TETRA
Terrestrial Trunked Radio

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Objectives behind TETRA standard

- Define a digital Professional Mobile Radio (PMR) standard to satisfy the current and future needs of especially Public Safety and other PMR users across Europe
- Unite fragmented PMR markets into one common market - harmonized use of spectrum
- Fulfill European authority co-operation requirements (Schengen Treaty) to enable European Integration – cross-border operation using common frequency spectrum
TETRA is no longer limited to only Europe

- TETRA has been adapted by many countries outside Europe, especially in Asia
- Latin America and Africa also emerging
- In early 2001 TETRA was awarded industry standard status in China
- Several TETRA contracts in China already now
Core TETRA standards and standard interfaces

- Air Interface (AI)
- Voice plus data (V+D)
- Direct Mode Operation (DMO)
- TETRA Speech Codec
- Packet Data Optimized (PDO)

- Inter-System Interface (ISI)
- Peripheral Equipment Interface (PEI)
Interoperability in practice

TETRA Interoperability ensures a multi vendor market with healthy price competition

Today we have wide participation in the interoperability work
What makes TETRA unique

- Instant group communication
- Fast call set-up time
- Direct Mode (DMO)
- Queuing
- Pre-emptive priorities
- Versatile dispatching and fleet management possibilities

- Uncompromising security
  - authentication of radios (and networks)
  - air interface encryption,
  - end-to-end encryption support
  - disabling of stolen radios

- **Access to data** from the field with TETRA data services

- TETRA radio interface is designed and optimized for **circuit voice and packet data**
Operational Management

- Organisations’ own dispatchers manage their own virtual private networks
- Co-operation when needed

Technical Management

Network Management

Co-operation group 1

Authorised dispatcher can modify groups over the air

Physical Radio Network
TETRA TDMA principle

- TDMA (Time Division Multiple Access)
- 4 channels per 25 kHz carrier
- 4 calls per 25 kHz carrier (data or voice)
- Voice and Data can be transmitted simultaneously

SPECTRUM EFFICIENCY

Four user channels multiplexed into one 25 kHz carrier
TM V+D Air Interface

- Air Interface
- Uplink
- Downlink

TETRA Infrastructure

TDMA FRAME

TS = Time Slot

TS 1
TS 2
TS 3
TS 4
**Spectrum Challenges**

**Primary Bands**
Spectrum Available (in almost all European Countries)

- **Emergency Services**
  - 380-385/390-395MHz

- **PMR & PAMR**
  - (amount available varies dependent on country)

- **PMR & PAMR**

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**Little Spectrum Available**
(Requires re-farming in many European Countries, spectrum has so far been allocated to TETRA in ES, P, I, NL and DK)

- **500-512/870-876 / 915-921MHz**
  - Spectrum Available
  - (this band is expected to be used in major urban areas, or for high speed data, or for local networks)
**TETRA service classification**

- TETRA is not only a radio access standard, it is also a standard defining the services and functionality.

- **Bearer services**
  - data transport:
    - packet, circuit, single/multi-slot

- **Teleservices**
  - voice calls:
    - one-to-one, group, broadcast

- Nearly 30 supplementary services:
  - priorities, late entry, DGNA, ...
  - fleet services
  - telephony supplementary services
Voice communication services

- Excellent voice quality
- Fast call set-up
- Individual (one-to-one) calls
- Express calls (push and talk)
- Group communication
  - group calls
  - scanning of groups
  - dynamic regrouping
  - group area
  - broadcast groups
- Emergency calls
- Direct mode
Dispatcher functions

- Group monitoring & communication
- Joining groups
- Preemptive speech item
- Group member list
- Dynamic regrouping
- Broadcast group.
Data communication services

- **Status service**
  - efficient, real time
- **Short Data Service, SDS**
  - text messaging + applications
- **IP packet data**
  - opens the world of network connectivity
- **Circuit mode data**
  - for specialized applications like video surveillance
What data services are defined?

TETRA Voice & Data Standard
- data services -

Short Data
• Status Messaging
• Free format text
  – Basic 140 bytes
  – Advance 256 bytes
• Point-to-point
• Point-to-multi point
• Emergency alarm

Circuit Mode
• Variable data loads
  – 2400 bps
    (high protection)
  – 4800 bps
    (normal protection)
  – 7200 bps (unprotected)
  – up to 28,800 bps on 4
    time slots

Packet Mode
Connection Oriented
• Need to 1st set up a connection
• Protocols used: CONP

Connection Less
• No need to set up a connection 1st
• Protocols used: S-CLNP & SNDCP

TETRA PDO Standard
- Packet Data Optimised -
Status Messaging

• Radio sends a pre coded status message to the console

• Sent from radio keypad or interface
  – Select anyone of 000’s pre-coded numeric messages
  – Radio typically hold 20-100 text alias for most commonly used messages
    • User rarely have to remember a numeric status code
    • Tailored for each agency

• Data sent on control channel, using free capacity
  – Efficient - low system load
  – Instant messaging typically (0.1-2s)
Short Data Service

- Allows messaging to and from a host
  - Via subscribers, consoles and data terminals
  - Allows cellular SMS type messaging
- Simultaneous “voice & short data”
  - Voice is never interrupted
  - Offers user multi tasking opportunities
- Better resource usage
  - Reduces operator contact
  - Faster information flow, through tailored applications
  - Applications can offer cellular type messaging service
  - Message received confirmation
Short Data Service

• Data sent via control channel, using ‘free’ capacity
  – Typically the ‘Main Control Channel’ or ‘Packet Data Channel’
  – Limited data capacity available on voice time slot

• Message length
  – Type 4
    • Basic link 140 bytes (characters) – IOP supported
    • Advanced link 256 bytes – no IOP tests
  – Type 1,2,3
    • Type 1 (1 byte), Type 2 (2 bytes) and Type 3 (8 bytes)

• Data application considerations
  – Very few applications can use Type 1 to 3
  – Application header + payload exceed the capacity
  – No applications seen to date working efficiently on Type 1 to 3
Data Services

- **Additional capabilities**
  - The need to support data intensive applications. Mobile file and image transfer, data base inquiry...

- **Brings critical information to the point of decision**
  - Immediate access to criminal records, stolen cars, warrants
  - On site decision can be made quickly

A4 document: Typically 4 s
Mug shot: Typically 12 s
Circuit Data Services

• Concept used by telephone networks for over 100 years
• Connection maintained for the entire duration of the call
• Called circuit switching as connection is in both directions
• Down side
  – Typically only one user per time slot or channel
  – Application needs to handle lost/corrupted messages
  – Resources tied up, even when not carrying data
    • Air interface and network resources tied up
  – No IOP (Interoperability) testing
• Upside
  – Choose whether application or network provides protection
    • Large available bandwidth at 7.2kps, burden of protection on application
    • Network protected mode reduces vulnerability to radio environment (2.4kps)
  – Ideal network situations, data speeds potentially greater than packet data
Packet Data Services

- **TETRA packet data service** extends the customer IP subnet to the radio terminal
- **No need to open a connection**, data is sent out knowing its destination
- **Receiving terminal**, reassembles the packets into the original data
- **Packet switching offers efficiency**
  - Only uses bandwidth while carrying data
  - Reduces the load on the network
  - Offers IP optimised error correction to improve accuracy & speed
  - Better service interaction
- **Packet data support**
  - Channel allocation efficiencies
  - Channel use efficiencies
  - VPN
### IP Packet Data Channel Allocation

- **Dedicated or dynamic data channels?**

<table>
<thead>
<tr>
<th>Voice</th>
<th>Data</th>
<th>Voice</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voice</strong></td>
<td><strong>Data</strong></td>
<td><strong>Voice</strong></td>
</tr>
<tr>
<td><strong>Dedicated Data Channel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Resource “ring fencing”</td>
<td>• Allocation of channel resources</td>
<td>• Options to “prioritise” user/groups for data capacity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Voice &amp; Data</th>
<th>Voice &amp; Data</th>
<th>Data</th>
<th>Voice</th>
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</thead>
<tbody>
<tr>
<td><strong>Dynamic Data Channel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Voice &amp; data flexibility</td>
<td>• Resource efficient</td>
<td>• Voice priority - returned when needed</td>
<td></td>
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</tbody>
</table>

- **Answer - Both**
  - Customers will have different requirements
IP Packet Data Channel Use

• Exclusive or shared use of a data channel?

Exclusive users
- Single user per channel
- Virtual “Circuit”
  - User camps on channel until job completed
- Suitable for small number of users sending large amounts of data
- Resource hungry

Shared users
- Channel supports multiple & simultaneous data users
- Resources shared between all users
- Greater efficiencies - Greater data throughput

• Answer – Both
  - Users directed to channels with the most appropriate configuration
### TM V+D AI Data Rate Capacities (kbit/s)

**BANDWIDTH ON DEMAND**

<table>
<thead>
<tr>
<th>Number of Timeslots</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Protection</td>
<td>7.2</td>
<td>14.4</td>
<td>21.6</td>
<td>28.8</td>
</tr>
<tr>
<td>Low Protection</td>
<td>4.8</td>
<td>9.6</td>
<td>14.4</td>
<td>19.2</td>
</tr>
<tr>
<td>High Protection</td>
<td>2.4</td>
<td>4.8</td>
<td>7.2</td>
<td>9.6</td>
</tr>
</tbody>
</table>
Direct Mode AI Scenarios

1. INDIVIDUAL CALL

2. GROUP CALL

3. DUAL WATCH

4. MANAGED DIRECT MODE
   DMO terminal is restricted from transmitting unless it receives an authorising signal
Direct Mode AI Scenarios (contd.)

5. DIRECT MODE REPEATER

6. DIRECT MODE GATEWAY

7. DIRECT MODE REPEATER/ GATEWAY

8. MANAGED REPEATER/ GATEWAY
‘Back-to-back’ DMO

Slot Structure

DMO Air Interface

DMO Master

DMO Slave

Pre-emption

Speech Slot

‘Frequency Efficient’ mode can use these timeslots for another call
DMO Repeater Type 1A

DMO Air Interface

Master Slot

Slave Slot

Frequency Usage

DM1

MS RX

1 2 3 4

1 2 3 4

1 2 3 4

1 2 3 4

Pre-Emption Upslot

DMO Master

DMO Slave

(Slave slot pattern moved for diagram clarity)
DMO Repeater Type 2

DMO Air Interface

Uplink Carrier

Downlink Carrier

DMO Master

DMO Slave

Type 2 Repeater

Direct Mode Channel DM1

Direct Mode Channel DM2

Pre-Emption Upslot

DM1 RPT RX

DM2 RPT TX

SPEECH UPSLOT

SPEECH DOWNSLOT

‘B’ channel can use other slots

Uplink Carrier

Downlink Carrier

1 2 3 4 1 2 3 4

1 2 3 4 1 2 3 4

1 2 3 4

1 2 3 4

DM1 RPT TX

DM2 RPT RX

(Slave slot pattern omitted for diagram clarity)
Security

TETRA defined:
• Authentication
• Air-interface encryption

Customer defined for complete security:
• Transmission Encryption
• End-to-end encryption
Typical TETRA Network

TETRA Infrastructure

1a

1b

BS

BS

BS

BS

BS

BS

BS

BS

NMS

5

Another TETRA Network

Remote Line Station (Despatcher)

PSTN, ISDN PDN

4

Central Network Management

3

Central Network Management
TETRA as an IP Network

- Internet
- IP Switching/Routing Network
- TETRA Infrastructure
- Voice/IP
- WAP Terminal
- Database
- LAN Server
- Bluetooth
- Dispatcher
- Control Room Server
- GPS
- Corporate Intranet
- Content Provider
TETRA HSD Road Map

**TERMINALS**

- TETRA R1 terminal
- TETRA R1 terminal
- R1+TAPS terminal
- TAPS terminal
- TETRA R1 terminal
- TEDS terminal
- TAPS terminal
- R1+TAPS terminal

**INFRATECATURE**

- TETRA R1 Base Station
- TETRA R1 Base Station
- TETRA TAPS Base Station
- TEDS
- TAPS
- INTEGRATED TAPS

**Network**

- TETRA R1 Network
- TETRA R2 Phase 1
- TAPS Network
- INTEGRATED TAPS
- TETRA TAPS Network

TETRA R1 max. 28.8kbps
TETRA R2 Phase 1
TAPS max. 384 kbps
TETRA R2 Phase 2
28.8kbps < TEDS < 384 kbps
TETRA Applications - ‘Technocop’

Aerial of the GPS which provides the officer’s location

The ordinary police helmet is transformed into a mobile computer and communications centre

A mini screen, attached to brim, can be pulled down in front of the eye

Miniature camera sending images to control centre

What the officer sees
Maps, files and pictures of criminals can be viewed on screen instantly

Officer can activate screen by voice commands
personal Comms. & info. pack
batteries and the support system
CIS using new antenna technology including an in-built GPS
visor with head-up display
video camera attached to the personal weapon
protective clothing, with built-in telepresence system, i.e. sensors monitoring chemical, rf or radiation attack
The end