



**DMR**  
DIGITAL MOBILE RADIO ASSOCIATION

*Kyle*

**VS**



**Celab**  
COMMUNICATIONS

**TETRA**

# DMR or TETRA - which standard is best?

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## DMR or TETRA - Which standard is best?

TETRA and DMR are the two dominant standards for digital radio communication on the market. Although the standards differ technically, their practical application can in some cases be almost identical, while in other cases they differ significantly. The answer to which one is “best” is therefore mainly based on needs and the communication plan.

Both standards are innovations from the European Telecommunications Standards Institute, ETSI, but they were originally developed with different objectives.

TETRA, launched in the mid-1990s, was created to meet the communication needs of the public safety sector — so-called mission-critical communication. DMR, on the other hand, was developed in the late 2000s to provide a more frequency-efficient commercial alternative to conventional analogue two-way radio systems, and can therefore be considered more business-critical.

Although private TETRA networks are well established in Sweden, DMR is the standard choice for the private sector.

### 1. Similarities

In order to describe the differences more effectively, the similarities need to be explained first — let us call this prerequisite knowledge.

#### 1.1 Digitalisation

In a digital radio system, human speech is converted into digital packets through a Voice Coder/Decoder, or vocoder. To optimise capacity, the vocoder registers only human speech, which in turn minimises background noise. After conversion, the digital packet is compressed and error-corrected before being transmitted via a radio signal by manipulating, or modulating, radio waves to carry the information.

The receiving side then reads this signal and converts the digital packets back to their original format, whether speech, text or data. In this way, digital systems make no distinction between data and voice.

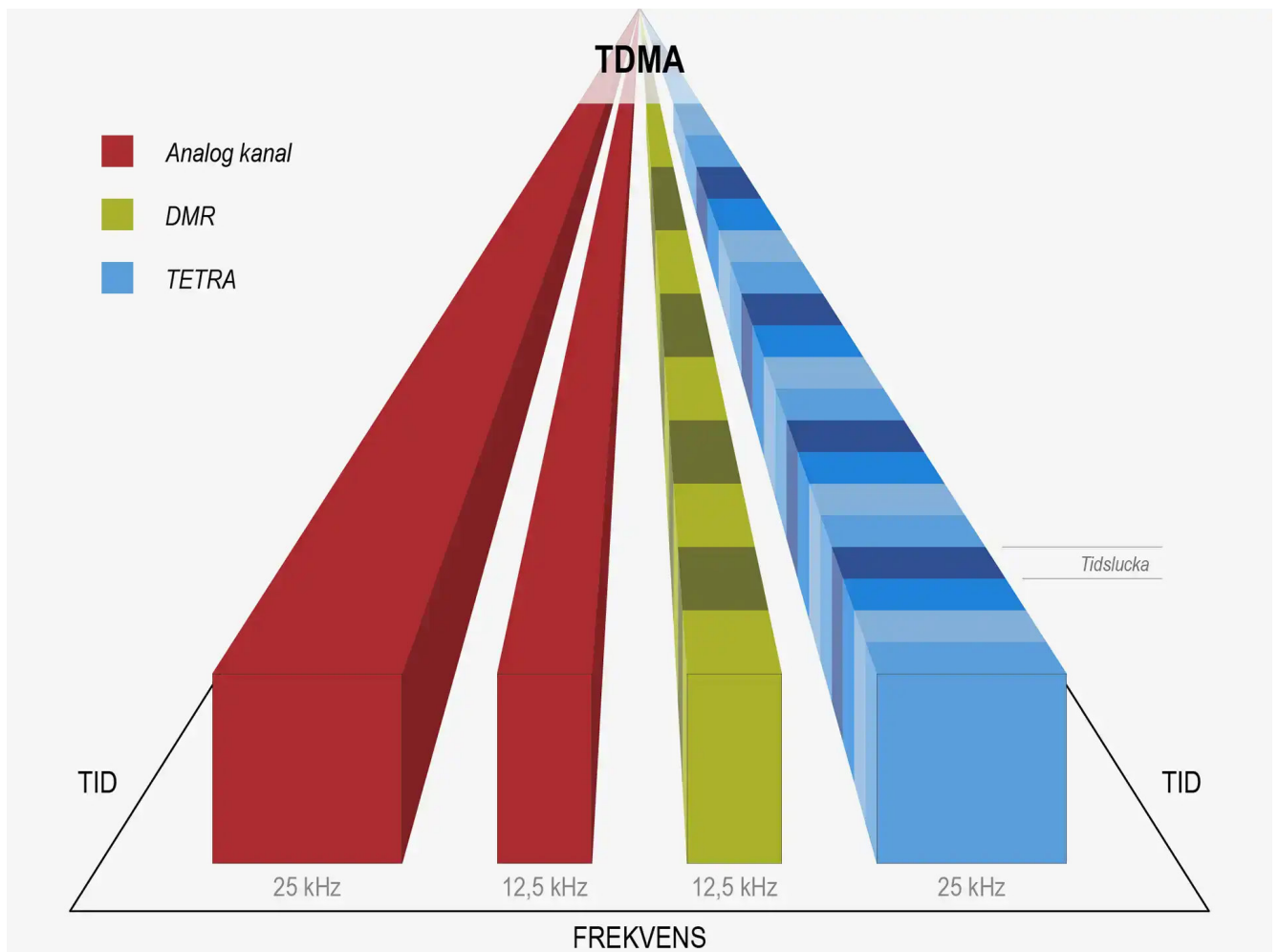
◆ 1 **Inspelning** Ljud spelas in ◆ 2 **Konvertering** Ljudet konverteras till en digital bitström ◆ 3 **Röstkodning** Röst filtreras ut och bitströmmen komprimeras



◆ 4 **Felkorrigering** Möjliggör för mottagande radio att korrigera för bitfel ◆ 5 **Framing** Organiserar informationen i digitala paket ◆ 6 **Sändning** Informationen skickas till mottagaren

## 1.2 TDMA

Time Division Multiple Access, TDMA, is a way of dividing radio waves into time slots. By doing this, several parallel communication paths are provided per frequency compared with an analogue radio channel, which at least doubles capacity.



### 1.3 Talkgroups

In an analogue system, each communication path is referred to as a channel because it directly correlates with a specific physical radio frequency.

In a digital system, this direct correlation does not exist, and the concept of a channel has instead been replaced by the concept of a talkgroup. A talkgroup consists of a number of users who have a mutual need to communicate — independently of frequency.

### 1.4 Trunking

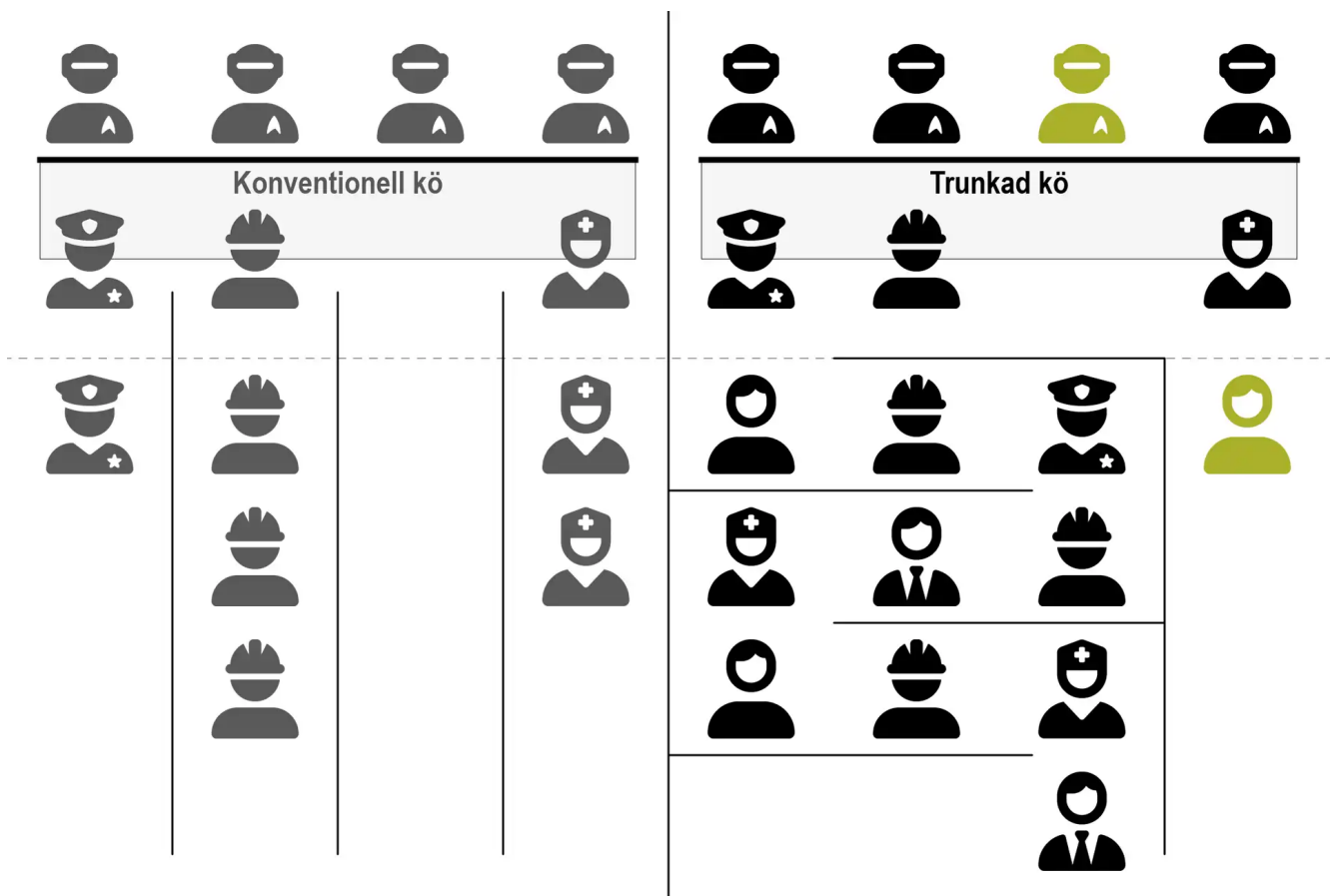
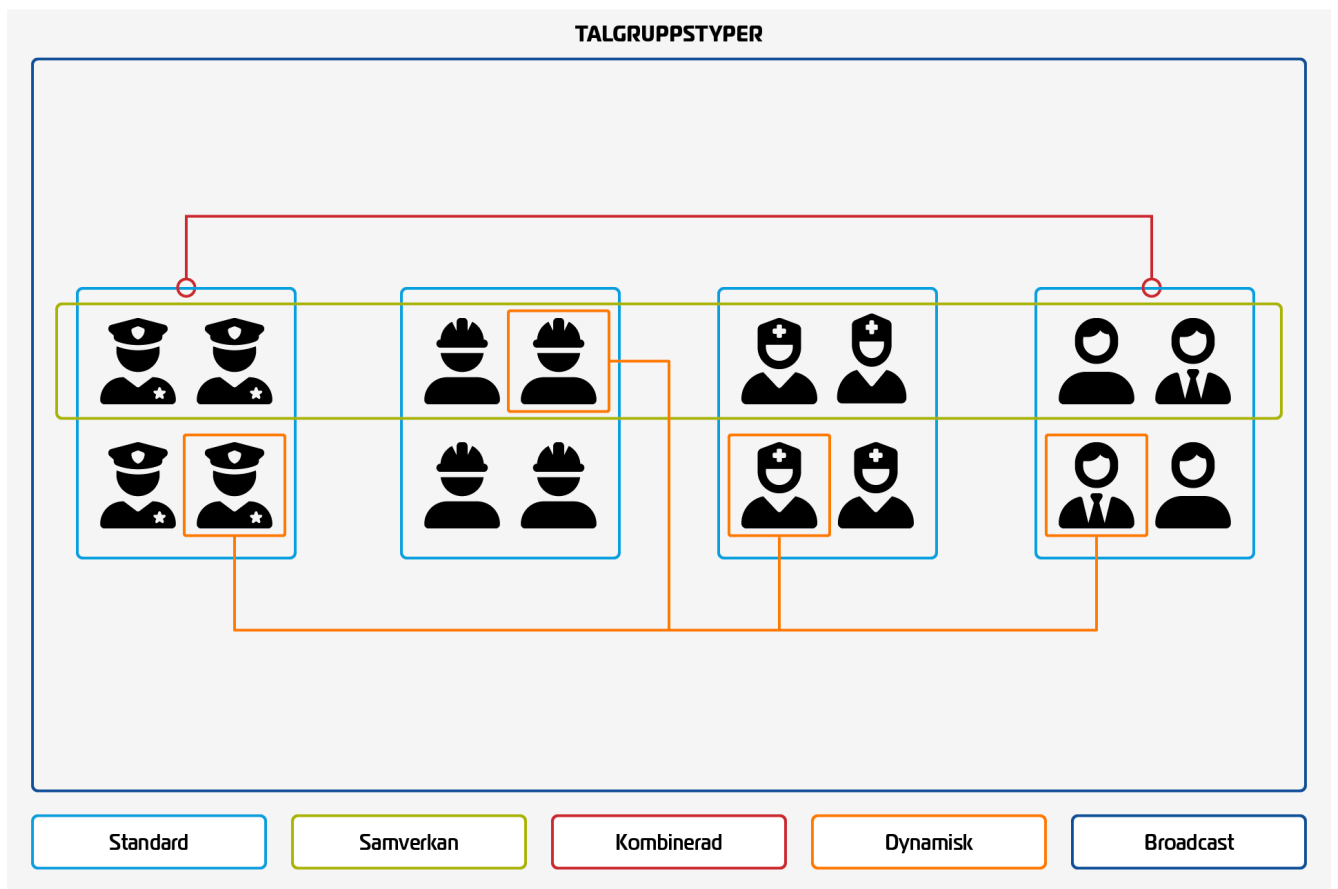
Trunking is a way of allowing multiple users to share the same resources efficiently. A conventional radio system works like a classic checkout queue, where customers are served at different speeds depending on how fast the particular cashier is. This can lead to both long queues and empty checkouts at the same time. In other words, an uneven flow and inefficient use of resources.

Trunked radio systems instead act like a shared queue or a queue-ticket system, where customers are served by the first available cashier. The result is that no checkout remains idle and the total waiting time is reduced. Trunked systems also make it possible to give prioritised users precedence for particularly important messages. To complete the analogy, it could be described as a dynamic VIP queue.

In a radio system, trunking means that all available resources, the time slots, are pooled into a common resource pool and all radios are placed in a shared “queue” where they listen to be “called”. When a call is initiated on a talkgroup, the call and its participants are automatically assigned an available time slot and return to standby mode, the call queue, once the call has ended. Through this dynamic resource allocation, capacity can be radically improved compared with a conventional radio system.

Through trunking, radio traffic can be distributed across a larger number of talkgroups with users without being limited by the available frequencies. In this way, only relevant recipients need to listen to ongoing calls, while, for example, a supervisor can communicate in several talkgroups in parallel or break in with important messages.

***It is worth noting that DMR, unlike TETRA, is not trunked by default. It is an option that involves software and/or hardware depending on the solution. Most DMR systems we deliver are trunked, whereas TETRA is always trunked.***



## 2. Differences

Although there are more theoretical and practical differences between the technologies, we have chosen here to focus on the factors that are generally most relevant. Some differences may be significant, but depending on the application they do not necessarily constitute a critical factor.

### 2.1 Characteristics

#### 2.1.1 Backward Compatibility

As mentioned earlier, DMR was developed as a direct replacement for existing analogue systems. This is achieved, among other things, by:

- using the same frequency bands, VHF/UHF
- allowing existing analogue frequencies to be reused
- offering both digital and analogue support
- providing equipment with corresponding output power levels

This means that both user devices and infrastructure equipment can be programmed with both digital and analogue communication. In practical terms, the user can therefore communicate either digitally or analogously by turning the talkgroup selector, or channel knob.

The reuse of frequency bands and output power levels also results in similar wave propagation, or coverage, to that of an analogue system. A DMR system can therefore, in principle, replace an existing analogue system one-to-one, since it is easier to reuse base station sites, antenna sites and other peripheral equipment. With some luck, the antenna system can also be reused if desired.

##### 2.1.1.1 Consequences

Thanks to backward compatibility, DMR offers the possibility to gradually replace parts of existing analogue systems and thereby spread the investment over time and according to need.

This is not possible with TETRA. With TETRA, all equipment must be replaced at the same time — assuming there is something to replace.

### 2.1.2 Capacity and Scalability

The statement that TETRA has higher capacity than DMR is true, but with some qualification. The theoretical maximum capacity is higher in a TETRA system, but in the vast majority of cases — if not all — we do not come close to the maximum limit regardless of technology choice.

Capacity refers to how much traffic the system can handle — in other words, the load. The load in a radio system is the product of the system’s user density, meaning the number of users per site, the frequency of calls and the types of calls used. Together, these generate a need for a certain number of simultaneous calls. In a digital system, the total number of time slots sets the ceiling for the number of simultaneous calls.

This ceiling applies per site, which can most simply be described as each independent coverage area in the system. The number of available time slots can be adjusted according to need for both technologies, and capacity can vary between the different sites in the system.



## DMR

DMR operates on frequencies with 12.5 kHz channel bandwidth divided into two time slots.

A DMR site consists of one or more repeaters. Each repeater uses one specific frequency, which means that the number of available simultaneous calls is equal to the number of repeaters multiplied by two.

In DMR systems, an idle channel is often used instead of a control channel, as in TETRA. The idle channel is dynamic and automatically moves on to the next available time slot. This means that all time slots in such a system can be used for calls.

Since DMR uses two time slots per frequency, such a system can be scaled up more gradually — from two to four to six time slots, and so on.

### 2.1.2.1 Consequences

The number of repeaters or base stations is a significant cost driver — especially for TETRA. TETRA systems also always require a hardware-based server/controller regardless of system size. Corresponding hardware is really only required in larger DMR systems, which makes the entry point higher for TETRA. Since the expansion steps are also smaller in DMR, it becomes easier and more cost-effective to expand a DMR system over time. Overall, DMR can be said to have a flatter investment curve.

However, if the initial requirement is more extensive, this difference decreases. For larger systems, the costs tend to converge, and considering that TETRA offers many other advantages, it should not be ruled out as an alternative without a price comparison for the specific system.

## TETRA

Instead of frequencies, TETRA uses the concept of a carrier. These use 25 kHz channel bandwidth divided into four time slots.

A TETRA site consists of one or more base stations, which in turn may include one or more base radios. Each base radio provides one carrier and therefore four time slots for each base radio at the site.

In TETRA systems, at least one time slot per site is always used as a static control channel. This cannot be used for calls, but is used to distribute SDS and status messages and to manage the queue in which all users remain in standby mode.

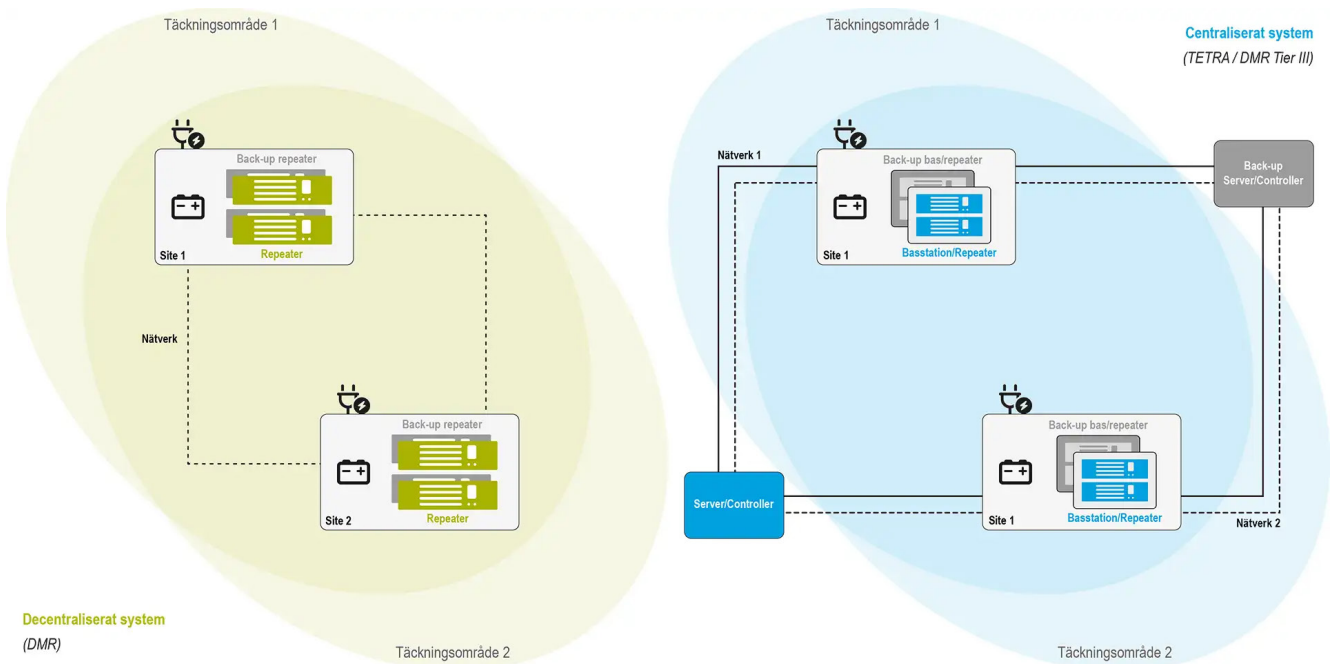
With its four time slots per carrier, including one control channel, TETRA systems are therefore expanded from one control channel plus three simultaneous calls, to one plus seven, to one plus eleven, and so on, per site.

*Two-way radio calls are inherently efficient because, in practice, they rarely last more than a few seconds while communication reaches multiple users at the same time. This means that both call duration and the number of calls are sharply reduced compared with other forms of communication. As a result, the need for simultaneous calls in a radio system is usually lower than intuition suggests, and a relatively small number of time slots can support a larger number of users.*

### 2.1.3 Operational Reliability

Operational reliability is about maximising system availability and minimising downtime. This is achieved by building systems based on reliable equipment and designing them with redundancy to avoid single points of failure.

Because two-way radio systems can be made fully standalone, this form of communication offers a very high degree of local control — regardless of the technology selected.



## Decentralised Systems – DMR

In some proprietary DMR solutions, trunking is handled by software in the repeater and radio respectively. This creates a decentralised architecture, which makes it somewhat more cost-effective to create redundancy, at least locally. By, for example, building identical sites with overlapping coverage areas, overcapacity is created that makes it possible for essentially half the system to stop working without causing downtime.

All system solutions should also be complemented with a well-balanced UPS or battery backup solution to further increase reliability.

## Centralised Systems – TETRA/DMR

In systems based on TETRA and DMR Tier III, trunking is handled by a central controller, which is a physical server that controls traffic in the system. On its own, this constitutes a potential single point of failure, but this can be avoided by duplicating the unit. The backup server can be located at another geographical site, and the entire system can be connected through two parallel networks.

With this configuration, dual sites with overlapping coverage and UPS on all critical parts, single points of failure can be completely avoided, albeit at a higher cost.

Motorola's TETRA base stations also offer the fallback function Local Site Trunking, LST, which means that group communication can continue at each site separately. This mitigates the effects of server failure or network problems. However, not all call types remain supported, communication between the sites is lost and functionality becomes somewhat limited.

### 2.1.3.1 Consequences

The availability of both centralised and decentralised solutions can be dimensioned entirely according to needs and requirements, while the infrastructure equipment for both DMR and TETRA is highly reliable and long-lived.

From this perspective, there is therefore no major difference between the options. It is a matter of budget, preference and design philosophy.

***With a system built with sufficient redundancy in combination with preventive maintenance, costly 24/7/365 agreements and emergency call-outs can be avoided. In our experience, this becomes more economical over the long lifetime of the systems, despite the higher initial cost.***

## 2.2 Functionality

### 2.2.1 Prioritisation

Prioritisation refers to whether, how and who has precedence in a system — especially when the system is busy. This kind of functionality is fundamental in, for example, the Rakel network, to ensure that critical information gets through even when tens of thousands of users collaborate across thousands of talkgroups in the same system.

#### DMR

DMR has limited prioritisation capabilities, particularly in its decentralised versions.

In the most common DMR systems, there are essentially only three priority levels that can be applied to users and call types. These sometimes also need to be tied to specific radios, which reduces flexibility.

#### TETRA

TETRA supports as many as 16 priority levels that can be applied to individual users, specific talkgroups and certain call types. In simplified terms, this means that it can be predetermined exactly which calls are handled first if the system is busy.

This allows very extensive and advanced communication plans and talkgroup structures for a very large number of users.

#### 2.2.1.1 Consequences

If internal communication requires a hierarchical structure, TETRA is the obvious choice.

*By making intelligent use of prioritisation functions, the maximum capacity of the system could theoretically be limited as a cost-saving measure. Important information would still be able to get through, while less important communication might have to wait.*

## 2.2.2 Call Types

### Trunked Mode – TMO

Trunked mode refers to communication that goes via the infrastructure. In TETRA, this is called Trunked Mode Operation, TMO, and in DMR it may be referred to as repeater mode.

#### DMR

- Group call, semi-duplex
- Emergency call, semi-duplex
- Individual call, semi-duplex
- Telephone call, semi-duplex

#### TETRA

- Group call, semi-duplex
- Emergency call, semi-duplex
- Individual call, semi-duplex and full-duplex
- Telephone call, semi-duplex and full-duplex
- DMO-TMO gateway, semi-duplex

### Direct Mode – DMO

Direct mode refers to communication directly between two or more radios without infrastructure. In TETRA, this is called Direct Mode Operation, DMO.

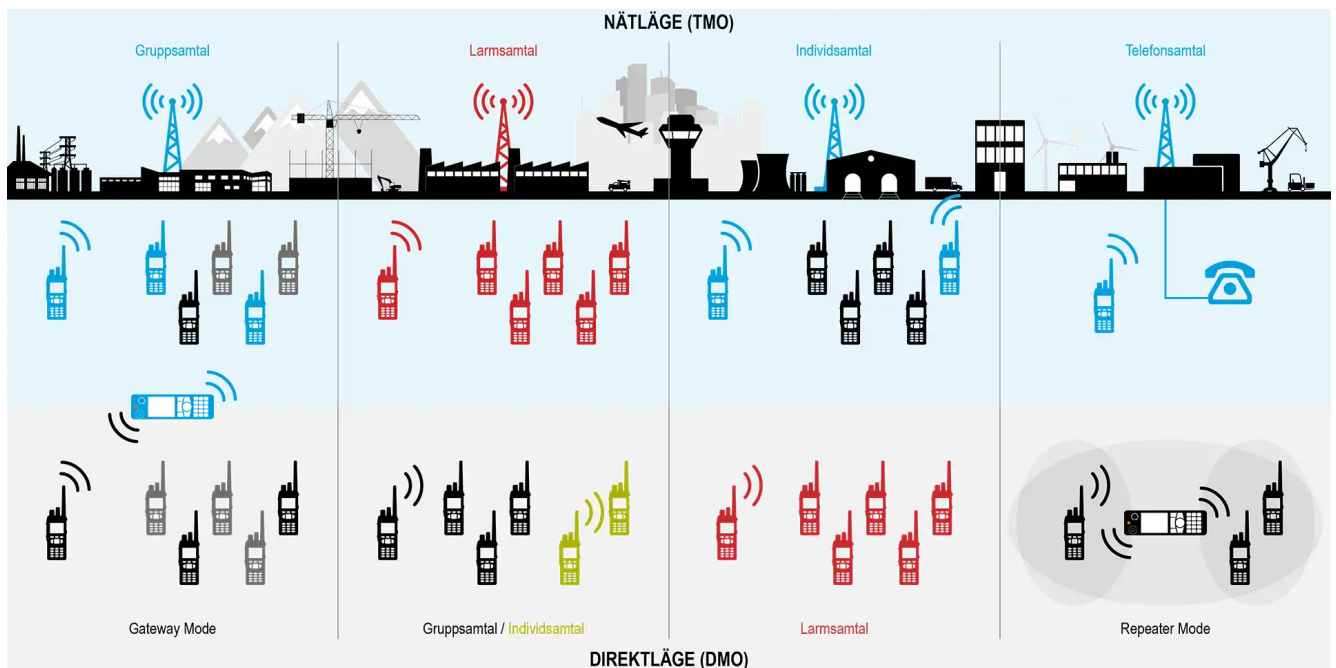
#### DMR

- Group call, simplex
- Individual call, simplex
- Emergency call, simplex

#### TETRA

- Group call, simplex
- Individual call, simplex
- Emergency call, simplex
- Repeater mode, simplex

*A semi-duplex call is a two-way call that requires PTT activation to open the voice path. A full-duplex call is a two-way call where PTT activation is not required, allowing users to speak at the same time just as in a telephone call.*



### 2.2.2.1 Consequences

TETRA offers broader support for different call types in general, and for full-duplex calls in particular. In addition to gateway and repeater modes, telephony integrations also work more naturally in TETRA.

If flexibility and dynamism in communication are important, TETRA is the winner. But if the need mainly consists of group calls, the technology choice does not matter from this perspective.

*Full-duplex calls use two time slots simultaneously and therefore require twice the capacity compared with other calls. If such calls are to be allowed, this must be considered when dimensioning the system. This type of call also tends to last longer than group calls, which adds further load and increases the required number of simultaneous calls, thereby increasing cost.*

*An alternative to telephony integration may be a connection to PTTtoC — push-to-talk over broadband. With such an integration, talkgroups from the radio system can be mirrored to smartphones, tablets and computers, allowing radio users to communicate directly with users outside the system's coverage area.*

### 2.2.3 Alarm Handling

#### Emergency Alarms / Personal Alarms

Personal alarms have the highest priority in both TETRA and DMR.

Because of its origin, TETRA offers many more possibilities in terms of recipients, alarm types and alarm information.

This is essential for, for example, the Rakel network, which includes hundreds of command-and-control and emergency dispatch centres for different organisations and users.

#### Case Management (ticketing)

Both technologies can be complemented with several different software solutions of varying capability for case management, or job ticketing.

In our experience, organisations with such needs often choose TETRA. However, this may be something of a self-fulfilling prophecy, since we ourselves have far more experience of these added-value capabilities in TETRA than in DMR, including through our own development of such solutions primarily for TETRA.

#### 2.2.3.1 Consequences

TETRA is the clear winner in terms of the possibilities offered, but once again it is a question of how extensive the current needs for alarms and alarm handling actually are.

## 2.3 User Experience

### 2.3.1 Devices

The user devices are very similar in design within both technologies, with model series that largely correspond to one another. Although there are exceptions, there is something for every user and purpose within both TETRA and DMR. The same applies to accessories, which are not rarely shared between terminals in the two technologies.

The main difference is perhaps the handling of the devices, although even that appears similar at first glance. Since TETRA offers more functions, more can also be done in a TETRA terminal, which more often requires a keypad and display.

#### 2.3.1.1 Consequences

As with many other parameters, the decisive factors here are also the specific needs that determine which devices are most suitable. However, it is probably previous technology decisions that determine the outcome.

## 2.3.2 Audio Quality

Audio transmission in a digital system has a particular character. While the technology provides better intelligibility at the edge of a coverage area and in demanding environments, it may be perceived as “unclear” by some users.

This is due to the digital conversion and compression, which flattens the range of voices and therefore makes them sound somewhat distorted or more “tinny” compared with analogue radio. The process also introduces a short delay.

### 2.3.2.1 Consequences

Many users — especially experienced users of analogue two-way radio — often initially have opinions about the characteristic sound of digital two-way radio. After a while, these opinions tend to fade as users instead notice the absence of noise, interference and ambient sound in the digital transmission.

This applies to both TETRA and DMR, but the scenario occurs noticeably more often with DMR. The different compression methods and conditions of the technologies may mean that the sound is often perceived as better in TETRA.

## 3. Conclusions

TETRA is, in principle, always as good as or better than DMR, but it is not always sufficiently better for the specific purpose. Both alternatives should be evaluated on a case-by-case basis, because the choice depends on the current project’s existing requirements and needs, as well as future objectives. This is especially true when considering the relationship between the importance of communication to the organisation and the available budget.

Both technologies are mature, but neither can be considered obsolete, since the development of the standards is likely to continue well into the 2030s. Today’s ability to combine both technologies with PTTtoC solutions and create relatively frictionless hybrid systems is probably a natural step towards the future and a way to future-proof today’s solutions.

Although this article became relatively long, we have really only scratched the surface. There are many nuanced differences that may seem trivial but can still be decisive in the technology choice. We can of course help you further in your evaluation by identifying and illustrating these differences.

## About Celab

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Celab Communications AB is a Swedish company within the Tången Group that, since its founding in 1978, has achieved significant success in mission- and business critical communications.

By this, we mean solutions for organizations where reliable communication is essential to operational success and/or employee safety.

The company's foundational idea is to provide communication systems based on world-leading equipment, which, through our unique expertise, are developed, refined, and optimized specifically for our customers and their unique operations.