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# Radio Equipment and Systems (RES); Trans-European Trunked Radio (TETRA); Technical requirements specification for Direct Mode (DM)

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# Contents

## Foreword

This ETSI Technical Report (ETR) has been produced by the Radio Equipment and Systems (RES) Technical Committee of the European Telecommunications Standards Institute (ETSI).

## Introduction

This ETR describes the technical requirements for TETRA Direct Mode (DM) operation. It is based on ETSI Technical Sub-Committee RES 6 WG1, WG2 and WG3 input documents. This version is an update of former STC RES 6 working documents describing services and facilities of DM operation.

Due to the large number of possible options and the corresponding complexity in the level of standardisation, it has become necessary that DM operation is treated as a separate, but complementary, part of the TETRA standard in order to sufficiently establish the required level of standardisation.

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# 1 Scope

This ETR is the technical requirements specification for TETRA Direct Mode (DM) operation.

The objective of this ETR is to describe TETRA DM Operation and to identify and define the services and facilities to be standardised for TETRA DM Operation.

TETRA DM Operation developed as a concept where a suitably equipped Mobile Station had the capability to communicate either via a base station in TETRA-Trunking mode and also in a direct terminal to terminal mode using TETRA-derived transmission standards and technology without the need for a intervening base station.

This Technical Requirements ETR is intended to provide the starting point for system design and should provide sufficient criteria against which a number of possible system options can be evaluated and considered. It will introduce some logical grouping of functions but it should remain implementation independent.

This ETR is applicable to both public and private networks.

This ETR covers digital speech and data services for terminals working in a DM of operation.

The following Mobile Station terminal types will not to be defined within the TETRA DM Standard:

a) A dual mode terminal that can operate in TETRA mode and also some other mode such as analogue FM (conventional or Trunking).

b) A gateway terminal which provides gateway connectivity between a DM terminal and a non-TETRA network such as to Integrated Services Digital Network (ISDN).

DM Operation should not preclude special (terminal) services and user features which are not specifically defined in this ETR.

# 2 Normative references

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

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

# 3 Definitions and abbreviations

## 3.1 Definitions

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

**bearer service:** A type of service which provides the capability for information transfer between user-network interfaces and as such usually only involves functionality of the lower layers (layers 1-3) in the Open Systems Interconnection (OSI) protocol stack.

NOTE: The customer may normally choose any set of higher (layers 4-7) protocols in order to complete the communication protocol stack, but the underlying bearer service will not ascertain compatibility between customers at these higher levels.

**bi-directional channel:** A channel that can carry information in both directions.

**direct set-up signalling:** A signalling procedure where immediate communication can take place between the calling and the called users without the alerting process and without an explicit response from the called user that he has answered.

**direct mode operation:** 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 operation is performed without intervention of any base station.

**duplex (full duplex):** A mode of operation by which information can be transferred in both directions and where the two directions are independent.

**gateway:** A device which will enable the interconnecting of two networks which inherently use different and incompatible protocols.

**incoming call:** A terminating call which, from the viewpoint of an individual party, is a call that was initiated by another party.

**intrinsic service:** An intrinsic service is a service which is inherent within a voice or data service. It forms an integral part of the signalling associated with that voice or data service.

**Mobile Station (MS):** A physical grouping that contains all of the mobile equipment that is used to obtain TETRA services. By definition, a MS contains at least one Mobile Radio Stack (MRS).

**on/off hook signalling:** A signalling procedure which includes an alerting process to the called user. The calling user must wait for an explicit response from the called user that he has answered before the call can be set-up.

**outgoing call:** A call which, from the viewpoint of an individual participant in the call, is initiated by that participant.

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

**teleservice:** A teleservice is defined as a type of service which provides the complete capability, including terminal equipment functions, for communication between users according to TETRA protocols

**trunking mode operation:** A mode of operation where mobile terminals may communicate via the TETRA voice and data air interface which is controlled by the TETRA switching and management infrastructure (SwMI).

### 3.2 Abbreviations

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

| | |
|---|---|
| AP2 | Access Point within Mobile Terminating Unit |
| AP3 | Access Point within Mobile Terminating Unit |
| DM | Direct Mode DM-MS Direct Mode capable Mobile Station |
| DMO-MS | Direct Mode Only Mobile Station |
| DM-GATE | Direct Mode Gateway terminal |
| DM-REP | Direct Mode Repeater terminal |
| DU-MS | Dual Mode Mobile Station |
| DW-MS | Dual Watch Mobile Station |
| GSSI | Group Short Subscriber Identity |
| GTSI | Group TETRA Subscriber Identity |
| ISI | Inter System Interface |
| ISO | International Organisation for Standardisation |
| ISSI | Individual Short Subscriber Identity |
| ITSI | Individual TETRA Subscriber Identity |
| MS | Mobile Station |
| MT | Mobile Termination |
| MT0 | Mobile Termination type 0 |
| MT2 | Mobile Termination type 2 |
| MTU | Mobile Terminating Unit |
| OSI | Open Systems Interconnection |
| RES-6 | ETSI Sub-Technical Committee RES-6 (Radio Equipment and Systems - 6) |
| SwMI | TETRA Switching and Management Infrastructure |

| | |
|---|---|
| SW-MS | Switchable Mobile Station (Direct Mode/Trunked) |
| TE | Terminal Equipment |
| TE2 | TE presenting a TETRA interface |
| TEI | TETRA Equipment Identity |
| TETRA | Trans European Trunked RAdio |
| Ud | TETRA Direct Mode air interface |
| Um | TETRA air interface V+D Voice Plus Data |

Refer to TETRA 01.04 for additional common definitions and abbreviations.

# 4 Terminal types

A number of alternatives are possible when considering the configuration and capability of terminals which could be applied to DM operation.

All variants should be identified here with the intention that the subset of these which are specifically applicable to DM operation should be standardised in the DM Specification.

There are some exceptions to this generalisation however where a terminal type will not be catered for in the TETRA DM standard. Examples of this are where a DM capable terminal has the ability to communicate with a non-TETRA network. It is entirely possible that such terminals could be produced and applied within a DM service, but this is an implementation and not a standardisation issue as the non-TETRA elements fall outside of the scope of this ETR.

Such terminal types may be standardised at a later date.

## 4.1 Terminal types standardised elsewhere

The following Mobile Station (MS) terminal type is defined within the TETRA trunked mode standard:

- **trunking mode only terminal:** A mobile terminal that can operate only in TETRA trunking mode.

## 4.2 Terminal types to be standardised in the DM standard

The following MS terminal types are to be defined within the TETRA DM Standard:

- **direct mode only terminal:** A mobile terminal that can operate only in TETRA DM;

- **dual watch terminal:** A mobile terminal that can operate either in TETRA DM or TETRA trunking mode. Only one mode can be selected at any given time but it is capable of monitoring the trunking control channel while in DM or a DM channel while in trunking mode;

- **switchable terminal:** A mobile terminal that can operate either in TETRA DM or TETRA trunking mode. Only one mode can be selected at any given time and the terminal is not capable of monitoring DM channels while in trunking mode or trunking channels while in DM;

- **repeater terminal:** A terminal that operates in TETRA DM and provides a repeater function to enable two or more DM capable terminals to extend their coverage range;

- **gateway terminal (direct mode - trunking mode):** A terminal which provides gateway connectivity between a DM mobile and a TETRA trunked network. The gateway provides the interface between TETRA DM and TETRA trunked mode.

# 5 Reference models

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

The reference models shown below should cover all distinct operating possibilities and should provide a framework for simply describing the technical requirements for these interfaces.

The abbreviations used in the reference models are defined in the abbreviations list earlier in the ETR. The abbreviation DM-MS is used as a generalised term to include all mobile terminals capable of working in DM, and so encompasses all types defined in clause 4.

### 5.1 Standard TETRA reference model

As a reference basis for comparison of the differences between standard TETRA trunked mode operation and TETRA DM operation, figure 1 shows the most basic standard TETRA trunked reference model.

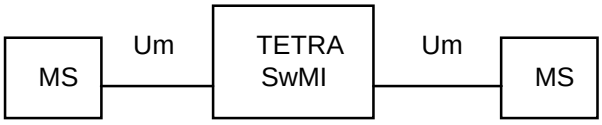


**Figure 1: Standard TETRA configuration using a TETRA SwMI**

Communication via the MSs is over the TETRA trunked mode air interface Um, as specified in the TETRA trunked mode standard and connectivity is provided via the TETRA Switching & Management Infrastructure (SwMI).

There are many other possible TETRA trunked model configurations but these are not relevant to this definition of DM models and so will not be discussed further here.

### 5.2 DM reference model

The basic reference model for DM operation applies to a simple point-to-point communication between two DM capable mobile terminals using the DM air interface. This is the most basic configuration and is the most simple with which to define the range of services which are to be supported by DM operation.

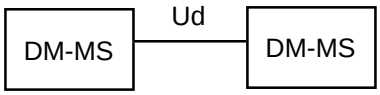


**Figure 2: DM-MS connected to DM-MS via DM air interface**

The DM air interface Ud is as described in a later subclause of this ETR.

The same air interface Ud applies in the case of a group connection, and will also apply to the following reference models.

NOTE: As far as the air interface Ud between terminals is concerned, there is no differentiation as to whether any terminal is a DM only terminal, a switchable terminal set for DM operation, a dual watch terminal set for DM operation, a dual mode terminal, or a repeater or gateway.

### 5.3 Dual watch reference model

This model applies to DM operation where one terminal is capable of dual watch operation.

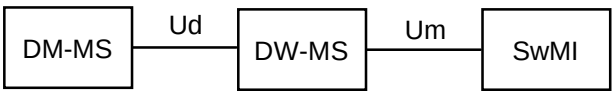


**Figure 3: Dual watch reference model**

The terminal DW-MS having dual watch capability can be in one of three states:

a) idle in both modes and monitoring both the trunked mode control channel and a DM channel;

b) communicating with another DM mobile via the DM air interface Ud and monitoring the trunked mode control channel over the trunked mode air interface Um; or alternatively

c) communicating with TETRA SwMI in normal TETRA trunked mode via the trunked mode air interface Um and monitoring a DM channel.

It is important to stress in the dual watch case that simultaneous active circuit mode communication over the two air interface types is not supported by the standard.

For switchable terminals a similar reference model applies but there is no capability to monitor the inactive channel. With switchable terminals either the basic trunked mode or the basic DM reference model would apply at any one time.

### 5.4 Repeater reference model

This model applies to DM operation using a repeater between the end terminals.


**Figure 4: Repeater reference model**

The diagram shows a link between the DM-MS's using the DM air interface Ud via the Repeater (REP).

The repeater terminal re-transmits information received from one mobile or set of mobiles to another mobile or set of mobiles and vice versa. There are different possibilities for repeater operation as defined in clause 4, but in both cases repeater reception and transmission is carried out over the DM air interface Ud. There are three possibilities:

a) a linear transponder using two frequencies, receiving an "uplink" on one DM frequency and re-transmitting the same information in an unmodified form as a "downlink" on another DM frequency;

b) a regenerating transponder again using two frequencies, one as an "uplink" and another as a "downlink", but differing from the type 1 case by performing de-encoding and re-encoding in order to regenerate transmission bits and improve Bit Error Ratio (BER);

c) a time division regenerating repeater which operates on a single transmit and receive frequency and repeats bursts received from the originating DM mobile within different time slots in the burst structure.

Depending on the repeater type the Ud interfaces on each side of the repeater could be on either the same or different DM channels.

### 5.5 Gateway reference models

This model applies to DM operation using a gateway into a TETRA network.


**Figure 5: Gateway into a TETRA SwMI**

When the desire is to interconnect between DM operation and trunked TETRA a gateway terminal should be employed. The gateway caters for the differences in protocol and provides for the required interfaces between DM and the trunked TETRA network.

### 5.6 Repeater/gateway combination reference models

This model applies to a combined repeater/gateway operation for example where a vehicle based repeater serving a DM communication is also required to link back to the trunked TETRA network.

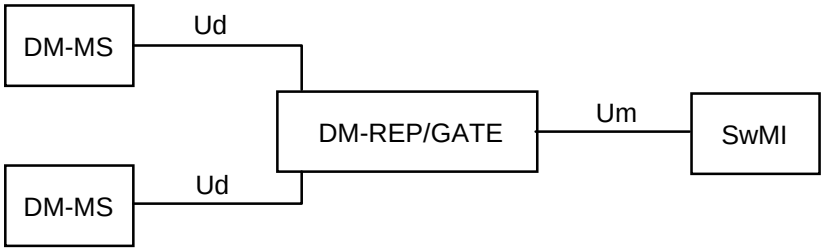


**Figure 6: Repeater/gateway combination into a TETRA SwMI**

The air interfaces for the above reference model are standard TETRA for the link between the gateway and the TETRA SwMI, and a DM air interface for the links from the DM terminals to the gateway (repeater included).

### 5.7 MS reference interfaces

In all of the above reference models, the MS has been only identified as a complete entity. In reality, when examining the MS in further depth it is useful to define reference access points for the DM terminal equipment connected to the DM air interface Ud. These interface points have been defined here so as to follow a standard TETRA notation in order to be compatible with existing TETRA standards.

The MS comprises a Mobile Termination Unit (MTU) and possibly additional Terminal Equipment (TE). The TE, where included, supports:

a) the DM application;

b) the man machine interface to the user; and

c) the interface to the MTU.

The MTU supports the functions specific to the DM air Interface and also for the interface to the TE. Each MTU contains the entire physical air interface protocol stack. A convenient reference point R0 has been defined to correspond to the top of the mobile radio stack not including the routing. R0 therefore provides a convenient service boundary and exists in all MTU types. Reference point R2 has been defined in the TETRA V+D standard for the air interface and will also be used here.

The following reference diagrams show different MTUs (MTU-0, MTU-2 ) corresponding to options which may exist in differing implementations of a DM mobile terminal.

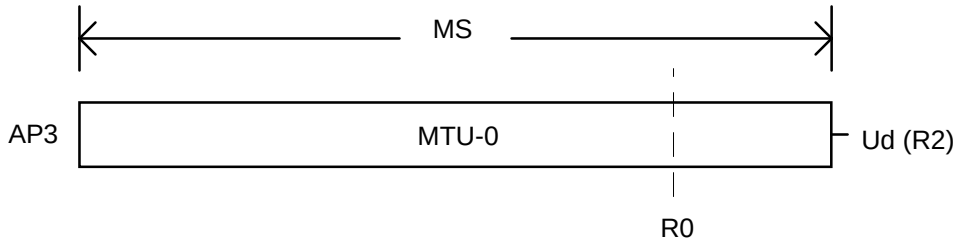


**Figure 7: DM terminal reference points - MTU type 0**

Here the MS comprises a MTU type 0 offering a user terminal interface at AP3 corresponding to the situation for teleservices and bearer services where an end-end service is provided. Internal to the MTU the reference point R0 is defined.

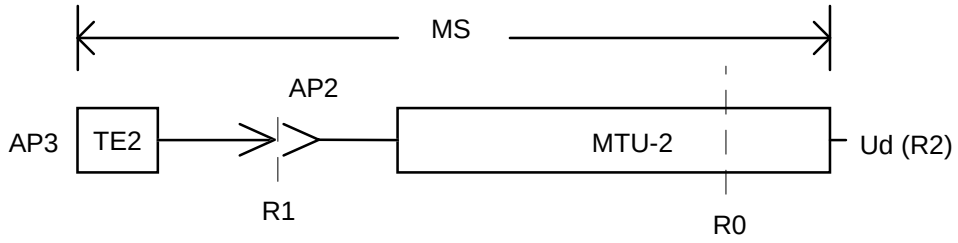


**Figure 8: DM terminal reference points - MTU type 2**

Here the MS comprises a MTU type 2 and an additional terminal equipment TE2. The AP3 level corresponding to the user terminal interface in the prior case is in this instance provided by the TE2 terminal equipment.

Here an additional access point AP2 is available at a lower level in the mobile station protocol stack. R1 defines this reference point between TE2 and the MTU-2. There may be a number of alternative interface protocols at R1, dependent on the implementation of the mobile. Again, internal to the MTU is the reference point R0 which exists for all MTU types.

### 5.8 Protocol stacks in the MS

To assist in the understanding of the previously defined reference points within the mobile terminals, the following subclauses identify how the various reference access points fit into the protocol stacks employed within the MS.

Figure 9 is a generalised protocol stack as pertinent to a TETRA DM mobile in a point-to-point communication over the DM air interface stack Ud. Reference points are in accordance with the previously defined mobile types and the terminology follows.

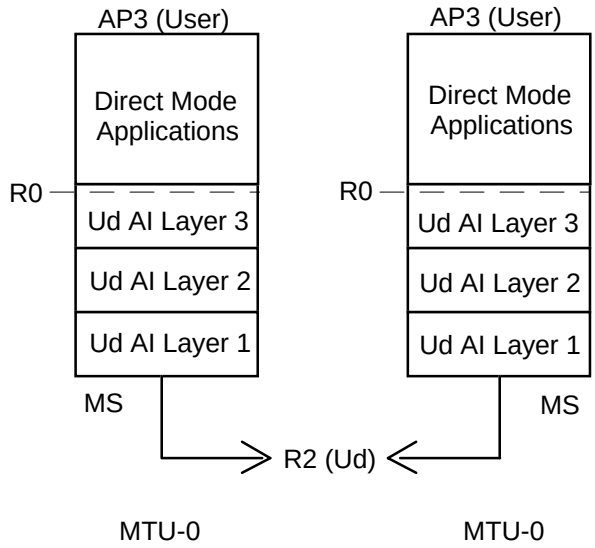


**Figure 9: Protocol stacks over the DM air interface (R2 reference point) for MTU type 0**

Figure 9 shows the basic protocol stacks which apply to a simple DM connection between two mobiles, in this case with MTU type 0. This case applies for example with DM teleservices which the MTU-0 supports to the user interface at AP3.

Air Interface encryption applied to both data and signalling will be provided within the lower layers as an option and will be TETRA standardised.

The DM applications layers can also support additional end-to-end user encryption which may also be TETRA standardised.

With alternative mobile types, e.g. MTU type 2 there are some differences in the protocol content in the stacks. With MTU type 2, user access is possible at both the AP3 and the AP2 interface (R1 reference point) and the TE can be thought of as a distinct unit forming part of the mobile.

Figure 10 is another example stack to illustrate this showing an end-to-end DM connection between an MTU type 2 and an MTU type 0.

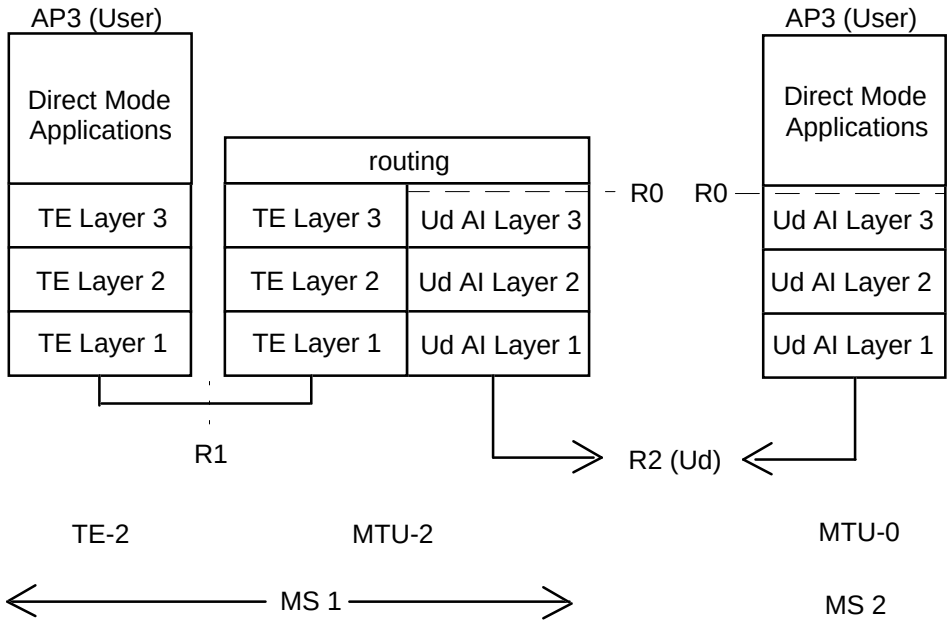


**Figure 10: Protocol stacks for MTU type 0 - MTU type 2 connection**

The detailed definition of the protocol content of each layer will depend on the terminal equipment types.

## 6 Operating scenarios

This clause identifies a number of typical operating scenarios which may be encountered with MSs equipped for DM operation.

They are provided here as a guide to help visualise situations in which DM mobiles could be applied and to illustrate the connectivity considerations which may arise in certain applications. Usage of gateways and repeaters has been included to illustrate in which scenarios they may be typically employed.

In clause 4 it is clear that there are a large number of ways in which DM mobiles could be connected. There are of course a vast number of possible permutations and combinations of how a collection of DM mobiles could be connected, and it would be difficult and probably not practical to try and cover all eventualities.

The following subclauses identifies those connectivities which are considered most likely to be encountered in a real application. The terminology used is in accordance with the abbreviations defined earlier in this ETR.

One or several of these possibilities can be encountered in a single scenario. For clarity however, and in order to make each scenario unambiguous, the scenarios have been kept as simple as possible, with as few connectivity permutations as possible. In real situations, it is of course possible that a number of these following possibilities could be combined.

### 6.1 All DM terminals outside of TETRA network coverage (DM-DM)

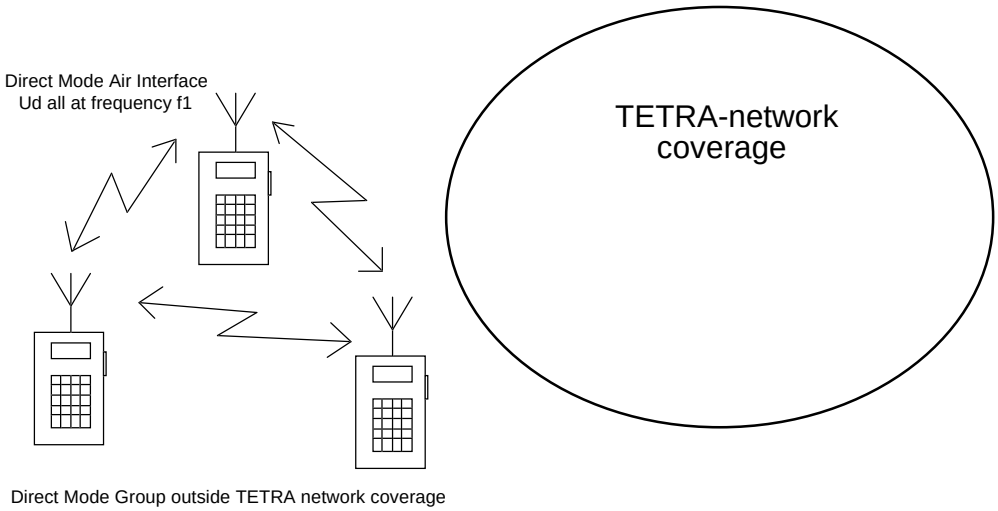


**Figure 11: DM operation outside of TETRA network coverage**

The figure shows the scenario where a DM group is communicating whilst all of the group terminals are all outside of the coverage zone of the TETRA network. A group call is shown, but the same scenario could also apply to an individual call between two terminals.

DM allows these users to communicate when they are outside of the coverage of a TETRA network. Communication takes place using specific DM channels which are distinct and separate from the standard TETRA trunked mode channels, and which are outside the control of the TETRA network.

When a terminal leaves the coverage zone of a TETRA network and cannot find the control channel of a network it is allowed to roam, and it may alert the user of being outside system coverage. Similarly, if the terminal is switched on and cannot find a trunking control channel, it may alert the user. With a DM capable terminal, the user is then able to switch the terminal into DM if desired.

If the terminal is a dual watch type, then the user can be re-alerted (should the facility be available and have been activated) at the point when the mobile comes back into the coverage zone of the TETRA network as the dual watch terminal can periodically check for the availability of a trunked mode control channel.

The same operational scenario applies with DM only terminals wishing to communicate, but of course DM only terminals can neither monitor nor switch back to trunked mode operation if they come within reach of a TETRA network.

### 6.2 All DM terminals inside of TETRA network coverage (DM-DM)

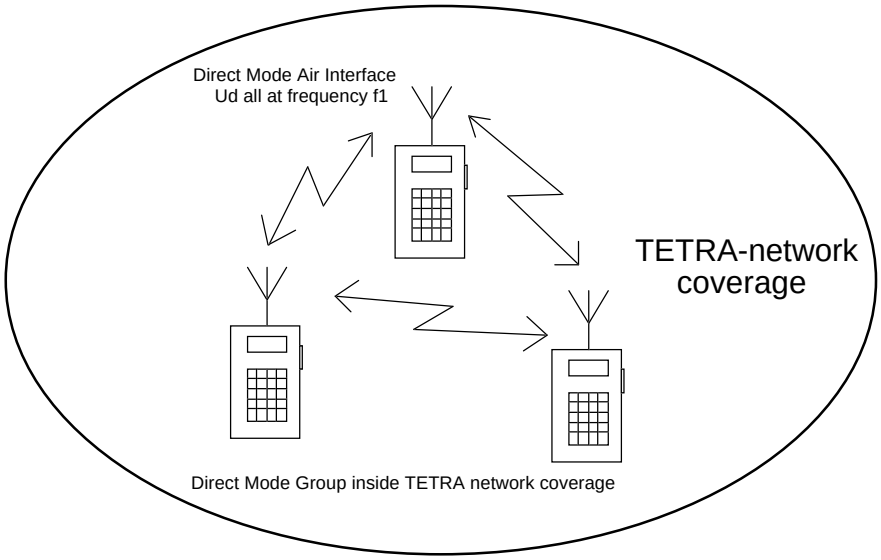


**Figure 12: DM operation within TETRA network coverage**

In this scenario, a number of DM capable mobile terminals are participating in a group call whilst they are within the coverage zone of the TETRA network. A group call situation is again shown, but the same scenario could equally apply to a broadcast or an individual call.

As in the previous scenario, if the mobiles were DM only this would be their only means of communication and so would be an identical scenario to the previous one.

With switchable terminals and dual watch terminals, the capability exists for operating in both direct and trunked modes. DM may be used by such terminals whilst inside system coverage for the following reasons:

a) users do not want to be dependent on the accessibility of the TETRA network, an example being when they are close to the coverage boundary;

b) users may wish to have maximum privacy;

c) many communications are short range and do not need a network therefore making it unnecessary to occupy network resources.

In this scenario, a dual watch terminal participating in a DM communication is able to monitor the trunking control channel for incoming calls from the TETRA network whilst participating in a DMl call within the group.

A switchable terminal applied to this scenario could of course operate in either DM or trunked mode, but these would be mutually exclusive.

### 6.3 Terminals both outside and within the TETRA network coverage zone 1(DM-DM)

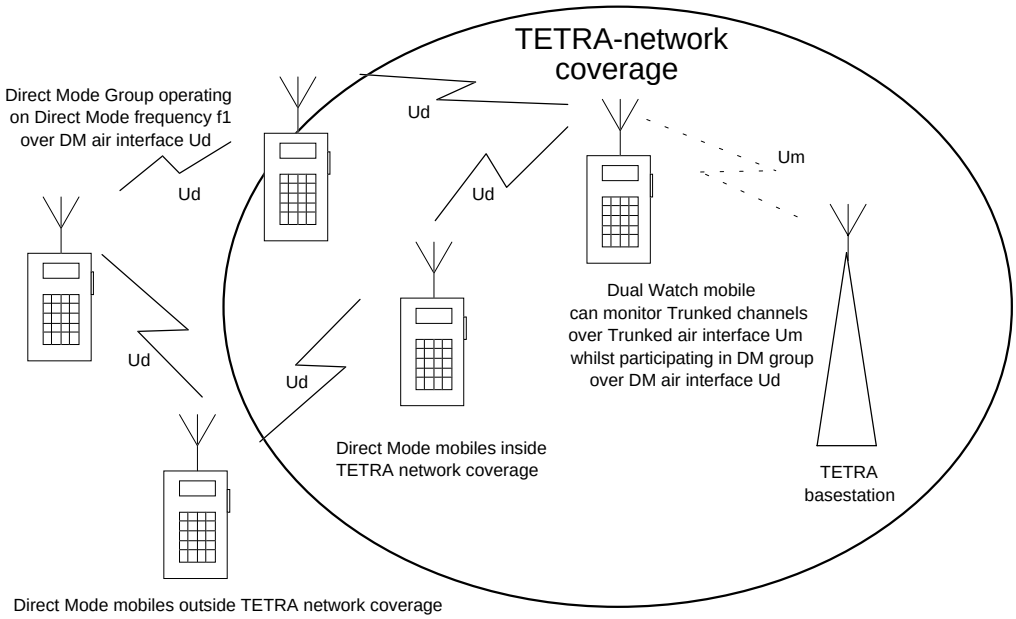


**Figure 13: DM operation overlapping the boundary of TETRA network coverage**

This scenario corresponds to the situation where DM communication is in use at the edge of network coverage clearly displaying the advantages of DM operation at the edge of network coverage in order to maintain the group integrity. Some of the terminals involved in the communication are inside coverage while others are outside of coverage. Those terminals which are inside coverage can use dual watch if they have this capability.

In this scenario, for example it is possible for dual watch terminals to monitor both the trunking control channel and a DM channel for incoming calls. In addition as demonstrated in the figure, under normal circumstances, a dual watch terminal participating in a DM communication is able to monitor the trunking control channel for incoming calls from the TETRA network whilst participating in a DMl call within the group.

An example advantage of dual watch is where a terminal is participating in a DM communication receives indication of an emergency call on the trunking control channel. It could then terminate the DM communication and switch to the emergency call on the Trunking system.

### 6.4 Terminals both outside and within the TETRA network coverage zone #2 (DM-DM)

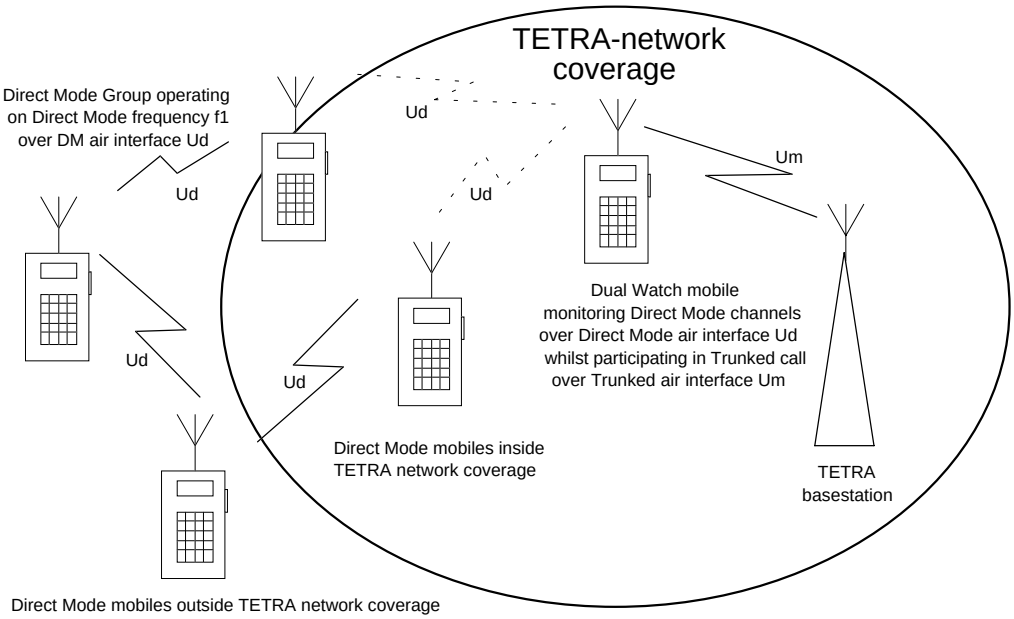


**Figure 14: DM operation overlapping the boundary of TETRA network coverage**

In this diagram the scenario is similar to the previous one, but here the dual watch terminal is participating in a trunked mode communication via the SwMI and is also able to monitor a selected DM channel for activity. It can be switched if desired to participate in the DM call if required.

### 6.5 Connection with a TETRA network coverage via a gateway (DM-GATE-SwMI)

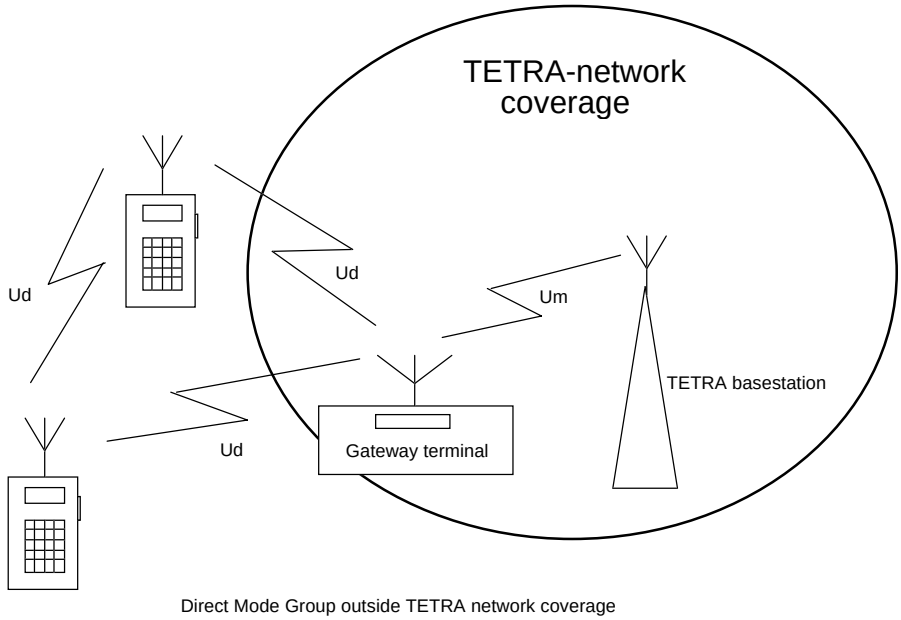


**Figure 15: Extension of TETRA network coverage using a gateway**

This scenario shows how DM operation can be used as a means of extending the coverage of a TETRA network by use of a DM gateway terminal. The gateway has to remain within the TETRA coverage zone in order to maintain communication into the network, and it provides the interfacing between the DM and trunked modes of operation over the Ud and Um air interfaces respectively. With the use of a gateway, the DM group terminals can maintain connectivity back to the TETRA network with limited services and facilities whilst they fall within the coverage zone of the gateway terminal. The same scenario can also apply to DM terminals inside the TETRA coverage zone.

### 6.6 Extension of DM coverage using a transponder repeater (DM-REP-DM)

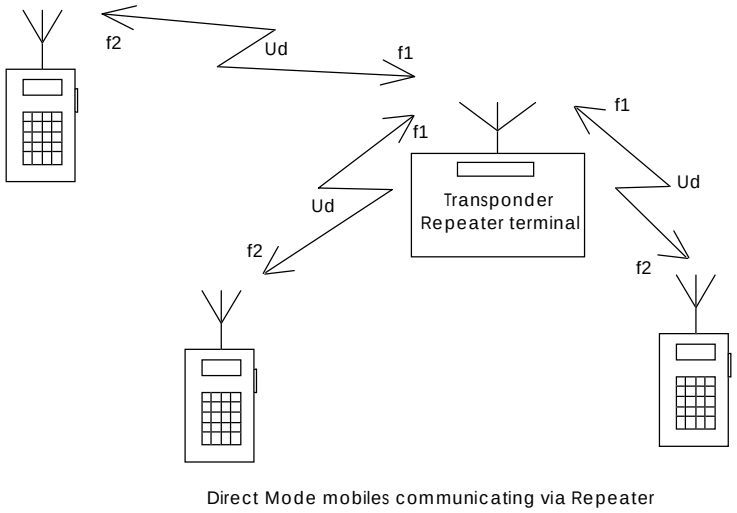


**Figure 16: Extension of DM coverage using a transponder repeater**

This scenario shows how a group of DM mobiles can be connected with a distant mobile by use of a repeater. In this scenario a single repeater terminal is used in order to extend the coverage zone of a DM group to enable a distant mobile to still participate in the group. Usage of a repeater terminal here is analogous to that found in the existing analogue situation, to provide increased range by virtue of the improved power output capability of the repeater terminal. The repeater terminal could for example be based in a car and thus have the benefit of improved power supply and thus increased range.

The air interface here is the normal DM air interface but the transponder repeater effects a frequency translation in order to provide isolation between transmission and reception. "uplinks" from mobiles to the repeater are shown at frequency f1 and the "downlinks" from repeater to mobile as f2.

### 6.7 Extension of DM coverage using a time division repeater (DM-REP-DM)

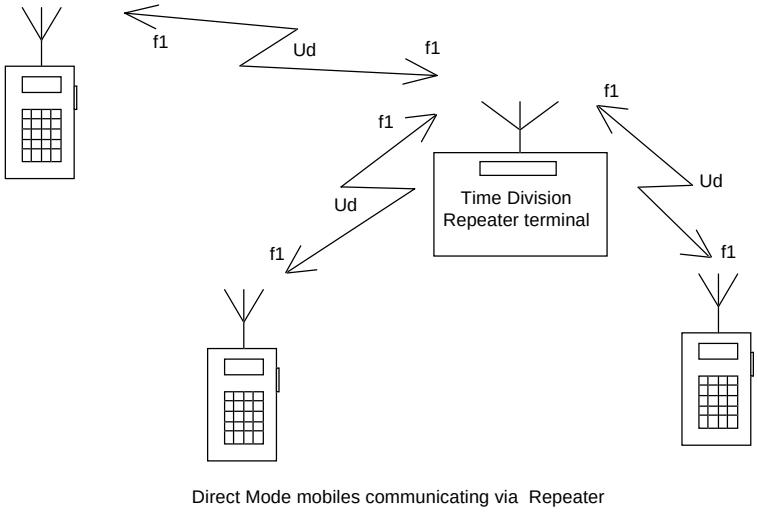


**Figure 17: Extension of DM coverage using a time division repeater**

This scenario is similar to the previous one, but here a time division repeater is employed which regenerates the bit stream but which does not effect a frequency translation. Transmit/receive isolation is provided by the fact that the bursts are repeated a number of time slots after reception. "uplinks" therefore received by the repeater on one timeslot would be repeated on a later timeslot on the "downlink" as shown.

### 6.8 Extension of DM coverage using repeater gateway combinations

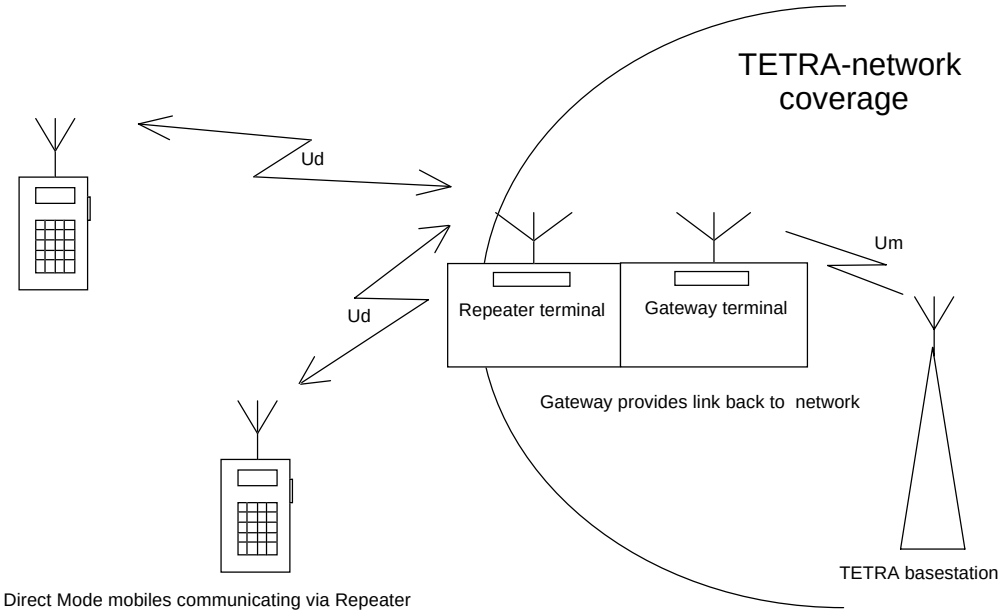


**Figure 18: Extension of DM coverage using a combined repeater/gateway**

This scenario utilises a combined repeater/gateway to provide, firstly the advantages of the repeater in improving the range of the DM group, and secondly the link back to the TETRA trunked network which is provided by the gateway. This scenario could be encountered in vehicle based mobiles supporting a DM group where a link back to a dispatch room would be provided via the gateway.

The repeater functionality in this scenario can be provided by any of the repeater types defined in the earlier subclause.

It should be noted that the above figure is not meant to pre-suppose any implementation issues pertinent to this combination.

## 7 Services supported by TETRA DM

### 7.1 Service definitions

In TETRA DM two distinct classes of basic service are provided, teleservices and bearer services. The following figure illustrates in a simple sense the basic differences between these two services in terms of the user access point and where it is provided within the mobile.

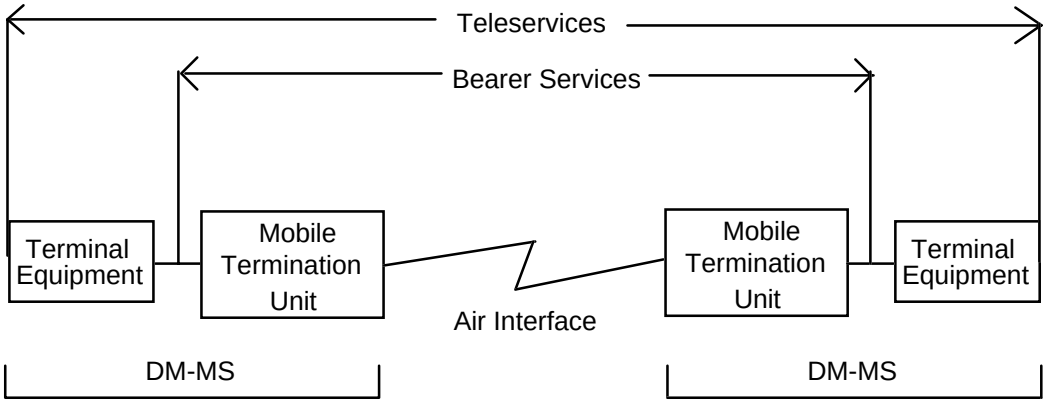


**Figure 19: DM bearer services and teleservices**

This figure shows a breakdown of the DM capable mobile terminal (DM-MS) into its constituent parts - the MTU and the TE.

The following definitions aim to clarify the differences between the services offered by DM.

### 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 low layer functions (layers 1-3). The customer may choose any set of high layer protocols (layers 4-7) for his communication, but the bearer service will not ascertain compatibility between customers at these layers.

### 7.1.2 Teleservice

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

### 7.1.3 Intrinsic service

An intrinsic service is a service which is inherent within a teleservice or bearer service. It exists by virtue of it being included as an integral part of the signalling associated with one or other of the basic service types.

## 7.2 Summary of basic services supported

TETRA DM has been conceived with a number of basic services in mind falling within the above categories.

It must be remembered that due to the lack of a network infrastructure in DM operation, the complete range of basic and supplementary services offered in the trunked standard cannot be supported under DM operation.

Table 1 gives a simple summary of the basic voice and data services which are to be supported in DM operation.

**Table 1: Voice and data services to be supported in DM**

| | Basic teleservice | Basic bearer service |
|---|---|---|
| TETRA Clear Speech | Ind. Call (Pt-Pt)<br>Group Call (Multipt) | |
| TETRA Encrypted Speech | Ind. Call (Pt-Pt)<br>Group Call (Multipt) | |
| Circuit Mode Unprotected Speech/Data | None | 7,2 kbit/s (Pt-Pt)<br>7,2 kbit/s (Multipt) |
| Circuit Mode Protected (low) Data | None | 4,8 kbit/s (Pt-Pt)<br>4,8 kbit/s (Multipt) |
| Circuit Mode Protected (high) Data | None | 2,4 kbit/s (Pt-Pt)<br>2,4 kbit/s (Multipt) |
| Short Data Service | None | Packets (Pt-Pt)<br>Packets (Multipt) |

## 7.3 Description of services supported in DM operation

### 7.3.1 Voice teleservices

TETRA DM voice teleservices will support the transmission of both clear and encrypted speech

Clear speech will use standard TETRA speech and channel coding as defined in ETS 300 392-2 [1].

Encrypted speech will also use standard TETRA speech and channel coding and as defined in ETS 300 392-2 [1].

Provision will be made to protect call progress by means of suitable hang times following the end of each transaction.

The following subclauses give a brief description of each of the voice and teleservice possibilities.

#### 7.3.1.1 Individual speech call

An individual call is a two way point-to-point communication between one calling party and one called party. It can only be set up between two terminals which have selected the same DM channel. Individual terminals have a pre-defined number which is called its individual number and by which it is addressed. The DM air interface (Ud) uses the same addressing scheme for individual numbers as defined in ETS 300 392-2 [3].

The normal mode of operation is simplex.

#### 7.3.1.2 Group speech call

A group call is a two way point-to-multipoint communication between a calling party and one or more called parties. It can only be set up between terminals 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 DM air interface (Ud) uses the same addressing scheme for group numbers as defined in ETS 300 392-2 [3]. This would support more than one group on a DM channel although only one group would be able to communicate using the channel at any given time.

In addition, there should 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 in TETRA terminology) is sent on the air interface and no acknowledgement is expected. The primary objective is to have a fast call set up.

It is assumed that the conversation is carried out in simplex mode and all users participating in the group call have a press to talk switch or equivalent.

The normal mode of operation is simplex.

### 7.3.2 Bearer services

Bearer services are provided in DM as a means to transfer data between DM terminals via the DM air interface.

This data can be speech or any other form of data. What the DM bearer service offers is similar to a data "pipe", and the transmission effected through that pipe is independent of its content.

Three circuit mode bearer services are offered within TETRA DM depending on whether or not the data is protected or unprotected, and depending on the level of protection provided. The only difference between the protected and unprotected bearer services is that the protected bearer service provides error protection 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 net reduction in the user data rate.

Provision will be made to protect call progress by means of suitable hang times following the end of each transaction.

#### 7.3.2.1 Circuit mode unprotected bearer services

Circuit mode unprotected bearer services are intended to support speech and data on a point-to-point, and point-to-multipoint circuit mode configuration. This service will be able to support non-standardised coding and encryption for speech or data however intelligibility cannot be guaranteed unless end systems use the same higher level protocols.

A circuit mode bearer connection is a two way point-to-point or point-to-multipoint data communication between one calling terminal and one or more called terminals. It can only be set up between terminals which have selected the same DM channel.

The normal mode of operation is simplex.

#### 7.3.2.2 Circuit mode protected bearer services

Circuit mode protected bearer services are intended mainly to support data on a point-to-point and point-to-multipoint basis. These services offer two levels of protection against bit error by using forward error correction in the transmitted bit stream. Speech transmission via protected bearer services will not be specifically excluded by the standard.

### 7.3.3 Short data service

The TETRA DM short data service will offer the same capabilities as that offered in the TETRA V+D standard. Both point-to-point and point-to-multipoint service will be supported.

This service provides a point-to-point and point-to-multipoint capability for sending a short message from one originating terminal to one or more receiving terminals. It is envisaged that the message will comprise of a limited number of data bits with the meaning being user defined. This could be used for applications such as automatic vehicle location, status or over the air re-keying.

A point-to-point data message is sent from one originating terminal to one receiving terminal using the currently selected channel. The receiving terminal is addressed by an individual number using the same addressing scheme as described in the TETRA voice and data standard. The receiving terminal may acknowledge receipt of the message and the originating terminal may retry a number of times if acknowledgement is expected and if no acknowledgement is received.

A point-to-multipoint data message is sent from one originating terminal to a group of one or more receiving terminals using the currently selected channel. The group is addressed by a group number using the same addressing scheme as described in the TETRA voice and data standard. There may be no acknowledgement from the receiving terminals but the originating terminal may re transmit the message a number of times for reliability.

There should be a group number which addresses all users currently listening on that channel.

## 7.4 Intrinsic services

### 7.4.1 Introduction

The following sections describe the intrinsic services applicable to DM. An intrinsic service is defined as a service which is inherent in a voice or data service. It is offered in association with all of the voice and data services described in the previous sections and forms an integral part of the signalling on the Ud interface.

### 7.4.2 DM late entry

This intrinsic service allows a terminal, 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 terminal can access a DM channel in a number of ways, for example:

a) the user switches the terminal from trunking mode to DM and selects that channel;
b) the user switches on the terminal and selects that channel;
c) the user switches from another DM channel to that channel;
d) the terminal returns to DM coverage after a period of lost coverage.

This service requires that, during a call, the transmitting terminal has to periodically transmit the group or individual number to which that call is addressed.

### 7.4.3 Transmitting party number identification

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

A user option would allow the transmission of the number to be disabled. This would allow a transmitting terminal to conceal its identity which may be required for certain authorised users.

### 7.4.4 Emergency calls

It is essential that the DM air interface supports emergency calling. A DM terminal initiating an emergency call out of coverage of the system has to use a DM channel and, if necessary, pre-empt any communication using that channel.

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

## 8 Services using a DM repeater

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

### 8.1 Voice and data services supported

It is envisaged that the repeater simply receives information on an inbound DM channel and re transmits the same information on an outbound DM channel. Therefore all of the voice teleservices and voice and data bearer services described in the clauses of this ETR should also be supported by DM repeater operation.

### 8.2 Intrinsic services

The same set of intrinsic services described for the DM air interface should be supported for DM repeater operation. In the case of Transmitting Party Number Identification (TPNI), it should be noted that the repeater should convey the number of the source terminal, and not its own address.

In addition, the intrinsic service is required given in the following subclause.

### 8.2.1 Repeater selection

This intrinsic service is similar to the Continuous Tone Controlled Signalling System (CTCSS) for analogue conventional radio. A DM terminal transmitting in repeater mode has to transmit some signalling to ensure that it keys up the correct repeater. Throughout transmission from the DM terminal, an address identifying the appropriate repeater has to be periodically transmitted. The repeater on receiving this address keys up its transmitter to re transmit the received information.

A possible scenario which describes the use of this function is given below.

A number of repeaters can be installed in a area to cover some specific actions. The frequency allocation will take care of a geographic separation for frequency reuse, nevertheless some protection has to be offered in the case where a DM terminal lies between two repeaters that use the same frequency. This problem is even more clearly illustrated where a repeater is installed on a vehicle that moves through an area and can get very near another repeater station using the same frequency.

## 9 Services using a direct/trunking mode gateway

A direct/trunking mode gateway terminal provides a gateway between the TETRA trunked air interface and the DM air interface. This is described in clause 4.

All of the voice teleservices and voice and data bearer services available in DM should also be supported by operation through a gateway into the trunked system. Again In the case of TPNI, it should be noted that the gateway should convey the number of the source terminal, and not its own address.

The limitations are given below.

A DM terminal can obtain access to the services offered by the trunked system via a gateway. The DM terminal is however limited in its access to trunked services by the capability of the DM air interface.

A DM terminal accessing the trunked system via a gateway is therefore only capable of accessing those trunked services which are supported by the Ud interface.

## 10 Services using a repeater/gateway combination

The service restrictions mentioned above for discrete repeater and gateway working apply. The lowest common denominator of service provision will be available with this combination, mainly due to the restrictions imposed by the gateway.

## 11 The DM air interface

This clause is intended to define the requirements placed upon the DM air interface. This interface has to support all DM teleservices, bearer services and intrinsic services. The requirements in this clause apply with reference to DM reference model.

DM will utilise TETRA signalling and protocols as far as possible.

### 11.1 Channels

The channels to support the DM air interface should each be single frequency simplex for direct communication between radios. These channels will be programmed into the mobile terminal and the user will select one of them for communication. Calls can only be initiated or received on the currently selected channel.

The DM channel centres will be separated by multiples of 25 kHz.

In DM, over the air reprogramming of DM channels is not required.

DM mobiles operating together or in a group are operational on the same radio frequency, selected by the user, apart from those which are communicating via a transponder repeater.

### 11.2 Presence checking in DM

There are two possibilities for call set-up in DM operation:

a) the calling mobile in an individual call or group call may directly start transmission without checking for the availability of the called mobile - this is the basic direct set-up mode and is the default method;

b) the calling mobile in an individual call may first perform a check to ascertain the availability of the called mobile within its coverage range, and only starts transmission after receiving a positive indication of presence - this is direct set-up with an initial presence check.

## 12 DM dual watch

Dual watch allows a terminal using a DM service to monitor the TETRA trunking control channel for any incoming signalling. It also allows a terminal in TETRA trunking mode to monitor a DM channel. This section defines the requirements for dual watch operation using the reference model defined in this ETR and in the light of the DM service requirements.

### 12.1 Idle state

A terminal 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 trunked mode, a terminal would generally be listening to the trunked control channel. In DM, a terminal would generally be listening to the currently selected DM channel. A dual watch terminal, in the idle mode, has the ability to alternate between listening to the trunked control channel and one or more DM channels. In this way it is able to monitor for an incoming call on either of the DM (Ud) or trunked (Um) air interfaces.

### 12.2 Active state

A terminal is defined as being in the active state when it is transmitting or receiving to participate in a call. A terminal may be active either in a DM call or a trunked call. Dual watch provides the ability for a terminal, while active in a DM call, to periodically monitor the trunked control channel for activity.

#### 12.2.1 Active in DM

A dual watch terminal active in DM (any of the voice or data services described) has to be able to periodically listen to the trunking control channel. This implies that it has to cease DM transmission or reception and switch frequency to that of the trunking control channel to listen to information in a control channel slot. It has to then switch back to the DM channel and resume transmission or reception. There should be no noticeable degradation in the DM speech quality due to this monitoring. An acceptable solution would be to monitor only the control information in the 18th frame of the TETRA control channel (which is transmitted approximately once every second). It is not necessary to listen to every slot of the control channel.

If the dual watch terminal receives indication of a call on the trunking 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 dual watch terminal 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 trunked system may require that the DM communication is terminated and the terminal switches to participate in the trunked emergency call.

#### 12.2.2 Active in trunked mode

A dual watch terminal active in trunked mode (i.e. participating in a communication on the Um interface) may also be required to be able to monitor a DM channel.

## 13 Security

DM should provide for the same level of security as that available in TETRA trunked mode.

## 14 Performance figures

The following subclauses identify the performance requirements for the various DM operating options. These performance figures relate to the DM Ud interface as defined by reference models in this ETR.

### 14.1 Performance figures - DM basic operation

#### 14.1.1 Coverage area

A typical requirement for coverage range is from 400 m in urban areas to 1 km to 2 km in rural areas.

#### 14.1.2 Call set up time

The call set-up time is defined as the time between a transmitting user pressing the Press To Talk (PTT) and the receiving terminal emitting audio.

The maximum set-up time for all DMO clear speech transmissions is 150 msec.

The maximum set-up time for an emergency call requiring pre-emption is 500 msec.

NOTE: If no pre-emption is required (i.e. the channel is free), then the normal speech set-up time applies.

#### 14.1.3 Call maintenance

For the purposes of call maintenance, the group or called party's individual number has to be transmitted at least every 1 second.

### 14.2 Performance figures - DM repeater operation

The following performance figures relate to the DM Ud interface as defined by the DM repeater reference model.

#### 14.2.1 Call set up time

The call set-up time is defined as the time between a transmitting user pressing the PTT and the receiving terminal emitting audio.

The maximum set-up time for all DMO clear speech transmissions through a repeater is 250 msec.

The maximum set-up time for an emergency call through a repeater requiring pre-emption is 500 msec.

#### 14.2.2 Call maintenance

For the purposes of call maintenance, the group or individual called party's number has to be transmitted at least every 1 second, the same requirement as for simplex working.

#### 14.2.3 Repeater selection

For the purposes of repeater selection, the repeater address has to be transmitted at least every 1 second.

### 14.3 Performance figures - DM gateway operation

Call set-up times through a gateway may be 50 % to 100 % longer than for a repeater.

#### 14.3.1 Call maintenance

For the purposes of call maintenance, the group or individual called party's number has to be transmitted at least every 1 second, the same requirement as for simplex working.

#### 14.3.2 Gateway selection

For the purposes of gateway selection, the gateway address has to be transmitted at least every 1 second.

### 14.4 Performance figures - dual watch operation

A dual watch terminal, when active in DM, has to be able to listen to the trunked control channel approximately every second.

A dual watch terminal, when active in trunked mode, has to be able to listen to a DM channel approximately every second.

## History

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