 4. It enhances the service provided by the layer 3 short data service by providing protocol mechanisms for end-to-end acknowledgement, store and forward and to ensure that applications using this service interpret the user data in the same way.

B.2.4.2 DMMM entity (optional)

This entity is applicable only to the C-plane, and is a platform for the management of DM-MS mobility.

B.2.5 Security management

B.2.5.1 Identity management (authentication)

In the normal (peer-to-peer) DMO case there is no explicit authentication of Individual TETRA Subscriber Identity (TTSI). Implicit authentication is assumed for successful encrypted calls using a common SCK.

B.2.5.2 Key management

Cipher keys for use in encrypted DMO calls, when supported, may be maintained as described in EN 300 396-6 [6], clause 6.

Annex C (informative): DM circuit mode teleservices and bearer services

C.1 Service definitions

In TETRA DMO three distinct classes of service are provided, teleservices and bearer services and intrinsic services.

The following clauses explain the differences between these services.

C.1.1 Bearer service

A bearer service is defined as a type of service that provides the capability for information transfer between user-network interfaces and only involves lower layer functions (layers 1-3). The user application may use any set of higher layer protocols for communication, but the bearer service may not ascertain compatibility between applications at these layers.

Bearer services are provided in DMO as a means to transfer data between DM-MSs via the DM air interface. This data may be speech or any other form of data. What the DMO bearer service offers is similar to a data "pipe", and the transmission effected through that pipe is independent of its content.

C.1.2 Teleservice

A teleservice is defined as a type of service that provides the complete capability, including Terminal Equipment (TE) functions, for communication between users according to TETRA protocols. In other words a teleservice provides the user with the possibility of gaining access to various forms of applications via the TE, and it is carried through the network by the bearer service.

Figure C.1 illustrates in a simple sense the basic differences between these two services in terms of user access point within the MS.

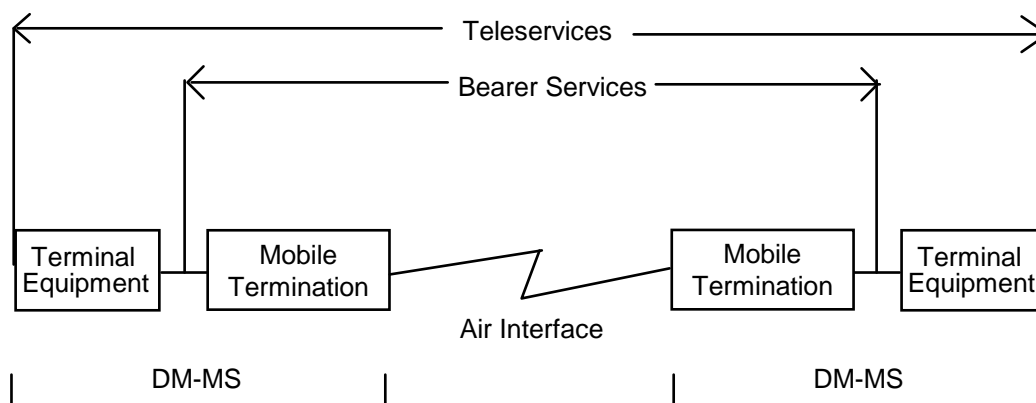


Figure C.1: DMO bearer services and teleservices

C.1.3 Intrinsic service

An intrinsic service is a service which is inherently available within a normal teleservice or bearer service. An intrinsic service exists by virtue of it being included as an integral part of the signalling associated with the basic services. In this respect it is somewhat different from the Supplementary Services (SS) which may be supported in TMO as it requires no explicit invocation. Options may however exist within an intrinsic service which require application level intervention.

C.2 Services offered in TETRA DMO

Table C.1 provides a summary of the tele- and bearer services supported within TETRA DMO.

Table C.1: Voice and data services supported in DMO

	Teleservice	Bearer service
TETRA speech	Individual Call (pt-to-pt) Group Call (pt-to-multipoint)	N/A
Circuit mode unprotected data	N/A	7,2 kbit/s (point-to-point) or (point-to-multipoint)
Circuit mode low protected data (one of three different interleaving schemes can be demanded)	N/A	4,8 kbit/s (point-to-point) 4,8 kbit/s (point-to-multipoint)
Circuit mode high protected data (one of three different interleaving schemes can be demanded)	N/A	2,4 kbit/s (point-to-point) 2,4 kbit/s (point-to-multipoint)
Short data service - type 1		16 bits user defined data
Short data service - type 2		32 bits user defined data
Short data service - type 3		64 bits user defined data
Short data service - type 4		Protocol identifier plus up to 2 039 bits user defined data
Status messages		16 bits
SDS-TL		Transport Layer for short data service - type 4
SDS based teleservices such as text messaging and Location Information Protocol	Yes	N/A

Speech, SDS-TL and circuit mode data services may, as an option, have end-to-end encryption and/or air interface encryption. Other Short data messages and status messages may have air interface encryption.

C.2.1 Direct Mode teleservices

TETRA DM voice teleservices support the transmission of speech utilizing a TETRA specific voice codec as defined in EN 300 395-2 [7]. They use standard TETRA speech and channel coding as defined in EN 300 396-2 [2]. Optional encryption is specified in EN 300 396-6 [6].

TETRA DM voice teleservices support speech on a point-to-point (individual call), and point-to-multipoint (group call) circuit mode basis. The voice mode of operation is always simplex.

C.2.1.1 Individual call

An individual call is a point-to-point communication between one calling party and one called party. It may only be set up between two MSs which have selected the same DM RF carrier. An individual MS has a pre-defined number (ITSI) by which it is addressed. The normal mode of operation is simplex.

Individual calls may be set up with or without a presence check. The presence check is a method by which the call initiator can find out whether the called party terminal is switched to the RF carrier and responds to an interrogating message in advance of the call being set up.

Unlike TMO, in DMO there is no facility for ON/OFF hook signalling. With DMO response to all calls comes from the radio terminal (i.e. there is no facility to wait for the user to go off hook).

C.2.1.2 Group call

A group call is a two way point-to-multipoint communication between a calling party and one or more called parties. It may only be set up between MSs which have selected the same DM RF carrier.

The members of a group have one common pre-defined number which is called their group number (GTSI) and by which they are addressed. The Ud air interface uses the same addressing scheme for group numbers as defined in EN 300 392-1 [i.2].

The air interface supports more than one group on a DM RF carrier although, for the normal mode of operation, only one group is able to communicate using the DM RF carrier at any given time and for the frequency efficient mode of operation, two groups are able to communicate using the DM RF carrier at any given time (see note).

NOTE: In normal mode of operation there is one DM channel per RF carrier, whilst in frequency efficient mode there are two.

In addition, there is an "open" or "common" group number which includes all of the users to allow calls to be made to all users who have selected the same DM RF carrier, providing for open channel operation, see clause 6.3.2.

Only one number (group number - GTSI) is sent on the air interface and no acknowledgement is expected. The primary objective is to have a fast call set up. The mode of operation is simplex.

C.2.1.3 SDS based teleservices

A number of SDS based teleservices are defined such as simple text messaging, text messaging using SDS-TL, Simple GPS, GPS using SDS-TL, Wireless Application Protocol (WAP) and TETRA Location Information Protocol (LIP), see TS 100 392-18-1 [i.8]. These use the SDS Transport Layer bearer service, see clause C.2.2.4, and hence could be supported in DMO or via a DMO gateway.

C.2.2 Direct Mode bearer services

A circuit mode bearer connection is a point-to-point or point-to-multipoint data communication between one calling MS and one or more called MSs. It may only be set up between MSs which have selected the same DM RF carrier. The mode of operation is simplex.

Three types of circuit mode bearer service are offered within TETRA DMO depending on whether or not the data is protected or unprotected, and depending on the level of protection provided. The difference between the protected and unprotected bearer services is that the protected bearer service provides error protection as defined in EN 300 396-2 [2], clause 8 for the user data being transmitted. The result as far as the user is concerned is a more reliable and robust channel at the expense of a reduction in the net user data rate.

C.2.2.1 Circuit mode unprotected bearer services

Circuit mode unprotected bearer services support circuit mode data on a point-to-point (individual call), and point-to-multipoint (group call) basis. Data throughput at the user interface is 7,2 kbit/s.

C.2.2.2 Circuit mode protected bearer services

Circuit mode protected bearer services support data on a point-to-point and point-to-multipoint basis. Six protected bearer services are defined in TETRA DMO offering two different levels of protection against bit error by using forward error protection in the transmitted bit stream. Error protection is as defined in EN 300 396-2 [2], clause 8 and the six services offer data throughput at the user interface at 4,8 kbit/s or 2,4 kbit/s with error protection rates of approximately 2/3 or 1/3 respectively. In order to provide further protection against errors, interleaving at depths 1, 4 or 8 may be applied along with the two levels of error protection, resulting in the six service options.

C.2.2.3 Short Data Service (SDS)

The TETRA DM SDS is similar to the SDS offered within the TETRA TMO. Both point-to-point and point-to-multipoint services are supported in DM SDS. Point-to-point SDS offers optional acknowledgement whereas the point-to-multipoint service is unacknowledged.

The SDS is essentially a message service which can be optimized for speed, enabling the user to exchange a short user defined message or a short pre-defined message such as an emergency message. In some cases messages may be sent or received during an ongoing speech or data call. The SDS may be used for applications such as automatic vehicle location or status messages.

The SDS in DM supports up to the same number of data bits as the SDS in TMO (2 047 bits maximum) with the content being user defined or pre-defined.

DMO SDS may be carried on an individual call or group call basis across the DMO air interface. It may also be carried via a DM-REP and may be directed into or received from the TMO system via a DM-GATE or a DM-REP/GATE.

A point-to-point short data message is sent from one originating MS to one receiving MS using the currently selected DM RF carrier. The receiving MS is addressed by its ITSI in the usual manner, see clause 6. The receiving MS acknowledges receipt of the message if acknowledgement has been requested and the originating MS may retry a number of times if acknowledgement is expected and if no acknowledgement is received.

A point-to-multipoint short data message is sent from one originating MS to a group of one or more receiving MSs using the currently selected DM RF carrier. The group is addressed by its GTSI in the normal manner, see clause 6. There is no acknowledgement from the receiving MSs in this case, but the originating MS may retransmit the message a number of times for reliability.

The following SDS/status message functional capabilities may be supported in DMO terminals:

- a) send/receive short data messages of defined length;

SDS type	Size of user defined message (bits)
1	16
2	32
3	64
4	Up to 2 039

- b) send/receive pre-defined status messages;

Status number	Definition
0	Emergency
1 to 31 743	Reserved
31 744 to 32 767	Reserved for SDS-TL Short Report [1]
32 768 to 65 535	Available for user/network definition

- c) address a single party by using the ITSI address of the target message receiver;
- d) receive the ITSI address of the message sender and to relay it to the user application;
- e) address multi-parties by using the GTSI of the target message receivers;
- f) apply priority to the message;
- g) receive the priority applied to the message and to relay it to the user application.

C.2.2.4 SDS-TL service

The SDS-TL protocol provides the following services:

- point-to-point message transfer;
- point-to-multipoint message transfer;
- broadcast message transfer;
- end-to-end acknowledgement of message receipt and consumption by application;
- support for multiple application protocols;

- support for store and forwards.

The short data service - type 4 protocol identifier indicates whether Transport Layer services are being used or not and the particular application protocol.

The SDS-TL supports the following types of application which use the SDS bearer service:

- standard applications which use Transport Layer services;
- non-standard applications which use Transport Layer services;
- standard applications which do not use Transport Layer services;
- non-standard applications which do not use Transport Layer services.

C.2.3 Intrinsic services

The following clauses describe the intrinsic services which are supported by DMO. Intrinsic services are offered in association with all of the voice and data services described in the previous clauses and forms an integral part of the signalling on the Ud interface.

C.2.3.1 DM late entry

This intrinsic service allows a MS, when it accesses an active DM RF carrier, to enter an ongoing call if that call is addressed either individually or to a group of which it is a member. A MS may access a DM RF carrier in a number of ways, for example:

- a) the user switches on the MS and selects that RF carrier;
- b) the user switches from another DM RF carrier to that RF carrier;
- c) the MS returns to DM coverage after a period of lost coverage;
- d) the user switches the MS from TMO to DM and selects that RF carrier (applies to DW-MS and DU-MS).

C.2.3.2 Transmitting Party Number Identification (TPNI)

This intrinsic service provides the ability for the MSs receiving a call to receive the number of the currently transmitting MS. This requires that the transmitting MS transmits an individual subscriber number at each call transaction. This allows the receiving MS(s) to display the identity of the transmitting MS.

A user option allows details of the originating ITSI to be concealed. This option allows a transmitting MS to withhold its identity (by substituting a pseudo SSI), a feature which may be required for certain authorized users.

NOTE: The pseudo SSI is an identity chosen at random by the MS and declared as such when it is used.

C.2.3.3 Emergency calls

The DM air interface supports emergency calling. A DM-MS initiating an emergency call may use a DM channel and, if necessary, over-ride any call on that channel. The only exception is if the existing call is also an emergency priority call.

Similarly the DM air interface supports pre-emptive priority calling. A DM-MS initiating a pre-emptive priority call may use a DM channel and, if necessary, over-ride any call on that channel apart from pre-emptive priority and emergency priority calls.

These intrinsic services provide the ability for the DM communication to be pre-empted in order to support the higher priority calling service.

Annex D (normative): TETRA type approval code information element

This annex defines TETRA Type Approval Code (TAC) information element application.

D.1 Encoding of the TAC information element

Clause 6.5.1 defines in figure 6.4 contents of TEI. The TAC comprises the first 24 bits of that field. The TAC is a binary encoded number.

When the TAC is presented for human reader e.g. printed on the equipment the value shall be presented using hexadecimal digits indicating the same value as the binary value. Leading zero bits shall be present in the TAC so that the total length is always 6 digits.

D.2 Application for the TAC value

Type Approval Code (TAC) shall be allocated by ETSI. ETSI shall assign individual TACs and keep register of the assigned codes. Allocation of individual TACs will remain private within ETSI.

PROVISION OF AND RESTRICTED USAGE UNDERTAKING

relating to

a **Type Approval Code, TAC**, to be used in mobile and line stations and in TETRA SwMIs for Terrestrial Trunked Radio (TETRA) systems.

Between

(COMPANY NAME).....

(COMPANY ADDRESS).....

hereinafter called: the BENEFICIARY;

and

(COMPANY NAME).....European Telecommunications Standards Institute

(COMPANY ADDRESS).....06921 Sophia Antipolis CEDEX, France

hereinafter called: the PROVIDER.

Whereas

The BENEFICIARY has alleged that he fulfils the following criteria:

- He is a manufacturer of TETRA equipment.

The PROVIDER undertakes to give to the BENEFICIARY:

- One globally unique TAC, registered by the PROVIDER.

The provided TAC is filled in below by the PROVIDER when he has received and approved two signed originals of this agreement.

TAC:	<table border="1" style="width: 100%; height: 20px; border-collapse: collapse;"> <tr> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> </tr> </table>							=	<table border="1" style="width: 100%; height: 20px; border-collapse: collapse;"> <tr> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> <td style="width: 16.6%;"></td> </tr> </table>						
	Hexadecimal number		Binary number												

The code above is given as a six hexadecimal (0 to F) number, and as a 24 bit binary number. The most significant digit and bit are positioned to the left.

On presentation of the code to the equipment user it shall be presented in hexadecimal digit format.

Example:

The hexadecimal number "9 F 7 1 0 A" equals the binary number "1001 1111 0111 0001 0000 1010".

The BENEFICIARY undertakes:

- 1. To apply and use the TAC in accordance with rules in ETSI EN 300 392-1, clause 7.5.
- 2. To return the TAC to the PROVIDER, within 5 years, if these has not been used.

Reference: ETSI EN 300 392-1: "Terrestrial Trunked Radio (TETRA), Voice plus Data (V+D), Part 1 General network design".

In case the BENEFICIARY violates any of the obligations incurred on him by the present undertaking, he shall be liable of indemnifying ETSI for all losses suffered directly or through claims from legitimate TETRA users.

All disputes which derive from the present undertaking or its interpretation shall be settled by the Court of Arbitration of the International Chamber of Commerce situated in Paris, in accordance with the procedures of this Court of Arbitration and with the application of French Law regarding questions of interpretation.

Made in two originals, one of which is for the PROVIDER, the other for the BENEFICIARY; both originals signed by a legal representative of his company/organization.

For the PROVIDER

For the BENEFICIARY

(signed).....

(Name, Title (typed))

.....

Director General

(signed).....

(Name, Title (typed))

.....

(Date)

(Date)

Annex E (normative): TETRA final assembly code information element

This annex defines TETRA Final Assembly Code (FAC) information element application.

E.1 Encoding of the FAC information element

Clause 6.5.1 defines in figure 6.4 contents of TEI. The FAC comprises the 8 bits of that field after the 24 bits long TAC code. The FAC is a binary encoded number and its value is presented in the applications for human beings as a hexadecimal number.

When the FAC is presented for human reader e.g. printed on the equipment the value shall be presented using hexadecimal digits indicating the same value as the binary value. Leading zero bits shall be present so that the total length of FAC information element shall be two digits.

E.2 Application for the FAC value

Final Assembly Code (FAC) shall identify the manufacturer and may identify the place of final assembly. These shall be allocated by ETSI. ETSI shall assign individual FACs and keep register of the assigned codes. ETSI maintains a public Web page of allocation of FACs.

E.3 WEB page contents for FAC data base

The WEB page should contain information as presented in table E.1. For clarity the FAC number may be presented in hexadecimal and binary codes.

Table E.1: WEB page information contents

Date of issue	Hexadecimal code	Binary code		Allocated to Manufacturer, Name and Place of Final Assembly
	00	0000	0000	(Not to be allocated to any manufacturer)
	01	0000	0001	

PROVISION OF AND RESTRICTED USAGE UNDERTAKING

relating to

a **Final Assembly Code, FAC**, to be used in mobile and line stations and in TETRA SwMIs for Terrestrial Trunked Radio (TETRA) systems.

Between

(COMPANY NAME).....

(COMPANY ADDRESS).....

hereinafter called: the BENEFICIARY;

and

(COMPANY NAME).....European Telecommunications Standards Institute

(COMPANY ADDRESS).....06921 Sophia Antipolis CEDEX, France

hereinafter called: the PROVIDER.

Whereas

The BENEFICIARY has alleged that he fulfils the following criteria:

- He is a manufacturer of TETRA equipment.

The PROVIDER undertakes to give to the BENEFICIARY:

- One globally unique FAC, registered by the PROVIDER.

The provided FAC is filled in below by the PROVIDER when he has received and approved two signed originals of this agreement.

FAC:

--	--

 =

--	--

Hexadecimal number

Binary number

The code above is given as a two digit hexadecimal (0 to F) number, and as an 8 bit binary number. The most significant digit and bit are positioned to the left.

On presentation of the code to the equipment user it shall be presented in hexadecimal digit format.

Example:

The hexadecimal number "9 F" equals the binary number "1001 1111".

The BENEFICIARY undertakes:

- 1. To apply and use the FAC in accordance with rules in ETSI EN 300 392-1, clause 7.5.
- 2. To return the FAC to the PROVIDER, within 5 years, if these has not been used.

Reference: ETSI EN 300 392-1: "Terrestrial Trunked Radio (TETRA), Voice plus Data, Part 1 General network design".

In case the BENEFICIARY violates any of the obligations incurred on him by the present undertaking, he shall be liable of indemnifying ETSI for all losses suffered directly or through claims from legitimate TETRA users.

All disputes which derive from the present undertaking or its interpretation shall be settled by the Court of Arbitration of the International Chamber of Commerce situated in Paris, in accordance with the procedures of this Court of Arbitration and with the application of French Law regarding questions of interpretation.

Made in two originals, one of which is for the PROVIDER, the other for the BENEFICIARY; both originals signed by a legal representative of his company/organization.

For the PROVIDER

For the BENEFICIARY

(signed).....

(Name, Title (typed))

.....

(signed).....

Director General

(Name, Title (typed))

.....

(Date)

(Date)

Annex F (normative): TETRA electronic serial number information element

This annex defines TETRA Electronic Serial Number (ESN) information element usage.

F.1 Encoding of the ESN information element

Clause 6.5.1 defines in figure 6.4 contents of TEI. The ESN comprises the 6 digits of that field after the 24 bits long TAC code and 8 bits long FAC code. The ESN shall be a hexadecimal number.

NOTE: The BCD coding uses 4 bits for each digit and only values "0" to "9" were utilized in the previous document. The present document uses all possible 16 values "0" to "F" in each 4 bits.

When the ESN is presented for human reader e.g. printed on the equipment the value shall be presented using hexadecimal digits. Leading zero bits shall be present so that the total length of the ESN is 6 digits.

F.2 Usage of the ESN

Electronic Serial Number (ESN) shall be an individual serial number that uniquely identifies each equipment within each TAC+FAC. ESN should be allocated by manufacturers in sequential order.

NOTE: As the previous and the current presentation of this field are different manufacturer may choose to apply binary encoded decimal presentation up to 999 999 and start to use hexadecimal encoding from A00 000 so that the hexadecimal presentation always contains at least one digit from values "A" to "F".

F.3 Usage of check sum of the equipment identity

A check sum may be applied to the TEI. The algorithm of the check sum calculation and the check sum presentation are outside the scope of the present document.

Annex G (informative): Bibliography

ETSI TR 102 300-3: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Designers' guide; Part 3: Direct Mode Operation (DMO)".

History

Document history		
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V1.2.1	December 2011	Publication