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Part 16: Network Performance Metrics

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Foreword

This Technical Specification (TS) has been produced by ETSI Project Terrestrial Trunked Radio (TETRA).

The present document is part 16 of a multi-part deliverable covering the Voice plus Data (V+D), as identified below:

EN 300 392-1: "General network design";

EN 300 392-2: "Air Interface (AI)";

EN 300 392-3: "Interworking at the Inter-System Interface (ISI)";

ETS 300 392-4: "Gateways basic operation";

EN 300 392-5: "Peripheral Equipment Interface (PEI)";

EN 300 392-7: "Security";

EN 300 392-9: "General requirements for supplementary services";

EN 300 392-10: "Supplementary services stage 1";

EN 300 392-11: "Supplementary services stage 2";

EN 300 392-12: "Supplementary services stage 3";

ETS 300 392-13: "SDL model of the Air Interface (AI)";

ETS 300 392-14: "Protocol Implementation Conformance Statement (PICS) proforma specification";

TS 100 392-15: "TETRA frequency bands, duplex spacings and channel numbering";

TS 100 392-16: "Network Performance Metrics";

TS 100 392-17: "TETRA V+D and DMO Release 1.1 specifications".

Introduction

The TETRA standard is intended to be an open standard that will support a multi-vendor market. In order to support this goal, it is necessary to have a common understanding of the parameters that affect a network's performance and how they can be measured. This is the scope of the present document. Further work may be carried out on values for some of these measured parameters, so that manufacturers and especially network operators can present a consistent quality of service to users of a network whilst supporting a multi-vendor environment.

1 Scope

The present document defines a series of network performance metrics that are applicable to TETRA networks, whose measurement and reporting makes it possible to know the impact of adding new terminals or new infrastructure to an existing TETRA network. Network performance parameters, inherent within a network, include those, which affect to the quality of an "end-to-end" connection as experienced by a subscriber. A network performance parameter may be considered as a function of the operation of the elements involved to form a connection, network load, network signalling and the processing required to realize a connection.

Requirements on the measured values are outside the scope of the present document.

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 300 903: "Digital cellular telecommunications system (Phase 2+) (GSM); Transmission planning aspects of the speech service in the GSM Public Land Mobile Network (PLMN) system (GSM 03.50)".

[2] ETSI EN 300 392-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[3] ITU-T Recommendation P.38: "Transmission characteristics of operator telephone systems (OTS)".

3 Definitions, symbols and abbreviations

3.1 Definitions

The definition for a specific network performance parameter or metric has been included in the annex applicable.

For the purposes of the present document, the terms and definitions given in EN 300 392-2 [2] and the following apply:

egress: elements within a network that comprise the output portion of an end-to-end connection between calling and called subscribers

end-to-end: scenario referred to a connection between the calling and called subscribers or applications (which may include more than one TETRA SwMI)

ingress: elements within a network that comprise the input portion of an end-to-end connection between calling and called subscribers

listener: subscriber who is currently receiving communication from the "talker"

network: network comprises all the elements required to provide the services available for the calling and, or, called subscriber including the users' apparatus as appropriate

NOTE: This definition of network is in contrast to the definition in the other parts of TETRA standards, where the word Network refers to the fixed part of the networks, also called SwMI without inclusion of radio terminals.

subscriber A: call originating user

NOTE: In other parts of TETRA standards "subscriber A" is also referred as "user A".

subscriber B: call receiving user

NOTE: In other parts of TETRA standards "subscriber B" is also referred as "user B".

talker: subscriber who is currently communicating with the "listener"

3.2 Symbols

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

E	Egress
E_R	Egress R reference point
E_{R1}	Egress R_1 reference point
ERP	Ear Reference Point
E_S	Egress S reference point
E_T	Egress T reference point
E_U	Egress U reference point
E_{U1}	Egress U_1 reference point
E_{Un}	Egress U_n reference point
E_V	Egress V reference point
E_{Vn}	Egress V_n reference point
E_W	Egress W reference point
I	Ingress
I_R	Ingress R reference point
I_{R1}	Ingress R_1 reference point
I_S	Ingress S reference point
I_T	Ingress T reference point
I_U	Ingress U reference point
I_{U1}	Ingress U_1 reference point
I_V	Ingress V reference point
I_{Vn}	Ingress V_n reference point
I_W	Ingress W reference point
ms	milliseconds

3.3 Abbreviations

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

BS	Base Station
GSM	Global System for Mobile communications
IMP	Intermediate Monitoring Point
ISI	Inter-System Interface
MOS	Mean Opinion Score
MRP	Mouth Reference Point
PLMN	Public Land Mobile Network
OLR	Overall Loudness Rating

POI	Point Of Interconnect
PSTN	Public Services Telephone Network
QoS	Quality of Service
RLR	Receive Loudness Rating
SLR	Send Loudness Rating
SwMI	Switching and Management Infrastructure
TCH	Traffic CHannel
TCL	Terminal Coupling Loss
TETRA	TErrestrial Trunked RAdio

4 Reference model for determination of a metric at an Intermediate Monitoring Point (IMP)

Figure 1 illustrates a model detailing Intermediate Monitoring Points (IMPs) where an intermediate network performance metric may be observed from.

Arrangements to monitor the appropriate information at an intermediate monitoring point, or points, are outside the scope of the present document.

The measurement of a metric may be a combination of the criterion detailed in the following clauses.

4.1 Intermediate Monitoring Point (IMP)

For the purposes of the present document Intermediate Monitoring Points (IMPs) shall be as defined in figure 1. It should be noted that some of the IMPs may be manufacturer specific, or non-existent in a particular network, and that several IMPs may be defined (from I_v to I_{vn} and from E_v to E_{vn}).

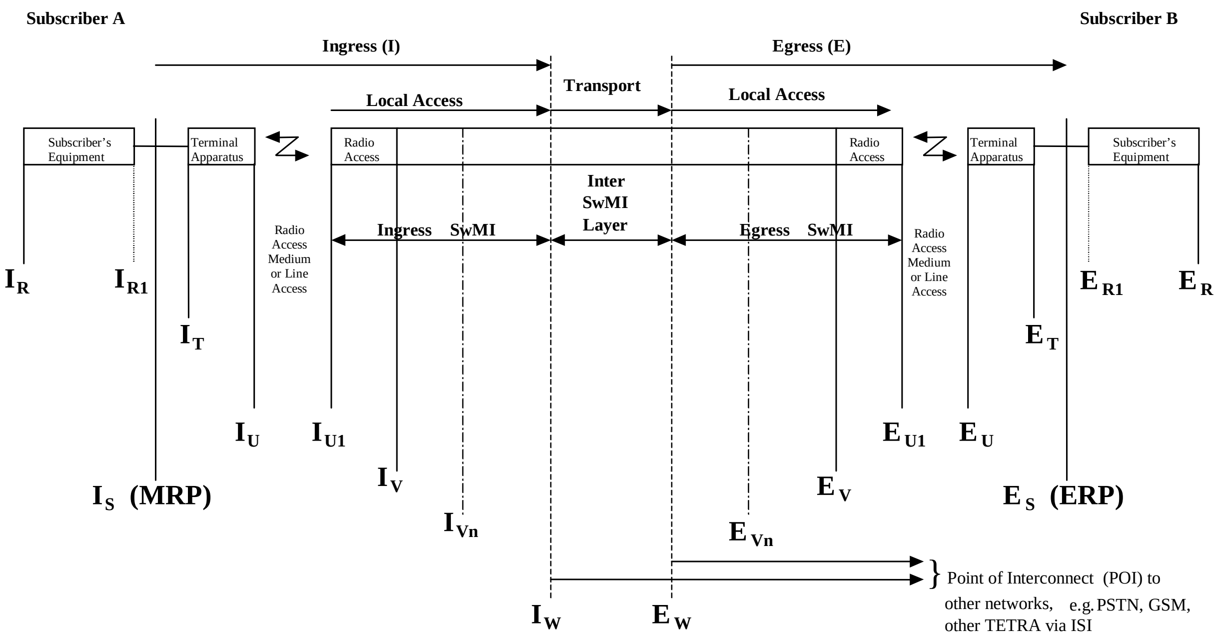

Figure 1: Intermediate Monitoring Point (IMP) model

4.2 Time domain model

Table 1 defines time instances to complement figure 1 to detailing the measurement of a network performance metric at IMPs in association with the time domain.

Table 1: Time domain instances

Time recorded at an IMP	Event	Remark
time t_a	Time when stimuli originating from subscriber A is observed at the given IMP.	The observed IMP may be any ingress or egress point.
time t_b	Time when stimuli originating from subscriber A is observed at the given IMP other than the IMP where time t_a was observed.	The observed IMP may be any ingress or egress point further towards subscriber B than IMP for t_a, so by default time t_a is less than time t_b.
time t_c	Time when network returns a valid response towards subscriber A due to the stimuli originating from subscriber A observed at the given IMP, (see note).	This time instance may be an intermediate or final response to the stimuli originating from subscriber A. Time t_b and time t_c has no pre-defined relationship.
time t_d	Time when network returns a valid response towards subscriber B due to the stimuli originating from subscriber A observed at the given IMP.	The observed IMP may be any ingress or egress point further towards subscriber B, so by default time t_a is less than time t_d.
time t_e	Time when stimuli originating from subscriber B is observed at the given IMP.	The observed IMP may be any ingress or egress point. When used in call set-up scenarios, then by default time t_d is less than time t_e. Time t_d may not have any relation to the measurement.
time t_f	Time when stimuli originating from subscriber B is observed at the given IMP other than the IMP where time t_e was observed.	The observed IMP may be any ingress or egress point further towards subscriber A, so by default time t_e is less than time t_f.
time t_g	Time when network returns a valid response towards subscriber B due to the stimuli originating from subscriber B observed at the given IMP, (see note).	This time instance may be an intermediate or final response to the stimuli originating from subscriber B. Time t_f and time t_g has no pre-defined relationship.
time t_h	Time when network returns a valid response towards subscriber A due to the stimuli originating from subscriber B observed at the given IMP.	The observed IMP may be any ingress or egress point further towards subscriber A other than IMP for t_e, so by default time t_e is less than time t_h.
time t_x	Time when network sends a first command.	The observed time t_x may be in relation of a call independent of observed time t_y in relation to another call.
time t_y	Time when network sends a second command.	The observed time t_y may be in relation of a call independent of observed time t_x in relation to another call.
NOTE: This table identifies only single observation time for a response back to the stimuli generating subscriber although even for that scenario there could be more than a single monitoring point.		

The time domain instances in table 1 are independent of possible interactions between subscriber A and network actions. Especially network may send a message observed at the IMP at time t_c without any stimuli originating from an action at subscriber B at time t_e.

NOTE: Multiple time instance may be observed due to a single stimuli e.g. t_a may be followed by one (t_c) in the direction towards subscriber A and another (t_d) in the direction towards subscriber (or subscribers) B.

As defined in table 1, a network performance metric observed from an IMP, or IMPs, may be determined as time differences e.g. from equations 1, 2 and 3:

Network performance metric time delay on subscriber A point of view = (time t_c) - (time t_a) **(1)**

An unidirectional network performance metric time delay = (time t_d) - (time t_a) **(2)**

Another unidirectional network performance metric time delay = (time t_h t_c) - (time t_e t_b) **(3)**

4.2.1 Measurements at a single IMP

When a network performance metric is measured at a single IMP, with the measurement in the direction towards subscriber B, times t_a and t_c or t_h, refer to table 1, shall be recorded at the same IMP for the purposes of calculation using e.g. equation 1 (e.g.: I_v within figure 1). When the measurement is in the directions towards subscriber A then e.g. times t_e and t_g are applicable.

4.2.2 Measurements between IMPs

When a network performance metric is to be measured from one IMP to another IMP, then almost any combination of times defined in the table 1 may be applicable and the times as appropriate shall be recorded at the appropriate two IMPs for the purposes of calculation (e.g.: between I_v and E_v within figure 1).

4.3 Traffic load

Traffic load may be considered to influence the result obtained when conducting measurements for a network performance metric. Network performance measurements may be considered for load levels of:

a) low traffic load;

b) medium traffic load; and

c) high traffic load.

NOTE: The traffic load definition may depend upon the service under measurement.

4.4 Network infrastructure

Network performance metrics may be considered in accordance with the infrastructure used to realize the connection serving subscribers A and B.

The geographical separation between subscribers A and B may influence the network performance metric result and measurement scenarios should be defined accordingly.

Measurement scenarios could be:

a) subscribers A and B served by the same TETRA Base Station (BS);

b) subscribers A and B are each served by TETRA Base Stations located at the effective extremities of the TETRA Network;

c) one of the subscribers is not served by the TETRA network.

In the scenario c) the network performance measurements may be performed at the Point of Interconnection (POI) between the TETRA network and the other network and be recorded for the TETRA network's portion.

Network performance measurement between monitoring points involving more than one network may be conducted end-to-end or between intermediate monitoring points, as appropriate.

4.5 TETRA services

A Network Performance Metric may be defined for:

a) Voice Services (Full-Duplex) involving a calling and called subscriber;

b) Voice Services (Half -Duplex) involving a calling and called subscriber;

c) Voice Services (Group Calls) involving more than two subscribers;

d) Data Services supporting Short Data Service messaging to and from a subscriber (including Status Messaging);

e) Data Services supporting Packet Data to and from a subscriber;

f) Data Services supporting Circuit Mode Data to and from a subscriber.

The definition of TETRA services is outside the scope of the present document, refer to EN 300 392-2 [2] for details.

When a new service is introduced to TETRA standard, the present document may need to be revised to cover it.

5 Factors affecting to the measurement results

The measurement results are dependent of many parameters, external as well as internal. Also the definition of the time an event has occurred has influence. The actual measurement arrangements should be recorded and results should be used carefully.

The measurements may be used as an aid to find difficulties in the system without actually identifying the reason or reasons. Operators may use the results to obtain a consistent grade of service in a multi-vendor TETRA network.

The identification of reason may require additional measurement equipment or measurement points.

Examples of parameters having influence on the measured values are:

- RF coverage;
- MCCH random access frame length;
- ACCH random access frame length;
- emergency call pre-emption;
- the number of intermediate entities (intra network signal routing);
- a traffic channel queue;
- subscriber access priority; and
- MS transmit permission.

Examples of definitions having influence on the measured values are:

- how the framing delay imposed by frame 18 is to be shared between the speech encoder and speech decoder, when determining the up-link voice delay of a terminal;
- whether a voice signal stimulus is considered as being detected at the air interface of the terminal, when transmission of the first block of two ACELP blocks is starting (start of slot), when both ACELP blocks have been transmitted (end of slot), or when both ACELP blocks have been sent (end of slot) plus the time represented by the displacement of the stimulus location from the start of the first block;
- whether message transmission time instance is at the start of the message transmission (first bit) or when the whole message is sent (last bit); and

- whether message reception time instance is at the reception of the message's first bit, at the reception of the message's last bit or at the completed decoding of the message (including total or partial re-transmissions due to propagation error and delivery to the message user).

One consistent manner to take into account message transmission and reception at the air interface is that:

- the message transmission instance is the time, when the transmission of the timeslot, which contains the message, starts (first bit); and
- the message reception instance is the time , when the message is completely received and delivered to the layer that is the user of the message (last bit plus needed lower layer processing time).

NOTE: Although the above definitions are nice on the air interface protocol point of view, their measurement may not be practicable in typical situations.

Although the present document identifies those factors their detailed mechanisms and how they should be taken into account are outside the scope of the present document.

Annex A (informative): Subscriber A, connection establishment time

A.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with connection establishment time experienced by subscriber A to be manageable. Connection establishment time is an inherent quantity within a network and is experienced by subscribers when invoking connections to be conveyed by the network. The parameter's magnitude may be considered as a function of the operation of elements involved to form the connection, network load, network signalling and the processing required to realize a connection.

NOTE: Clause B.4 discusses interaction between subscriber A and subscriber B connections times.

A.2 Subscriber A, connection establishment time

Connection establishment time: The time span from the instant of the "last key press" from a subscriber's apparatus required to initiate a connection to the instant when a valid supervisory signal or connection confirmation, as appropriate, is returned by the network to that subscriber.

NOTE 1: A valid supervisory signal or connection confirmation may depend upon the type of call being set-up and conditions. For example: For hook signalling, the supervisory signal is the receipt of a "D-Alert" message. Normally a reception of "D-Call Proceeding" message should not be considered as a valid supervisory signal.

NOTE 2: Connection establishment time may be dependent upon the type of call. For Pre-emptive Priority Calls, SwMI actions may be used to minimize call establishment time.

NOTE 3: The connection establishment time as defined in this clause is the same as the time to the through connection as used in EN 300 392-2 [2], clause 14, only in specific situations.

The "end-to-end", Intermediate Monitoring Points (IMPs) and the time model as defined in figure 1, including their supportive clauses, are used in this annex.

A.3 Observation and reporting of connection establishment time

A.3.1 End-to-end connections between subscribers on the subscriber A point of view

To convey connection establishment information to the TETRA network from the calling subscriber A for a called subscriber B, signalling stimuli and response messages are involved. Connection establishment time may be determined for a connection invoked by subscriber A through monitoring the time difference between the instant a valid connection establishment stimuli message is issued (time $\mathbf{t_a}$) and the instant when a valid and appropriate connection establishment response message is received (time $\mathbf{t_c}$ or $\mathbf{t_h}$ as appropriate) at the same monitoring point detailed in figure 1 and table 1.

NOTE 1: Typically this measurement incorporates terminal apparatus (I_T) and may incorporate subscriber's equipment (I_R) processing times and the results are affected by implementation choices.

NOTE 2: End-to-end in this context means that the called subscriber's terminal apparatus has responded to the call set-up and that response has reached back to the calling subscriber.

NOTE 3: The end-to-end connection establishment time on both subscriber A and subscriber B point of view is further discussed in clause B.4.

A.3.2 Intermediate monitoring point in the direction towards subscriber B

Connection establishment time may be determined for a connection at an Intermediate Monitoring Point (IMP) in the direction towards Subscriber B through monitoring the time difference between the instant a valid connection establishment stimuli message is observed (time $\mathbf{t_a}$ at IMP) and the instant when a valid and appropriate connection establishment response message is recognized (time $\mathbf{t_c}$ at the same IMP) as illustrated in figure 1.

NOTE: This measurement method can remove effects of the subscriber equipment and terminal apparatus especially when the measurement is performed by special measurement equipment, for example, at the I_U reference point.

A.3.3 Measurements in-between intermediate monitoring points

Connection establishment time may be determined for a connection in-between Intermediate Monitoring Points (IMPs) by monitoring the time difference between the instant a valid connection establishment stimuli message is observed (time $\mathbf{t_a}$ at an IMP) and the instant when a valid and appropriate connection establishment response message is recognized (time $\mathbf{t_b}$ or $\mathbf{t_c}$ at another IMP) as illustrated in figure 1.

A.3.4 Examples of measurements

Example A, at a single IMP: where TETRA signalling, or similar, may be accessed referred to a "time-stamp", the connection establishment time at a single IMP may be calculated:

- **for voice or circuit mode data connections using hook signalling:** the time difference between the time instant when a "Set-up" message is detected and the time instant when an "Alerting" message is recognized, in this scenario the time instance are t_a and t_c;

- **for voice or circuit mode data connections using direct set-up signalling:** the time difference between time instant when a "Set-Up" message is detected and the time instant when a "Connect" message is recognized, in this scenario the time instances are t_a and t_h (direct call-setup response from subscriber B is generated by the MS not by the actual user).

NOTE 1: In some networks full duplex voice connections always use hook signalling and half duplex voice calls (group calls) use direct set-up signalling. That linkage is outside the TETRA standard, which supports any combination of hook/direct signalling and half duplex/full duplex voice calls for individual calls.

Example B, between IMPs: where TETRA signalling, or similar, may be accessed referred to a "time-stamp", the connection establishment time in-between two IMPs may be calculated:

- **for voice or circuit mode data connections for "a call originated from subscriber A":** the time difference between the time instant when a "Set-Up" message is detected at an IMP close to subscriber A and the time instant when the "Set-Up" message is recognized at a distant IMP, in this scenario the time instances are typically t_b and t_d;

- **for voice or circuit mode data connections using hook signalling for "a call received by subscriber B":** the time difference between the time instant when an "Alerting" message is detected at the distant IMP and the time instant when the "Alerting" message is recognized at the IMP close to the subscriber A, in this scenario the time instances are typically t_e and t_h;

NOTE 2: This scenario assumes that the SwMI implementation generates response towards subscriber A from a "U-Alert" message generated by the subscriber B MS.

- **for voice or circuit mode data connections using direct set-up signalling referred to "a call received by subscriber B":** the time difference between the time instant when a "Connect" message is detected at the distant IMP and the time instant when the "Connect" message is recognized at the IMP close to subscriber A, in this scenario the time instances are typically t_e and t_h.

NOTE 3: The above measurements are a division of example A scenarios into two time durations.

NOTE 4: Although these examples do involve some subscriber B (or subscriber B subscriber apparatus) actions the measurements are intended for subscriber A grade of service measurements. Refer to annex B for subscriber B related measurements.

NOTE 5: For actual measurements exact scenarios indicating which actual messages are used may be needed in order to get comparable results.

Annex B (informative): Subscriber B, connection establishment time

B.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with connection establishment time for the called subscriber B to be manageable. Subscriber B connection establishment time is an inherent quantity within a network and is experienced following subscriber B answering a call invoked by subscriber A. The parameter's magnitude may be considered as a function of the operation of elements involved to form the connection, network load, network signalling and the processing required to realize a connection.

Clause B.4 discusses interaction between subscriber A and subscriber B connection times.

B.2 Subscriber B connection establishment time

Subscriber B connection establishment time: the time span from the instant of the "last key press" from subscriber B's apparatus required to answer a call invoked by subscriber A to the instant when a valid connection confirmation is returned by the network to subscriber B.

NOTE: For direct call set-up, the "last key press" is considered to be the sending of the "U-Connect" message by subscriber B apparatus.

B.3 Observation and reporting of subscriber B connection establishment time

B.3.1 Subscriber B connection establishment time

To convey a connection establishment confirmation to the TETRA network from called subscriber B (following a connection establishment request from subscriber A), signalling stimuli and response messages are involved. Subscriber B connection establishment time may be determined for a connection invoked by subscriber A by monitoring the time difference between the instant a valid connection establishment acceptance message is issued (time $\mathbf{t_e}$ subscriber B "last key press") compared to the instant when a valid and appropriate connection establishment confirmation message is received (time $\mathbf{t_g}$) at the Intermediate Monitoring Point detailed in figure 1. Subscriber B connection establishment time is then calculated by equation:

Subscriber B connection establishment time = **(time $\mathbf{t_g}$) - (time $\mathbf{t_e}$).**

B.3.2 Intermediate Monitoring Point in the direction towards subscriber A

Subscriber B connection establishment time may be determined at an Intermediate Monitoring Point (IMP) towards subscriber A by monitoring the time difference from the instant that a valid connection establishment confirmation message is issued by subscriber B (time $\mathbf{t_f}$) compared to the instant when a valid connection establishment confirmation message is recognized (time $\mathbf{t_g}$) at the same IMP as illustrated in figure 1 and table 1. The subscriber B connection establishment time at that IMP can then be calculated using equation:

Subscriber B connection establishment time = **(time $\mathbf{t_g}$) - (time $\mathbf{t_f}$).**

B.3.3 Measurements in-between Intermediate Monitoring Points

Subscriber B connection establishment time may be determined for a connection in-between Intermediate Monitoring Points (IMPs) in the direction towards subscriber A by monitoring the time difference between the instant a valid connection establishment confirmation message is observed (e.g. time $\mathbf{t_f}$ $\mathbf{t_b}$) at one IMP compared to the instant when a valid and appropriate connection establishment confirmation message is recognized (e.g. time $\mathbf{t_g}$) at another IMP illustrated in figure 1. The subscriber B connection establishment time at the in-between IMPs can then be calculated using equation:

Subscriber B connection establishment time = **(time $\mathbf{t_g}$) - (time $\mathbf{t_f}$).**

NOTE: This scenario is different than the one in clause B.3.2 although the same time instance name is used, refer to note in table 1.

B.3.4 Examples of measurements

Example A, at subscriber B: where TETRA signalling, or similar, may be accessed referred to a "time-stamp", the subscriber B connection establishment time may be calculated as the time difference between the instant subscriber B issues the last key press to answer the incoming call and the time instant when a "Connect Acknowledgement" message is recognized at subscriber B's apparatus, refer to clause B.3.1.

Example B, between subscriber B and an IMP in the direction towards subscriber A: where TETRA signalling, or similar, may be accessed referred to a "time-stamp", the subscriber B connection establishment time at an IMP may be calculated as the time difference between the time instant of the subscriber B issued "Connect" message to the incoming call and the time instant when the "Connect Acknowledgement" message is recognized at an IMP in the direction towards subscriber A, in this scenario time instances are typically t_e and t_g.

Example C, between two IMPs: where TETRA signalling, or similar, may be accessed referred to a "time-stamp", the subscriber B connection establishment time at two IMPs may be calculated as the time difference between the time instant of the subscriber B issued "Connect" message to the incoming call is detected at an IMP in the direction towards subscriber A and the time instant when a "Connect Acknowledgement" message is recognized at another IMP in the direction towards subscriber B, in this scenario time instances are typically t_h and t_g.

B.4 Interaction between subscriber A and subscriber B connections times

Through connection establishment time: the time span from the instant of the "last key press" from subscriber A's apparatus to the instant when a voice or circuit mode data path is established between subscribers A and B.

Connection times defined in annex A and in clauses B.1 to B.3.4 interact in the calculation of the through connection time and there is no single equation for the calculation in a general scenario.

In a network, time instances $\mathbf{t_g}$ and $\mathbf{t_h}$ can be arranged so that the voice or circuit mode data path is available before the traffic sending party is permitted to start transmission. That may affect the user perception of the call set-up time e.g. in the cases:

- the called subscriber B receives a "Connect Acknowledgement" message, but the calling subscriber A side has a traffic channel queue;
- the calling subscriber A receives a "Connect" message, but the called subscriber B side has a traffic channel queue and the called subscriber B will get the first permission to transmit.

NOTE: Total call set-up time on the subscribers' point of view may be defined from t_a to t_g or t_h as appropriate. In this case t_g or t_h are instances of the reception of the transmit allocations.

Annex C (informative): Disconnecting user initiated connection release time

C.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with connection release time to be manageable. Connection release time is an inherent quantity within a network and is experienced by subscribers when releasing connections through that network. The parameter's magnitude may be considered as a function of the operation of elements involved, network load, network signalling and the processing required to realize the connection release. The time duration for a network to return to its dormant state following a subscriber's connection release request may influence the network's total call attempt capacity.

C.2 Disconnecting user initiated connection release time

Disconnecting user initiated connection release time: the time span from the instant of the "last key press" (from a subscriber's apparatus) to release a connection to the instant when a valid release confirmation is returned by the network to the subscriber.

Total connection and resource release comprises also release of the other subscriber or subscribers in the call and it may be useful to extend the measurement to cover also the other subscribers.

C.3 Observation and reporting of connection release time

C.3.1 End-to-end connection release between subscribers

For an established connection between subscribers, connection release information is conveyed by signalling stimuli and response messages to/from the TETRA Network following a subscriber's "last key press" to release the connection. Connection release time, experienced by the subscriber who releases the connection, may be determined through monitoring the time difference between the instant a valid "key press" (or equivalent) is made to release the connection (e.g. time $\mathbf{t_a}$ or time $\mathbf{t_e}$) to the instant when a valid and appropriate connection release message is received (e.g. time $\mathbf{t_c}$ or time $\mathbf{t_g}$) at the monitoring point detailed in figure 1 (e.g.: I_T or I_R as appropriate in figure 1).

the end-to-end connection release includes also release of the other than the disconnection initiating subscriber release and from the network point of view the disconnection time instance is when the last valid and appropriate connection release message is received (any of the times $\mathbf{t_c}$, $\mathbf{t_d}$, $\mathbf{t_g}$ or $\mathbf{t_h}$) at the monitoring point related to the last subscriber in the released call.

C.3.2 Subscriber connection release at Intermediate Monitoring Point

Connection release time may be determined at an Intermediate Monitoring Point (IMP) for the subscriber who releases the connection by monitoring the time difference between the instant a valid connection release stimuli message is observed at an IMP (time $\mathbf{t_a}$ or $\mathbf{t_e}$ as appropriate) and the instant when a valid and appropriate connection release response message is recognized at the same IMP (time $\mathbf{t_a}$ or $\mathbf{t_g}$ as appropriate) as illustrated in figure 1 (e.g.: I_U). The connection release request may be issued by either the "near" or "far" end subscribers.

Also in this case measurements of disconnection of all subscribers in the call may be appropriate, refer to clause C.3.1.

C.3.3 Measurements in-between Intermediate Monitoring Points

Connection release time may be determined for a connection in-between Intermediate Monitoring Points (IMPs) by monitoring the time difference between the instant a valid connection release stimuli message is observed at an IMP (e.g. time $\mathbf{t_b}$) and the instant when a valid and appropriate connection release response message is recognized at another IMP (time $\mathbf{t_c}$) as illustrated in figure 1.

C.3.4 Examples of measurements

Example A, from a single IMP from the disconnecting subscriber point of view: where a TETRA, or similar, "disconnect" message may be accessed referred to a "time-stamp", the connection release time at one IMP may be calculated:

- **For voice and circuit mode data connections:** the time difference between the time instant when a "disconnect" message is detected compared to the time instant when a "release" message to the disconnecting subscriber is recognized, in this scenario time instances are e.g. t_a and t_c.

Example B, between IMPs: where a TETRA, or similar, "release" message may be accessed referred to a "time-stamp", the connection release time in-between IMPs may be calculated:

- **For voice and circuit mode data connections:** the time difference between the time instant when a user "release" message is detected at an IMP compared to the time instant when the "release" message is recognized at another IMP, in this scenario time instances are e.g. t_b and t_c.

Example C, total call release: where a TETRA, or similar, "release" message may be accessed referred to a "time-stamp", the connection release time at one or more IMPs may be calculated:

- **For voice and circuit mode data connections:** the time difference between the time instant when a "release" message is detected at an IMP compared to the last time instance when the or "release" message is recognized for the last subscriber in that call at the same or another IMP, in this scenario time instances are e.g. t_b and t_d.

Annex D (informative): One-way time delay

D.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with one-way time delay to be manageable. One-way time delay is an inherent quantity within a network and may be experienced by subscribers when communicating over established end-to-end connections within a network. The parameter's magnitude may be considered as a function of the elements involved to form the established connection, network load and the processing required to realize an established end-to-end connection. Excessive one-way time delay may be perceived by a subscriber as the hesitancy in the far-end subscriber responding during conversation or the perception of talker echo signals. For circuit mode data connections an excessive delay may also affect, for example, the performance of re-transmission protocols.

NOTE: Actually the user experiences the sum of one-way delays in both directions.

D.2 One-way time delay

One-way time delay: One-way time delay is the time taken by a signal applied at the input of an equipment to reach the output of that equipment, where the equipment may be an end-to-end connection.

D.3 Observation and reporting of time delay

D.3.1 End-to-end connections between subscribers

To convey information (e.g.: voice or circuit mode data) between subscribers connected by a network a time delay is experienced between the signal presented (by the "transmitter") and the signal received (by the "receiver"). One-way time delay may be determined for a connection between subscriber A and subscriber B by monitoring the time difference between the instant a defined voice or circuit mode data signal stimuli is applied (figure 1, e.g. time $\mathbf{t_a}$) and the instant when the same voice or circuit mode data signal stimuli is recognized at the far-end (figure 1 and table 1, time $\mathbf{t_d}$). The reference points are considered to be at user access points such as I_R, I_S or I_T and E_R, E_S or E_T.

For circuit mode data connections a predefined data pattern may be used as the signal stimuli.

NOTE: In the scenarios of this annex the subscriber A and subscriber B identifiers are used although they may not refer to the calling and called user of the call but to the source and destination subscribers in the actual measurement.

D.3.2 Measurements in-between Intermediate Monitoring Points

One-way time delay may be determined for a connection in-between Intermediate Monitoring Points (IMPs) by monitoring the time difference between the instant a voice or circuit mode data signal stimuli is observed (time $\mathbf{t_a}$) at an IMP and the instant when the same voice or circuit mode data signal stimuli is recognized at another IMP (time $\mathbf{t_b}$) as illustrated in figure 1 and table 1.

The IMPs may also be the user access points such as I_R, I_S and I_T and E_R, E_S or E_T for direct one-way time delay measurement, refer to clause D.3.1.

D.3.3 Two-way time delay measurement

Two-way time delay may be determined for a connection at a single Intermediate Monitoring Point (IMP) by observing the time difference between the instant (time $\mathbf{t_a}$) a defined signal stimuli in the direction towards the far end and the instant (time $\mathbf{t_h}$), when the defined signal stimuli in the direction from the far end is recognized at the same IMP as illustrated in figure 1 and table 1. The measurement requires a loop back connection at the far end e.g. at E_R, E_S or E_T.

The two-way time delay measurement is possible only when the connection is a full duplex circuit.

D.3.4 Examples of measurements

Example A, at user access point: measurement of two-way time delay for a duplex voice or circuit mode data connection may be performed on an established end-to-end connection by observing the difference in time between the instant when a defined voice or circuit mode data signal stimuli is applied at a monitoring point (e.g.: I_S in figure 1) and the time instant when a recognizable version of the applied voice or circuit mode data signal stimuli is detected at the same monitoring point (e.g.: I_S in figure 1). Arrangements are required at the far-end of the connection to ensure that the received voice or circuit mode data signal stimuli are relayed via a "loop-back" (e.g.: looped at E_s in figure 1). An estimate of the one-way time delay can be calculated by dividing the result by two.

Example B, at an IMP: monitoring two-way time delay of a full duplex call at an Intermediate Monitoring Point (IMP in figure 1) may be performed using the difference in time between the instant when a defined voice or circuit mode data signal stimuli is observed at an Intermediate Monitoring Point (e.g.: I_v in figure 1) and the instant when a recognizable version of the applied signal stimuli is observed at the same Intermediate Monitoring Point (e.g.: I_v in figure 1). Arrangements are required at the far-end of the connection to ensure that the received voice or circuit mode data signal stimuli are relayed via a "loop-back" (e.g.: looped at IMP E_s in figure 1). In this scenario time instances are e.g. t_a and t_h.

Example C, measurements between IMPs: when measurements can be referred to "time-stamps", then monitoring one-way time delay between Intermediate Monitoring Points (IMP in figure 1) may be performed using the difference in time between the instant when a defined voice or circuit mode data signal stimuli is observed at an Intermediate Monitoring Point (e.g.: I_v in figure 1) and the instant when a recognizable version of the applied signal stimuli is observed at another Intermediate Monitoring Point (e.g.: I_w in figure 1). In this scenario time instances are e.g. t_a and t_d.

Annex E (informative): Voice quality

E.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with voice quality to be manageable. Subscribers' perception of "end-to-end" voice quality is influenced by all the losses comprising the connection between the subscribers, including acoustic, physical, electrical and coding losses inherent within the connection. Voice quality performance is typically specified and measured between the Mouth Reference Point (MRP), Ear Reference Point (ERP) and an Intermediate Monitoring Point (IMP) in terms of loudness ratings and Mean Opinion Score (MOS).

NOTE: The mean opinion score measurements are outside the scope of the present document.

E.2 Voice quality

Voice quality: measurement which takes account of all the acoustic and electrical losses that comprise a connection between subscribers enabling a representative assessment of the performance of the connection to be reportable.

NOTE: This voice quality measurement assumes a perfect connection without digital transmission errors. The voice quality due to the transmission bit errors and lost speech frames is outside the scope of the current document.

The "end-to-end" and Intermediate Monitoring Points (IMPs) defined in figure 1, including supportive clauses, are referred to within this annex.

For mobile networks EN 300 903 [1] provides guidance related to definition of OLR, SLR and RLR.

It is outside the scope of the present document to define overall, send and receive loudness ratings.

Subscribers' perception of Voice Quality associated with speech "echo" is presented in annex F.

E.3 Observation and reporting of voice quality

E.3.1 End-to-end connections between subscribers

For an established connection between subscribers, voice quality measurements may be made in terms of the Overall Loudness Rating (OLR), from the near-end MRP to the distant ERP (i.e.: between I_S and E_S) as detailed in figure 1.

E.3.2 Intermediate Monitoring Point measurement

For an established connection between subscribers, voice quality measurements may be made, in terms of the Send or Receive Loudness Rating (SLR and RLR), from the near-end MRP or ERP to/from a distant Intermediate Monitoring Point (IMP) as appropriate.

E.3.3 Measurements in-between Intermediate Monitoring Points

Voice quality, in terms of transmission loss (decibels, dB), may be determined for a connection in-between electrical Intermediate Monitoring Points (IMP) through monitoring the loss. As TETRA is a digital communication networks the loss measurement is meaningful when at least one of the reference points is an analog signal reference point such as I_S, E_T or POI as illustrated in figure 1.

NOTE: Loss measurements where signal is converted into a digital signal using a redundancy removing voice codec as in TETRA require a suitable measurement signal. This might be as defined in ITU-T recommendations P.50 and P.501.

E.4 Examples of measurements

The following examples are applicable to full and half-duplex calls.

Example A, connections with terminal handsets.

Example B, connections with handsfree terminals.

Example C, connections with a terminal supporting a headset. The methods given in ITU-T Recommendation P.38 [3] may be used in connection with measurements of SLR and RLR for such terminals.

Example D, connections with terminals in "speaker" mode of operation, including group calls.

Example E, overall loudness between terminals.

Example E1: between terminal handsets or terminals supporting a headset.

Example E2: between terminals handsets/terminals supporting a headset and hands free terminals.

Example E3: between hands free terminals.

Annex F (informative): Echo performance

F.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with communication echo to be manageable. Listener and talker echoes are inherent quantities within a network and may be experienced by either subscriber A or subscriber B following the establishment of a connection. The parameter's magnitude may be considered as a function of the operation of elements involved to form the connection, including terminal apparatus.

NOTE: ITU-T recommendation G.131 has results of the tests of the user perception of connection quality as a function of echo and one-way delay.

F.2 Echo performance

Echo: the perception by the user of speech reverberation(s) within an established connection is referred to as echo. Talker echo refers to the perception by the talker of speech echo, while listener echo refers to the perception of echoes of the talker's speech by the listener.

The "end-to-end", Intermediate Monitoring Points (IMP) defined in figure 1, including their supportive clauses, are used in this annex.

F.3 Observation and reporting of echo performance

Guidance for echo performance observation and reporting is provided within ETSI Standard EN 300 903 [1]. A TETRA network may be considered as a Public Land Mobile Network when referring to these documents.

For Terminal Coupling Loss (TCL), reference is made to ETSI Standard EN 300 903 [1].

NOTE: The EN 300 903 [1] further refers to ITU-T Recommendations G.131 and G.165.

Annex G (informative): Channel re-assignment time

G.1 Scope

This annex defines the measurements and metrics applicable to TETRA networks to enable the effects associated with channel re-assignment time to be manageable. This parameter is applicable for TETRA systems where Traffic CHannel (TCH) resources are queued and may be experienced by subscribers when establishing connections to be conveyed by the network. The parameter's magnitude will impact the effective TCH capacity, call holding times, call attempt volumes and call establishment time.

Channel re-assignment time parameters will apply where normal subscriber connection establishment requests are in a queue for TCH resources.

G.2 Channel re-assignment time

Channel re-assignment time: the time span from the instant of a "Call Clear" to the instant when a traffic channel resource is successfully allocated by the network to another call.

NOTE 1: "Call Clear" is the sending of the appropriate message, e.g.: "D-Release", monitored e.g. at IMP I_U (in figure 1) or the reception of a "U-Disconnect" message monitored e.g. at I_{U1} (in figure 1).

NOTE 2: The definition of the channel re-assignment time implies that there is a queue for that traffic channel at the time of the "Call Clear" message.

The "end-to-end" and Intermediate Monitoring Points (IMP) and the times defined in figure 1, including supportive clauses, are used in this annex.

G.3 Observation and reporting of channel re-assignment time

Channel re-assignment time may be determined for a connection invoked by subscriber A through monitoring the time difference between the instant of the sending of a "Call Clear" message by the network for an ongoing call (time $\mathbf{t_x}$) at a air interface related IMP and the instant when a Traffic Channel (TCH) resource is allocated to support the new connection (time t_y) (time $\mathbf{t_c}$) at the same IMP detailed in figure 1.

NOTE: The channel re-assignment time as defined is independent of for what reason the call is released.

Annex H (informative): Mobility management success

For further study.

Annex I (informative): Packet data Quality of Service metrics

For further study.

Annex J (informative): Bibliography

- ITU-T Recommendation E.721: "Network grade of service parameters and target values for circuit-switched services in the evolving ISDN".
- ITU-T Recommendation I.352: "Network Performance Objectives for Connection Processing Delays in an ISDN".
- ITU-T Recommendation G.111: "Loudness Ratings (LRs) in an international connection".
- ITU-T Recommendation G.121: "Loudness ratings (LRs) of national systems".
- ITU-T Recommendation G.131: "Control of talker echo".
- ITU-T Recommendation G.165: "Echo cancellers".
- ITU-T Recommendation P.50: "Artificial voices".
- ITU-T Recommendation P.501: "Test signals for use in telephonometry".
- ETSI EN 300 392-1: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 1: General network design".
- ETSI ETR 300-2: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Designers' guide; Part 2: Radio channels, network protocols and service performance".

History

Document history		
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