DMR Tier III: the Standard and Some Case Studies

THE 8TH FEDERAL CONFERENCE
CRITICAL COMMUNICATIONS RUSSIA

Digital Technologies for National, Social and Business Communications and Security

05.11.2020

Alessandro Guido
DMR System Design, Leonardo S.p.A.
Technical Working Group Laboratory Coordinator, DMR Association

DMR Tier I: Unlicensed

- Products for license-free, non-professional use: PMR446

DMR Tier II: Conventional

- Professional licensed conventional radio systems operating in PMR frequency bands 30 to 1000 MHz. Targeted at users who need smooth migration from analogue with existing spectrum & licensing, spectral efficiency, advanced voice features and integrated IP data services in licensed bands

DMR Tier III: Trunked

- Professional trunking operation in frequency bands 30 to 1000 MHz. The ETSI Tier III standard is derived from MPT1327 and is based on Tier II building blocks and features with plenty of additional added-value features

Current (May 2020) Standard

- ETSI TS 102 361-1 V2.5.1 (2017-10)　　　DMR Air Interface Protocol
- ETSI TS 102 361-2 V2.4.1 (2017-10)　　　DMR Voice and Generic Services
- ETSI TS 102 361-3 V1.3.1 (2017-10)　　　DMR Data Protocol
- ETSI TS 102 361-4 V1.10.1 (2019-08)　　DMR Trunking Protocol

- ETSI TR 102 398 V1.4.1 (2018-11)　　　DMR General System Design

All these documents can be freely downloaded from the
ETSI or DMR Association websites:
www.etsi.org
www.dmrassociation.org

DMR Overview

- <u>12.5 kHz channel compatible with current analogue frequency allocation schemes</u>

- Free combination of tx and rx frequencies (for complex freq. assignments)

- 9.6 kbps gross bit rate

- <u>4FSK modulation: constant envelope for simple RF design</u>

- <u>2 slot TDMA channel => 6,25 kHz equivalent channel: 2 communication paths; permitting forward and reverse transmission on a time division basis</u>

- Built around a 30ms slot structure

- 50% duty cycle slot structure allows

- Transmission can be used either for voice, data or signalling

- Low cost, low complexity

- Great range: same or better link budget then analogue

- Conventional (Tier II), Trunking (Tier III), Simulcast

Voice Features

- Talkgroup Call

- Late Entry (for Talkgroup Call)

- OACSU (Off Air Call Set Up) Individual Call

- FOACSU (Full Off Air Call Set Up) Individual Call

- Priority and Emergency Call

- Broadcast Call (mono-directional)

- All MS Call (mono-directional to pre-defined Talkgroup Addresses)

- Gateway Calls (PSTN, PABX, Dispatch) Half- and Full-Duplex

- Full-Duplex MS to MS Call

Data Features

- Text Messaging over UDT (Unified Data Transfer)

- Text Messaging over UDP/IP

- Location Messaging over UDT (basic approach – smaller fleets)

- Location Messaging over UDP/IP – Location Information Protocol (LIP) (compatible with IP-based localisation SW's)

- Voice associated in-band data features (radio position and talker alias together with speech)

- LIP Positioning (via Unified Single Block Data Polling advanced approach – up to 1000 terminals per minute in one Timeslot of the TDMA channel)

- Generic IP data

- Full-Duplex MS to MS Packet Data Call

Supplementary Features

- Common Dialling Plan

- Talker Identification

- Radio Check

- Short Data Polling

- Status Delivery

- Status Polling

- MS Stun and Revive

- MS Kill

- Answer Call (immediate or deferred)

- Cancel Call

- Call Diversion

- Ambient Listening (if enabled)

- Channel Authorisation (to avoid collisions in Talkgroup Calls)

- Supplementary User Data Transfer (e.g. sensor data at call set-up time)

Supplementary Features (continuation)

- Network System Announcements
- Emergency Alarm (e.g. transmission of alarm status to Control Rooms)
- Emergency Pre-emptive Call
- PTT De-key
- Transmit Interrupt
- MS Dynamic Power Control
- Group Subscription/Attachment
- Dynamic Group Number Assignment
- Trunk Station Control Channel Alternate Slot management
- End-to End Encryption (ARC4, DES, AES128, AES256 – introduced by the DMR Association)
- Possibility of implementing specific encryption algorithms (voice & data)
- Application Interface Specification (AIS - Introduced by the DMR Association; used also in Tier II systems)
- Flexibility to introduce new and/or proprietary features

Application development on DMR technology

- Community of 100's of application developers who are developing vertical market and customer specific applications

Location, Location, Location.	Intelligent Dispatch Solutions	Security, Scanning, Alerting	Monitoring & Control, SCADA	People & Asset Tracking

Customer and requirements

- The Bachatsky Coal Mine, operated by "Kuzbassrazrezugol (KRU)", is in South-West Siberia, north of Kazakhstan. Linear structure: 10 km long and 4 km width; depth up to 300 m

- Previous technology:
  - analogue open channel network, two separate channels for all users, more than 400 radios
  - system was always busy and the coverage was poor

- Main requirements are:
  - providing coverage of the whole mine
  - increased capacity
  - providing high audio quality
  - management of several work groups in the system: mine supervisor, mine transport, blast team, power network, etc.
  - providing high-throughput high-precision location information to the Control Room for persons carrying radios, geofencing to provide an alarm if any of the workers are in the wrong place (e.g. a blast zone) at the wrong time, Control Room integration of location data of mobile devices from legacy AVL system (GSM)
  - man down
  - announce radio users simultaneously with dispatch application about wrong zone
  - at least 4 hours of infrastructure working in case of power cut (to keep communication during blast time)
  - voice recording
  - coping with very low temperatures, up to – 42°C
  - integration with applications developed by local partner
  - frequency band: 400 - 430 MHz

Solution - Network

- **Radio infrastructure**: Tait's DMR Tier III solution based on TB7300 Base stations

  - 2 Base stations, 3 carriers each

  - over 4 hours of infrastructure working in case of power cut

  - interconnected via optical cables with wireless redundancy

- **Control Room:**
  - DIP interface for dispatch application
  - LIP interface for location
  - VR protocol for Voice Recording
  - "Track " software solution developed by Tait's local partner "MPT-Service project" (dispatch +record)
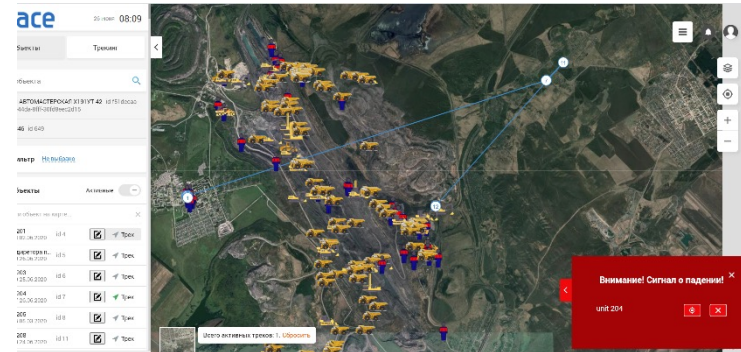 - IP PABX open source Asterisk

DMR
DIGITAL MOBILE RADIO ASSOCIATION

Solution – Terminals

Tait (currently over 400 terminals) will grow to over 500:

- Handhelds: TP9300s
- Mobiles: TM9300s

Tier III Features

- Individual and Group Voice Calls
- PABX Calls
- Localisation both GPS (for handhelds over LIP protocol, for high throughput) and Glonass
- Geofencing providing an alarm both to the Control Center and to the miner, if any of the miners are in the wrong place (a blast zone, for instance) at the wrong time
- Man down

Future Enhancements

- Expand system to the private railway inside the mine for AVL
- Use radio technology for Glonass truck AVL data (currently based on GSM)
- Introduce integration PMR + PoC

Customers and requirements

- Télécommunications de l'Est (TDE), a Category 2 member of the DMR Association, is a Specialised Mobile Radio (SMR) operator offering business telecoms services across a 1,000,000 square km area in eastern Canada, particularly in areas where public mobile phone operator coverage is limited

- Many of these areas have mountainous and rugged terrain, with limited cellular coverage; TDE had already established several analogue VHF radio systems in the region with a total of 75 sites; in order to provide customers with additional services and improved voice quality, TDE choose VHF DMR Tier III as the best solution to increase capacity, expand coverage areas with minimal infrastructure commitments, same or better range than analogue and manage the network efficiently and cost-effectively

- Project to build a public SMR network to replace existing the 75 site analogue stand alone systems, many customers having just few terminals; presently 25 sites are in service and the other 50 replacement of analogue will be installed in 2021; also plan to extend the network after for a total of 125 sites Tier III system

- Requirements: phone patch like cellular style user experience with full duplex; low cost system on site to enable to start small and increase capacity; can work in some cases with only 1 basestation for solar site; POC available; GPS-based AVL, recording available, pre-emption, OTAP and possibility to make special features if needed

- Examples of Users: Société de gestion de la rivière Matane (salmon river management); Municipalité de saint-Adelme (city and truck management); some individual persons in cottages where cellphones are not available; wind farms; fire departments

THE 8TH FEDERAL CONFERENCE
CRITICAL COMMUNICATIONS RUSSIA
Digital Technologies
for National, Social
Organizer: and Business Communications
COMNEWS and Security
CONFERENCES

DMR
DIGITAL MOBILE RADIO ASSOCIATION

Solution - Network

- Radio infra: Simoco's Xd DMR Tier III solution based on SDB680 Basestation
    - MPLS link, internet fiber, cellular connection, UHF link
    - The new network, named Nomad, is available to users across a number of important industrial and economic regions and organizations from a wide range of sectors needing reliable communications in order to manage operations effectively, see https://www.reseaumobilenomade.ca/en
    - Simoco Xd's IP Ethernet-based distributed architecture makes it easy for TDE to expand the Nomad network across wider operational areas; the infrastructure comprises just one core component, the SDB680 Basestation, which is interconnected over IP at both site and multi-site levels providing a completely scalable infrastructure: this provides high resilience at a low cost
- Control Room:
    - Eschat POC integration with AIS
    - GPS webserver provides by Simoco
    - Recorder server by Simoco
    - Asterix phone system with AIS integration
    - Eschat PC application for dispatch need for small customers
    - Work presently with Telex/Bosch to integrate dispatch for a 911 center

Solution – Terminals

Simoco (total 400 terminals; 4000 after analogue switch off) and a few Hytera:

- Handhelds: Simoco SDP760
- Mobiles: Simoco SDM730

Tier III Features

- Individual and Group Voice Calls
- Radio-telephone Calls, both Individual and Group
- Full-duplex Voice Calls
- Pre-emptive Emergency Calls
- Localisation
- Hibernation (for solar-powered sites)
- Encryption (ARC4 planned)
- Over-The-Air-Programming (OTAP)

Other Features

- Integration with Push-to-Talk (PTT) functionality over 3G/LTE commercial networks with Eschat cloud service
- Same user experience as with cell phones
- Private sites connected to the network

Future Enhancements

- SCADA solutions with Simoco's Pulse technology
- Pre-emption for phone calls if available
- Lower cost terminals if available

Customer and requirements

- MPWiK manages the Warsaw Aqueduct for Warsaw region + Pruszkow and Jachranka (3 million people)

- 419-429 MHz with 10 MHz MHz duplex spacing

- MPWiK wanted to replace an analogue multi-site trunking MPT system used till year 2010: 1 Control Channel and 4 Voice Channels with around 300 terminals

- 2015: study of the most suitable choice based on ETSI standards; study of the most suitable vendors, both infrastructure and terminals; followed by field trials

- Up to 2016 MPWiK used GSM and CDMA while preparing a new system based on DMR Tier III with simulcast (first implementation in Poland)

- Constraint: simulcast and DMR were chosen, as they had a license for 5 channels @ 12.5 kHz and the regulator gave them only 1 further channel duplex, now used now for Jachranka extension

- Requirements: network expansion, good coverage, experimentation of SCADA features for industrial automation

- Further requirements: readiness for further expansion of radio coverage and further data features

THE 8TH FEDERAL CONFERENCE
CRITICAL COMMUNICATIONS RUSSIA
Digital Technologies
for National, Social
Organizer: and Business Communications
and Security
COMNEWS CONFERENCES

DMR
DIGITAL MOBILE RADIO ASSOCIATION

Solution - Network

- Local partner: Xentia

- Radio infra: Leonardo's ECOS-D RBS
  - 1 Simulcast macrocell: 5 sites with 4 DMR Tier III carriers each (1 control and 7 payload channels)
  - 1 single cell: 1 site with 1 Tier III carrier
  - 1 Simulcast macrocell: 3 sites with 2 DMR Tier III carriers each
  - GPS and Precise Time Protocol PTP1588V2 for Simulcast management
  - Back-up Control Stations
  - Enhanced Proxy Servers (EPS) to connect RBS and Control Room devices

- Control Room
  - TrboNet dispatcher system
  - License for 300 terminals
  - AVL
  - 6 Tipro BeFree15 dispatcher consoles
  - IPBX

- All full IP equipment: RBS, backbone and Control Room
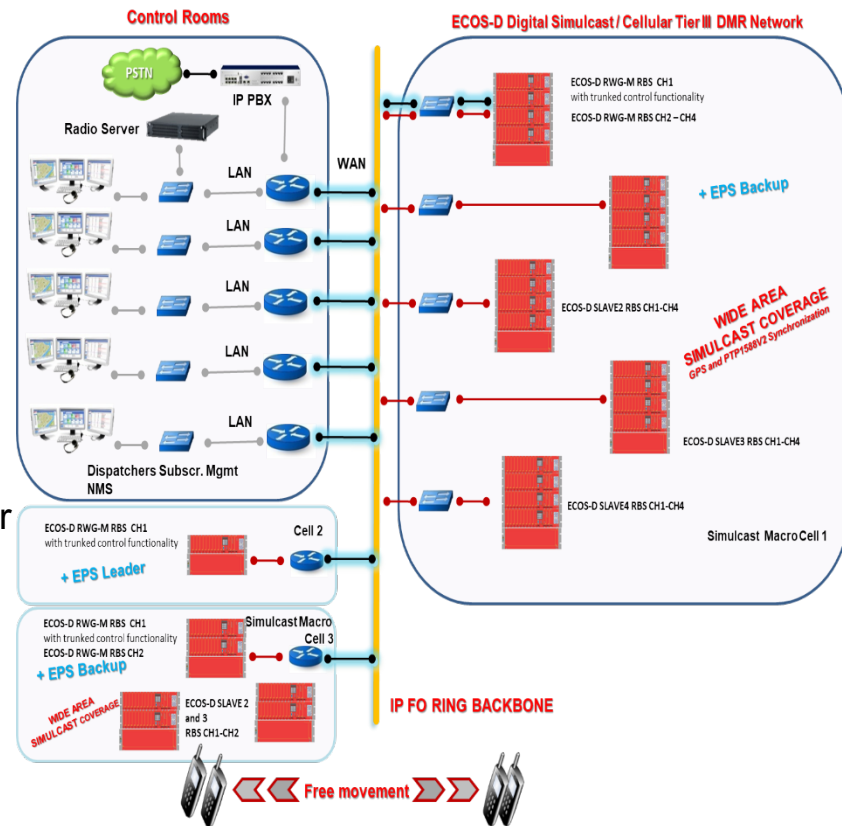
Solution – Terminals

Hytera (total 270 terminals):

- Handhelds: PD785G (210) + PD795Ex (10) + PG985G (2) + X1p (3)

- Mobiles: MD785G (40) + MD785G/AD (5)

Tier III Features

- Individual and Group Voice Calls

- Radio-telephone Calls

- Emergency Alarm

- Emergency Calls

- Emergency Pre-emptive Calls

- Short Data Messages

- Localisation

- ARC4 and AES 128/256 encryption

Possible Feature Enhancements

- SCADA: planned to be finished June 2020; due to COVID-19 end moved to October 2020

- Full-duplex Voice Calls

THE 8TH FEDERAL CONFERENCE
CRITICAL COMMUNICATIONS RUSSIA
Digital Technologies for National, Social
Organizer: and Business Communications and Security
COMNEWS CONFERENCES

DMR
DIGITAL MOBILE RADIO ASSOCIATION

The feature set of DMR Tier III has grown significantly over the past couple of years.

We believe that the combination of radio link performance, set of functions, number of suppliers and simplicity makes DMR the first choice for business critical mobile radio applications.

DMR technology is already supporting 12 Million users worldwide.

DMR
DIGITAL MOBILE RADIO ASSOCIATION

In memory of Tom Johnson

alessandro.guido@leonardocompany.com
https://dmrassociation.org