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Technical Specification

Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 4: DMR trunking protocol



Reference

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM).

The present document is part 4 of a multi-part deliverable covering the Technical Requirements for Digital Mobile Radio (DMR), as identified below:

- Part 1: "DMR Air Interface (AI) protocol";
- Part 2: "DMR voice and generic services and facilities";
- Part 3: "DMR Data protocol";
- Part 4: "DMR trunking protocol".**

1 Scope

The present document contains technical requirements for Digital Mobile Radio (DMR) trunking systems operating in the existing licensed land mobile service frequency bands, as identified in CEPT/ERC/T/R 25-08 [11].

The present document describes the trunking services and facilities protocol of a scalable Digital Mobile Radio system, which covers three tiers of possible products:

- Tier I: DMR equipment having an integral antenna and working in Direct Mode (unit-to-unit) under a general authorization with no individual rights operation.
- Tier II: DMR systems operating under individual licences working in Direct Mode (unit-to-unit) or using a Base Station (BS) for repeating.
- Tier III: DMR trunking systems under individual licences operating with a controller function that automatically regulates the communications.**

NOTE: Tier II and Tier III products encompass both simulcast and non-simulcast systems.

The DMR air interface complies with either EN 300 113-1 [1], EN 300 113-2 [2] or EN 300 390-1 [3], EN 300 390-2 [4], that has been specifically developed with the intention of being suitable for all identified product tiers.

The DMR protocol is intended to be applicable to the land mobile service frequency bands, physical channel offset, duplex spacing, range assumptions and all other spectrum parameters without need for any change.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

- [1] ETSI EN 300 113-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 1: Technical characteristics and methods of measurement".
- [2] ETSI EN 300 113-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and/or speech) using constant or non-constant envelope modulation and having an antenna connector; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".
- [3] ETSI EN 300 390-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and speech) and using an integral antenna; Part 1: Technical characteristics and test conditions".
- [4] ETSI EN 300 390-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Land mobile service; Radio equipment intended for the transmission of data (and speech) and using an integral antenna; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive".

- [5] ETSI TS 102 361-1: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 1: DMR Air Interface (AI) protocol".
- [6] ETSI TS 102 361-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 2: DMR voice and generic services and facilities".
- [7] ETSI TS 102 361-3: "Electromagnetic compatibility and Radio spectrum Matters (ERM); Digital Mobile Radio (DMR) Systems; Part 3: DMR Data protocol".
- [8] IEC 61162-1 "Maritime navigation and radiocommunications equipment and systems - Digital Interfaces - Part 1: Single talker and multiple listeners".
- [9] "Unicode: technical standards" www.unicode.org.
- [10] ISO/IEC 9979: "Information technology - Security techniques - Procedures for the registration of cryptographic algorithms".
- [11] CEPT/ERC/T/R 25-08: "Planning criteria and coordination of frequencies in the land mobile service in the range 29.7 - 960 MHz".
- [12] ISO/IEC 646 (1991): "Information technology - ISO 7-bit coded character set for information interchange".
- [13] ISO/IEC 8859-series (1998 - 2001): "Information technology - 8-bit single-byte coded graphic character sets".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

1:1-mode: 1 payload channel mode

NOTE: 1:1-mode supports one "MS to fixed end" duplex call or one simplex call with an optional inbound Reverse Channel using a two frequency BS.

2:1-mode: 2 payload channel mode

NOTE: 2:1-mode supports two independent calls which may be either "MS to fixed end" duplex calls or simplex calls using a two frequency BS.

assigned channel: channel that has been allocated by the infrastructure to certain MSs using channel allocation command(s) addressed to those MSs

NOTE: An assigned channel may be allocated for secondary control purposes or for a circuit mode call.

asynchronous access: mode of operation whereby MS are permitted access to TS by employing the polite protocol defined in TS 102 361-2 [6]

NOTE: In this mode MS are not required to listen to a TSCC to first determine their access rights.

Base Station (BS): fixed end equipment that is used to obtain DMR services

bearer service: telecommunication service providing the capability for information transfer between access point

burst: elementary amount of bits within the physical channel

NOTE 1: The burst may include a guard time at the beginning and end of the burst used for power ramp-up and ramp-down.

NOTE 2: Two bursts with different length are defined for DMR. A TDMA bursts which has a length of 30 ms and a Reverse Channel burst which has a length of 10 ms.

NOTE 3: For detailed burst definition see TS 102 361-1 [5], clause 4.2.1.

NOTE 4: A burst represents the physical content (channel) of a timeslot.

call: complete sequence of related transactions between MSs

NOTE: Transactions may be one or more bursts containing specific call related information.

Caller Line Identity (CLI): ability to see who is calling you before answering the telephone

channel: in the Time Division Multiple Access (TDMA) slot structure arrangement a channel comprises the pair of same numbered slots on the inbound and outbound duplex frequencies

composite control channel: TSCC that may temporarily revert to a payload channel (if for instance the instantaneous traffic exceeds that which may be accommodated by the available payload channels)

Control plane (C-plane): part of the DMR protocol stack dedicated to control and data services

coverage area: geographical area within which the received signal strength from a radiating BS exceeds a specified threshold value

dedicated control channel: TSCC that is continuously transmitted by a TS and never reverts to a payload channel

Digital Mobile Radio (DMR): physical grouping that contains all of the mobile and/or fixed end equipment that is used to obtain DMR services

direct mode: mode of operation where MSs may communicate outside the control of a network

NOTE: This is communication technique where any MS (MS) may communicate with one or more other MSs (MSs) without the need for any additional equipment (e.g. BS).

duplex: mode of operation by which information can be transferred in both directions and where the two directions are independent

NOTE: Duplex is also known as full duplex.

Extended address: source or destination that is not an MS address (such as a PABX extension, PSTN number or IP address)

Supplementary Data Transfer Service: service to transfer supplementary data between DMR MS or MS/TS entities connected through gateways

First In First Out (FIFO): storage type that retrieves information in the order in which it was stored

fixed non-volatile storage: storage facility within a MS, the contents of which cannot be modified or added to by the operation of the MS or its user

high-rate : Packet Data Transmission that uses dual slot data timing

inbound: MS to BS transmission

information element: subset (field) within a PDU

intrinsic service: service which is inherent within a voice or data service

NOTE: It forms an integral part of the signalling associated with that voice or data service.

item: MS payload transmission from the point at which the PTT is pressed to the PTT released

line connected: call whereby one end of the call is connected to the radio system that does not use the DMR Air Interface

NOTE: Examples may be connection to the PSTN or a PABX.

logical channel: distinct data path between logical endpoints

message trunking: mode of operation that a payload channel is permanently allocated for the complete duration of the call, which may include several separate PTT items (several PTT activation's by separate terminals)

NOTE: The channel is only de-allocated if the call is (explicitly) released or if a time-out expires.

Mobile Station (MS): physical grouping that contains all of the mobile equipment that is used to obtain DMR mobile services

multi-part call set-up : call set-up procedure whereby the full source and destination address cannot be accommodated in a single CSBK signalling block

NOTE: The UDT procedure is invoked to transfer the address information using Multi Block Control (UDT) signalling. UDT is also invoked to transport supplementary and user data between DMR entities.

network personalization: configuration parameters appropriate to network configuration programmed into a MS that may be set by an external agency but not by the user of an MS

non-volatile storage: read/Write storage that stores information during operation of a MS that is protected from the effects of switching off the MS

outbound: BS to MS transmission

packet data : method for the transmission of information by which the information is transmitted as packets each containing a fragment of the total information to be transmitted

PARtition (PAR): Information Element used to partition MSs on a TS that implements two control channels (TSCCs)

payload: bits in the information field

personalization: configuration parameters that may be set by an external agency but not by the user of an MS

physical channel: TDMA burst

NOTE: The DMR radio frequency channel contains two physical channels.

polite protocol: "Listen Before Transmit" (LBT) protocol

NOTE: This is a medium access protocol that implements a LBT function in order to ensure that the channel is free before transmitting.

power-save-frame: sixteen time slots (480 ms) defining a period for sleeping MS to wake

privacy: secret transformation

NOTE: Any transformation of transmitted information that is derived from a shared secret between the sender and receiver.

Protocol Data Unit (PDU): unit of information consisting of protocol control information (signalling) and possibly user data exchanged between peer protocol layer entities

radio frequency channel: radio frequency carrier (RF carrier)

NOTE: This is a specified portion of the RF spectrum. In DMR, the RF carrier separation is 12,5 kHz. The physical channel may be a single frequency or a duplex spaced pair of frequencies.

random access attempt: period from the initiation of the random access procedure until the MS receives a response from the BS or abandons the procedure (e.g. after sending the maximum permitted number of retries)

read write storage: storage facility within the MS the contents of which may be modified by the operation of the MS. The stored data is lost when the MS is switched off

Received Signal Strength Indication (RSSI): root mean squared (rms) value of the signal received at the receiver antenna

registration (MS view): network procedure whereby the MS asks for and the TSCC grants access to a particular MS. The MS is required to inform the system whenever it enters a new registration area

servicing site: radio site that is currently providing service to the MS

signalling: exchange of information specifically concerned with the establishment and control of connections, and with management, in a telecommunication network

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

NOTE: Simplex is also known as half duplex.

single-part call set-up : call set-up procedure whereby the full source and destination address is accommodated in a single CSBK signalling block

site: totality of BSs and trunk site control equipment that processes calls in one location

slot: See time-slot.

superframe: 6 continuous TDMA bursts labelled "A" to "F"

NOTE: A superframe has a length of 360 ms and is used for voice payload only.

TDMA-frame: two continuous time-slots

time-slot: elementary time unit for allocation of a burst

NOTE: A timeslot has a length of 30 ms.

transmission: transfer period of bursts containing information or signalling

NOTE: The transmission may be continuous, i.e. multiple bursts transmission without ramp-up, ramp-down, or discontinuous, i.e. single burst transmission with ramp-up and ramp-down period.

transmission trunking: mode of operation that a payload channel is individually allocated for each call transaction (for each activation of the PTT)

NOTE: The channel is immediately de-allocated at the end of the call transaction (subject to unavoidable protocol delays).

Trunked Station (TS): physical grouping that contains all of the fixed end equipment in one location that is used to obtain DMR Tier III services

Trunk Station Control Channel (TSCC): control channel transmitted by the infrastructure to control the MS population

TS Authorization: complete procedure whereby a MS tests the System Identity code and an optional step of authentication to ascertain if it is permitted to gain access

Unified Data Transport: universal methodology used to transport data in DMR systems

user plane (U-plane): part of the DMR protocol stack dedicated to user voice services

vocoder socket: 216 bits vocoder payload

3.2 Symbols

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

Hz	absolute frequency
Nibble	4 bits grouped together
Octet	8 bits grouped together, also called a byte

3.3 Abbreviations

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

AI	Air Interface
BCD	Binary Coded Decimal
BER	Bit Error Rate
BS	Base Station

NOTE: A reference designating a fixed end device.

CACH	Common Announcement CHannel
CC	Colour Code
CCL	Call Control Layer
CLI	Caller Line Identity
C-plane	Control-plane
CRC	Cyclic Redundancy Checksum for data error detection
CSBK	Control Signalling BloCk
CSBKO	CSBK Opcode
DLL	Data Link Layer
DMR	Digital Mobile Radio
FEC	Forward Error Correction
FID	Feature set ID
FIFO	First In First Out
HMSC	High Level Message Sequence Chart
IE	Information Element
ID	IDentifier
IP	Internet Protocol
LB	Last Block
LBT	Listen Before Transmit
LC	Link Control
MBC	Multiple Block Control packets
MS	Mobile Station

NOTE: A reference designating a mobile or portable radio.

MSB	Most Significant Bit
MSC	Message Sequence Chart
PABX	Private Automatic Branch eXchange
PAR	PARtition
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PF	Protect Flag
PL	Physical Layer
PSTN	Public Switched Telephone Network
PTT	Push To Talk
RC	Reverse Channel
RF	Radio Frequency
RS	Reed-Solomon code
RSSI	Received Signal Strength Indication
SAP	Service Access Point

NOTE: Where a network provides a service.

SDL	Specification and Description Language
SFID	Standard FID
SLCO	Short LC Opcode
SYNC	SYNChronization
TDMA	Time Division Multiple Access
TS	Trunked Station
TSCC	Trunk Station Control Channel
UAB	UDT Appended Blocks
UDT	Unified Data Transport

Unicode	16 bit character encoding
U-plane	User-plane

4 Overview

The present document describes a Digital Mobile Radio (DMR) protocol for Tier III trunked mobile radio systems that employ a Time Division Multiple Access (TDMA) technology with a 2-slot TDMA solution and RF carrier bandwidth of 12,5 kHz.

Radio equipments (fixed, mobile or portable), which conform to the present document shall be interoperable with equipment from other manufacturers. Radio equipment of the present document shall also comply with TS 102 361-1 [5]. The payload voice channel procedures specified in clause 6.6.2 closely follow the procedures specified in TS 102 361-2 [6]. Similarly the packet data is transported on a payload channel described in clause 6.6.3 follow the procedure specified in TS 102 361-3 [7]. Where differences exist those differences are stated in the payload channel clauses of the present document.

Slot formats, field definitions, and timing are defined for MS/BS (TS/TSCC) control signalling. The standard can be used to implement a wide variety of systems, from small systems with only a few physical radio channels (even single physical radio channel systems), through to large networks, which may be formed by the interconnection of BS radio sites.

A description of the TDMA structure is provided followed by the basic slot formats and bit definitions appropriate to the trunking protocol. Where procedures are common to the Service and Facilities defined in TS 102 361-2 [6] and TS 102 361-3 [7], only the differences are described in the present document.

The present document does not provide the specification or operational detail for system implementation that include but are not limited to network management, vocoder, security, data, subsystems interfaces and data between private and public switched telephone networks. It describes only the appropriate access requirements compatible with the Air Interface.

The protocol offers a broad range of user facilities and system options. However, it is not necessary to implement any or all of the facilities available; an appropriate subset of the protocol could be implemented, according to the user requirements. Also, there is scope for customization for special requirements, and provision has been made for further standardized facilities to be added to the protocol in the future.

The standard defines only the over-air signalling and imposes only minimum constraints on system design.

Trunked radio systems are characterized by regulating channel access. A logical channel is assigned as a control channel (TSCC). The TSCC has an Inbound path for transmissions from MSs (inbound and outbound path for transmissions from the Trunked Station (TS) to MSs (outbound channel). Control channel packets generated by a Trunk Station Control Channel (TSCC) transmit on the outbound path that all MSs listen to when not involved in a call. MSs request access to the system by random access. The system resources are then granted by the Trunk Station Control Channel (TSCC). This trunking protocol is designed to minimize the signalling required to provide MSs with a particular service in order to provide the greatest possible throughput.

Trunked radio systems may be characterized by the following possible configurations:

- a) Dedicated Control Channel:
 - A Trunk Station Control Channel (TSCC) is transmitted continuously. This channel occupies one DMR TDMA channel. MS access is strictly controlled and access is by invitation only. One TSCC can support a large number of payload channels. There are a number of tier III services (such as short data messaging) that only utilize the TSCC. This mode of operation yields the highest performance and throughput.

b) Composite Control Channel:

- A Trunk Station Control Channel (TSCC) may revert to a payload channel if a payload services is requested and no other payload channels are available. When the payload call is completed, the channel returns to its control channel function. The ability to have composite control channels is of benefit for TS with a very small number of physical radio channels. When the TSCC reverts to a payload function. MS who remain idle lose the control channel and cannot access the system and its services until the control channel returns. Thus the throughput and performance must be assessed and balanced with the benefits of the additional temporary payload channel. The present document does not specify if a TSCC shall continuously transmit slots inviting access.

c) "Time Share" Control Channel:

- The term "time-shared control channel" refers to a control channel where multiple TS (whether co-sited or multi-sited) share one physical radio channel for control purposes by dividing the use of the frequency in time. (not to be confused by DMR TDMA). Each TS transmits a burst of control channel activity in turn. This mode of operation is complicated in DMR systems because each physical channel is able to support two independent TDMA logical channels. The present document does not attempt to solve the difficulty. ETSI-DMR does not support time-share control channels.

d) Asynchronous Access:

- In some radio spectrum, independent users/agencies share frequencies and national administrations mandate that when not transporting payload, the TS must de-key and yield use of the channel(s) to the co-channel users (i.e. by default, the equipment is de-keyed). Also, there can be no interconnection between the independent users/agencies because, they are independent and may not even be co-located at a site (independent users/agencies may not wish to coordinate use of the channel). Additionally, some co-channel users may just be conventional talk-around users, in which case there is no fixed end equipment to coordinate. What may be practical in this scenario is to trade-off (or sacrifice) control channel capacity/performance for the ability to support trunking. The present document provides the facility for MS to activate a physical TSCC channel whereupon a short burst will regulate and invite access.

4.1 Protocol architecture

The purpose of this clause is to provide a model where the different functions and processes are identified and allocated to different layers in the DMR protocol stack.

The protocol stack in this clause and all other related clauses describe and specify the interfaces, but these stacks do not imply or restrict any implementation.

The DMR protocol architecture that is defined herein follows the generic layered structure, which is accepted for reference description and specification of layered communication architectures.

The DMR standard defines the protocols for the following three-layered model as shown in figure 4.1.

The base of the protocol stack is the Physical Layer (PL), which is the layer 1.

The Data Link Layer (DLL), which is the layer 2, shall handle sharing of 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 (e.g. voice or data stream), and the Control plane (C-plane) for signalling with addressing capability, as illustrated by figure 4.1.

The Call Control Layer (CCL), which is layer 3, lies in the C-plane and is responsible for control of the call (addressing, facilities), provides the services supported by DMR, and supports the Data Service. U-plane access at layer 2 (DLL) supports voice and packet data service, which is available in DMR. The Control Layer and the facilities and services offered by Tier III DMR are described in the present document.

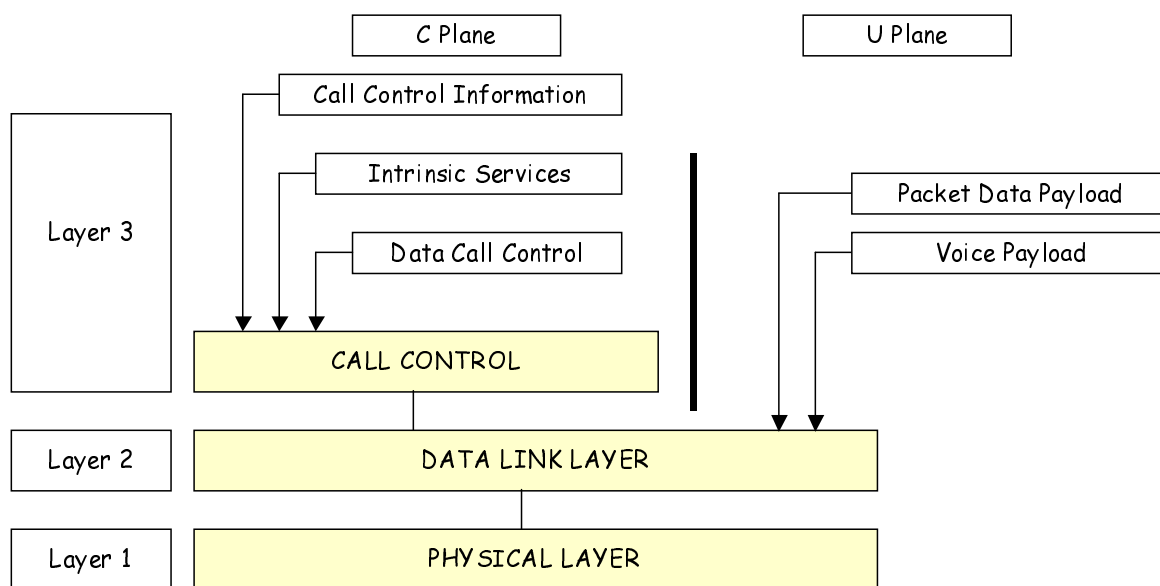


Figure 4.1: DMR protocol stack

4.1.1 Air Interface Physical Layer (layer 1)

The Air Interface layer 1 shall be the physical interface. It shall deal with the physical burst, composed of bits, which is to be sent and/or received. The Physical Layer is described in part 1 of this multi-part deliverable, see TS 102 361-1 [5].

The Air Interface layer 1 contains the following functions:

- modulation and demodulation;
- transmitter and receiver switching;
- RF characteristics;
- bits and symbol definition;
- frequency and symbol synchronization;
- burst building.

4.1.2 Air Interface Data Link Layer (layer 2)

The Air Interface layer 2 handles logical connections and hides the physical medium from the upper layers. The Data Link Layer is described in clauses 5 to 9 of TS 102 361-1 [5]. Layer 2 services are described in the present document if those services are not already described in TS 102 361-1 [5].

The main functions are as follows:

- channel coding (FEC, CRC);
- interleaving, de-interleaving and bit ordering;
- service answer response and retry mechanism;
- media access control and channel management;
- framing, superframe building and synchronization;
- burst and parameter definition;
- link addressing (source and/or destination);

- interfacing of voice applications (vocoder data) with the PL;
- data bearer services;
- exchanging signalling and/or user data with the CCL;
- authentication by challenge and response.

4.1.3 Air Interface Call Control Layer (layer 3)

Air Interface layer 3 (CCL) is applicable only to the C-plane, and shall be an entity for the services and facilities supported by DMR on top of the layer 2 functionality. The Call Control Layer for trunking described in the present document and may have embedded intrinsic services associated to it.

The CCL provides the following functions:

- BS/TS/TSCC activation / deactivation (for asynchronous access mode);
- establishing, maintaining and terminating of calls;
- individual or talkgroup call transmission and reception;
- destination addressing (DMR ID's or gateways as appropriate);
- support of intrinsic services (emergency signalling, pre-emption, late entry, etc.);
- data call control;
- announcement signalling;
- management of available resources:
 - management of a control channel resource by a random access protocol;
 - queuing for payload resource;
- individual or talkgroup call set-up via a dedicated signalling channel;
- MS location information by registration;
- MS power save;
- broadcast of system parameters to radio subscriber terminals.

4.2 Services and Facilities

A Tier III system is able to support either a wide range or narrow range of Services and Facilities. Users who select a service specified in the present document that is not supported by a particular system shall receive an unambiguous refusal of service response.

The services and facilities defined in the present document may be used for Tier III products and is called the "default feature set" which is allocated to the "Standards Feature ID (SFID)". There is a possibility in the DMR standard which allows manufacturers to define and implement "private" feature sets which contain additional "private" services and facilities, which may possibly not be understood by products not supporting this "private" feature set. In addition, some "Standards Feature ID" PDUs may contain optional manufacturer specific information elements.

The "standard feature set" contains the following services and facilities:

- a) Generic services:
 - 1) MS Access control and management using a control channel and a random access protocol;
 - 2) MS Location within the system radio coverage by radio site identification and registration;

- 3) Control Channel hunting;
 - 4) System acquisition authorization;
 - 5) A unified data transport mechanism to support the short data service, the supplementary data service and destination addressing through gateways;
 - 6) Broadcast of system parameters to MS;
 - 7) MS Authentication;
 - 8) Feature Not Supported;
- b) Primary voice services:
- 1) talkgroup call service;
 - 2) individual call service;
- c) Supplementary voice services:
- 1) all call service;
 - 2) broadcast voice call service;
 - 3) open voice channel mode call service;
- d) Primary Data Services:
- 1) Short Data Service;
 - 2) Packet Data Service;
- e) Supplementary Service:
- 1) Supplementary data transfer service;
 - 2) MS stun and revive.

The description of the services and features use diagrams where necessary to illustrate and highlight specific points both on the control channel and payload channel.

4.3 Device Addresses

4.3.1 MS Addresses

Tier I and Tier II MSs shall be personalized with at least one individual **or** one talkgroup identity (TS 102 361-2 [6], clause C.2.2). Tier III MSs shall be personalized with at least one individual identity and may be a member of one or more talkgroups.

4.3.2 Services and Gateway Addresses

The Tier III protocol defines additional addresses to identify Services and Gateways in PDUs exchanged between MS and TS (TS 102 361-1 [5], annex A). The addresses prescribed in tier III systems are defined in clause A.4 of the present document.

4.4 Conventional/Trunked Systems

Conventional Tier I and Tier II DMR systems permit MS to control their own channel access (subject to any polite protocol).

Many of the conventional operations such as selection of the physical radio channel is automated by this protocol:

- a) A single site trunked network is characterized by multiple MS communicating with a single location Trunked Station (TS).
- b) A wide area trunked network is characterized by multiple MS communicating with a multiplicity of Trunked Stations (TS).

A TS shall be equipped with one or more physical channels. Each TS may be configured with one or two control channels (TSCCs). Where two TSCCs are configured, the TSCCs may be arranged in one physical channel or separate physical channels. The tier III protocol can separate the population of MS fleets between multiple TSCCs so that there is effective load sharing.

For a fully regulated system, at least one channel shall be configured as a Trunk Station Control Channel (TSCC) for MS management, signalling, and broadcast of system parameters. MS access is strictly controlled on the TSCC.

An unregulated asynchronous system shall permit MS access subject to polite rules.

4.5 MS Location

As MS travel around a wide area network they may be within range of a number of different Trunked Stations (TSs). Registration is a method by which the system can determine which radio site or group of radio sites MSs are located within a wide area network. This information avoids searching for MSs throughout the whole network, consequently reducing call set-up time and control channel loading.

Registration may also be employed by a Single Site system to determine when MSs are active and able to receive calls.

A secondary application of the registration process is that it enables power save parameters to be passed between MS and the system.

If an MS is switched off or is subjected to a user selected change of network, the MS may attempt to de-register. The MS makes a de-registration random access to the TSCC on a "best endeavours" basis. If the procedure is not completed within a short time window (T_dereg) the process is abandoned.

4.6 Tier III Services

A DMR TS can allocate resources for a range of services including individual call, talkgroup call, line connected call, and a selection of data services.

Calls to talkgroups may be restricted by the Network to a single radio site or connected to a multiplicity of radio sites. The particular sites involved in the call may be defined by the Network using manual configuration or automatic selection.

Supplementary data may be sent between MS and the network during the call set-up phase using the Supplementary Data Transfer Service to poll for, or deliver additional information using a Unified Data Transport method. Examples include:

- a) the inbound transport of dialling digits for calls to the PSTN, PABX extensions or dotted addresses for IP gateways;
- b) the transport of MS location information using data collected from IEC 61162-1 [8] compatible devices;
- c) the transport of any supplementary user data;
- d) the outbound transport of CLI information for calls from PSTN and PABX gateways to the called MS(s);
- e) the outbound transport of an IP address to called MS.

4.6.1 MS initiating calls

A MS may initiate a call to any of the following called parties:

- a) an individual MS;
- b) a line-connected terminal device including a PABX extension or PSTN destination;
- c) a talkgroup, or all MSs in the system.

The system shall send a refusal of service response to any calls that request inappropriate Services and Facilities for a particular destination address.

Some services may be addressed to the TS itself.

During the call set-up phase, the TSCC may pass information back to the caller, to indicate the progress of the call. For example, it shall indicate the reason for any delays in call set-up or the reason for a call failure.

4.6.2 MS receiving calls

A MS may receive calls from a MS or line connected terminal device (such a device may be a PABX extension or the PSTN).

In addition, some PDUs may originate from the TS itself.

For a call from an MS, the calling address shall be supplied to the called unit. For a call from certain line connected gateways such as a PABX extension or from the PSTN, the protocol enables Source Address information to be carried to the MS. (An example is CLI information from a PABX extension or the PSTN).

Incoming calls may be addressed to the MS individually or to a talkgroup.

4.6.2.1 MS receiving individual calls

A MS may refuse to accept all incoming calls, for example by means of a "will call-back" control, or incoming calls could be refused selectively, depending on the source of the call. If an MS user does not wish to proceed with an incoming call immediately, the user can indicate that the call will be returned. If a MS user does not wish to receive any incoming calls, the calls may be rejected completely.

Systems may be configured to alert a called individual and require the user to indicate that he is ready, before a payload channel is allocated for a call (full off air call set-up). This feature is not available for this release of the document.

4.6.2.2 MS receiving calls to talkgroups

A MS may be a member of an arbitrary number of talkgroups.

An MS may be configured such that it may selectively accept or ignore a call to one of its talkgroup memberships. An MS may also be configured to ignore a call to one of its talkgroup memberships if it is waiting for an individual call.

4.7 Physical Link Organization

This protocol makes use of the physical layer 1 prescribed in TS 102 361-1 [5] DMR Air Interface protocol.

4.7.1 Radio Frequency Allocation

The Tier III protocol supports a number of different physical channel strategies to accommodate operation in radio channels that may be dedicated, in blocks or re-farmed.

Physical radio channels may be specified by either:

- a logical channel plan whereby a transmitter and receiver frequency is mapped to a logical channel number. The tier III protocol permits up to 4 094 such logical / physical relationships; and/or
- a mechanism whereby the absolute transmitter and receiver frequencies are specified in the PDUs that are passed between BS and MS at the air interface.

4.7.2 Colour Code (CC)

A Colour Code (CC) is present in the Embedded Signalling Field (EMB) and general data burst to provide a simple means of distinguishing overlapping sites, in order to detect co-channel interference. Tier III systems assign the physical channels automatically therefore the MS and TS must know and be in agreement which colour code is allocated for each physical channel. The following strategy is employed in tier III systems:

- The default colour code is 0000_2 . If a colour code has not been specifically assigned, or transmitted on the TSCC in an extended Channel Grant or extended Move PDU, the colour code shall be set to the default.
- In tier III systems MS shall be polite to own colour code.
- MS may maintain a list of logical channel numbers and their corresponding colour code assignments (see annex C).

4.8 DMR TDMA burst and channel structure

The described solution is based on the 2-slot TDMA structure described in TS 102 361-1 [5] clause 4.2.

The logical channels are separated into two categories:

- a control channel carrying signalling; and
- payload channels carrying speech or data information.

Generally MSs operate in half duplex mode using aligned channel timing (see TS 102 361-1 [5], clause 5.1.1) but full duplex is possible for calls to line connected terminals using Offset TDMA timing (see TS 102 361-1 [5], clause 5.1.1.2) by allowing a MS to transmit in one time slot and receive the fixed end transmission on the alternate time slot. MS that are directed to a physical channel using offset timing shall be notified by an identifier transmitted to the MS(s) during the call set-up.

A generalized diagram of exchanges between the TSCC and MS is shown in figure 4.2 where the slots for the two TDMA physical channels are shown.

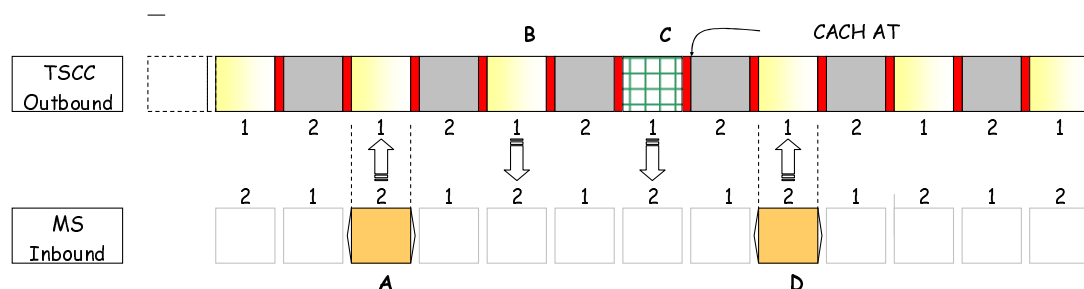


Figure 4.2: Key points for a Tier III TSCC

Key points particular to Tier III trunking illustrated by figure 4.2 includes the following:

- While the TSCC is keyed up, the two outbound logical channels are continuously transmitted, even if there is no information to send. If either of the logical channels are configured as a control channel, and that control channel is idle, information is constantly transmitted to manage MS access and broadcast parameters to MSs.

- The channel 1 and 2 bursts in the inbound channel are offset 30 ms in time from the channel 1 and 2 bursts in the outbound channel. This number scheme allows a single channel identifier field in the outbound CACH to use the same channel number when referring to the inbound and outbound channels.
- Differing SYNC patterns are used in voice bursts and data bursts to allow the receiver to differentiate between them. Different SYNC patterns are used for inbound and outbound channels to help the receiver reject co-channel interference.
- A physical channel that carries a TSCC shall use aligned timing as prescribed in clause 5.1.1.1 of TS 102 361-1 [5]. Two independent control channels or one control channel + one payload channel may be configured. A TSCC may temporarily revert to a payload channel.
- Referring to figure 4.2, a random access burst on the inbound channel labelled "A" shall be acknowledged by a PDU on the outbound channel. This acknowledgement may be transmitted in slot "B", although the protocol is able to postpone the acknowledgement to allow for computational or network delays.
- For a MS response to a PDU received from the TSCC, the MS shall transmit its PDU in the timeslot but one following the end of the TSCC PDU. I.e. a PDU from the TSCC in slot "C" that requires a response from a MS shall be acknowledged on the TSCC in slot "D".
- The MS response at "D" cannot collide with another random access burst because the slot is protected by setting the AT bit in the CACH to busy. MS must test this bit before making a random access attempt. Random access is not permitted if AT=1.
- The outbound channel defines a CACH channel between TDMA bursts that manages the framing and channel access of the logical channels and provides a low speed channel for signalling. CACH framing bits are defined, allowing the low speed channel to support a range of PDU sizes.

4.9 Introduction to the TS Structure

These clauses outline some key aspects of the Tier III protocol by reference to examples. The Tier III protocol manages MS access and Service provision by means of a TSCC (control channel). MSs request Service by means of random access. The tier III protocol provides a wide variety of configurations to match the requirements of dedicated and shared radio spectrum. The TSCC outbound channel may be:

- a) continuously transmitting slots that invite MS access, broadcast of system parameters to, and managing the resources that are available to MS;
- b) transmitting information as a) but reverting to a payload channel when other payload channels are not available;
- c) de-keyed until activated by an MS burst when used in shared spectrum.

4.9.1 An individual voice call example

Two MS, MS(A) and MS(B) are active listening to the TSCC. MS(A) requests a voice service to MS(B). Before a payload channel is assigned on the TSCC, the system checks that the MS(B) is in radio contact and wishes to accept the call. If MS(B) sends a positive acknowledgement response (indicating that MS(B) will accept the call), the system allocates a payload channel for the call.

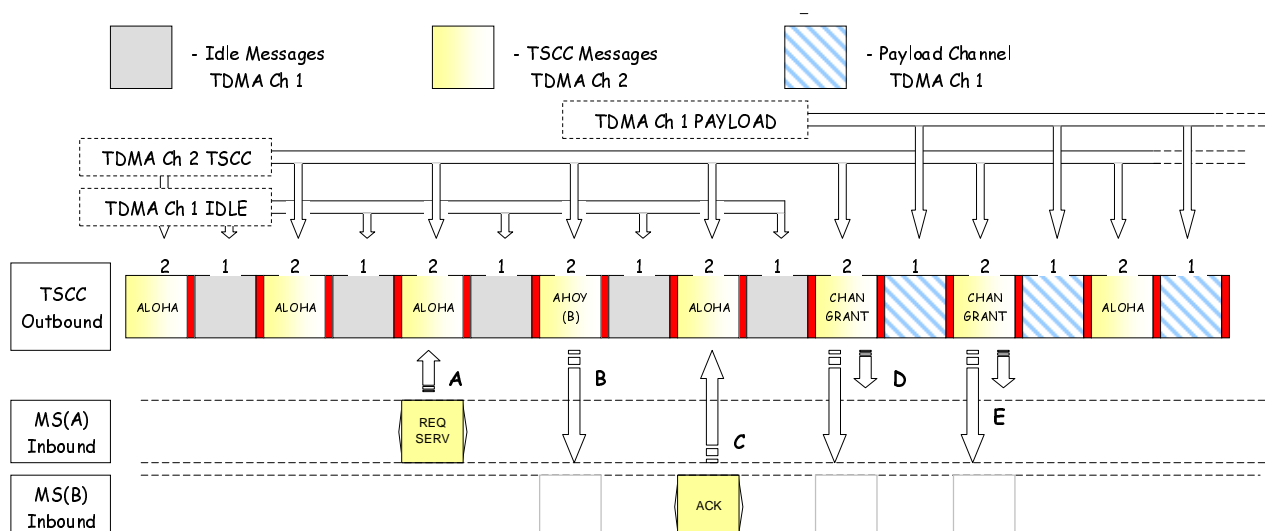


Figure 4.3: Individual Call Set-up example

Referring to figure 4.3, some key aspects are described:

- TDMA Channel 2 is assigned as a TSCC. TDMA Channel 1 is idle.
- When a TSCC has no calls in progress, it will transmit system management or system broadcast PDUs to all MSs listening to the TSCC. MSs may listen to TDMA Channel 1 for the purposes of error rate measurement but they shall not make use of any information from those PDUs.
- MS(A) makes a Service Request at point "A" using aligned timing (see TS 102 361-1 [5], clause 5.1.1.1).
- The TSCC sends an AHOY PDU (point "B") addressed to MS(B) that requires an acknowledgement response.
- MS(B) responds with an acknowledgement at point "C".
- At point "D", the TSCC sends a Channel Grant PDU addressed to MS(A) and MS(B). A logical channel information element in the Channel Grant PDU directs the MSs to a particular physical and logical channel. The Channel Grant PDU is not acknowledged so the PDU is repeated for reliability at "E". A TSCC may transmit the repeated Channel Grant PDUs consecutively, or wait for a few slots before repeating the Channel Grant.
- In this particular example the TSCC has chosen to allocate the logical Channel 1 of this physical channel for the call. Logical Channel 1 therefore changes from idle to payload immediately after the TSCC transmits the first Channel Grant PDU.
- Since each TDMA burst takes 30 ms, the best case performance for a Tier III individual call set-up is 210 ms.

4.9.2 A talkgroup call example

For a talkgroup call, the intermediate step of checking if MS(B) is in radio contact is not required so the best case performance for a Tier III talkgroup call is 90 ms.

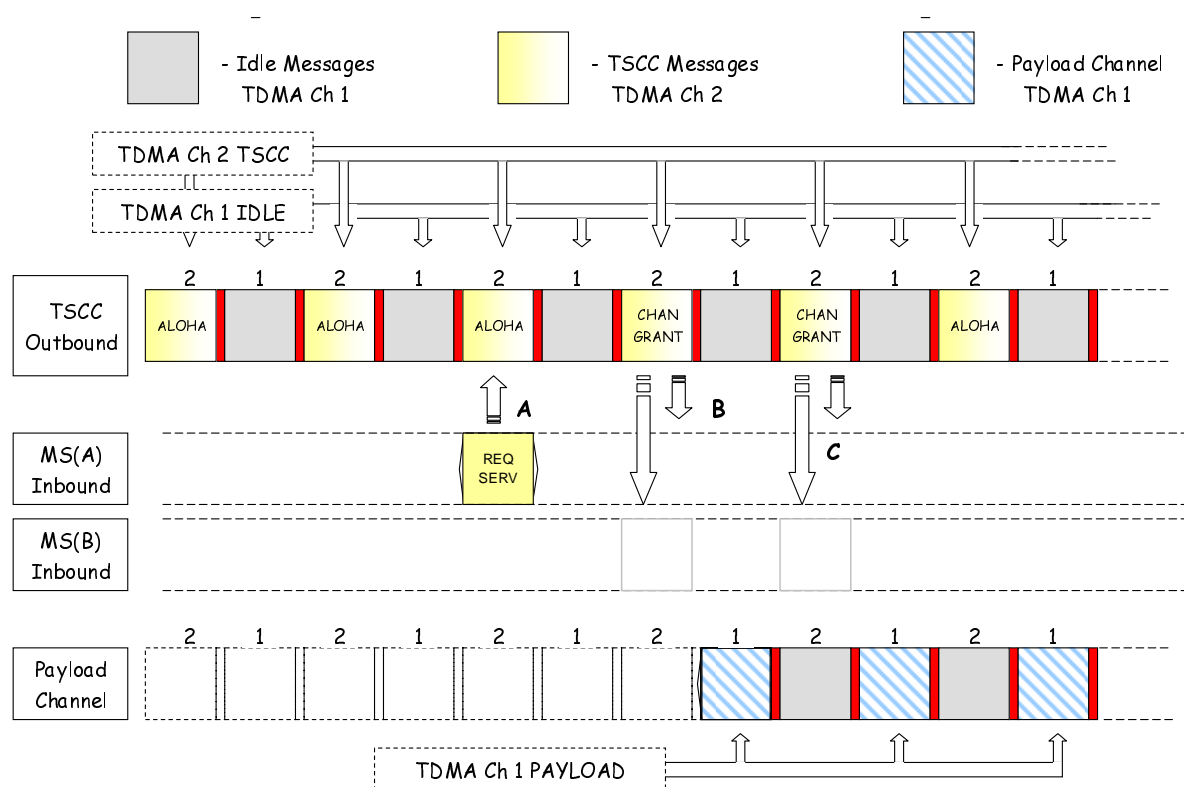


Figure 4.4: Talkgroup Call set-up example

Figure 4.4 illustrates a call set-up for a talkgroup. MS(B) is a party to that talkgroup. For a talkgroup call, the intermediate step of checking if MS(B) is in radio contact is not required so the best case performance for a Tier III talkgroup call set-up is 90 ms.

In this particular example the TSCC chooses a separate physical radio channel for the call. The particular physical and logical TDMA channel information elements are carried in the Channel Grant PDUs. The Channel Grant PDUs are repeated for reliability.

Key protocol aspects are:

- When both payload channels are idle, no radio transmission is necessary.
- When at least one payload channel is assigned the transmitter is activated and one logical channel carries the payload for the call. The other logical channel remains idle.
- Although in this example the clocks and bursts in the payload channel are time aligned with the TSCC, there is no requirement to do so.

4.10 Network architecture

The DMR trunked protocol is defined in terms of the Services and Facilities. It is defined to ensure interoperability with DMR MSs. The Tier III structure relies on the Air Interface TS 102 361-1 [5].

The gateways to Public Switched Telecommunication Network (PSTN), and other non Air-Interface gateways are not defined within the present document. They are shown only for informative purposes.

A Trunked Station (TS) consists of one or more physical radio channels (BS), each physical channel supporting two TDMA logical channels. Either or both logical channels of a BS may carry a TSCC. All of the clocks of the BS making up a TS may be derived from a common reference standard so that the framing structure is synchronized across all BS within a TS.

4.10.1 Network functions

In addition to the normal call handling functions required to provide the telecommunication services identified above, a number of standard network procedures are needed for the efficient operation of the system and to provide an acceptable grade of service to the users.

4.10.1.1 Establishing service

A notable feature of a Tier III trunked system is that physical channel acquisition is performed automatically when a MS is powered up. The user does not need to manually select physical channels. The relevant physical channel is stored in the MS or a search is performed to find an applicable TSCC. If the MS is directed to a payload physical channel on the TSCC, the applicable payload channel is transmitted to the MS by a Channel Grant PDU that specifies the physical and logical channel.

4.10.1.2 Network Identifier

All TS carry a network and radio site identifier. This identifier, the System Identity Code (C_SYSCode) is transmitted frequently by a TSCC. The C_SYSCode is carried in CSBK signalling packets and also embedded in the CACH. The C_SYSCode is composed of MODEL, NET, SITE and PAR information elements. Within a particular network, the MODEL and NET remains a constant. Each TS is designated a different SITE parameter. MSs use the MODEL and NET to determine if they are authorized to attempt to become active on that network.

4.10.2 MS Location by Registration

The coverage area of a Tier III trunked network is divided into a number of Location Areas (DMRLAs). A DMRLA corresponds to a single radio site or a small number of radio sites structured as a DMRLA's.

Implicit registration is the network functionality that registers the location of the MS without need for an explicit registration PDU. Implicit registration can be attained by any system PDU that conveys the MS individual identity, e.g. call request, service answer response.

It is possible that due to adverse conditions the registration information held by the network and that held by the MS may not be the same. To restore and maintain the registration records:

- a) The system shall update its registration records from MS random access call requests (The network may however deny the service requested by the MS for other reasons).
- b) Responses from MS (resulting from a radio check for example) implicitly update the system registration records.

4.11 Trunking methods

DMR Tier III systems are able to implement the "message trunking", "transmission trunking" or "quasi-transmission" trunked methods.

4.11.1 Message trunking

Message trunking is a payload channel allocation strategy in which the same payload channel is continuously allocated for the duration of a call, which may include several separate call items or transactions (i.e. PTT activation by separate terminals). The payload channel is only de-allocated when the call is explicitly cleared by the call owner in the case of a talkgroup call, either party hanging up during an individual call or if an activity timer expires. The BS may also clear the call at any time but the BS must be confident that all parties in the call hear the PDU to clear down the call.

Once a payload channel has been allocated the users will experience the minimum delay for each transmission item since there is no queuing for the allocation of channel resources. The absence of any perceptible delay when the PTT is activated ensures that a conversation can proceed without interruption. This strategy is likely to minimize the processing and signalling overheads in the network infrastructure.

The disadvantage of this strategy is that the channel remains allocated even when there may be significant gaps in the PTT items and this may result in less efficient use of the available channel capacity.

4.11.2 Transmission trunking

A payload channel is allocated for each PTT item. When the user releases the PTT, the payload channel is de-allocated down and the MS returns to the control channel. The following PTT is allocated a new payload channel.

Users may experience a delay for each transmission item particularly when the system is busy because a payload channel may not be immediately available. In this case the system must queue the MS until a payload resource becomes available. An indication may be provided to the user that the payload channel is allocated for the speech item.

4.11.3 Quasi-Transmission trunking

A payload channel is allocated to the called and calling parties at the start of the call. When the user releases the PTT, a short hang-timer holds the payload channel to permit the other party to speak. If the hang-timer expires the payload channel is de-allocated and the next PTT item sets up a new call. This method overcomes the delay in transmission trunking but users experience different effects depending on the possible expiry of the hang-timer.

5 Trunking Control Channel Formats

A TS shall employ a minimum of one physical channel partitioned in time into TDMA frames and timeslots as defined in TS 102 361-1 [5], clause 4.2. At least one of the TDMA channels shall carry control channel signalling. When idle, MSs shall monitor the Trunk Station Control Channel (TSCC) outbound channel. This protocol permits one additional TSCC to be employed in a TS to share the load.

The following SYNC patterns shall be deployed (see TS 102 361-1 [5], clause 9.1.1 for details and bit patterns for the frame SYNC):

- For the TS outbound channel - BS sourced data.
- For the MS inbound channel - MS sourced data.

Signalling on the TSCC outbound channel is nominally continuous, with each TDMA Frame comprising two independent logical channels. The channel consists of two TDMA traffic channels (channels 1 and 2) as well as a CACH for channel numbering, channel access, system identification and power save.

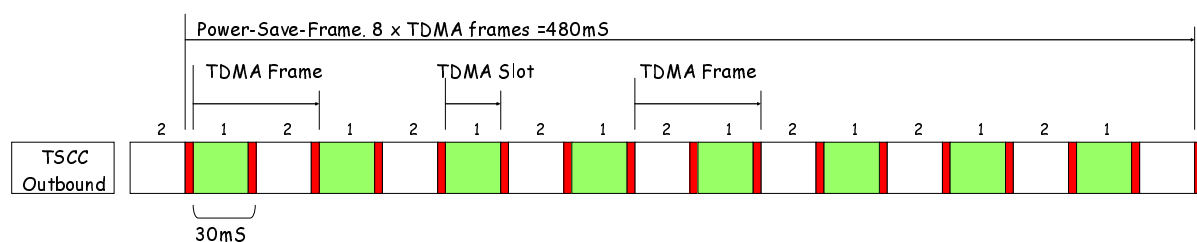


Figure 5.1: Slots and Frames

Figure 5.1 illustrates slots, TDMA frames, random-access-frames and power-save-frames.

A slot is the elementary DMR burst described in TS 102 361-1 [5].

A TDMA-frame encompasses two continuous time slots 1 and 2 or 2 and 1.

A power-save-frame is defined by transmission of four consecutive Short LC PDUs embedded in the CACH. A power-save-frame is transmitted by a TSCC every 480 ms.

5.1 The use of the CACH

The Short LC contains 3 octets of data associated with the SYS_Parms Short Link Control (Opcode - 0010₂) (see TS 102 361 1 [5], clause 7.1.4). Tier III systems that have any one of the logical channels configured as a TSCC shall continuously or periodically transmit the SYS_Parms Short Link Control to broadcast a sub-set of the System Identity Code, the Reg information element and a Common_Slot_Counter. All information carried by the Short Link Control is common to both logical channels.

Since the entire Short LC payload can be delivered in 4 CACH bursts, one SLCO can be sent by the CACH every $4 \times 30 \text{ ms} = 120 \text{ ms}$.

NOTE: The Tier III protocol makes use of the AT bit transmitted in the CACH as key elements in the random access protocol described in clause 6.2.

5.1.1 SYS_Parms - System Identity Code Subset

The full C_Syscode information element is length 16 bits. Only the most significant 14 bits of the C_SYScore are carried in the CACH because the CACH is common to the two logical channels. One physical channel may carry one or two TSCCs. Each TSCC is identified by the two bit PAR information element that is conveyed in the two Least Significant Bits (LSBs) of the C_SYScore.

The CACH is common to both logical channels so the PAR field cannot be specified in the CACH. Not all CSBKs on the outbound channel contain the SYScore. If a MS is searching for a control channel and trying to determine if it is permitted access, it may disregard a sampled channel by decoding the CACH. If there is no match then the MS does not need to stay looking for a CSBK that contains the C_Syscode.

5.1.2 SYS_Parms - Reg

The Reg information element carries a flag that specifies if this particular system requires MS to register before becoming active. The Reg is also carried in the Aloha CSBK PDU.

5.1.3 SYS_Parms - Common_Slot_Counter

The Common_Slot_Counter is broadcast by the SYS_Parms and represents a positive integer in the range 0 to 511. The counter is incremented in each successive SYS_Parms Short Link Control PDU. When the counter is incremented from 511 it rolls over to 0. The Common_Slot_Counter therefore increments every 120 ms.

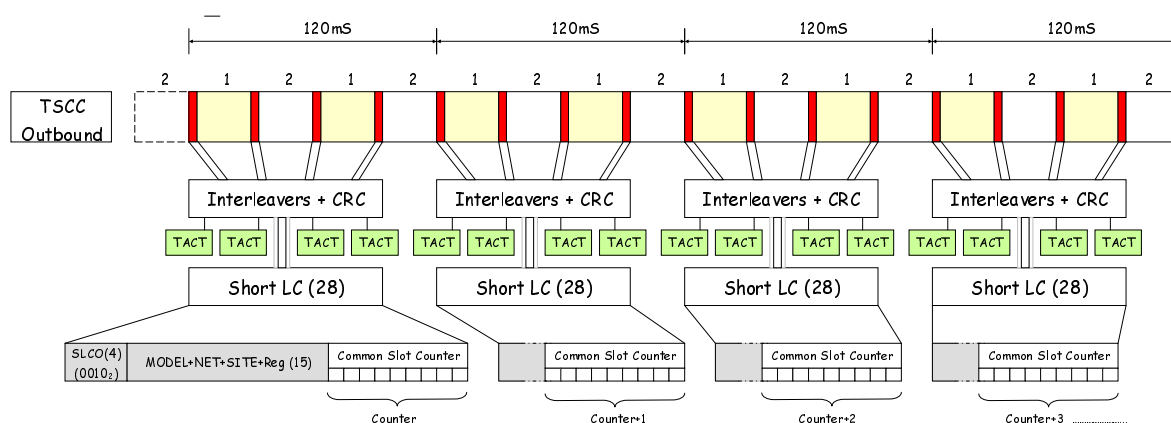


Figure 5.2: Common Slot Counter

Figure 5.2 shows how the Common Slot Counter is broadcast in the CACH. The Common_Slot_Counter is read by MS wishing to synchronize power save periodic sleep cycles (see clause 6.4.7).

5.2 Tier III signalling

The tier III protocol makes use of the single block CSBK and Multiple Block Control signalling packet structure described in TS 102 361-1 [5], clause 7.2. PDUs addressed to an individual MS or a talkgroup shall contain the Source Address. The Tier III protocol also uses the Unconfirmed Data type for the Unified Data Transport mechanism. UDT blocks consist of a header and a number of intermediate blocks contiguously transmitted. The UDT transmits the UDT header followed by one to four appended data (UDT intermediate blocks) to transport variable length system or user data between entities.

5.3 Modes of control channel

TSCCs may be dedicated, composite or asynchronous. A dedicated TSCC never reverts to a payload channel whereas a composite TSCC may change its mode and carry payload if all other payload channels within a particular TS are busy.

5.3.1 Dedicated TSCC

A dedicated TSCC is generally employed in a TS where a large number of BS (hence payload channels) are employed. The advantage of a dedicated TSCC are:

- a) The TSCC is always available for MS who are hunting for a appropriate and valid service.
- b) The TSCC is always available to process secondary services such as MS location (registration), short data calls, etc.
- c) The TSCC is always available to accept random access requests and queue such requests if resource is not immediately available.
- d) The TSCC can broadcast information to MSs more frequently as the TSCC function is not interrupted.

5.3.2 Non-Dedicated TSCC

A composite TSCC may suspend its control channel function and revert to a payload mode. This is suitable for TSs that are equipped with a very small number of payload channels and the traffic expected exceeds the capacity of those channels. The control channel reversion provides one additional payload resource. However, the shortcoming is:

- a) MS who are hunting for a appropriate and valid service may sample the physical channel when it has reverted to payload and therefore skip the channel.
- b) The TSCC is not available to process secondary services such as MS location (registration), short data calls, etc.
- c) The TSCC cannot accept random access requests. The control channel interruption will most likely cause the MS not involved in the call to hunt.
- d) MS that return from a payload channel expecting the TSCC to be present will see a payload channel and therefore hunt for a new control channel.

5.3.3 Operation in shared spectrum

Clause 4d) describes an asynchronous access. In this mode the TSCC remains inactive (in fact the physical channel remains de-keyed) until a MS activates the TSCC with a short burst. The MS then synchronizes to the forward control channel before making its random access service request.

5.4 CSBK/MBC/UDT Block Structure

CSBK/MBC/UDT PDUs may be sent by a TS on the outbound channel and MS on the inbound channel. In some instances it is necessary to send more information than can be accommodated in a single block CSBK PDU. In those cases multi-block PDUs of type MBC or UDT are transmitted. Multi-block PDUs shall use the following Data Type information elements. (see TS 102 361-1 [5], clause 6.2):

- For PDUs except UDT, MBC Header and MBC Continuation are used.
- PDUs of type Data Header and Unconfirmed Data Continuation are used to transport information on the outbound channel and inbound channel for the Unified Data Transport (UDT) mechanism.

5.4.1 CSBK/MBC/UDT PDUs on the TSCC outbound channel

The PDUs sent by a TSCC on the outbound channel are classified as shown in figure 5.3.

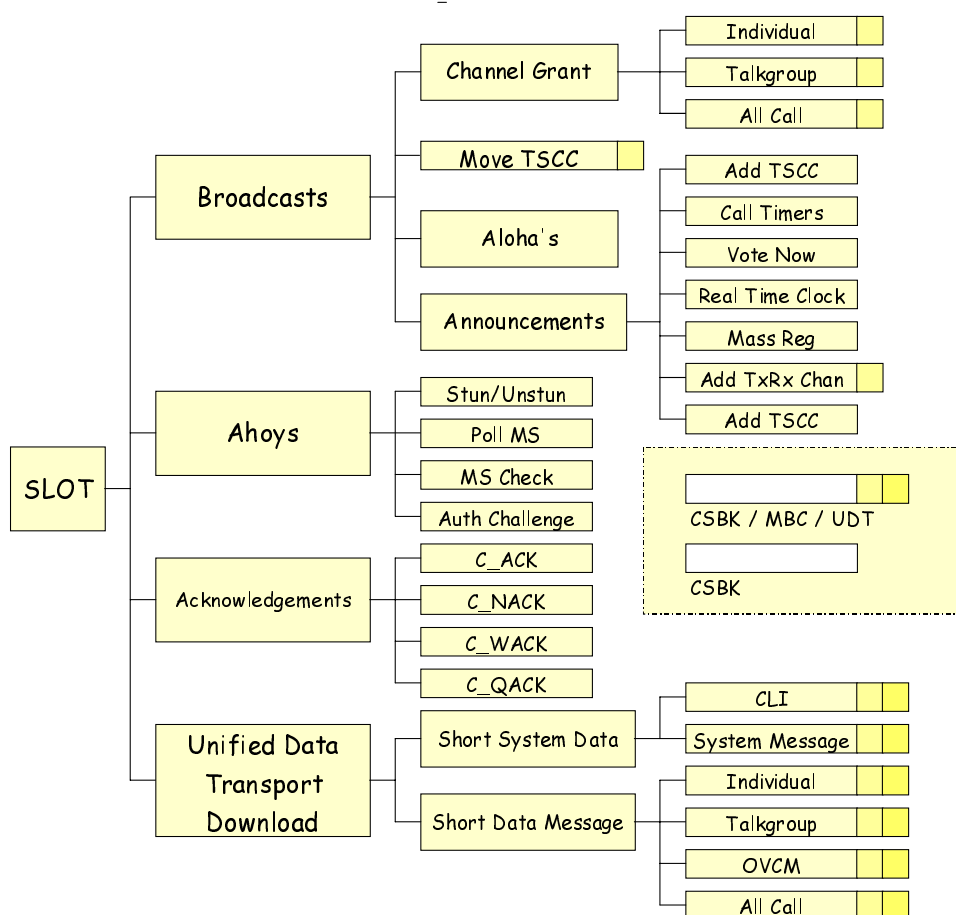


Figure 5.3: TSCC CSBK/MBC/UDT Outbound channel Structure

Table 5.1: TSCC CSBK/MBC/UDT Outbound channel PDUs

Class	Mnemonic	PDU Descriptor	Description
Broadcast	C_GRANT	- Channel Grant	Transfer a call to the payload channel
	C_MOVE	- Move to a new physical channel	MSs shall move to an alternative TSCC
	C_ALOHA	- Aloha	To Manage Random Access
	C_BCAST	- Announcements	PDUs intended for all MSs listening to this TSCC
Ahoys	C_AHOY	- Ahoy	Sent to an individually addressed MS and demand a response
Acknowledgements	C_xACKD	- Acknowledgements	A response to PDUs from the MS that demand a response: C_ACKD, C_NACKD, C_WACKD.C_QACKD
Unified Data Transport Outbound	C_UDTHD	- Short System Message Outbound (see note)	System PDU addressed to an individually addressed MS and demand a response
		- Short Data Message Outbound (see note)	Short data message addressed to an individual MS or talkgroup
NOTE: C_UDTHD PDUs are made up of multiple blocks that consist of a UDT Header followed by 1 to 4 appended UDT data blocks - see annex B.			

5.4.2 CSBK/MBC/UDT PDUs on the TSCC inbound channel

The PDUs sent by a MS on the TSCC inbound channel are classified as shown in figure 5.4.

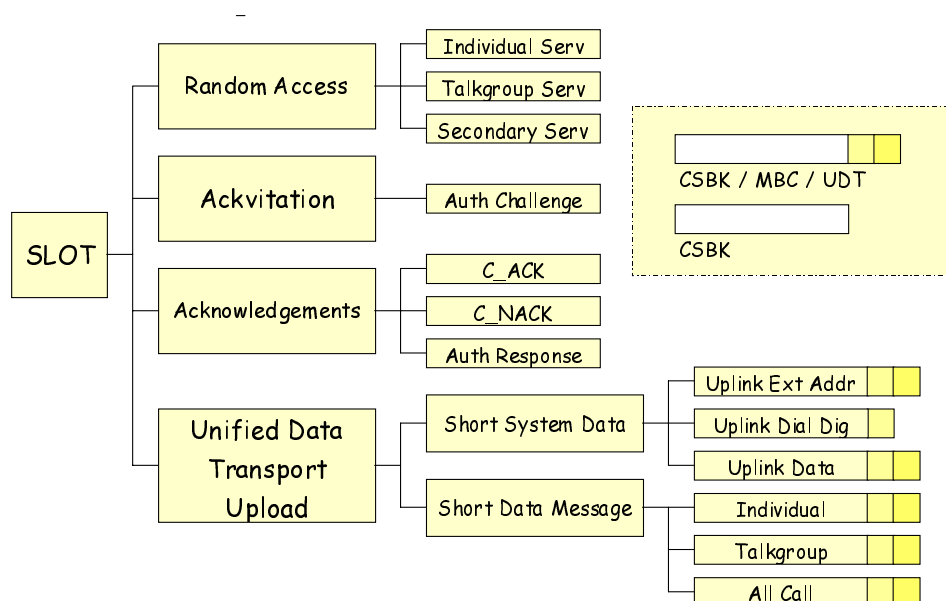


Figure 5.4: TSCC CSBK/MBC/UDT Inbound channel structure

Table 5.2: TSCC CSBK/MBC Inbound channel PDUs

Class	Mnemonic		PDU Descriptor	Description
Random Access	C_RAND	-	Random Access	Random Access Requests
Ackvitation	C_ACVIT	-	Ackvitation	A response to PDUs that invite a further response
Acknowledgements	C_xACKU	-	Acknowledgements	A response to PDUs from the TSCC that demand a response C_ACKU, C_NACKU
Unified Data Transport Inbound	C_UDTHU	-	Short System Message Inbound	System PDU addressed to an individually addressed MS or the TSCC as a response to an Ahoy PDU from the TSCC
		-	Short Data Message Inbound	Short Data Message addressed to an individually addressed MS or the TSCC as a response to an Ahoy PDU from the TSCC

5.4.3 CSBK/MBC PDUs on the Payload Channel Outbound channel

The PDUs sent by a TSCC on the outbound channel are classified as shown in figure 5.5.

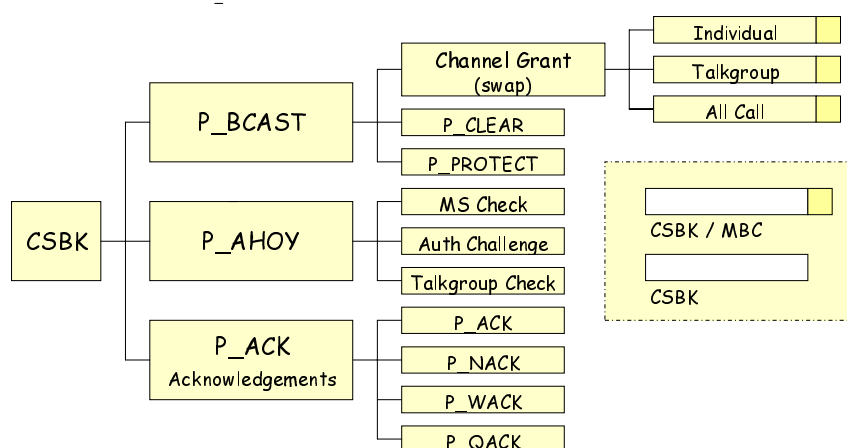


Figure 5.5: Payload CSBK Outbound channel Structure

Table 5.3: Payload CSBK Outbound channel PDUs

Class	Mnemonic		PDU Descriptor	Description
Broadcast	P_GRANT	-	Channel Grant (see note)	Swap a call to a new payload channel
	P_CLEAR	-	Payload Channel Clear	Clear the call from the payload channel
	P_PROTECT	-	Channel Protection	Access control
Ahoys	P_AHOY	-	Ahoy	Sent to an individually addressed MS and demand a response
Acknowledgements	P_xACKD	-	Acknowledgements	A response to PDUs from the MS that demand a response P_ACKD, P_NACKD, P_WACKD.P_QACKD
NOTE: A Channel Grant PDU is transmitted by the TS on a payload channel to swap an ongoing call to a new payload channel.				

5.4.4 CSBK PDUs on the Payload Channel Inbound channel

The PDUs sent by a MS on the Payload Channel inbound channel are classified as shown in figure 5.6.

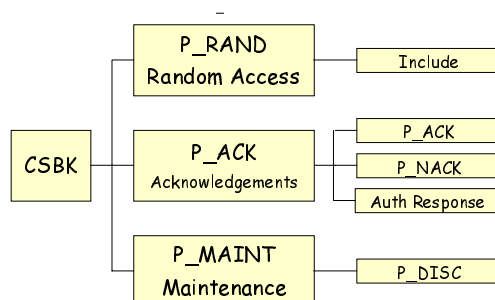


Figure 5.6: Payload CSBK Inbound channel Structure

Table 5.4: Payload CSBK Inbound channel PDUs

Class	Mnemonic		PDU Descriptor	Description
Random Access	P_RAND	-	Random Access	Random Access Requests
Acknowledgements	P_xACKU	-	Acknowledgements	A response to PDUs from the TS that demand a response P_ACKU, P_NACKU
Maintenance	P_MAINT	-	Call Maintenance PDUs	Disconnect

6 Trunking Procedures

6.1 Basic Structure

6.1.1 Channel Structure

6.1.1.1 Fully Regulated Structure

MS require a TSCC to regulate channel access. Therefore a TS shall incorporate one channel that is configured as a TSCC. A TS may support one additional TSCC within this protocol.

The TSCC shall provide the following facilities:

- Management and control of channel access by MS using a random backoff mechanism.
- Processing service requests to and from MS and optionally to and from line connected entities.
- Allocating payload resources to calls.
- Broadcast of system information to MS.
- MS location management by registration.
- Provision of supplementary services such as short data polling and transfer.

6.1.1.2 Shared Channel Unregulated Structure

MS access the channel for services using the basic channel access rules prescribed in TS 102 361-1 [5], clause 5.2.1. MS shall be permitted to transmit asynchronous "BS activation" signalling to the TS in accordance with the "BS activation" feature (described in TS 102 361-2 [6]). On becoming activated, the TS shall commence transmitting TSCC activity on the outbound channel, and the MS shall derive slot timing from this activity. When activated, the TSCC shall transmit PDUs inviting random access.

For Tier III, the outbound channel shall activate one TDMA channel as a TSCC and shall transmit Aloha and/or Broadcast PDUs in accordance with the random access procedures specified in the present document.

The TS shall maintain the timer T_BS_Inactive for each active inbound channel. The T_BS_Inactive timer runs when there is no activity on the inbound channel. If the T_BS_Inactive timer expires the TS shall transition to the Hibernating state in accordance with in TS 102 361-2 [6], clause G.2.1. Here the TS shall cease transmitting, which deactivates the outbound channel.

6.1.2 Physical Channel Addressing

The Tier III protocol supports a number of different physical channel strategies to accommodate operation in radio channels that may be dedicated, in blocks or allocated on an ad-hoc basis by an external agency. Physical radio channels may be specified by either:

- a) a logical channel plan whereby a transmitter and receiver frequency is mapped to a CHAN information elements. CHAN information elements permit up to 4 094 such logical / physical relationships; and/or
- b) a mechanism whereby the absolute transmitter and receiver frequencies are specified in the information elements of PDUs that are passed between DMR entities at the air interface.

For b) there will be a degradation in performance over a) because the information that must be passed between entities is greater. However new physical / logical relationships that adds to or modifies the existing channel plan stored in MS may be broadcast on the TSCC.

Annex C provides an illustration how the logical channels may be mapped to physical frequencies.

6.1.3 Sub-Division of the MS population

Certain PDUs transmitted on the TSCC may be directed to and applicable only to a sub-set of the MS population. Examples are Aloha (C_ALOHA) PDUs and Broadcast (C_BCAST) PDUs. Applicable PDUs contain a 24 bit address information elements and a 5 bit (Mask) number information element. The sub-set division is achieved by using the address qualifier (Mask) from the PDU. This parameter instructs a MS to compare the "Mask" least significant bits of its individual address with the "Mask" least significant bits of the address field from the PDU (containing the MASK) to determine if that PDU is applicable.

A MS shall note the population subdivision contained in each applicable PDU that it receives. For Mask = 0 to 24, the PDU is applicable to the unit if the "Mask" least significant bits of the Aloha address match the "Mask" least significant bits of its individual address.

In this way, the MS population is effectively divided into 2^{Mask} subsets:

- If Mask = 0 then no address bits are compared, so there is no subdivision.
- If Mask = 1 then only MS whose least significant individual address bit matches the least significant individual address bit from the PDU received shall consider the PDU to be applicable to that particular MS.

This process continues up to Mask = 24. In this case the PDU is only applicable to one MS.

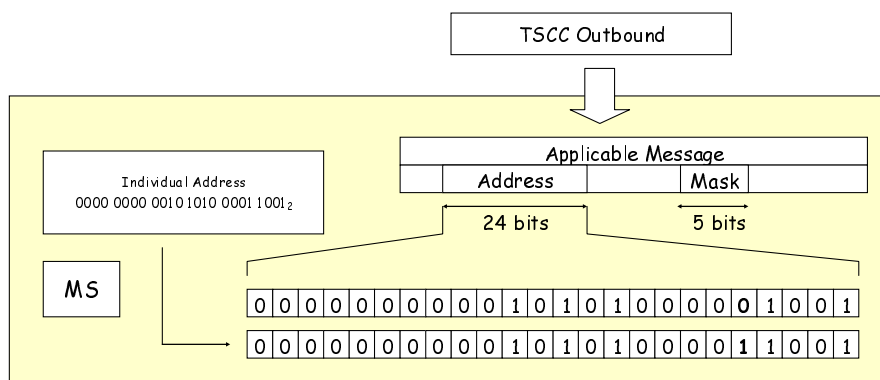


Figure 6.1: Example of PDU containing the "Mask" information element

Figure 6.1 illustrates a MS personalized with the address 0000 0000 0010 1010 0001 1001₂.

A PDU is received that contains a Mask information element. The MS shall therefore determine if that PDU is applicable or the PDU shall be discarded.

EXAMPLE 1: The Mask information element contains the value 0 0100₂.

The value of the Mask is 4 therefore the MS compares the 4 least significant bits of the address information element in the PDU received with the 4 least significant bits of the MS individual address.

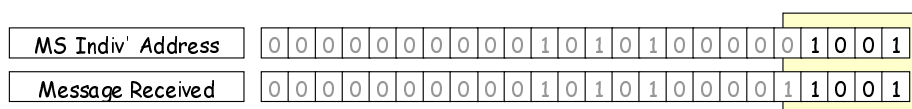


Figure 6.2: Applicable PDU defined by Address and Mask

The least significant 4 bits are compared as shown in figure 6.2. In this case the bits match so this IS an applicable PDU for this particular MS. (If Mask were any value from 0 to 4 the PDU would still be applicable.)

EXAMPLE 2: The Mask information element contains the value 0 0101₂.

The value of the Mask is 5 therefore the MS compares the 5 least significant bits of the address information element in the PDU received with the 5 least significant bits of the MS individual address.

The least significant 5 bits are compared as shown in figure 6.3. In this case the bits do NOT match so this PDU shall be discarded by this particular MS. (If Mask were any value from 5 to 24 the PDU would still be discarded).

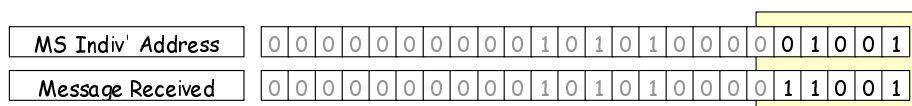


Figure 6.3: Non-Applicable PDU defined by Address and Mask

6.2 Random Access Procedures

These clauses define the random access protocol, which is based on slotted aloha that is used to:

- control the collision of simultaneous random access attempts from different MSs;
- manage the TSCC to minimize access delays;
- ensure system stability; and

- maintain optimum throughput under heavy traffic loads.

Random access is the only access method permitted for MS on a fully regulated TSCC. For a tier III system employing asynchronous access, and when the TSCC is de-keyed, the first random access attempt shall activate the physical TSCC channel whereupon the outbound burst shall regulate further signalling.

6.2.1 The Random Access Principle

The figures in the random access procedure clauses adopt the conventions illustrated in figure 6.4.

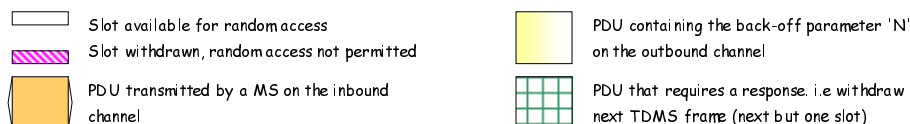


Figure 6.4: Conventions used in the figures

In addition, the TDMA-slot and TDMA-Frame is illustrated in figure 5.1.

PDU's transmitted on the TSCC on the outbound channel are divided between those that invite random access (such as Aloha's) and those that withdraw one or more slots for the purpose of soliciting responses from MSs on the inbound channel (see clause 6.2.1.1.3).

6.2.1.1 Random Access Control

The TSCC outbound channel creates an environment where TSCC access may be managed and controlled. This protocol specifies a specific C_ALOHA PDU that contains the information elements Random-Backoff, Mask, and Service Function, to manage and control random access. Other PDU's transmitted on the TSCC also contain the random backoff information element.

All MS initiated services are by random access. If an MS wishes to make a random access attempt, the MS may send the random access service request PDU so long as:

- access is not inhibited by Mask (see clause 6.2.1.1.1); or
- access is not inhibited by the Service Function (see clause 6.2.1.1.2); or
- the slot chosen is not withdrawn (see clause 6.2.1.1.3).

6.2.1.1.1 Sub dividing the MS population

C_ALOHA PDU's contain an address information element and a Mask information element. The procedure described in clause 6.1.3 is therefore applied.

A MS shall note the population subdivision contained in each Aloha PDU that it receives. When attempting random access, the MS shall check if the population subdivision is applicable to it using the qualifier (Mask) and the address field from the Aloha PDU. For Mask = 0 to 24, the PDU is applicable to the MS if the "Mask" least significant bits of the Aloha address match the "Mask" least significant bits of its individual address.

The subdivision is applied to subsequent TDMA frames marked PDU's that do not contain the Mask information element, until updated or changed by the next Aloha PDU.

In this way, the MS population is effectively divided into 2^{Mask} subsets:

- If Mask = 0 then no address bits are compared, so there is no subdivision (under normal traffic loading, this will usually be the case).
- If Mask = 1 then only units whose least significant individual address bit matches the Aloha address may send non-emergency random access PDU's. Thus the MS population has been divided into two subsets.
- This process continues up to Mask = 24. In this case only one MS shall be permitted to make a random access attempt. (unless the MS requested an emergency service whereupon the MS may make a random access attempt for all values of Mask except Mask = 24).

When a MS becomes active on a TSCC, including when returning from a payload channel, it shall either assume that the population is not subdivided (i.e. that the last C_ALOHA PDU was applicable to all MSs) or wait for a C_ALOHA PDU before attempting random access.

6.2.1.1.2 Checking the Service-Function

For service requests except emergency:

- A MS shall use the Service Function from the C_ALOHA PDU. A MS shall not choose a slot for random access unless the random access attempt is for a service type invited by the Service Function information element.

Table 6.1: Service-Function

Value	Remark
00 ₂	Random Access invited for all Services
01 ₂	Random Access Invited for Services that require a physical payload channel Random Access Invited for registration requests
10 ₂	Random Access Invited for Services that do not require a physical payload channel Random Access Invited for registration requests
11 ₂	Random Access invited for random access registration requests only

- The Service function shall apply until the Service-Function is updated by a subsequent C_ALOHA PDU.

For emergency service requests the MS is not required to check the Service-Function.

6.2.1.1.3 Withdrawing slots from Random-Access

The TSCC may transmit a PDU (consisting of single block CSBK, multi block MBC's or multi-block UDT's) on the outbound channel that solicits a response from a specified MS. The MS response shall be sent in the next TDMA-frame following the last block of the TSCC PDU. In order to prevent a collision occurring between this solicited response and a random access transmission, the TSCC withdraws this timeslot, thereby prohibiting any random access transmissions in the given timeslot. The protocol makes use of the AT bit transmitted in the CACH to indicate to all MS that the following slot is withdrawn (see TS 102 361-1 [5], clause 4.5). (This, therefore implies that an MS intending to transmit a PDU by random access in a given timeslot shall successfully decode the appropriate CACH and note the value of the AT bit to ensure that the chosen timeslot has not been withdrawn from random access.)

In the following example in figure 6.5, when the TSCC transmits a PDU that requires a response, that PDU withdraws the following TDMA frame (slot but one).

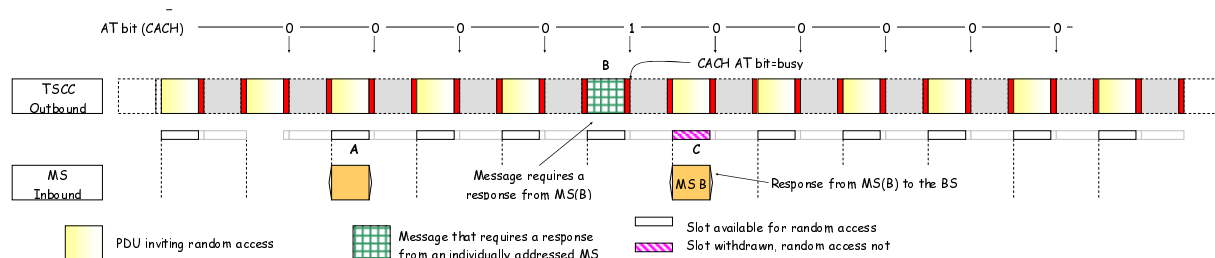


Figure 6.5: Withdrawn Slots Example

The TSCC transmits PDUs inviting random access:

- a) Aloha PDUs invite random access. Therefore an MS is permitted to transmit a random access PDU. The CACH following each of the Aloha PDUs sets the AT bit to 0₂. Aloha PDUs never withdraw slots but an Aloha PDU with Mask=24, MS address=NULL, shall specifically prohibit random access even though the slot is not withdrawn.
- b) TSCC transmits a PDU that demands a response followed by the CACH with the AT bit set. The result is that the following slot but one at "C" is withdrawn - i.e not available for random access. The TSCC withdraws that slot because the PDU "B" requires response from a specific MS(B).
- c) MS(B) transmits its acknowledgment PDU.
- d) If the slot chosen for the random access attempt is not available because the slot is withdrawn, the MS shall choose another slot for a subsequent random access attempt using the random backoff procedures specified in clause 6.2.1.1.6.

6.2.1.1.4 TSCC responses to Random Access attempts

After receiving a random access PDU, the TSCC shall send a response. Valid responses are specified in the sections detailing the registration and call procedures. The response may be sent in the TDMA-frame following the random access PDU or it may be delayed. The TSCC shall use a NRand_Wait information element in the C_ALOHA PDU to specify the delay (in TDMA-frames) a MS shall wait before choosing another slot using a random backoff timer for a repeat random access attempt.

6.2.1.1.5 Noting the response delay

An MS shall note the delay parameter NRand_Wait from each C_ALOHA PDU it receives and shall use table 6.2 below to derive from it the number of TDMA-frames, NWait, by which the TSCCs response to a random access PDU may be delayed. (NWait = 0 means that the response is expected by the MS in the TDMA-frame following the random access PDU.) At the start of a session, until it receives an Aloha PDU, the unit shall assume a default value of NWait = NDefault_NW.

Table 6.2: System Response delays indicated by the delay parameter NRand_Wait

NRand_Wait	Nwait(TDMA-frames)	NRand_Wait	Nwait(TDMA-frames)
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	11
4	4	12	12
5	5	13	13
6	6	14	15
7	7	15	24

6.2.1.1.6 Random Backoff

This clause specifies the method to manage the TSCCs receipt of random access PDUs. A system periodically broadcasts a random back-off timer (specified in TDMA frames).

When a MS initiates a call, the MS may send its first random access PDU in the next slot (subject to Mask, Service Function and withdrawn slot specified in clauses 6.2.1.1 a), b) and c)).

The MS shall invoke the random backoff procedures specified in this clause if:

- a) The MS could not make its random access attempt because access was inhibited by Mask.
- b) The MS could not make its random access attempt because access was inhibited by the Service Function.
- c) The MS could not make its random access attempt because the slot was withdrawn.
- d) The MS did make a random access attempt but that attempt was unsuccessful (the TSCC did not respond before the expiry of Nrand_Wait).

If the MS makes a random access attempt and is unsuccessful, the MS shall choose a slot for its next random access attempt by choosing a random number between the limits of one and the backoff parameter using a statistically uniform distribution.

Figure 6.6 shows a TSCC using parameters $N_{Rand_Wait}=0$. The most recent value of back-off received=4.

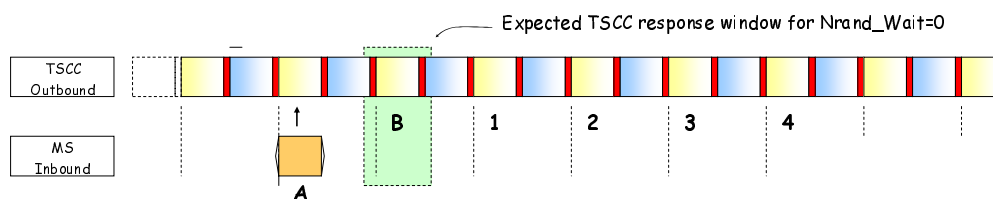


Figure 6.6: Random Backoff Example #1

- At [A] the MS makes a random access attempt. $N_{Rand_Wait}=0$ indicates that the TSCC will respond in the next TDMA frame at [B].
- After TDMA frame [B] a response has not been received, therefore the MS chooses one of the slots 1, 2, 3, 4 randomly for its next access attempt.

Figure 6.7 shows a TSCC using parameters $N_{Rand_Wait}=1$. The most recent value of back-off received=4.

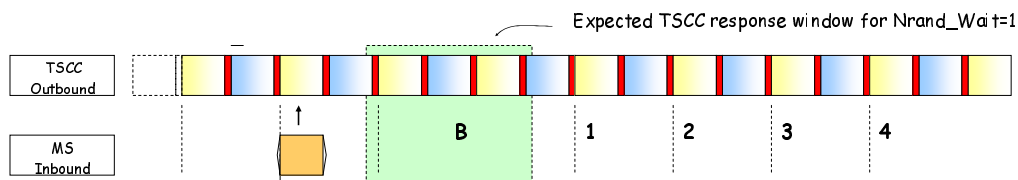


Figure 6.7: Random backoff Example #2

- The MS makes a random access attempt. $N_{Rand_Wait}=1$ indicates that the TSCC will respond in one of the next two TDMA frames at [B].
- After TDMA frame [B] a response has not been received, therefore the MS chooses one of the slots 1, 2, 3, 4 randomly for its next access attempt.

A number of outbound channel PDUs including an Aloha PDU contain the backoff information element.

NOTE: Future releases of the standard may define CACH messages that contain this information element.

The backoff may be altered by the TSCC and broadcast to MS to respond to varying load conditions presented to the system throughout the course of operation. If the system has a light traffic load, the backoff may be small, so decreasing random access latency. If the traffic load increases a longer backoff may be warranted to spread competing of random access attempts from different MSs by the TSCC transmitting a larger backoff number. This traffic load may be estimated from historical usage or may be calculated from the burst traffic being received at that time.

The backoff parameter may change while the MS is already making random access attempts. When the MS has chosen a random slot, that slot shall be preserved for the duration of the current random access attempt. Any new value of backoff parameter from the TSCC shall be noted by the MS and shall be employed if the MS needs to choose a new random slot for its next random access attempt.

For PDUs that contain the backoff information element, the number of backoff TDMA-frames is coded, so that more backoff TDMA-frames can be realized than a pure binary representation would permit. The explicit numbers of TDMA-frames resulting from the back-off number is indicated by table 6.3.

Table 6.3: Number of backoff TDMA frames indicated by the Backoff Number

Backoff Number	Back-off TDMA Frames	Backoff Number	Back-off TDMA Frames
0	Reserved	8	15
1	1	9	20
2	2	10	26
3	3	11	33
4	4	12	41
5	5	13	50
6	8	14	70
7	11	15	100

Note that:

- A C_ALOHA PDU with M=24 invites access only for one specific individual MS.
- In the example in figure 6.5, if an MS had chosen the slot "C" for a random access attempt, that MS would be able to determine that the slot was not available for random access because the slot was withdrawn by decoding the AT bit from the CACH and noting that the slot the MS had chosen was withdrawn. The MS would abandon that random access attempt, and choose another candidate slot using the random backoff parameter.
- The MS shall rely on the AT bit to determine if the following random-access slot is withdrawn. If the MS does not successfully receive the preceding AT bit, the MS shall assume the slot is withdrawn.

6.2.1.1.7 Retry decision and time-outs

After sending a random access PDU, a MS shall wait to receive a response from the TSCC. Various PDUs shall be accepted as a valid response (as specified in the sections detailing the registration and call procedures).

The MS shall abandon its access attempt if it has sent the maximum permitted number of random access for the particular service requested and received no valid response. This number depends on the service and priority of service being requested:

- For non-emergency random access requests, it is N_{Rand_NR}.
- For emergency random access requests, it is N_{Rand_NE}.

The MS shall also operate a time-out T_{Rand_TC} that defines the maximum time it waits trying to achieve random access, and abandon the attempt if this time-out expires.

If the unit's access attempt fails as a result of T_{Rand_TC} timeout then:

- if the MS has not transmitted a PDU, it shall return to the idle state (and may indicate the failure to the user);
- otherwise, (the MS has made at least one random access attempt) if the T_{Rand_TC} timer expires while the MS is waiting N_{wait}+1 for the last random access attempt, the MS will complete the N_{wait}+1 TDMA-frames before abandoning its random access.

6.2.1.2 Action after receiving an acknowledgement

The MS shall not re-transmit any further random access PDU when an appropriate acknowledgement has been received from the TSCC. Various PDUs that are acceptable in addition to specific acknowledgement PDUs are indicated in the procedures specified in the present document. An applicable TSCC response to a random access request shall start an MS timer. This timer may be restarted by the reception of a further applicable acknowledgement PDU from the TSCC. Two values are specified for this timer. One value T_{P_Timer} shall be used if the random access service requires a payload channel (for example a speech or packet data service). The second value T_{NP_Timer} shall be used for services that only use the TSCC (for example Registration, Short Data service).

6.2.1.3 MS Arriving on a Control Channel

Channel access regulation for trunked systems is implemented by a TSCC transmitting signalling on the outbound channel with periodic PDUs that define regulated channel access.

When an MS tunes to a new channel where the recent history of channel activity is unknown, the MS shall establish that the TSCC is identified as one that the MS is permitted to access.

- a) The MS shall first wait until it receives a colour code information element. If the colour code being transmitted by the TSCC is 0000₂ the MS shall skip the colour code check and check the C_SYSCode as specified in clause 6.2.1.3 b). If the colour code being transmitted by the TSCC is a value other than 0000₂ the MS shall check that this particular channel is transmitting a colour code that is expected by the MS. The MS may maintain a list of logical channel numbers and their corresponding colour code assignments (see annex C).
- b) The MS shall wait until it explicitly receives the C_SYSCode being transmitted on the TSCC. If the MS is authorized to access this TSCC, the MS shall wait for an applicable C_ALOHA PDU before it attempts access by random access procedures defined in these clauses.

6.3 Control Channel Acquisition and Retention

Unless assigned to a payload channel (including immediately after switch-on), the MS shall attempt to find a TSCC appropriate to the MSs selected network. The search for a TSCC may be performed by a general hunt through all likely channels or by reference to parameters stored within the MS. A framework for MS hunting is described in annex D.

A MS shall not make any transmissions on a TSCC unless it is active on that channel. It shall not become active until it has received a C_SYSCode that authorizes the MS to access that TSCC.

If an MS is hunting over a number of candidate channels, it shall leave the selected channel as soon as it becomes evident that the MS shall not be permitted service.

The discipline for MSs whilst active a TSCC and the circumstances which may result in a search for a new TSCC are the subjects of clause 6.3.2 Control Channel Acquisition Procedures.

In particular:

- the method by which the MS searches for an appropriate TSCC;
- the criteria to which a TSCC must be considered appropriate by the MS - authorization;
- procedures for returning to the TSCC acquisition procedures.

The methods specified in this clause recognize that designers of networks may choose from a variety of control channel strategies, including both Dedicated Control Channels and Non-dedicated Control Channels.

These methods may result in the MS encountering a variety of control channel situations, including:

- a) receiving a TSCC which suffers short-term interruptions (radio fading and multi-path reception);
- b) suffering long-term interruptions to TSCC reception during which no appropriate TSCC can be received by the MS (Non-dedicated Control Channels, or moving out of range of the network);
- c) being in a location where it is possible for more than one TSCC to be received from the selected network, involving the unit in a choice;
- d) being instructed to leave a TSCC;
- e) being instructed to leave or being barred from access to, a TSCC as a result of a network load sharing arrangement;
- f) Being instructed to sample an alternative TSCC on an adjacent radio site (Vote Now).

NOTE: It should be noted that a Non-dedicated Control Channel strategy may only be suitable for small single site trunked networks using only a few physical channels. If a multi-site trunked network employed a site with a non-dedicated TSCC, the network may find it impossible to connect a wide area call or transport services that only used the TSCC for delivery.

Procedures have been specified in the present document to indicate to MS when they may sample an adjacent site for a TSCC that may provide an improved grade of service for the MS user. This is achieved on the TSCC transmitting a PDU that invites all MS to leave the TSCC momentarily. During this sample time the TSCC can discontinue call transactions. Notwithstanding this, manufacturers may devise their own procedures that will allow a MS to leave the current TSCC to sample for an alternative TSCC. However it must be noted that if the MS leaves the TSCC on its own volition the MS may miss a TSCC transaction.

6.3.1 MS Parameter Volatility

In order to satisfy the procedures specified in this clause, the MS shall retain certain parameters for each selected network when the MS is switched off. Other parameters shall be discarded when the MS is switched off. Table 6.4 lists the behaviour of each applicable parameter. MS parameters that are not listed in table 6.4 shall assume that it must be discarded when the MS is switched off.

Table 6.4: MS Parameter Volatility for Control Channel Acquisition and Retention

Parameter	Clause	Fixed during MS Personalization. Retained when MS is switched off	Changes during operation and retained when MS is switched off	Changes during operation and discarded when MS is switched off
MODEL	6.3.2.2.1.1	X		
NET	6.3.2.2.1.1	X		
DMRLA	6.3.2.2.1.1	X		
MS Category	6.3.2.2.1.3	X		
Acquisition Authorization Data	6.3.2.2.2	X See note		
Logical Channel Hunt List	Also see annex D	X		
Additions to the hunt list from Announcements received	7.2.20.1		X	
Any parameter not listed				X

NOTE: Length of authorization data is dependent on MODEL. Huge - 10 bits, Large - 8 bits, Small - 5 bits, Tiny - 3 bits.

6.3.2 Control Channel Acquisition Procedures

Control Channel (TSCC) acquisition consists of the steps of checking the C_SYSCode (verification) and, if successful measuring the signal quality (confirmation) as shown in figure 6.8.

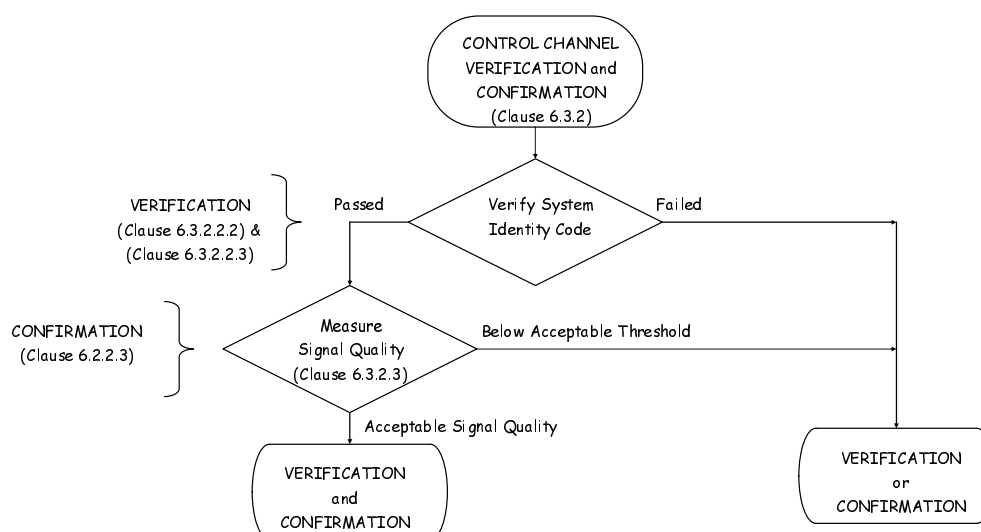


Figure 6.8: Verification and Confirmation Steps

6.3.2.1 Entry into TSCC Acquisition Procedures

The TSCC acquisition procedures enable a MS that is not assigned to a payload physical channel to attempt to select a TSCC. TSCC acquisition is a procedure that consists of hunting for candidate TSCCs and attempting to verify that the MS is authorized to become active on that selected TSCC.

The MS shall enter into the TSCC acquisition procedures under the following circumstances:

- a) immediately after switch-on;
- b) a user-initiated change of selected network;
- c) when it has relinquished the current TSCC under the procedures specified in clause 6.3.3;
- d) when it has received a P_CLEAR PDU on a payload channel;
- e) when it has sent disconnect PDUs P_MAINT(Maint_Kind=DISCON) or timed-out on a payload physical channel;
- f) when it has received a call P_AHOY(Service_Kind=Cancel Call Service) PDU on a payload physical channel which requires it to vacate that physical channel.

At all times during the TSCC acquisition procedures the MS shall mute its received audio and transmission shall be inhibited.

A framework for TSCC control channel hunting is provided in annex D.

6.3.2.2 Identifying a Candidate Control Channel

When an MS is searching for a suitable control channel, the MS shall examine any signal detected for conformity with TSCC structure. The MS shall accept as a candidate TSCC any channel on which a TSCC synchronization sequence is detected.

The method by which the MS identifies candidate TSCCs during hunting is not detailed in the present document. In particular no maximum time allowance for this procedure is specified, although attention is drawn to the necessity of completing tests as quickly as possible, notably on channels which can be easily rejected as TSCC candidates (e.g. invalid parameters from the C_SYSCode), since the overall speed of the hunt (and thus efficiency of service to the user) depends on the rapidity with which these tests can be carried out.

6.3.2.2.1 Checking the System Identity Code

When the MS has identified a candidate TSCC, it shall examine the values of the C_SYSCode fields from the TSCC PDUs that transmit the C_SYSCode information element.

The time which the MS may continue to search for a value of C_SYSCode information element for verification is not specified since this depends on the regularity by which the TSCC transmits PDUs that contain the C_SYSCode information element. However it should be noted that the essential C_SYSCode parameters for TSCC searches are also transmitted in the CACH.

When the MS has selected a C_SYSCod information element for verification, it shall decide if it is authorized to acquire the TSCC (see clause 6.3.2.2.2). If acquisition is permitted then the MS shall become active on that TSCC and start the signal quality checking procedures specified in clause 6.3.2.3.

Whilst active on a TSCC, after verification but prior to confirmation, the MS shall not transmit any random access PDUs, but it shall comply with any applicable PDUs received, as required, provided that to do so does not involve transmitting on the TSCC.

6.3.2.2.1.1 Structure of the System Identity Code (C_SYSCode)

DMR trunked networks may range from tiny systems consisting of a very small number of sites to very large systems covering a wide geographic area. To accommodate this wide range of networks, DMR specifies four network models, each with characteristics appropriate to each model.

Table 6.5: Network Model

Network Model	Model Coding	Number of Networks	Number of Sites per Network	DMRLA
Tiny	00 ₂	512	8	0 to 3
Small	01 ₂	128	32	0 to 5
Large	10 ₂	16	256	0 to 8
Huge	11 ₂	4	1024	0 to 10

In order to identify the network and site to MSs, a TSCC frequently transmits a C_SYSCode. MSs shall examine the C_SYSCode to determine if they are permitted to become or remain active on the TSCC. The C_SYSCode information elements are structured as follows.

Table 6.6: Network Model Description

Parameter	Descriptor and section	Description
MODEL	Network Model	Tiny, Small, Large, Huge
NET	Network Identity	Identifies a particular DMR trunked network
SITE		The SITE parameter identifies a particular site within a network
PAR		for multiple TSCCs within oneTS (site)

A bit specific representation of the Syscode information element is shown in figure 6.9. The MODEL defines the length of the NET and SITE information elements. Table 6.5 shows the effect of this partition. It is likely that in a particular geographical area a large number of small networks may be employed but only a small number of large networks. The MODEL parameter enables a number of differing archetypal networks to be defined.

NOTE: The DMRLA parameter illustrated in figure 6.9 is used for registration. The registration protocol is specified in clause 6.4.4).

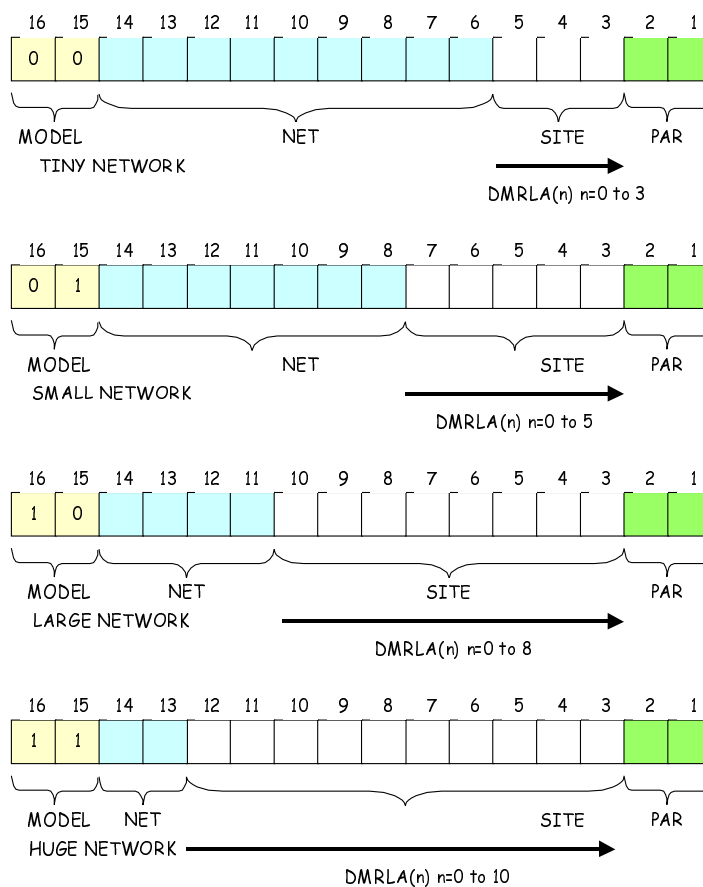


Figure 6.9: Allocation of NET and SITE information elements in C_SYSCode

6.3.2.2.1.2 Multiple Control Channels

DMR trunked networks may operate with one or two TSCCs at a single site. The site may sub-divide the MS population to allow load sharing between TSCCs. This facility is provided by the PAR sub-field in the C_SYSCode and by control categorization of MSs.

6.3.2.2.1.3 Control Categorization of Radio Units

At the time of MS network personalization, the MS shall be allocated a control category (ContCAT) stored in the MS fixed non-volatile storage. Two control categories are available, which are designated A and B.

The control category governs acquisition and retention of a TSCC, since the PAR sub-field in the C_SYSCode indicates which MS control categories are allowed to become active.

6.3.2.2.1.4 The PAR Sub-field

The PAR information element occupies two bits of the C_SYSCode. The meanings assigned to the four possible values of PAR shall be:

- 00₂ Reserved.
- 01₂ Category A MSs only permitted.
- 10₂ Category B MSs only permitted.
- 11₂ Category A MSs and B MSs permitted.

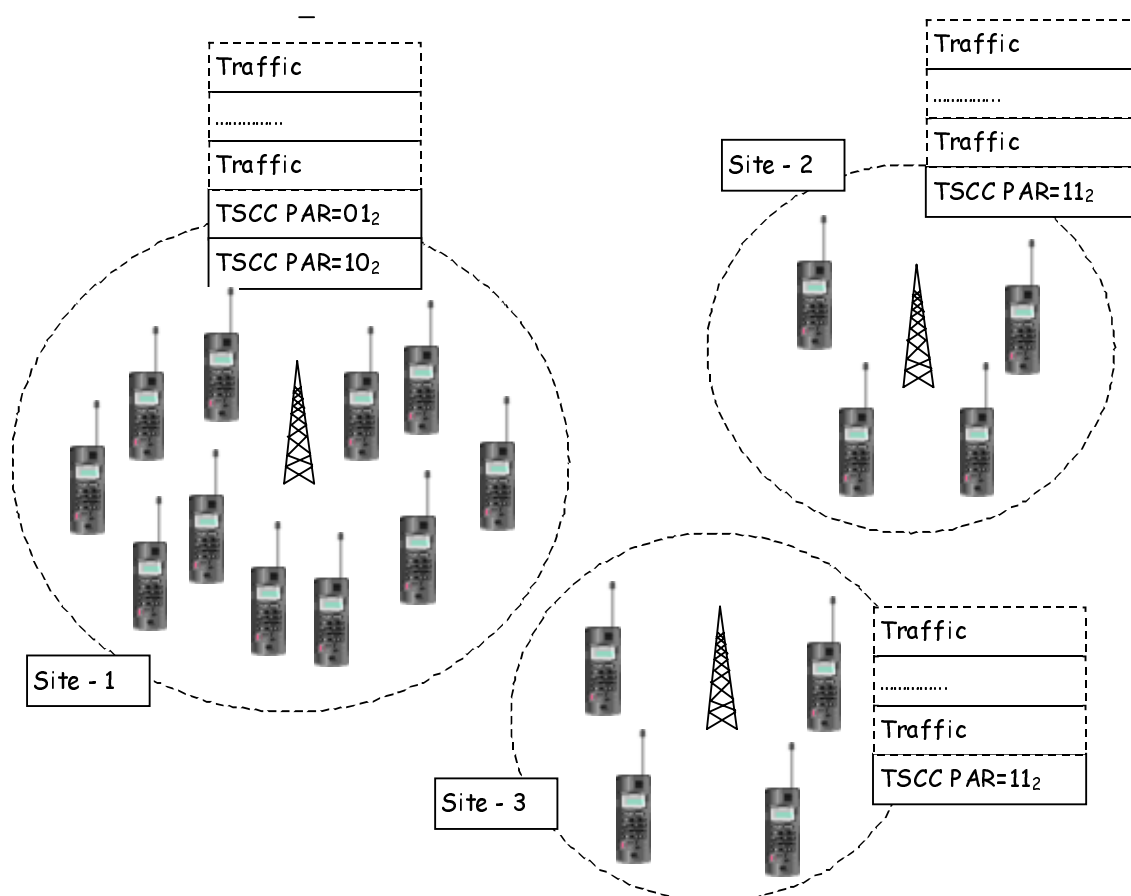


Figure 6.10: Multiple Control Channels by PAR

EXAMPLE: A wide area DMR trunked network has a number of radio sites that employ one TSCC and one site that is equipped with two TSCCs. Differing fleets of MS are personalized such that the total MS population is evenly distributed between Category A and Category B units. Referring to figure 6.10, Site '1' is configured with two TSCCs and radiates PAR=01 on the first TSCC and PAR=10 in the second TSCC. Any MS, whether Category A or B can become active on the TSCC from site 2 and site 3. When MS travel to site 1 however they will cluster on their appropriate TSCC.

6.3.2.2.2 TSCC Authorization Procedure

The MS shall read the C_SYSCode being transmitted on the TSCC:

a) Checking the MODEL:

- The MS shall compare the MODEL transmitted in the C_SYSCode on the TSCC with the MODEL stored in MS fixed non-volatile storage. If there is no match then the MS unit shall assume that it is not authorized to acquire the TSCC under test.

b) Checking the NET:

- If the MS has successfully verified a) above then:
 - The MS shall compare the NET transmitted in the SYS code on the TSCC with the NET stored in MS fixed non-volatile storage. If there is no match then the MS unit shall assume that it is not authorized to acquire the TSCC under test.

c) Checking the SITE_Acquisition Authorization Data:

- If the MS has successfully verified a) and b) above then:
 - The MS shall first check if it has stored any SITE acquisition authorization parameters. If no SITE acquisition authorization parameters are stored then no checking of SITE acquisition authorization shall be performed. However if the MS holds at least one parameter, each value stored shall be compared with the SITE parameter transmitted in the C_SYSCode on the TSCC. If there are no matches then the MS unit shall assume that it is not authorized to acquire the TSCC under test.

d) Checking the PAR Sub-field:

- If the MS has successfully verified a), b) and c) above then it shall examine the PAR sub-field in the light of its control category held in fixed non-volatile storage. If the control category of the MS is not one of the categories permitted access by the PAR sub-field value, then the MS shall assume that it is not authorized to acquire the TSCC under test.

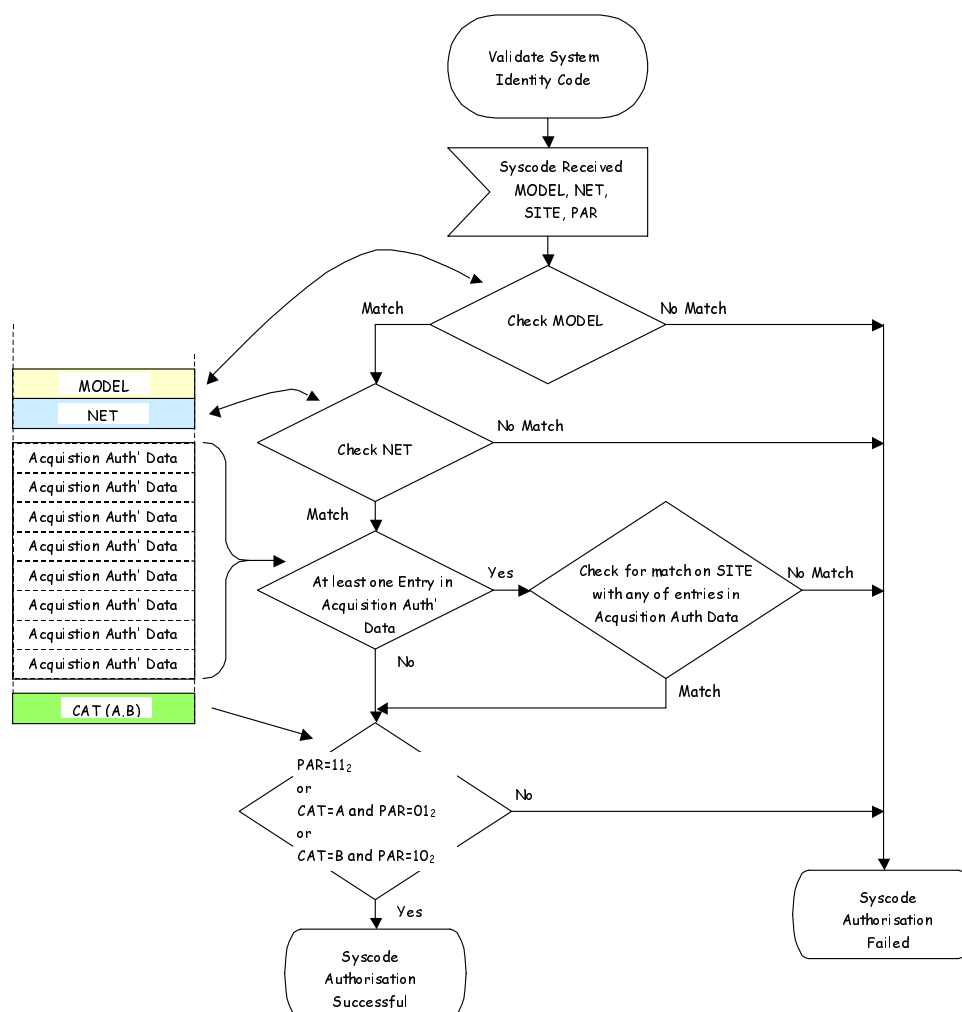


Figure 6.11: Checking the C_SYSCode

Figure 6.11 illustrates the TSC Authorization procedure specified in clause 6.3.2.2.2 a), b), c) and d).

6.3.2.2.3 Checking the SYS_AREA information element

If the MS has successfully verified the C_SYSCode (according to clause 6.3.2.2.2), then it shall examine the SYS_AREA information element from the C_SYSCode. The SYS_AREA is formed by applying a mask to the Site information element of width specified by DMRLA.

The SYS_AREA information element is then compared with a list in the light of denied registrations applicable to the selected network held by the MS. (That list is discarded when the MS is switched off. see clause 6.3.2.2.2).

If the value of the SYS_AREA information element under examination matches with any of the records of denied registrations applicable to the selected network, then the MS unit shall not be authorized to acquire the TSCC under test.

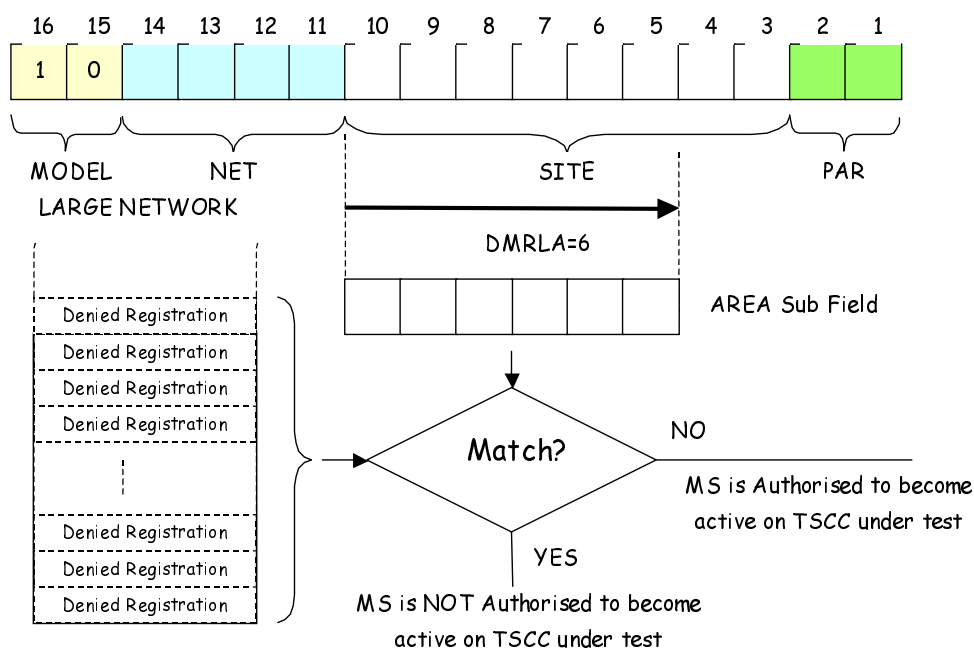


Figure 6.12: SYS_AREA information element from the C_SYSCode

EXAMPLE: A large network has MS personalized with DMRLA=6. The MS retrieves the SYS_AREA information element from the C_SYSCode and compares that result with each entry in the list of denied registrations. If there is a match in any one of the entries then the MS shall not be authorized to acquire the TSCC under test.

6.3.2.3 Confirmation - Monitoring the TSCC outbound channel signal quality

While idle on a control channel the MS shall determine the outbound channel signal quality. This may be e.g. examination of the error rate, from measurement of the RF signal strength.

The MS shall hold two thresholds of signal quality:

- One threshold shall be used while the MS is hunting for a TSCC prior to confirmation (see clause 6.3.2).
- The second threshold shall be used after verification and confirmation and the MS is idle on the TSCC.

NOTE: When an MS enters a call set-up phase, it suspends signal quality measurement of the TSCC.

6.3.3 MS Leaving a Control Channel

6.3.3.1 Reasons for Leaving a Control Channel when active but idle

When active, the MS shall monitor the TSCC and return to hunting procedures if any of these conditions are met:

- After confirmation, the bit error rate exceeds the minimum prescribed in clause 6.3.2.3.
- The value of C_SYSCode received differs from the value verified during acquisition authorization for a NSYSerr consecutive occurrences.
- No decodable TSCC PDUs are received by the MS for T_Nosig seconds.
- The user initiates a change of selected network.
- A C_MOVE PDU applicable to the MS is received. In this case the MS shall note the value of the CONT information element from the C_MOVE PDU.

- f) The MS receives N_ACK(Reason=Denied) as a result of sending a random access registration PDU. In the case of a random access registration request, the MS shall assume the hunt stage that it was last engaged in prior to the registration attempt.
- g) After C_SYSCode confirmation, the MS receives N_ACK(Reason=failed) as a result of random access registration procedures. In this case the MS shall assume the hunt stage that it was last engaged in prior to the registration attempt.
- h) After confirmation, the MS has timed out after a random access registration procedure due to N_Rand_NR being reached or Trand_TC being exceeded. In this case the MS shall assume the hunt stage that it was last engaged in prior to the registration attempt.
- i) After confirmation, the MS has timed-out after a random access attempt for a service request, except registration, due to N_Rand_NR or Nrand_NE being reached or Nrand_TC being exceeded.

6.3.3.2 Leaving a Control Channel Whilst Waiting for Signalling

A MS waiting for signalling shall leave the TSCC on which it is currently active when any of the following events as listed in clause 6.3.3.1 occur - b), c), e). In such circumstances the MS shall retain its state of waiting for signalling during any hunting procedures and subsequent TSCC confirmation tests. Any timers relevant to the waiting state shall be maintained.

6.4 Registration, Power Save, and Authentication Procedures

6.4.1 General

6.4.1.1 Introduction

Registration is a method of recording the area or group of areas where a MS is likely to be located within a wide area network. This information avoids searching for MSs throughout the whole network, consequently reducing call set-up time and TSCC loading.

A secondary feature is that it provides a means of restricting the service to individual MSs to specific TSs by allowing the network to deny other registration requests (see clause 6.4.4.1.4).

The registration strategy describes two types of registration. The first of these is explicit registration, where registration is achieved by means of a MS random access procedure. The second is implicit registration, where registration is achieved as the result of any PDUs exchanged between a TSCC and a MS.

Explicit registration also enables MS to request power save. Power save is prescribed in clause 6.4.7.

6.4.1.2 The Principle

The principle of registration requires that the MS shall only retain a valid registration record where it has received confirmation that it is the same record as that currently held within the network. If a MS fails to receive a response to a registration request, this could be due to:

- a) the registration request not being received by the network, in which case the network will regard the previous successful registration by the unit as the currently-valid registration record;
- b) the registration request being accepted by the network but the service answer response not being received by the MS, in which case the network will regard the unsuccessful registration by the unit as the currently-valid registration record.

Accordingly, in such cases the MS is not able to confirm whether the network holds a valid record for the unit and if it does, whether it is the previous registration or the present registration. The MS shall therefore only replace its current registration record when a successful registration is confirmed by a suitable service answer response to the registration service random access request from the TSCC.

The registration record shall be extracted from the C_SYScore using the following procedure:

- a) The MS extracts the SITE parameter from the C_SYScore.
- b) The MS then extracts the SYS_AREA information from the SITE parameter by masking the most significant bits (MSBs) with DMRLA.

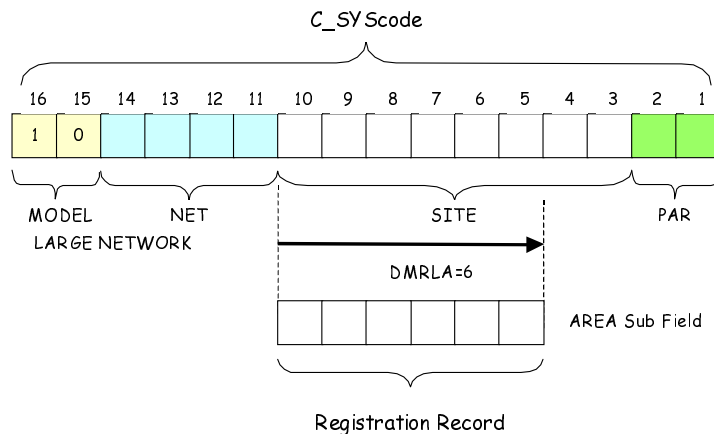


Figure 6.13: Extraction of the registration record from the C_SYScore

EXAMPLE: Figure 6.13 shows a Large Network. The SITE parameter for a Large Network has a field length of 8 bits. DMRLA in this example=6, therefore the most significant 6 bits become the registration record.

6.4.2 MS Parameter Volatility

In order to satisfy the procedures specified in this clause and annex D, the MS shall retain certain parameters for each selected network when the MS is switched off. Other parameter shall be discarded when the MS is switched off. Table 6.7 lists the behaviour of each applicable parameter.

Table 6.7: MS Parameter Volatility for Registration

Parameter	Clause	Fixed during MS Personalization. Retained when MS is switched off	Changes during operation and retained when MS is switched off	Changes during operation and discarded when MS is switched off
The Current Registration Record	6.4.4		X	
List of Denied Registrations	6.3.2.2.3 see note			X

NOTE: At least 8 different values of SYS_AREA information element from the received C_SYScore verified when acquiring the TSCC on which a registration attempt by the MS has been denied. These shall be managed as a FIFO list: when the MS has a full list of entries, any further addition to the list shall displace the earliest entry.

6.4.3 Action on confirmation of a TSCC

A MS shall not make any attempt at random access until TSCC confirmation has been achieved.

When a MS confirms a TSCC it shall either:

- a) if the Reg information element (carried in C_ALOHA PDUs and in the CACH) is zero, the MS shall not seek to register by random access nor shall it create or alter any registration record. The MS shall note that registration is not required and that it is free to initiate calls; or
- b) if the verified SYS_AREA information element from the C_SYScore matches any entry in the list of denied registrations then the MS shall not be authorized to acquire the TSCC under test. The MS shall resume hunting; or

- c) if the MS does not hold a successful registration record for the verified SYS_AREA, the MS shall attempt to register by random access.

Once confirmed on a TSCC, the MS shall not transmit any PDU other than:

- a) registration service random access request PDU; or
 - b) an acknowledgement to an authentication challenge as specified in clause 6.4.8.3;
- until it holds a successful registration record relating to the verified SYS_AREA unless Reg = 0.

If the MS holds a successful registration record relating to the verified SYS_AREA code, it is free to transmit any PDU conforming to the requirements of the present document.

6.4.4 Registration Procedures

6.4.4.1 Registration by Random Access

When a MS determines that it is required to register, it shall attempt to do so by random access using the procedures defined in clause 6.2. If the random access timeout C_RandTC expires and the MS has not sent a random access registration request, the MS shall enter the TSCC acquisition procedures.

Immediately upon sending the registration request by random access, the MS shall delete its current SYS_AREA code retained from its previous registration.

Valid TSCC responses to the random access request are C_WACKD(Reason=Wait) more signalling to follow, C_ACKD(Reason=Reg_Accepted), C_NACKD(Reason=Reg_Refused), C_NACKD(Reason=Reg_Denied), or C_AHOY(Source Address or Gateway=AUTHI) (see clause 6.4.8).

NOTE: AUTHI is the authentication identifier (see clause A.4).

6.4.4.1.1 Intermediate Acknowledgement

If the TSCC cannot respond immediately to the random access request, it can send a C_WACKD(Reason=Wait) to the MS. This acknowledgement shall start timer TNP_Timer in accordance with clause 6.2.1.2. If further signalling is not received after the expiry of the timer, the MS shall comply with the procedures in clause 6.4.4.1.6.

6.4.4.1.2 Registration accepted

The registration attempt shall be considered successful on receipt of ACK(Reason=Reg_Accepted). The MS shall record the SYS_AREA information from the TSCC C_SYScode. The MS shall replace any old registration record with the new record extracted from the C_SYScode.

6.4.4.1.3 Registration Refused

The registration attempt shall be considered to have been unsuccessful if the MS receives C_NACKD(Reason=Reg_Failed).

The MS shall resume hunting, and after confirming a TSCC and receiving a suitable C_ALOHA PDU, shall re-commence a random access registration attempt.

NOTE: Until a successful registration is achieved, the MS shall not attempt to transmit other than random access registration service requests.

6.4.4.1.4 Registration Denied

The registration attempt shall be considered denied if the MS receives C_NACKD(Reason=Reg_Denied). The MS shall keep the SYS_AREA code in the list of denied registration records and enter the TSCC acquisition procedures.

6.4.4.1.5 Challenge & Response Authentication

The TSCC may apply an intermediate step of authenticating the MS during the registration procedure.

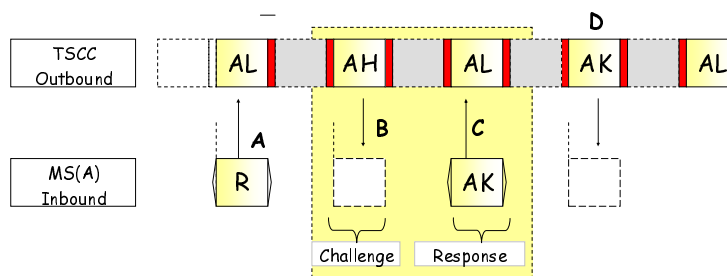


Figure 6.14: Registration with authentication check

Figure 6.14 shows a MS registration procedure with the optional steps "B" and "C":

- At "A" the MS makes a random access registration attempt.
- The AHOY PDU at "B" is the acknowledgement to the random access and challenges the MS to respond with its authentication response. The timer TNP_Timer timer is started.
- "C" is the MS response to the TSCC containing the authentication response.
- The final C_ACKD or C_NACKD is sent on the TSCC to the MS.

The specific authentication procedures are prescribed in clause 6.4.8.

6.4.4.1.6 Registration Attempt Times Out

If the MS times out from waiting for further signalling for the registration (expiry of timer TNP_Timer), it shall enter the TSCC acquisition procedures.

6.4.4.1.7 Registration Demand Received During Random Access Registration

The TS shall avoid conflict in the protocol. If, while waiting for a response to a random access registration request PDU, the MS receives a C_BCAST(Announcement_type=MassReg) PDU applicable to the MS, the MS shall note the information elements from the C_BCAST and initiate the procedure specified in clause 6.4.5.1 then continue with its registration request in accordance with the random access procedures.

6.4.4.1.8 No answer response Received after the maximum number of random access attempts

If no response is received within WAIT+1 slots after the MS has transmitted NRand_NR random access attempts, the MS shall make no consequential changes to its registration record.

6.4.4.1.9 Registration Action on Switch-on or equivalent

If an MS determines that the TSCC requires MS to register, the MS shall register by random access on switch on or change of selected network.

6.4.5 Mass re-registration

A wide area network relies on the integrity of the registration records for MS location management. It is possible that the records may be suspect for many reasons including loss of connections between the various TS. This clause describes a mechanism whereby a TSCC may re-establish those registration records from the MS that are currently confirmed on that TSCC. A broadcast PDU is transmitted on the TSCC that causes all applicable MS that are confirmed to re-register by random access. If this re-registration procedure is activated it is essential to avoid congestion from the increased random access activity that would result. To manage this process therefore, a Reg_Window information element is transmitted in the broadcast PDU that permits MS to make their random access registration attempt over an extended period of time.

An MS shall note the delay parameter Reg_Window from the C_BCAST(Announcement_type=MassReg) PDU it receives and shall use table 6.8 to derive from it a time window to make a random access registration attempt.

The Mass registration may be used to demand a registration from a specific MS by setting the MS address in the Mass Registration Broadcast PDU to the individual address of a MS and setting the Mask = 24.

6.4.5.1 Procedure for MS on receipt of Mass Re-registration Broadcast

When confirmed on a TSCC a MS shall make use of information C_BCAST(Announcement_type=MassReg). This PDU may be transmitted on the TSCC to cause all MS or a subset of the MS population to re-register by random access.

A MS shall note the population subdivision contained in each C_BCAST(Announcement_type=MassReg) PDU that it receives (as prescribed in clause 6.1.3) using the qualifier (Mask) and the address field from the C_BCAST PDU. For Mask = 0 to 24, the PDU is applicable to the MS if the "Mask" least significant bits of the C_BCAST address information element match the "Mask" least significant bits of its individual address.

Table 6.8: Reg_Window lookup for Mass-Registration

Reg_Window	Treg_Window	Reg_Window	Treg_Window
0	Cancel Mass Reg	8	100
1	.5	9	300
2	1	10	1 000
3	2	11	3 000
4	5	12	10 000
5	10	13	30 000
6	20	14	100 000
7	30	15	200000

If the MS determines that the C_BCAST(Announcement_type=MassReg) PDU is applicable, the MS shall:

- examine the Reg_Window information element from the C_BCAST(Announcement_type=MassReg). If the Reg_Window information element is non-zero, the MS shall derive the window size TReg_Window (in seconds) for a Random Access Registration attempt using table 6.8;
- choose a random number (using a statistically uniform distribution) from zero to TReg_Window;
- count real time seconds until the random value is reached;
- make a random access registration attempt using the procedures prescribed in clause 6.4. If the MS is in power save mode, the PowerSave_RQ information element in the Service_Options of the registration service request shall be set to maintain the power save mode currently in operation;
- also count real time seconds until the TReg_Window slot is reached. If the MS receives other applicable C_BCAST(Announcement_type=MassReg) containing a non zero Reg_Window information element before Reg_Window is reached the MS shall ignore that C_BCAST PDU;
- if Power Save is in operation, the TSCC shall ensure that the Mass-Registration is transmitted in the wake period.

If the MS is confirmed on a TSCC and the MS receives other applicable C_BCAST(Announcement_type=MassReg) containing a zero Reg_Window information element the mass re-registration procedure and any pending random access attempt shall be cancelled. If such a broadcast is received when the random access procedure is in progress that random access procedure shall be completed before the mass re-registration procedure is cancelled.

If the MS leaves the currently confirmed TSCC, and successfully confirms a different TSCC, any Mass-registration procedure shall be cancelled.

6.4.6 De-registration

When an MS is switched off, or a user initiated change of system is invoked, the MS may first attempt to de-register from the current system. It shall attempt to do so by random access using the procedures defined in clause 6.2. In the Service_Options of the registration service request the information elements shall be set to IP_Inform=0₂, Reg_Dereg=0₂ and PowerSave_RQ=000₂

When an MS switch-off or change of network is performed, the MS shall start a timer T_Dereg.

Immediately upon sending the de-registration request by random access, the MS shall discard its current SYS_AREA code retained from its previous registration.

The only valid TSCC response to the de-register random access request shall be C_ACKD(Reason=Reg_Accepted). If the acknowledgement is received, the MS shall complete the switch off or change of network.

If timer T_Dereg expires, the MS shall abandon the de-registration procedure and complete the action of switch-off or change of network.

6.4.7 Power Save

6.4.7.1 Overview

Tier III systems may support a synchronized power saving feature.

An MS can synchronize to the timing parameters that have been exchanged with the TSCC and adopt a periodic sleep cycle. Calls to that MS shall be synchronized to the wake-up periods (power save frames) that are agreed between MS and the TSCC.

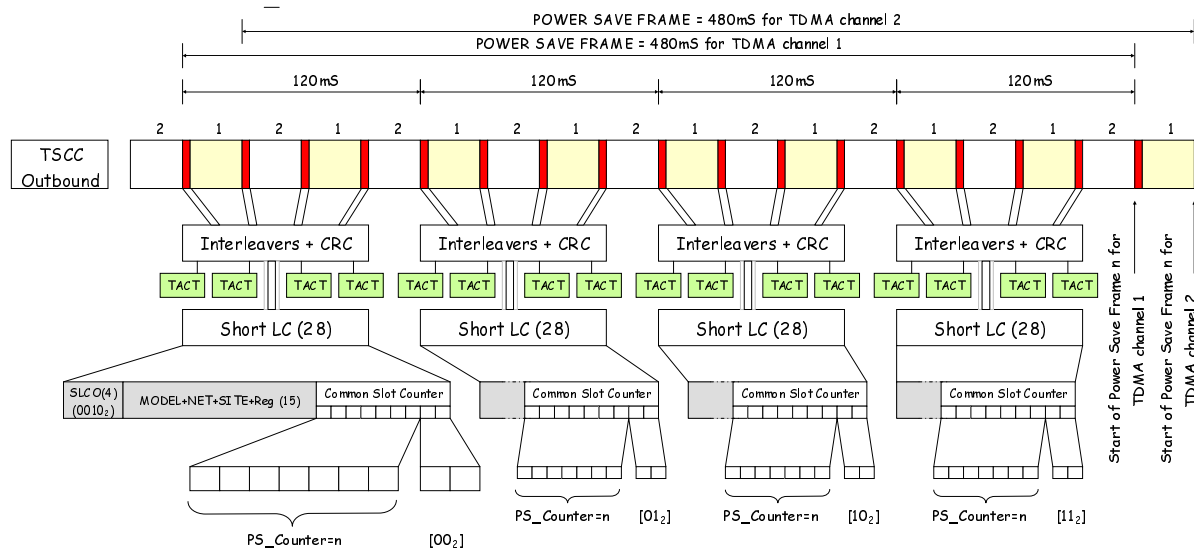


Figure 6.15: Power Save Frame Structure

The power save frames are defined by the PS_Counter information element, a sub-set of the Common_Slot_Counter broadcast in the CACH. A sleeping MS shall wake for a designated power save frame. If the TSCC has a PDU or transaction for the sleeping MS, that PDU shall be queued until a designated power save frame is transmitted on the TSCC. MS or other entity that initiates a transaction to a sleeping MS (or group of MSs) shall be queued on the TSCC until the designated power save frame has been reached. Figure 6.15 shows a power save frame. For each logical channel there are eight slots available to signal MS during a designated power save frame.

- The MS and TSCC shall have previously synchronized a particular wake frame.
- The TSCC must know when a particular MS has woken and is able to receive signalling addressed to that MS. If several MSs are in a fleet and are party to a talkgroup call, all MSs in that particular talkgroup may share the same wakeup frame. The way in which the TSCC manages the power save and allocates particular wakeup frames is not prescribed in the present document.
- Different MSs sharing a common TSCC may have differing power save and the TSCC/MSs must be able to deal with this.
- The Short LC that carries the Power Save Counter does not have to be continuously transmitted. When MS have received a Power Save Short LC they are able to calculate power save frames from that point. MS may then refresh by occasional appropriate short LC PDUs.

6.4.7.2 Power Save Procedures

6.4.7.2.1 Basic Power Save Procedures

For a MS to activate power save, it registers with the TSCC. In the registration service request the MS may ask for power save it wishes to employ, by sending a non-zero three bit PowerSave_RQ information element with a number between 1 and 7. A registration service request with a zero PowerSave_RQ indicates that no power save is required or a previous power save is cancelled. The TSCC responds positively if it supports power save for that request, with a PowerSave_Offset information element (length 7) in the range 0 to 1, 0 to 3, 0 to 7, 0 to 15, 0 to 31, 0 to 63 or 0 to 127.

Table 6.9: Power Save information elements during MS registration

Power Save	PowerSave_RQ	PowerSave_Offset
OFF	0	0
1:2	1	0 to 1
1:4	2	0 to 3
1:8	3	0 to 7
1:16	4	0 to 15
1:32	5	0 to 31
1:64	6	0 to 63
1:128	7	0 to 127

A PowerSave_RQ=1 indicates the MS shall sleep for one Power Save Frame and awake for the second. A "2" indicate 1 awake and 3 sleeping. A "3" indicates 1 in 8 awake and so on. In this example the greatest power save would be "7" indicating 1 in 128 awake as shown in table 6.9.

The TSCC responds with an acknowledgement containing a PowerSave_Offset information element (the Response_Info information element in the acknowledgement PDU) that indicates the power save frame number that the TSCC will send signalling to that particular MS. The TSCC may therefore average out signalling across all power save frames for differing fleets (or differing talkgroups). The frame number is read by the MS and a mask applied according to the power save request. The answer gives the power save frame number for that power save value asked for in the registration request. The MS can then calculate when to wake for incoming traffic.

EXAMPLE: A MS requests a power save of 4 by setting the value of PowerSave_RQ = 2 in the registration service request. The TSCC responds with Powersave_Offset = 2.

The PS_Counter is counting up continuously. Suppose the PS_Counter at this moment = 65_{decimal}.

Table 6.10: Power Save Example - MS state

PS_Counter	Count	Mask Counter with PowerSave RQ							MS state
		0	1	0	0	0	0	1	
...
65	010 0001 ₂	0	1	0	0	0	0	1	Sleep
66	010 0010 ₂	0	1	0	0	0	1	0	Wake
67	010 0011 ₂	0	1	0	0	0	1	1	Sleep
68	010 0100 ₂	0	1	0	0	1	0	0	Sleep
69	010 0101 ₂	0	1	0	0	1	0	1	Sleep
70	010 0110 ₂	0	1	0	0	1	1	0	Wake
...

Table 6.10 shows how a TSCC determines when a MS is awake. The TSCC applies a mask of length PowerSave_RQ. In this example the mask leaves two bits. When the masked PS_Counter equals the PowerSave_Offset the TSCC may signal the MS.

MS can sample the CACH at any time, read the Common_Slot Counter and determine when the wake frame will be transmitted. The MS may then sleep until a point at which its wake frame is scheduled. A PDU addressed to the MS by its individual address shall cause the MS to awaken for T_Awake seconds. Each MS individually addressed or applicable talkgroup address PDU transmitted on the TSCC or MS shall refresh T_Awake. If no PDUs have been transmitted or received by the MS when T_Awake expires the MS shall return to its sleeping state retaining its previous power save settings.

If an MS awakes and receives an applicable C_AHOY PDU that will result in a payload channel being assigned, the MS shall stay awake for a time T_Pending for the Channel Grant PDUs to be transmitted. When that call is completed and the MS returns to the TSCC, the MS shall wait for T_Awake seconds and then return to the sleeping state.

If while awake, the MS receives a C_MOVE PDU, the MS shall retain its T_Awake timer and return to its sleeping state after T_Awake expires, unless the move to the replacement TSCC causes the MS to re-register when new power save information elements shall be exchanged.

6.4.8 Authentication Procedures

Authentication is a procedure to verify that a MS (or TSCC) is genuine. The procedures rely on a key that is shared between an individual MS and the TS. When authenticating an MS, a convenient point for applying the authentication procedure is during MS registration. When a MS attempts to register by random access, the TSCC sends a random number in a C_AHOY PDU (the challenge). The MS calculates the response to the challenge, using a key using a standard algorithm (RC4) [10].

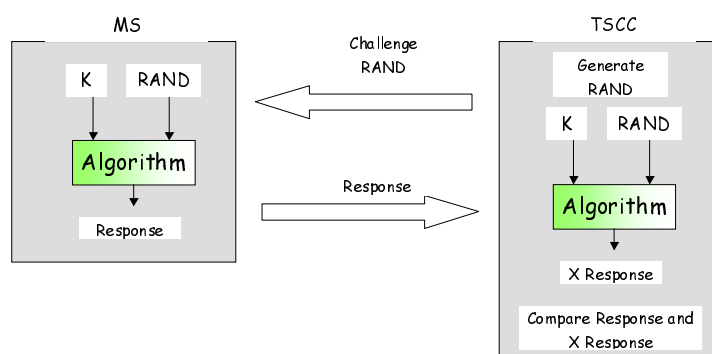


Figure 6.16: Challenge and Response Authentication

Figure 6.16 shows the mechanism. The MS calculates the response to the challenge. The TSCC uses the same algorithm and the same K,RAND values as the MS. The TSCC then compares the expected response with the actual response. If the responses match then the authentication is considered successful.

6.4.8.1 Key Management

A 56 bit authentication key (K) is programmed into each MS. Key generation is specific to each manufacturer and not specified in the present document. The (K) of each MS is also programmed into the TS. (K) is intended to be valid for the lifetime of the MS, but if (K) is compromised for a particular MS, a manufacturer may choose to re-program the key (K) both in the MS and in the network management.

NOTE: A compromised key only affects one MS and not the entire system.

6.4.8.2 Authentication Procedures for the TSCC to authenticate a MS

The TSCC challenges an MS by transmitting a C_AHOY PDU to an individual MS address and information elements as shown in table 6.11. If the C_AHOY is transmitted as part of the registration procedure, the Service_Options_Mirror is set to the Service_Options from the C_Rand PDU. If the C_AHOY is transmitted as an authentication poll from the TSCC (and unconnected with a registration procedure) the Service_options_Mirror shall be set to 000 0000₂.

Table 6.11: C_AHOY information elements for authentication challenge

Service_Options_Mirror	7	
Service_Kind_Flag	1	0 ₂
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	1110 ₂
Target address	24	Address of Called MS
Source Address or Gateway	24	Authentication challenge value

6.4.8.3 Authentication Procedures for the MS

If an MS receives an applicable C_AHOY PDU it shall pass the authentication challenge value to the authentication algorithm. The result from this algorithm is a 24 bit authentication result. That is transmitted to the TSCC by a C_ACKU PDU.

Table 6.12: Authentication response elements

Source Type	1	1_2 - Acknowledgement sourced by MS
Response_Info	7	$000\ 0000_2$
Reason Code	7	$010\ 0100_2$
Reserved	1	0_2
Target address	24	authentication challenge response
Additional Information (Source Address)	24	MS individual address that is transmitting the acknowledgement

6.4.9 MS Stun/Revive

MS may be denied access to certain tier III services using the stun mechanism. If a MS has been disabled by a stun procedure, the MS may not request nor receive any user initiated services on the network that performed the procedure. However hunting and registration, authentication, stun / unstun and registration services shall remain active.

While an MS is stunned, it may also retain the NMEA polling service described in clause 6.6.5.1.5.

In the present document, MS shall only be stunned/revived from a TSCC gateway STUNI as described in clause 6.4.9.1.1.

6.4.9.1 MS Stun/Revive without authentication

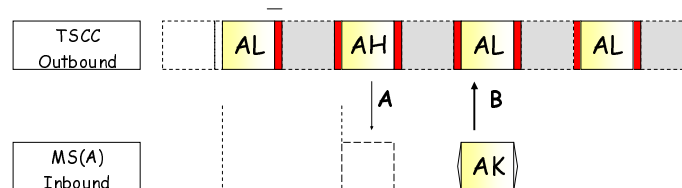


Figure 6.17: MS Stun/Revive Procedure

Figure 6.17 shows the mechanism where the MS does not demand authentication prior to the stun.

- The TSCC sends a C_AHOY at "A".
- MS makes an appropriate acknowledgement at "B".

6.4.9.1.1 Stun / Revive procedures for the TSCC

The TSCC transmits a C_AHOY with the information elements as shown in table 6.13.

Table 6.13: C_AHOY information elements for Stun/Revive

Service_Options_Mirror	7	$000\ 0000_2$
Service_Kind_Flag	1	0_2 to stun, 1_2 to revive
Reserved	2	00_2
Appended_Blocks	2	00_2
Service_Kind	4	Supplementary Service - 1101_2
Target address	24	Individual Address of Called MS
Source Address or Gateway	24	STUNI (see clause A.4)

- If the response is C_ACKU(Reason=Message_Accepted) the TSCC shall interpret the acknowledgement that the stun / revive procedure was successful.

- b) If the response is C_NACKU (Reason=MSNot_Supported) the TSCC shall interpret the acknowledgement that stun / revive is not supported by the MS.

6.4.9.1.2 Stun / Revive procedures for the MS

If the MS receives an applicable stun/revive C_AHOY but the MS does not support stun / revive it shall respond with C_NACKU (Reason=MSNot_Supported).

If the MS receives an applicable stun/revive C_AHOY and the MS supports stun / revive it shall examine the Service_Kind_Flag, call the appropriate stun or revive procedure and respond with C_ACKU (Reason=Message_Accepted).

6.4.9.2 MS Stun/Revive with authentication

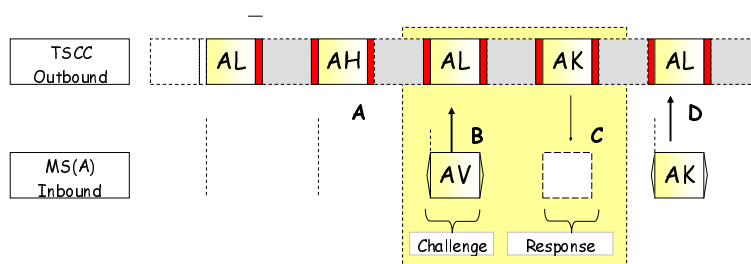


Figure 6.18: MS Stun/Revive with Authentication

Figure 6.18 shows the mechanism where the MS demands authenticates the TSCC prior to the stun:

- The TSCC sends a C_AHOY at "A" to stun the MS.
- The MS makes its authentication challenge at "B" by transmitting a C_ACVIT PDU. This Ackvitation sent by the MS is the acknowledgement to the initial C_AHOY from the TSCC.
- At "C" the TSCC sends the challenge response to the MS. The MS authenticates the challenge response. If the challenge response is ratified by the MS, the MS stuns/revives and sends C_ACKU(Reason=Message_Accepted). If the challenge response fails authentication, the MS shall send C_NACKU(Reason=Recipient_Refused) ("D"), and the MS shall not stun. The TSCC may repeat step "C" if a response is not successfully received at "D".
- The final acknowledgement is sent to the TSCC.

6.4.9.2.1 Stun / Revive procedures with authentication for the TSCC

The TSCC transmits a C_AHOY with the information elements as shown in table 6.14.

If the MS response is a C_Ackvitation (Target Address=AUTHI, Source Address=challenge value) the TSCC shall interpret that PDU as an acknowledgement and that the TSCC is being challenged that the TSCC is authentic.

The TSCC shall send the response C_ACKD(Reason=Message_Accepted) with the information elements as shown in table 6.14.

Table 6.14: Authentication Response Elements

Source Type	1	0 ₂ - Acknowledgement sourced by TSCC
Response_Info	7	000 0000 ₂
Reason Code	8	0100 0000 ₂
Reserved	1	0 ₂
Target address	24	authentication challenge response
Additional Information (Source Address)	24	AUTHI (see clause A.4)

When the TSCC response to the challenged has been transmitted to the MS, the MS shall send a final acknowledgement:

- a) If the final acknowledgement transmitted by the MS is C_ACKU(Message_Accepted) the TSCC shall identify that the stun/revive procedure was successful.
- b) If the final acknowledgement transmitted by the MS is C_NACKU(Recipient_Refused) the TSCC shall identify that the authentication was unsuccessful.

6.4.9.2.2 Stun / Revive procedures with authentication for the MS

If the MS receives an applicable stun/revive C_AHOY but the MS does not support stun / revive it shall respond with C_NACKU (Reason=MSNot_Supported).

If the MS receives an applicable stun/revive C_AHOY the MS may authenticate the TSCC by transmitting a C_Ackvitation with information elements as shown in table 6.15.

Table 6.15: C_Ackvitation - MS challenges the TSCC

Service_Options_Mirror	7	0000 000 ₂
Service_Kind_Flag	1	0 ₂ to stun, 1 ₂ to revive
Reserved	2	0 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Supplementary Service - 1101 ₂
Target address	24	AUTHI (see clause A.4)
Source Address or Gateway	24	Authentication Challenge Value

The MS shall examine the response to the authentication challenge and validate the authentication. The MS shall then send a final acknowledgement C_ACKU(Reason=(Message_Accepted)) if the authentication was successful or C_NACKU(Reason= Recipient_Refused) if the authentication was unsuccessful.

If the MS supports stun / revive it shall then examine the Service_Kind_Flag, and call the appropriate stun or revive procedure.

Table 6.16: Final Acknowledgement

Source Type	1	1 ₂ - Acknowledgement sourced by MS
Response_Info	7	000 0000 ₂
Reason Code	8	Message_Accepted - 0100 0100 ₂
		Recipient_Refused - 0011 0000 ₂
Reserved	1	0 ₂
Target address	24	AUTHI (see clause A.4)
Additional Information (Source Address)	24	MS Individual Address

6.5 Unified Data Transport Mechanism

A tier III network supports a wide range of services. To support these services, the transporting of data is a very common necessity. Although Short Data is a primary data service, there are many instances where data needs to be transported to support other services. (For example when a MS dials a PABX or PSTN destination, the dialled digits are uploaded to the TSCC.) Whether the data remains within the network or is used to support other services, the Supplementary Data Transfer Service may be invoked. To reduce the tier III complexity, all data transport using the TSCC share a common method - the Unified Data Transport Mechanism.

- a) Supplementary Data Transfer Service:
 - 1) Inbound transport of destination addresses that are connected through system gateways.
 - 2) Inbound transport of PSTN and PABX dialling digits from MS.

- 3) Inbound transport of IPV4/IPV6 addresses.
 - 4) Inbound transport of a MS address in a number of standard and proprietary formats.
 - 5) Inbound transport of MS NMEA location information.
 - 6) Outbound channel transport of remote addresses that are connected through system gateways.
 - 7) Outbound channel transport of CLI information from PABX/PSTN networks.
 - 8) Outbound channel transport of IPV4/IPV6 address information from ip networks.
 - 9) Outbound channel transport of a Source Address in a number of standard and proprietary formats.
 - 10) Outbound channel transport of NMEA (IEC 61162-1 [8]) MS location.
- b) Short Data Transfer Delivery Service.
 - c) Short Data Polling Service.
 - d) Inbound transport of digits for the Call Diversion Service.

The format for the data transfer is the same for transfers using the outbound channel and transfers using the inbound channel. The UDT employs the UDT type (UDT) PDU. The first block is the header as shown in figure 6.19. This block carries source and destination addresses, the format of the data being carried, and UDT Format that denotes the service being supported. Up to four Appended data blocks may follow the header to carry the data. All blocks of the UDT shall be transmitted consecutively.

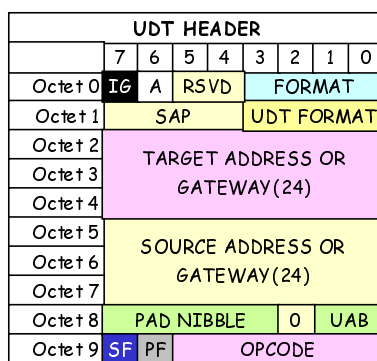


Figure 6.19: UDT Header

The UAB information element indicates the number of UDT blocks that are appended to this header. For a UDT addressed to an individual MS, the A information element denotes if a response to this multi-block UDT is expected.

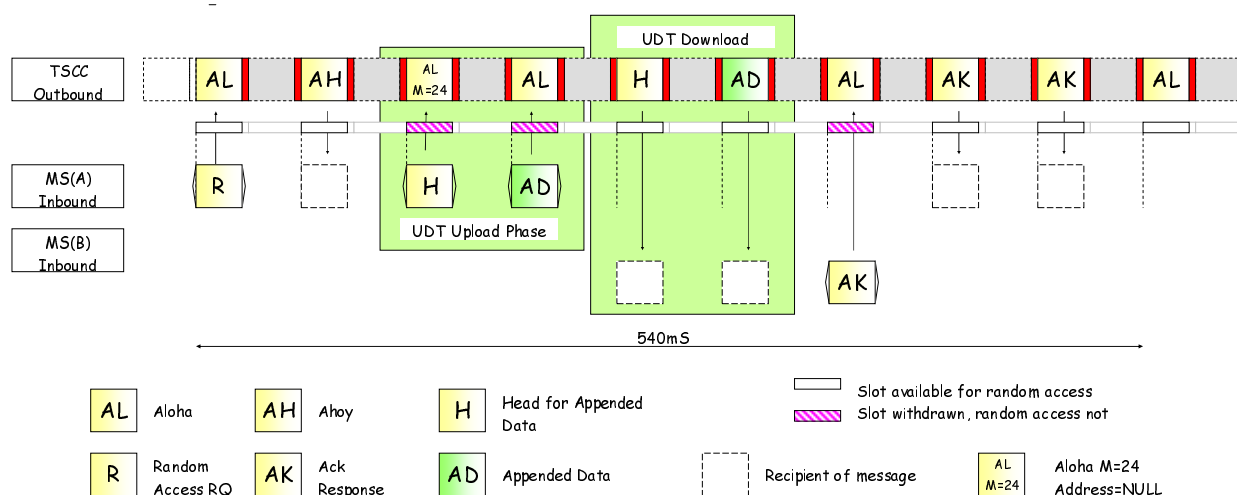


Figure 6.20: A Short Data call using the UDT mechanism

Figure 6.20 is just one example showing how the Short Data service makes use of the UDT mechanism. The Short Data employs a store and forward technique and the procedures are fully described in clause 6.6.4.

However the UDT segments are highlighted to show the upload and download phases that are described in these clauses. In this example the MBC blocks consist of a Header + one appended block.

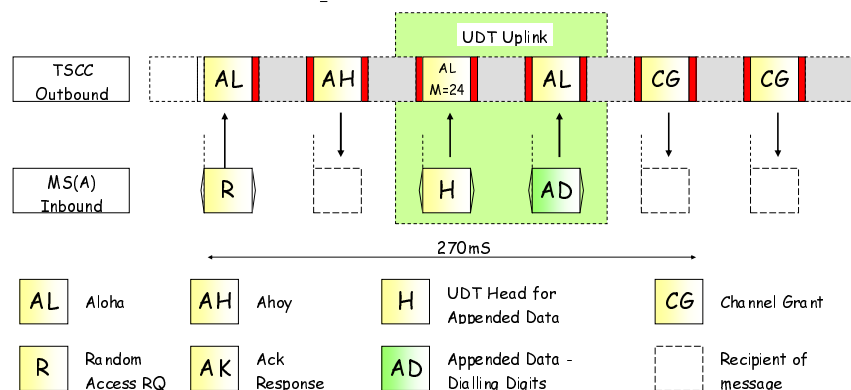


Figure 6.21: MS to PABX/PSTN Call using the UDT Mechanism

Figure 6.21 shows a call set-up for a call from an MS to the PABX/PSTN. Calls to these destinations are characterized by the necessity of passing the dialled destination to the system. The UDT mechanism provides an unambiguous transfer. In this example the UDT consists of a Header + one appended block. In this example the UDT consists of a Header + one appended block for up to 20 dialled digits.

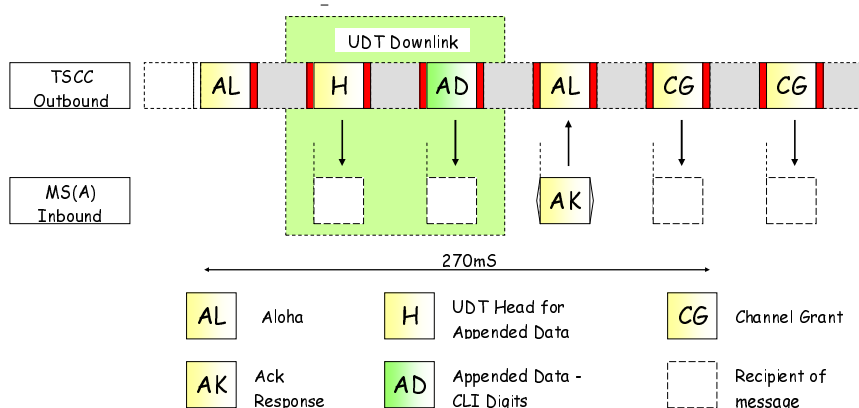


Figure 6.22: Call from the PSTN/PABX using the UDT Mechanism

Figure 6.22 shows a further example of a call from the PSTN. The TSCC has elected to download the CLI information to the recipient as part of this call set-up. The Service_Kind information element is passed in the header therefore the recipient MS knows the call is inbound and the call is from the PSTN. Since the Service_Kind is known to the recipient, a secondary feature of the UDT mechanism is that it may serve as a radio check. Only if the MS responds with a positive (C_ACKU) acknowledgement does the call mature.

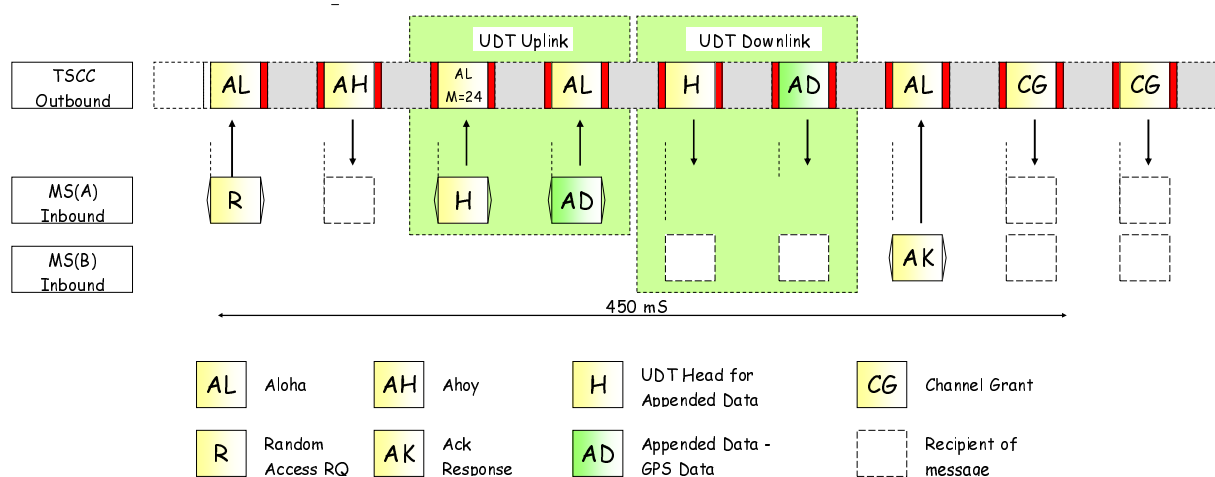


Figure 6.23: UDT mechanism carrying supplementary data

Figure 6.23 shows how supplementary data may be carried as part of a call. MS(A) wishes to send its GPS position as part of a voice call set-up. MS therefore elects to indicate that supplementary data is available in the Service_Options information element. The TSCC uploads the supplementary data and passes the data to the recipient. The UDT download/acknowledgement also serves as the radio check.

6.5.1 Format of the appended data

The format of the appended data is specified in annex B. The standard formats are:

- Address format - the appended block(s) contain DMR addresses.
- Binary Format - the appended block(s) contain binary data.
- BCD format - the appended blocks contain digit coded.
- 7 bit text coded - the appended data is text coded using ISO 7 bit character set (ISO/IEC 646 [12]).
- 8 bit character coded - the appended data is character coded using ISO 8 bit character set (ISO/IEC 8859 [13]).
- NMEA (IEC 61162-1 [8]) location format - the appended data is coded specifically for NMEA (IEC 61162-1 [8]) position data.
- 16 bit Unicode format [9].

6.5.1.1 UDT Block Structure

The UDT block structure is described in TS 102 361-1 [5], clause 8.2.2.3.

6.5.1.2 UDT Content for Services Carried on the Outbound channel

The UDT outbound channel mechanism may be invoked as part of a DMR service. The UDT head PDU contains all parameters for a MS or talkgroup UDT. The data to be downloaded is held in the TSCC and the information elements formed as table 6.17.

Table 6.17: UDT Outbound channel information elements

UDT Outbound channel Mechanism								
UDT Outbound channel PDUs								
Service	Operation	Service Kind	Supplementary Flag	UDT-Format	UDT-Response	Target address or gateway	Source or gateway Address	MS Response to Head+Data
Voice Call from PSTN to Individual MS	Send CLI information from PSTN	Individual Voice Call Service (0001 ₂)	1 ₂	BCD (0010 ₂)	0 ₂ option	Destination MS Address	PSTNI	No
					1 ₂ option			ACK, NACK
Voice Call from PABX to Individual MS	Send CLI information from PABX	Individual Voice Call Service (0001 ₂)	1 ₂	BCD (0010 ₂)	0 ₂ option	Destination MS Address	PABXI	No
					1 ₂ option			ACK, NACK
Voice Call from PSTN to Talkgroup	Send CLI information from PSTN	Talkgroup Voice Call Service (0010 ₂)	1 ₂	BCD (0010 ₂)	0 ₂	Destination Talkgroup	PSTNI	No
Voice Call from PABX to Talkgroup	Send CLI information from PABX	Talkgroup Voice Call Service (0010 ₂)	1 ₂	BCD (0010 ₂)	0 ₂	Destination Talkgroup	PABXI	No
Voice Call from MS to Individual MS	Send NMEA information from Source MS	Individual Voice Call Service (0001 ₂)	1 ₂	NMEA formatted (0101 ₂)	0 ₂ option	Destination MS Address	Source MS	No
					1 ₂ option			ACK, NACK
Voice Call from MS to Individual MS	Send supplementary text PDU as part of call setup	Individual Voice Call Service (0001 ₂)	1 ₂	7 bit txt (0011 ₂)	0 ₂ option	Destination MS Address	Source MS	No
					1 ₂ option			ACK, NACK
Short Data call from MS to MS	Short Data Outbound Phase	Indiv Short Data (0100 ₂)	0 ₂	UDT_Format	1 ₂	Destination MS Address	Source MS	ACK, NACK
Short Data call from Dispatcher to MS	Short Data Outbound Phase	Indiv Short Data (0100 ₂)	0 ₂	UDT_Format	1 ₂	Destination MS Address	DISPATI	ACK, NACK
Send Diverted address to caller	See clause 6.6.7							

The information elements of the PDUs in the UDT Header information elements are summarized:

UDT_Format	<ul style="list-style-type: none"> - specifies the format of the data transported in the appended data blocks of the multi-block UDT if the UDT outbound is the second phase preceded by a UDT Inbound, the UDT_Format shall be copied from the UDT_Inbound Header
Appended_Blocks Supplementary_Flag	<ul style="list-style-type: none"> - specifies the number of appended data blocks concatenated to the header - specifies if: <ul style="list-style-type: none"> - this UDT Header is carrying the data for a user initiated service (e.g Short Data Delivery); or - this UDT Header is carrying supplementary data, supporting another service
UDT_Response	<ul style="list-style-type: none"> - specifies if the TSCC is expecting a response from this UDT download: <ul style="list-style-type: none"> - If the UDT download is addressing an individual MS then: <ul style="list-style-type: none"> * If the UDT download is supporting an Supplementary_Data transfer then this information element may be set or clear * For the Short Data Service then this information element shall be set to 1₂ - response expected - If the UDT download is addressing a talkgroup then: <ul style="list-style-type: none"> * The UDT information element shall be set to 0₂ - response not expected
Service_Kind Target_address or Gateway Source_address or gateway	<ul style="list-style-type: none"> - specifies the service being supported by the UDT mechanism - Individual MS address or Talkgroup or All_Unit - Source MS address for a service originating from an MS PABXI for a service originating from a PABX extension PSTNI for a service originating from the PSTN IPI for a service originating from an IP network

6.5.1.3 UDT Mechanism for the Inbound channel

The UDT inbound channel mechanism is invoked as part of a DMR service. The UDT head PDU contains all parameters for the UDT. The data to be uploaded is set as table 6.18. This table is not exhaustive and many other arrangements are possible to support tier III services.

Table 6.18: UDT Inbound channel information elements

UDT Inbound channel Mechanism							
UDT Inbound channel information elements							
Service	Operation	Service_Kind	Supplementary Flag	Format	UDT Response	Target address or gateway	Source Address or gateway
Voice Call from Individual MS to PSTN	Send PSTN dialling information from MS	Individual Voice Call Service (0001 ₂)	1 ₂	BCD (0001 ₂)	0 ₂ (N/A)	PSTNI	MS Address
Voice Call from Individual MS to PABX	Send PABX dialling information from MS	Individual Voice Call Service (0001 ₂)	1 ₂	BCD (0001 ₂)	0 ₂ (N/A)	PABXI	MS Address
Voice Call from MS to Individual MS	Inbound NMEA information from Source MS	Individual Voice Call Service (0001 ₂)	1 ₂	NMEA (0101 ₂)	0 ₂ (N/A)	Destination MS	MS Address
Short Data call from MS to MS	Short Data Inbound Phase	Indiv Short Data (0100 ₂)	0 ₂	UDT_Format	0 ₂ (N/A)	Destination MS	Source MS
NMEA polling from a gateway	Short Data Inbound Phase	Short data polling serv (0111 ₂)	0 ₂	NMEA (0101 ₂)	0 ₂ (N/A)	Destination MS	A TSCC Gateway
Call Diversion Service	Diversion Inbound phase	Call Diversion serv (0110 ₂)	0 ₂	value	0 ₂ (N/A)	DIVERTI	MS
Authentication	Inbound MS Authentication	Authentication serv	0 ₂	AUTH (0111 ₂)	0 ₂ (N/A)	AUTHI	MS
IP Address registration	Inbound IP address	Registration Service	1 ₂	IP (0110 ₂)	0 ₂ (N/A)	TSI	MS

The Key protocol aspects of the information element settings in the UDT Header feature elements are:

- UDT_Format - specifies the format of the data transported in the appended data blocks of the multi-block UDT
- Appended_Blocks - specifies the number of appended data blocks concatenated to the header
- Supplementary_Flag - specifies if:
 - this UDT Header is carrying the data for a user initiated service (Short Data, Data Polling); or
 - this UDT Header is carrying supplementary data, supporting another service
- UDT_Response - N/A
- Service_Kind - specifies the service being supported by the UDT mechanism
- Target_address or Gateway - Target MS address
PABXI for a service to a PABX extension
PSTNI for a service to the PSTN
IPI for a service to an IP network
- Source_address or gateway - Source MS address or gateway

6.6 Call procedures

Access to Tier III Services from MS shall be by random access using the random access protocol described in clause 6.2. The C_RAND CSBK random access PDU contains all parameters necessary to signify the particular tier III service requested.

- a) Individual Voice Call Service.
- b) Talkgroup Voice Call Service.
- c) Individual Packet Data Call Service.

- d) Packet Data Call Service for a talkgroup.
- e) Individual Short Data Delivery Service.
- f) Talkgroup Short Data Delivery Service.
- g) Call Diversion Service.
- h) Short Data Polling (from an MS) Service.
- i) Include Individual Call Service (Payload Channel only).
- j) Include Talkgroup Call Service (Payload Channel only).
- k) Registration Service (see clause 6.4).
- l) Cancel Call Service.

To support these services the tier III protocol implements a supplementary data transport mechanism whereby data may be carried between entities to support or enhance other services.

For MS call to an MS, talkgroup or All-MS, the full source and destination address is provided in the C_RAND PDU so a single-part call set-up procedure shall be invoked. For MS calls to destinations connected through a gateway (such as PSTN), a multi-part call procedure sets an appropriate gateway address as the destination in the C_RAND PDU. The TSCC then demands the extended addressing information from the calling MS using the Unified Data Transport Service (see clause 6.5).

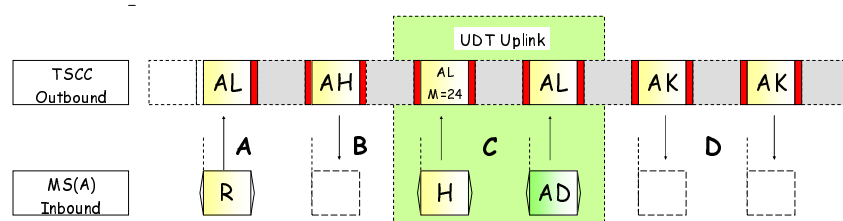


Figure 6.24: Example of Multi-part call procedure

Figure 6.24 shows an example of a call to a PABX extension:

- a) "A" is the random access C_RAND PDU. The destination address is set to PABXI indicating a multi-part call setup for a call service to the PABX.
- b) "B" is a C_AHOY PDU to ask the calling MS for the PABX extension digits.
- c) The UDT inbound channel "C" contains a multi-block UDT consisting of a header and an appended data block containing the PABX extension digits.
- d) The TSCC sends the Channel Grant PDUs to the MS at "D".

The procedures for Voice and packet data are specified in clauses 6.6.2 and 6.6.3 respectively. The procedures include:

- e) Call Setup:
 - 1) Random Access Call Request;
 - 2) Possible AHOY/UDT procedure to provide extended addressing for calls through gateways;
 - 3) Availability check to called party;
 - 4) Channel Grant.
- f) Call Management on the payload channel:
 - 1) Call maintenance;
 - 2) Call clear-down.

6.6.1 Procedures common to Voice calls and Packet Data Calls

6.6.1.1 Availability of requesting MS

A MS requests a call service by transmitting a random access service request. While the call set-up is in progress, the TSCC may check that the requesting MS is still in radio contact at any time by sending a C_AHOY PDU addressed to it. The C_AHOY PDU demands a response from the calling MS.

6.6.1.2 Call Cancellation

If a Voice call service request has been passed to the MS CC layer, and the call is cancelled before the Random Access PDU has been transmitted to the TSCC, the MS shall return to the idle state.

If a MS has initiated a voice call service and the call has not matured (by the transmission of Channel Grant PDUs) the call may be cancelled by the calling party initiating a Call Cancel Service request. This is a random access service request (Service_Kind=Cancel Call Request). The TSCC response to a call cancel request shall be C_ACKD (Reason=Message accepted).

6.6.1.3 Acknowledgements sent to calling MS

From the point at which a MS has requested a particular service, the TSCC may send acknowledgement PDUs to indicate to the calling MS the progress of the service request.

- a) The TSCC may send PDUs that complete or terminate the call service request as follows:
 - 1) The TSCC may send C_NACKD to indicate to the calling MS that the call has failed. The C_NACKD PDU contains a Reason code to indicate to the caller why the service request failed.
 - 2) The TSCC may send a UDT header + appended UDT block to indicate that the call is diverted. From the TSCC perspective the service transaction is completed. The MS may choose to indicate the diverted address to the caller and return to the idle state, or automatically make a new service request with the diverted address as the destination.
 - 3) The TSCC may send C_ACKD(Reason=Callback) to inform the calling MS that the caller has indicated they will call back.
- b) The TSCC may send progress PDUs to the calling MS as a valid response to the random access request as follows:
 - 1) C_WACKD - An intermediate acknowledgement, more signalling to follow.
 - 2) C_QACKD - The TSCC has queued the call because the resource requested or called party is busy, more signalling to follow.
 - 3) C_AHOY - The TSCC has sent a C_AHOY PDU with the calling MS address in either the Source or Target address information element.

6.6.1.4 Maintenance of call progress waiting timers

6.6.1.4.1 Call waiting timer for the calling MS

From the point at which a MS has requested a particular service, the TSCC may send acknowledgement PDUs to indicate to the calling MS the progress of the service request. If the calling MS receives an acknowledgement to its random access request, it shall start one of two timers. The timer TP_Timer shall be started for any random access service request that requires the allocation of a payload channel. The timer TNP_Timer shall be started for a call that only uses the TSCC for the call. If, while the timer is running the MS receives another acknowledgement PDU, the timer shall be refreshed. If the timer expires, the MS may assume that the TSCC has abandoned the call and the MS shall return to the idle state.

The TSCC shall maintain an identical timer. If the TSCC receives a random access request for a call that requires the allocation of a payload channel, it will start timer TP_Timer. A call that only requires the TSCC shall start timer TNP_Timer. The TSCC may send a further acknowledgement to the calling MS and refresh its timer. If the timer expires, the TSCC shall abandon that call service.

6.6.1.4.2 Call waiting timer for the called MS

If a MS receives an individually addressed C_AHOY PDU (Service_Kind=0000₂) or C_AHOY PDU (Service_Kind=0010₂) indicating an availability check for a payload channel, the MS shall start timer T_Pending.

While T_Pending is running, if the MS receives a Talkgroup voice channel grant or Packet Data Talkgroup Channel Grant PDU, the PDU shall be discarded. If the timer T_Pending expires and the MS has not been directed to a payload channel, the MS may assume that the TSCC has abandoned the call that was indicated in the C_AHOY PDU.

If while T_Pending is running, the TSCC transmits another individually addressed C_AHOY PDU (Service_Kind=0000₂) or C_AHOY PDU (Service_Kind=0010₂), the MS shall refresh timer T_Pending.

If while T_Pending is running, the TSCC transmits an individually addressed C_AHOY call cancellation PDU C_AHOY (Service_Kind=1111₂), the T_Pending timer shall be suspended.

The TSCC shall maintain the same timer T_Pending. If the TSCC transmits a C_AHOY PDU (Service_Kind=0000₂) or C_AHOY PDU (Service_Kind=0010₂) indicating an availability check for a payload channel, T_Pending is started. If the TSCC has not transmitted the Channel Grant PDU(s) for this call before T_Pending expires, the TSCC shall abandon the call.

6.6.1.5 Payload Channel Assignment

The TSCC shall assign a payload channel for the call by transmitting applicable Channel Grant PDUs for the service supported (individual MS or talkgroup).

The Channel Grant PDUs may be single block CSBK format if the logical channel to absolute Tx / Rx frequency relationship is known, or the MBC Channel Grant PDUs may have an appended MBC block that contains the absolute Tx /Rx frequencies.

For individual voice and packet data services to and from certain gateways, the payload channel may select offset timing to provide a full duplex service to MS. The TSCC provides a differing gateway identifier to distinguish between the aligned and offset mode of payload assignment:

- a) for aligned timing PSTNI, PABXI, LINEI, IPI, (see clause A.4);
- b) for offset timing PSTNDI, PABXDI, LINEDI, IPDI, (see clause A.4);

Channel Grant PDUs may be transmitted by the TS on a payload channel to swap the call to a replacement channel.

If a particular talkgroup call is active on a payload channel, the TSCC may continue to transmit appropriately addressed Channel Grant PDUs at regular intervals to permit late joining MSs (MSs who may have just arrived on the control channel) to join that talkgroup call.

6.6.2 Voice Call Procedures

Voice calls require a payload channel over which the call is conducted. Calls may be transacted between the entities in table 6.19.

Table 6.19: Voice Call Services

Mode	Originator		Recipient
Voice	MS	-	MS or Talkgroup
	MS	-	All MS (Broadcast)
	MS	-	Line Connected destination through a Gateway: PABX Extension PSTN destination Other gateway equipped for voice
	Line Connected source via a Gateway: PABX Extension PSTN destination Other gateways equipped for voice	-	MS or Talkgroup or All MS

The Individual/Talkgroup PDU in the Random Access Service Request shall determine if the caller has selected a tier III service to an individual MS or a talkgroup.

The Service_Options PDU in the Random Access Service Request shall activate options for the Voice Call Service Request:

- Emergency service:
 - Emergency calls shall take precedence over all other calls. Emergency call may be pre-emptive causing another call to be cleared down if the resource requested for the emergency call is not available.
- Supplementary Data Transfer Service requested for this call:
 - Information may be sent to the called party as part of and to support another call service. For instance the PSTN Call Line Identity may be passed to the called party as part of a voice call setup.
- Broadcast service:
 - The Broadcast Call Voice service provides a one-way voice call from any user to a predetermined talkgroup.
- OVCM call:
 - The Open Voice Channel Mode service allows users to monitor and participate to the voice channel activity. From the voice activity originator's point of view the OVCM gives the opportunity to place group and individual calls that may be listened from third party users that are not the targeted users of the call. In addition these third party users are part of the conversation in progress and they can also talk.
 - Third party users are those that have radios configured to take part to calls set as OVCM and not addressed explicitly to them.
- Priority:
 - The priority option permits the originator to select one of four levels of priority. The TSCC may manage and manipulate a call queue to cause calls with a higher priority to mature faster. The procedures the TSCC may employ are not prescribed in the present document.

6.6.2.1 Voice Call Procedures for the TSCC

A MS requests a tier III voice service by generating a random access request PDU with the Target Address set to one of the following:

- a) An individual MS address (single-part call set-up).
- b) A talkgroup MS address (single-part call set-up).
- c) A gateway address that indicates a multi-part call set-up.

When the TSCC responds to the random access request, it shall start a timer (TP_Timer). This timer shall be refreshed if the TSCC sends further call related PDUs C_WACKD, C_QACKD or C_AHOY, to the calling party.

6.6.2.1.1 TSCC Response to single-part voice call set-up

When a random access voice service PDU is received on the TSCC, the TSCC shall send a response in accordance with the random access procedures prescribed in clause 6.2.

The PDUs that represent a valid response to the voice call single-part service random access request are:

- a) An acknowledgement PDU C_NACKD, C_QACKD, C_WACKD, C_ACKD(reason=callback).
- b) A UDT Head + appended block(s) (voice call is diverted) UDT Header PDUs Source_Address=DIVERTI (conveying a diverted address) Supplementary Flag = 1₂ and UDT_Response = 0₂.
- c) A C_AHOY PDU (called party radio check) if the call is to an individual MS address.
- d) A Channel Grant PDU(s) for this call.

6.6.2.1.2 TSCC Response to multi-part voice call set-up

For calls to extended addresses, the MS requests multi-part addressing by generating a voice call random access request with the Destination Address information element set to a gateway address (PABXI, PSTNI, etc) and the Proxy Flag information element to indicate if one or two appended UDT blocks are required to transport the extended address from the MS. For calls to the PABX/PSTN one appended UDT can carry up to 20 dialled digits, and in that case the Proxy Flag information element shall be set to 0₂, and for the number of dialled digits = 21 to 44 the Proxy Flag information element shall be set to 1₂.

The PDUs that shall represent a valid response to the voice call multi-part part voice service random access request are:

- a) An acknowledgement PDU C_NACKD, C_WACKD(reason=Wait), C_QACKD.
- b) A C_AHOY PDU for the calling MS to send the extended address information.
- c) A C_AHOY PDU for the calling MS to send supplementary data (see clause 6.5).

For b) The TSCC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the extended address information. For a call to the PABX or PSTN the extended address information shall be BCD digits. The Proxy Flag information element in the C-AHOY PDU shall be copied from the Proxy Flag information element received from the MS C_RAND PDU. If the TSCC does not successfully receive the UDT from the MS, the TSCC may repeat the C_AHOY, or transmit a C_NACKD to indicate failure of the call.

For c) The TSCC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the supplementary data. The format of the supplementary data is specified in the UDT. If the TSCC does not successfully receive the UDT from the MS, the TSCC may repeat the C_AHOY, or transmit a C_NACKD to indicate failure of the call, or continue with the call setup and abandon the supplementary data.

6.6.2.1.3 Acknowledgements sent on the TSCC to the calling MS (voice)

The TSCC may send acknowledgement PDUs following the random access voice service request to indicate the progress of the call, to terminate the call or indicate call-back. If the TSCC sends a PDU to indicate the progress of a call it shall start a waiting timer TP_Timer. (The calling party MS maintains a similar timer):

- a) Progress PDUs are:
 - 1) C_WACKD: Intermediate acknowledgement. More PDUs to follow;
 - 2) C_QACKD: Called MS engaged in another call;
 - 3) C_QACKD: Call is queued because the resource is in use at the moment.
- b) Termination PDUs are selected from an appropriate Reason information element in a C_NACKD PDU (see clause 7.2.8):
 - 1) C_NACKD.

- c) Call-Back PDUs indicate to the calling MS that the voice call service has been accepted by the called party for call back:
- 1) C_ACKD(reason=CallBack).
- d) If the TS has previously accepted a call diversion indicating that this type of service request should be directed to another called party, the TSCC shall invoke the UDT and send a UDT Head + Appended data to the calling party. UDT Header PDUs Source Address=DIVERTI (conveying a diverted address) Supplementary Flag = 1₂ and UDT_Response = 0₂.

6.6.2.1.4 Voice Radio Check

For calls to individual MS, the TSCC shall check that the called party is in radio contact and will accept the call before a payload channel is allocated.

The TSCC may check availability of the called party by:

- a) Sending a C_AHOY PDU to that called party.
- b) Sending a Multi-block UDT with supplementary data (if the supplementary data service is active for this call).

If a response is not received from the called party the TSCC may repeat the C_AHOY.

The availability check demands a response from the called party:

- If the response is C_NACKU, the TSCC shall send an appropriate call failed response to the calling MS and echo the Reason in the C_NACKU PDU.
- If the response is C_ACKU(Reason=CallBack), the TSCC shall send an appropriate CallBack response to the calling MS.
- If the response is C_ACKU(Reason=Message_Accepted), the TSCC shall progress the service request and allocate a payload channel by transmitting appropriate Channel Grant PDUs.

6.6.2.1.5 Availability Check for Voice Calls connected through Gateways

For calls connected through gateways the TS equipment may wait until the destination is ready before allocating the payload channel. For example a TS may wait until the PSTN handset has been answered before sending Channel Grant PDUs.

6.6.2.2 Voice Call Procedures for MS

A MS is able to request a voice call service to another individual MS or a talkgroup using a single-part service request. For a voice service requested to extended addresses through a gateway the MS requests a multi-part service request. For multi-part service requests the MS sets the gateway address as the called party. The full destination address is then uploaded from the MS to the TSCC by the UDT procedure.

A MS requests a voice service by sending a C_RAND random access request complying with the random access procedures in clause 6.2. The information elements in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.20.

Table 6.20: C_RAND information elements for a Voice Call Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark	
Service_Options	7	1	EMERG	0 ₂	Non-emergency service	
				1 ₂	Emergency service	
		1			0 ₂	Privacy (see note 1)
					1 ₂	
		1	SUPED_SV		0 ₂	No Supplementary Data Transfer Service required for this call
					1 ₂	Supplementary Data Transfer Service requested for this call
		1	BCAST_SV		0 ₂	Non-broadcast service
					1 ₂	Broadcast service (see note 2)
		1	OVCM_SV		0 ₂	Non-OVCM call
					1 ₂	OVCN call
		2	PRIORITY_SV (see note 3)		00 ₂	Normal (low) priority
					01 ₂	Medium Priority
10 ₂	High Priority					
11 ₂	Highest Priority					
Proxy Flag	1		PROXY	0 ₂	Number of Extended BCD digits for addressing through a gateway = 1 to 20	
				1 ₂	Number of Extended BCD digits for addressing through a gateway = 21 to 44	
Appended_Supplementary_Data	2		SUPED_VAL	Value	Number of appended UDT's required to transport supplementary data	
Appended_Short Data	2		SDATA_VAL	00 ₂	Not Defined for a Voice Service	
Service_Kind	4			0000 ₂	Individual Voice Call Service	
				0001 ₂	Talkgroup Voice Call Service	
Target_address or Gateway	24			Value	Target Address (see note 4)	
Source_address	24			Value	Individual Address of the requesting MS	
NOTE 1: Privacy is not defined in the present document.						
NOTE 2: The broadcast option is only applicable to the talkgroup call service.						
NOTE 3: If EMERG = 1 ₂ then PRIORITY_SV is set to 00 ₂ .						
NOTE 4: If Service_Kind = IND_V_SRV then Target_Address represents an Individual address. If Service_Kind = GRP_V_SRV then Target_Address represents a Talkgroup.						
NOTE 5: OVCM calls apply to MS destinations only.						

6.6.2.2.1 Initiating a single-part voice call service

For a voice service request to an individual MS or talkgroup, the destination address is completely expressed by the Target Address information element in the random access PDU. The Service_Kind specifies if the voice call service is addressed to an individual address or a talkgroup.

6.6.2.2.2 Response to the single-part voice service request

MS shall accept the following PDUs as valid response to the single-part voice service request.

- an acknowledgement C_WACKD, C_QACKD, C_NACKD, C_ACKD(reason=callback);
- for an individual call service request, a C_AHOY called party radio check;
- a UDT header + appended UDT block. UDT Header Source_Address=DIVERTI (conveying a diverted address) Supplementary Flag = 1₂ and UDT_Response = 0₂;
- a Channel Grant PDU;
- if the Service_Options SUPED_SV = 1₂ a C_AHOY to upload the supplementary data from the calling MS.

6.6.2.2.3 Response to the multi-part voice service request

MS shall accept the following PDUs as valid response to the multi-part voice service request.

- a) an acknowledgement C_WACKD, C_QACKD, C_NACKD;
- b) a C_AHOY PDU to upload the extended address:
 - 1) for a call to the PABX/PSTN a C_AHOY to upload the dialled digits;
 - 2) if the Service_Options SUPED_SV = 1₂ a C_AHOY to upload the supplementary data from the calling MS.

For b), if the Voice Call Service Request requires extended address information and the calling MS has selected the Supplementary Data in the Service_Options, the TSCC uploads the information in two steps. The order in which the information is uploaded is not prescribed because the C_AHOY specifically indicates which UDT inbound procedure has been invoked by setting appropriate unambiguous Gateway information elements in the C_AHOY PDU. The gateway information elements for C_AHOY PDUs to support voice services are prescribed in table 6.21.

Table 6.21: C_AHOY information elements for multi-part voice call setup

Action	Gateway address	Remark
MS send PSTN digits	PSTNI	The calling party shall send BCD dialled digits
MS sends PABX digits	PABXI	The calling party shall send BCD dialled digits
MS sends supplementary data	SUPLI	The format of the data shall be determined by the calling party

6.6.2.2.4 Acknowledgements received by the calling MS (voice)

At some time after sending the voice service request random access PDU the calling MS may receive an acknowledgement. On receiving the acknowledgement, the MS shall start or restart a waiting timer, TP_Timer. (The TSCC maintains a similar timer).

The MS shall take the actions prescribed:

- a) Progress PDUs for a single-part voice call Service Request are:
 - 1) C_WACKD: Intermediate acknowledgement. More PDUs to follow. The MS shall wait TP_Timer for further signalling and may indicate a possible delay to the calling MS;
 - 2) C_QACKD: Called MS engaged in another call. The MS shall wait TP_Timer for further signalling;
 - 3) C_NACKD: Call is queued because the resource is in use at the moment. The MS shall wait TP_Timer for further signalling and may indicate a possible delay to the calling MS.

(The MS may choose to differentiate between 1), 2) and 3) by providing the calling MS with a visual or audible indication for each of the conditions).
- b) Termination PDUs are selected from an appropriate Reason information element in a C_NACKD PDU (see clause 7.2.8):
 - 1) C_NACKD: Call refused and terminated. The C_NACKD PDU provides a versatile range of Reason codes to indicate to the calling party why the Service request was terminated. The calling party shall return to the idle state.
- c) Call-Back PDU to indicate to the calling MS that the voice call service has been accepted by the called party for call back. Service concluded. The calling party shall return to the idle state:
 - 1) C_ACKD(reason=CallBack).
- d) If the TS has previously accepted a call diversion indicating that this type of service request be directed to another called party, a UDT Head + Appended data indicating the diverted address.

6.6.2.2.5 Availability Check to the called MS (voice)

For an individual MS address call set-up, the called MS shall receive a radio check to which it will respond with an appropriate acknowledgement:

- The called party shall respond C_NACKU, if it cannot accept the call (the TSCC shall send an appropriate call failed response to the calling MS).
- The called party shall respond C_ACKU(Reason=CallBack), if the called MS wishes to return the call at some future time (the TSCC shall send an appropriate CallBack response to the calling MS).
- The calling party shall respond C_ACKU(Reason=Message_Accepted), if the call is accepted (the TSCC shall progress the service request and allocate a payload channel by transmitting appropriate Channel Grant PDUs).

6.6.2.2.6 Payload Channel Allocation

MS shall check the address information elements received in Voice Channel Grant PDUs. If it is determined that the Channel Grant PDU is applicable then it shall retune to the indicated physical/logical payload channel to commence the Voice Service.

- a) For Private Voice Channel Grant CSBK PDU:
 - 1) If an MS receives a Private Channel Grant PDU where either the Source Address or the Target Address information element matches its individual address then that PDU is applicable.
- b) Talkgroup Voice Channel Grant CSBK PDU (OVCM information element = 0₂):
 - 1) If an MS receives a Talkgroup Channel Grant PDU with the Target Address information element matching one of its talkgroup addresses then that PDU is applicable.
 - 2) If an MS receives a Talkgroup Channel Grant PDU with the Source Address matching its individual address then that PDU is applicable.
 - 3) If an MS receives a Broadcast Talkgroup Channel Grant PDU with the Target Address matching one of its talkgroup addresses then that PDU is applicable.
 - 4) If an MS receives a Broadcast Talkgroup Channel Grant PDU with the Source Address matching its individual address then that PDU is applicable.
- c) Talkgroup Voice Channel Grant CSBK PDU (OVCM information element = 1₂):
 - 1) If an MS receives a Talkgroup Channel Grant PDU with the Target Address information element matching one of its talkgroup addresses or one of its OVCM addresses then that PDU is applicable.
 - 2) If an MS receives a Talkgroup Channel Grant PDU with the Source Address matching its individual address then that PDU is applicable.
 - 3) If an MS receives a Broadcast Talkgroup Channel Grant PDU with the Target Address matching one of its talkgroup addresses or one of its OVCM addresses then that PDU is applicable.
 - 4) If an MS receives a Broadcast Talkgroup Channel Grant PDU with the Source Address matching its individual address then that PDU is applicable.

6.6.2.3 Procedures for the Voice Payload Channel

MSs are directed to a voice payload physical/logical channel on the TSCC. When the voice call is terminated, MS returns to the TSCC and the payload channel is reassigned to another call.

A voice call may extend over several MS PTT items for the duration of the call (unless the call is terminated prematurely by the expiry of the voice payload timer) if the system has assigned the call as "message trunking". If the system has assigned the call as pure "transmission trunking" the call shall be terminated after the end of each PTT item. A third possibility is that the call has been assigned as "quasi-transmission trunking". In this case a short interval timer (TV_Hangtime) between PTT items holds the payload channel. If this short interval timer expires, the call is terminated and the next PTT item sets up a new call.

The voice payload channel may be assigned to one of two basic timing models. The particular timing model is specified on the TSCC and signalled to MS by the Channel Grant PDUs (see TS 102 361-1 [5]):

- a) Aligned timing supports Reverse Channel (RC) signalling by providing the receiving MS with a Reverse Channel transmit opportunity on the inbound channel without missing any of its outbound traffic. Aligned timing also supports "MS to MS" duplex traffic by allowing a MS to transmit in one timeslot and receive the repeated transmission of the other MS on the alternative timeslot:
 - 1) 1:1-mode. 1 traffic channel mode: 1:1-mode supports one "MS to fixed end" duplex call or one simplex call with an optional inbound Reverse Channel using a two frequency BS.
 - 2) 2:1-mode. 2 traffic channel mode: 2:1-mode supports two independent calls which may be either "MS to fixed end" duplex calls or simplex calls using a two frequency BS.
- b) Offset timing supports "MS to fixed end" duplex traffic by allowing a MS to transmit in one time slot and receive the fixed end transmission on the alternate time slot.

The procedures for TS/MS behaviour on the voice payload channel are described in TS 102 361-2 [6]. In the trunked environment however, call maintenance PDUs are exchanged between MS and TS in addition to the PDUs described in TS 102 361-2 [6].

When active, a payload channel shall transmit the CACH in the same form as described in TS 102 361-2 [6], clause 7.1.3.2).

The beginning of a call shall use PATCS method (see TS 102 361-2 [6], clause 5.2.2.1). For an individual MS call service, the called party will already have had a radio check as part of the call set-up procedure.

6.6.2.3.1 TS Procedures for the Voice Payload Channel

A physical payload channel may carry one or two independent voice calls. If a new physical channel is allocated on the TSCC, the CCL_BS shall start both the CCL_1 and CCL_2 processes as described in TS 102 361-2 [6], clause 5.1.1.1.3), and start the voice channel payload timer as follows:

- a) For an individual MS/MS or MS/Talkgroup normal or high priority call T_MS-MS_TIMER.
- b) For a gateway individual MS or Talkgroup normal or high priority call T_MS-Line_TIMER.
- c) For an emergency call T_EMERG_TIMER.

6.6.2.3.1.1 MS radio check

The TS may poll an individual MS to check if the MS is active on the payload channel by transmitting a P_AHOY PDU with the information elements set as follows.

The TSCC transmits a P_AHOY with the information elements as shown in table 6.22.

Table 6.22: P_AHOY information elements for voice service individual radio check

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Individual Call Service - 0000 ₂
Target address	24	Individual Address of Called MS
Source Address or Gateway	24	TSI

The response is P_ACKU(Reason=Message_Accepted).

The TS may also poll a talkgroup to check if at least one member of the talkgroup is active on the payload channel by transmitting a P_AHOY PDU with the information elements as shown in table 6.23.

Table 6.23: P_AHOY information elements for voice service talkgroup radio check

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Talkgroup Call Service - 0001 ₂
Target address	24	Address of the talkgroup
Source Address or Gateway	24	TSI

The response is P_ACKU (Reason=Message_Accepted). If more than one MS makes a response to this PDU, it is likely that the TS will be unable to decode it because of collisions. The purpose of this procedure is to determine if any talkgroups are active therefore the TS may use the presence of the burst for the result of the talkgroup radio check.

6.6.2.3.1.2 Authentication Check

The authentication procedures are identical to the authentication procedures described in clause 6.4.8.2 but with the C_AHOY PDU replaced by a P_AHOY PDU.

6.6.2.3.1.3 Disabling/enabling a users PTT

The TS may at any time send a P_PROTECT (Protect_Kind=DIS_PTT) addressed to an individual MS, talkgroup, or All Unit ID to disable the PTT. Since the P_PROTECT PDU is unacknowledged the PDU may be repeated at layer 2.

The TS may also at any time send a P_PROTECT (Protect_Kind=EN_PTT) addressed to an individual MS, talkgroup, or All Unit ID to enable the PTT. Since the P_PROTECT PDU is unacknowledged the PDU may be repeated at layer 2.

6.6.2.3.1.4 Swapping the call to a replacement voice payload channel

The TS may send Channel Grant PDUs on the payload channel to move MS already active to an alternative voice payload channel. If MS had previously received a P_PROTECT to disable their PTT, the PTT shall be re-enabled on the replacement voice payload channel unless the call service was a broadcast when called party(s) shall retain their PTT status (enable/disable) from the original call.

6.6.2.3.1.5 Removing MS from the payload channel that are not legitimate parties

The TS may transmit P_PROTECT(ILLEGALLY_PARKED) PDUs at any time. A MS whose address does not match either of the address information elements in the P_PROTECT PDU shall leave the payload channel without making any further transmissions.

6.6.2.3.1.6 Clearing down the voice call

The TS shall clear the parties involved in the payload voice call if:

- The relevant overall payload call timer T_MS-MS_TIMER, T_MS-Line_TIMER or T_EMERG_TIMER expires.
- The TS receives a P_MAINT (Maint_Kind = DISCON) PDU.
- The TS detects by any other means that the call has ended (e.g. PSTN destination on hook).
- The TV_Hangtime interval timer expires.

The TS shall clear down the call by transmitting P_CLEAR PDU(s). Since this PDU is not acknowledged it may be repeated at layer 2.

6.6.2.3.1.7 Clearing down a particular MS or talkgroup

The TS may selectively clear an individual MS by transmitting a P_AHOY with information elements set as table 6.24.

Table 6.24: P_AHOY information elements to clear an individual MS from a voice payload channel

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂ Indicates that the target is an Individual Address
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Cancel Call Service - 1111 ₂
Target address	24	Individual Address of MS
Source Address or Gateway	24	TSI (see clause A.4)

The permitted response is P_ACKU(Message_Accepted).

The TS may clear a talkgroup by transmitting a P_AHOY with information elements set as table 6.25.

Table 6.25: P_AHOY information elements to clear a talkgroup from a voice payload channel

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	1 ₂ Indicates that the target is a talkgroup
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Cancel Call Service - 1111 ₂
Target address	24	Talkgroup
Source Address or Gateway	24	TSI

The permitted response is P_ACKU(Message_Accepted).

6.6.2.3.2 MS Procedures for the Voice Payload Channel

6.6.2.3.2.1 MS receives an MS radio check

If an MS receives a P_AHOY to its individual address with information elements set as table 6.22, then it shall respond with a P_ACKU (Reason=message_accepted).

If an MS receives a P_AHOY to the talkgroup address previously transmitted in the Channel Grant PDU that directed this MS to the payload channel (PDUs set as table 6.23), then it shall respond with a P_ACKU (Reason=message_accepted).

6.6.2.3.2.2 MS receives a Authentication Check Challenge

The authentication procedures are identical to the authentication procedures described in clause 6.4.8.2 but with the authentication response C_ACKU PDU replaced by a P_ACKU PDU.

6.6.2.3.2.3 Disabling/enabling a users PTT

If the MS receives a P_PROTECT (Protect_Kind=DIS_PTT) addressed to its individual address, to it is talkgroup address previously transmitted in the Channel Grant PDU directed it to the payload channel, or All Unit ID, the MS shall disable it is PTT.

If the MS receives a P_PROTECT (Protect_Kind=EN_PTT) addressed to its individual address, to it is talkgroup address previously transmitted in the Channel Grant PDU, or All Unit ID, the MS shall re-enable it is PTT unless this MS was the recipient of a broadcast call.

6.6.2.3.2.4 MS receives a Channel Grant PDU(s)

If a MS receives an applicable Channel Grant addressed to its individual address or to its talkgroup address previously transmitted in the Channel Grant PDU directed it to the payload channel, then it shall return to the designated physical/logical channel. If the PTT was disabled prior to receiving the Channel Grant, the PTT shall be re-enabled unless this MS was the recipient of a broadcast call set-up or a call to All-Unit ID.

6.6.2.3.2.5 End of call

The MS shall signify the end of the call by transmitting a number of P_MAINT (Maint_Kind=DISCON). The MS shall send the P_MAINT PDUs consecutively then return to the control channel acquisition procedures (it is suggested that the TSCC sampled is the TSCC that transferred the call to the payload channel).

6.6.2.3.2.6 MS receives P_CLEAR

If a MS receives a P_CLEAR PDU then it shall move to the TSCC indicated by the Logical Physical Channel Number PDU.

6.6.2.3.2.7 MS receives a selective clear P_AHOY

If a MS receives an individually addressed P_AHOY, Service_Kind=1111₂, Service_Kind_Flag=0₂ information element then it shall send a P_ACKU (Reason=Message_Accepted), abandon the payload channel and return to the control channel acquisition procedures (it is suggested that the TSCC initially sampled is the TSCC that transferred the call to the payload channel).

If a MS receives a P_AHOY, Service_Kind=1111₂, Service_Kind_Flag=1₂ information element addressed to its talkgroup address previously transmitted in the Channel Grant PDU the talkgroup then it shall send a P_ACKU (Reason=Message_Accepted) abandon the payload channel and return to the control channel acquisition procedures (it is suggested that the TSCC initially sampled is the TSCC that transferred the call to the payload channel).

6.6.2.3.2.8 MS receives a P_PROTECT PDU(s)

If a MS receives a P_PROTECT(ILLEGALLY_PARKED) PDU, and the source or target address in the P_PROTECT PDU does not match the source or target address from the Channel Grant PDU that directed the MS to the payload channel, the MS shall leave the payload channel without making any further transmissions.

6.6.2.3.2.9 Time out on the Payload Channel

A MS shall maintain a number of timers while active on a voice payload channel.

a) Inactivity timer:

- A MS shall measure the length of time the MS is unable to detect adequate signal quality. If the MS fails to detect adequate signal quality for a continuous time TV_Inactive, the MS shall assume that the call has ended and return to the control channel acquisition procedures without sending any call termination signalling (it is suggested that the TSCC sampled is the TSCC that transferred the call to the payload channel).

b) Item Duration timer:

- A MS shall maintain a maximum item duration timer. If the MS reaches the maximum item duration TV_Item, the MS shall transmit a Terminator with LC, disable the PTT and wait until the user releases the PTT before re-enabling the PTT.

- c) An overall payload call timer:
- If the overall voice payload call timer T_MS-MS_TIMER, T_MS-Line_TIMER or T_EMERG_TIMER expires, the MS shall transmit a number (N_Maint) of P_MAINT PDUs consecutively then return to the control channel acquisition procedures (it is suggested that the TSCC sampled is the TSCC that transferred the call to the payload channel) If the MS was sending speech frames when the overall voice payload call timer expires, the MS shall transmit a Terminator with LC prior to transmitting the P_MAINT PDUs.

6.6.3 Packet Data Call Procedures

Packet data calls require a payload channel over which the call is conducted. Calls may be transacted between the entities in table 6.26.

Table 6.26: Packet Data Call Services

Mode	Originator		Recipient
Packet Data	MS	-	MS or Talkgroup
	MS	-	All MS (Broadcast)
	MS	-	Line Connected destination through a Gateway: IP Gateway Data Gateway Other gateway equipped for data
	Line Connected source via a Gateway: IP Gateway Data Gateway Other gateway equipped for data	-	MS or Talkgroup or All MS

A packet data payload channel may support multiple simultaneous calls.

6.6.3.1 Packet Data Call Procedures for the TSCC

A MS requests a tier III service by generating a random access request PDU with the Target Address set to:

- a) An individual MS address (single-part call setup).
- b) A talkgroup MS address (single-part call setup).
- c) A gateway address that indicates a multi-part call setup.

When the TSCC responds to the random access request, it shall start a timer (TP_Timer). This timer shall be refreshed if the TSCC sends further call progress PDUs to the calling party.

6.6.3.1.1 TSCC Response to single-part packet call set-up

When a random access packet data PDU is received on the TSCC, the TSCC shall send a response in accordance with the random access procedures prescribed in clause 6.2.

The PDUs that represent a valid response to the packet call single-part service random access request are:

- a) An acknowledgement PDU C_NACKD, C_QACKD, C_WACKD.
- b) A UDT Head + appended block(s) (packet data call is diverted) UDT Header PDUs
Source_Address=DIVERTI (conveying a diverted address) Supplementary Flag = 1₂ and
UDT_Response = 0₂.
- c) A C_AHOY PDU (called party radio check).
- d) A C_AHOY PDU to upload supplementary data from calling MS.
- e) A Channel Grant PDU(s) for this call.

6.6.3.1.2 TSCC Response to multi-part packet call setup

For calls to extended addresses, the MS requests multi-part addressing by generating a packet data call random access request with the Destination Address information element set to a gateway address (PABXI, PSTNI, IPI etc) and the Proxy Flag information element to indicate the number of digits for the extended address. For the number of dialled digits = 1 to 20 the Proxy Flag information element shall be set to 0₂. For the number of dialled digits = 21 to 44 the Proxy Flag information element shall be set to 1₂. The PDUs that shall represent a valid response to the voice call multi-part part voice service random access request are:

- a) An acknowledgement PDU C_NACKD, C_WACKD(reason=Wait).
- b) A C_AHOY PDU for the calling MS to send the extended address information.
- c) A C_AHOY PDU for the calling MS to send supplementary data (see clause 6.5).

For b) The TSCC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the extended address information. For a call to the PABX or PSTN the extended address information shall be BCD digits. The Proxy Flag information element in the C-AHOY PDU shall be copied from the Proxy Flag information element received from the MS C_RAND PDU.

For c) The TSCC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the supplementary data. The format of the supplementary data is specified in the UDT.

If the TSCC does not successfully receive the UDT from the MS, the TSCC may repeat the C_AHOY or transmit a C_NACKD to indicate failure of the call.

6.6.3.1.3 Acknowledgements sent on the TSCC to the calling MS (packet)

The TSCC may send acknowledgement PDUs following the random access data packet service request to indicate the progress of the call, to terminate the call. If the TSCC sends a PDU to indicate the progress of a call it shall start a waiting timer TP_Timer. (The calling party MS maintains a similar timer).

- a) Progress PDUs are:
 - 1) C_WACKD: Intermediate acknowledgement. More PDUs to follow.
 - 2) C_QACKD: Called MS engaged in another call.
 - 3) C_QACKD: Call is queued because the resource is in use at the moment.
- b) Termination PDUs are selected from an appropriate Reason information element in a C_NACKD PDU (see clause 7.2.8):
 - 1) C_NACKD.
- c) If the TS has previously accepted a call diversion indicating that this type of service request be directed to another called party, the TSCC shall invoke the UDT and send a UDT Head + Appended data to the calling party.

6.6.3.1.4 Radio Check for packet

For calls to individual MS, the TSCC shall check that the called party is in radio contact and will accept the call before a payload channel is allocated. The radio check may also indicate that the called party data terminal equipment is ready.

The TSCC may check availability of the called party by:

- a) Sending a C_AHOY PDU to that called party.
- b) Sending a Multi-block UDT with supplementary data (if the supplementary data service is active for this call).

If a response is not received from the calling party the TSCC may repeat the C_AHOY.

The availability check demands a response from the called party:

- If the response is C_NACKU, the TSCC shall send an appropriate call failed response to the calling MS and echo the Reason in the C_NACKD PDU.
- If the response is C_ACKU(Reason=Message_Accepted), the TSCC shall progress the service request and allocate a payload channel by transmitting appropriate Channel Grant PDUs.

6.6.3.1.5 Availability Check for Packet Calls connected through Gateways

For calls connected through gateways the TS equipment may wait until the destination is ready before allocating the payload channel. For example a TS wait until PSTN equipment has linked the data terminal before sending Channel Grant PDUs.

6.6.3.2 Packet Data Call Procedures for MS

A MS is able to request a packet data call service to another individual MS or a talkgroup using a single-part service request. For a packet data service requested to extended addresses through a gateway the MS requests a multi-part service request. For multi-part service requests the MS sets the gateway address as the called party. The full destination address is then provided by the MS to the TSCC by the UDT procedure.

A MS requests a packet data service by sending a C_RAND random access request complying with the random access procedures in clause 6.2. The information elements in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.27.

Table 6.27: C_RAND information elements for a Packet Data Call Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark
Service_Options	7	1	EMERG	0 ₂	Non-emergency service
				1 ₂	Emergency service
		1	SUPED_SV	0 ₂	No Supplementary Data Transfer Service required for this call
				1 ₂	Supplementary Data Transfer Service requested for this call
		1	HI_RATE	0 ₂	Payload channel expects single slot data timing
				1 ₂	Payload channel expects dual slot data timing
		1	OVCM_SV	0 ₂	Non-OVCM call
				1 ₂	OVCM call
		2	PRIORITY_SV (see note 3)	00 ₂	Normal (low) priority
				01 ₂	Medium Priority
				10 ₂	High Priority
				11 ₂	Highest Priority
Proxy Flag	1	PROXY	0 ₂	Number of Extended BCD digits for addressing through a PSTN/PABX gateway = 1 to 20. For IP gateway extended address is IPV4	
			1 ₂	Number of Extended BCD digits for addressing through a PSTN/PABX gateway = 21 to 44. For IP gateway extended address is IPV6	
Appended_Supplementary_Data	2		SUPED_VAL	Value	Number of appended UDT's required to transport supplementary data
Appended_Short Data	2		SDATA_VAL	00 ₂	Not Applicable for Packet Data
Service_Kind	4		IND_D_SRV	0010 ₂	Individual packet data Call Service
			GRP_D_SRV	0011 ₂	Talkgroup packet data Call Service
Target_address or Gateway	24			Value	Target Address (see note 4)
Source_address	24			Value	Individual Address of the requesting MS
NOTE 1: Privacy is not defined in the present document.					
NOTE 2: The broadcast option is only applicable to the talkgoup call service.					
NOTE 3: If EMERG = 1 ₂ then PRIORITY_SV is set to 00 ₂ .					
NOTE 4: If Service_Kind = IND_D_SRV then Target_Address represents an Individual address. If Service_Kind = GRP_D_SRV then Target_Address represents a Talkgroup.					

6.6.3.2.1 Initiating a single-part packet data call service

For a packet data service request to an individual MS or talkgroup, the destination address is completely expressed by the Target Address information element in the random access PDU. The Service_Kind specifies if the data packet call service is addressed to an individual address or a talkgroup.

6.6.3.2.2 Response to the single-part packet service request

MS shall accept the following PDUs as valid response to the single-part data packet service request:

- an acknowledgement C_WACKD, C_QACKD, C_NACKD;
- for an individual call service request, a C_AHOY called party radio check;
- a Channel Grant PDU;
- if the Service_Options SUPED_SV = 1₂ a C_AHOY to upload the supplementary data from the calling MS;

- e) a UDT Head + appended blocks UDT Header PDU's Source_Address=DIVERTI, Embedded_Flag = 1.

6.6.3.2.3 Response to the multi-part packet data service request

MS shall accept the following PDUs as valid response to the multi-part data packet service request:

- a) an acknowledgement C_WACKD, C_QACKD, C_NACKD;
- b) a C_AHOY PDU to upload the extended address:
 - 1) for a call to the PABX/PSTN a C_AHOY to upload the dialled digits;
 - 2) if the Service_Options SUPED_SV = 1₂ a C_AHOY to upload the supplementary data from the calling MS.

NOTE: For b), if the Data packet Call Service Request requires extended address information and the calling MS has selected the Supplementary Data in the Service option, the TSCC uploads the information in two steps. The order in which the information is uploaded is not prescribed because the C_AHOY specifically indicates which UDT inbound procedure has been invoked by setting appropriate unambiguous information elements in the C_AHOY PDU.

6.6.3.2.4 Acknowledgements received by the calling MS (packet data)

At some time after sending the packet data service request random access PDU the calling MS may receive an acknowledgement. On receiving the acknowledgement, the MS shall start or restart a waiting timer, TP_Timer. (The TSCC maintains a similar timer).

The MS shall take the actions prescribed:

- a) Progress PDUs for a single-part data packet call Service Request are:
 - 1) C_WACKD: Intermediate acknowledgement. More PDUs to follow. The MS shall wait TP_Timer for further signalling and may indicate a possible delay to the calling MS;
 - 2) C_QACKD (Reason=1000 0001₂): Called MS engaged in another call. The MS shall wait TP_Timer for further signalling and may indicate a possible delay to the calling MS;
 - 3) C_QACKD (Reason=1000 0000₂): Call is queued because the resource is in use at the moment. The MS shall wait TP_Timer for further signalling and may indicate a possible delay to the calling MS. The MS may choose to differentiate between 1), 2) and 3) by providing the calling MS with a particular indication for each of the conditions.
- b) Termination PDUs are selected from an appropriate Reason information element in a C_NACKD PDU (see clause 7.2.8):
 - 1) C_NACKD: Call refused and terminated. The C_NACKD PDU provides a versatile range of Reason codes to indicate to the calling party why the Service request was terminated. The calling party shall return to the idle state.

6.6.3.2.5 Availability Check to the called MS (packet data)

For an individual MS address call set-up, the called MS shall receive a radio check to which it will respond with an appropriate acknowledgement.

- The called party shall respond C_NACKU, if it cannot accept the call or its data terminal equipment is not ready (the TSCC shall send an appropriate call failed response to the calling MS).
- The calling party shall respond C_ACKU (Reason=Message_Accepted), if the call is accepted (the TSCC shall progress the service request and allocate a payload channel by transmitting appropriate Channel Grant PDUs).

6.6.3.2.6 Payload Channel Allocation

MS shall check the address information elements received in Packet Data Channel Grant PDUs. If it is determined that the Channel Grant PDU is applicable then it shall return to the indicated physical/logical payload channel to commence the Packet Data Service.

- a) For Private Packet Data Channel Grant CSBK PDU:
 - 1) If an MS receives a Private Channel Grant PDU where either the Source Address or the Target Address information element matches its individual address then that PDU is applicable.
- b) Talkgroup Packet Data Channel Grant CSBK PDU:
 - 1) If an MS receives a Talkgroup Channel Grant PDU with the Target Address information element matching one of its talkgroup addresses then that PDU is applicable.
 - 2) If an MS receives a Talkgroup Channel Grant PDU with the Source Address matching its individual address then that PDU is applicable.

6.6.3.3 Procedures for the Packet Data Payload Channel

MSs are directed to a Packet Data payload physical/logical channel on the TSCC. When the Packet Data call is terminated by either the TS or MS, the MS shall return to the TSCC. When a physical channel has been assigned, data PDUs of arbitrary length are transferred over the DMR Air Interface using the packet technique described in TS 102 361-1 [5] and TS 102 361-3 [7].

A Packet Data call may continue unless the call is terminated by a) the MS or b) the TS or c) terminated prematurely as a result of the expiry of a overall payload call payload timer).

A physical channel may be configured such that two independent payload channels are available to the system (single slot transmission mode) or a high-speed data mode (dual slot transmission mode) where both logical channels are combined to provide a high-speed Packet Data service. The particular data speed configuration is requested by the calling MS and signalled to the parties by the Channel Grant PDUs.

The procedures for TS/MS behaviour on the Packet Data payload channel are described in TS 102 361-3 [7]. In the trunked environment however, additional call maintenance PDUs are exchanged between MS and TS in addition to the PDUs described in TS 102 361-3 [7].

When active on a payload channel shall transmit the CACH in the same form as described in TS 102 361-2 [6], clause 7.1.3.2).

The system may direct a number of independent Packet Data calls to the same Packet Data channel. MSs may then share that channel, but it must be noted that while MS are away from the TSCC, they are unable to receive new calls. New Packet Data calls directed to a MS that is active on a Packet Data channel may either be queued by the system or such a call may be directed to the Packet Data channel and share the channel with other ongoing calls.

If the destination is an ipv4 or ipv6 address, the destination address will have been specified by the calling party as a function of a multi-part call set-up. Therefore when the MS is directed to the packet data payload channel the system will have the full destination address. The MS may therefore set the destination address to IPI for all packet data items.

If an MS receives a packet data call set-up from an ipv4 or ipv6 address, the UDT protocol is able to send the full calling party IP address as part of the call set-up using the supplementary data transfer service. The system may then use IPI as the source address for the packet data call.

6.6.3.3.1 TS Procedures for the Packet Data Payload Channel

If a new physical channel is allocated on the TSCC, the CCL_BS shall start both the CCL_1 and CCL_2 processes as described in TS 102 361-2 [6], clause 5.1.1.1.3) and start the Packet Data payload timer T_PACKET_TIMER.

6.6.3.3.1.1 MS radio check

The TS may poll an individual MS to check if the MS is active on the payload channel by transmitting a P_AHOY PDU with the information elements set as follows.

The TSCC transmits a P_AHOY with the information elements as shown in table 6.28.

Table 6.28: P_AHOY information elements for Packet Data service individual radio check

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Individual Packet Call Service - 0010 ₂
Target address	24	Individual Address of Called MS
Source Address or Gateway	24	TSI

The response is C_ACKU (Reason=Message_Accepted).

The TS may also poll a talkgroup to check if at least one member of the talkgroup is active on the payload channel by transmitting a P_AHOY PDU with the information elements set as follows.

The TSCC transmits a P_AHOY with the information elements as shown in table 6.29.

Table 6.29: P_AHOY information elements for packet service talkgroup radio check

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Talkgroup Packet Call Service - 0011 ₂
Target address	24	Address of the talkgroup
Source Address or Gateway	24	TSI

The response is P_ACKU (Reason=Message_Accepted). If more than one MS makes a response to this PDU, it is likely that the TS will be unable to decode it because of collisions. The purpose of this procedure is to determine if any talkgroups are active therefore the TS may use the presence of the burst for the result of the talkgroup radio check.

6.6.3.3.1.2 Authentication Check

The authentication procedures are identical to the authentication procedures described in clause 6.4.8.2 but with the C_AHOY PDU replaced by a P_AHOY PDU.

6.6.3.3.1.3 Disabling/enabling a users transmission

The TS may at any time send a P_PROTECT (Protect_Kind=DIS_PTT) addressed to an individual MS, talkgroup, or All Unit ID to disable all MS transmissions for the remainder of the call. Since the P_PROTECT PDU is unacknowledged the PDU may be repeated.

The TS may also at any time send a P_PROTECT (Protect_Kind=EN_PTT) addressed to an individual MS, talkgroup, or All Unit ID to enable the users transmission. Since the P_PROTECT PDU is unacknowledged the PDU may be repeated at layer 2.

6.6.3.3.1.4 Swapping the call to a replacement Packet Data payload channel

The TS may send Channel Grant PDUs to move MS already active to an alternative packet data payload channel. If MS had previously received a P_PROTECT to disable its transmissions, the transmissions shall be re-enabled on the replacement packet data payload channel. The replacement packet data channel shall be with the same slot configuration (single or dual slot). If the packet data payload channel supports multiple simultaneous calls then channel grant PDUs must be transmitted for each of the MS or talkgroups currently active on the payload channel.

6.6.3.3.1.5 Clearing down the packet data channel

The TS shall clear down the parties involved in all payload calls if:

- a) the relevant overall payload call timer T_PACKET_TIMER expires;
- b) the TS receives a P_MAINT (Maint_Kind = DISCON) PDU;
- c) the TS detects by any other means that the call has ended (e.g PSTN destination on hook);
- d) the TV_Hangtime interval timer expires.

The TS shall clear down the data call by transmitting P_CLEAR PDU(s). Since this PDU is not acknowledged it may be repeated at layer 2.

6.6.3.3.1.6 Clearing down a particular MS or talkgroup

The TS is able to clear down the parties involved in a payload call if:

- a) the TS receives a P_MAINT (Maint_Kind = DISCON) PDU;
- b) the TS detects by any other means that the packet call has ended.

The TS response to an applicable P_MAINT(Maint_Kind=DISCON) is P_NACKD.

The TS may selectively clear a MS by transmitting a P_AHOY with information elements set as table 6.30.

Table 6.30: P_AHOY information elements to clear an individual MS from a packet payload channel

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	0 ₂ Indicates that the target is an Individual Address
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Cancel Call Service - 1111 ₂
Target address	24	Individual Address of MS
Source Address or Gateway	24	TSI

The permitted response is P_ACKU (Message_Accepted).

The TS may selectively clear a talkgroup by transmitting a P_AHOY with information elements set as table 6.31.

Table 6.31: P_AHOY information elements to clear a talkgroup from a packet payload channel

Service_Options_Mirror	7	000 0000 ₂
Service_Kind_Flag	1	1 ₂ Indicates that the target is a talkgroup
Reserved	2	00 ₂
Appended_Blocks	2	00 ₂
Service_Kind	4	Cancel Call Service - 1111 ₂
Target address	24	talkgroup
Source Address or Gateway	24	TSI

The permitted response is P_ACKU (Message_Accepted).

6.6.3.3.2 MS Procedures for the Packet Data Payload Channel

6.6.3.3.2.1 MS receives an MS radio check

If an MS receives a P_AHOY to its individual address with information elements set as table 6.30, then it shall respond with a P_ACKU (Reason=message_accepted).

If an MS receives a P_AHOY to it is the talkgroup address previously transmitted in the Channel Grant PDU that directed this MS to the payload channel (information elements set as table 6.31) then it shall respond with a P_ACKU (Reason=message_accepted).

6.6.3.3.2.2 MS receives a Authentication Check Challenge

The authentication procedures are identical to the authentication procedures described in clause 6.4.8.2 but with the authentication response C_ACKU PDU replaced by a P_ACKU PDU.

6.6.3.3.2.3 Disabling/enabling a user transmission

If the MS receives a P_PROTECT (Protect_Kind=DIS_PTT) addressed to its individual address, or to its talkgroup address previously transmitted in the Channel Grant PDU, or All Unit ID, the MS shall disable its transmissions.

If the MS receives a P_PROTECT (Protect_Kind=EN_PTT) addressed to its individual address, to its talkgroup address previously transmitted in the Channel Grant PDU, or All Unit ID, the MS shall re-enable its transmissions.

6.6.3.3.2.4 MS receives a Channel Grant PDU(s)

If a MS receives an applicable Channel Grant addressed to its individual address or to its talkgroup address previously transmitted in the Channel Grant PDU, then it shall retune to the designated physical/logical channel. If the PTT was disabled prior to receiving the Channel Grant, the PTT shall be re-enabled unless this MS was the recipient of a broadcast call set-up or a call to All-Unit ID.

6.6.3.3.2.5 End of call

The MS shall signify the end of the call by transmitting a number of P_MAINT (Maint_Kind = DISCON). The MS shall send the P_MAINT PDUs consecutively then return to the control channel acquisition procedures (it is suggested that the TSCC initially sampled is the TSCC that transferred the call to the payload channel).

6.6.3.3.2.6 MS receives P_CLEAR

If a MS receives a P_CLEAR PDU then it shall abandon the payload channel and move to the TSCC indicated by the Logical Physical Channel Number PDU.

6.6.3.3.2.7 MS receives a selective clear P_AHOY

If a MS receives an individually addressed P_AHOY, Service_Kind=1111₂, Service_Kind_Flag=0₂ information element then it shall send a P_ACKU (Reason=Message_Accepted), abandon the payload channel and return to the control channel acquisition procedures (it is suggested that the TSCC initially sampled is the TSCC that transferred the call to the payload channel).

If a MS receives a P_AHOY, Service_Kind=1111₂, Service_Kind_Flag=1₂ information element addressed to its talkgroup address previously transmitted in the Channel Grant PDU the talkgroup then it shall send a P_ACKU (Reason=Message_Accepted) abandon the payload channel and return to the control channel acquisition procedures (it is suggested that the TSCC initially sampled is the TSCC that transferred the call to the payload channel).

6.6.3.3.2.8 Time out on the Payload Channel

A MS shall maintain a number of timers while active on a packet data payload channel.

a) Inactivity timer:

- A MS shall measure the length of time the MS is unable to detect adequate signal quality. If the MS fails to detect adequate signal quality for a continuous time TD_Inactive, the MS shall assume that the call has ended and return to the control channel acquisition procedures without sending any call termination signalling (it is suggested that the TSCC sampled is the TSCC that transferred the call to the payload channel).

b) Item Duration timer:

- A MS shall maintain the maximum item duration timer TD_Item. If the MS reaches the maximum item duration TD_Item, the MS shall transmit a Terminator with LC, discontinue the item and indicate to the higher layers that the item was not successfully transmitted.

c) An overall payload call timer:

- If the overall packet data payload call timer T_PACKET_TIMER expires, the MS shall transmit a number(N_Maint) of P_MAINT PDUs consecutively then return to the control channel acquisition procedures (it is suggested that the TSCC sampled is the TSCC that transferred the call to the payload channel) If the MS was sending speech frames when the overall data packet payload call timer expires, the MS shall transmit a Terminator with LC prior to transmitting the P_MAINT PDUs.

6.6.4 Short Data Message Procedure

The Short Data Message service enables data to be transmitted between DMR entities using the control channel. Up to 462 bits of data may be transported using this service formatted in a number of formats including binary, BCD, 7 bit text, 8 bit characters, NMEA, Unicode, ip, authentication and manufacturer specific proprietary formats.

The Short Data Message procedure uses the multi-part call set-up. A MS may send a Short Data Message to an MS, a talkgroup, the PSTN or PABX, a line connected gateway, a dispatcher gateway, or all MS (if the TSCC permits it). The TSCC may also transmit a short data message from a gateway addressed to an individual MS or talkgroup.

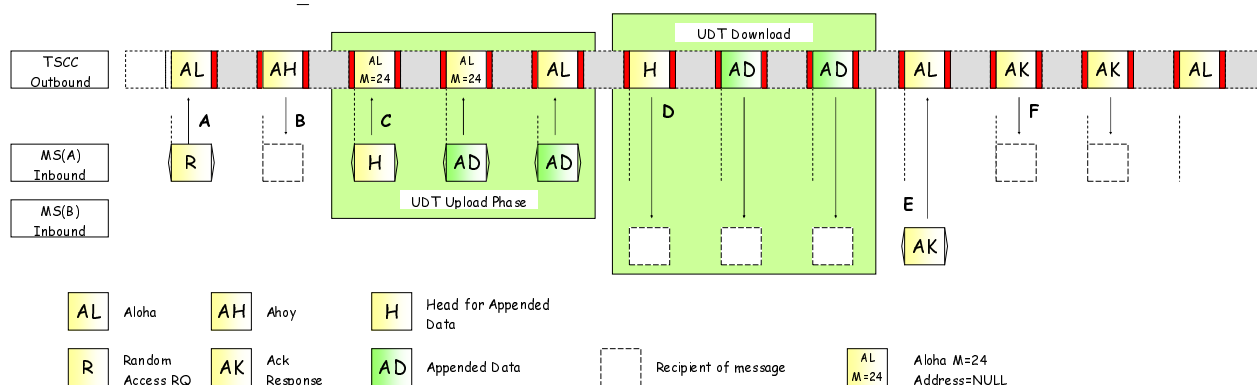


Figure 6.25: Example of a Short Data Message transfer

Figure 6.25 shows an example of a short data message transfer from MS to MS:

- MS(A) calculates the number of appended UDT's needed to transmit the short data. In this example, two appended UDT's are required;
- "A" is the random access C_RAND PDU. The called party is MS(B) and Service_Kind set to 'Short Data' and the Appended_Short_Data PDU to the number of data blocks needed to transport the short data;
- "B" is a C_AHOY PDU that request MS(A) to transport the short data using the UDT mechanism;
- "C" is the inbound phase consisting of a Multi-block UDT header + appended data;
- "D" is the outbound phase consisting of a Multi-block UDT header + appended data;
- "E" is the acknowledgement from MS(B);
- "F" is the final acknowledgement to the calling party MS(A). Note that the acknowledgement is repeated for reliability.

For a call to an extended address destination the TSCC uses the UDT mechanism to transport the extended address information. In this case the inbound phase will use two UDT procedures. The PDUs in the C_AHOY PDU indicate which UDT inbound transport is requested by unambiguous PDUs in the C_AHOY PDU.

The maximum number of bits that may be transported by the short data message service is limited by the maximum number of appended data UDT's. The tier III protocol permits up to four appended UDT's.

For a short data message service to a talkgroup, the called party shall not send a response. The TSCC may repeat the outbound phase to improve the probability of a successful message transfer. The TSCC shall send a final acknowledgement to the calling unit even though the receipt of the short data message is not certain.

The timing for the inbound and outbound phases are not prescribed in the present document. Figure 6.26 shows examples of other applicable short data message delivery.

In the first example, the UDT Header and appended UDT's are re-transmitted by the TSCC as soon as they have been received. This timing has the advantage of minimizing end-to-end latency (between two subscriber units); however, messages received with detectable but uncorrectable errors on the inbound phase result in messages containing uncorrectable errors on the downlink which is essentially wasted bandwidth. The whole uplink and downlink phase would have to be repeated.

If the inbound phase is completed in its entirety as shown in the second example (and in figure 6.25), if uncorrectable errors are detected, that phase may be repeated before moving to the outbound phase. However, end-to-end latency (between the two MS) is sacrificed.

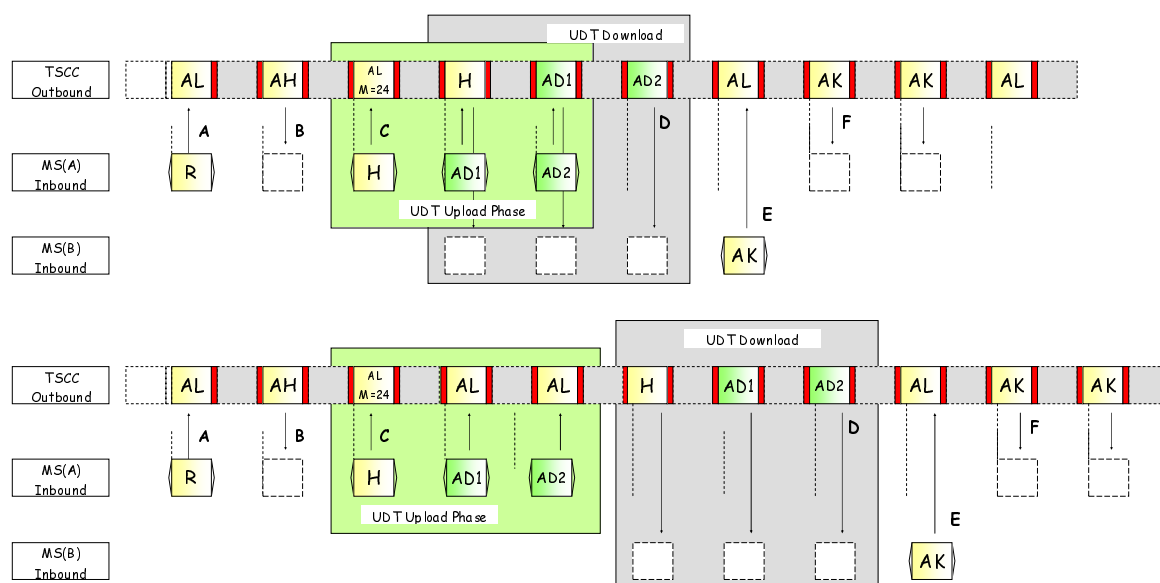


Figure 6.26: More Examples of a Short Data Message transfer

6.6.4.1 Short Data Procedures for the TSCC

A MS requests a tier III short data message service by generating a random access request PDU with the Target Address set to:

- an individual MS address;
- a talkgroup MS address;
- a gateway address (a UDT to transport the extended destination address from the MS).

When the TSCC responds to the random access request, it shall start a timer (TNP_Timer). This timer shall be refreshed if the TSCC sends further call progress messages to the calling party.

6.6.4.1.1 TSCC Response to a call to an individual MS or talkgroup

When a random access short message service PDU is received on the TSCC, the TSCC shall send a response in accordance with the random access procedures prescribed in clause 6.2.

The PDUs that represent a valid response to the short data message service random access request to a MS or talkgroup are:

- an acknowledgement PDU C_NACKD, C_QACKD, C_WACKD;

- b) a UDT Head + appended block(s) (short data call is diverted);
- c) a C_AHOY PDU instructing the calling MS to transport its short data message using the UDT mechanism;
- d) a C_AHOY PDU instructing the calling MS to transport supplementary data using the UDT mechanism;
- e) for a call to an extended address, A C_AHOY PDU instructing the calling party to send its extended address (such as PSTN, PABX etc) using the UDT mechanism.

NOTE: c) d) and e) may be performed in any order.

6.6.4.1.2 TSCC Response to a call to an extended address destination

When a random access short message service PDU is received on the TSCC, the TSCC shall send a response in accordance with the random access procedures prescribed in clause 6.2.

The PDUs that represent a valid response to the short data message service random access request to an extended address are:

- a) an acknowledgement PDU C_QACKD, C_WACKD;
- b) a C_AHOY PDU instructing the calling MS to transport its short data message using the UDT mechanism;
- c) a C_AHOY PDU instructing the calling MS to transport supplementary data using the UDT mechanism;

NOTE: b) and c) may be performed in any order.

The gateway PDUs for C_AHOY PDUs to support short data message services are prescribed in table 6.32.

Table 6.32: C_AHOY information elements for short data message service to a gateway

Action	Gateway Address	Remark
Send PSTN digits for the short data destination	PSTNI	The calling party shall uplink BCD dialled digits
Send PABX digits for the short data destination	PABXI	The calling party shall uplink BCD dialled digits
Uplink IP address for the short data destination	IPI	The calling party shall uplink the IPV4 or IPV6 address

- d) C_NACKD: Call refused and terminated. The calling party shall return to the idle state;
- e) if the TS has previously accepted a call diversion indicating that this type of service request be directed to another called party, a UDT Head + Appended data indicating the diverted address.

6.6.4.1.3 Availability Check to the called MS (short data)

For calls to individual MS, the TSCC may check that the called party is in radio contact before downloading the short data.

The TSCC may check availability of the called party by:

- a) Sending a C_AHOY PDU to that called party.
- b) Sending a Multi-block UDT with supplementary data (if the supplementary data service is active for this call).

If a response is not received from the calling party the TSCC may repeat the C_AHOY.

The availability check demands a response from the called party:

- If the response is C_NACKU, the TSCC shall abandon the short message call send an appropriate call failed response to the calling MS and echo the Reason in the C_NACKD PDU.
- If the response is C_ACKU (Reason=Message_Accepted), the TSCC shall progress the service request and download the short data message using the UDT mechanism.

6.6.4.1.4 Final acknowledgement to the calling party

In the outbound phase, the TSCC downloads the short data message to the called party. If the recipient is an individual MS an acknowledgement shall be received on the TSCC. For a short data message service to a talkgroup the outbound phase may be repeated but no acknowledgement shall be expected.

The TSCC shall send an appropriate acknowledgement to the calling party to indicate the outcome of the short data transfer request.

6.6.4.2 Short Data Message procedures for MS

A MS requests a short data message call service to another individual MS or a talkgroup or gateway using a multi-part service request. For calls to an extended address the transport of the extended address and the short data message is uploaded by two separate UDT transfers.

A MS requests a short data service by sending a C_RAND random access request complying with the random access procedures in clause 6.2. The PDUs in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.33.

Table 6.33: C_RAND information elements for a Short Data Message Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark
Service_Options	7	1	EMERG	Not applicable - 0 ₂	
		1		0 ₂	Privacy (see note 1)
		1	SUPED_SV	0 ₂	No Supplementary Data Transfer Service required for this call
				1 ₂	Supplementary Data Transfer Service requested for this call
		1	BCAST_SV	0 ₂	Not applicable - 0 ₂
		1	OVCM_SV	0 ₂	Not applicable - 0 ₂
		2	PRIORITY_SV	0 ₂	Not applicable - 0 ₂
Proxy Flag	1		PROXY	0 ₂	Number of Extended BCD digits for addressing through a gateway = 1 to 20
				1 ₂	Number of Extended BCD digits for addressing through a gateway = 21 to 44
Appended_Supplementary_Data	2		SUPED_VAL	Value	Number of appended UDT's required to transport supplementary data
Appended_Short Data	2		SDATA_VAL	00 ₂	Number of appended UDT's required transport short data
Service_Kind	4		IND_SD_SRV	0100 ₂	Individual Short Data Call Service
			GRP_SD_SRV	0101 ₂	Talkgroup Short Data Call Service
Target_address or Gateway	24			Value	Target Address (see note 2)
Source_address	24			Value	Individual Address of the requesting MS
NOTE 1: Privacy is not defined in the present document.					
NOTE 2: If Service_Kind = IND_SD_SRV then Target_Address represents an Individual address. If Service_Kind = GRP_SD_SRV then Target_Address represents a Talkgroup.					

6.6.4.3 Initiating a Short Data Message service

For a short data message service request to an individual MS or talkgroup, the destination address is completely expressed by the Target Address information element in the C_RAND random access PDU. The Service_Kind specifies if the Short Data Message call service is addressed to an individual address or a talkgroup. For calls to a gateway addresses the Target_address or Gateway information element in the C_RAND is set to the gateway address.

The MS shall attempt access until it receives a valid response, or the service is cancelled by the user, or the attempt fails by sending the maximum number of random access PDUs or the random access timer expires.

6.6.4.4 Response to a random access short data message

The calling MS shall accept the following PDUs a valid response to the SDM random access request:

- a) an acknowledgement PDU C_NACKD, C_QACKD, C_WACKD;
- b) a UDT Head + appended block(s) (short data call is diverted);
- c) a C_AHOY PDU instructing the calling MS to transport its short data message using the UDT mechanism;
- d) a C_AHOY PDU instructing the calling MS to transport supplementary data using the UDT mechanism;
- e) for a call to an extended address, A C_AHOY PDU instructing the calling party to send its extended address using the UDT mechanism.

NOTE: c) d) and e) may be performed in any order.

6.6.4.5 Acknowledgements received by the calling MS

When the C_RAND PDU has been transmitted by the calling party, an initial response may be received by the calling party as specified in clause 6.6.4.4.

At any time further PDUs may be sent to the calling party as follows:

- a) a C_NACKD at any time to indicate the call has failed. The Reason information element shall be set to indicate the reason for the call failure;
- b) a C_WACKD if more signalling will follow;
- c) after the short data message has been successfully transported, C_ACKD PDU.

If a C_NACKD is received, the calling MS shall abandon the short data message call and return to the idle state.

Any applicable call progress acknowledgement received shall restart the TNP_timer.

6.6.4.6 Timeout waiting for further signalling

A MS waiting for further signalling shall abandon the short data message service and return to the idle state if the TNP_Timer expires.

6.6.4.7 MS receiving a short data message

If a MS receives a multi block UDT Head PDU with the Target Address matching its individual address, it shall respond with an appropriate acknowledgement. The Appended_Blocks information element in the UDT header indicates the number of appended UDT blocks.

If a MS receives a multi block UDT Head PDU with the Target Address matching a talkgroup, it shall accept the information contained in the appended blocks, but shall transmit no response.

6.6.5 Short Data Polling Service

The Short Data Polling Message service enables data to be polled from MS using the control channel. Up to 288 bits of data may be transported using this service formatted in a number of formats including binary, BCD, ISO 7 bit text (ISO/IEC 646 [12]), ISO 8 bit characters (ISO/IEC 8859 [13]), NMEA (IEC 61162-1 [8]) formatted location data, and manufacturer specific proprietary formats.

NOTE: Calling and polled MSs must pre-arrange the number of appended UDT's required to transport the polled data.

The Short Data Message polling procedure uses the single-part call set-up.

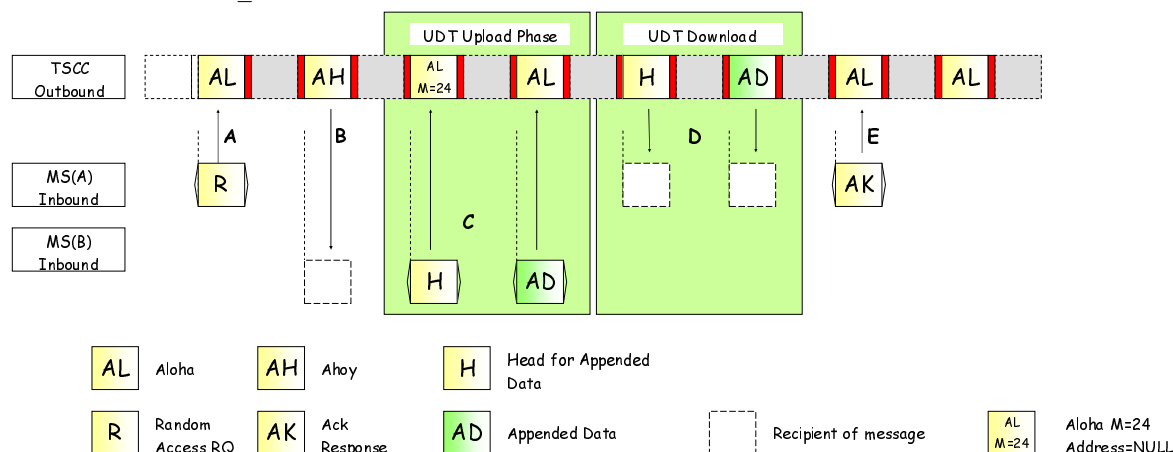


Figure 6.27: Example of a Short Data Polling transfer

Figure 6.27 shows an example of a short data polling service:

- MS(A) specifies the number of appended UDT's for the polled short data. In this example, one appended UDT is required;
- "A" is the random access C_RAND PDU. The target address is set to the polled party, Service_Kind set to 'Short Data Polling' and the Appended_Short_Data information element to the number of data blocks to transport the polled short data;
- "B" is a C_AHOY PDU that requests MS(B) to transport the short data using the UDT mechanism;
- "C" is the inbound phase consisting of a Multi-block UDT header + appended data;
- "D" is the outbound phase consisting of a Multi-block UDT header + appended data;
- "E" is the final acknowledgement from MS(A).

The maximum number of bits that may be transported by the short data message polling service is limited by the maximum number of appended data UDT's. The tier III protocol permits up to four appended UDT's.

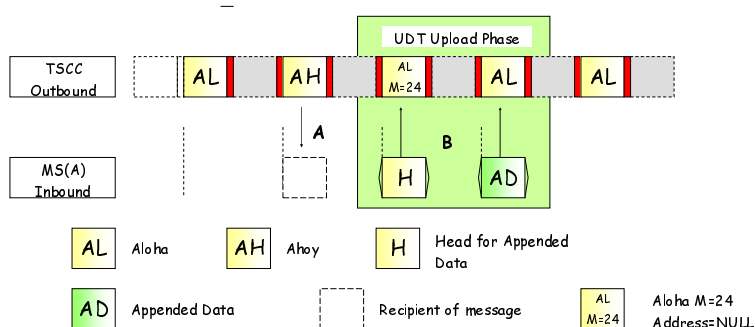


Figure 6.28: Example of short data polling from a gateway

Figure 6.28 shows a short data polling transfer from a gateway to a MS. The TSCC requests the short data by transmitting a C_AHOY PDU addressed to MS(A). MS(A) responds with the UDT head + short data.

6.6.5.1 Short Data Polling Procedures for the TSCC

A MS requests a tier III short data polling message service by generating a random access request PDU with the Target Address set to an individual address.

When the TSCC responds to the random access request, it shall start a timer (TNP_Timer). This timer shall be refreshed if the TSCC sends further call progress PDUs to the calling party.

6.6.5.1.1 TSCC Response to a poll request from an MS

When a random access short data poll service PDU is received on the TSCC, the TSCC shall send a response in accordance with the random access procedures prescribed in clause 6.2.

The PDUs that represent a valid response to the short data polling service random access request to a MS or talkgroup are:

- a) an acknowledgement PDU C_NACKD, C_QACKD, C_WACKD;
- b) a C_AHOY PDU instructing the polled MS to transport supplementary data using the UDT mechanism.

NOTE: If the polled MS has diverted its calls the response shall be C_NACKD (Reason= Div_Cause_Fail).

6.6.5.1.2 Availability Check to the called MS (short data poll)

The TSCC may check that the called party is in radio contact before polling the MS for the short data.

The TSCC may check availability of the polled party by sending a C_AHOY PDU addressed to the polled MS individual address. If a response is not received from the calling party the TSCC may repeat the C_AHOY at layer 2.

The availability check demands a response from the called party:

- a) If the response is C_NACKU, the TSCC shall abandon the short message polling transaction, send an appropriate call failed response to the calling MS and echo the Reason in the C_NACKU PDU.
- b) If the response is C_ACKU (Reason=Message_Accepted), the TSCC shall progress the service request and poll the MS for the short data using the UDT mechanism.

6.6.5.1.3 Delivery of the polled data to the calling party

In the outbound phase, the TSCC downloads the short data polled message to the calling party using the UDT mechanism.

The calling MS shall send an appropriate acknowledgement to the TSCC to indicate the outcome of the short data polling request.

6.6.5.1.4 Final acknowledgement by the calling party to the TSCC

The final phase of the polling transaction is the acknowledgement from the calling MS that the polled data was successfully received. If the TSCC does not receive a response, it may repeat the outbound phase described in clause 6.6.5.1.3.

6.6.5.1.5 Short Data Polling procedures from a TSCC gateway

The short polling service initiated through a gateway is illustrated in figure 6.28. The TSCC transmits a C_AHOY PDU addressed to an individual MS. The C_AHOY PDU demands a response:

- a) If the response is C_NACKU, the TSCC shall abandon the short message polling transaction.
- b) If the response is a multi-block UDT containing the polled data, the transaction is complete.

6.6.5.2 Short Data Polling Message procedures for MS

A MS requests a short data polling call service to another individual MS, using a single-part service request.

A MS requests a short data service by sending a C_RAND random access request complying with the random access procedures in clause 6.2. The information elements in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.34.

Table 6.34: C_RAND information elements for a Short Data Polling Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark
Service_Options	7	1	EMERG	Not applicable - 0 ₂	
		1		0 ₂	Privacy (see note)
		1	SUPED_SV	0 ₂	Not applicable - 0 ₂
		4	POL_FMT	Value	Format of the polled data
Proxy Flag	1		PROXY	0 ₂	Not Defined for the polling service
Appended_Supplementary_Data	2		SUPED_VAL	00 ₂	Not Defined for the polling service
Appended_Short Data	2		SDATA_VAL	00 ₂	Number of UDT's required to transport the polled short data
Service_Kind	4		SD_P_SRV	0110 ₂	Short Data Polling Service
Target_address	24			Value	Polled individual MS address
Source_address	24			Value	Individual Address of the requesting MS
NOTE: Privacy is not defined in the present document.					

6.6.5.3 Initiating a Short Data Polling service

For a short data polling service request to an individual MS, the polling MS address is completely expressed by the Target Address information element in the C_RAND random access PDU. The Service_Kind specifies the Short Data Message call service.

The MS shall attempt access until it receives a valid response, or the service is cancelled by the user, or the attempt fails by sending the maximum number of random access PDUs or the random access timer expires.

6.6.5.4 Response to a random access short data polling message

The calling MS shall accept the following PDUs a valid response to the SDM random access request:

- a) An acknowledgement PDU C_NACKD, C_QACKD, C_WACKD.
- b) A C_AHOY PDU instructing the polled MS to transport its short data message using the UDT mechanism.

6.6.5.5 Final Acknowledgement transmitted by the calling MS

In the outbound phase, the TSCC downloads the short data polled message to the calling party. Valid responses to the TSCC are:

- a) An acknowledgement PDU C_NACKU indicating the transaction has failed.
- b) An acknowledgement PDU C_ACKU indicating the transaction was successful.

6.6.5.6 Timeout waiting for further signalling

A MS waiting for further signalling shall abandon the short data polling service and return to the idle state if the TNP_Timer expires.

6.6.5.7 MS receiving a C_AHOY poll for a short polling message

If a MS receives a C_AHOY PDU with the Target Address matching its individual address and the Service_Kind = Short Data Polling Service it shall respond with:

- a) A multi block UDT Head PDU with the Target Address matching its calling party (source) address from the C_AHOY PDU. The Appended_Blocks information element in the UDT header indicates the number of appended UDT blocks.
- b) A C_NACKU PDU if the polled MS does not wish to accept the polling request.

6.6.6 Status Call Service

The Status Message service enables data to be transmitted between DMR entities on the control channel. Seven bits of data may be transported using this service. The status delivery service transports a status message from the initiator to a recipient. The status polling service enables an initiator to request a status message from an addressed entity. Seven bits are transported representing 128 status messages. Each status message has a user-defined meaning.

Status message addressed from MS to the TSSC are system messages.

6.6.6.1 Status Service Delivery Procedure

The Status Message procedure employs a store and forward mechanism. An MS may send a Status Message to an individual MS, the PSTN or PABX, a line connected gateway, a dispatcher gateway or the TSSC. The TSSC may also transmit a short data message from a gateway or special ident addressed to an individual MS.

6.6.6.1.1 Status Service Delivery Procedures for the TSSC

A MS initiates a Status Service by random access addressed to:

- a) An individual MS address (single-part call set-up).
- b) A gateway address that indicates a multi-part call set-up.
- c) The TSSC.

When the TSSC responds to the random access request it shall start timer (TNP_Timer). This timer shall be refreshed if the TSSC sends further call progress messages to the calling party.

6.6.6.1.1.1 TSSC Response to a single part Status Service Delivery call setup

On receipt of the random access service request the TSSC shall transmit either:

- a) An acknowledgement PDU C_NACKD, C_WACKD (Reason=Wait), C_ACKD addressed to the calling MS.
- b) A C_AHOY PDU addressed to the called party for this call to pass the status to the called MS.
- c) A UDT Head _ appended block(s) (status message service is diverted. If the TS has previously accepted a call diversion indicating that this type of service request be directed to another called party, the TSSC shall invoke the UDT and send a UDT Head + Appended data to the calling party.

6.6.6.1.1.2 TSSC Response to a multi part Status Service Delivery call setup

For calls to extended addresses, the MS requests multi-part addressing by generating a status call random access request with the Destination Address information element set to a gateway address (PABXI, PSTNI, etc) and the Proxy Flag information element to indicate the number of digits for the extended address. For the number of dialled digits = 1 to 20 the Proxy Flag information element shall be set to 0₂. For the number of dialled digits = 21 to 44 the Proxy Flag information element shall be set to 1₂. The PDUs that shall represent a valid response to the multi-part part Status service random access request are:

- a) An acknowledgement PDU C_NACKD, C_WACKD(reason=Wait).
- b) A C_AHOY PDU for the calling MS to send the extended address information.
- c) A C_AHOY PDU for the calling MS to send supplementary data (see clause 6.5).

For b) The TSSC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the extended address information. For a call to the PABX or PSTN the extended address information shall be BCD digits. The Proxy Flag information element in the C-AHOY PDU shall be copied from the Proxy Flag information element received from the MS C_RAND PDU. If the TSSC does not successfully receive the UDT from the MS, the TSSC may repeat the C_AHOY, or transmit a C_NACKD to indicate failure of the call.

For c) The TSCC shall then invoke the UDT procedure by sending a C_AHOY to the calling MS to send the supplementary data. The format of the supplementary data is specified in the UDT. If the TSCC does not successfully receive the UDT from the MS, the TSCC may repeat the C_AHOY, transmit a C_NACKD to indicate failure of the call or continue with the call setup and abandon the supplementary data.

6.6.6.1.1.3 Acknowledgements sent on the TSCC to the calling MS (status)

The TSCC may send acknowledgement PDUs following the random access Status service request to indicate the progress of the call, or terminate the call. If the TSCC sends a PDU to indicate the progress of a call it shall start a waiting timer TNP_Timer. (The calling party MS maintains a similar timer).

- a) Progress PDUs may be:
 - 1) C_WACKD: Intermediate acknowledgement. More PDUs to follow.
 - 2) C_QACKD: Called MS engaged in another call.
 - 3) C_QACKD: Call is queued because the resource is in use at the moment.
- b) Termination PDUs are selected from an appropriate Reason information element in a C_NACKD PDU (see clause 7.2.8):
 - 1) C_NACKD.

6.6.6.1.1.4 Delivery of the status to the called party

The TSCC delivers the status to the called MS by transmitting a C_AHOY PDU containing the Status information element. The status message may have originated from another MS, a gateway or the TSCC. The C_AHOY PDU demands a response from the called MS. If the response is C_ACKU or C_NACKU, the TSCC shall send an equivalent acknowledgement to the calling party. If no response is received the TSCC may repeat the C_AHOY or abandon the service and indicate the failure to the called party by transmitting a C_NACKD.

6.6.6.1.1.5 Call Time Out

The TSCC shall maintain a timeout defining the maximum time it shall store a status message request waiting for the called MS or TSCC resource to become free.

6.6.6.1.2 Status Service Delivery Procedures for MS

A MS requests a status message call service to another individual MS using a single part service request or gateway using a multi-part service request. For calls to an extended address the sending of the extended address is by a UDT transfer.

A MS requests a status service by sending a C_RAND random access request complying with the random access procedures in clause 6.2. The information elements in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.35.

Table 6.35: C_RAND information elements for a Status Message Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark
Service_Options	7		STATUS	value	
Proxy Flag	1		PROXY	0 ₂	Number of Extended BCD digits for addressing through a gateway = 1 to 20
				1 ₂	Number of Extended BCD digits for addressing through a gateway = 21 to 44
Appended_Supplementary_Data	2		SUPED_VAL	Value	Number of appended UDT's required to transport supplementary data
Appended_Short Data	2		SDATA_VAL	00 ₂	Not Defined for the status Service
Service_Kind	4		IND_ST_SRV	0111 ₂	Status Transport Service
Target_address or Gateway	24			Value	Target Address (see note 2)
Source_address	24			Value	Individual Address of the requesting MS
NOTE 1: Privacy is not defined in the present document.					
NOTE 2: Target_Address represents an Individual address or gateway.					

6.6.6.1.2.1 Initiating a Status Message service

For a status message service request to an individual MS, the destination address is completely expressed by the Target Address information element in the C_RAND random access PDU. The Service_Kind specifies the Status Message call service. For calls to a gateway addresses the Target_address or Gateway information element in the C_RAND is set to the gateway address.

The MS shall attempt access until it receives a valid response, or the service is cancelled by the user, or the attempt fails by sending the maximum number of random access PDUs or the random access timer expires.

6.6.6.1.2.2 Response to a random access status message service request

The calling MS shall accept the following PDUs a valid response to the status service random access request:

- An acknowledgement PDU C_NACKD, C_QACKD, C_WACKD.
- A UDT Head + appended block(s) (short data call is diverted).
- A C_AHOY PDU to the called MS containing the status PDU.
- A C_AHOY PDU instructing the calling MS to transport supplementary data using the UDT mechanism.
- For a call to an extended address, A C_AHOY PDU instructing the calling party to send its extended address using the UDT mechanism.

NOTE: d) and e) may be performed in any order.

6.6.6.1.2.3 Acknowledgements received by the calling MS

When the C_RAND PDU has been transmitted by the calling party, an initial response may be received by the calling party as specified in clause 6.6.6.1.1.3.

At any time further PDUs may be sent to the calling party as follows:

- A C_NACKD at any time to indicate the call has failed. The Reason information element shall be set to indicate the reason for the call failure.
- A C_WACKD if more signalling will follow.
- After the status message has been successfully transported, a C_ACKD PDU.

If a C_NACKD is received, the calling MS shall abandon the status message call and return to the idle state.

If a C_WACKD is received the MS shall start/restart the TNP_Timer and wait for further signalling.

Any acknowledgement or valid C_AHOY PDU received shall restart the TNP_timer.

6.6.6.1.2.4 Timeout waiting for further signalling

A MS waiting for further signalling shall abandon the status message service and return to the idle state if the TNP_Timer expires.

6.6.6.1.2.5 MS receiving a status message

If a MS receives a C_AHOY message with the Target Address matching its individual address, it shall respond with an appropriate acknowledgement. The Service_Options information element contains the status message.

6.6.7 Call Diversion

6.6.7.1 Call Diversion Service

The call diversion service supports a self initiated diversion - that is a MS may request that all future services be redirected to an alternative destination. Requests are applicable to:

- Voice call service.
- Packet Data service.
- Short data message delivery service.
- Status message service.

Applicable Services may be redirected to another MS, a talkgroup, or an extended address through a gateway.

The "Set Diversion" call diversion service uses a multi-part call set-up and the diversion address is sent by the caller using the UDT mechanism. This is recognized by the DIVONOFF information element in the diversion service request set to "Set Call Diversion" (=1₂).

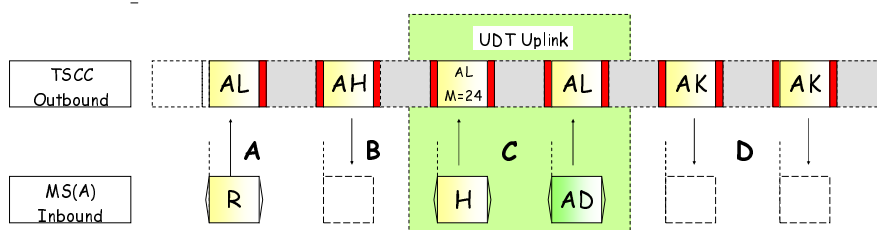


Figure 6.29: Example of a Call Diversion Call

- MS(A) defines the number of appended UDT's needed to transport the diverted address to the TSSC. In this example, one appended UDT is required.
- "A" is the random access C_RAND PDU. The Service_Kind set to 'Call Diversion Service' and the Appended_Short_Data PDU to the number of UDT appended blocks to transport the diverted address.
- "B" is a C_AHOY PDU that requests MS(A) to transport the diversion address using the UDT mechanism.
- "C" is the inbound phase consisting of a Multi-block UDT header + appended data transporting the diverted address to the TSSC.
- "D" is the acknowledgement from the TSSC.

If the Service_Options information element DIVONOFF in the call diversion Service request is set to "Clear Diversion" then a single part call set-up with the Target Address set to DIVERTI.

6.6.7.1.1 TSCC Procedures for the Call Diversion Service

A MS initiates a Set Call Diversion Service by random access addressed to the gateway identifier appropriate to the diverted destination - individual MS address, talkgroup, PTSN, PABX, IP. The set call diversion service uses the multi-part call set-up. When the TSCC responds to the random access request it shall start timer (TNP_Timer). This timer shall be refreshed if the TSCC sends further call progress PDUs to the calling party.

A MS initiates a Clear Call Diversion Service by random access addressed to the gateway identifier DIVERTI. The clear call diversion service uses the single-part call set-up. When the TSCC responds to the random access request it shall start timer (TNP_Timer). This timer shall be refreshed if the TSCC sends further call progress PDUs to the calling party.

6.6.7.1.1.1 TSCC Response to a multi-part Set Call Diversion Service call setup

To set call diversion service, the MS generates a random access diversion service request with the C_RAND information elements set as table 6.37 and the DIVONOFF information element set to Set Call Diversion (=1₂).

The PDUs that shall represent a valid response to the set call diversion service multi-part random access request are:

- a) An acknowledgement PDU C_NACKD, C_WACKD(reason=Wait).
- b) A C_AHOY PDU for the calling MS to send the diverted address using the UDT mechanism.

For b) The TSCC shall invoke the UDT procedure by sending a C_AHOY to the calling MS to send the diverted address information. For a call diversion to the PABX or PSTN the diverted address information shall be BCD digits. The Proxy Flag information element in the C-AHOY PDU shall be copied from the Proxy Flag information element received from the MS C_RAND PDU. If the TSCC does not successfully receive the UDT from the MS, the TSCC may repeat the C_AHOY, or transmit a C_NACKD to indicate failure of the call.

The gateway information elements for C_AHOY PDUs to upload the diverted address is prescribed in table 6.36.

Table 6.36: C_AHOY information elements for the Set Call Diversion Service

Action	Gateway Address	Remark
Send the individual MS Address	MSI	The calling party shall send the MS Individual diversion address
Send the Talkgroup Address	GPI	The calling party shall send the MS talkgroup diversion address
Send PSTN digits	PSTNI	The calling party shall send BCD dialled digits
Send PABX digits	PABXI	The calling party shall send BCD dialled digits
Send IP address	IPI	The calling party shall send the IPV4 or IPV6 address

6.6.7.1.1.2 TSCC Response to a single-part Clear Call Diversion Service set-up

For the clear call diversion service, the MS generates a random access diversion service request with the C_RAND information elements set as table 6.38 and the DIVONOFF information element set to Clear Call Diversion (=0₂).

The PDUs that shall represent a valid response to the clear call diversion service multi-part random access request are:

- a) An acknowledgement PDU C_NACKD indicating that the service request has not succeeded.
- b) C_WACKD(reason=Wait) further signalling to follow.
- c) An acknowledgement C_ACKD indicating that the service request has succeeded.

6.6.7.1.2 MS Procedures for the Call Diversion Service

A MS requests the call diversion service using a random access service request.

If the MS wishes to divert its calls the DIVONOFF information element in the Service_Options is set to "Set Diversion (=1₂)". A multi-part service request is invoked. The information elements in the random access request are passed to the CC layer - set appropriately as prescribed in table 6.37.

If the MS wishes to cancel a previously set diversion, the same random access request is.

Table 6.37: C_RAND information elements for a Call Diversion Service

Information Element (I.E)	I.E Length	length	Alias	Value	Remark
Service_Options	7	1	EMERG	Not applicable - 0 ₂	
		1		0 ₂	Privacy (see note)
		1	DIVONOFF	0 ₂	Clear Call Diversion
				1 ₂	Set Call Diversion
		1	DIV_VD	Active 1 ₂	Divert Voice Calls
		1	DIV_PD		Divert Packet Data Calls
		1	DIV_SD	Inactive 0 ₂	Divert Short Data Calls
1	DIV_S	Divert Status Calls			
Proxy Flag	1		PROXY	0 ₂	Number of Extended BCD digits for addressing through a gateway = 1 to 20 or IPV4
				1 ₂	Number of Extended BCD digits for addressing through a gateway = 21 to 44 or IPV6
Appended_Supplementary_Data	2		SUPED_VAL	00 ₂	Not Defined for the call diversion Service
Appended_Short Data	2		SDATA_VAL	00 ₂	Not Defined for the call diversion Service
Service_Kind	4		DIV_SRV	1000 ₂	Call Diversion Service
Target_address or Gateway	24			value	Gateway Identifier - MSI, GPI, PSTNI, PABXI, IPI
Source_address	24			Value	Individual Address of the requesting MS
NOTE: Privacy is not defined in the present document.					

If DIVONOFF=1₂, the alias DIV_VD, DIV_PD, DIV_SD and DIV_S that are set to Active (1₂): define which services shall be diverted for this call diversion service request.

If DIVONOFF=0₂, the alias DIV_VD, DIV_PD, DIV_SD and DIV_S that are set to Active (1₂): define which services shall have the call diversion cancelled.

Table 6.38: Information element definitions for the Call Diversion Service

Diversion Address	Target Address or Gateway	Proxy Flag
Individual MS Address	MSI	0 ₂
Talkgroup Address	GPI	0 ₂
PSTN Address (1 to 20 dialled digits)	PSTNI	0 ₂
PSTN Address (21 to 44 dialled digits)	PSTNI	1 ₂
PABX Address(1 to 20 dialled digits)	PABXI	0 ₂
PABX Address (21 to 44 dialled digits)	PABXI	1 ₂
Ipv4 Address	IPI	0 ₂
Ipv6 Address	IPI	1 ₂

6.6.7.1.2.1 MS Sends the Diversion Address

After the MS has made a call diversion service request, the TSCC sends a C_AHOY PDU to which the MS shall respond with a UDT Header + Appended block(s) using the UDT mechanism. The UDT header shall contain the destination address type (MS, PSTN etc) and the appended block(s) shall contain the diversion address.

The information elements for the UDT inbound Header are specified in table 6.39.

Table 6.39: Information element Definitions for the Call Diversion UDT Header

Diversion Address	UDT Inbound Channel Header Information Element			
	UDT Format	Appended Blocks	Target Address or Gateway	Source Address or Gateway
Individual MS	Address - 0001_2	00_2	MSI	MS Address
Talkgroup	Address - 0001_2	00_2	GPI	MS Address
PSTN destination	BCD - 0010_2	1 to 20 digits - 00_2 21 to 44 digits - 01_2	PSTNI	MS Address
PABX destination	BCD - 0010_2	1 to 20 digits - 00_2 21 to 44 digits - 01_2	PABXI	MS Address
IP destination	IP - 0110_2	IPV4 - 00_2 IPV6 - 01_2	IPI	MS Address

NOTE: Supplementary_Flag = 0_2 , UDT_Response = 0_2 , Service_Kind = 1000_2 .

6.6.7.2 Diverting Calls

An MS makes a service access request by random access. If the destination address selected is an individual MS address and the system determines that calls to this address are diverted, the TSCC shall acknowledge the random access request with a UDT header + appended with the diverted address.

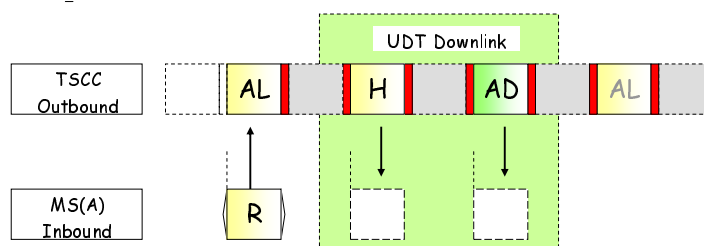


Figure 6.30: TSCC provides diverted address to MS

The UDT Header sets the following information elements:

- DIV = 1_2 .
- Supplementary Flag = 1_2 .
- UDT Response - 1_2 .
- Target_address or Gateway - Address of the calling MS.

Where the appended UDT block conveys an address the ADDRESS1 information element shall convey the diverted address.

Table 6.40 indicates the UDT Header information elements for the services and diversion addresses.

Table 6.40: Information elements for UDT Header to convey diverted address

Service Request	Divert to	UDT Header information elements			
		UDT Format	Appended Blocks	Service_Kind	Source Address
Private Voice	MS address	Address 0001 ₂	00 ₂	0000 ₂	MSI
	Talkgroup	Address 0001 ₂	00 ₂		TGI
	PTSN	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PSTNI
	PABX	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PABXI
Private Packet Data	MS address	Address 0001 ₂	00 ₂	0010 ₂	MSI
	Talkgroup	Address 0001 ₂	00 ₂		TGI
	PSTN	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PSTNI
	PABX	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PABXI
	IP	IP 0110 ₂	IPV4 - 00 ₂ IPV6 - 01 ₂		IPI
Short Data	MS address	Address 0001 ₂	00 ₂	0100 ₂	MSI
	Talkgroup	Address 0001 ₂	00 ₂		TGI
	PTSN	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PSTNI
	PABX	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PABXI
	IP	IP 0110 ₂	IPV4 - 00 ₂ IPV6 - 01 ₂		IPI
Status	MS address	Address 0001 ₂	00 ₂	0111 ₂	MSI
	PTSN	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PSTNI
	PABX	BCD 0010 ₂	1 to 20 digits - 00 ₂ 21 to 44 digits - 01 ₂		PABXI
	IP	IP 0110 ₂	IPV4 - 00 ₂ IPV6 - 01 ₂		IPI

6.7 System Management Procedures

6.7.1 Network System Announcements

Announcement PDUs are transmitted by a TSCC and contain information about system parameters for either this TS or another TS. Announcement PDUs may be transmitted frequently and therefore contain the System Identity Code for TSCC identification.

Announcement Type (BCASTTYP) specifies which system parameters are being broadcast:

- a) Announce/Withdraw TSCC.
- b) Specify Call Timer Parameters.

- c) Vote Now Advice.
- d) Announce Local Time.
- e) Mass registration.
- f) Announce a logical / physical frequency plan relationship.
- g) Adjacent site information.

6.7.1.1 Announce/Withdraw TSCC

This announcement adds and/or withdraws a TSCC radio channel that is active in a wide area system. The announcement PDU carries up to two Logical Physical Channel Number Elements. If only one Logical Channel Number is announced, the remaining element shall be set to CHNULL. MSs shall add/withdraw the logical channel(s) to/from their Short Hunt list of physical channels to hunt (see annex D).

6.7.1.2 Specify Call Timer parameters

This PDU specifies the call timer parameters for:

- a) Calls between MS and MS or MS and a talkgroup.
- b) Calls between a Line Connected Service and an MS or Talkgroup.
- c) Calls that use the Packet Data Service.
- d) Emergency Calls.

6.7.1.3 Vote now advice

The Network System Announcements (Vote Now Advice) PDU gives an opportunity to idle MSs to assess the signal quality of another TSCC specified by the announcement(see clause 7.2.20.3). The PDU provides a sub-set of the system identity code (C_SYSCode), and the logical channel number (CH_VOTE) of the TSCC the MS is being invited to assess for improved signal quality.

While MSs are assessing the signal quality of an adjacent TSCC, they are not able to receive call set-up PDUs. The TSCC shall therefore not use the next VOTE_BLK TDMA frames to signal to MSs that are likely to be assessing the signal strength of the adjacent site. Only the following PDUs may be transmitted on the TSCC in the VOTE_BLK slots following transmission of a Vote Now Advice announcement:

- a) An Aloha PDU with MS Address = NULL and Mask=24.
- b) A C_WACKD.

6.7.1.4 Announce Local Time

This PDU transmits the local date and time to MSs. The PDU permits the date to be omitted from the announcement. UTC_OFFSET enables the MS to calculate UTC time.

6.7.1.5 Mass Registration

This PDU invites all MS or a sub-set of MS to register over a short or extended time period. The description and procedures are specified in the registration clauses 6.4.5.

6.7.1.6 Announce a logical physical channel relationship

This PDU announces a logical to physical channel relationship. The PDU defines the physical transmitter and receiver frequencies to be assigned to a logical channel.

7 PDU description

This clause describes the PDUs which apply to the DMR layer 3, the tier III trunking services and facilities protocol.

The following clauses contain descriptions of the PDUs and the information elements contained within them. The structure of the PDU definition represented by the tables is as follows:

- the information element column gives the name of the contained element(s);
- the element length column defines the length of the element in bits;
- the Alias used in the description of the procedures;
- the remarks column contains other information on the information element.

The elements shall be transmitted in the order specified by TS 102 361-1 [5].

7.1 Layer 3 PDUs

Due to the nature of DMR, with close interaction between layers 2 and 3, and with a high degree of information about the state of the channel being needed, the layer 3 PDUs detailed in the following clauses may include two element types:

- Message dependent elements:
 - These elements are visible to layer 2 and may be used by any MS (that is able to decode them), irrespective of addressing. These elements depend on the message type element. Some are generated by layer 2 when it constructs the complete message whereas others are generated by layer 3.
- Facility elements:
 - These are "true" layer 3 elements. They are only processed by the MSs to which they are addressed.

Where both types exist in the PDU they are shown separately.

7.1.1 Control Signalling Block (CSBK/MBC/UDT) PDUs

CSBK/MBC and UDT PDUs form a core part of the tier III protocol. The control signalling PDUs are classified into their core functionality.

The Call Control Layer 3 requires three Data Type bursts (see TS 102 361-1 [5], clause 6.2). These are listed in:

- table 7.1 for TSCC outbound PDUs;
- table 7.2 for TSCC inbound PDUs;
- table 7.3 for Payload channel outbound PDUs; and
- table 7.4 for Payload inbound PDUs.

Table 7.1: TSCC Outbound channel PDU Structure

Class	Alias	Function	Opcode	Data Type	Value
Broadcast	PV_GRANT	Private Voice Channel Grant (logical)	11 0000 ₂	CSBK	0011 ₂
		Private Voice Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast	TV_GRANT	Talkgroup Voice Channel Grant (logical)	11 0001 ₂	CSBK	0011 ₂
		Talkgroup Voice Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast	BTV_GRANT	Broadcast Talkgroup Voice Channel Grant (logical)	11 0010 ₂	CSBK	0011 ₂
		Broadcast Talkgroup Voice Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast	PD_GRANT	Private Data Channel Grant (logical)	11 0011 ₂	CSBK	0011 ₂
		Private Data Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast	TD_GRANT	Talkgroup Data Channel Grant (logical)	11 0100 ₂	CSBK	0011 ₂
		Talkgroup Data Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast	CG_AP	Channel Grant Appended MBC	Value from header	MBC Continuation	0101 ₂
Broadcast	C_MOVE	Move TSCC (logical)	11 1000 ₂	CSBK	0011 ₂
		Move TSCC (absolute)		MBC Header	0100 ₂
Broadcast	MV_AP	Move Appended MBC	11 1000 ₂	MBC Continuation	0101 ₂
Broadcast	C_ALOHA	Aloha	01 1001 ₂	CSBK	0011 ₂
Broadcast (C_BCAST)	Ann_WD_TSCC	Announce/Withdraw TSCC (logical)	10 1000 ₂	CSBK	0011 ₂
	Ann_WD_TSCC	Announce/Withdraw TSCC (absolute)		MBC Header	0100 ₂
	CallTimer_Parms	Specify Call Timer Parameters		CSBK	0011 ₂
	Vote_Now	Vote Now Advice		CSBK	0011 ₂
	Local_Time	Broadcast Local Time		CSBK	0011 ₂
	MassReg	Broadcast Mass Registration		CSBK	0011 ₂
	Chan_Freq	Announce a logical channel / frequency relationship		CSBK	0011 ₂
Broadcast	BC_AP	Broadcast Appended MBC	10 1000 ₂	MBC Continuation	0101 ₂
Ahoy (AHOY)	AHOY	Stun/Unstun Poll MS MS Check	01 1100 ₂	CSBK	0011 ₂
Acknowledgements	C_ACKD C_NACKD C_QACKD C_WACKD	Positive Acknowledgement Negative Acknowledgement The call is queued Wait - further PDUs follow	10 0000 ₂	CSBK	0011 ₂
Unified Data Transport	C_UDTHD	Unified Data Transport Header	N/A	Data Header (UDT)	0110 ₂
Unified Data Transport	UDT	Unified Data Transport Appended Data	N/A	Unconfirmed Data Continuation	0111 ₂

Table 7.2: TSCC Inbound Channel PDU Structure

Class	Alias	Function	Opcode	Data Type	Value
Random Access	C_RAND	Random Access Requests	01 1111 ₂	CSBK	0011 ₂
Ackvitation	C_ACKVIT	Ackvitation	01 1110 ₂	CSBK	0011 ₂
Acknowledgement	C_ACKU C_NACKU	Acknowledgement	10 0001 ₂	CSBK	0011 ₂
Unified Data Transport	C_UDTHD	Unified Data Transport Header	N/A	Data Header (UDT)	0110 ₂
Unified Data Transport	UDT	Unified Data Transport Appended Data	N/A	Unconfirmed Data Continuation	0111 ₂

Table 7.3: Payload Outbound channel PDU Structure

Class	Alias	Function	Opcode	Data Type	Value
Broadcast	P_GRANT	Channel Grant (logical)	Value from Chan Grant	CSBK	0011 ₂
		Private Voice Channel Grant (absolute)		MBC Header	0100 ₂
Broadcast (Clear)	P_CLEAR	Clear the call from the payload channel. MS return to the TSCC	10 1110 ₂	CSBK	0011 ₂
Broadcast (Protect)	P_PROTECT	Broadcast Talkgroup Voice Channel Grant (logical)	10 1111 ₂	CSBK	0011 ₂
Ahoy	P_AHOY	MS Check	01 1100 ₂	CSBK	0011 ₂
Acknowledgements	P_ACKD P_NACKD	Positive Acknowledgement Negative Acknowledgement	10 0000 ₂	CSBK	0011 ₂

Table 7.4: Payload Inbound Channel PDU Structure

Class	Alias	Function	Opcode	Data Type	Value
Random Access	P_RAND	Random Access Include Request	01 1111 ₂	CSBK	0011 ₂
Acknowledgement	P_ACKU	Acknowledgement	10 0001 ₂	CSBK	0011 ₂
Maintenance	P_MAINT	Call Maintenance	10 1010 ₂	CSBK	0011 ₂

Figure 7.1 illustrates the hierarchy of the TSCC outbound channel PDU structure.

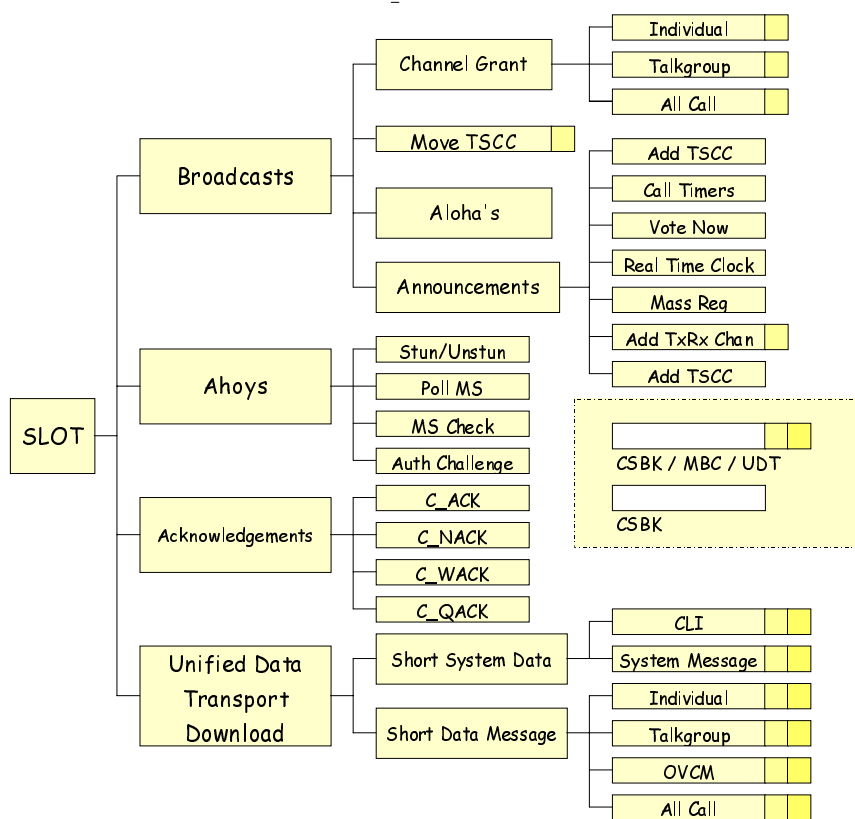


Figure 7.1: Hierarchy for the TSCC outbound channel PDUs

The top level of the structure describes a basic behaviour shown in table 7.5.

Table 7.5: Top Level Structure for TSCC Outbound channel CSBKs / MBC's /UDT's

Broadcasts	PDUs sent by a TSCC to manage the channel access, transfer MS or talkgroups to payload channels and announce information about the TS
Ahoys	To demand a response from MS and also to acknowledge random access channel access
Acknowledgments	To provide responses to Ahoys and UDT
UDT	To transport information between TSCC and MS

A similar structure exists for the inbound channel illustrated in figure 7.2.

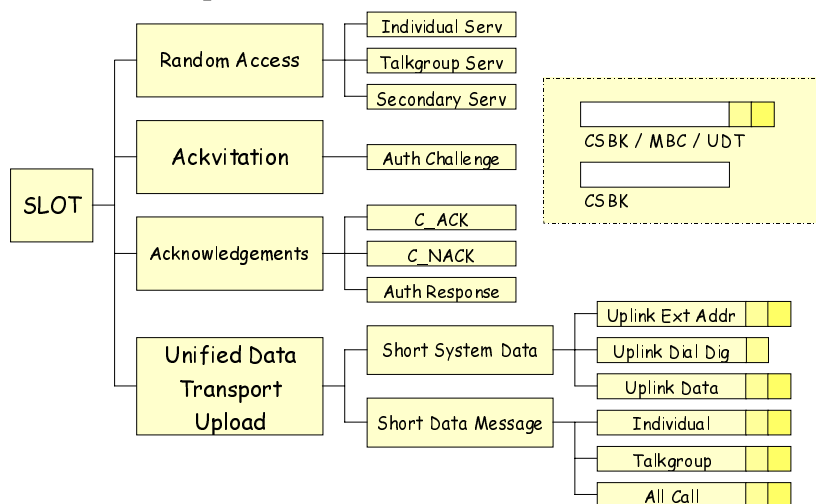


Figure 7.2: Hierarchy for the MS inbound channel PDUs to a TSCC

The basic PDU behaviour for the inbound channel is shown in table 7.6.

Table 7.6: Top level structure for MS on the TSCC inbound

Random Access	Used for channel access and request tier III services
Acknowledgments	To provide responses to Ahoys and UDT
UDT	To transport information between MS and TSCC

A payload channel outbound channel is illustrated in figure 7.3.

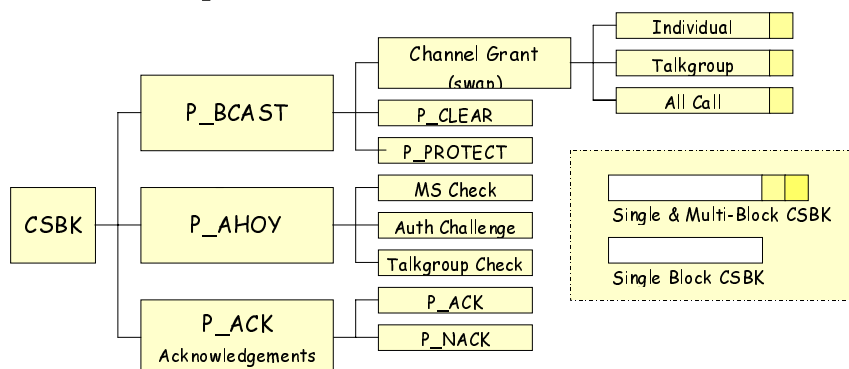


Figure 7.3: Hierarchy for Outbound channel CSBKs/MBC's on a payload channel

The top level of the structure describes a basic behaviour shown in table 7.7.

Table 7.7: Top level structure for MS inbound channel CSBKs on a control channel

Broadcasts	PDUs sent by TS to manage the payload channel - swap MS to a new channel, clear the participants from the channel and protect the channel during breaks in MS transmission items
Ahoys	For polling MS - demands a response
Acknowledgments	To provide responses to Ahoys and UDT

The payload inbound channel.

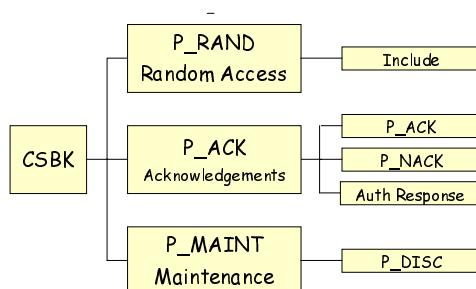


Figure 7.4: Hierarchy for the MS inbound channel PDUs to a payload channel

The basic PDU behaviour for the inbound channel is shown in table 7.8.

Table 7.8: Top level structure for MS on the payload channel inbound channel

Random Access	Used to request an include call service
Acknowledgments	To provide responses to Ahoys and UDT
Maintenance	To provide call maintenance PDUs

7.1.1.1 TSCC Outbound channel CSBK/MBC/UDT

7.1.1.1.1 Channel Grant CSBK/MBC PDU

7.1.1.1.1.1 Private Voice Channel Grant (PV_GRANT) CSBK/MBC PDU

Octet 0 and 1 of the Private Voice Channel Grant CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Private Voice Channel Grant specific information shown in table 7.9. The Private Voice Channel Grant is transmitted by the TS and does not solicit a response. The Private Voice Channel Grant PDU is transmitted on the TSCC or a payload channel either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.
- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Private Voice Channel Grant PDU is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a multi-block MBC where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

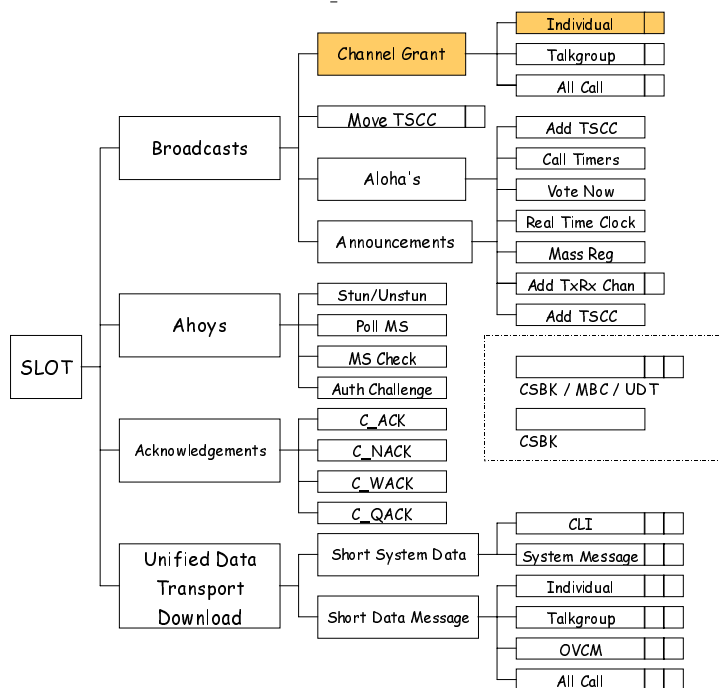


Table 7.9: Private Voice Channel Grant PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 11 0000 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
OVCM	1	0 ₂ - not OVCM call 1 ₂ - OVCM Call
Emergency	1	0 ₂ - not an emergency call 1 ₂ - emergency call
Offset	1	0 ₂ - Payload Channel uses aligned timing 1 ₂ - Payload Channel uses offset timim
Target Address	24	Called party Individual MS Address or Gateway
Source Address	24	Calling Party or Gateway

7.1.1.1.1.2 Talkgroup Voice Channel Grant (TV_GRANT) CSBK/MBC PDU

Octet 0 and 1 of the Talkgroup Voice Channel Grant CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Talkgroup Voice Channel Grant specific information shown in table 7.10. The Talkgroup Voice Channel Grant is transmitted by the TS. The Talkgroup Voice Channel Grant is transmitted by the TS and does not solicit a response. The Talkgroup Voice Channel Grant PDU is transmitted on the TSCC or a payload channel either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.

- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Talkgroup Voice Channel Grant PDU is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a Multi Block Control (MBC) where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

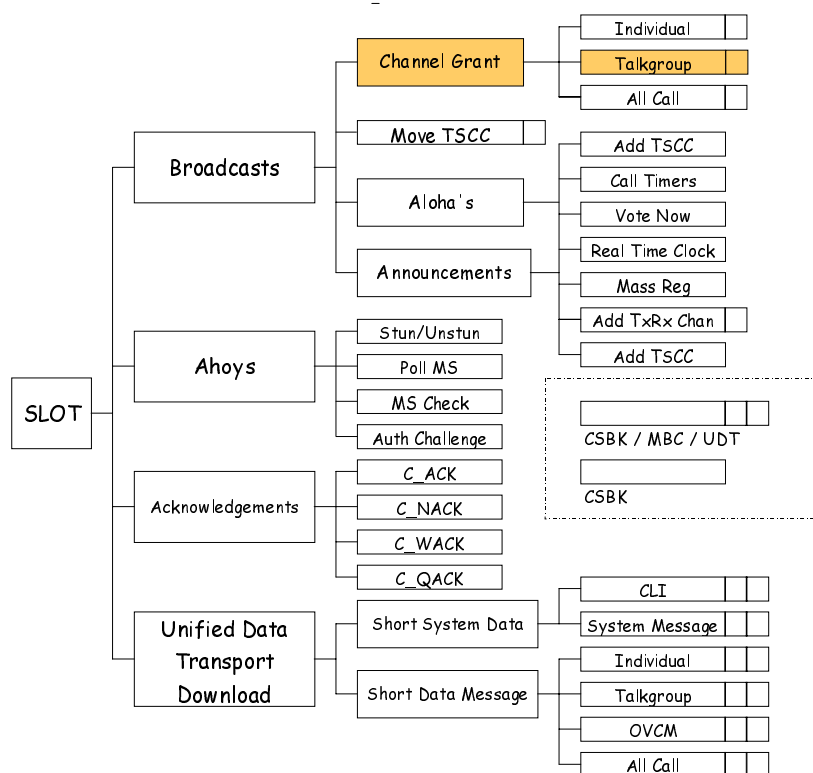


Table 7.10: Talkgroup Voice Channel Grant PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 110001 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
OVCM	1	0 ₂ - not OVCM call 1 ₂ - OVCM Call
Emergency	1	0 ₂ - not an emergency call 1 ₂ - emergency call
Offset	1	0 ₂ - Payload Channel uses aligned timing 1 ₂ - Payload Channel uses offset timing
Target Address	24	MS Talkgroup Address
Source Address	24	Calling Party or Gateway

If the Target Address is the All Unit Address (see TS 102 361-1 [5], annex A) then a MS shall interpret this PDU as a broadcast.

7.1.1.1.1.3 Broadcast Talkgroup Voice Channel Grant (BTV_GRANT) CSBK/MBC PDU

Octet 0 and 1 of the Broadcast Talkgroup Voice Channel Grant CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Broadcast Talkgroup Voice Channel Grant specific information shown in table 7.11. The Broadcast Talkgroup Voice Channel Grant is transmitted by the TS and does not solicit a response. The Broadcast Talkgroup Voice Channel Grant PDU is transmitted on the TSCC or a payload channel either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.
- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Broadcast Talkgroup Voice Channel Grant is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a Multi-Block Control (MBC) where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

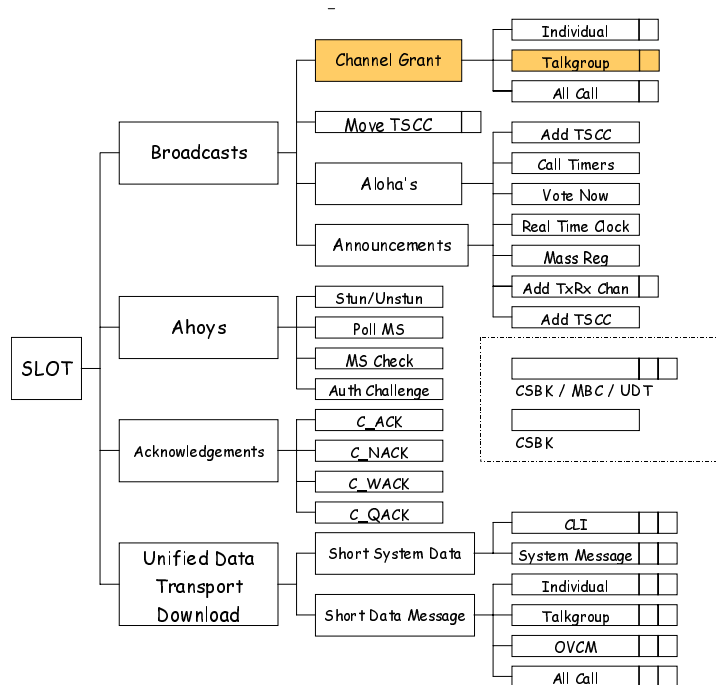


Table 7.11: Broadcast Talkgroup Voice Channel Grant PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 110010 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
OVCN	1	0 ₂ - not OVCN call 1 ₂ - OVCN Call
Emergency_Flag	1	1 ₂ -if an emergency call
Offset	1	0 ₂ - Payload Channel uses aligned timing 1 ₂ - Payload Channel uses offset timing
Destination_Address	24	MS Talkgroup Address
Source_address	24	Calling Party or Gateway

7.1.1.1.1.4 Private Data Channel Grant (PD_GRANT) CSBK/MBC PDU

Octet 0 and 1 of the Private Data Channel Grant CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCN. Octets 2 to 9 contain the Private Channel Grant specific information shown in table 7.12. The Private Data Channel Grant is transmitted by the TS and does not solicit a response. The Private Data Channel Grant PDU is transmitted on the TSCC or a payload channel either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.
- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Private Data Channel Grant PDU is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a Multi Block Control (MBC) where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

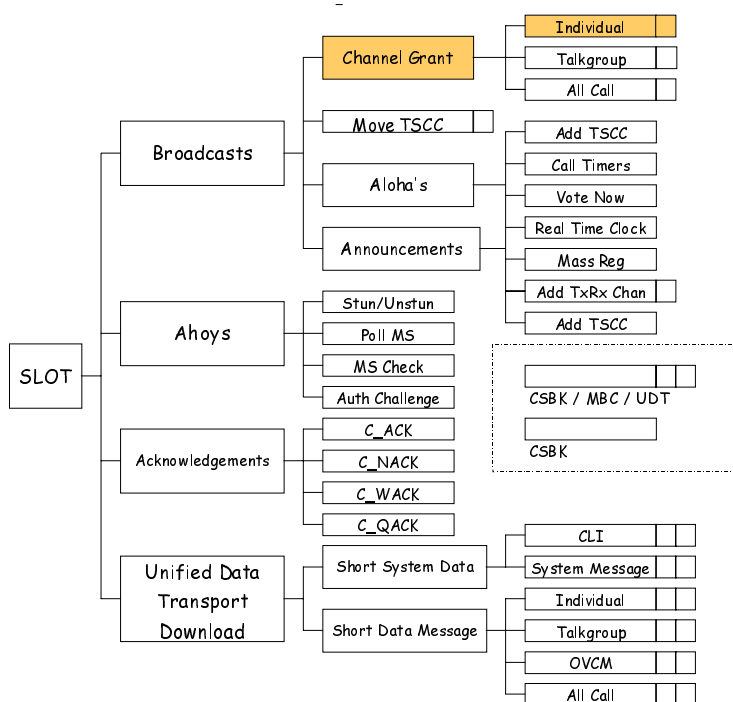


Table 7.12: Private Data Channel Grant PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 11 0011 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
Packet Mode	1	0 ₂ - Payload Channel uses 2:1 mode 1 ₂ - Payload Channel uses 1:1 mode
Emergency	1	0 ₂ - not an emergency call 1 ₂ - emergency call
Offset	1	0 ₂ - Payload Channel uses aligned timing 1 ₂ - Payload Channel uses offset timing
Destination_Address	24	Called party Individual MS Address or Gateway
Source_address	24	Calling Party or Gateway

7.1.1.1.1.5

Talkgroup Data Channel Grant (TD_GRANT) CSBK/MBC PDU

Octet 0 and 1 of the Talkgroup Data Channel Grant CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Talkgroup Data Channel Grant specific information shown in table 7.13. The Talkgroup Data Channel Grant is transmitted by the TS and does not solicit a response. The Talkgroup Data Channel Grant PDU is transmitted on the TSCC or a payload channel either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.

- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Talkgroup Data Channel Grant PDU is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a Multi Block Control (MBC) where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

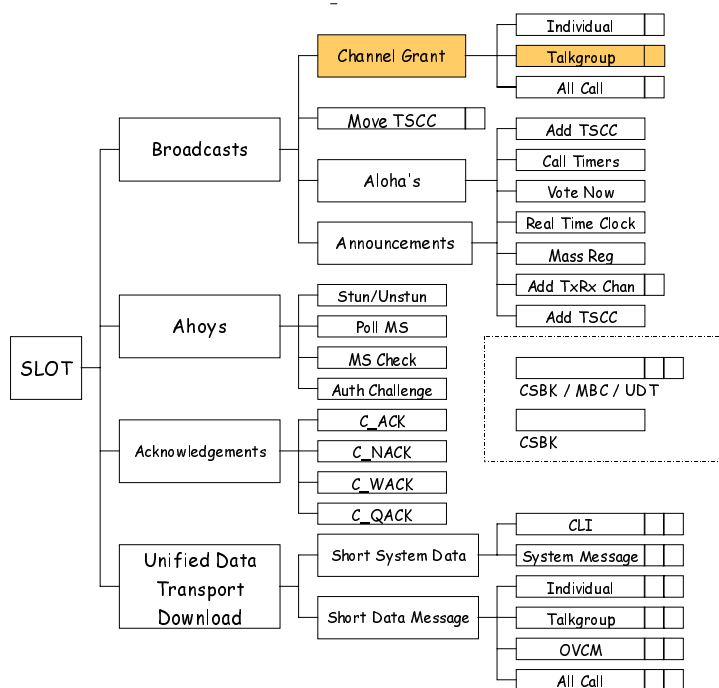


Table 7.13: Talkgroup Data Channel Grant PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBK0)	6	Shall be set to 11 0100 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
Packet Mode	1	0 ₂ - Payload Channel uses 2:1 mode 1 ₂ - Payload Channel uses 1:1 mode
Emergency	1	0 ₂ - not an emergency call 1 ₂ - emergency call
Offset	1	0 ₂ - Payload Channel uses aligned timing 1 ₂ - Payload Channel uses offset timing
Destination_address	24	MS Talkgroup Address
Source_address	24	Calling Party or Gateway

7.1.1.1.2 Channel Grant Absolute Parameters (CG_AP) appended MBC PDU

The second (continuation) block of the multi-block Channel Grant MBC conforms to the format specified in table 7.14. The CdefParms PDU is specified in clause 7.2.20.8 and the physical characteristics described in annex C.

Table 7.14: C_DEF appended Channel Grant MBC PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ because this PDU is appended to either a an applicable Channel Grant MBC Header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to the CSBKO of the first block of the multi-block CSBK
Reserved	4	0000 ₂
Colour Code	4	Colour Code used for the destination physical channel
Cdeftype	4	Meaning of CdefParms (see clause 7.2.20.8)
Reserved	2	00 ₂
CdefParms	58	information elements describing the logical / physical channel frequency relationship

7.1.1.1.3 Move TSCC (C_MOVE) CSBK/MBC PDU

Octet 0 and 1 of the Move TSCC CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Move TSCC specific information shown in table 7.15. The Move PDU is transmitted on the TSCC either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- a) If the value = 0000 0000 0000₂ the Physical Channel number is invalid.
- b) If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Move PDU is transmitted on the TSCC as a single block CSBK.
- c) If the value = 1111 1111 1111₂, the Physical Channel number defines a Multi Block Control (MBC) where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (see clause 7.1.1.1.3.1).

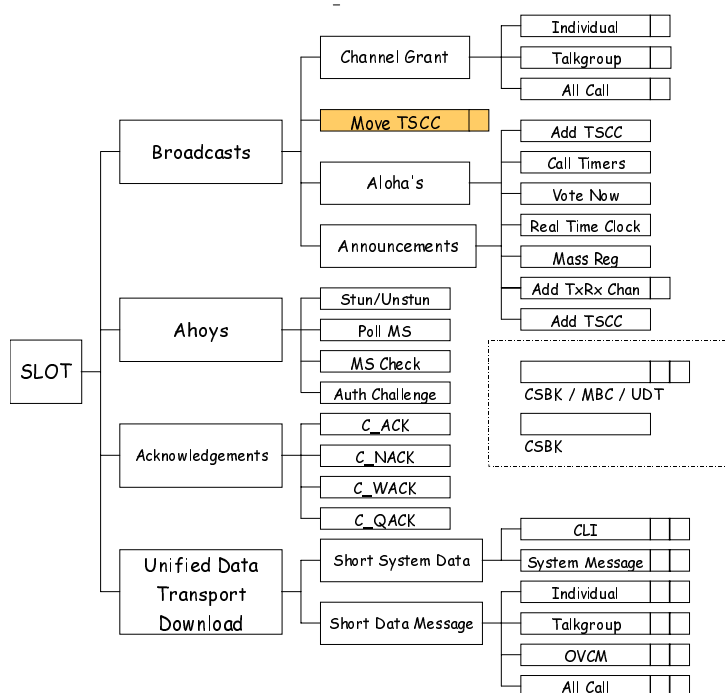


Table 7.15: Move TSCC PDU content

Information element	Length	Remark
Message dependent elements		
Last First block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 11 1000 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Reserved	9	0 0000 0000 ₂
Mask	5	
Reserved	5	
Reg	1	This bit is set if the TSCC demands MS register before becoming active
Backoff	4	Backoff Number
Reserved	4	
Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
MS address	24	MS Individual Address

7.1.1.1.3.1 Move Absolute Parameters appended (MV_AP) MBC PDU

The second block of the Multi Block Move MBC conforms to the format specified in table 7.16. The CdefParms PDU is specified in clause 7.2.20.8 and the physical characteristics described in annex C.

Table 7.16: C_DEF appended Move MBC PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ because this PDU is appended to an applicable Move MBC Header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to the CSBKO of the first block of the multi-block CSBK
Reserved	4	0000 ₂
Colour Code	4	Colour Code used for the destination physical channel
Cdeftype	4	Meaning of CdefParms (see clause 7.2.20.8)
Reserved	2	00 ₂
CdefParms	58	information elements describing the logical / physical channel frequency relationship

7.1.1.1.4 Aloha (C_ALOHA) CSBK PDU

Octet 0 and 1 of the C_ALOHA CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the C_ALOHA PDU specific information. The C_ALOHA PDU is shown in table 7.17. C_ALOHA PDUs are transmitted by a TSCC.

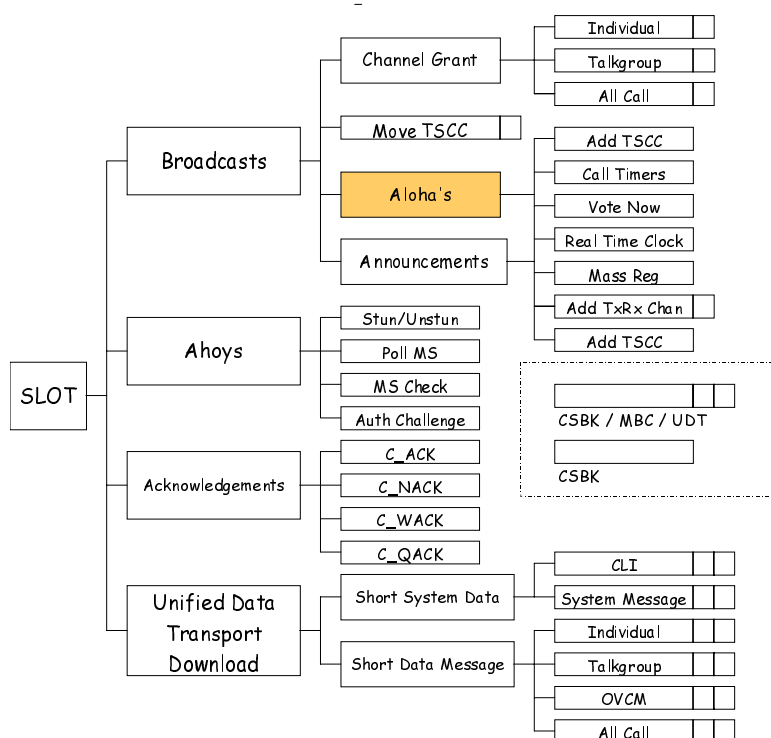


Table 7.17: C_ALOHA PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 01 1001 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Reserved	7	
Active_Connection	1	0 ₂ - The TS does not have a connection with the network 1 ₂ - The TS has a connection with the network
Mask	5	
Service Function	2	
NRand_Wait	4	
Reg	1	This bit is set if the TSCC demands MS register before becoming active
Backoff	4	Backoff Number
System Identity Code	16	
MS Address	24	MS Individual Address

7.1.1.1.5 Announcements (C_BCAST) CSBK/MBC PDU

Octet 0 and 1 of the C_BCAST PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the C_BCAST PDU specific information. The C_BCAST PDU is transmitted on the TSCC either as a single block CSBK or a Multi Block Control (MBC).

The C_BCAST PDU is shown in table 7.18.

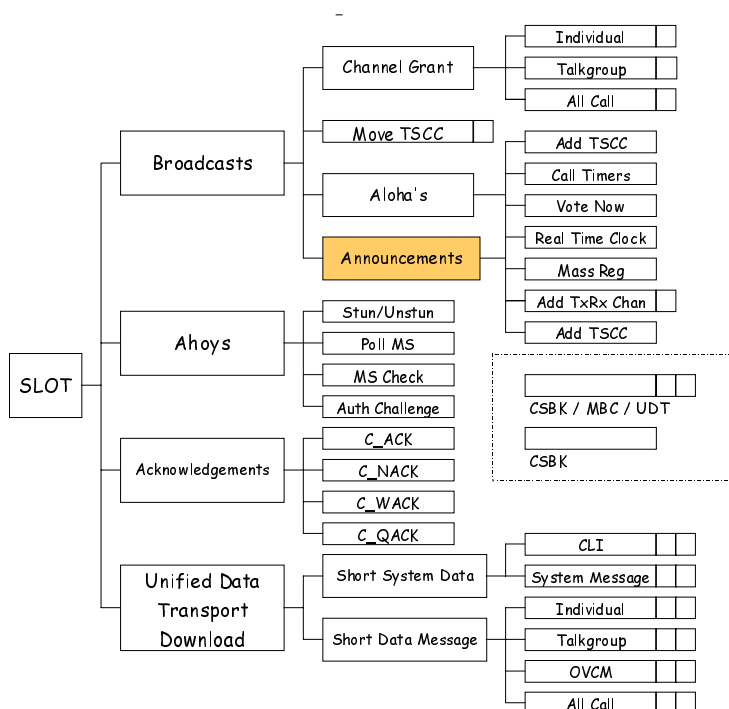


Table 7.18: C_BCAST PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 10 1000 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Announcement type	5	Defines which system parameters are being broadcast
Broadcast Parms 1	14	
Reg	1	This bit is set if the TSCC demands MS register before becoming active
Backoff	4	Backoff Number
System Identity Code	16	
Broadcast Parms 2	24	

The Announcement type PDU determines the category of Announcements:

- a) Announce/Withdraw TSCC.
- b) Specify call Timers.
- c) Vote now advice.
- d) Announce local time.
- e) Broadcast Mass Registration.
- f) Announce a logical physical channel relationship.
- g) Announce Adjacent site information.

7.1.1.1.5.1 Broadcast Absolute Parameters (BC_AP) appended MBC PDU

The second block of the multi-block Broadcast Absolute Parameters MBC (announce logical/absolute frequency relationship) conforms to the format specified in table 7.19. The CdefParms PDU is specified in clause 7.2.20.8 and the physical characteristics described in annex C.

Table 7.19: BC_AP appended Broadcast MBC PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 0 ₂ because this PDU is appended to an applicable Announcement MBC Header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to the CSBKO of the first block of the multi-block CSBK
Reserved	8	
Cdeftype	4	
Reserved	2	
CdefParms	58	Information elements describing the logical / physical channel frequency relationship

7.1.1.1.6 Ahoy (AHOY) CSBK PDU

Octet 0 and 1 of the AHOY CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the C_AHOY specific information. The generic AHOY PDU is shown in table 7.20. AHOY PDUs are transmitted by the TS.

The AHOY PDU is transmitted by the TS as a single block CSBK.

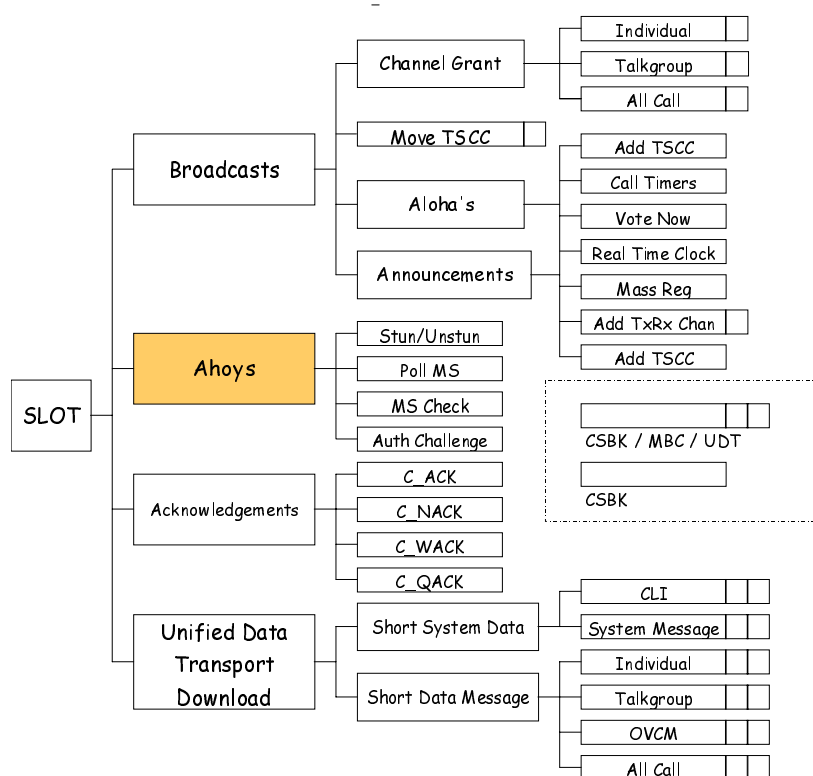
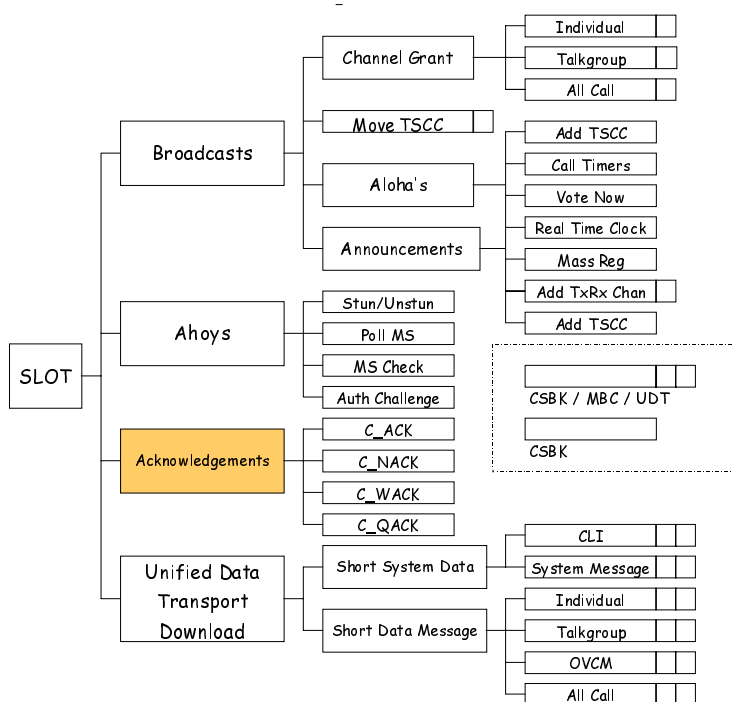


Table 7.20: AHOY PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 01 1100 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Service_Options_Mirror	7	
Service_Kind_Flag	1	Meaning dependent on Service_Kind
Reserved	2	00 ₂
Appended_Blocks	2	For a demand to the MS to send a multi-block CSBK, the number of appended data blocks
Service_Kind	4	Service for which this C_AHOY is supporting
Target address	24	Address of Called MS
Source Address or Gateway	24	Address of calling party MS or gateway, or Authentication challenge value

7.1.1.1.7 Acknowledgement C_ACKD) TSCC Response CSBK PDU

Octet 0 and 1 of the Acknowledge Response (C_ACKD) CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Acknowledge Response specific information. The generic Acknowledge Response PDU is shown in table 7.21.



NOTE: Acknowledgement Responses are transmitted by both TS and MS.

Table 7.21: TS Acknowledgement Response PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1_2
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to $10\ 0000_2$
Feature set ID (FID)	8	Shall be set to $0000\ 0000_2$
Response_Info	7	Supplementary response information
Reason Code	8	
Source Type	1	0_2 - the acknowledgement is sourced by the TS
Target address	24	Address of Called MS
Additional Information (Source Address)	24	Address of calling party MS or gateway

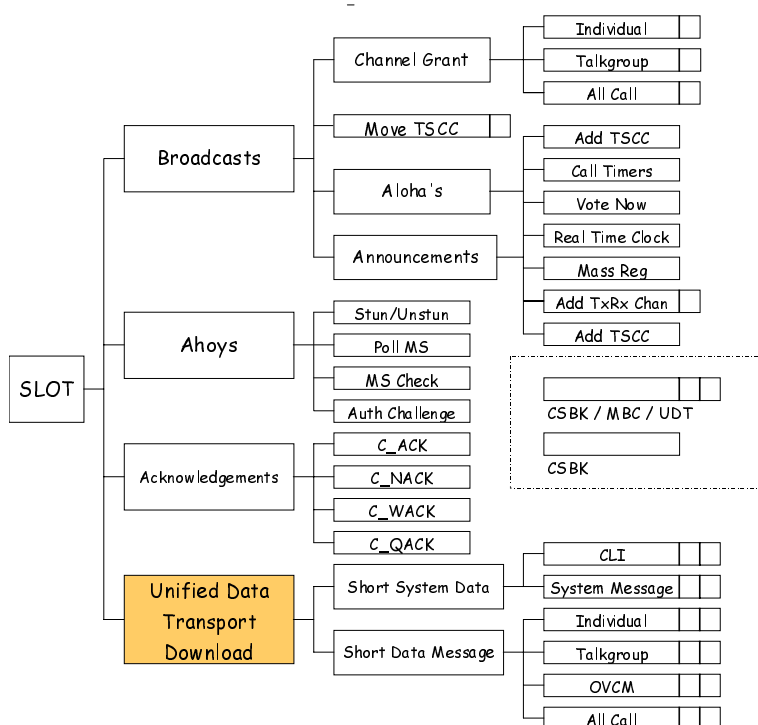
Acknowledge Response PDUs are arranged into classes:

- C_ACKD - Positive Acknowledgement.
- C_NACKD - Negative Acknowledgement.
- C_QACKD - Queued.
- C_WACKD - Intermediate Acknowledgement.

7.1.1.1.8 Unified Data Transport Download Header (C_UDTHD) UDT PDU

This PDU is a multi-block UDT conforming to the format specified in table 7.22. The number of UDT Appended data blocks is indicated by the Appended Blocks (UAB) information element.

The UDT Appended Data Format is prescribed in annex B.



NOTE: UDT Headers are transmitted by both TS and MS.

Table 7.22: Unified Data Transport Download Header PDU content

Information element	Length	Remark
Feature elements		
Elements defined in TS 102 361-1 [5]		
G/I (IG)	1	0 ₂ = Destination is an individual MS address 1 ₂ = Destination is a Talkgroup address. Response not expected
A	1	0 ₂ = Response not expected if Destination is an individual MS address 1 ₂ = Response demanded if Destination is an individual MS address
Reserved	2	
Format	4	1110 ₂
SAP	4	Service Access Point - 0000 ₂ for UDT
UDT_Format	4	Format of the data following the UDT Header
Target_address or Gateway	24	
Source_address or Gateway	24	
Pad Nibble	5	
Reserved	1	0 ₂
Appended_Blocks(UAB)	2	Number of Blocks appended to this UDT Header 00 ₂ = 1 Appended Data UDT block 01 ₂ = 2 Appended Data UDT blocks 10 ₂ = 3 Appended Data UDT blocks 11 ₂ = 4 Appended Data UDT blocks
Supplementary_Flag(SF)	1	0 ₂ = This UDT Header is carrying the data for a user initiated service (Short Data, Data Polling) 1 ₂ = This UDT Header is carrying supplementary data, supporting another tier III service.
Protect Flag (PF)	1	Reserved for Future Use
Opcode (UDTO)	6	Shall be set to 01 1010 ₂
NOTE: Shaded rows are information elements that are defined in TS 101 361-1 [5].		

7.1.1.2 TSCC Inbound channel CSBKs/UDT's transmitted by MS

7.1.1.2.1 Random Access Request (C_RAND) PDU

Octet 0 and 1 of the Random Access CSBK (C_RAND_CSBK) PDU conform to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Random Access Request specific information specified in table 7.23. Random Access Requests are sent by MS.

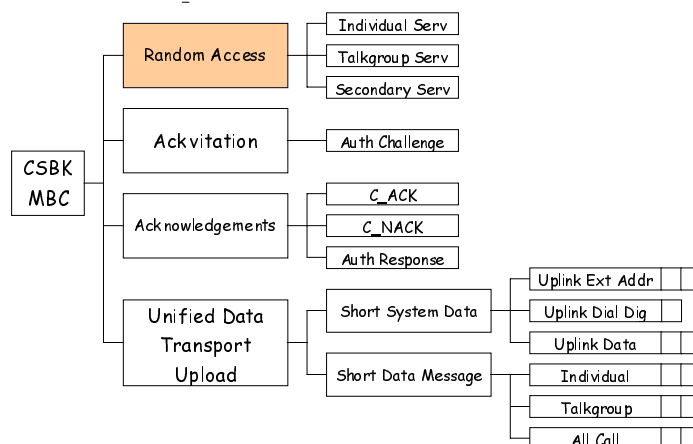


Table 7.23: Random Access Request PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 01 1111 ₂
Manufacturers Feature ID	8	Shall be set to 0000 0000 ₂
Service_Options	7	
Proxy Flag	1	0 ₂ - Number of Extended BCD digits for addressing through a gateway = 1 to 20 1 ₂ - Number of Extended BCD digits for addressing through a gateway = 21 to 44
Appended_Supplementary_Data	2	Number of appended CSBKs required to transport supplementary data
Appended_Short_Data	2	Number of appended CSBKs required to transport short data
Service_Kind	4	Service requested
Target_address or Gateway	24	
Source_address	24	Address of the requesting MS

7.1.1.2.2 C_Ackvitation (C_ACKVIT) CSBK PDU

Octet 0 and 1 of the C_ACKVIT CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the C_Ackvitation specific information. The generic C_Ackvitation PDU is shown in table 7.24. C_Ackvitation PDUs are transmitted by MS.

The C_Ackvitation PDU is transmitted by the MS as a single block CSBK.

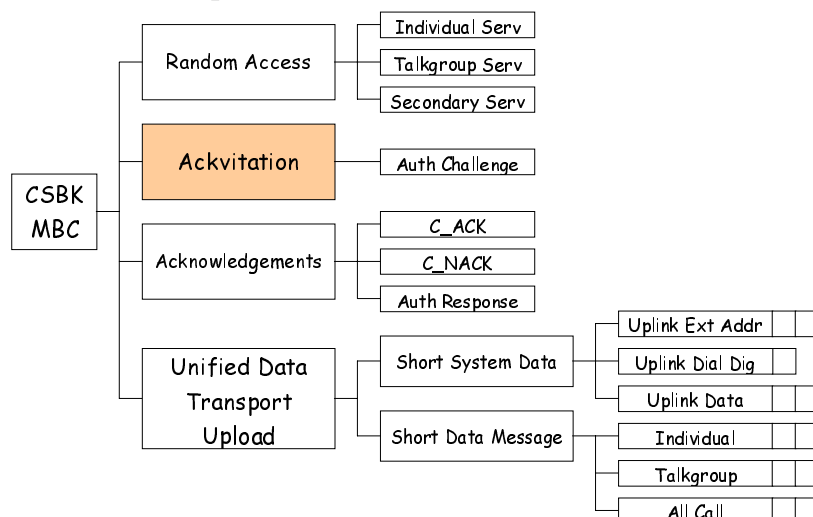
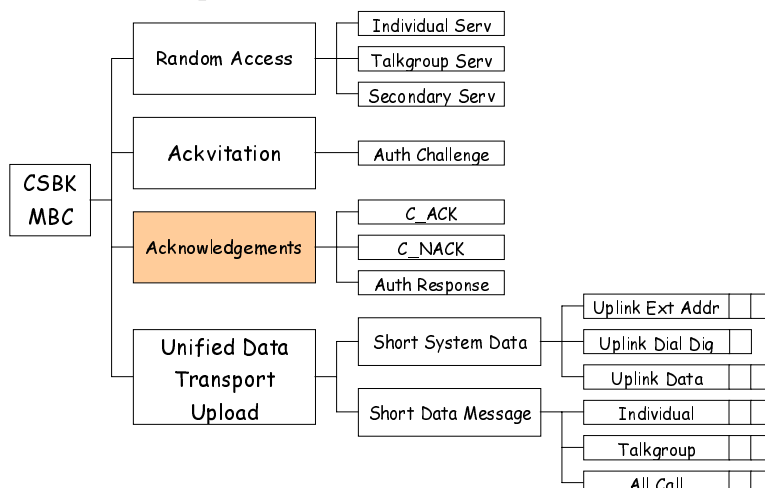


Table 7.24: C_Ackvitation PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ for a all but the last block of a multi-block CSBK
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 01 1110 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Service_Options_Mirror	7	
Service_Kind_Flag	1	Meaning dependent on Service_Kind
Reserved	2	00 ₂
Appended_Blocks (UAB)	2	For a demand to the TS to send a multi-block CSBK, the number of appended data blocks
Service_Kind	4	Service for which this C_AHOY is supporting
Target address	24	Address of Called MS
Source Address or Gateway or Authentication	24	Address of calling party MS or gateway, or Authentication challenge value

7.1.1.2.3 C_Acknowledge (C_ACKU) MS Response CSBK PDU

Octet 0 and 1 of the Acknowledge Response CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the Acknowledge Response specific information. The generic Acknowledge Response PDU is shown in table 7.25.



NOTE: Acknowledgement Responses are transmitted by both TS and MS.

Table 7.25: MS Acknowledge Response PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1_2
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to $10\ 0001_2$
Feature set ID (FID)	8	Shall be set to $0000\ 0000_2$
Response_Info	7	Supplementary response information
Reason Code	8	
Source Type	1	1_2 - acknowledgement sourced by the MS
Target address or Authentication	24	The Source Address from the TS PDU for which this acknowledgement is being transmitted or authentication challenge response if this acknowledgement is being transmitted as part of authentication challenge
Additional Information (Source Address)	24	MS individual address that is transmitting the acknowledgement

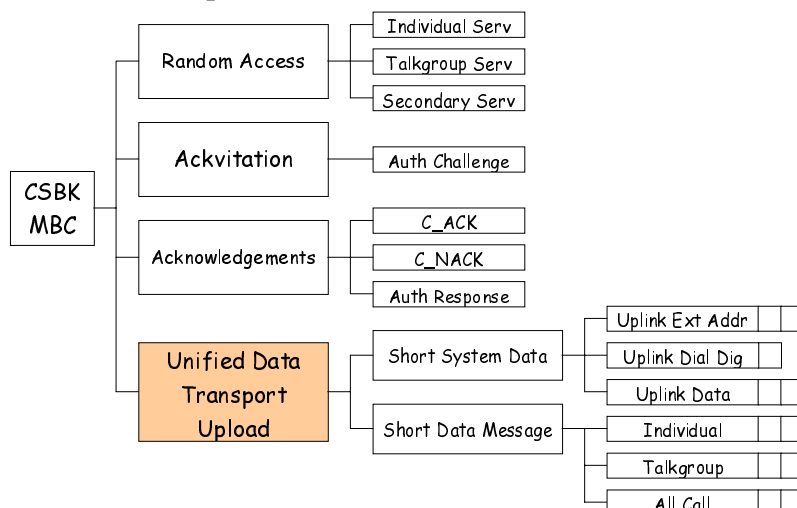
Acknowledge Response PDUs are arranged into classes:

C_ACKU - Positive Acknowledgement.

C_NACKU - Negative Acknowledgement.

7.1.1.2.4 Unified Data Transport Inbound channel Header (C_UDTHU) UDT PDU

C_UDT PDUs are sent by TS and MS. This PDU is a multi-block UDT conforming to the format specified in table 7.26. The number of UDT Appended data blocks is indicated by the Appended Blocks (UAB) information element.



NOTE: UDT Headers are transmitted by both TS and MS.

Table 7.26: Unified Data Transport Inbound channel Header PDU content

Information element	Length	Remark
Feature elements		
Elements defined in TS 102 361-1 [5]		
G/I (IG)	1	0 ₂ = Destination is an individual MS address 1 ₂ = Destination is a Talkgroup address. Response not expected
A	1	0 ₂ = Response not expected if Destination is an individual MS address 1 ₂ = Response demanded if Destination is an individual MS address
Reserved	2	00 ₂
Format	4	1110 ₂
SAP	4	Service Access Point - 0000 ₂ for UDT
UDT_Format	4	Format of the data following the UDT Header
Target_address or Gateway	24	
Source_address or Gateway	24	
Pad Nibble	5	
Reserved	1	
Appended_Blocks(UAB)	2	Number of Blocks appended to this UDT Header 00 ₂ = 1 Appended Data UDT block 01 ₂ = 2 Appended Data UDT blocks 10 ₂ = 3 Appended Data UDT blocks 11 ₂ = 4 Appended Data UDT blocks
Supplementary_Flag(SF)	1	0 ₂ = This UDT Header is carrying the data for a user initiated service (Short Data, Data Polling) 1 ₂ = This UDT Header is carrying supplementary data, supporting another tier III service.
Protect Flag (PF)	1	Reserved for Future Use
Opcode (UDTO)	6	Shall be set to 01 1011 ₂
NOTE: Shaded rows are information elements that are defined in TS 101 361-1 [5].		

7.1.1.3 Outbound channel CSBKs transmitted on a Payload Channel by a TS

7.1.1.3.1 Channel Grant (P_GRANT) CSBK/MBC PDU

Channel Grant PDUs transmitted on the payload channel conform to the same structure as channel grant PDUs transmitted on the TSCC. When transmitting such a PDU on the payload channel, the TS shall retain all PDUs to the value from the TSCC channel grant PDU except the logical channel number (and absolute frequency if the channel grant PDU has an appended CSBK block).

The Payload Channel Grant PDU is transmitted by the TSCC either as a single block CSBK or a Multi Block Control (MBC). For the Physical Channel Number Information Element:

- If the value = 0000 0000 0000₂ the Physical Channel number is invalid.
- If the value = 0000 0000 0001₂ to 1111 1111 1110₂, the Physical Channel number represent a logical channel number for the physical transmitter and receiver frequency. The Private Data Channel Grant PDU is transmitted by the TSCC as a single block CSBK.
- If the value = 1111 1111 1111₂, the Physical Channel number defines a multi-block CSBK where the absolute transmitter and receiver frequency is defined in a second block concatenated to this block (defined in clause 7.1.1.1.2).

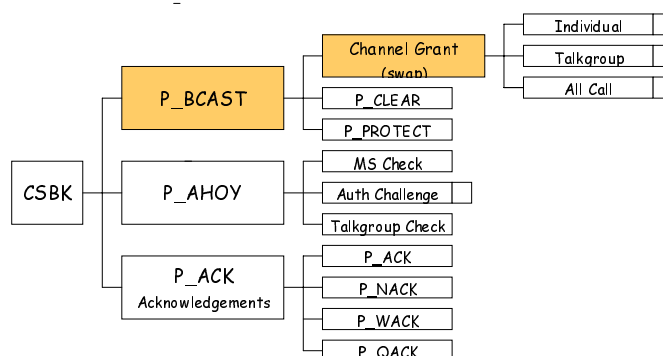


Table 7.27: Payload Channel Grant PDU Content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂ for a single block CSBK or 0 ₂ if this is a MBC header
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 11 0011 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Payload Channel for the Call or an indicator that the absolute Tx & Rx frequency is specified in an appended CSBK block
Logical Channel Number	1	0 ₂ - TDMA channel 1 1 ₂ - TDMA channel 2
Reserved	3	000 ₂
Destination_address	24	Called party Individual MS Address, Gateway or Talkgroup
Source_address	24	Calling Party or Gateway

7.1.1.3.2 Clear (P_CLEAR) CSBK PDU

Octet 0 and 1 of the P_CLEAR CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the P_Clear specific information shown in table 7.28. P_Clear is transmitted by the TS on a payload channel only and does not solicit a response. . The P_Clear PDU is transmitted by the TS as a single block CSBK.

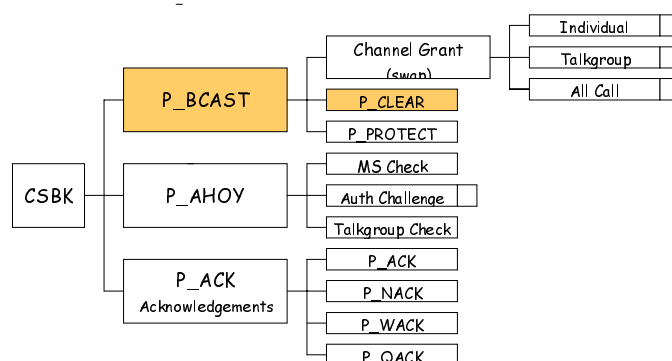


Table 7.28: Clear PDU Content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 10 1110 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Logical Physical Channel Number	12	Logical Physical Channel to which the MS shall move
Reserved	4	0000 ₂
Target Address	24	Called party or MSI identifier
Source Address	24	TSI

7.1.1.3.3 Protect (P_PROTECT) CSBK PDU

Octet 0 and 1 of the P_Protect CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the P_Protect specific information shown in table 7.29. P_Protect is transmitted by the TS on a payload channel only and does not solicit a response. The P_Protect PDU is transmitted by the TS as a single block CSBK.

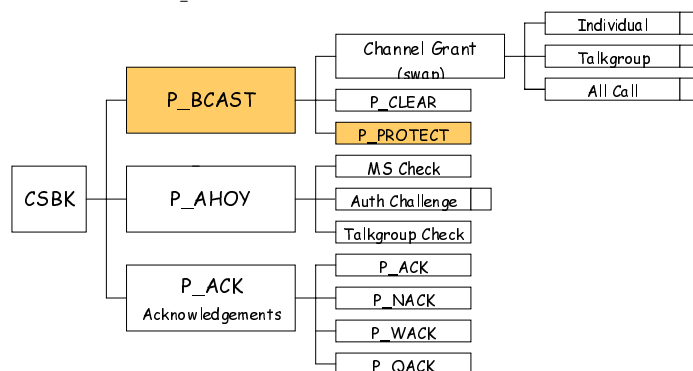
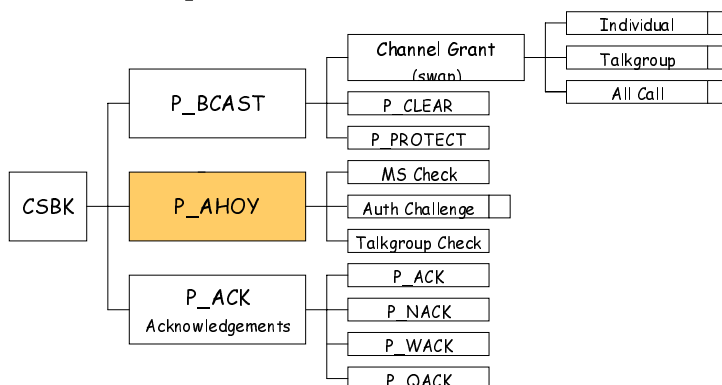


Table 7.29: P_Protect PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 10 1111 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Reserved	12	0000 0000 0000 ₂
Protect_Kind	3	
IG	1	
Target Address	24	MS Address or talkgroup
Source Address	24	TSI

7.1.1.3.4 Ahoy (P_AHOY) CSBK PDU

Octet 0 and 1 of the AHOY CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the P_AHOY specific information shown in table 7.20. The P_AHOY is transmitted by the TS on a payload channel and if addressed to a talkgroup does not solicit a response.



7.1.1.3.4.1 MS Presence Check

The TS may send a MS Presence Check P_AHOY on the payload channel to check if an individually addressed MS is present on the payload channel.

7.1.1.3.4.2 MS Authentication Check

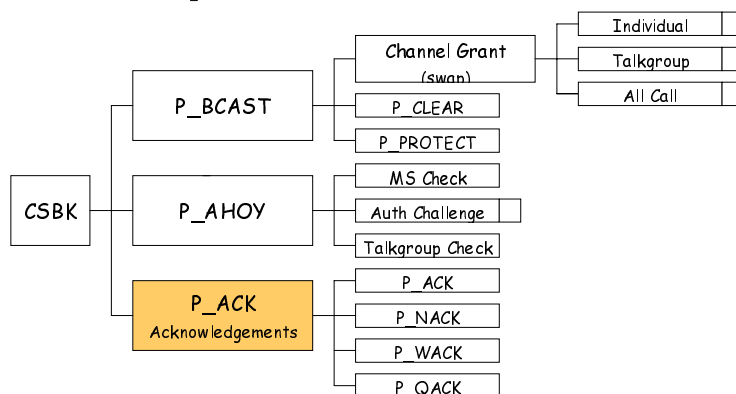
The TS may send a MS Authentication Check P_AHOY on the payload channel to challenge an MS. The MS Authentication Check uses a multi-block CSBK (two blocks).

7.1.1.3.4.3 Talkgroup Presence Check

The TS may send a Talkgroup Presence Check P_AHOY on the payload channel to check if at least one talkgroup is present on the payload channel.

7.1.1.3.5 P_Acknowledgement response

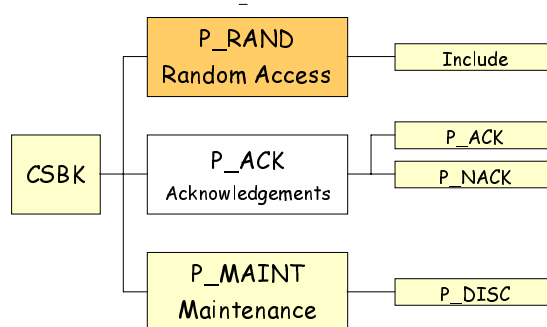
Acknowledgement PDUs transmitted on the payload channel conform to the same structure as acknowledgement PDUs transmitted on the TSCC.



7.1.1.4 Inbound channel CSBKs transmitted on a Payload Channel by MS(s)

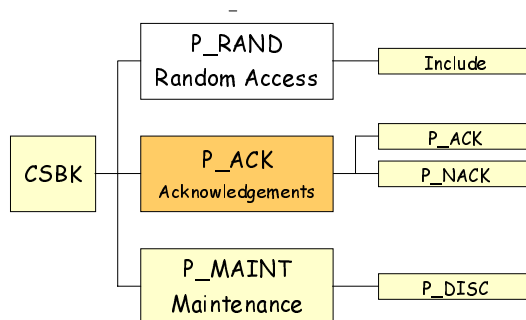
7.1.1.4.1 Random Access Request PDU

Random Access PDUs transmitted on the payload channel conform to the same structure as Random Access PDUs transmitted on the TSCC. However the only random access Service_Kind permitted on the payload channel shall be to request an include service.



7.1.1.4.2 P_ACK Acknowledgements

Acknowledgement PDUs transmitted on the payload channel conform to the same structure as acknowledgement PDUs transmitted on the TSCC.



7.1.1.4.3 P_MAINT Maintenance PDUs

Octet 0 and 1 of the P_MAINT CSBK PDU conforms to the LC format structure as defined in figure 7.1 in TS 102 361-1 [5] of the standard with the CSBKO replacing the FLCO. Octets 2 to 9 contain the P_MAINT specific information shown in table 7.30. P_MAINT is transmitted by MS on a payload channel only. The P_MAINT PDU is transmitted by MS as a single block CSBK.

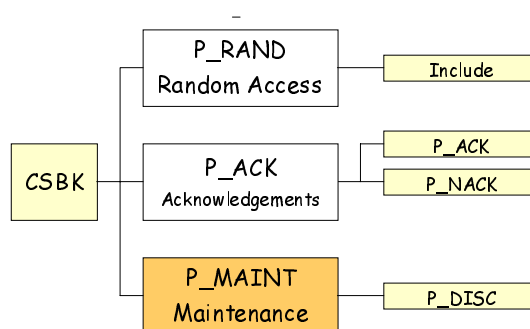


Table 7.30: P_MAINT PDU content

Information element	Length	Remark
Message dependent elements		
Last block (LB)	1	This bit shall be set to 1 ₂
Protect Flag (PF)	1	
Feature elements		
CSBK Opcode (CSBKO)	6	Shall be set to 10 1010 ₂
Feature set ID (FID)	8	Shall be set to 0000 0000 ₂
Reserved	12	
Maint Kind	3	
Reserved	1	
Target Address	24	TSI
Source Address	24	MS Address

7.1.2 Short Link Control PDUs

7.1.2.1 System Parameters

Bits 0 to 3 of Octet 0 of the System Parameters (SYS_Parms) Short LC PDU conform to the Short LC format structure as defined in figure 7.2 of clause 7.1 in TS 102 361-1 [5]. Octets 1 to 3 contain the System Parameters specific information. The SYS_Parms PDU is shown in table 7.31.

Table 7.31: SYS_Parms PDU Content

Information element	Length	Value	Remark
Elements			
Short LC Opcode (SLCO)	4	0010 ₂	
MODEL	2	00 ₂	Tiny Network Model
		01 ₂	Small Network Model
		10 ₂	Large Network Model
		11 ₂	Huge Network Model
NET SITE	12		Network and Site Definition
Reg		1	
		1 ₂	This TSCC requires the MS to register before becoming active
Common_Slot_Counter	9		Common Slot Counter
NOTE: Compressed algorithm is the same as the short LC CRC calculation algorithm as defined in clause B.3.8 of TS 102 361-1 [5].			

7.2 Layer 3 information element coding

The following clauses contain descriptions of the information elements contained within layer 3 PDUs, and provide a description of what the elements represent in relation to their bit representation. The structure of the tables is as follows:

- the information element column gives the name of the element;
- the element length column defines the length of the element in bits;
- the value column denotes fixed values or a range of values;
- the remarks column defines the meaning of the information element against each of its bit represented values.

7.2.1 Mask

The Mask information element has a length of 5 bits and is shown in table 7.32.

Table 7.32: Mask

Information element	Length	Value	Remark
Mask	5	0 to 24	Value in the range 0 to 24 (decimal)

7.2.2 Service Function

The Service Type information element has a length of 2 bits and is shown in table 7.33.

Table 7.33: Service Function

Information element	Length	Value	Remark
Service Function	2	00 ₂	Random Access invited for all Services
		01 ₂	Random Access Invited for Services that require a payload channel Random Access Invited for registration requests
		10 ₂	Random Access Invited for Services that do not require a payload channel Random Access Invited for registration requests
		11 ₂	Random Access invited for random access registration requests only

7.2.3 NRand_Wait

The NRand Wait information element has a length of 4 bits and is shown in table 7.34. The TSCC shall specify, using NRand_Wait, the delay (in TDMA-frames) a MS must wait before deciding to retransmit and choose another slot from a new random-access-frame.

Table 7.34: NRand_Wait

Information element	Length	Value	Remark
NRand_Wait	4	0 to 15	TSCC response to a Random Access Request 0 = response in the next TDMA-frame 1 - MS shall wait for 1 TDMA frame 2 - MS shall wait for 2 TDMA frames 3 - MS shall wait for 3 TDMA frames 4 - MS shall wait for 4 TDMA frames 5 - MS shall wait for 5 TDMA frames 6 - MS shall wait for 6 TDMA frames 7 - MS shall wait for 7 TDMA frames 8 - MS shall wait for 8 TDMA frame 9 - MS shall wait for 9 TDMA frames 10 - MS shall wait for 10 TDMA frames 11 - MS shall wait for 11 TDMA frames 12 - MS shall wait for 12 TDMA frames 13 - MS shall wait for 13 TDMA frames 14 - MS shall wait for 15 TDMA frames 15 - MS shall wait for 24 TDMA frames

7.2.4 Reg

The Reg information element has a length of 1 bits and is shown in table 7.35.

Table 7.35: Reg

Information element	Length	Value	Remark
Reg	1	0 ₂	MSs are not required to register
		1 ₂	MSs are required to register

7.2.5 Backoff

The Backoff information element has a length of 4 bits and is shown in tables table 7.36.

Table 7.36: Backoff Number

Information element	Length	Value	Remark
Backoff	4	0	0 - Reserved
		1	Backoff TDMA Frame length = 1
		2	Backoff TDMA Frame length = 2
		3	Backoff TDMA Frame length = 3
		4	Backoff TDMA Frame length = 4
		5	Backoff TDMA Frame length = 5
		6	Backoff TDMA Frame length = 8
		7	Backoff TDMA Frame length = 11
		8	Backoff TDMA Frame length = 15
		9	Backoff TDMA Frame length = 20
		10	Backoff TDMA Frame length = 26
		11	Backoff TDMA Frame length = 33
		12	Backoff TDMA Frame length = 41
		13	Backoff TDMA Frame length = 50
		14	Backoff TDMA Frame length = 70
15	Backoff TDMA Frame length = 100		

7.2.6 System Identity Code

The System Identity Code information element has a length of 16 bits and is shown in table 7.37.

Table 7.37: System Identity Code

Information element	Length	Value	Remark
System Identity Code C_SYSCode	16	value	System identity Code transmitted on the TSCC

7.2.7 Response_Info

The Response_Info information element contains supplementary information in acknowledgement PDUs. It has a length of 7 bits and is shown in table 7.38.

Table 7.38: Response_Info

Information element	Length	Alias/value	Remark
Acknowledgement Reason Code = Message_Accepted (0100 0000 ₂)			
Response_Info	7	PowerSAve_Offset	Acknowledgement to a random access registration request that invokes power save (see clause 6.4.7)
All other acknowledgement Reason Codes			
Response_Info	7	000 0000 ₂	Reserved

7.2.8 Reason

The Reason information element has a length of 8 bits and is shown in tables 7.39, 7.40, 7.41 and 7.42. Separate tables are shown for the classifications C_ACK, C_NACK, C_QACK, C_WACK.

Table 7.39: Answer Response C_ACK

Information element	Length	Value	Alias	Remark	
		Acknowledgement Transmitted by a TS Message Accepted by the MS			
Reason	8	0100 0000 ₂	Message_Accepted	Message accepted by TS - Proceed	
		0100 0001 ₂	Store_Forward	Call is placed in store and forward buffer for onward transmission when the called MS registers.	
		0100 0010 ₂	Reg_Accepted	Request from MS to register has been accepted	
		0100 0011 ₂	Call-Back	Called Party will call back	
		Acknowledgement Transmitted by a MS Message Accepted by the TS			
		0100 0100 ₂	MS_Accepted	Message accepted by MS	
		0100 0101 ₂	CallBack	Called MS is indicating to the TS that it will call back later	

Table 7.40: Answer Response C_NACK

Information element	Length	Value	Mnemonic	Remark		
			Message/Service rejected by network (TS)			
Reason	8	0010 0001 ₂	Not_Supported	Network does not support this service		
		0010 0010 ₂	Perm_User_Refused	Request refused because service has not been authorized for this user (permanent) (Meaning of permanent is manufacturer specific)		
		0010 0011 ₂	Temp_User_Refused	Request refused because service is not currently authorized for this user (temporary) (Meaning of temporary is manufacturer specific)		
		0010 0100 ₂	Transient_Sys_Refused	Request refused because the service is not available to this network at this time		
		0010 0101 ₂	NoregMSaway_Refused	Request refused because called party is not in radio contact (and is not registered with the network)		
		0010 0110 ₂	MSaway_Refused	Request refused because called party is not in radio contact (but is registered with the network)		
		0010 0111 ₂	Div_Cause_Fail	Call cannot be processed because the MS has diverted its calls		
		0010 1000 ₂	SYSbusy_Refused	Request refused because the network is experiencing congestion (Network Overload)		
		0010 1001 ₂	SYS_NotReady	Request refused because the network is not ready (try later)		
		0010 1010 ₂	Call_Cancel_Refused	Request to <i>cancel</i> a call has been refused i.e. the call may still mature		
		0010 1011 ₂	Reg_Refused	Request from a MS to register has been refused		
		0010 1100 ₂	Reg_Denied	Request from a MS to register has been denied		
		Message/Service rejected by MS				
		0010 1100 ₂	MSNot_Supported	MS does not support this service or feature		
		0010 1101 ₂	LineNot_Supported	Request refused because service is not supported by the called party (Line)		
		0010 1110 ₂	StackFull_Refused	Request refused because the called party's internal call stack is full and is not employing a FIFO		
		0010 1111 ₂	EquipBusy_Refused	Request refused because called party ancillary equipment is busy		
		0011 0000 ₂	Recipient_Refused	Request refused by called party user (like in FOACSU)		
0011 0001 ₂	Custom_Refused	Request refused due to custom-defined reason				

Table 7.41: Answer Response C_QACK

Information element	Length	Value	Alias	Remark
			Acknowledgement Transmitted by a TS	
Reason	8	1000 0000 ₂	Queued-for-channel	Message accepted by TS - more signalling to follow
		1000 0001 ₂	Queued-for-busy	

Table 7.42: Answer Response C_WACK

Information element	Length	Value	Alias	Remark
				Acknowledgement Transmitted by a TS
Reason	8	1100 0000 ₂	Wait	Message accepted by TS - more signalling to follow

7.2.9 Source Type

The Source Type information element has a length of 1 bit and indicates the entity that transmitted the PDU. The Source Type is shown in table 7.43.

Table 7.43: Source Type

Information element	Length	Value	Alias	Remark
Source Type	1	0 ₂		The PDU is transmitted by the TS
		1 ₂		The PDU is transmitted by the MS

7.2.10 Digits

The Digits information element represents dialled digits coded as table 7.44.

Table 7.44: Digits

Information element	Length	Value	Alias	Remark
Digits	4	0000 ₂	Digit '0'	
		0001 ₂	Digit '1'	
		0010 ₂	Digit '2'	
		0011 ₂	Digit '3'	
		0100 ₂	Digit '4'	
		0101 ₂	Digit '5'	
		0110 ₂	Digit '6'	
		0111 ₂	Digit '7'	
		1000 ₂	Digit '8'	
		1001 ₂	Digit '9'	
		1010 ₂	Digit '*'	* character
		1011 ₂	Digit '#'	# character
		1100 ₂	Reserved	
		1101 ₂	Reserved	
		1110 ₂	Reserved	
1111 ₂	Digit 'NULL'			

7.2.11 Active_Connection

This information element specifies if the TS has an active network connection with the rest of the network, i.e. communication with other radio sites is possible.

Table 7.45: Active_Connection

Information element	Length	Value	Alias	Remark
Active Connection	1	0 ₂		0 ₂ - The TS does not have a connection with the network
		1 ₂		1 ₂ - The TS has a connection with the network

7.2.12 Packet Mode

The Packet Mode information element has a length of 1 bit and is shown in table 7.46.

Table 7.46: Packet Mode

Information element	Length	Value	Alias	Remark
Packet Mode	1	0 ₂		0 ₂ - Payload Channel uses 2:1 mode
		1 ₂		1 ₂ - Payload Channel uses 1:1 mode

7.2.13 Service_Kind

The Service_Kind information element has a length of 4 bits and is shown in table 7.47.

Table 7.47: Service_Kind information element

Information element	Length	Value	Remark
Service_Kind	4	0000 ₂	Individual Voice Call Service (Include Voice Individual Call Service if sent on a payload channel)
		0001 ₂	Talkgroup Voice Call Service (Include Voice Talkgroup Call Service if sent on a payload channel)
		0010 ₂	Individual Packet Data Call Service
		0011 ₂	Packet Data Call Service to a talkgroup
		0100 ₂	Individual Short Data Call Service
		0101 ₂	Talkgroup Short Data Call Service
		0110 ₂	Short Data Polling Service
		0111 ₂	Status Transport Service
		1000 ₂	Call Diversion Service
		1001 ₂ to 1100 ₂	Reserved
		1101 ₂	Supplementary Service
		1110 ₂	Registration or Authentication Service (and deregistration)
		1111 ₂	Cancel Call Service

7.2.13.1 Service_Kind_Flag

The Service_Kind_Flag information element has a length of 1 bit and is shown in table 7.48. The meaning of Service_Kind_Flag supports the Service_Kind information element. The meaning of the Service_Kind_Flag depends on the value of Service_Kind.

Table 7.48: Service_Kind_Flag information element

Information element	Length	Value	Remark
Service_Kind_Flag	1	0 ₂	

7.2.14 Service_Options

The number of Service_Options that are applicable is dependent on the DMR service requested. The Service_Options information element has a length of 7 bits and is shown for each applicable service in figures 7.2.14.1 to 7.2.14.5.

7.2.14.1 Service_Options for a Voice, Packet Service Request

The Service_Options information for the Voice, Packet Data and Short Data Service request is shown in table 7.49.

- The Emergency Service information element is applicable to voice and packet data calls.

- The Broadcast Service information element is applicable to voice talkgroups.
- The OVCM information element is applicable to voice calls.
- The Priority Service information element is applicable to any call that may be queued on the TSCC.
- The Supplementary Data information element is applicable to all tier III services.

Table 7.49: Service_Options for Voice/Packet Service Request

Information element	Length	Value	Remark
Emergency	1	0 ₂	Non-emergency service
		1 ₂	Emergency service
Privacy	1	0 ₂	See note 1
Supplementary Data	1	0 ₂	No Supplementary Data Transfer Service required for this call
		1 ₂	Supplementary Data Transfer Service requested for this call
Broadcast	1	0 ₂	Non-broadcast service
		1 ₂	Broadcast service (see note 3)
Open Voice Call Mode (OVCM)	1	0 ₂	Non-OVCM call
		1 ₂	OVCM call
Priority level	2	00 ₂	No priority
		01 ₂	Priority 1 (see note 2)
		10 ₂	Priority 2 (see note 2)
		11 ₂	Priority 3 (see note 2)
NOTE 1: Privacy is not defined in the present document.			
NOTE 2: Priority 3 is the highest priority.			
NOTE 3: Broadcast is applicable to talkgroups.			

7.2.14.2 Service_Options for a Call Diversion Service Request

The Service_Options information for the call diversion Service request is shown in table 7.50. The Divert Kind information element determines to which call service the call diversion shall be applicable.

Table 7.50: Service_Options for Call Diversion Service Request

Information element	Length	Value	Remark
Emergency	1	0 ₂	Not applicable
Privacy	1	0 ₂	See note
Divert Set/Clear	1	0 ₂	Clear Call Diversion
		1 ₂	Set Call Diversion
Divert Kind	1	Active 1 ₂	Divert applicable to Voice Calls
	1		Divert applicable to Packet Data Calls
	1	Inactive 0 ₂	Divert applicable to Short Data Calls
	1		Divert applicable to Status Calls
NOTE: Privacy is not defined in the present document.			

7.2.14.3 Service_Options for a Registration Service Request

The Service_Options information for the registration service request is shown in table 7.51. There are no applicable service options for a registration service request.

Table 7.51: Service_Options for the Registration Service

Information element	Length	Value	Remark
Reserved	1	0 ₂	
Privacy	1	0 ₂	See note
IP_Inform	1	0 ₂	No supplementary data is required for the registration
		1 ₂	If Reg_Dereg=1 ₂ MS wishes to add an IP address to the TSCC If Reg_Dereg=0 ₂ MS wishes to subtract an IP address from the TSCC
PowerSave_RQ	3	000 ₂	Power Save not requested
		001 ₂ to 111 ₂	Power Save requested
Reg_Dereg	1	0 ₂	The MS is attempting to de-register
		1 ₂	The MS is attempting to register

NOTE: Privacy is not defined in the present document.

7.2.14.4 Service_Options for an Include Call Service Request

The Service_Options information for the include service request is shown in table 7.52. Include call service requests shall be restricted to the payload channel. There are no applicable service options for a registration service request.

Table 7.52: Service_Options for the Registration Service

Information element	Length	Value	Remark
Reserved	1	0 ₂	
Privacy	1	0 ₂	See note
Reserved	5	0 0000 ₂	

NOTE: Privacy is not defined in the present document.

7.2.14.5 Service_Options for a Status Transfer Request

The Service_Options information for the include service request is shown in table 7.53. Include call service requests shall be restricted to the payload channel. There are no applicable service options for a registration service request.

Table 7.53: Service_Options for the Status Transport Service

Information element	Length	Value	Remark
Status	7	Value	Status value to be transported

7.2.15 Service_Options_Mirror

The Service_Options_Mirror information element is transmitted in C_AHOY PDUs.

If the C_AHOY PDU has been transmitted as an immediate (or delayed) acknowledgement to a C_RAND Service request, the Service_Options_Mirror is set to the Service_Options information element from the C_RAND PDU.

7.2.15.1 Service_Options_Mirror for MS Authentication

If the C_AHOY PDU has been transmitted as the result of a polling PDU from the TSCC for Authentication, then the Service_Option_Mirror shall be set to the values specified in table 7.54.

Table 7.54: Service_Options_Mirror for MS Authentication Poll

Information element	Length	Value	Remark
Service_Options_Mirror	Reserved	1	0 ₂
	Privacy	1	0 ₂ See note
	Reserved	5	0 0000 ₂
NOTE: Privacy is not defined in the present document.			

7.2.15.2 Service_Options_Mirror for MS Stun/Revive

If the C_AHOY PDU has been transmitted as the result of a polling PDU from the TSCC for MS stun/revive then the Service_Option_Mirror shall be set to the values specified in table 7.55.

Table 7.55: Service_Options_Mirror for MS Stun/Revive Poll

Information element	Length	Value	Remark
Reserved	1	0 ₂	
Privacy	1	0 ₂	See note
Stun_Revive	1	0 ₂	Action by the MS is Revive
		1 ₂	Action by the MS is Stun
Reserved	4	0000 ₂	
NOTE: Privacy is not defined in the present document.			

7.2.16 Proxy Flag

For calls to destinations connected through a TS gateway, the proxy flag indicates the number of Appended Data UDT's needed to upload the address of the final destination. For a call to a PABX or the PSTN, one appended data UDT will carry up to 20 dialled digits and two appended data UDT's will carry up to 44 dialled digits.

Table 7.56: Proxy Flag information element

Information element	Length	Value	Remark
Proxy Flag	1	0 ₂	Number of appended data MBC's needed to upload the final destination address = 1 Number of Extended BCD digits for addressing through a PSTN/PABX gateway = 1 to 20. For IP gateway extended address is IPV4
		1 ₂	Number of appended data UDT's needed to upload the final destination address = 2 Number of Extended BCD digits for addressing through a PSTN/PABX gateway = 21 to 44. For IP gateway extended address is IPV6Number

7.2.17 POL_FMT

Specifies the format of polled data from the Short Data Polling procedures specified in clause 6.6.5.3.

Table 7.57: POL_FMT information element

Information element	Length	Value	Remark
POL_FMT	4	0000 ₂	Binary
		0001 ₂	MS Addresses
		0010 ₂	4 bit BCD
		0011 ₂	ISO 7 bit character set (ISO/IEC 646 [12])
		0100 ₂	ISO 8 bit character set (ISO/IEC 8859 [13])
		0101 ₂	NMEA location information
		0110 ₂	IP address
		0111 ₂	16 bit Unicode characters
		1000 ₂	Reserved
		1001 ₂	Reserved
		1010 ₂	Reserved
		1011 ₂	Reserved
		1100 ₂	Reserved
		1101 ₂	Reserved
		1110 ₂	Reserved

7.2.18 Appended_Block

If the Supplementary Data Service has been invoked as an option with other voice or data services, the Appended Supplementary Data information element is used to pass the number of Appended Data UDT's needed to upload the Supplementary Data.

If the Short Data Service has been invoked, the Appended Short Data information element is used by an MS to pass the number of Appended Data UDT's needed to upload the Short Data.

Table 7.58: Appended Supplementary Data information element

Information element	Length	Alias	Value	Remark
Appended_Block	2	UAB	00 ₂	Number of appended data UDT's needed to upload the supplementary data = 1
			01 ₂	Number of appended data UDT's needed to upload the supplementary data = 2
			10 ₂	Number of appended data UDT's needed to upload the supplementary data = 3
			11 ₂	Number of appended data UDT's needed to upload the supplementary data = 4

7.2.19 Opcode

The Opcode information element specifies the function of a UDT Header.

Table 7.59: Opcode

Information element	Length	Value	Remark
Opcode	6	00 0000 ₂	MBC is a UDT header
		00 0001 ₂ to 11 1111 ₂	Reserved

7.2.20 Announcement type

The Announcement type Format Code information element has a length of 5 bits and is shown in figure 7.2.

Table 7.60: Announcement type

Information element	Length	Value	Alias	Remark
Announcement_type	5	0 0000 ₂	Ann-WD_TSCC	Announce/Withdraw TSCC
		0 0001 ₂	CallTimer_Parms	Specify Call Timer Parameters
		0 0010 ₂	Vote_Now	Vote Now Advice
		0 0011 ₂	Local_Time	Broadcast Local Time
		0 0100 ₂	MassReg	Mass_Registration
		0 0101 ₂	Chan_Freq	Announce a logical channel / frequency relationship
		0 0110 ₂	Adjacent_Site	Adjacent Site information
		0 0111 ₂ to 1 1101 ₂		Reserved
		1 1110 ₂		Manufacturer Specific
		1 1111 ₂		Manufacturer Specific

7.2.20.1 Announce/Withdraw TSCC (Ann-WD_TSCC)

Table 7.61: Announce/Withdraw TSCC

Information element	Length	Value	Alias	Remark
Broadcast Parms 1	4	0 ₂		Reserved
	4	Value		Colour code for CH_1 (default=0000 ₂)
	4	Value		Colour Code for CH_2 (default=0000 ₂)
	1	0 ₂	AW_FLAG1	Add BCAST_CH1 to hunt list
		1 ₂		Withdraw BCAST_CH1 from hunt list
	1	0 ₂	AW_FLAG2	Add BCAST_CH2 to hunt list
1 ₂			Withdraw BCAST_CH2 from hunt list	
Broadcast Parms 2	12	0 or 1 to 4095	BCAST_CH1	CHNULL or Logical Physical Channel Number
	12	0 or 1 to 4095	BCAST_CH2	CHNULL or Logical Physical Channel Number

7.2.20.2 Specify Call Timer Parameters (CallTimer_Parms)

Table 7.62: Specify Call Timer Parameters

Information element	Length	Value	Alias	Remark
Broadcast Parms 1	9	0 ₂	T_EMERG_TIMER	MS uses its Internal Emergency Timer
		1 to 510		Call Timer for Emergency Calls
		511		Emergency Call Timer is Infinity
	5	0	T_PACKET_TIMER	MS uses its Internal Packet Timer
		1 to 30		Call Timer for Packet Data
		31		Packet Call Timer is Infinity
Broadcast Parms 2	12	0	T_MS-MS_TIMER	MS uses its Internal Timer for MS-MS calls
		1 to 4 094		Call Timer for MS-MS Calls
		4 095		MS-MS Call Timer is Infinity
	12	0	T_MS-LINE_TIMER	MS uses its Internal Timer for line connected calls
		1 to 4 094		Call Timer for Line Connected calls
		4 095		Line Connected Call Timer is Infinity

7.2.20.3 Vote Now Advice (Vote_Now)

Table 7.63: Vote Now Advice

Information element	Length	Value	Alias	Remark
Broadcast Parms 1	14			Most Significant 14 bits of the System Identity Code of the TSCC being assessed
Broadcast Parms 2	12	0000 0000 0000 ₂		Reserved
	12	1 to 4095	CH_VOTE	Physical Channel Number to be assessed

7.2.20.4 Broadcast Local Time (Local_Time)

Table 7.64: Broadcast Local Time

Information element	Length	Value	Alias	Remark
Broadcast Parms 1	5		B_DAY	Day of the Month 1 to 31 (or 0 if date is not being broadcast)
	4		B_MONTH	Month 1 to 12 (or 0 if month is not being broadcast)
	5		UTC_OFFSET	Offset between local time and UTC time (as a two's complement number in the range -12 to +12 (or 11111 ₂ if offset is not being broadcast))
Broadcast Parms 2	5		B_HOURS	Hours 0 to 23
	6		B_MINS	Minutes 0 to 59
	6		B_SECS	Seconds 0 to 59
	3		DAYOF_WEEK	The day of the week (or 0 if the day of week is not being broadcast)
	4	0000 ₂		Reserved

The information element meaning of B_MONTH and DAYOF_WEEK values are specified in tables 7.65 and 7.66.

7.2.20.4.1 Broadcast Local Time - Month (B_MONTH)

Table 7.65: B_MONTH information element

Information element	Length	Value	Remark
B_MONTH	4	0000 ₂	<Month not broadcast>
		0001 ₂	January
		0010 ₂	February
		0011 ₂	March
		0100 ₂	April
		0101 ₂	May
		0110 ₂	June
		0111 ₂	July
		1000 ₂	August
		1001 ₂	September
		1010 ₂	October
		1011 ₂	November
		1100 ₂	December

7.2.20.4.2 Broadcast Local Time - Day of Week (DAYSOF_WEEK)

Table 7.66: DAYSOF_WEEK information element

Information element	Length	Value	Remark
DAYSOF_WEEK	3	000 ₂	<Days of Week not broadcast>
		001 ₂	Sunday
		010 ₂	Monday
		011 ₂	Tuesday
		100 ₂	Wednesday
		101 ₂	Thursday
		110 ₂	Friday
		111 ₂	Saturday

7.2.20.5 Broadcast Mass Registration (MassReg)

Table 7.67: Mass Registration

Information element	Length	Value	Alias	Remark
Broadcast Parms 1	5	0 0000 ₂		Reserved
	4			Reg_Window
	5			Aloha Mask
Broadcast Parms 2	24			NULL or MS Individual Address

7.2.20.5.1 Reg_Window

Table 7.68: Reg_Window

Information element	Length	Value	Treg_Window	Remark
Reg_Window	4	0		<Cancel Mass Registration>
		1	.5	Values in Seconds
		2	1	
		3	2	
		4	5	
		5	10	
		6	20	
		7	30	
		8	100	
		9	300	
		10	1 000	
		11	3 000	
		12	10 000	
		13	30 000	
		14	100 000	
		15	200 000	

7.2.20.6 Broadcast logical/absolute frequency relationship

Table 7.69: Broadcast logical/absolute frequency relationship information element

Information element	Length	Value	Alias	Remark
Broadcast Parns 1	5	0 0000 ₂		Reserved
	4			Reg_Window
	5			Aloha Mask
Broadcast Parns 2	24			NULL or MS Individual Address

7.2.20.7 Broadcast Adjacent Site information

Table 7.70: Broadcast Adjacent Site information

Information element	Length	Value	Alias	Remark
Broadcast Parns 1	14			Most significant 14 bits of the C_SYScode
Broadcast Parns 2	1			Active_Connection
	23			Reserved

7.2.20.8 CdefParns

Table 7.71: CdefParns information element Definition

CdefParns	Information element	Length	Value	Alias	Remark
	CdefParns				
Cdeftype=0000 ₂	Logical Physical Channel Number	12		CHAN	
	Absolute transmitter frequency - integer MHz	10		TXMHz	Absolute transmitter frequency - integer MHz
	Absolute transmitter frequency	13		TXKHz	Part transmitter MHz in 250Hz steps
	Absolute receiver frequency - integer MHz	10		RXMHz	Absolute transmitter frequency - integer MHz
	Absolute receiver frequency	13		RXKHz	Part receiver MHz in 250Hz steps
	CdefParns				
Cdeftype=0001 ₂ to 1111 ₂		58	Reserved		

The mechanism for calculating the absolute frequency is defined in annex C.

7.2.21 Individual/Group (IG)

Table 7.72: IG information element Definition

Information element	Length	Value	Alias	Remark
IG		0 ₂	G/I	The Target Address information element in the PDU represents an individual MS address
		1 ₂		The Target Address information element in the PDU represents a talkgroup

7.2.22 Protect_Kind

Table 7.73: Protect_Kind information element Definition

Information element	Length	Value	Alias	Remark
Protect_Kind	3	000 ₂	DIS_PTT	Disable Target MS or Talkgroup transmission
		001 ₂	EN_PTT	Enable Target MS or Talkgroup transmission
		010 ₂	ILLEGALLY_PARKED	Clear down from the payload channel, MS who's address does not match Source or Target Address
		011 ₂		Reserved
		100 ₂		Reserved
		101 ₂		Reserved
		110 ₂		Reserved
		111 ₂		Reserved

7.2.23 Maint_Kind

Table 7.74: Maint_Kind information element Definition

Information element	Length	Value	Alias	Remark
Maint_Kind	3	000 ₂	DISCON	Disconnect. End of payload channel use
		001 ₂		Reserved
		010 ₂		Reserved
		011 ₂		Reserved
		100 ₂		Reserved
		101 ₂		Reserved
		110 ₂		Reserved
		111 ₂		Reserved

7.2.24 Response expected (A)

Table 7.75: A information element Definition

Information element	Length	Value	Alias	Remark
A	1	0 ₂		Response not expected
		1 ₂		Response expected

7.2.25 Format

Table 7.76: Format information element

Information element	Length	Value	Remark
Format	4	0000 ₂	Reserved
		0001 ₂	Reserved
		0010 ₂	Reserved
		0011 ₂	Reserved
		0100 ₂	Reserved
		0101 ₂	Reserved
		0110 ₂	Reserved
		0111 ₂	Reserved
		1000 ₂	Reserved
		1001 ₂	Reserved
		1010 ₂	Reserved
		1011 ₂	Reserved
		1100 ₂	Reserved
		1101 ₂	Reserved
		1110 ₂	UDT header for UDT
		1110 ₂	Reserved

7.2.26 Service Access Point (SAP)

Table 7.77: SAP information element

Information element	Length	Value	Remark
SAP	4	0000 ₂	UDT
		0001 ₂	See TS 102 361-1 [5]
		0010 ₂	See TS 102 361-1 [5]
		0011 ₂	See TS 102 361-1 [5]
		0100 ₂	See TS 102 361-1 [5]
		0101 ₂	See TS 102 361-1 [5]
		0110 ₂	See TS 102 361-1 [5]
		0111 ₂	See TS 102 361-1 [5]
		1000 ₂	See TS 102 361-1 [5]
		1001 ₂	See TS 102 361-1 [5]
		1010 ₂	See TS 102 361-1 [5]
		1011 ₂	See TS 102 361-1 [5]
		1100 ₂	See TS 102 361-1 [5]
		1101 ₂	See TS 102 361-1 [5]
		1110 ₂	See TS 102 361-1 [5]
		1110 ₂	See TS 102 361-1 [5]

7.2.27 Pad Nibble (PN)

The PN information element specifies the number of pad nibbles which have been appended to the data to form an integer number of blocks. The number of pad nibbles for each of the UDT data formats is specified in annex B.

Table 7.78: Pad Nibble

Information element	Length	Value	Remark
Pad Nibble	5	Value	Number of pad nibbles appended to the data

7.2.28 UDT Format

Specifies the format of the user or system data carried in UDT's for the UDT mechanism.

Table 7.79: UDT_Format information element

Information element	Length	Value	Remark
UDT Format	4	0000 ₂	Binary
		0001 ₂	MS Address
		0010 ₂	4 bit BCD
		0011 ₂	ISO 7 bit character set (ISO/IEC 646 [12])
		0100 ₂	ISO 8 bit character set (ISO/IEC 8859 [13])
		0101 ₂	NMEA location coded (IEC 61162-1 [8])
		0110 ₂	IP address
		0111 ₂	16 bit Unicode characters
		1000 ₂	Custom Coded (manufacturer specific)
		1001 ₂	Custom Coded (manufacturer specific)
		1010 ₂	Reserved
		1011 ₂	Reserved
		1100 ₂	Reserved
		1101 ₂	Reserved
		1110 ₂	Reserved
1111 ₂	Reserved		

7.2.29 Offset

On the outbound channel, specifies if the payload channel shall use offset or aligned timing.

Table 7.80: Offset information element

Information element	Length	Value	Remark
Offset	1	0 ₂	The payload channel shall use aligned timing
		1 ₂	The payload channel shall use offset timing

Annex A (normative): Timers, constants levels and addresses

This annex lists the timers and constants in a DMR MS.

Where indicated, a value should be chosen from within the specified range. For other timers and constants, a default value may be specified and the value of these timers and constants shall be configurable within the DMR entity (MS, BS or TS).

A.1 Layer 3 timers

Table A.1: Layer 3 Timers

Mnemonic		Value	Description
Trand_TC	-	2 to 60 seconds	Timeout for MS attempting Random Access
T_Nosig	-	1 to 15 seconds	Timeout for entering hunting procedures if no TSCC is received
T_EMERG_TIMER	-	1 to 510	Emergency Timer in steps of 30 seconds (e.g 1 = 30 seconds, 2 = 60 seconds, etc.)
		511	Emergency Timer is Infinity
T_PACKET_TIMER	-	1 to 30	Packet Timer in steps of 5 seconds
		31	Packet Timer is Infinity
T_MS-MS_TIMER	-	1 to 4 094	MS-MS Timer in steps of 10 seconds (e.g 1 = 10 seconds, 2 = 20 seconds, etc.)
		4 095	MS-MS Timer is Infinity
T_MS-LINE_TIMER	-	1 to 4 094	MS-Line Timer in steps of 10 seconds (e.g 1 = 10 seconds, 2 = 20 seconds, etc.)
		4 095	MS-Line Timer is Infinity
TP_Timer	-	4 to 60 seconds	Timeout for a calling MS waiting for a call that requires a payload channel
TNP_Timer	-	2 to 20 seconds	Timeout for a calling MS waiting for a call that does not require a payload channel
T_Awake	-	0.1 to 60 seconds	Time MS stays awake after receiving a PDU (in steps of 0,1 seconds)
TV_Hangtime	-	1 to 60 seconds	Payload Voice Hangtime timer
TV_Item	-	10 to 60 seconds	Payload Voice Maximum Item Timer
TV_Inactive	-	0 to 20 seconds	Payload Voice Inactivity Timer
TD_Inactive	-	0 to 20 seconds	Payload Data inactivity Timer
TD_Item	-	1 to 60 seconds	Payload Packet Data Maximum Item Timer
T_Pending	-	2 to 60 seconds	Timeout for called MS after receiving AHOY
T_dereg	-	0,2 to 2 seconds	Timer to de-register before abandon in 0,1 second steps
T_BS_Inactive	-	1 to 300 seconds	Timer to hibernate if no inbound activity on an unregulated TSCC

A.2 Layer 3 constants

Table A.2: Layer 3 Constants

Mnemonic		Value	Description
NDefault_NW	-	5	NRand_Wait at MS switch on
NRand_NR	-	6	Number of random access attempts for a normal and high priority service
NRand_NE	-	10	Number of random access attempts for a emergency priority service
N_Maint	-	4	Number of P_MAINT PDUs transmitted by an MS to clear down the payload channel
Nmax_Ch	-	50	Minimum Number of channels in Short Hunt List
Low_Comp_Ch	-	1 to 4 095	Lowest logical channel in use by the network
High_Comp_Ch	-	Low_Comp_Ch to 4 095	Highest logical channel in use by the network
Comp_Flag	-	True/False	Suppress Comprehensive Hunt (see annex D)
NSYSerr	-	1 to 3	Number of C_SYScodes received that differ from the value verified
DMRLA	-	0 to 10	Length of SYS_AREA information field from the C_SYSCode

A.3 Layer 3 levels

Table A.3: Layer 3 signal levels

Mnemonic		Value	Description
L_Upper_Short	-	Units and values are manufacturer specific	The threshold of signal quality above which will be sampled first in a short hunt
L_Lower_Short	-		The threshold of signal quality below which the MS shall be unable to become active
L_Squelch	-		Signal level (or equivalent) below which physical channels are to be rejected because the received signal quality is inadequate

A.4 Tier III Gateways/Identifiers

Table A.4: Gateways / Identifiers

DMR ID	Alias	Remark
FFFE0 ₁₆	PSTNI	Gateway address for services to the PSTN using payload aligned timing
FFFE1 ₁₆	PABXI	Gateway address for services to the PABX using payload aligned timing
FFFE2 ₁₆	LINEI	Address for services to a Line Gateway using payload aligned timing
FFFE3 ₁₆	IPI	Address for services to an IP Gateway using payload aligned timing
FFFE4 ₁₆	SUPLI	Address used to identify an supplementary data service
FFFE5 ₁₆	SDMI	Address used to identify a short data service
FFFE6 ₁₆	REGI	Address used to identify a registration service
FFFE7 ₁₆	MSI	Address used to identify the totality of individual MS address space
FFFE8 ₁₆	TGI	Address used to identify the totality of talkgroup address space
FFFE9 ₁₆	DIVERTI	Address used to identify a call diversion cancellation
FFFEA ₁₆	TSI	Address of the TS
FFFEB ₁₆	DISPATI	Address of the system dispatcher
FFFEC ₁₆	STUNI	MS Stun/Unstun Identifier
FFFED ₁₆	AUTHI	Authentication Identifier
FFFE ₁₆	GPI	Talkgroup Identifier

Annex B (normative): Opcode Reference Lists

B.1 CSBK/MBC/UDT Opcode List

Table B.1: CSBK/MBC/UDT Opcode List

OPCODE	OPCODE ₂	Description	Alias
Channel Grant			
48	11 0000 ₂	Private Voice Channel Grant	PV_GRANT
49	11 0001 ₂	Talkgroup Voice Channel Grant	TV_GRANT
50	11 0010 ₂	Private Broadcast Voice Channel Grant	PBV_GRANT
51	11 0011 ₂	Private Data Channel Grant	PD_GRANT
52	11 0100 ₂	Talkgroup Data Channel Grant	TD_GRANT
Move			
56	11 1000 ₂	Move PDUs	C_MOVE
Aloha			
24	01 1001 ₂	Aloha PDUs for the random access protocol	C_ALOHA
Announcements			
40	10 1000 ₂	Announcement PDUs that shall not demand a response. Announce/Withdraw TSCC Specify call Timers Vote now advice Announce local time Announce a logical physical channel relationship	C_BCAST
44	10 1110 ₂	Clear	P_CLEAR
45	10 1111 ₂	Protect	P_PROTECT
Ahoy PDUs			
28	01 1100 ₂	Ahoy - enquiry that demands a response TSCC	AHOY
Acknowledgements			
32	10 0000 ₂	Acknowledgement response outbound TSCC	C_ACKD
33	10 0001 ₂	Acknowledgement response inbound TSCC	C_ACKU
34	10 0010 ₂	Acknowledgement response outbound Payload	P_ACKD
35	10 0011 ₂	Acknowledgement response inbound Payload	P_ACKU
UDT Header			
26	01 1010 ₂	Unified Data Transport Download Header	C_UDTHD
27	01 1011 ₂	Unified Data Transport Upload Header	C_UDTHU
Random Access Service Request			
31	01 1111 ₂	Random Access Service Request	C_RAND
Ackvitation			
30	01 1110 ₂	Ackvitation PDU	C_ACKVIT
Maintenance PDU			
42	10 1010 ₂	Maintenance	P_MAINT

B.2 Short Link Control Opcode List

Table B.2: SLCO Opcode List

SLCO	Description	Alias
0010 ₂	System Parameters and slot counter	SYS_Parm

B.3 Appended Data Information Elements

A UDT PDU may carry information elements. A UDT header PDU carries the source and destination addresses and a UDT Format information element that prescribes the format of the appended data.

The UDT Header is the first block of a multi-block UDT. The number of blocks making up the multi-block UDT is specified by the AB information element. All PDUs are specified in clause 7.2.

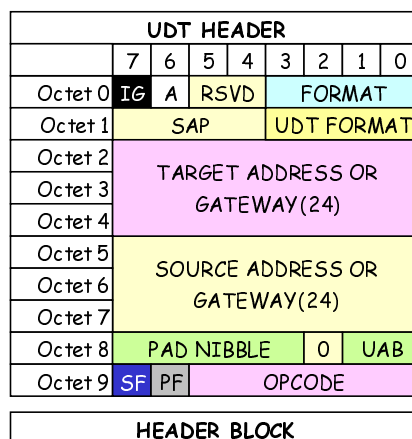


Figure B.1: UDT header Block

B.3.1 Appended Data Binary Format

Appended data is binary coded. Up to four appended UDT blocks may be concatenated with the UDT header to form a multi-block UDT PDU. Up to 297 bits may be transported. For binary format transport the Pad Nibble information element in the UDT header is set to 0 0000₂. If variable length binary data is being transported, the last bit of the user data may be identified as follows:

- A 0₂ is appended to the user data and the remaining bits to fill a UDT block are set to 1₂. The UDT header and appended blocks are then transmitted.
- The receiver may identify the end of user data by counting backwards until the first 0₂ is reached. That point is one bit past the user data.

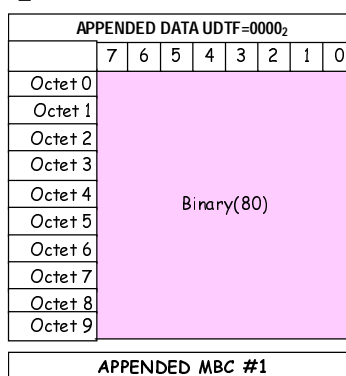


Figure B.2: Unified Data Transport Format (Binary) 1 bit to 79 bits

One appended UDT may transport from 1 bit to 79 bits (because the last user bit must be identified by adding a 0₂ to the end of the user data).

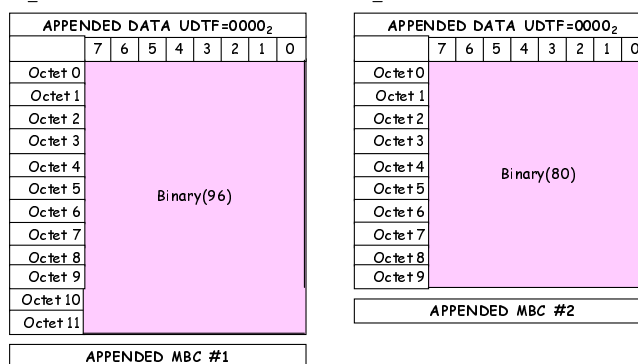


Figure B.3: Unified Data Transport Format (Binary) 80 bits to 175 bits

Two appended UDT's may transport from 80 bits to (96+79) = 175 bits.

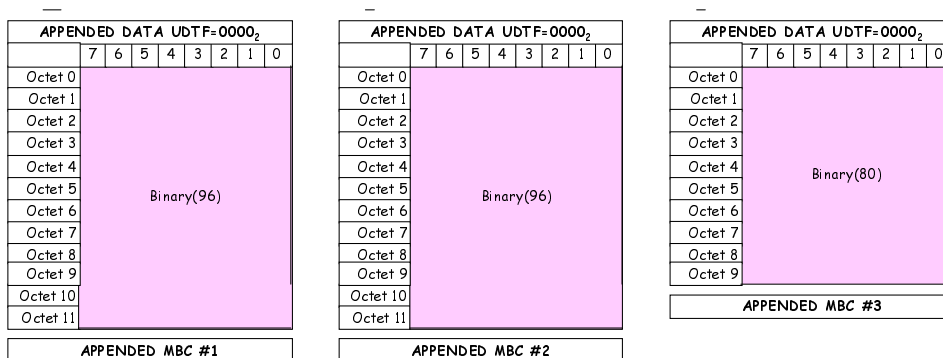


Figure B.4: Unified Data Transport Format (Binary) 176 bits to 366 bits

Three appended UDT's may transport from 176 bits to (96+96+79) = 366 bits.

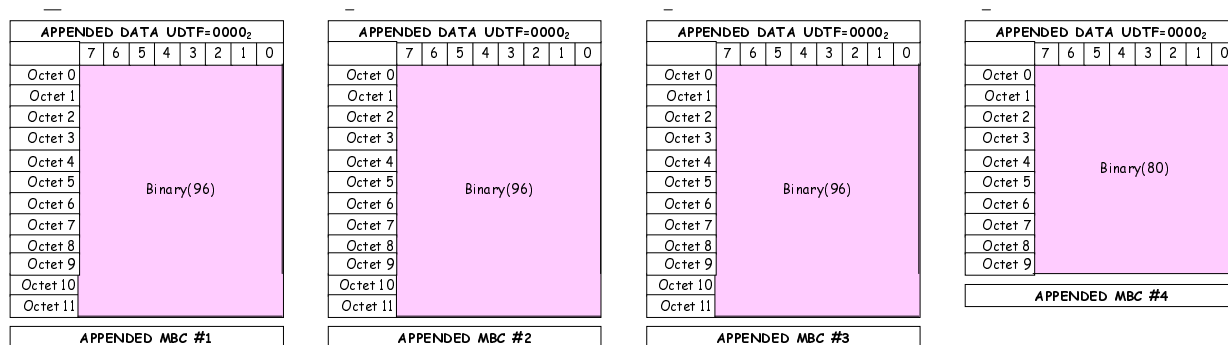


Figure B.5: Unified Data Transport Format (Binary) 366 bits to 462 bits

Four appended UDT's may transport from 366 bits to $(96+96+96+79) = 462$ bits.

B.3.2 Appended Data Addressing Format

Appended data is 24 bit address coded. One appended data UDT's may be concatenated with a UDT appended data header to form a multi-block UDT PDU. Up to three addresses may be transported.

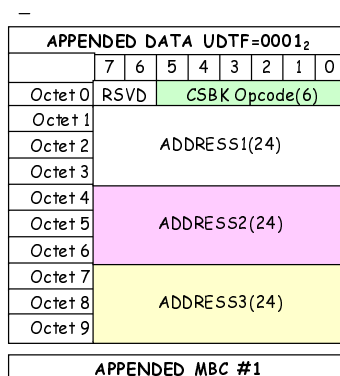


Figure B.6: Appended data Address Format

Unused address information elements are filled with NULL.

B.3.3 Appended Data BCD Format

Appended data is BCD coded. Up to four appended data UDT's may be concatenated with UDT appended data header to form a multi-block UDT PDU. Up to 92 BCD digits may be transported. The Pad Nibble information element in the UDT header specifies the number of 4 bit nibbles (1111_2) that have been padded to the user digits to completely fill a block.

The number of user BCD digits and the corresponding value of AB and Pad Nibble is given by table B.3.

Table B.3: Relationship of user BCD digits, UAB and Pad Nibble information elements

User BCD Digits	UAB	Pad Nibble	User BCD Digits	UAB	Pad Nibble	User BCD Digits	UAB	Pad Nibble
1	0	19	32	1	12	63	2	5
2	0	18	33	1	11	64	2	4
3	0	17	34	1	10	65	2	3
4	0	16	35	1	9	66	2	2
5	0	15	36	1	8	67	2	1
6	0	14	37	1	7	68	2	0
7	0	13	38	1	6	69	3	23
8	0	12	39	1	5	70	3	22
9	0	11	40	1	4	71	3	21
10	0	10	41	1	3	72	3	20
11	0	9	42	1	2	73	3	19
12	0	8	43	1	1	74	3	18
13	0	7	44	1	0	75	3	17
14	0	6	45	2	23	76	3	16
15	0	5	46	2	22	77	3	15
16	0	4	47	2	21	78	3	14
17	0	3	48	2	20	79	3	13
18	0	2	49	2	19	80	3	12
19	0	1	50	2	18	81	3	11
20	0	0	51	2	17	82	3	10
21	1	23	52	2	16	83	3	9
22	1	22	53	2	15	84	3	8
23	1	21	54	2	14	85	3	7
24	1	20	55	2	13	86	3	6
25	1	19	56	2	12	87	3	5
26	1	18	57	2	11	88	3	4
27	1	17	58	2	10	89	3	3
28	1	16	59	2	9	90	3	2
29	1	15	60	2	8	91	3	1
30	1	14	61	2	7	92	3	0
31	1	13	62	2	6			

APPENDED DATA UDTF=0010 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(4)				Digit(4)			
Octet 1	Digit(4)				Digit(4)			
Octet 2	Digit(4)				Digit(4)			
Octet 3	Digit(4)				Digit(4)			
Octet 4	Digit(4)				Digit(4)			
Octet 5	Digit(4)				Digit(4)			
Octet 6	Digit(4)				Digit(4)			
Octet 7	Digit(4)				Digit(4)			
Octet 8	Digit(4)				Digit(4)			
Octet 9	Digit(4)				Digit(4)			
APPENDED MBC #1								

Figure B.7: Unified Data Transport Format (BCD) 1 digit to 20 digits

Table B.4: Relationship of ISO 7 bit symbols, UAB and Pad Nibble information elements

User 7 bit Symbols	UAB	Pad Nibble	User 7 bit Symbols	UAB	Pad Nibble	User 7 bit Symbols	UAB	Pad Nibble
1	0	18	19	1	10	37	2	3
2	0	16	20	1	9	38	2	1
3	0	14	21	1	7	39	3	23
4	0	13	22	1	5	40	3	22
5	0	11	23	1	3	41	3	20
6	0	9	24	1	2	42	3	18
7	0	7	25	1	0	43	3	16
8	0	6	26	2	22	44	3	15
9	0	4	27	2	20	45	3	13
10	0	2	28	2	19	46	3	11
11	0	0	29	2	17	47	3	9
12	1	23	30	2	15	48	3	8
13	1	21	31	2	13	49	3	6
14	1	19	32	2	12	50	3	4
15	1	17	33	2	10	51	3	2
16	1	16	34	2	8	52	3	1
17	1	14	35	2	6			
18	1	12	36	2	5			

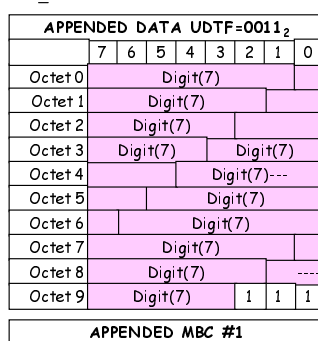


Figure B.11: Unified Data Transport Format (ISO 7 bit) 1 text symbol to 11 text symbols

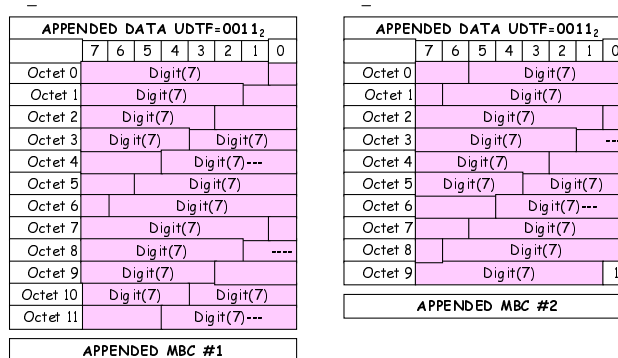


Figure B.12: Unified Data Transport Format (ISO 7 bit) 12 text symbols to 25 text symbols

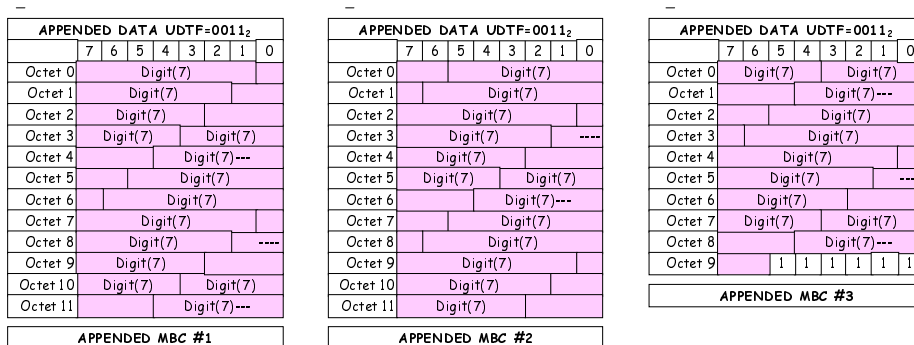


Figure B.13: Unified Data Transport Format (ISO 7 bit) 26 text symbols to 38 text symbols

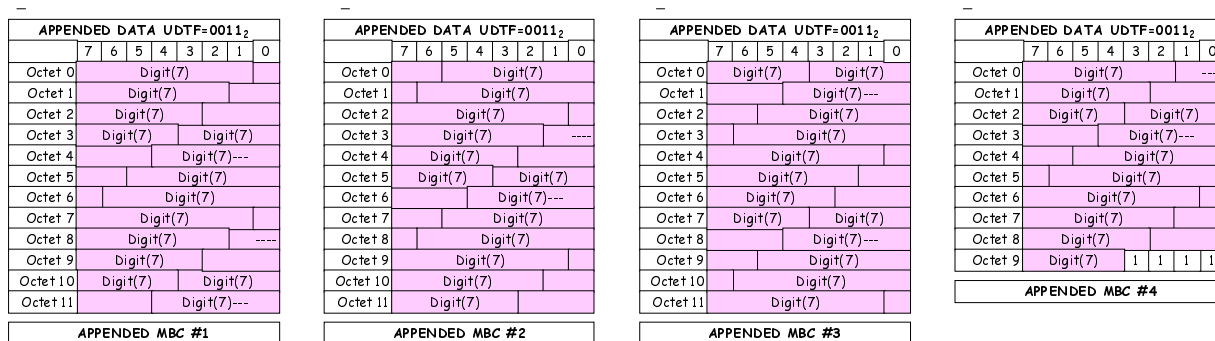


Figure B.14: Unified Data Transport Format (ISO 7 bit) 39 text symbols to 52 text symbols

B.3.5 Appended Data ISO 8 bit Character Format

Appended data is coded ISO 8 bit character format (ISO/IEC 8859 [13]). Up to four appended data UDT's may be concatenated with UDT appended data header to form a multi-block UDT PDU. Up to 46 ISO 8 bit characters may be transported. The Pad Nibble information element in the UDT header specifies the number of 4 bit nibbles (1111₂) that have been padded to the Character symbols to completely fill a block.

The number of user 8 bit characters, and the corresponding value of UAB and Pad Nibble is given by table B.5.

Table B.5: Relationship of 8 bit character symbols, UAB and Pad Nibble information elements

User Character Symbols	UAB	Pad Nibble
1	0	18
2	0	16
3	0	14
4	0	12
5	0	10
6	0	8
7	0	6
8	0	4
9	0	2
10	0	0
11	1	22
12	1	20
13	1	18
14	1	16
15	1	14
16	1	12
17	1	10
18	1	8
19	1	6
20	1	4
21	1	2
22	1	0
23	2	22
24	2	20
25	2	18
26	2	16
27	2	14
28	2	12
29	2	10
30	2	8
31	2	6
32	2	4
33	2	2
34	2	0
35	3	22
36	3	20
37	3	18
38	3	16
39	3	14
40	3	12
41	3	10
42	3	8
43	3	6
44	3	4
45	3	2
46	3	0

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
APPENDED MBC #1								

Figure B.15: Unified Data Transport Format (8 bit character) 1 character symbol to 10 character symbols

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							
APPENDED MBC #1								

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
APPENDED MBC #2								

Figure B.16: Unified Data Transport Format (8 bit character) 11 character symbols to 22 character symbols

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							
APPENDED MBC #1								

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							
APPENDED MBC #2								

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
APPENDED MBC #3								

Figure B.17: Unified Data Transport Format (8 bit character) 23 character symbols to 34 character symbols

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							

APPENDED MBC #1

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							

APPENDED MBC #2

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							
Octet 10	Digit(8)							
Octet 11	Digit(8)							

APPENDED MBC #3

APPENDED DATA UDTF=0100 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Digit(8)							
Octet 1	Digit(8)							
Octet 2	Digit(8)							
Octet 3	Digit(8)							
Octet 4	Digit(8)							
Octet 5	Digit(8)							
Octet 6	Digit(8)							
Octet 7	Digit(8)							
Octet 8	Digit(8)							
Octet 9	Digit(8)							

APPENDED MBC #4

Figure B.18: Unified Data Transport Format (8 bit character) 35 character symbols to 46 character symbols

B.3.6 Appended Data NMEA format

Appended data is with essential data elements for NMEA formatted (IEC 61162-1 [8]) coordinates. Up to two appended data UDT's may be concatenated with a UDT appended data header to form a multi-block UDT PDU. The information elements are described in table B.6.

APPENDED DATA UDTF=0101 ₂								
	7	6	5	4	3	2	1	0
Octet 0	C	NS	EW	Q	SPEED(7)---			
Octet 1	---			NDEG(7)---				
Octet 2	---			NMIN(6)				
Octet 3	NMINF(14)---							
Octet 4	-----			---				
Octet 5	---			EDEG(8)				
Octet 6	--EMINm(6)			---				
Octet 7	----EMINF(14)----							
Octet 8	---			SPARE(6)				
Octet 9	SPARE(8)							

APPENDED MBC #1

Figure B.19: Appended Data Short NMEA format

APPENDED DATA UDTF=0101 ₂								
	7	6	5	4	3	2	1	0
Octet 0	C	NS	EW	Q	SPEED(7)---			
Octet 1	---			NDEG(7)---				
Octet 2	---			NMIN(6)				
Octet 3	NMINF(14)---							
Octet 4	-----			---				
Octet 5	---			EDEG(8)				
Octet 6	--EMINm(6)			---				
Octet 7	----EMINF(14)----							
Octet 8	---			UTCh(5)				
Octet 9	UTCmm(6)			UTCss(6)---				
Octet 10	---			SPARE(5)				
Octet 11	SPARE(8)							

APPENDED MBC #1

APPENDED DATA UDTF=0101 ₂								
	7	6	5	4	3	2	1	0
Octet 0	UTChh(5)							---
Octet 1	UTCmm(6)			UTCss(6)---				
Octet 2	---							
Octet 3	---							
Octet 4	---							
Octet 5	---							
Octet 6	---							
Octet 7	---							
Octet 8	---							
Octet 9	---							

APPENDED MBC #2

Figure B.20: Appended Data Long NMEA format

Table B.6: Appended Data NMEA Elements

Alias	Length	Value	Description
C	1	0	Data is not encrypted
		1	Data is encrypted
NS	1	0	Latitude Direction - South
		1	Latitude Direction - North
EW	1	0	Longitude Direction - West
		1	Longitude Direction - East
Q	1	0	GPS Quality Indicator - No fix
		1	GPS Quality Indicator - Fix Valid
SPEED	7		Speed in knots (0-126)
NDEG	7		Latitude Degrees (00-89)
NMINmm	6		Latitude Minutes (00-59)
NMINF	14		Latitude Fractions of minutes (0000-9999)
EDEG	8		Longitude Degrees (00-179)
EMINmm	6		Longitude Minutes (00-59)
EMINF	14		Longitude Fractions of minutes (0000-9999)
RSVD	6		
UTCCh	5		UTC time hours (00-23)
UTCmm	6		UTC time minutes (00-59)
UTCss	6		UTC time seconds (00-59)

B.3.7 UDT DMR IP format

The UDT IP format is shown in figures B.21 and B.22.

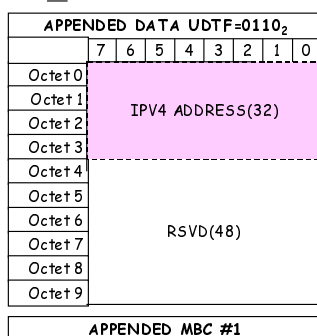


Figure B.21: Appended Data IPV4 format

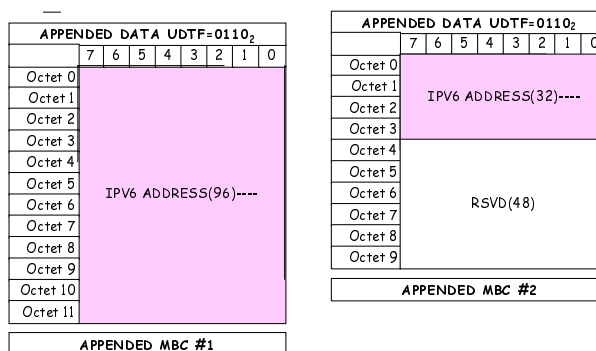


Figure B.22: Appended Data IPV6 format

B.3.8 Appended Data Unicode 16 bit Character Format

Appended data is coded Unicode (IEC 61162-1 [8]) 16 bit character format. Up to four appended data UDT's may be concatenated with UDT appended data header to form a multi-block UDT PDU.. Up to 23 Unicode characters may be transported. The Pad Nibble information element in the UDT header specifies the number of 4 bit nibbles (1111_2) that have been padded to the Unicode Characters to completely fill a block.

The number of user ISO 7 bit symbols, and the corresponding value of UAB and Pad Nibble is given by table B.7.

Table B.7: Relationship of 16 bit UnicodeCharacter symbols, UAB and Pad Nibble information elements

User Character Symbols	UAB	Pad Nibble
1	0	16
2	0	12
3	0	8
4	0	4
5	0	0
6	1	20
7	1	16
8	1	12

User Character Symbols	UAB	Pad Nibble
9	1	8
10	1	4
11	1	0
12	2	20
13	2	16
14	2	12
15	2	8
16	2	4

User Character Symbols	UAB	Pad Nibble
17	2	0
18	3	20
19	3	16
20	3	12
21	3	8
22	3	4
23	3	0

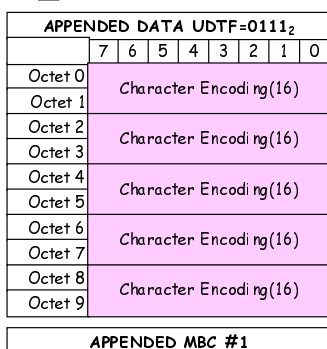


Figure B.23: Unified Data Transport Format (16 bit character) 1 character symbol to 5 character symbols

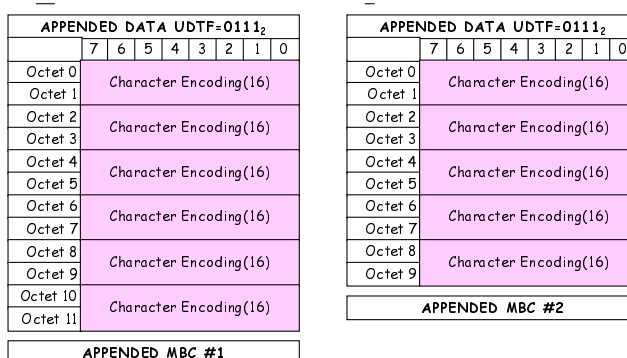


Figure B.24: Unified Data Transport Format (16 bit character) 6 character symbols to 11 character symbols

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
Octet 10	Character Encoding(16)							
Octet 11	Character Encoding(16)							
APPENDED MBC #1								

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
Octet 10	Character Encoding(16)							
Octet 11	Character Encoding(16)							
APPENDED MBC #2								

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
APPENDED MBC #3								

Figure B.25: Unified Data Transport Format (8 bit character) 12 character symbols to 17 character symbols

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
Octet 10	Character Encoding(16)							
Octet 11	Character Encoding(16)							
APPENDED MBC #1								

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
Octet 10	Character Encoding(16)							
Octet 11	Character Encoding(16)							
APPENDED MBC #2								

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
Octet 10	Character Encoding(16)							
Octet 11	Character Encoding(16)							
APPENDED MBC #3								

APPENDED DATA UDTF=0111 ₂								
	7	6	5	4	3	2	1	0
Octet 0	Character Encoding(16)							
Octet 1	Character Encoding(16)							
Octet 2	Character Encoding(16)							
Octet 3	Character Encoding(16)							
Octet 4	Character Encoding(16)							
Octet 5	Character Encoding(16)							
Octet 6	Character Encoding(16)							
Octet 7	Character Encoding(16)							
Octet 8	Character Encoding(16)							
Octet 9	Character Encoding(16)							
APPENDED MBC #4								

Figure B.26: Unified Data Transport Format (8 bit character) 18 character symbols to 23 character symbols

Annex C (informative): Physical Channel Plan

C.1 Transmission and Reception

C.1.1 RF carriers

C.1.1.1 Nominal carriers frequencies

The nominal carrier frequencies for DMR may be allocated in any of the frequency bands in the range 50 MHz to 999 MHz. Upper layers of the protocol stack define a single logical channel number that equates to a transmitter and receiver frequencies in the range 1 to 4 094. Since the DMR Standard supports re-assigning of existing analogue channels, flexibility may be provided where prescribed channel plans are suitable.

DMR may therefore support:

- a number of fixed channel plans where the MS transmit frequency, the split between transmit and receive, the channel separation and if the receiver is high or low relative to the transmitter;
- a flexible channel plan whereby each logical channel may represent a transmitter and receiver frequency pair;
- a broadcast PDU that enables the TSCC to announce a logical / physical transmitter and receiver relationship;
- an extended channel grant PDU that specifies the physical transmitter and receiver frequencies.

The higher DMR layers only have the logical CHAN SDU to define the physical frequencies. The additional parameters (type of channel plan, Tx/Rx separation, etc.) exist in the physical layer only and are programmed during personalization or manufacture of the equipment. It must be remembered that a National Administration may mandate certain limitations on particular frequencies (such as transmitter power).

C.1.1.2 Fixed Channel Plan

The nominal MS Tx frequency f_{MS_Tx} corresponds to its logical carrier number, CHAN, which is defined as:

f_{MS_Tx} - MS transmit frequency (MHz)

f_{base} - The lowest frequency in a particular band relating to logical CHAN=1 (MHz)

$f_{separation}$ - The frequency separation between two adjacent channels (kHz)

$f_{duplexsplit}$ - The difference between MS Tx and MS Rx [for clarity MS Tx minus MS Rx] (\pm MHz)

$f_{MS_Tx} = f_{base} + ((CHAN-1) \times (f_{separation}/1\ 000))$ MHz

$f_{MS_Rx} = f_{MS_Tx} \pm f_{duplexsplit}$ MHz

$f_{duplexsplit} = 0$ MHz to 50 MHz in 2,5 kHz steps

$f_{separation}$ - Definition

Table C.1: Frequency Separation

SDU Code (SEP)	Separation (kHz)
0000 ₂	5
0001 ₂	6,25
0010 ₂	10
0011 ₂	12,5
0100 ₂	15
0101 ₂	20
0110 ₂	25
0111 ₂	30
1xxx ₂	reserved

f_{split} - The difference between MS Tx and MS Rx [for clarity MS Tx minus MS Rx] (\pm MHz)

Table C.2: Frequency Split high/low

SDU Code (TXRX_SPLIT)	
0 ₂	MS Tx is high of MS Rx
1 ₂	MS Tx is low of MS Rx

$f_{\text{duplexsplit}}$ - Definition

Table C.3: Frequency Split

SDU Code (DUPLEX_SPLIT)	Duplex Split (kHz)
000 0000 0000 0000 ₂	0
000 0000 0000 0001 ₂	2,5
.....	
000 0111 0011 0000 ₂	4 600 (4,6 MHz)
.....	
000 1100 1000 0000 ₂	8 000 (8 MHz)
.....	
000 1111 1010 0000 ₂	10 000 (10 MHz)
.....	
100 0110 0101 0000 ₂	45 000 (45 MHz)

f_{base} - Band Definition

Table C.4: Band Definition

SDU Code (BAND)	f_{base} MHz
000 0011 ₂	30
000 0100 ₂	40
000 0101 ₂	50
000 0110 ₂	60
000 0111 ₂	70
.....	
010 1100 ₂	450
.....	
101 0000 ₂	800
110 0100 ₂	1 000

chan - Logical Channel Numbers

Table C.5: Logical Channel Numbers

Channel Number	SDU Code (CHAN)	Colour Code (see note)
1	0000 0000 0001 ₂	Value
.....	
4 094	1111 1111 1110 ₂	Value

NOTE: The default colour code =0000₂.

C.1.1.3 Flexible Channel Plan

Each logical channel number has the transmitter and receiver frequency defined.

Table C.6: Flexible Channel Plan

Channel Number	SDU Code (CHAN)	Transmitter Frequency	Receiver Frequency	Colour Code (see note)
1	0000 0000 0001 ₂			Value
.....			
4 094	1111 1111 1110 ₂			Value

NOTE: The default colour code =0000₂.

C.1.1.4 Determination of Transmitter and Receiver frequency from CdefParms

The MS absolute transmitter and receiver frequency is defined in 125 Hz steps as shown in table C.7.

Table C.7: Absolute Transmitter and Receiver SDU's

ALIAS	SDU Code	Transmitter/Receiver Frequency
TXMHz	000 0011 0010 ₂	50 Mhz
RXMHz	111 1100 1111 ₂	999 MHz
TXKHz RXKHz	0 0000 0000 0000 ₂	0 Hz
	0 0000 0000 0001 ₂	+125 Hz
	0 0000 0000 0010 ₂	+250 Hz
	1 1111 0011 1111 ₂	+999 875 Hz

The absolute transmitter frequency (MHz) = TXMHz + (TXKHz × 125)/1 000.

The absolute receiver frequency (MHz) = RXMHz + (RXKHz × 125)/1 000.

Annex D (informative): Control Channel Hunting Procedures

D.1 Introduction

In order to locate a valid TSCC, the MS hunts through a list candidate physical channels until an appropriate TSCC is selected and confirmed. This TSCC hunting may involve a variety of hunting sequences depending on the circumstances of the hunt. This annex shows a framework for MS hunting strategy.

Since two logical TDMA channels occupy one physical channel, the MS can appraise both logical channels concurrently when sampling a physical channel. The MS may use information from the CACH or PDUs that contain a C_SYSCode information element to use for verification tests specified in clause 6.3.2.2.1.

The Control Channel Hunting Procedure stages are:

- a) The "resuming a TSCC hunt channel" allows an MS, after a period of activity on a payload physical channel, to resume the TSCC on which it was last confirmed prior to the payload Channel Grant PDU.
- b) The "commanded TSCC hunt channel" is employed when a MS is directed on the TSCC to a particular TSCC (from a C_MOVE or P_CLEAR PDU) or seeks to regain a TSCC after a period of inactivity on the selected network (due to being switched off or a user-initiated change of selected network when details of the last confirmed TSCC number have been stored by the MS in non-volatile storage).

"Short Hunt Sequence": A hunting sequence, which samples all physical channel numbers likely to be employed as TSCCs by the selected network. A list of Nmax_Ch likely logical candidate physical channel numbers is held in MS fixed non-volatile storage for the selected network. The MS should have the storage for up to 64 values of the logical physical channel number information element defining the extent of the "short hunt sequence". Unused storage locations are marked such that the MS may ignore them. Particular Physical channel numbers may be stored in the list numerous times to provide a bias to that particular TSCC.

- c) "Comprehensive Hunt Sequence". A hunting sequence, that samples all possible physical channel numbers in use by the network. This hunting sequence provides a contingency to allow TSCCs to be acquired even when physical channel numbers not normally employed for this purpose are in use. The "comprehensive hunt sequence" may be temporarily suspended to sample likely physical channels or repeat a "short hunt sequence". The lowest Low_Comp_Ch and highest High_Comp_Ch is held in the MS fixed non-volatile storage.

NOTE 1: The "Comprehensive Hunt Sequence" may be suppressed by network personalization.

When carrying out a "resuming a TSCC hunt channel" or "commanded TSCC hunt channel" the hunting procedure is considered complete when the MS has tuned directly to the physical channel and has carried out the appropriate verification and confirmation procedures specified in clause 6.3.

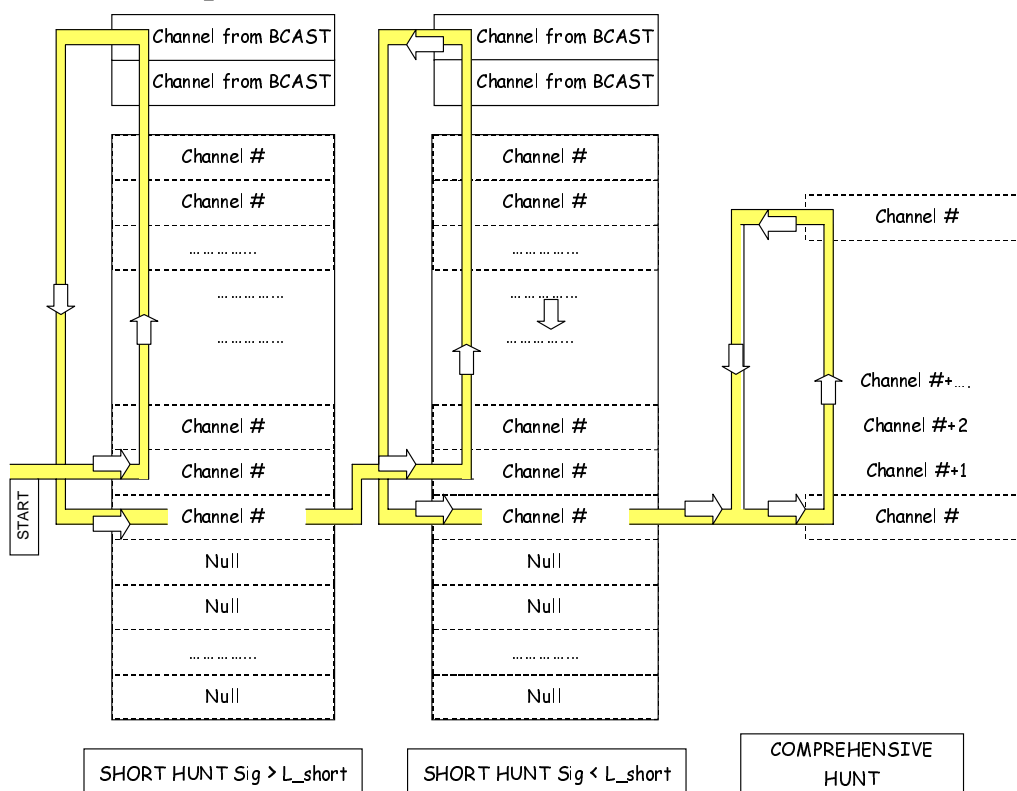


Figure D.1: Physical Channel Hunting

Figure D.1 shows a possible implementation of the "Short Hunt Sequence" and "Comprehensive Hunt" Sequence. If the MS needs to search for an appropriate TSCC, this process searches the most likely physical channel candidates first. This example of a possible implementation carries out the short hunt twice, the first loop being exercised looking for a TSCC whose signal strength exceeds a defined value ($L_{SigShort}$).

A hunting sequence may be considered complete when either:

- a physical channel is found that satisfies the TSCC verification and confirmation tests specified in clause 6.3. (The hunting procedure was successful);
- all physical channel numbers within the scope of the hunting sequence have been tested without a physical channel being found which satisfies the TSCC confirmation tests specified in clause 6.3 (the hunting sequence failed).

The MS carries out the hunting procedure in the order described in this clause. If a hunting sequence is unsuccessfully completed, then the MS starts the next hunting sequence. The final hunting sequence is the "comprehensive hunt sequence". If this hunting sequence cannot be completed, the MS stays in this hunting sequence until a TSCC is confirmed. However, the foregoing provisions of this paragraph may be relaxed in the following circumstances:

- the "comprehensive hunt sequence" may be suppressed by MS personalization for a network;
- a MS in a "comprehensive hunt sequence" may elect to perform complete hunting sequences of any other type, returning to the "comprehensive hunt sequence" in the event of failure to confirm an appropriate TSCC;
- a MS may elect to sample any physical channel that may satisfy the TSCC verification and confirmation tests specified in clause 6.3.

Where a hunting stage involves more than one physical channel the order in which physical channels are sampled is not specified. However, in order to guard against bias towards certain physical channels, MSs should ensure randomness in the order in which physical channels are sampled by one of the following:

- hunting physical channel numbers sequentially (e.g. from lowest to highest number) but beginning the hunting stage at a random position in the sequence of physical channel numbers;
- hunting physical channel numbers in a random fashion.

The procedures defined in the present document are intended to provide a comprehensive range of methods that may be used as a basis for the design of MSs.

NOTE 2: The specified mechanism is a framework for MSs. The use of additional or differing procedures is not prohibited provided that they satisfy the verification and confirmation procedures defined in the present document.

EXAMPLE: A MS locating a physical channel which satisfies the TSCC confirmation tests specified in clause 6.3 may continue the hunt in anticipation that an alternative TSCC may be found with a higher received signal quality or level. Also, MSs need not limit the hunting procedures to the receiver sensitivity threshold levels specified and may conduct additional hunts at other levels.

D.1.1 Resuming a TSCC hunt channel

When "resuming a TSCC hunt channel" the MS retunes to the logical physical channel number of the TSCC on which it was last confirmed. The MS should be capable of receiving on the TSCC outbound channel, which it is resuming within two TDMA-frames of the following instants:

- a) the end of any P_CLEAR PDU, which requires the MS to cease activity on the payload channel to which it is currently tuned;
- b) the end of the last payload disconnect PDU P_MAINT (Maint_Kind=DISCON) sent by the MS on a payload channel;
- c) the end of any call authorization check PDU (P_AUTH) received on a payload channel where the MS address information element in the P_AUTH PDU does NOT match one of the addresses from the Channel Grant PDU that directed the MS to the payload channel;
- d) the operation of the any user initiated "call end request" by the user during a talkgroup call when the MS was not the call originator of the call.

Before confirming the TSCC the MS should verify any C_SYSCode received on the channel in accordance with the procedures of clause 6.3.2.2.1. In the event of the C_SYSCode fails the verification procedures, the hunting sequence is considered unsuccessfully completed and the MS enters the "short hunt sequence".

D.1.2 Commanded TSCC hunt channel

D.1.2.1 Conditions to enter a Commanded TSCC hunt

A "single channel hunt" applies when the MS is directed to a TSCC other than the one on which it was last confirmed, or when it is switched on whilst still retaining valid network information from previous activity on the selected network, or the user initiates a change of selected network and the MS still retains valid information of previous activity on the new selected network. The MS should be able to receive the nominated physical channel within 3 TDMA slots of the following instants:

- a) the end of any valid C_MOVE PDU that is applicable to the MS;
- b) the MS being switched on, provided that the unit holds a valid record of the channel number on which the MS was most recently confirmed;
- c) a change of selected network being initiated by the user, provided that the MS holds a valid record of the channel number on which the MS was most recently confirmed on the new selected network.

D.1.2.2 Nominated Channel for the Single Channel Hunt

The nominated channel is:

- a) the logical physical channel number indicated in the CONT information element of the P_CLEAR PDU; or
- b) the channel number indicated in the CONT information element the C_MOVE PDU; or
- c) the channel number held in the MSs read/write storage as the TSCC on which the unit was most recently confirmed on the selected network.

The MS shall not make any transmissions on a TSCC until it has confirmed the channel in accordance with the procedure specified in clause 6.3. In the event of a failure of the TSCC to meet the channel confirmation criteria the hunting sequence is considered unsuccessfully completed. Upon unsuccessful completion of the "commanded TSCC hunt channel" the MS enters the "short hunt sequence".

D.1.2.3 Short Hunt Sequence

A "Short Hunt Sequence" samples all physical channels most likely to be employed as TSCCs by the selected network. There are many strategies that may be employed but all shall search from a shortlist of candidates as follows:

- a) A list of likely physical channels shall be specified by an external agency stored in MS fixed non-volatile storage.
- b) The MS may modify the scope of the shortlist of physical channels from information broadcast from the network and held in its non-volatile storage as follows:
 - 1) by adding to the compass of the hunting sequence channel numbers received in C_BCAST (Announce/Withdraw) PDU from the selected network;
 - 2) by removing from the compass of the hunting sequence channel numbers received in C_BCAST (Announce/Withdraw) PDUs from the selected network.

One strategy illustrated in figure D.1 entails hunting the list of physical channel numbers sequentially (e.g. from the randomly chosen list position to the highest then circling to the lowest list position) but beginning the hunting stage at a random position in the sequence of physical channel numbers. The shortlist is sampled twice, the first loop being exercised looking for a TSCC whose signal strength exceeds a defined value (L_Short).

Another possible strategy entails hunting the complete shortlist of physical channel numbers sequentially (e.g. from lowest list position to highest list position) recording the signal strength and/or BER. After sampling all channels in the list the MS chooses the most appropriate TSCC.

D.1.2.3.1 Conditions to enter a Short Channel Hunt

A MS enters the "short hunt sequence":

- a) immediately after switch-on, provided that the MS holds no valid information of previous activity on the selected network;
- b) when the user indicates a change of selected network, provided that the MS holds no valid information of previous activity on the selected network.

The MS may enter the "short hunt sequence" at any time during the "comprehensive hunt sequence", at the MSs discretion.

The MS should not make any transmissions on a TSCC located during the "short hunt sequence" until it has verified and confirmed the channel in accordance with the procedures specified in clause 6.3.

Upon unsuccessful completion of the "short hunt sequence" the MS enters the "comprehensive hunt sequence", except when the "comprehensive hunt sequence" has been suppressed by MS personalization for a network.

D.1.2.4 Comprehensive Hunt Sequence

The "comprehensive hunt sequence" shall include every channel within the range set by the lowest and highest channel numbers set by the network personalization, held in the MSs fixed non-volatile storage.

D.1.2.4.1 Conditions to enter a Comprehensive Channel Hunt

A MS enters the "comprehensive hunt sequence" when a "short hunt sequence" has been unsuccessfully completed.

A MS may repeat the "comprehensive hunt stage" until such a time as a physical channel which satisfies the TSCC confirmation tests specified in clause 6.3 is found.

The MS shall not make any transmissions on a TSCC located during the "comprehensive hunt sequence" until it has confirmed the channel in accordance with the procedures specified in clause 6.3.

At any time during the "comprehensive hunt sequence" a MS may undertake a "short hunt sequence", or sample any physical channels that the MS is able to determine may be successful, returning to the "comprehensive hunt sequence" in the event that these choices is unsuccessful.

It shall be possible to suppress the "comprehensive hunt sequence" by MS network personalization. In this case the MS shall remain in the "short hunt sequence" with the acquisition threshold set to a level L_{Squelch} until such time as a channel which satisfies the TSCC confirmation tests specified in clause 6.3.

D.1.2.5 Receiver Sensitivity During Control Channel Acquisition

The MS should not attempt to become active on any physical channel for which the received signal level (or signal quality) is less than the specified acquisition threshold.

The acquisition threshold L_{Short} is set to a signal level within the range $L_{\text{Upper_Short}}$ to $L_{\text{Lower_Short}}$ at the input of the receiver (or an equivalent if the receiver measures signal quality).

L_{Squelch} is set at a level determined by the MS manufacturer which enables unsuitable physical channels to be rejected on which the received signal is inadequate for a suitable grade of service (or an equivalent if the receiver measures signal quality).

NOTE: The MS may be unable to determine the received signal level but may use other methods such as bit error measurements to determine the signal quality.

Annex E (informative): Bibliography

- ETSI TR 102 335-2: "Electromagnetic compatibility and Radio spectrum Matters (ERM); System reference document for harmonized use of Digital Mobile Radio (DMR); Part 2: Systems operating under individual licences in the existing land mobile service spectrum bands".

History

Document history		
V1.1.1	January 2006	Publication