VERON & VRZA **Zuid Limburg**
17 september 2014
‘t Weverke
Hoofdstraat 77
6333 BG Schimmert

Lezing over DMR door PA7DVM

ETSI
World Class Standards

DMR
DIGITAL MOBILE RADIO ASSOCIATION

Onderwerpen

1. Introductie
2. Digitale Radio’s anno 2014
3. Theorie: Analoog naar Digitaal
4. Theorie: Modulatie technieken
5. DMR
6. Handige website
7. Vragen ronde

Digitale mogelijkheden (Anno 2014)

1. Digital Mobile Radio
   DMR
2. Digital Professional Mobile Radio
   dPMR
3. Digital Smart Technologies for Amateur Radio
   D-Star
4. Terrestrial Trunked Radio
   TETRA
5. Association of Public Safety Communication Officials
   APCO P25
6. Ministry of Post and Telecommunications 1327
   MPT 1327
7. NeXt generation Digital Narrowband
   NXDN

1. DMR

- ETSI Standaard (zie volgende slide)
- Doel: Lage kosten, lage digitale complexiteit om het analoge netwerk te vervangen.
- Heeft 3 modes (Tier I, Tier II, Tier III)
- Voordelen:
  a. Non-proprietary open standard
  b. Commercieel aantrekkelijker tov TETRA en P25
  c. 6.25 kHz kanaal efficiëntie
- Nadelen:
  a. Interface maakt geen deel uit van de standaard
  b. Fabrikanten kunnen extra ‘features’ inbouwen

ETSI DMR Standaard

- ETSI TS 102 361-1 DMR Air Interface Protocol
- ETSI TS 102 361-2 DMR Voice and Generic Services
- ETSI TS 102 361-3 DMR Data Protocol
- ETSI TS 102 361-4 DMR Trunking Protocol
- ETSI TR 102 398 DMR General System Design

- Download: http://dmrassociation.org/

2. dPMR

- ETSI standaard
- DMR gebruikt TDMA
- dPMR gebruikt FDMA
- 3 modes
  1) Mode 1: Peer-to-Peer
  2) Mode 2: Conventional
  3) Mode 3: Trunking

3. D-Star

- Open standaard
- Opgezet door de Japanse regering en de Japanse vereniging van radiozendamateurs (JARL)
- ICOM primaire HW
- Modulatie GMSK
- Nadeel: AMBE spraakcodec is gepatenteerd

4. TETRA

- Non-proprietary open standaard (ETSI)
- 4 slot TDMA
- Interoperabiliteit met andere merken
- Nadelen
  a. Kanalen 25 kHz
  b. Niet “backward compatible”
  c. Vocoder is verouderd

5. APCO P25

- Non-proprietary open standaard
- Analoog FM en/of digitaal P25 mode
- Fase 1 FDMA, C4FM
- Fase 2 TDMA, CQPSK, AMBE+2
- Nadelen:
  a. Fase 1 alleen 12.5 kHz spectraal
  b. Trunked P25 systemen → geen dual-mode

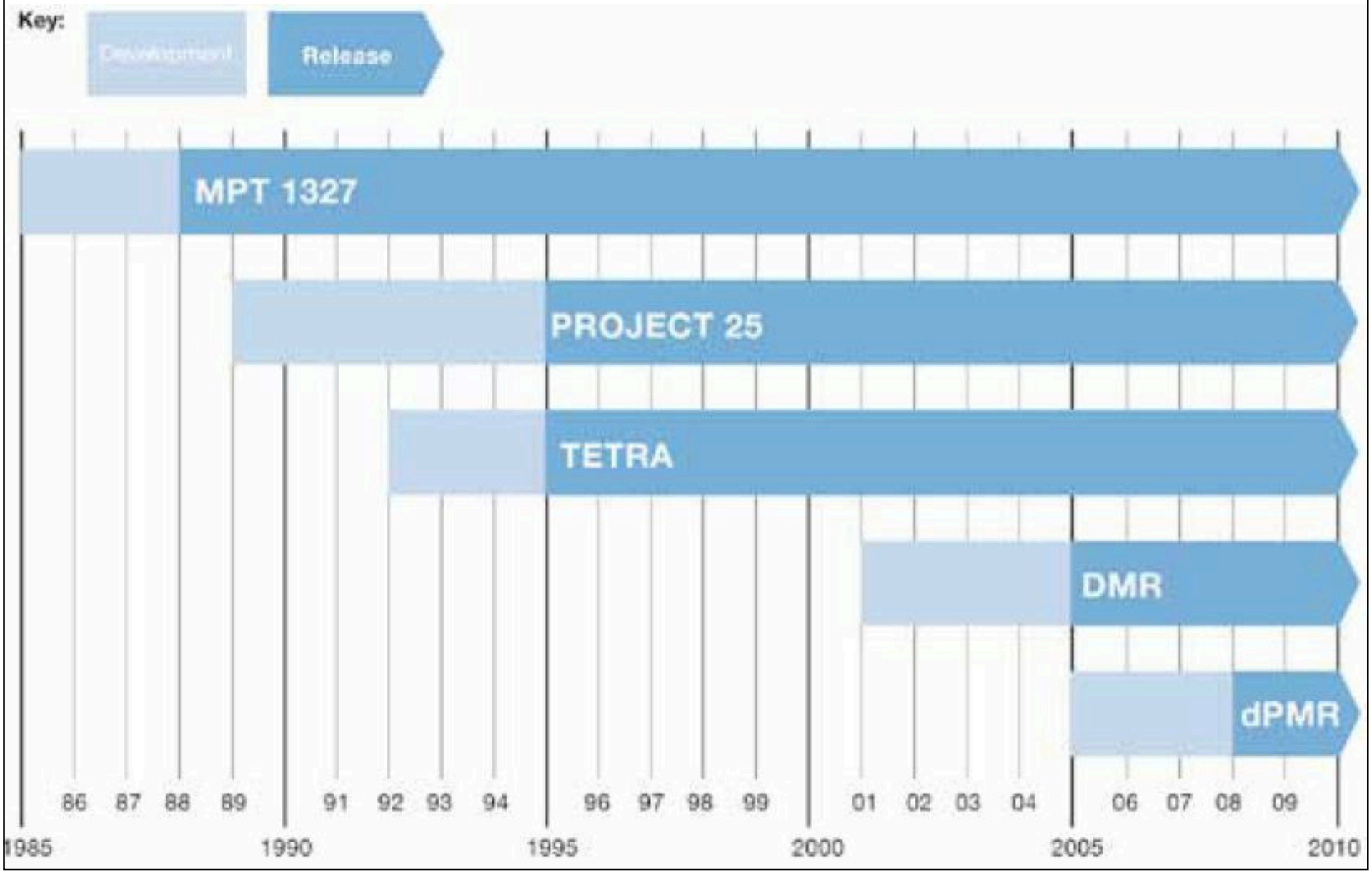
6. MPT 1327

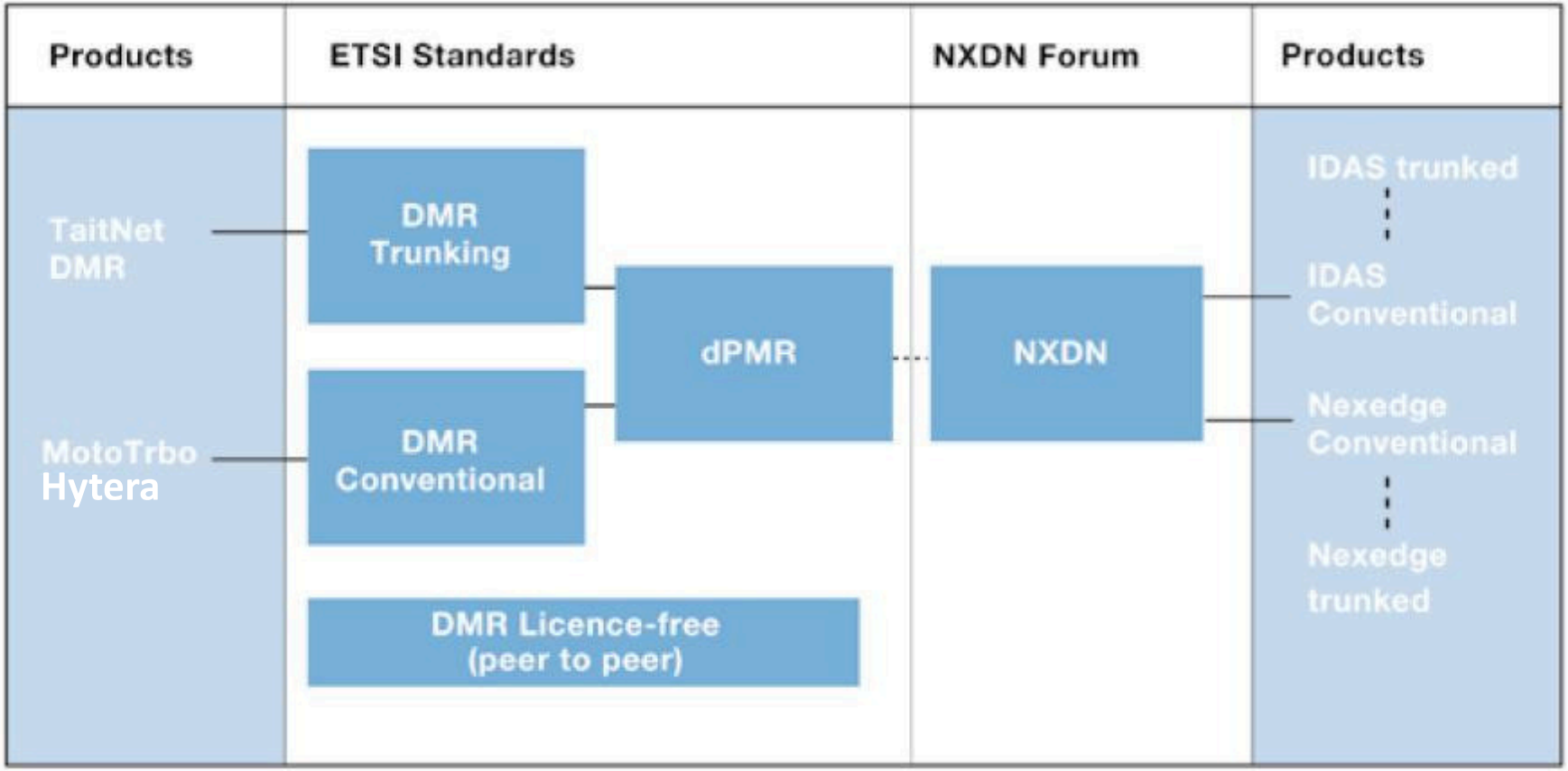
- Non-proprietary open standaard (1988)
- Trunking
- Beheerskosten zijn laag

7. NXDN

- Proprietary maar open
- NXDN is gebasseerd op dPMR (werkt niet samen)
- NXDN: Icom [IDAS] en Kenwood [Nexedge]
- Trunking NXDN tussen Icom en Kenwood niet mogelijk

Digitale ontwikkelingen




Products
ETSI Standards
NXDN Forum
Products
TaitNet DMR
MotoTrbo
Hytera
DMR Trunking
DMR Conventional
dPMR
NXDN
DMR Licence-free (peer to peer)
IDAS trunked
IDAS Conventional
Nexedge Conventional
Nexedge trunked

Selectie

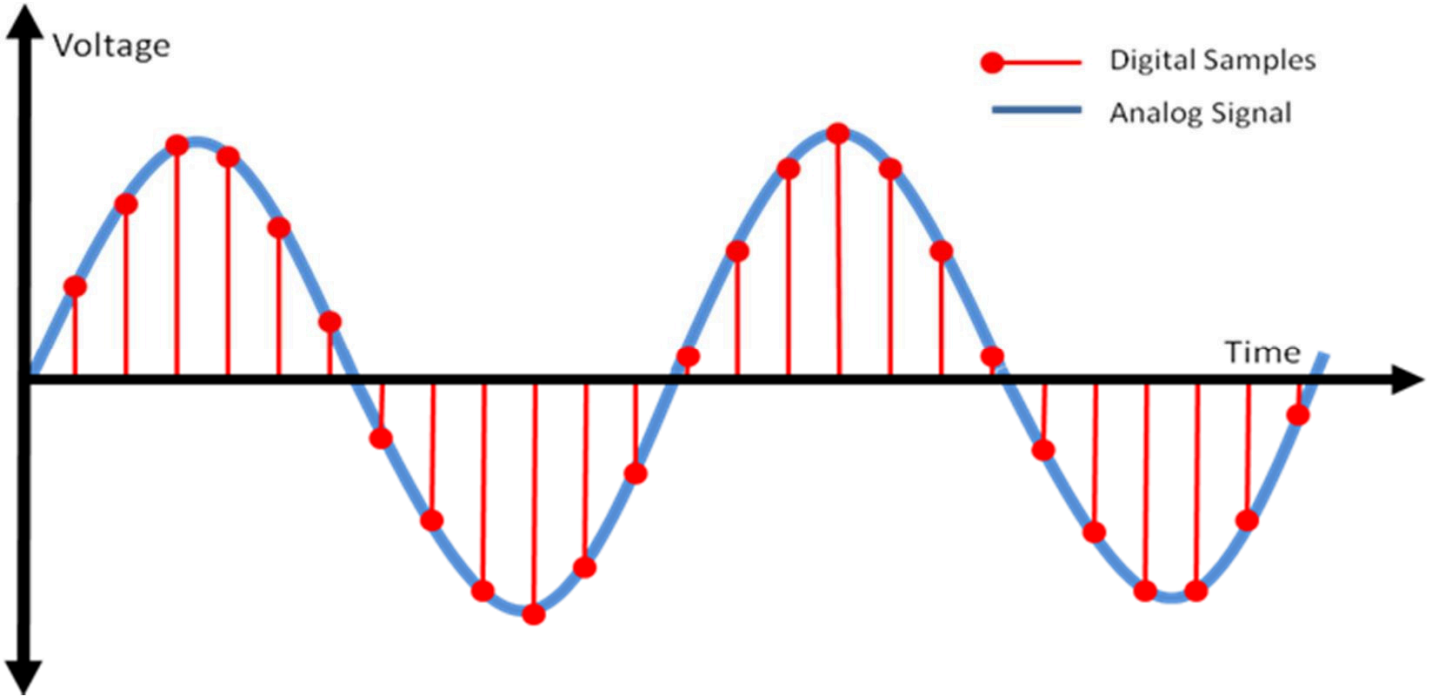
Mission Critical (Public Safety, Defense, Security)	Critical Infrastructure (Utilities, Transportation, PAMR/SMR)	Professional, Business and Industry (Education, Mining, Agriculture, Hospitality)	Commercial (Contruction, Retail, Family (FRS), Sports)
P25 trunked and conv			
	Tetra trunked		
	MPT trunked		
	DMR trunked		
		DMR licensed	
		pDMR licensed	
			DMR unlicensed
			pDMR unlicensed

Samenvatting:
Trunked of Conventional

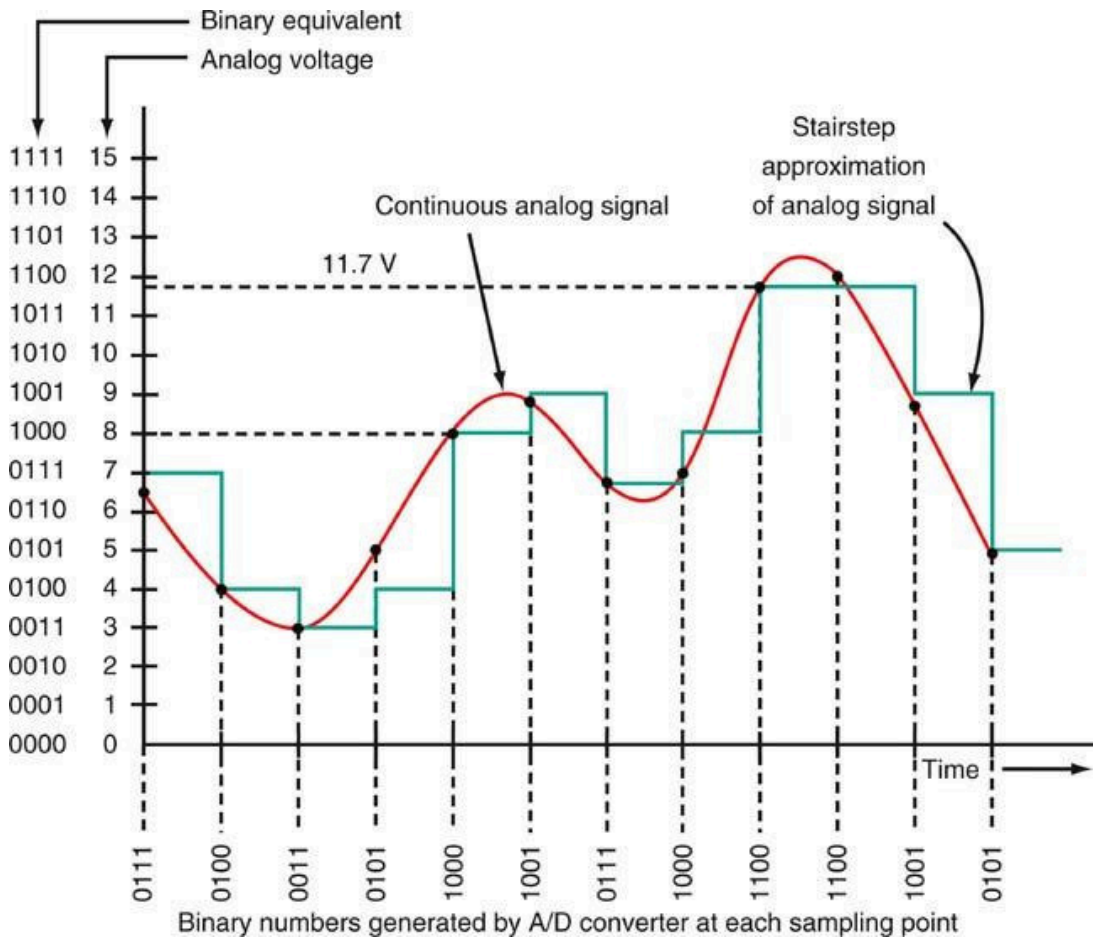
	Trunked	Conventional
DMR	Ja (TIER III)	Ja (TIER II)
dPMR	Ja	Ja
TETRA	Ja	Nee
APCO P25 fase 1	Ja	Ja
APCO P25 fase 2	Ja	Nee (in ontwikkeling)

Theorie

- Analoog → Digitaal
- Radio toegangstechnieken
- Modulatie technieken



Analoog → Digitaal



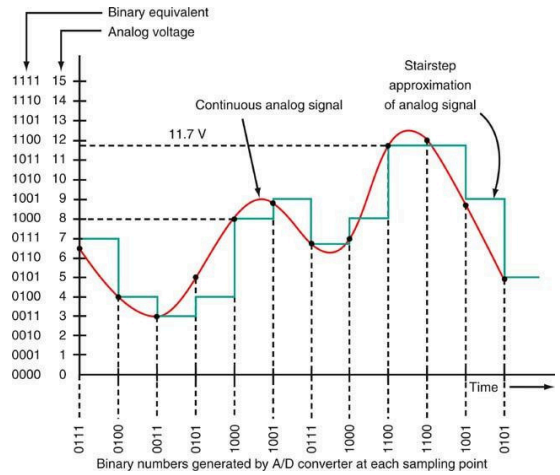
A D/A converter produces a stepped approximation of the original signal

Data Conversion

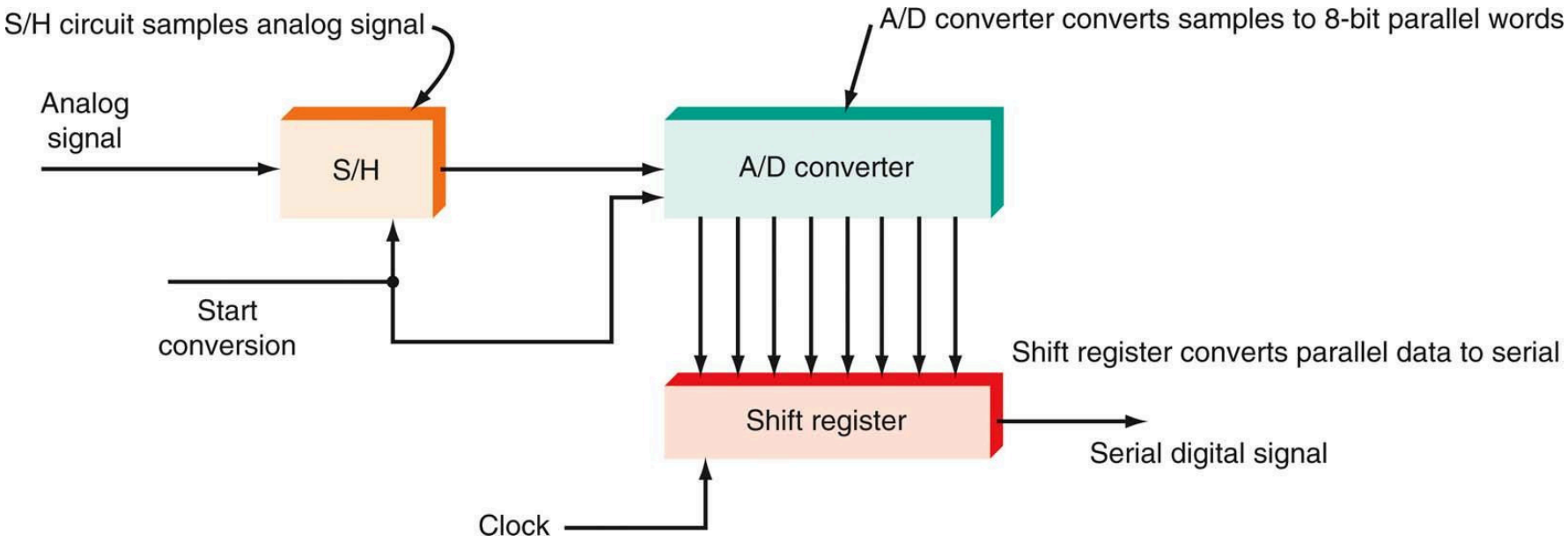
- Common ways to translate an analog voltage to a binary number include:
  - <u>Successive-Approximations Converters:</u>
    - This converter contains an 8-bit **successive-approximations register (SAR).**
    - Special logic in the register causes each bit to be turned on one at a time from MSB to LSB until the closest binary value is stored in the register.
    - The clock input signal sets the rate of turning the bits off and on.
    - Successive-approximations converters are fast and consistent.

ADC Specifications

– The key ADC specifications are
  1. Resolution
  2. Dynamic range
  3. Signal-to-noise ratio
  4. Effective number of bits
  5. Spurious free dynamic range.



PCM



Basic PCM system.

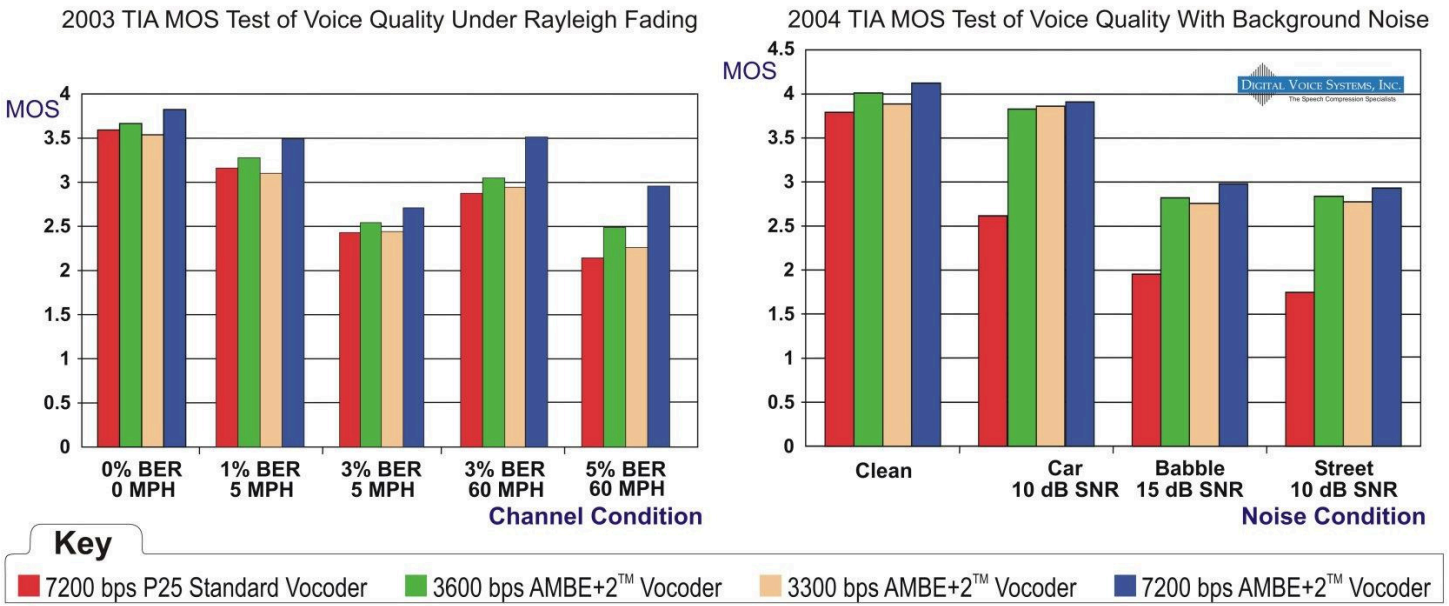
Companding and codecs

Pulse-Code Modulation: Companding and Codecs and Vocoders

- **Companding** is a process of signal compression and expansion that is used to overcome problems of distortion and noise in the transmission of audio signals.
- Companding is the most common means of overcoming the problems of quantizing error and noise.
- All A/D and D/A conversion and related functions, as well as companding, are taken care of by a single large-scale IC chip known as a **codec** or **vocoder**.

Vocoder

- D-STAR: AMBE Vocoder
  AMBE-2000 of AMBE-2020
- P-25 fase 1: IMBE Vocoder
- DMR en P-25 fase 2: AMBE+2 Vocoder



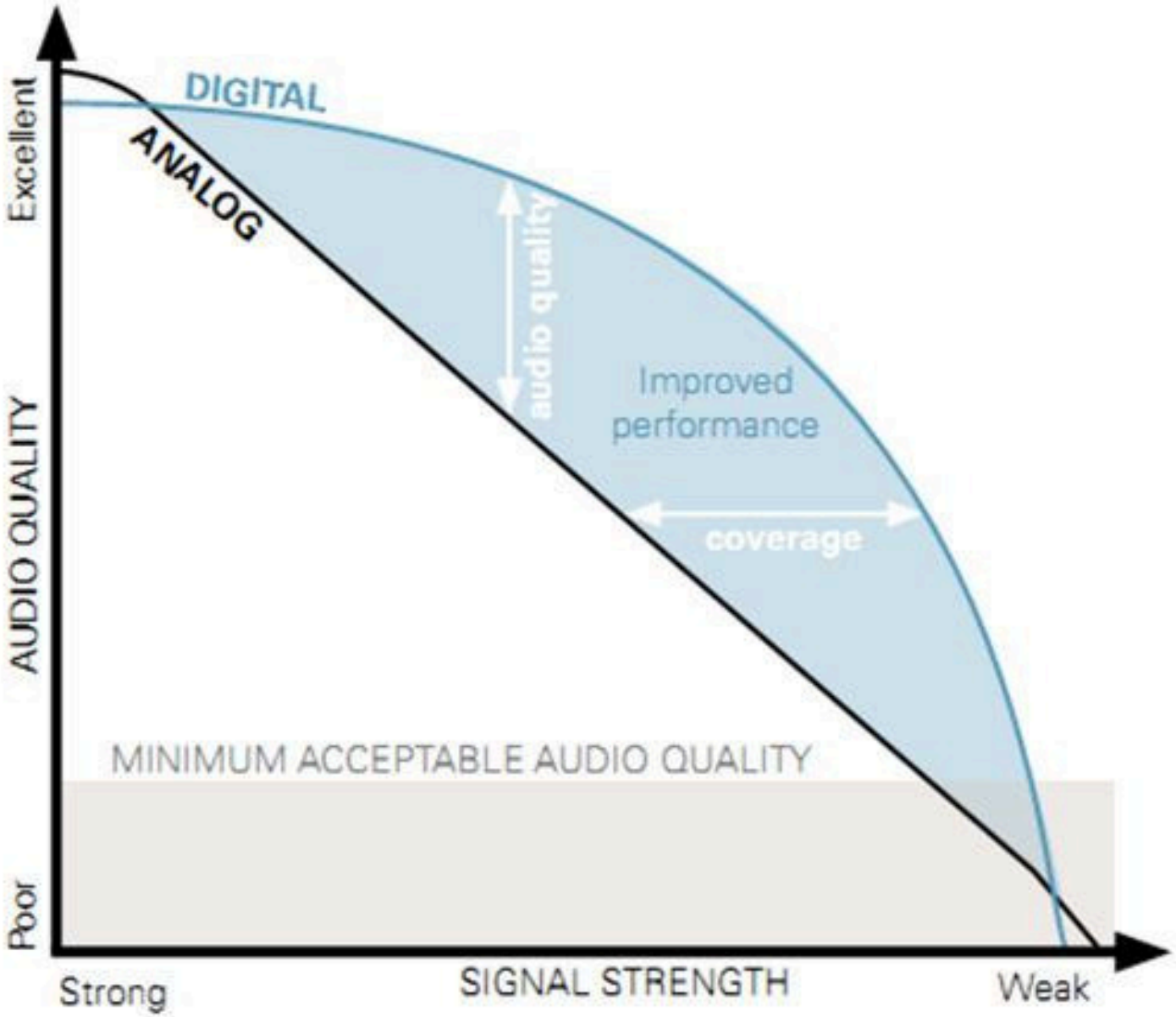
Digital Transmission of Data

Benefits of Digital Communication

1. Noise Immunity: Digital signals, which are usually binary, are more immune to noise than analog signals.
2. Error Detection and Correction: With digital communication, transmission errors can usually be detected and corrected.
3. Compatibility with Time-Division Multiplexing: Digital data communication is adaptable to time division multiplexing schemes. Multiplexing is the process of transmitting two or more signals simultaneously on a single channel.

Digitaal vs Analoog

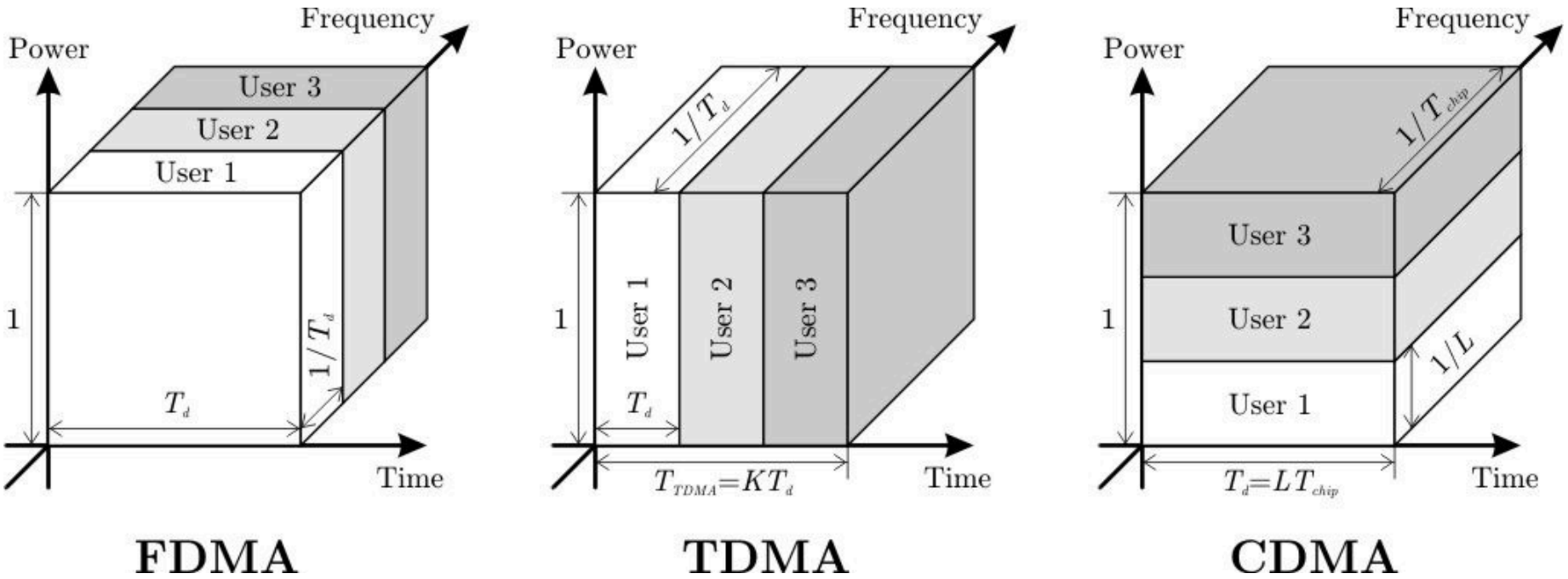
- Analoog
  >> afstand
  >> ruis
- Digitaal
  >> afstand
  audio blijft lange tijd goed tot een kritisch punt
  → interrupties door “packet-loss”
- DMR maakt gebruik van
  “Forward Error Correction (FEC)”
- Digitaal verbuikt 40% minder energie



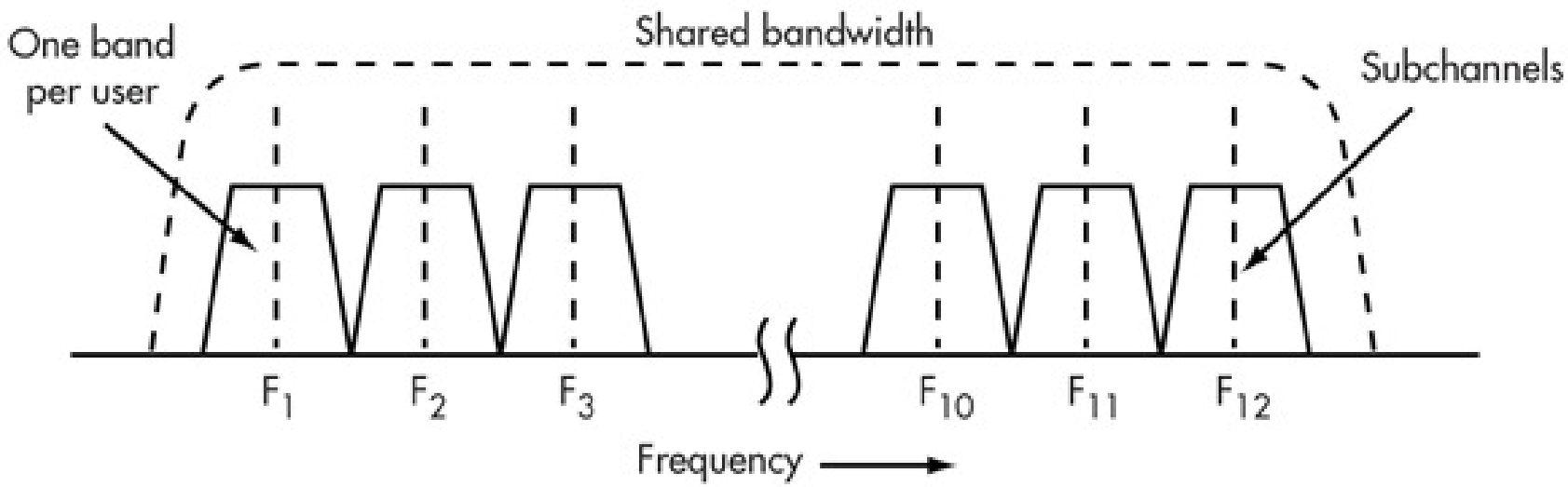
Digital voice retains better quality than analog as signal strength decreases.

Delen van een radiokanaal / communicatie toegang

1. Frequency Division Multiple Access (FDMA)
2. Time Division Multiple Access (TDMA)
3. Code Division Multiple Access (CDMA)



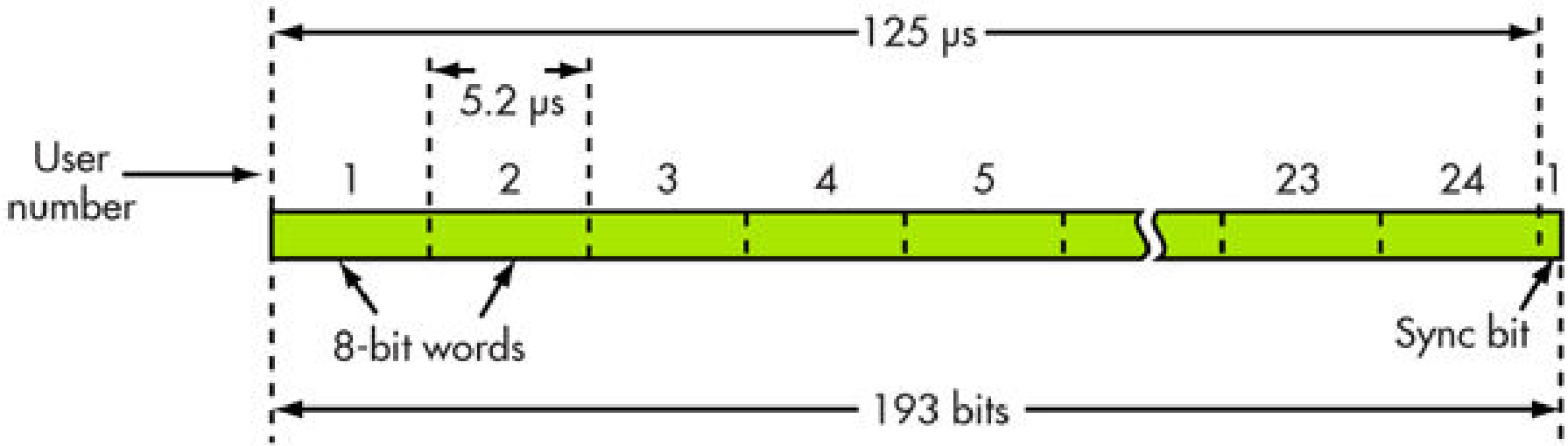
FDMA



Voorbeelden FDMA:

1) Kabel TV
2) Glasvezel kabel transmissie

TDMA



Voorbeelden:

1) Telefonie (T1 transmissie systeem)
2) GSM

DMR TDMA

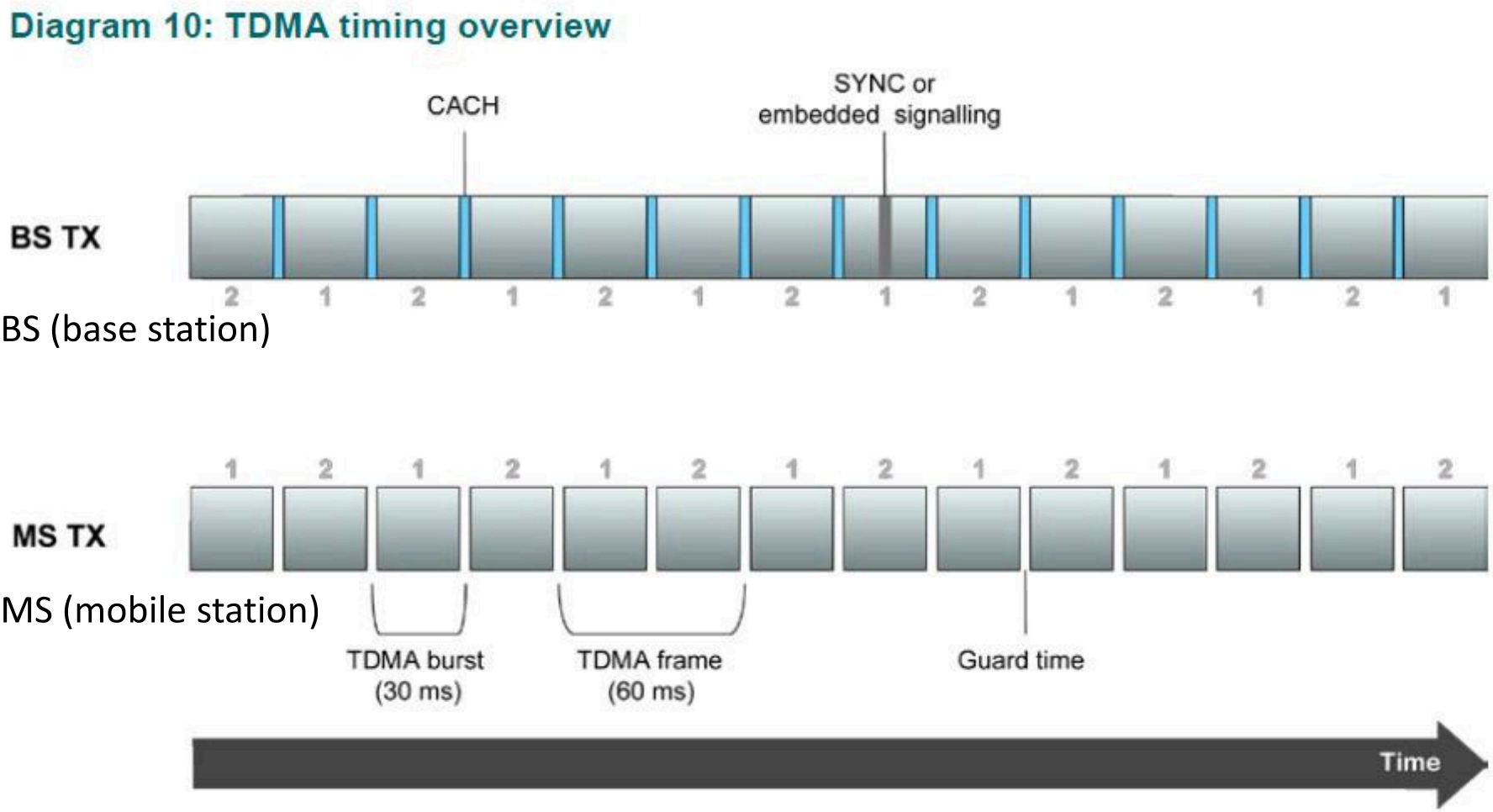


Diagram 10: TDMA timing overview
CACH
SYNC or
embedded signalling
BS TX
2 1 2 1 2 1 2 1 2 1 2 1 2 1
BS (base station)
1 2 1 2 1 2 1 2 1 2 1 2 1 2
MS TX
MS (mobile station)
TDMA burst
(30 ms)
TDMA frame
(60 ms)
Guard time
Time

Voor- en nadelen

- FDMA beter bij “multipath”
- FDMA spectrum efficiënter dan TDMA in de “direct-mode”
- TDMA beter voor migratie (analoog → digitaal)
- Batterij duur verbetering bij TDMA (40%)

D-Star satelliet: **TabletSat-Aurora**

- DMR en P25 niet mogelijk

Toepassingen

FDMA

- P25 fase 1
- dPMR
- MPT1327

Hytera TC-780M

MPT 1327

Ministry of Posts and Telegraph 1327

Open Standard/Proprietary	Open
Analog/Digital	Analog
FDMA/TDMA	FDMA
Conventional/Trunked	Trunked
Typical frequency band	VHF/UHF/800
Channel bandwidth	25, 20, 12.5, 10 kHz

TDMA

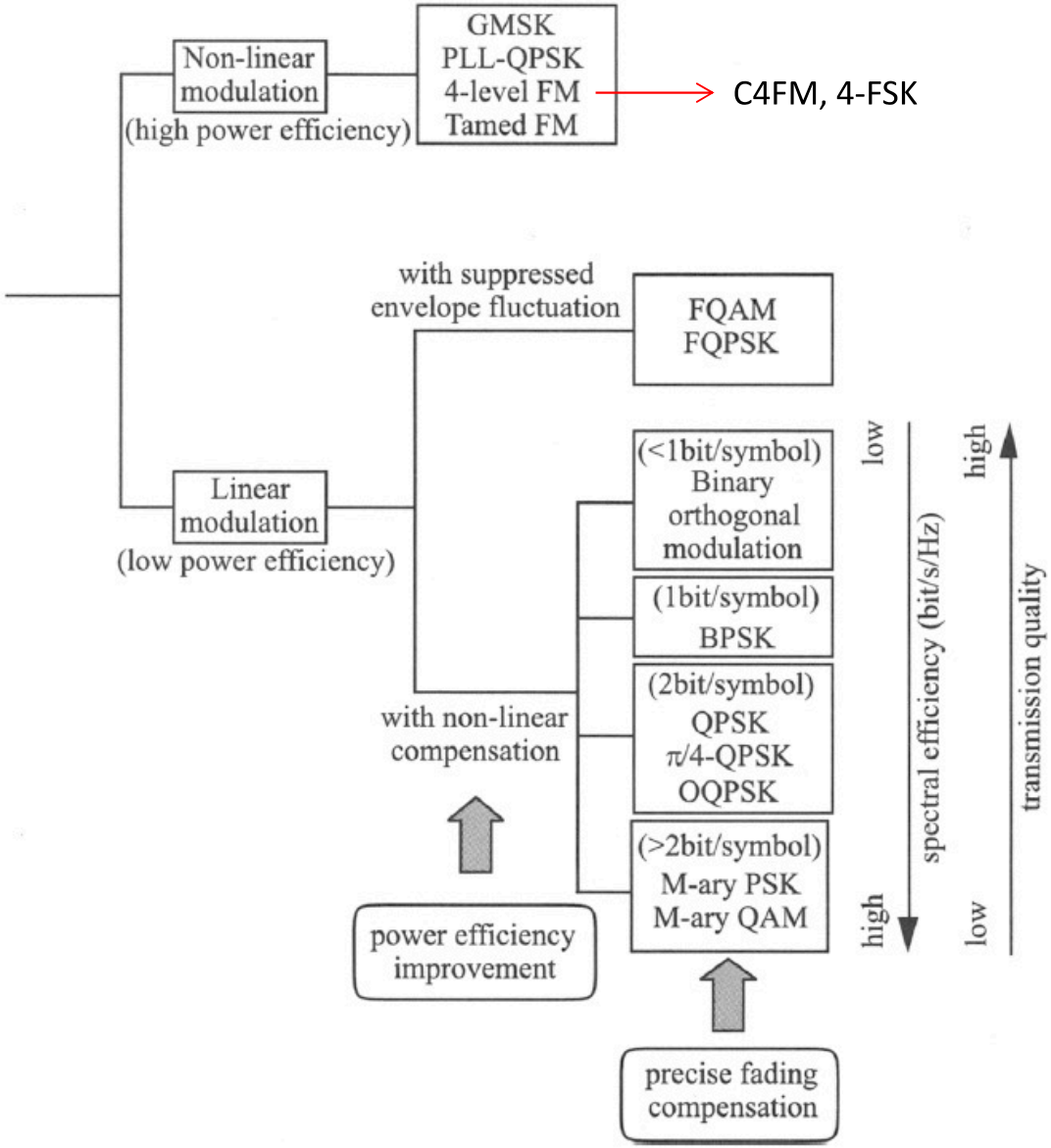
- P25 fase 2
- DMR
- TETRA

Type: TM9400 Series
P25 Phase 2 Mobile Radio
Brand: Tait
TDMA

Modulatie technieken

- Fast Frequency Shift keying (FFSK)
  MPT1327
- Compatible 4-Level Frequency Modulation (C4FM)
  P25 Fase 1, Fusion (Yeasu)
- 4-Level Frequency Shift Keying (4FSK)
  DMR, dPMR, NXDN
- $^{\pi}/_{4}$ Differential Quadrature Phase Shift Keying ($\pi/4$ DQPSK)
  TETRA
- Gaussian Minimum Shift Keying (GMSK)
  D-Star

Modulatie technieken



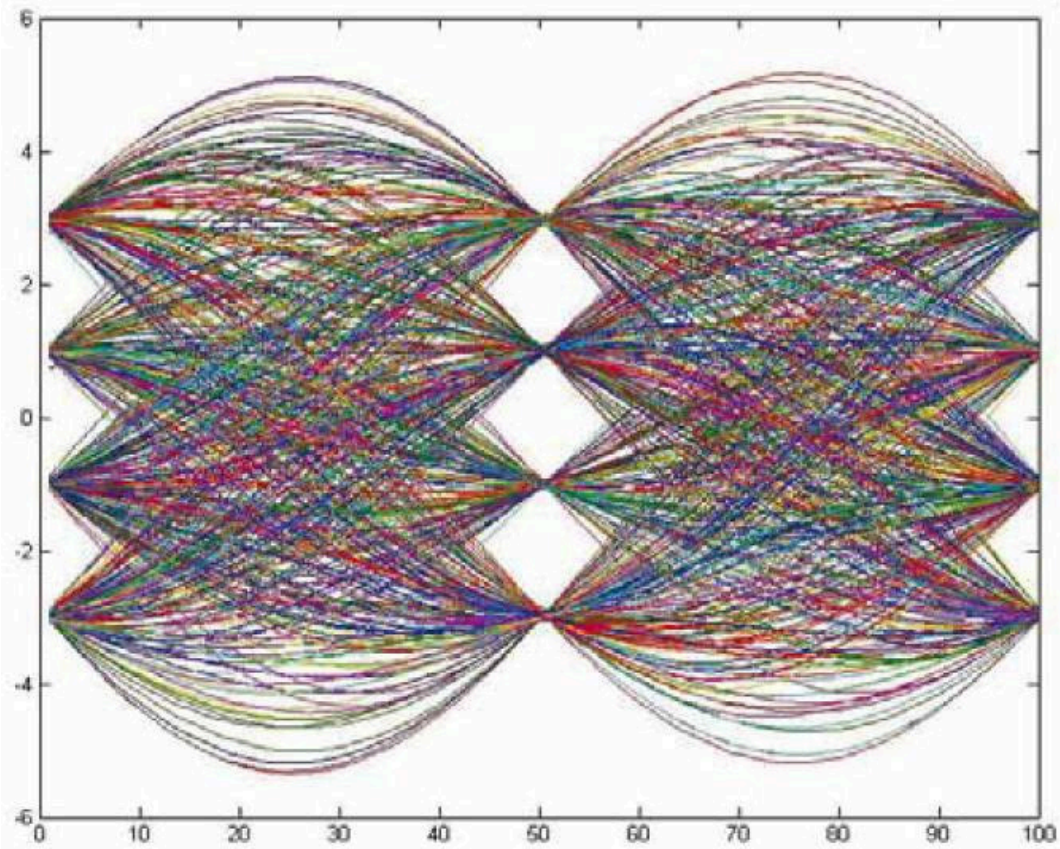
C4FM

- Elke set van 2 bits (dibit) krijgt een vaste deviatie

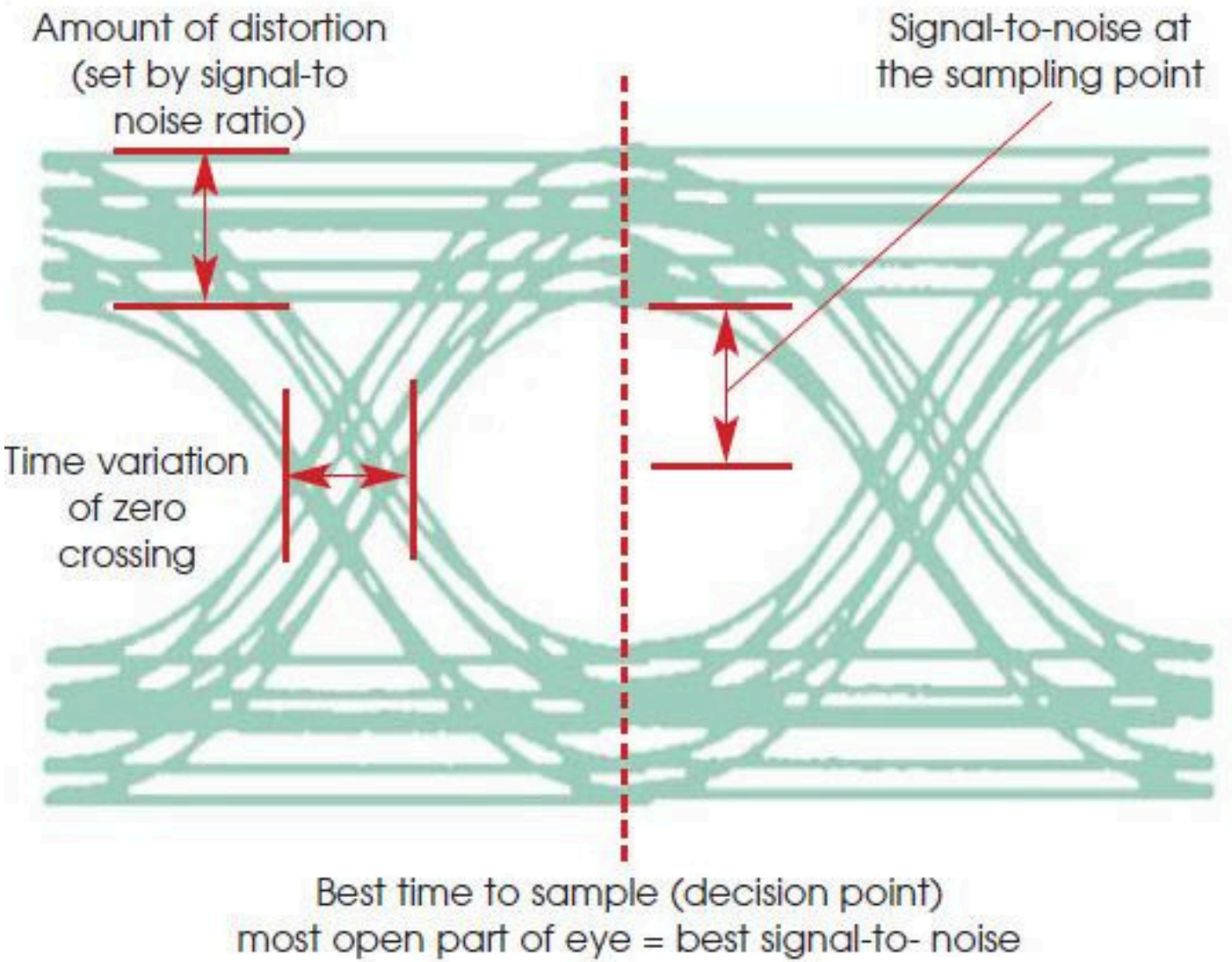
Informatie	Frequentie deviatie
01	+1.8 kHz
00	+ 0.6 kHz
10	- 0.6 kHz
11	- 1.8 kHz

C4FM

- Eye diagram C4FM
- Eye diagram geeft inzicht over o.a. “signal-to-noise”, “clock timing” en “jitter”



Eye diagram



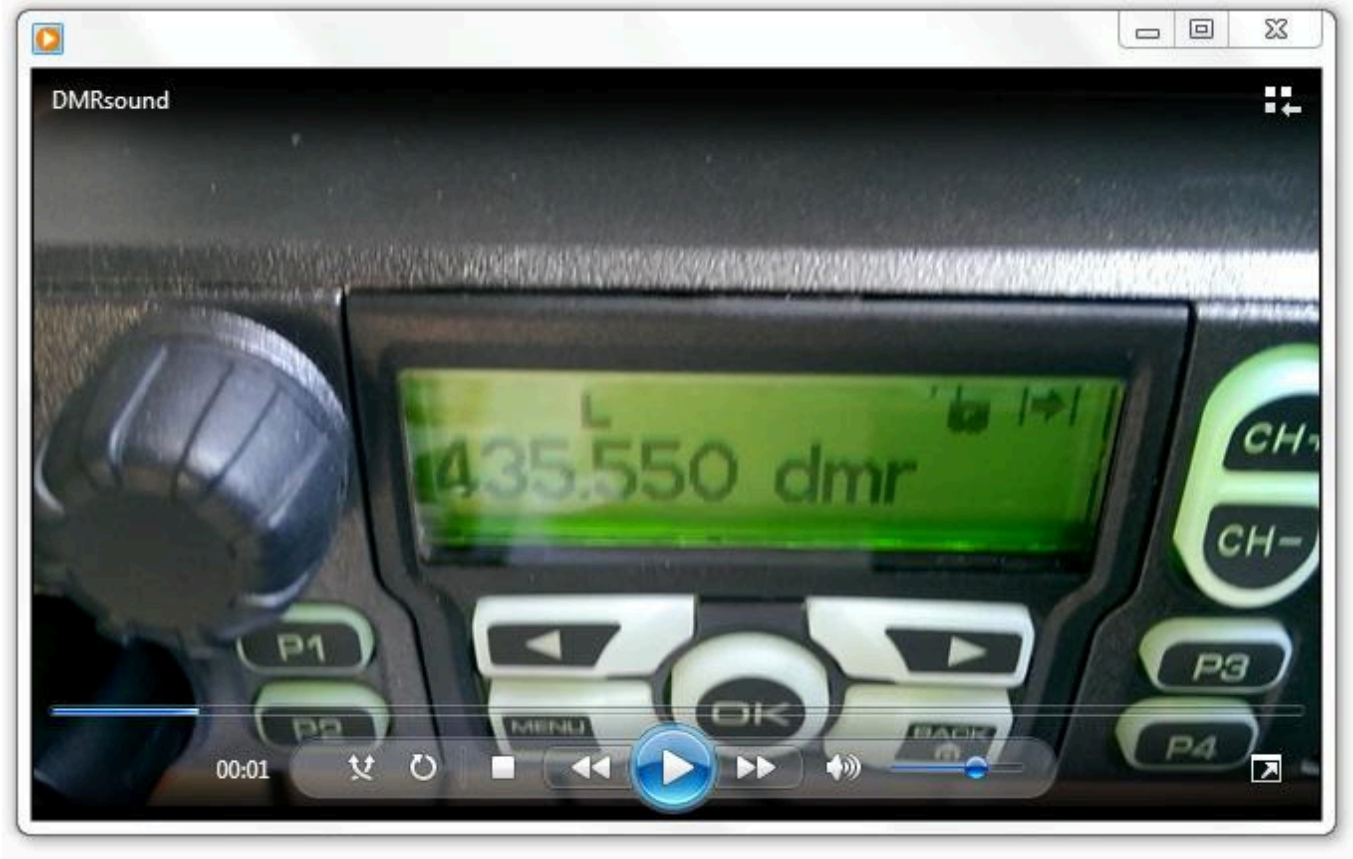
From November 2005 High Frequency Electronics

4FSK

Information bits		Symbol	4FSK deviation
Bit 1	Bit 0		
0	1	+3	+1,944 kHz
0	0	+1	+0,648 kHz
1	0	-1	-0,648 kHz
1	1	-3	-1,944 kHz

4FSK klinkt als…

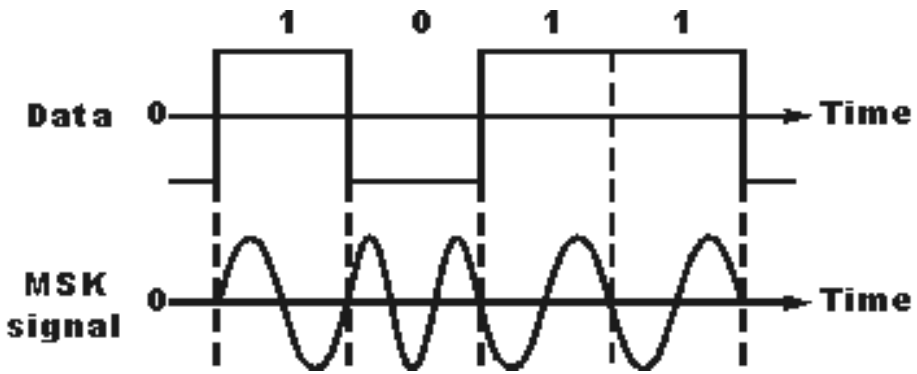
- Video

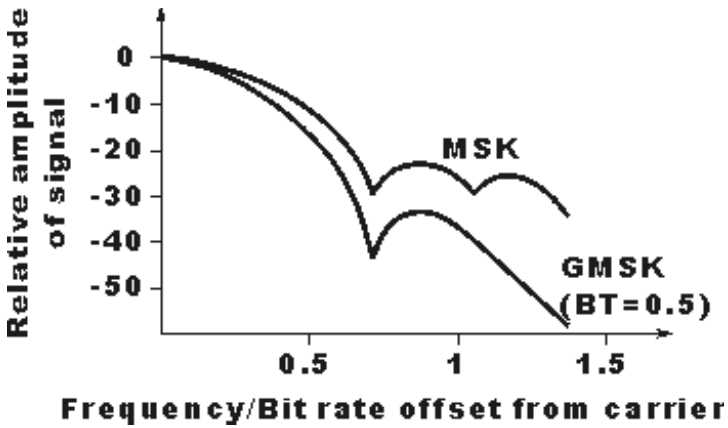


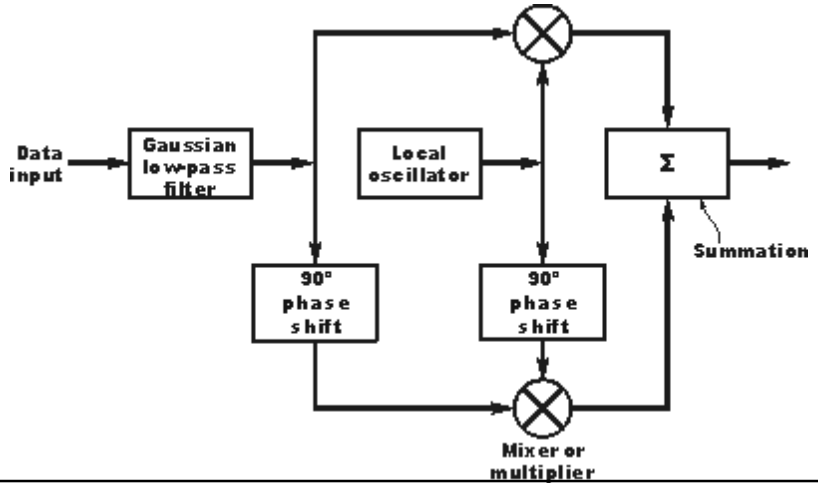
GMSK

Manier 1

Modulation index = 0.5







Manier 2

GMSK klinkt als…

- Video

DMR

DIGITAL MOBILE RADIO ASSOCIATION

ETSI

World Class Standards

DMR eisen

- Spectraal meer efficiënt
- Analoog en Digitaal
- Audio verbetering
- Gemakkelijk
- Robuust
- Open standaard
- Security
- Batterij duur verbetering

DMR tier

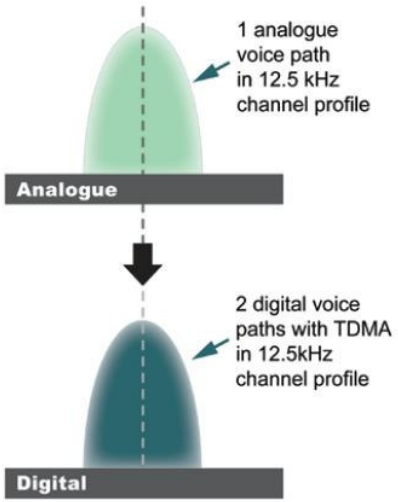
- DMR Tier I: Unlicensed
  freq = 446 MHz
- DMR Tier II: Conventional
  Licentie, freq 30 tot 1000 MHz
- DMR Tier III: Trunked
  freq 30 tot 1000 MHz
  (Tier III kan ook uitkomen op Tier II)

Zendamateurs

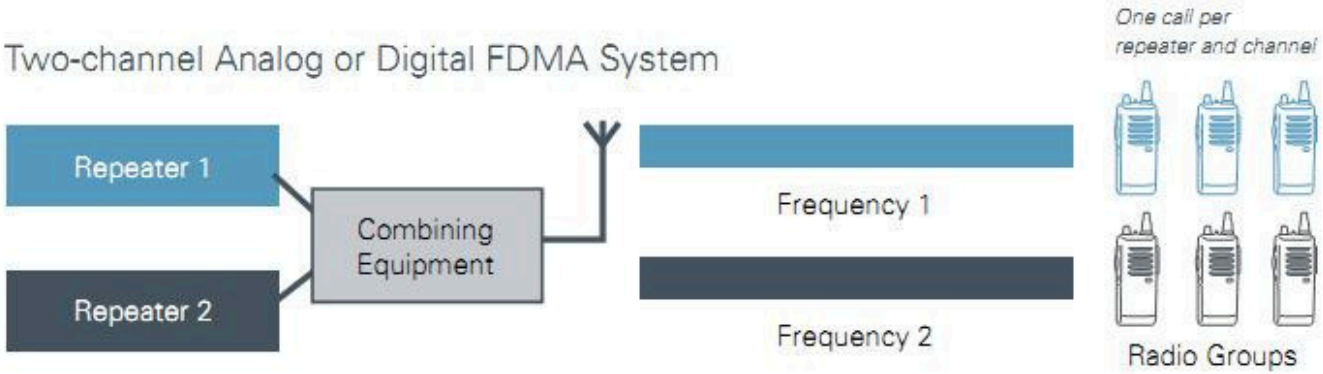
DMR Tier I en Tier II DMR service

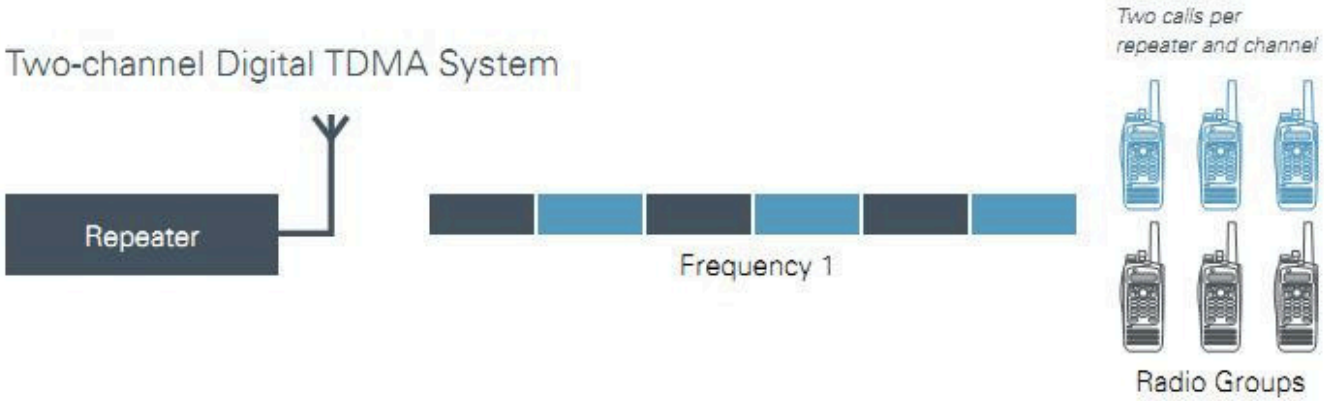
Services		Supplementary services
Voice	Individual Call	Late Entry
		Open Voice Channel Mode Call
		Talking Party Identification
	Group Call	Late Entry
		Unaddressed Voice Call
		Open Voice Channel Mode Call
		Talking Party Identification
	All Call	Late Entry
		Talking Party Identification
	Broadcast Call	Late Entry
		Talking Party Identification
Confirmed Packet Data Protocol (PDP)	IP over PDP	-
	Short Data over PDP	-
Unconfirmed Packet Data Protocol	IP over PDP	-
	Short Data over PDP	-

DMR: Twee repeaters in 1

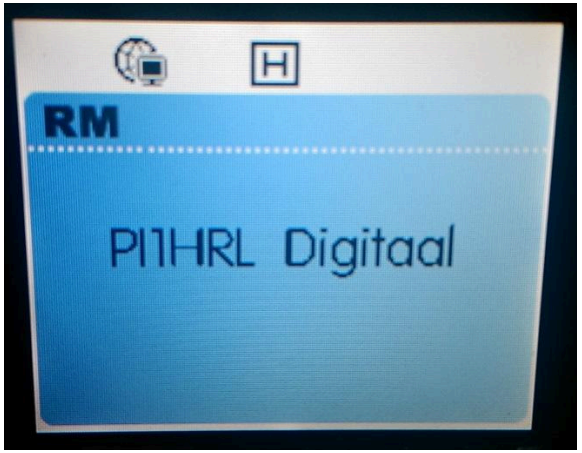


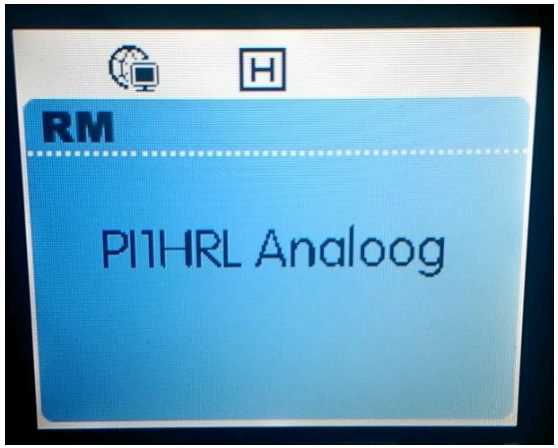
TDMA saves licensing and equipment costs by enabling the equivalent of two 6.25 kHz channels within a single licensed 12.5 kHz channel

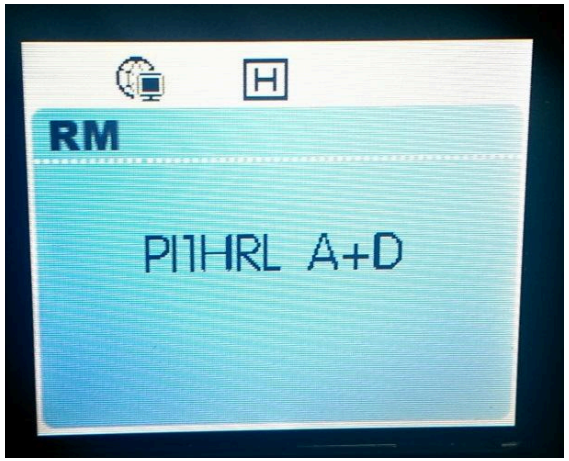




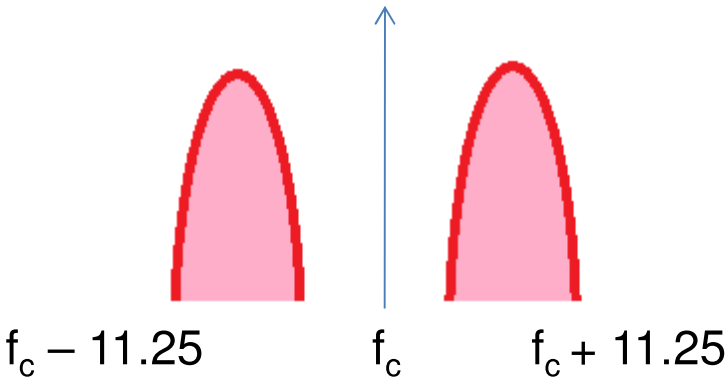
DMR repeater modes

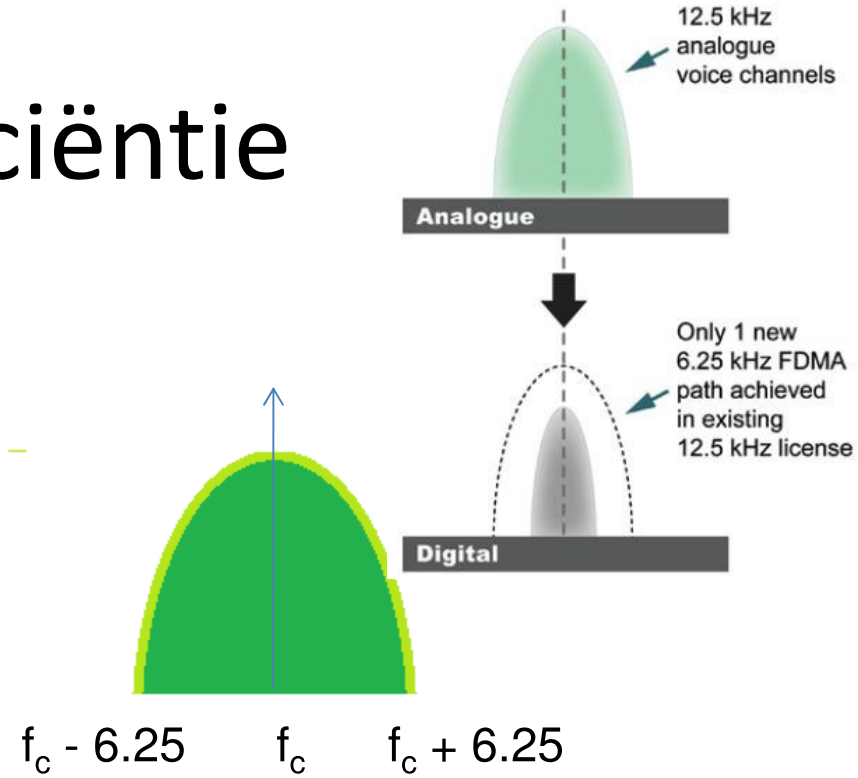






Spectrum efficiëntie





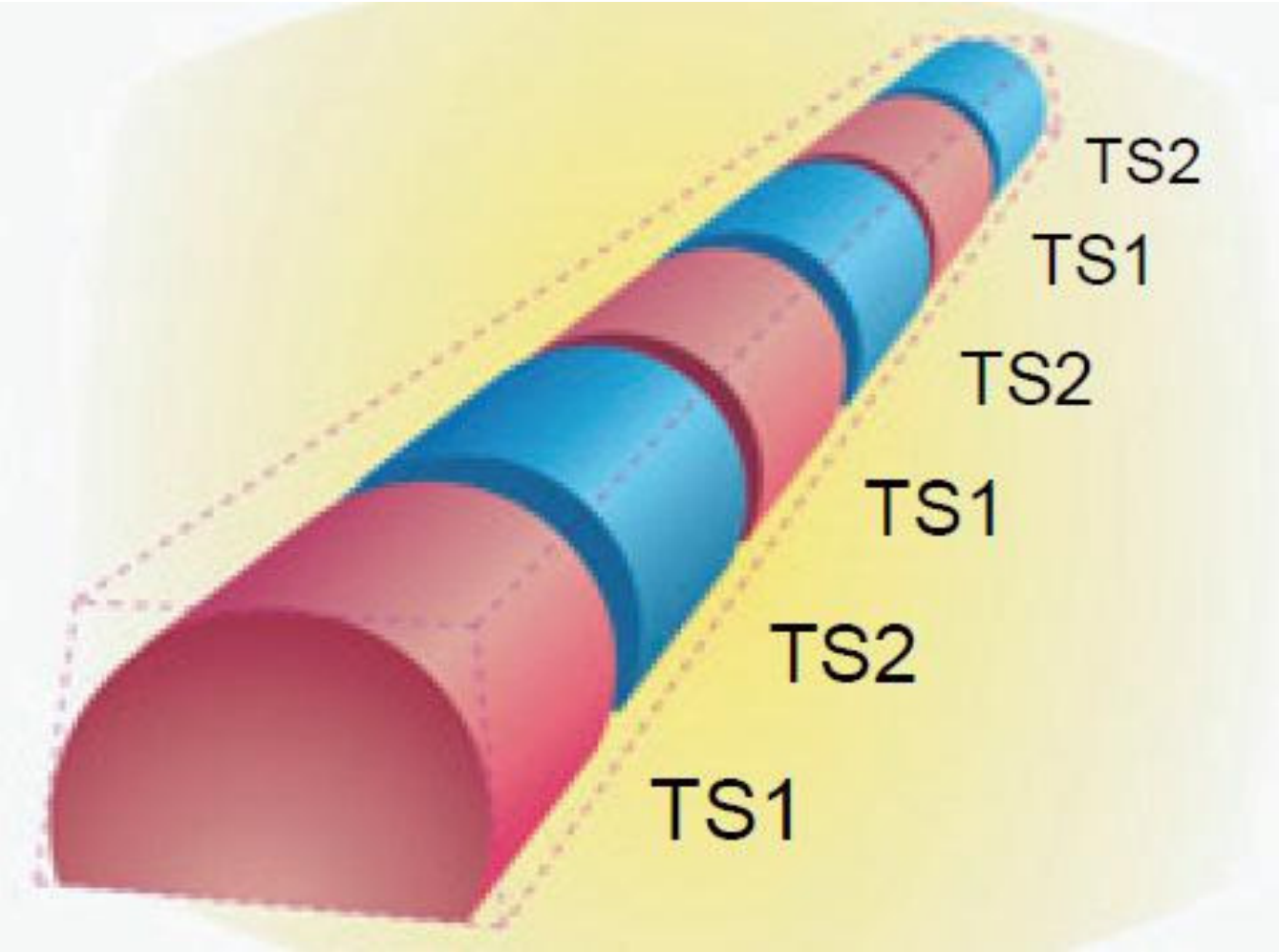
Guard Band
10 kHz
tussen de kanalen
Totale BW= 22.5 kHz

Geen Guard Band
tussen 2
kanalen
Totale BW= 12.5 kHz

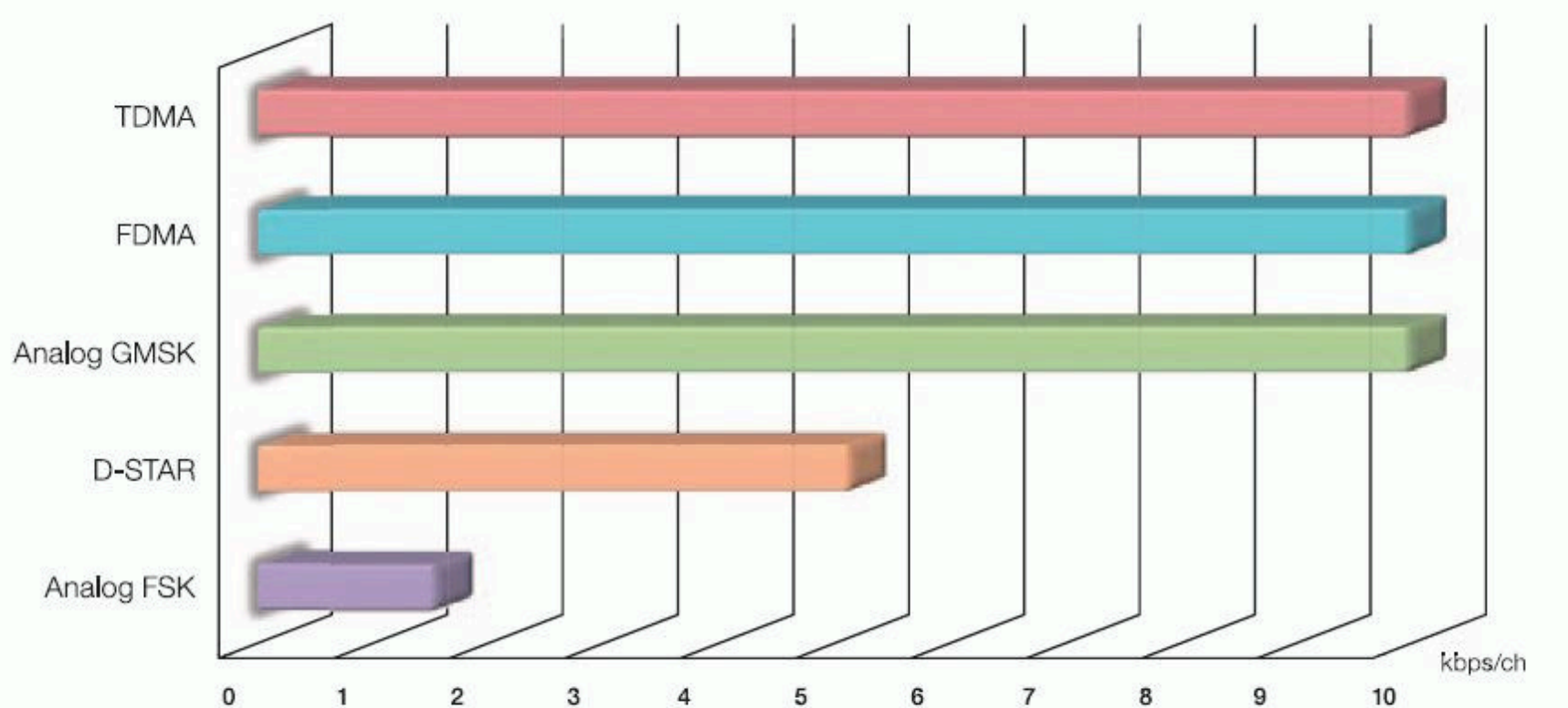
DMR Kenmerken

- 12,5 kHz kanaal
- 2-slot TDMA kanaal (spectrale efficiëntie 6.25 KHz)
- 9,6 kbps bit rate
- 4-FSK modulatie
- 30 ms slot
- 50% duty cycle slot structure
  (=allows forward and reverse)
- PTT op basis van tijd divisie
- Spraak & data (GPS)
- Frequentie van 30 tot 1000 MHz
- Twee netwerken
  a) Mototrbo™ (DMR-MARC)
  b) Hytera

Two-slot TDMA

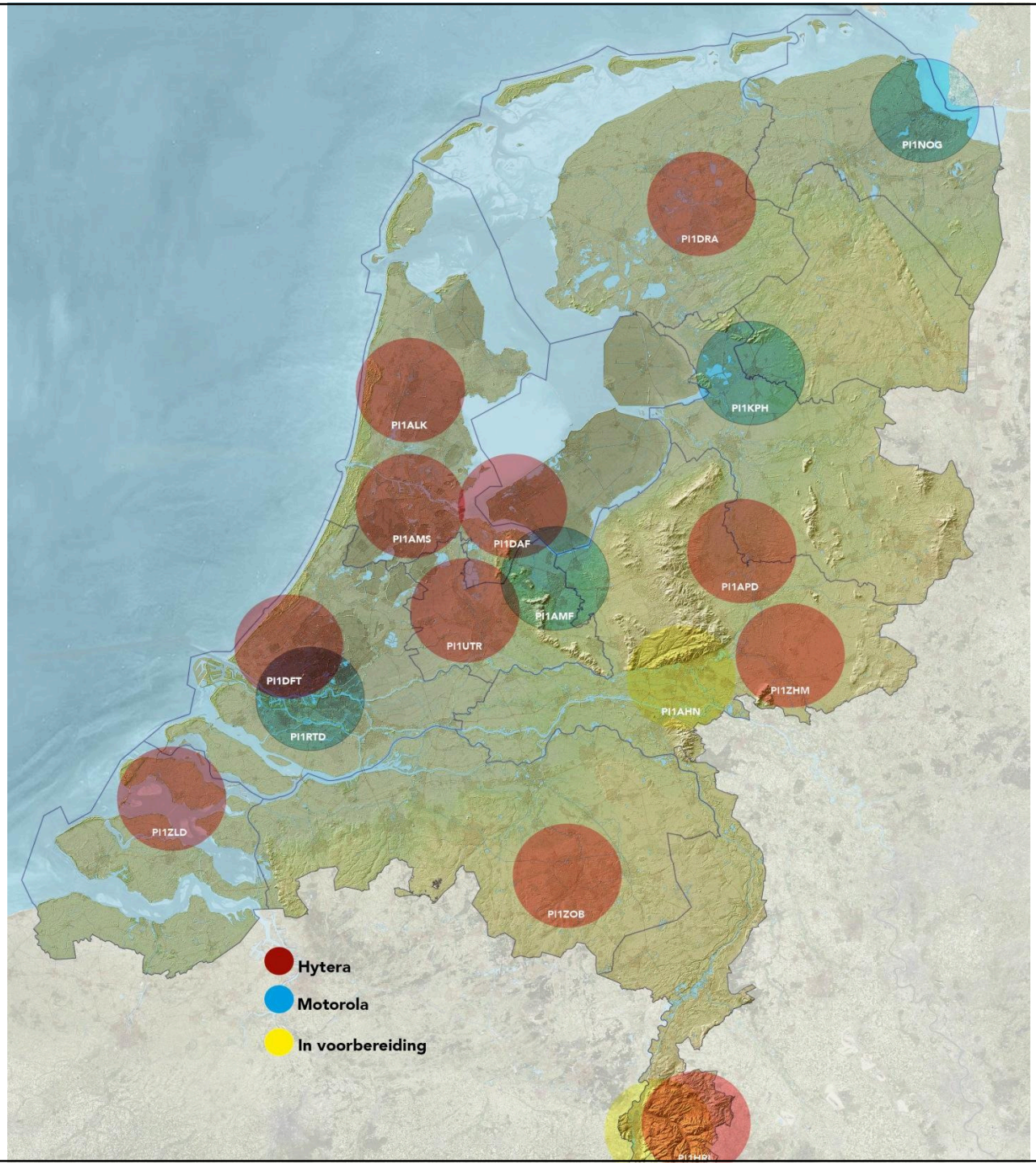


Data snelheden



TDMA	FDMA	Analog GMSK	D-STAR	Analog FSK
9.6 kbps/ch	9.6 kbps/ch	9.6 kbps/ch	4.8 kbps/ch	1.2 kbps/ch

DMR
MotoTRBO – Hytera


PI1NOG
PI1DRA
PI1KPH
PI1ALK
PI1AMS
PI1DAF
PI1APD
PI1AMF
PI1UTR
PI1DFT
PI1ZHM
PI1AHN
PI1RTD
PI1ZLD
PI1ZOB
Hytera
Motorola
In voorbereiding

DMR in PA TheNetherlands

Type	QTH	Call	QRG	Shift	ID	CC	Sysop
MARC	Rotterdam	PI1RTD	438.2	-7.6	204200	1	PA0HTW
MARC	Amersfoort	PI1AMF	438.3375	-7.6	204311	1	PA1GF
HYT	HYT Maastricht	PI1ZLB	438.150	-7.6	204402	3	PD3R
MARC	Zwolle	PI1KPH	438.15	-7.6	204777	2	PA4DEN
MARC	Delfzijl	PI1NOG	438.15	-7.6	204800	1	PA3GAZ
HYT	HYT Alkmaar/Test	PI1KMP	438.275	-7.6	204100	1	PD0LVS
HYT	HYT Amsterdam	PI1AMS	438.400	-7.6	204101	1	PH4X
HYT	HYT Delft	PI1DFT	438.375	-7.6	204204	1	PD7N
HYT	HYT Ijsselstein	PI1UTR	438.350	-7.6	204300	1	PE1RJV
HYT	HYT Heerlen	PI1HRL	438.2625	-7.6	204400	2	PD4RS
HYT	HYT Zierikzee	PI1ZLD	438.400	-7.6	204401	2	PA9KM
HYT	HYT Eindhoven	PI1ZOB	438.250	-7.6	204500	1	PE1DGW
HYT	HYT Apeldoorn	PI1APD	438.3875	-7.6	204600	1	PD0PVL
HYT	HYT Zelhem	PI1ZHM	438.2875	-7.6	204601	1	PA3ANB
HYT	HYT Almere	PI1DAF	438.2625	-7.6	204700	1	PD0POH
HYT	HYT Drachten	PI1DRA	438.000	-7.6	204801	1	PD0SDO