ETSI

Radio Equipment and Systems (RES);
Trans-European Trunked Radio (TETRA);
Technical requirements for Direct Mode Operation (DMO);
Part 1: General network design

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Contents

Foreword

This draft European Telecommunication Standard (ETS) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI), and is now submitted for the Public Enquiry phase of the ETSI standards approval procedure.

This ETS is a multi-part standard and will consist of the following parts:

Part 1: "General network design";

Part 2: "Radio Aspects";

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

Part 4: "Repeaters ", (DE/RES-06007-4);

Part 5: "Gateways", (DE/RES-06007-5);

Part 6: "Security", (DE/RES-06007-6).

Proposed transposition dates	
Date of latest announcement of this ETS (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this ETS (dop/e):	6 months after doa
Date of withdrawal of any conflicting National Standard (dow):	6 months after doa

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1 Scope

This ETS defines the Trans-European Trunked RAdio system (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.

This part 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 organisation 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: This part of this ETS may, by its nature as a general design statement, require updating as later specific parts of the ETS are completed in order to avoid any non-alignment. If a discrepancy occurs between this part and any other part of this ETS, then the other part will take precedence. This part will be updated at a frequency consistent with maintaining the integrity of this ETS as a whole.

2 Normative references

This ETS incorporates by dated and undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this ETS only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

[1]   prETS 300 396-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements for Direct Mode Operation (DMO); Part 2: Radio aspects".

[2]   ETS 300 392-1: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 1: General network design".

[3]   prETS 300 395-2: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 5: Codec".

[4]   prETS 300 392-7: "Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Voice plus Data (V+D); Part 7: Security".

[5]   CCITT Recommendation X.121 (1992): "International numbering plan for public data networks".

[6]   CCITT Recommendation E.212 (1988): "Identification plan for land mobile stations".

[7]   ITU-T Recommendation I.411 (1993): "ISDN user-network interfaces - Reference configurations".

3   Definitions and abbreviations

3.1   Definitions

For the purposes of this ETS, the following definitions apply:

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

call transaction: All of the functions associated with a complete unidirectional transmission of information during a call. A call can be made up of one or more call transactions. In a simplex call these call transactions are sequential.

data link block: The unit of information transferred between the upper data link and lower data link for a particular logical channel (e.g. SCH/F, SCH/H). The lower data link performs channel coding for insertion into the appropriate physical slot or halfslot.

Direct Mode (DM): A 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 Trunked network. DM is performed without intervention of any Base Station (BS).

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

Direct Mode Mobile Station (DM-MS): A physical grouping that contains all of the mobile equipment that is used to obtain TETRA DM services. By definition, a DM-MS contains at least one Mobile Radio Stack (MRS). For synchronisation purposes, DM-MSs can have one of two status levels:

-       **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 and hence is providing synchronisation information to the channel;

-       **slave:** if the DM-MS is receiving traffic and/or signalling and hence is deriving synchronisation information from the channel.

Direct Mode GATEway (DM-GATE): A device which provides gateway connectivity between a DM-MS and the TETRA V+D network. The gateway provides the interface between TETRA DMO and TETRA V+D mode.

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

Direct Mode REPeater/GATEway (DM-REP/GATE): A device that combines the functionality of a DM-REP and a DM-GATE in a single unit.

DUal mode switchable MS (DU-MS): A MS that can operate either in TETRA DMO or TETRA V+D mode. Only one mode can be selected at any given time and the MS is not capable of monitoring DM channels while in V+D mode or V+D channels while in DMO.

Dual Watch MS (DW-MS): A MS that can operate either in TETRA DMO or TETRA V+D mode. Only one mode can be selected at any given time but the MS is capable of monitoring the V+D mode control channel while in DMO or a DM channel while in V+D mode.

logical channel: A generic term for any distinct data path. Logical channels are considered to operate between logical endpoints.

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

simplex: A mode of single or dual frequency working in which information can be transferred in both directions but not at the same time.

3.2 Abbreviations

For the purposes of this ETS, the following abbreviations apply:

BER	Bit Error Rate
CRC	Cyclic Redundancy Check
DLL	Data Link Layer
DM-GATE	Direct Mode GATEway.
DM-MS	Direct Mode Mobile Station
DM-REP	Direct Mode REPeater.
DM-REP/GATE	Direct Mode REPeater/GATEway.
DMCC	Direct Mode Call Control
DMO	Direct Mode Operation
DO-MS	Direct mode Only Mobile Station
DSB	Direct mode Synchronisation Burst
DU-MS	DUal mode switchable Mobile Station
DW-MS	Dual Watch Mobile Station
GSSI	Group Short Subscriber Identity
GTSI	Group TETRA Subscriber Identity
ISSI	Individual Short Subscriber Identity
ITSI	Individual TETRA Subscriber Identity
MCC	Mobile Country Code
MER	Message Erasure Rate.
MM	Mobility Management
MNC	Mobile Network Code
MNI	Mobile Network Identity
MRS	Mobile Radio Stack
MS	Mobile Station
MT	Mobile Termination
OTAR	Over The Air Re-keying
PACQ	Probability of synchronisation burst ACQuisition
PDU	Protocol Data Unit
PL	Physical Layer
SCH	Signalling CHannel
SCK	Static Cipher Key
SDS	Short Data Service
SDU	Service Data Unit
SSI	Short Subscriber Identity
SwMI	Switching and Management Infrastructure
TE	Terminal Equipment
TEI	TETRA Equipment Identity
TSI	TETRA Subscriber Identity
TVP	Time Variant Parameter
Ud	Abbreviation for Direct Mode Air Interface
Um	Abbreviation for Trunked Mode Air Interface
V+D	Voice plus Data

4 DMO reference points

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 abbreviations used in the reference models are defined in clause 3. The abbreviation DM-MS is used throughout the ETS as a generalised term to include all MSs capable of working in DMO. The full capability of any particular DM-MS is not a standardised 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 this ETS, the following terminology is used:

DM-MS: generalised 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 end equipment (see subclause 4.2), are not considered to be distinct and separate stations, but for the purposes of this ETS are considered to be combinations of those listed above.

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

4.1   Reference models

4.1.1   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, Ud. Figure 1 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.
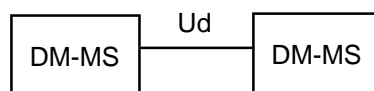
Figure 1: DM-MS connected to DM-MS via DM air interface, Ud

The basic Ud air interface is fully described in subsequent parts of this ETS. In the definition of this air interface, differentiation is made between the current transmitting and the current receiving MSs at any point in a call.

The DM-MS which provides the synchronisation reference is defined as the "master" DM-MS. A DM-MS which initiates a call becomes the master for the duration of that transaction. Any DM-MS which synchronises on a "master" DM-MS is defined as a "slave" DM-MS.

The same Ud 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 Ud air interface also applies to links between DM-MSs and DM-REPs, or to links between DM-MSs and DM-GATEs, though in these latter cases there may be slight differences within the protocol operating over the air interface in order to cater for additional functionality.

Air interface links to the TETRA V+D system from DW-MSs or from DM-GATEs are supported over the TETRA V+D mode air interface, Um, as detailed in ETS 300 392-1 [2].

4.1.2   DW-MS

This model applies to a DM-MS which is capable of dual watch operation.

Figure 2: Dual Watch reference model

The DW-MS can be in one of three states as follows:

a)   idle in both modes and monitoring both the V+D mode control channel and a selected DM channel; or

b)   communicating with another DM-MS via the Ud air interface and monitoring the V+D mode control channel over the Um air interface; or
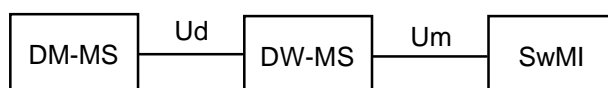
c)   communicating with the TETRA Switching and Management Infrastructure (SwMI) in V+D mode via the Um air interface and monitoring a selected DM channel.

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

For DU-MSs, a similar reference model applies but there is no capability to monitor the inactive channel. With DU-MSs, either the V+D mode or the DMO reference model applies at any one time.

4.1.3   DM-REP

This model applies to operation using a DM-REP between the end MSs.

Figure 3 shows the simplest form of link between DM-MS's using the Ud air interface via a DM-REP.
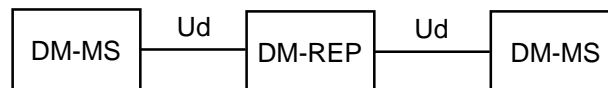
Figure 3: DM-REP reference model

The DM-REP receives information from a transmitting mobile on an "uplink" and re-transmits this information to another mobile or group of mobiles on a "downlink". The DM-REP specified within this ETS is regenerative, in that it decodes and re-encodes bursts which it receives, to improve the overall link performance.

The DM-REP also has the optional feature to be set to operate on different DM channels (frequencies) for the "uplink" and "downlink". This additional frequency translation possibility is to add operational flexibility in the deployment of DM-REPs.

4.1.4   DM-GATE

This model applies to operation when using a DM-GATE into a TETRA V+D network, and in this ETS concerns only the link between TETRA DMO and TETRA V+D mode.

Figure 4 shows the simplest form of link between a DM-MS and the TETRA V+D SwMI (and hence onward, e.g. to a V+D MS or Line connected Station (LS)) using the Ud air interface via a DM-GATE.
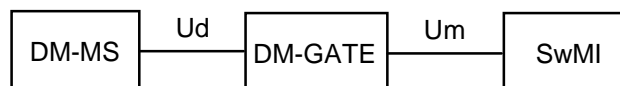
Figure 4: Gateway into a TETRA SwMI

The DM-GATE caters for the differences in protocol between the Ud and Um air interfaces and provides for the required inter-connectivity between DM and the TETRA V+D network.

4.1.5   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 V+D network over the Um air interface.
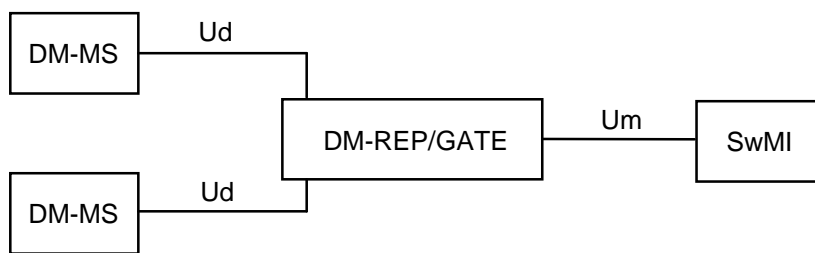
Figure 5: Repeater/gateway into a TETRA SwMI

The Ud and Um air interfaces for the above reference model are no different from those in the previous examples. The V+D mode 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).

4.2 Reference points

4.2.1 Terminology

Functional groups are sets of functions which may be needed in specific access arrangements. In any particular access arrangement, specific functions of a functional group may or may not be present.

Reference points are conceptual points dividing functional groups. This subclause uses terminology consistent with ITU-T Recommendation I.411 [7] in order to specify conceptual reference points which are relevant to TETRA DMO. For consistency with the TETRA V+D standard, common terminology for the reference points highlighted here has been used. The terms used are as follows:

Rx: physical interface reference point x used for a specific interface not specified by ITU-T I-series Recommendations (i.e. not ISDN);

APx: Access Point type x (x=1 represents an ISDN S reference point, which is not relevant to DMO; x=2 represents access point for bearer services at an R reference point; x=3 represents access point for teleservices at user interface);

TEx: Terminal Equipment type x (x=1 represents ISDN interface; x=2 represents TETRA specific interface, nominally ITU-T V-series);

MTx: Mobile Termination type x, the radio equivalent to a Network Termination unit $NT_{(x)}$ in ISDN terminology (x=0 represents a termination which includes TE functionality and provides a user interface, not necessarily standardised; x=1 is not used in TETRA DMO; x=2 represents a termination providing a standardised TE interface).

Figure 6 provides a diagrammatic representation of the two mobile functional groups considered in this ETS, MT0 and MT2, highlighting the access points and the Ud air interface.
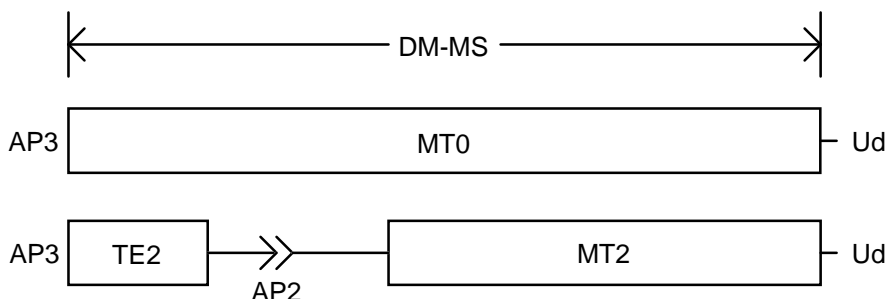
Figure 6: MS access points

A DM-MS shall include a Mobile Termination (MT) and may include TE. The TE where included shall support the user application, the Man Machine Interface (MMI) to the user and the interface to the MT. The MT supports the functions specific to the DM air Interface and also for the interface to the TE. Each MT contains the entire physical air interface protocol stack.

The concept of teleservice and bearer service access is shown in figure 7 where end-to-end teleservices are supported to the user application at the TE interface and bearer services extend to the MT/TE interface, which with TETRA corresponds to the AP2 access point shown in figure 6.
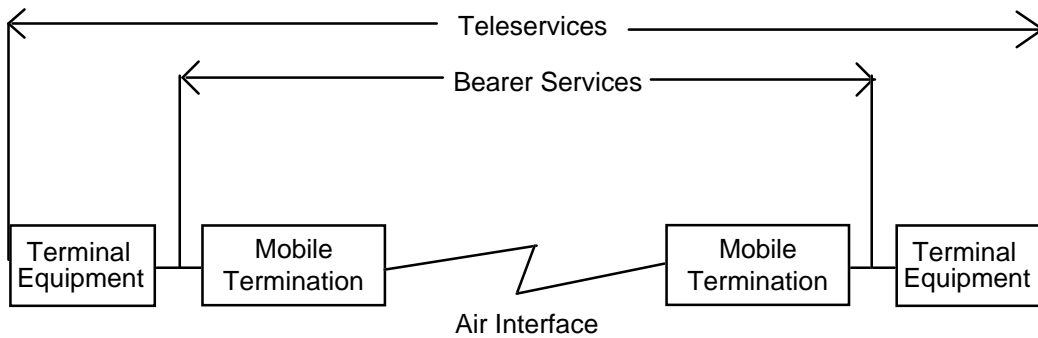
Figure 7: Concept of bearer services and teleservices

A reference point R0 has been defined in TETRA for convenience to correspond to the top of the MRS but not including the routing. R0 provides a convenient conceptual service boundary and exists in all MT types.

A reference point R2 has been defined in the TETRA V+D standard to correspond with the TETRA air interface, Um, and the same reference point will be used in DM to correspond to the TETRA air interface, Ud.

To further clarify the locations of reference points and the MS functional groups, figure 8 shows the generic protocol stack as applicable to a TETRA DM-MS of functional group type 0 (combined MT and TE) in communication over the Ud air interface.
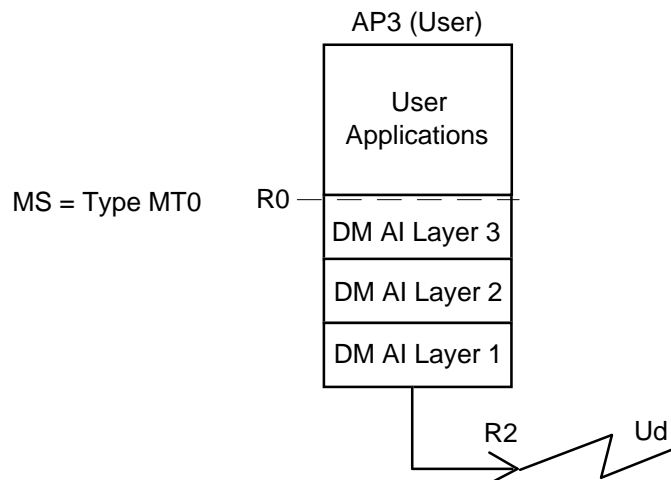
Figure 8: MT0 protocol stack for DM air interface

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 9 shows another generic protocol stack as applicable to a TETRA DM-MS of functional group type 2 (separate MT and TE) in communication over the Ud air interface.
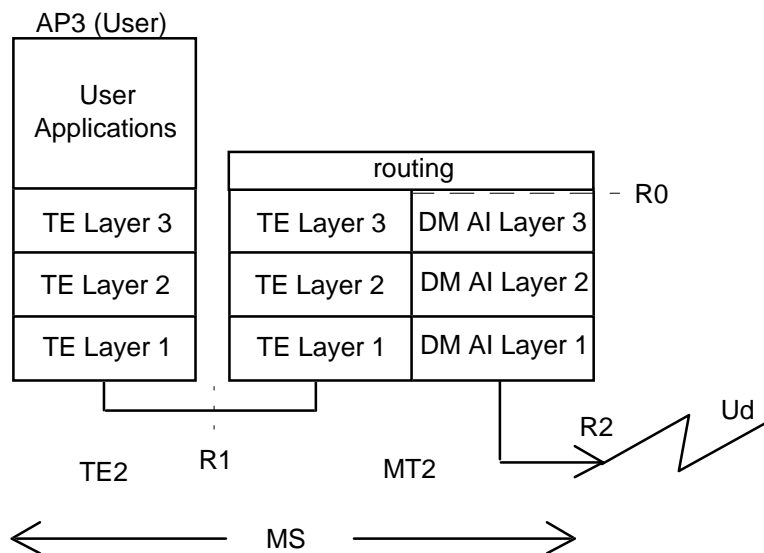
Figure 9: MT2 protocol stack for DM air interface

With mobile type MT2 in addition to user access at the AP3 point, a fully defined access point is also available at the boundary between MT and TE, the AP2 interface mentioned above. The AP2 point exists at reference point R1 in figure 9.

Detailed definition of the protocol content of each layer will depend on the mobile equipment types. This ETS specifies the DM protocol stack (DM air interface layers in figure 8 and figure 9) but does not specify the stack which applies to the MT to TE interface. The content of this stack is determined by the particular choice of TE and may be either proprietary or standardised (e.g. X.25).

5 DM protocol architecture

5.1 Introduction

The purpose of this subclause is to provide a model where the different functions and processes are identified and allocated to different layers in the DM-MS, DM-REP and DM-GATE protocol stacks.

The protocol stacks are used to define the functionality of the TETRA protocols for interfaces. The protocol stacks in this clause and in all other related clauses are used to describe functionality of the interfaces, but these stacks do not imply or restrict any implementation.

5.2 DM-MS protocol architecture

5.2.1 Overview

The TETRA DM protocol architecture which is defined herein follows the generic OSI seven layer structure.

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

The Data Link Layer (DLL) (layer 2) shall handle the problem of sharing the medium by a number of users. At the DLL, the protocol stack shall be divided vertically into two parts, the User plane (U-plane), for transporting information without addressing capability, and the Control plane (C-plane) for signalling with addressing capability.

A third level of the protocol stack exists in the C-plane responsible for control of the call.

Figure 10 shows this protocol layering as it applies to a basic DM-MS and also to a DM-REP .
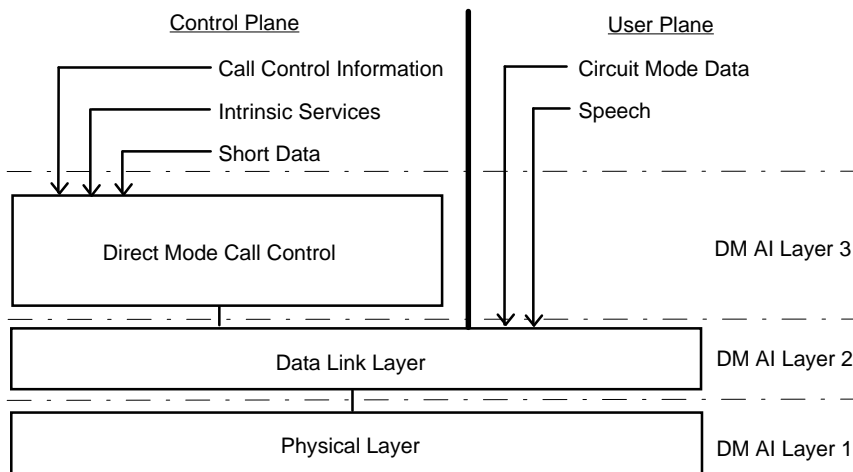
Figure 10: Protocol stack for MS and repeater functionality

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

A modification of layer 3 is necessary when DM to V+D mode gateway functionality is considered in order to support the additional requirements of registration and authentication. To meet this need, an additional Mobility Management (MM) entity has been added to the basic protocol structure to support DM-GATEs as shown in figure 11.
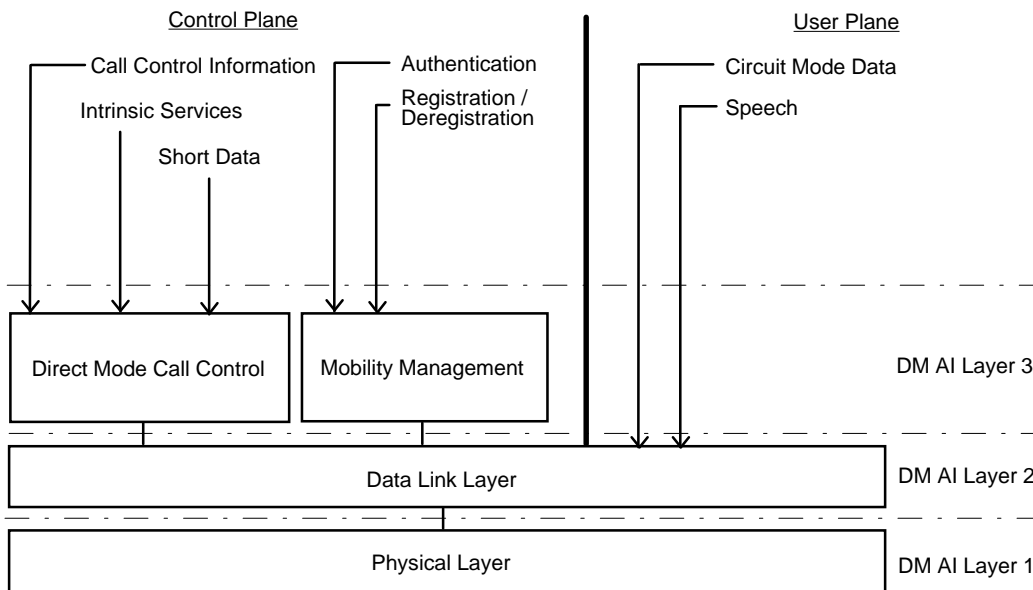
Figure 11: Protocol stack for gateway functionality (DM side)

The following subclauses describe the major functions handled by each layer, and apply to both figures 10 and 11 unless otherwise specified.

5.2.2 Air interface layer 1

The air interface layer 1 shall be the physical interface. It shall deal 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 shall contain the following functions:

radio oriented:

- modulation/demodulation;

- transmitter/receiver switching;

- RF characteristics:

    - frequency (or channel) setting;
    - Radio-Signal-Strength-Indicator (RSSI);

- fine adjustments of radio parameters:

    - frequency correction:

        - synchronisation using a specific frequency correction sequence located inside the Direct Mode Synchronisation Burst (DSB);

    - power control (applies only to a DM-MS working to a repeater or a repeater/gateway);

bits and symbol oriented:

- symbol synchronisation:

    - a specific training sequence, located inside the burst, shall precisely determine the occurrence of the symbols. The PL shall then be 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 shall be able to determine the starting and ending points of the burst, at the emission, it shall map the data link block onto the physical burst and shall add its specific information (layer 1 only) at the correct place. At the reception, it shall extract its specific information (layer 1 only) from the burst and shall rebuild data link block(s). The data link block(s) shall then be passed to the DLL;

- slot flag coding/de-coding using two distinct training sequences;

- scrambling/de-scrambling:

    - DM-MSs shall scramble frames prior to sending them. Scrambling shall be carried out using part of the DM-MS address, known as colour code. The colour code is used to prevent cross calls on the DM channel and the DM frame shall be decoded (hence de-scrambled) correctly only by the receiving station(s) having the appropriate colour code.

5.2.3 Air interface layer 2

The air interface layer 2 shall handle logical connections and shall hide the physical medium from the upper layers.

The main functions shall be as follows:

encryption:

- TETRA DMO shall provide, as an option, call confidentiality against eavesdropping by means of air interface encryption with the use of a transmitted Time Variant Parameter (TVP) to initialise and synchronise the encryption units to give some replay protection. TVP may contain a time of day element to prevent replay. DM encryption shall use Static Cipher Keys (SCKs);

channel coding:

- interleaving, de-interleaving and re-ordering of the protected bits over one block or two blocks to allow spreading the errors instead of having them grouped;

- in order to protect bits transmitted on the radio path, Forward Error Correction (FEC) using convolutional coding shall add 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) shall be 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;

radio channel access control:

- frame synchronisation:

    - keeping 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 and after channel reservation time a simple random access protocol shall be employed to prevent colliding signalling. A transmitting radio unit must always first ensure that the channel is free.;

- fragmentation/re-construction:

    - this shall split the content of one single PDU into several SDUs. On the other side, parts shall be re-constructed together in order to re-constitute the original PDU;

- multiplexing/de-multiplexing of the logical channels: in order to create all layer 2 parts of the burst;

- multiframe building and synchronisation:

    - the frames shall be assembled during a call and reservation time to form a multiframe varying according to a cyclic law. The frames are numbered explicitly. A synchronisation block shall contain information about time slot, frame number and colour code.

radio resource management:

- this part shall be unique to one MS. It shall enable powerful control of the radio resources to be available at any time without explicit involvement of layer 3. The following functions shall be provided:

    - Bit Error Rate (BER) and Message Erasure Rate (MER) measurements: independently or under control of other layers;

    - address management for individual and group calls;

- power control management (repeater and repeater/gateway only):

  - execution is in PL;

- radio link establishment;

- buffering of control information and traffic frames until transmitted;

- interfacing of circuit mode applications (e.g. those of codec and circuit mode data) with the PL;

- exchanging control and/or user data with the layer 3 entity;

- acknowledgement of received data.

5.2.4 Air interface layer 3

The air interface layer 3 shall handle Call Control (CC) and related procedures.

In a DM-GATE layer 3 shall also be responsible for additional operations necessary in order to communicate with the V+D mode system. These additional tasks are concerned with the registration and de-registration of the DM-MSs to a gateway, and identity management of the DM-MSs.

5.2.4.1 DMCC entity

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

The functions shall be as follows:

- protocol discrimination;

- identity management (see below);

- establishing, maintaining and clearing basic service calls;

- addressing (destination, repeater and gateway as appropriate).

5.2.4.2 Identity management (authentication)

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

5.2.4.3 Key management

Cipher keys for use in encrypted DMO calls shall be maintained in layer 3 of the DMO protocol stack.

5.2.4.4 Intrinsic services control

Intrinsic services control shall handle the processes associated with the following services:

- transmitting party identification;

- transmitting party identification restriction;

- pre-emption;

- late entry;

- Over The Air Re-keying (OTAR).

5.2.4.5 Short Data Service (SDS)

SDS shall handle 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.

5.2.4.6 MM entity (for operation via a gateway only)

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

The functions shall be as follows:

- authentication;

- registration/updating.

6 DM addressing and identities

6.1 Introduction

This clause defines the DMO TETRA addresses and identities that shall be used by all TETRA DMO equipment.

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

- Mobile Network Identity (MNI);

- TETRA Subscriber Identities (TSI);

- Short Subscriber Identities (SSI);

- TETRA Equipment Identities (TEI).

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.

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: in particular group and individual identities shall have the same structure and shall be allocated from the same TETRA identities address space.

The individual subscriber identities shall have a special role to provide a unique identification of MS 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 V+D mode, thus the subscriber identities used in TETRA DM may be the same ones as used in the TETRA V+D mode domain.

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 12.
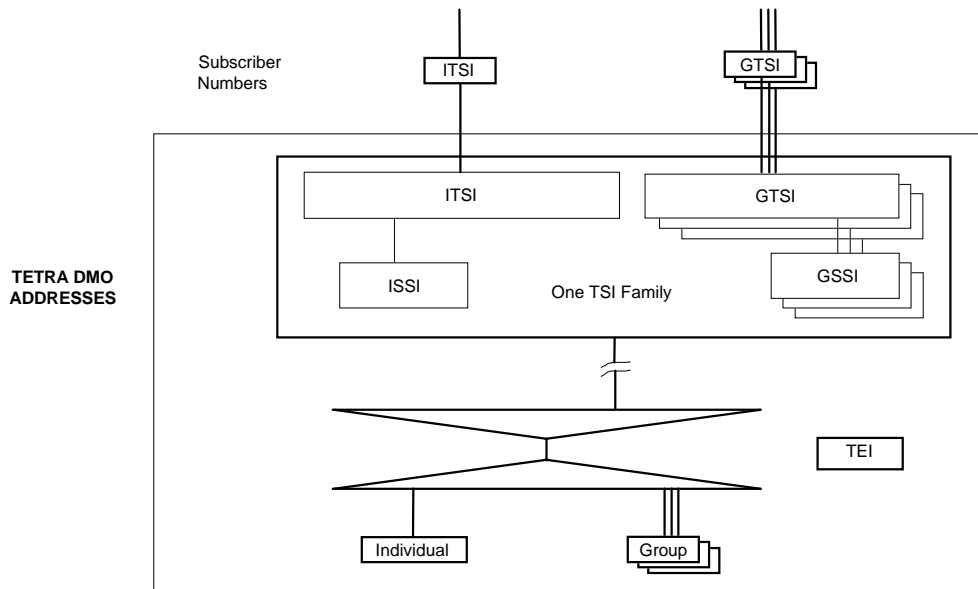
Figure 12: Relationship between TETRA addresses

6.2 MNI

The MNI shall consist of two sub-parts as shown in figure 13.
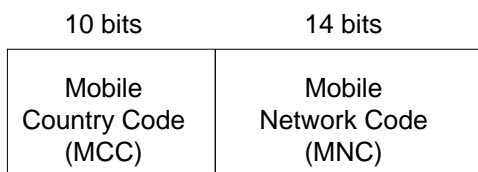
Figure 13: Contents of MNI

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

- MCC shall use 10 bits to encode the 3 decimal digit value of the country code as defined in CCITT Recommendation X.121 [5], annex D.

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

The undefined binary codes (decimal values 1 000 to 1 023) are reserved and shall not be used.

MNC shall be allocated by the national administration for each country or an equivalent authorised body. A unique MNC shall be allocated to each operator using binary code on 14 bits.

6.3 Subscriber identities

6.3.1 General

Subscriber identities shall exist in two forms:

- TSI, 48 bits long;

- SSI, 24 bits long.

The TSI shall consist of the MNI and the SSI combined as shown in figure 14. The SSI is therefore a truncation of the full TSI.

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

Figure 14: Contents of TSI

TSI identities shall have a fixed length structure that is based on the identity structures defined in CCITT Recommendation E.212 [6].

Each TSI shall be unique across the complete TETRA domain (i.e. all TETRA networks) by virtue of the use of MNI, but each SSI shall only be unique within one TETRA sub-domain (i.e. one TETRA network).

6.3.2 TSI

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

One TSI family =

- 1 x ITSI;

- N x GTSI.

The following only considers 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 valid TSI shall refer to a TSI that has been allocated by the network where it is being used. A DM-MS shall possess at least one valid ITSI before it can be used.

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

6.3.3 SSI

The SSI is the network specific part of the TSI. SSIs shall be unique for a given MNI. The same SSI 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 formed from a GTSI by removing the MCC and the MNC.

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

- ISSI = SSI from ITSI;

- GSSI = SSI from GTSI.

6.3.4 Installation of TSIs

TSIs may be installed by several alternative mechanisms such as:

- by the dealer (i.e. not usually changed by the user);

- by inserting a SIM module or "smart card";

- by the user entering a login code via a local application.

These mechanisms are only provided as examples. No methods of installation are defined by this ETS.

6.3.5 Use of subscriber identities

Subscriber identities shall be used as a layer 2 address for the air interface.

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 identification.

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 TETRA Equipment Identity (TEI)

6.4.1 Contents of TEI

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

Figure 15: Contents of TEI

TEI digits shall only use the decimal digits: 0-9 inclusive.

6.4.2 Allocation principles for TEI

Type Approval Code (TAC) shall be allocated by a central body.

Final Assembly Code (FAC) shall identify the manufacturer and place of final assembly. These shall be also allocated by a central body.

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

6.4.3 Use of TEI

TEI shall be used to support security functions.

6.5 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 may be used.

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

6.5.1 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 synchronisation burst, but with a code of all zeroes.

The colour code shall be a 30 bit sequence generated as an algorithmic combination of the TETRA SSI and the 6 least significant bits of the MNC. These identities shall be used as the "seed" for the colour code scrambling function as specified in ETS 300 396-2 [1], 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).

6.6 Use of TETRA addresses

6.6.1 Air interface addressing functions

The address functions for all layers are summarised in table 1.

Table 1: Addressing functions per layer

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

The overview through all layers of the functions related to the addresses is illustrated in figure 16.
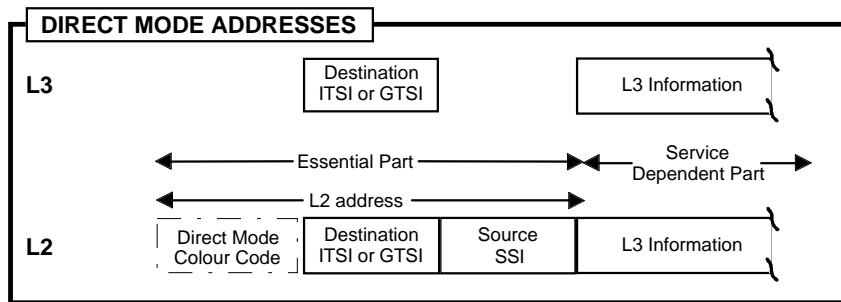
Figure 16: Message addressing

6.6.2 Address placement in primitives and PDUs

The inclusion of the addresses within primitives and PDUs is shown in figure 17.

6.6.2.1 Use of addresses at layer 2

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.

At the sender, the DLL shall place both the source SSI and destination TSI into PDUs.

At the receiver the DLL shall have received the both destination TSI and source SSI.

6.6.2.2 Use of TSI at layer 3

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.

DMCC supplies destination ITSI/GTSI with PDU

Layer 3 (DMCC)   TSId   DMCC PDU

TSId   Data Link SDU   - - Primitives

Data Link Layer

Data Link layer fragments SDU if necessary

Data Link layer attaches destination TSI to first Data Link PDU

TSId SSIs   Data Link PDU   Data Link PDU

Data Link layer adds source SSI to first Data Link PDU

PHL SDU   - - - -   PHL SDU   - - Primitives

Physical layer
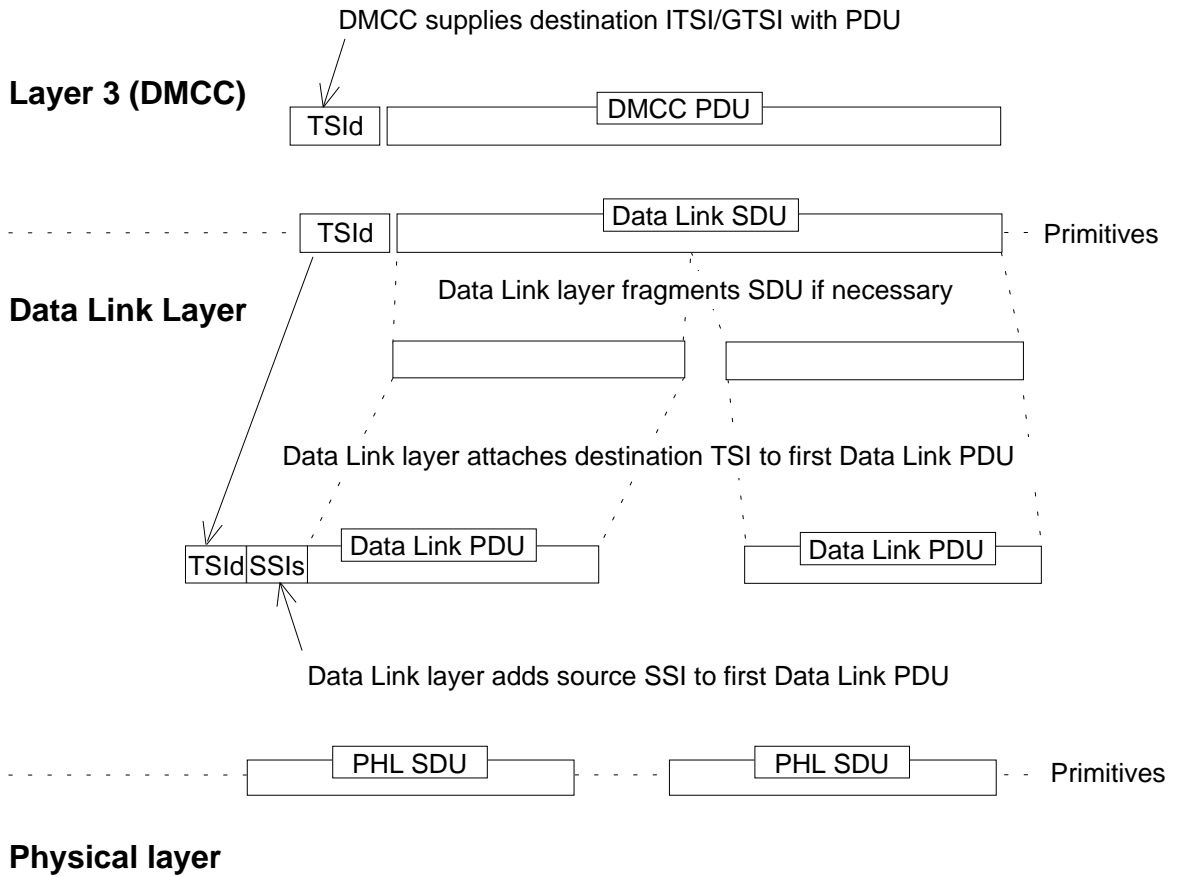
Key : TSId = Destination TSI, SSIs = Source SSI

Figure 17: TETRA DMO air interface addressing

6.6.3 Address and identity comparison

DMO and V+D mode addresses and identities are compared in table 2.

Table 2: Comparison of addresses and identities between DMO and V+D mode

DMO	V+D mode
ITSI/GTSI	ITSI/GTSI
ISSI/GSSI	ISSI/GSSI
-	ASSI
-	USSI
-	TMI
TEI	TEI
-	NSAP

7 DM circuit mode teleservices and bearer services

7.1 Service definitions

In TETRA DMO two distinct classes of basic service are provided, teleservices and bearer services.

The following subclauses aim to clarify the differences between these services.

7.1.1 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 shall 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.

7.1.2 Teleservice

A teleservice is defined as a type of service that provides the complete capability, including 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.

The following figure illustrates in a simple sense the basic differences between these two services in terms of user access point within the MS.
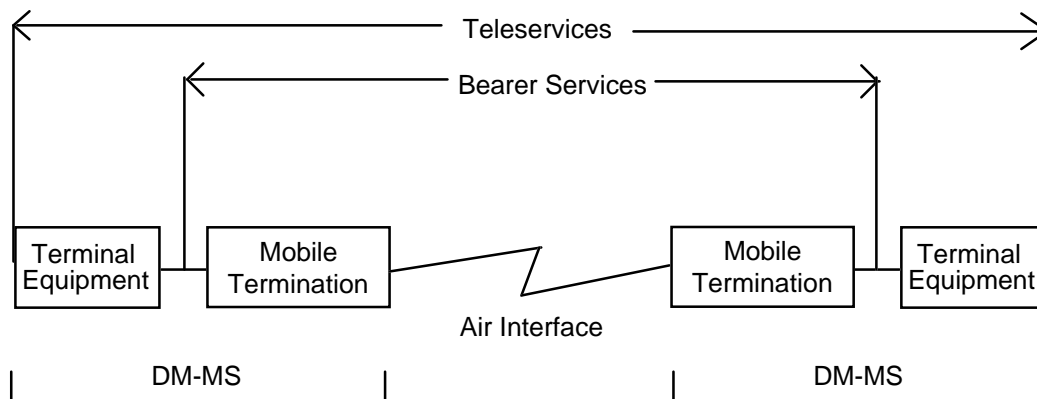

Figure 18: DMO bearer services and teleservices

7.2 Services offered in TETRA DMO

Table 3 provides a summary of the basic services supported within TETRA DMO.

Table 3: Voice and Data (V+D) services supported in DMO

	Basic teleservice	Basic bearer service
TETRA speech	Individual Call (point-to-point) Group Call (point-to-multipoint)	N/A
Circuit mode unprotected data	N/A	7,2 kbit/s (point-to-point) 7,2 kbit/s (point-to-multipoint)
Circuit mode protected (low) data with interleaving where N=1 (note)	N/A	4,8 kbit/s (point-to-point) 4,8 kbit/s (point-to-multipoint)
Circuit mode protected (low) data with interleaving where N=4 (note)	N/A	4,8 kbit/s (point-to-point) 4,8 kbit/s (point-to-multipoint)
Circuit mode protected (low) data with interleaving where N=8 (note)	N/A	4,8 kbit/s (point-to-point) 4,8 kbit/s (point-to-multipoint)
Circuit mode protected (high) data with interleaving where N=1 (note)	N/A	2,4 kbit/s (point-to-point) 2,4 kbit/s (point-to-multipoint)
Circuit mode protected (high) data with interleaving where N=4 (note)	N/A	2,4 kbit/s (point-to-point) 2,4 kbit/s (point-to-multipoint)
Circuit mode protected (high) data with interleaving where N=8 (note)	N/A	2,4 kbit/s (point-to-point) 2,4 kbit/s (point-to-multipoint)
NOTE: Interleaving as specified in subclauses 8.3.2.2 and 8.3.2.3		

Speech and data services may have as an option end-to-end encryption and/or air interface encryption.

7.2.1 DM teleservices

TETRA DM voice teleservices are designed to support the transmission of speech utilising a TETRA specific voice codec as defined in ETS 300 392-5 [3]. They shall use standard TETRA speech and channel coding as defined in ETS 300 396-2 [1]. Optional encryption is specified in Part 6 of this ETS. TETRA DM voice teleservices support speech on a point-to-point, and point-to-multipoint circuit mode basis. The normal mode of operation is simplex.

7.2.2 DM 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 channel. 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 ETS 300 396-2 [1], 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.

7.2.2.1 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.

7.2.2.2 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 ETS 300 396-2 [1], 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.

Speech transmission via circuit mode protected bearer services is not standardised but its use is not specifically excluded by this ETS.

7.3 Individual calls and group calls in TETRA DMO

7.3.1 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 channel. An individual MS has a pre-defined number which is called its individual number and by which it is addressed. The normal mode of operation is simplex.

7.3.2 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 channel.

The members of a group have one common pre-defined number which is called their group number and by which they are addressed. The Ud air interface uses the same addressing scheme for group numbers as defined in ETS 300 392-5 [3]. The air interface may support more than one group on a DM channel although only one group shall be able to communicate using the channel at any given time.

In addition, there may be an 'open' group number which includes all of the users to allow calls to be made to all users who have selected the same DM channel, providing for open channel operation.

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 normal mode of operation is simplex.

7.4 DW-MS

A DW-MS is one that can operate either in TETRA DM or TETRA V+D mode and is capable of monitoring the V+D mode control channel whilst in DMO or a selected DM channel while in V+D mode. Only one mode may be selected at any given time.

In order to operate with the V+D system a DW-MS must first register with the SwMI in the same manner as a normal V+D mode MS.

The states of a DW-MS are given in the following subclauses.

7.4.1 Idle state

A DW-MS is defined as being in the idle state when it is not participating in a call. In this state, it is in receive mode listening for any incoming calls. In the V+D mode, a MS shall generally be listening to the V+D control channel. In DMO, a MS shall generally be listening to the currently selected DM channel.

A DW-MS, in the idle mode, has the ability to alternate between listening to the V+D control channel and one or more DM channels. In this way it is able to monitor for an incoming call on either of the Ud or Um air interfaces.

7.4.2 Active state

A DW-MS is defined as being in the active state when it is transmitting or receiving in a call. A MS may be active either in a DM call or a V+D mode call. Dual watch provides the ability for a MS, while active in a DM call, to periodically monitor the V+D mode control channel for activity and vice-versa.

7.4.2.1 Active in DMO

A DW-MS active in DM (any of the voice or data services described) shall periodically listen to the V+D mode control channel. This implies that it has to cease DM transmission or reception and switch frequency to that of the V+D mode control channel to listen to information in a control channel slot. The DW-MS shall then switch back to the DM channel and resume transmission or reception.

If the DW-MS receives indication of a call on the V+D control channel, it may alert the user with an acoustic and/or optical indication. The user can then decide whether or not to respond to that call. The type of calls which alert a DW-MS are to be defined by the operator as well as the exact nature of the alert indication. For example, for some users, indication of an emergency call on the V+D system may require that the DM communication is terminated and the MS switches to participate in the V+D emergency call.

7.4.2.2 Active in V+D mode

A DW-MS active in V+D mode shall be able to monitor a DM channel.

7.5 Repeater operation

Repeater working, as depicted by the reference models in subclause 4.1.3, provides an enlarged coverage area for DM operation. The repeater receives and re-transmits information on the DM air interface.

The repeater receives information on an inbound DM channel and re-transmits the same information on an outbound DM channel. The speech teleservices and data bearer services described in subclause 7.2 shall be supported by DM-REP operation.

A DM-MS transmitting to a repeater shall include an appropriate repeater address to ensure that it keys up the correct repeater. Throughout transmission from the DM-MS, an address identifying the appropriate repeater shall be periodically transmitted.

7.6 Gateway operation

A Direct/V+D mode gateway provides inter-working between the TETRA V+D air interface and the DM air interface. This is described in the reference models subclause 4.1.4 above.

In order to operate with the V+D system a gateway shall first register with the SwMI in the same manner as a normal V+D mode MS.

All of the speech teleservices and data bearer services available in DM shall be supported by operation through a gateway into the V+D system.

The limitations are as follows:

- a DM-MS may obtain access to the services offered by the V+D system via a DM-GATE. The DM-MS is however limited to those V+D services it may use by the capability of the DM air interface;

- a DM-MS accessing the V+D system via a gateway is therefore only capable of utilising those V+D services which are supported by the Ud interface;

- a DM-MS transmitting to a gateway shall include an appropriate gateway address to ensure that it keys up the correct gateway. Throughout transmission from the DM-MS, an address identifying the appropriate gateway shall be periodically transmitted.

7.7   Repeater/gateway operation

A DM-REP/GATE provides a combination of the functions of a DM-REP and a DM-GATE. The repeater section provides a greater coverage area for the DM channel and inter-networking capability with the TETRA V+D system is also provided.

In order to operate with the V+D system a repeater/gateway shall first register with the SwMI in the same manner as a normal V+D mode MS.

A DM-MS transmitting to a repeater/gateway shall include an appropriate address to ensure that it keys up the correct repeater/gateway. Throughout transmission from the DM-MS, an address identifying the appropriate repeater/gateway shall be periodically transmitted.

8   DM intrinsic services

8.1   Intrinsic service definition

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 V+D mode as it requires no explicit invocation. Options may however exist within an intrinsic service which require application level intervention.

The following subclauses 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.

8.2   DM late entry

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

a)   the user switches on the MS and selects that channel;

b)   the user switches from another DM channel to that channel;

c)   The MS returns to DM coverage after a period of lost coverage;

d)   The user switches the MS from V+D mode to DM and selects that channel (applies to DW-MS and DU-MS).

8.3   Transmitting party number identification

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

A user option shall allow details of the originating ITSI to be concealed. This option allows a transmitting MS to withhold its identity, a feature which may be required for certain authorised users.

8.4   Emergency calls

The DM air interface supports emergency calling. A DM-MS initiating an emergency call out of coverage of the system may use a DM channel and, if necessary, pre-empt any lower priority communication using that channel.

This intrinsic service provides the ability for a DM communication to be pre-empted in order to support the emergency calling service.

8.5 OTAR

DMO shall support OTAR by means of a specially designated MS. The OTAR MS may generate and distribute SCKs for each MS using a sealing key distributed from an authentication centre in a secure manner that is specific to each DM-MS (derived from the secret key K associated with each ITSI). A multi-pass protocol for key request and key delivery shall be defined with implicit authentication only required (as the SCK can only be recovered by the holder of K).

Any DM-MS may act as a store and forward station for a Sealed Static Cipher Key (SSCK).

9 DM Short Data Service (SDS)

The TETRA DM SDS is similar to the SDS offered within the TETRA V+D V+D standard. Both point-to-point and point-to-multipoint services are supported in DM SDS. Point-to-point SDS shall offer optional acknowledgement whereas the point-to-multipoint service shall be unacknowledged.

The SDS is essentially a message service which shall be optimised to be a quick service enabling the user to exchange a short user defined message or a short pre-defined message such as an emergency message. The message is sent within signalling capacity and may be sent or received in parallel with an ongoing speech or data call. The SDS may be used for applications such as automatic vehicle location, status or OTAR etc.

The SDS in DM shall support up to the same limited number of data bits as the SDS in V+D mode (2 047 bits max.) 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 V+D system via a DM-GATE.

A point-to-point short data message is sent from one originating MS to one receiving MS using the currently selected DM channel. The receiving MS is addressed by its ITSI using the addressing scheme as described in clause 6 of this ETS. The receiving MS shall acknowledge 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 channel. The group is addressed by its GTSI using the addressing scheme as described in clause 6 of this ETS. There shall be no acknowledgement from the receiving MSs in this case, but the originating MS may re transmit the message a number of times for reliability.

9.1 Short data functional entities

An Originating Short Data Agent (OSDA) shall exist within the DMCC of a source DM-MS. It shall have capability to receive primitives and parameters from the user and to send this information to a peer Destination Short Data Agent (DSDA) in the destination DM-MSs or to an Originating Short Data (OSD) functional entity within the SwMI if the message is directed toward the V+D system via a DM-GATE.

The following functional capabilities shall exist within the OSDA:

- ability to send a user defined message limited in length;

- ability to send a pre-defined message, e.g. emergency message;

- ability to address a single point by using the ITSI address of the message receiver;

- ability to address a multipoint by using the GTSI of the message receivers;

- ability to apply priority to the message.

A DSDA shall exist within the DMCC of a destination DM-MS. It shall have capability to receive information from the OSDA of a source DM-MS or from a Destination Short Data (DSD) functional entity in the SwMI if the message comes from the V+D system via a DM-GATE, and then forward primitives and parameters to the end user.

The following functional capabilities shall exist within the DSDA:

- ability to receive a user defined message and relay it to the user;

- ability to receive a pre-defined message and relay it to the user, e.g. emergency message;

- ability to receive the ITSI address of the message sender and relay it to the user;

- ability to receive the priority applied to the message, and relay it to the user.

History

Document history			
July 1996	Public Enquiry	PE 109:	1996-07-08 to 1996-11-01