ROHILL

# LTE for Critical Communications

White paper

LTEtraNode

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# 1 Introduction

LTE is destined to become the next standard for critical communications according to many representatives of the industry, consultants and end-users. The TETRA Association has changed its name to TETRA + Critical Communications Association (TCCA) to reflect this imminent shift in the industry. Many LTE-only suppliers, cellular operators and user groups became members of the TCCA to join the debate and benefit from new insights.

The adoption of LTE by FirstNet for public safety organisations in the US, the preference for LTE by the UK Home Office, and intentions of South Korea to build a nationwide LTE network for Public Safety has become the catalyst for development of LTE for Critical Communications.

Being at the forefront of TETRA-LTE integration, Rohill has developed a comprehensive strategy to accept the challenge and identify the opportunities for an integrated TETRA-LTE solution, considering all benefits and limitations of LTE for broadband communication. The LTEtraNode product range is developing towards an open standards-based mission-critical solution, while on short term offering all benefits that are offered by LTE today.

Although Public Safety is the primary focus of LTE for Critical Communications, also other segments can benefit from our LTEtraNode solution, down to cost-sensitive commercial applications that can operate on public LTE networks.

This white paper provides an analysis of standards development as well as benefits, limitations, opportunities and challenges of LTE for Critical Communications. This analysis was the basis for the comprehensive strategy for LTEtraNode product development, of which the architecture, features and benefits are explained as well.

# 2 Evolution path for critical communications

Critical communications require integrated voice and broadband data capabilities. TETRA is traditionally strong in critical voice and short data messaging capabilities, whereas LTE is obviously the preferred standard for broadband data. By combining both technologies and migrating TETRA functionality and TETRA-like features to LTE, coherent solutions can be created that fulfil the current and future requirements for voice, status, text, location, picture and video transmission.

This section provides an introduction to the evolution of standards of both cellular and mission-critical communications. It is expected that LTE will overtake TETRA to some extent, so it is important to understand the timeline and current work undertaken by the industry and operators to reach consensus on standards.

In addition to TETRA and LTE, also TETRA Enhanced Data Service (TEDS), WiMAX and proprietary LTE solutions are considered. This is relevant to at least understand the merits of these possible alternatives.

## 2.1 TETRA

TETRA is an open standard developed by the European Telecommunications Standards Institute (ETSI). The main purpose of the TETRA standard is to define a series of open interfaces, as well as services and facilities, in sufficient detail to enable independent manufacturers to develop infrastructure and terminal products that are fully interoperate with each other as well as meet the needs of traditional PMR user organisations.

Although the prime responsibility of ETSI is to develop standards for Europe, many of its standards are also adopted worldwide, as evidenced by the uptake of GSM, the first wireless technology standard to be developed by ETSI. Similarly, TETRA has already been deployed in many regions and nations outside Europe, resulting in TETRA becoming a truly global standard.

Release 2 of the TETRA standard includes the TETRA Enhanced Data Service (TEDS), providing wideband data capabilities in the order of 30 to 260 kbit/s under good coverage conditions. This is possible by using other modulation techniques like D8PSK and QAM, and combining TETRA channels up to 150 kHz.

The ETSI TETRA standard continues to evolve beyond Release 1 and Release 2 to provide additional enhancements as driven by user needs, technology innovations and other parallel standard developments.

## 2.2 LTE

LTE is the abbreviation for Long-Term Evolution, a fourth generation wireless communication standard, offering broadband data capability for mobile devices, including smartphones, tablets, PCs and dedicated devices like mobile cameras.

LTE is based on GSM/EDGE and UMTS/HSPA network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP (3rd Generation Partnership Project) and is specified in its Release 8 document series, with enhancements described in Release 9. The primary goals were to simplify the network architecture to an IP-based system with significantly reduced transfer latency compared to the 3G architecture, and to benefit from new modulation techniques in order to provide more throughput, capacity and flexibility. LTE is the natural upgrade path for carriers with both GSM/UMTS networks and CDMA2000 networks, but can also be deployed stand-alone.

LTE will evolve further in performance and capabilities. These are described in additional 3GPP Releases, adding new features for scalability, reliability, resilience and management. In terms of performance, one of the completed working items in Release 10 includes LTE-Advanced, also referred to as “True 4G”, with speeds of up to 1 Gbit/s. The next step is 5G, bringing base station capacity even closer to the user by means of small indoor cells, offering data throughput of 3 Gbit/s and higher.

Regarding critical communications, the upcoming 3GPP Release 12, 13 and 14 standards will support phased introduction of the following enhancements:

- Group System Communication Enablers (GSCE) to allow streaming of voice and video to multiple devices using a single downlink data stream;
- Proximity Services (ProSe) for support of device-to-device communication when no coverage is available from the LTE network;
- Isolated E-UTRAN operations (IOPS) for isolated operation of LTE base stations when no backhaul link to the LTE core infrastructure is available;
- Mission Critical Push To Talk (MCPTT) for delivering PTT operated group-oriented and individual (private) calls.

The roadmap of LTE standards development and expected timeline of implementation of 3GPP releases by telecom equipment manufacturers is illustrated in Figure 1.

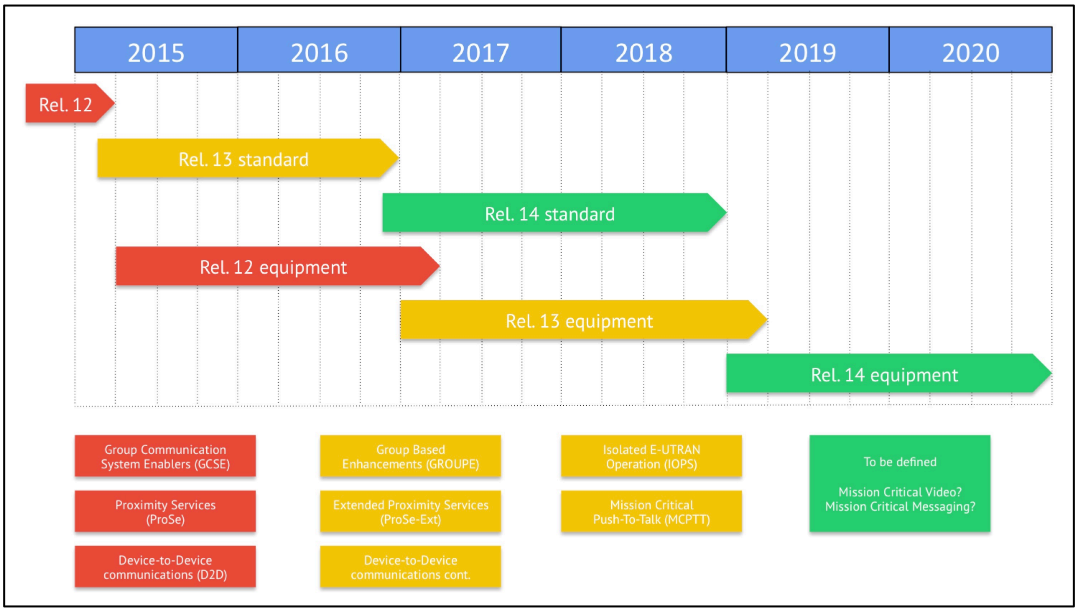



*Figure 1 – Roadmap of LTE standards*

The improvements in 3GPP standards for critical communications are applicable also for LTE Advanced as well as future 5G standards, while these features become integrated services in the core and base stations equipment.

## 2.3 WiMAX

WiMAX (Worldwide Interoperability for Microwave Access) has its origin in the IEEE standards track that has previously resulted in the highly successful Wi-Fi standards. WiMAX has been the favourite solution for wireless broadband networks for some time around the year 2008-2010. Similar to LTE, WiMAX is based on a pure IP architecture, but is more IT oriented with a focus on generic IP packet transmission and less on specific voice and data services.

Providing a wireless alternative to cable and DSL connection was the primary goal of WiMAX. The standard is designed to provide 30 to 40 Mbit/s data rates. The coverage of a WiMAX cell can be extended up to 50 km by using high-gain directional panel antennas at the customer premises. It should be noted that these distances can only be supported by using robust modulation and error correction, resulting in lower throughput.

Mobility support was added later to WiMAX, as well as support of higher bitrates of up to 1 Gbit/s.

## 2.4 Proprietary LTE

Similar to proprietary CDMA solutions that include Push To Talk services, there are proprietary “LTE trunking” solutions promoted today, supporting critical voice and broadband data today. The LTE air interface has been modified in order to support broadcast and multicast of voice and video streams, thus these solutions are not compliant to 3GPP standards.

Standards-based LTE smartphones, tablets and data-only devices do not operate on these proprietary LTE networks. This means that users have to rely on a limited product range offered by the manufacturer of the LTE infrastructure. Also due to the lack of competition after the initial investment, the pricing of additional devices or renewal of devices can be dictated by the supplier. Although these suppliers may promise a standards-compliance solution later, the guarantees and upgrade cost must be carefully considered before accepting such a solution.

# 3 LTE for Critical Communications

LTE for critical communications has been widely debated between industry representatives, consultants and end-users. Some vendors and end-users embrace LTE as the only necessary technology for building critical communications networks, while others maintain a more careful approach for a phased migration of TETRA to LTE.

Rohill concludes that LTE is not ready yet for critical communications, although LTE certainly offers significant benefits and opportunities to enhance operational efficiency of organisations. These benefits and opportunities are weighted with the limitations and challenges related to LTE, providing a neutral point of view.

As part of the conclusion of this chapter, also the relevance of TETRA Enhanced Data Service (TEDS) and WiMAX is evaluated against the features and performance of TETRA and LTE.

## 3.1 Benefits

LTE offers exceptional performance in regard to data throughput and latency; using 2 x 20 MHz of bandwidth the peak throughput for the downlink is 300 Mbit/s. Even with a modest spectrum allocation of 2 x 5 MHz a bitrate of 75 Mbit/s can be achieved, sufficient for at least twenty simultaneous streams of high definition video. Latency is typically in the order from 10 to 20 ms.

LTE is a real world standard created by the 3G Partnership Project (3GPP). This creates a clear benefit of interoperability of LTE networks and devices. LTE goes a lot further than TETRA in regards to standardisation of interfaces; not only the air interface is precisely specified in standards, but also the interfaces between the LTE core infrastructure and base stations, as well as application-level interfaces with LTE core components.

The pure open-standards IP based architecture of LTE offers significant benefits for building LTE networks and creating end-to-end solutions for end-users. Expensive and mostly obsolete synchronous telecommunication links are not needed anymore to build LTE networks; instead operators can benefit from a wide array of cost-effective private and public IP network services. Also, a vast amount of IP-based products and solutions can immediately benefit from LTE as a transport medium.

Solutions based on LTE are very scalable in size and capacity, supporting both public and private network deployments. This also allows for interoperability of devices and applications over both public and private networks, provided that the solution does not depend on specific requirements on the core components of a LTE network.

Finally, LTE infrastructure and devices are already affordable for many applications, thanks to system architecture simplicity, competition introduced by open standards, and the economy of scale.

## 3.2 Limitations

Availability of spectrum is a serious issue for deployment of private LTE networks. Although higher frequencies (above 3 GHz) can often be licensed for operation of private networks for reasonable or no cost, these frequencies are not suitable nor available for wide area coverage. The existing spectrum below 3 GHz is already captured by the public network operators or reserved by governments for specific applications. The "digital dividend" (spectrum that can be released because of more spectrum-efficient digital communication compared to analogue communication) will be granted to mobile operators as well, although a part of the spectrum could be reserved for PPDR applications through time consuming regional and world conferences on radio spectrum usage.

The coverage of a LTE cell is limited by a number of factors. First, higher operating frequencies will experience higher path loss resulting in reduced coverage. Secondly, the data throughput will be significantly lower when the distance to the base station increases due to the adaptive modulation techniques to overcome data transmission errors when the signal-to-noise ratio is poor. This can be compensated for to a certain extend by using higher output power and diversity / MIMO techniques.

The support of Quality of Service is often absent in public LTE networks, or even not permitted because of net neutrality legislation. This makes public networks unsuitable for critical communications when massive amounts of voice calls and data capacity is used by the public, which can be expected exactly when it is needed most during a large incident or event. A private standards-based LTE network overcomes the QoS issue, although critical communications also require more sophisticated mechanisms like pre-emptive priority in order to allow emergency voice and video to get immediate priority over other classes of service.

Due to the absence of effective multicasting methods to establish group-oriented voice and video calls, the current standards-based LTE networks do not offer the scalability needed to support scenarios where hundreds of users need to receive the same voice and video stream while connected to the same base station. Whereas TETRA supports a virtually unlimited number of receivers within a group call, in LTE these must be served each by an individual voice or video stream, requiring far more downlink bandwidth and packet switching performance.

This issue will be addressed by enhancements planned in upcoming 3GPP standards, although it will take a considerable time for mature support. The current mechanisms offered by the Multimedia Broadcast Multicast Service (MBMS) are too slow, complicated and inflexible for establishing group-oriented calls.

Support of resilience is definitely a limitation in the solutions based on the open LTE standards. Resilience requires isolated base station operations that are not defined and specified yet in the standards.

## 3.3 Opportunities

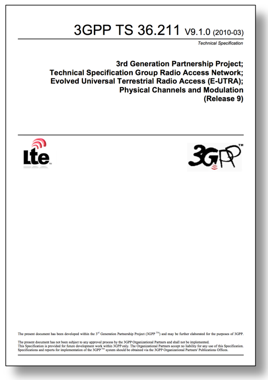
Public LTE network services are definitely suitable for non-critical broadband data applications, even for mission- and safety critical user groups. By supplementing mission-critical voice services with broadband data services, the operational efficiency can be significantly improved by making data centric applications available everywhere. Examples include remote access to databases (remote office) for public safety officers, and timetable information to be exchanged with vehicles for public transport.

Less critical professional and commercial applications can also benefit from voice services over LTE today. The ubiquitous availability of LTE coverage today is an appealing proposition for many applications that require wide area coverage for low operational cost. Examples include (international) freight transport, parcel delivery, road services, bus companies and city government services.

Hybrid networks are an important opportunity to create a cost-effective integrated solution serving both mission-critical voice and data requirements combined with non-critical voice and broadband data over wide-area public LTE networks. A good example is the opportunity whereby TETRA is used for metro, tram en bus service inside the city, and LTE for broadband communication combined with voice services for buses operating outside the city perimeter, where large incidents and events are unlikely to happen. Drivers and dispatcher do not need to worry about the underlying communication networks, while voice and data services seamlessly operate between networks.


For selected applications like Airports, Oil & Gas platforms and Industry, the use of private LTE networks becomes feasible today by using licensed or unlicensed spectrum above 3 GHz. This requires a dense network of small base stations or indoor coverage solutions, but with the advantage of high capacity and full control over Quality of Service.

## 3.4 Challenges


3GPP TS 36.211 V9.1.0 (2010-03)
Technical Specification

**3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
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Physical Channels and Modulation
(Release 9)**

The present document has been developed within the 3rd Generation Partnership Project (3GPP ™) and may be further elaborated for the purposes of 3GPP.

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The process of standardisation is a time consuming effort. Standards are often compromises to satisfy a large number of manufacturers, operators and end-user representatives, whereby Intellectual Property Rights play an important role to balance the influence of different parties. The resulting solutions are often more complex with more implementation options than absolutely necessary.

The telecom equipment suppliers should then adopt the resulting standards. The complexity and available options will increase the time to implement and validate the functionalities enabled by the new standards. Often, certain options may not be considered important by some manufacturers and thus will not get precisely implemented according to the standards, resulting in interoperability issues.

Another threat is the cost and potential side-effects of 3GPP features that are made available in new software releases; public operators tend to be conservative of rolling out these features if not absolutely necessary.

Critical communication can be considered a very small subset of the overall needs for mobile communication. Studies have shown that the percentage of critical communications users is in the order from 0.2 to 0.5% of all mobile telephony users. Serving critical communications users requires investment into additional features as well as measures to provide higher resilience, availability and coverage in order to meet their Service Level Agreements. These improvements are of limited value for consumer and business users; on the contrary, the need for pre-emption of capacity during events and incidents will potentially make the proposition of the public operator less attractive.

The final challenge is the availability of specialty devices. Critical communication users require dedicated devices that are designed to operate safe, reliable and comfortable under severe conditions. Shock and fall resistance, high operating temperature tolerance, protection against moisture and dust, good voice clarity and secure and robust software operation are criteria that cannot be met by standard smartphones. Specialised LTE smartphones, tablets and basic radios must be developed to serve these specific needs.

## 3.5 Alternatives

Two options still remain to serve high-speed data requirements, which include WiMAX and TETRA Enhanced Data Service (TEDS).

WiMAX is broadband capable, but is targeted for wireless links with limited or no mobility. Also, no interoperability exist with 2G and 3G telephony services, which is one the reasons why LTE has become the preferred choice for cellular network operators, despite earlier availability of WiMAX. The added capabilities in the WiMAX standard for mobility and 1 Gbit/s bitrate also arrived too late to make WiMAX a serious alternative to LTE. Nowadays, frequency spectrum for WiMAX networks is allocated to LTE instead and LTE networks are replacing existing WiMAX networks, underlining the fact that WiMAX adoption is rapidly deteriorating.

TEDS data throughput is limited from 30 to 260 kbit/s, barely suitable for moving video with standard resolution and frame rates. In reality, the resolution will be limited to 160 x 120 to 320 x 240 pixels with typically 15 frames per second. Data oriented applications may benefit from TEDS for mission-critical applications, although the benefit of the increased bandwidth is very limited and certainly not enough to offer an acceptable intranet browsing experience. Most important, TEDS is a “bag of incompatible operating modes” that severely limits interoperability between devices and infrastructure sourced from different brands.

Just like LTE and WiMAX, also TEDS requires additional spectrum to carry the extra data bandwidth. The existing licensed TETRA bands often do not provide the capacity for TEDS, resulting in the need for licensing extra TETRA channels or spectrum in other frequency bands.

Rohill refers to TEDS as “too little, too late”, which is acknowledged by most TETRA network operators and confirmed by tier 1 TETRA suppliers that are not further pursuing opportunities for TEDS product development, offering integrated LTE solutions instead.

To conclude, both WiMAX and TEDS became niche solutions that are supported by a small and shrinking number of suppliers, while LTE overtakes both standards in terms of performance, flexibility, frequency band support and choice of devices.

## 3.6 Conclusion

After careful evaluation of benefits, limitations, opportunities and challenges of LTE it becomes clear that standards-based LTE is not capable of fulfilling mission- and safety critical voice and data services today. But even in the future, private LTE networks will remain too expensive to cover large areas because of the potential cost of spectrum and higher number of base stations. Hybrid networks are the answer by integrating public and private LTE networks with TETRA infrastructures for a reliable, scalable and truly seamless communication experience.

Above all, LTE is really future-proof, paving the way to interoperable 5G standards for ultra high-bandwidth (1 Gbit/s+) networks for local coverage, whereby standard LTE will continue to serve the wide area coverage requirements.

The following overview provides a summary of strong and weak aspects of TETRA, TEDS, WiMAX, LTE Release 10 (today) and Release 14 (expected from 2020).

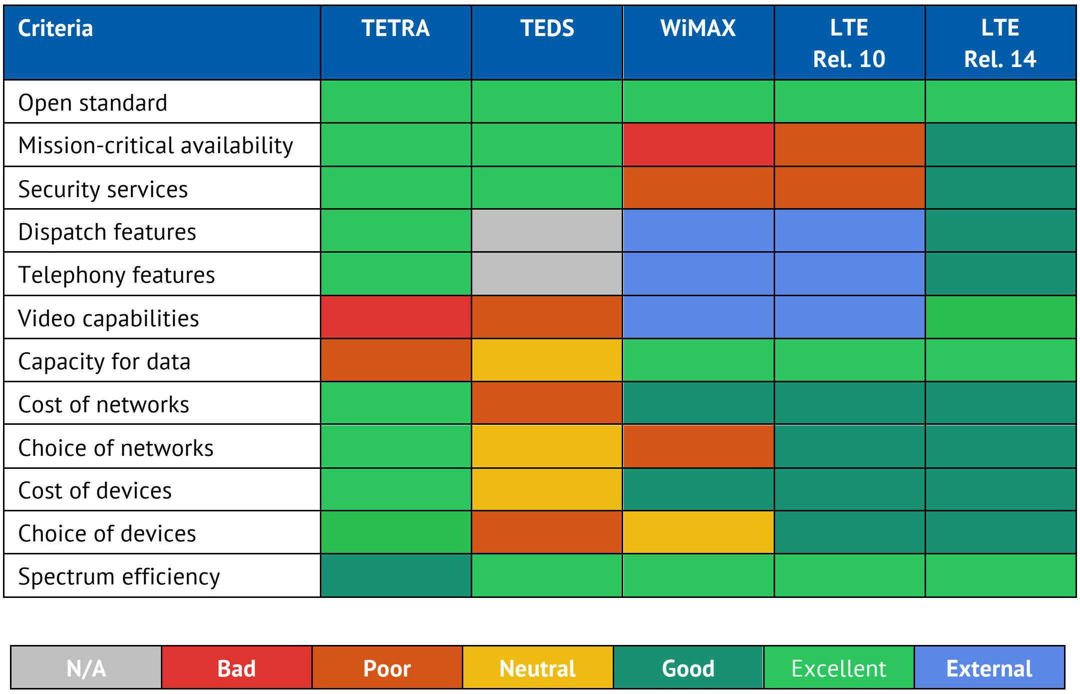


*Figure 2 – Comparison of standards*

Note that for the External category specific solutions are available from multiple suppliers that provide Push To Talk services on top of LTE, including the TeamLink suite of applications from Rohill.

# 4 New opportunities for TETRA

When carefully considering the pros and cons of LTE for Critical Communications, most representatives of the industry, consultants and end-users agree that TETRA remains the preferred choice for mission-critical communications for at least the next decade.

To introduce an analogy with the road system, let's compare LTE and TETRA with a motorway: LTE can be considered the motorway, whereas TETRA is the shoulder. The motorway offers high throughput, but drivers get easily stuck in traffic jams. The authorities can then still use the shoulder, which is always there but with lower capacity. Mechanisms to control the speed and priorities of vehicles in the motorway are required before the shoulder can be made redundant.

But even if the features are available to make LTE a truly mission-critical network solution, it is expected that TETRA will continue to serve critical communication needs. Reasons such as cost of private network coverage, limited spectrum availability and expected lack of critical communications support by public operators are just a few reasons why TETRA remains the preferred choice, even beyond 2025.

## 4.1 Second life of TETRA

The first generation of TETRA networks have now passed their technical lifetime. Spare components are obsolete or very expensive to obtain, software releases are not supported anymore, the performance has fallen much behind modern TETRA solutions, and the backhaul is based on expensive and out-dated communication links.

Replacement or upgrading of these TETRA networks by modern TETRA solutions results in lower operational cost, even when considering the extra investment needed for replacement or upgrade of the existing TETRA network. In addition, improved RF and switching performance results in a better user experience, lower energy consumption saves on electricity bills, and network availability increases significantly by using modern IP-based link redundancy concepts.

Recently Rohill has executed a number of replacement and mid-life upgrade projects with excellent results. Experience has shown that this is possible with virtually no downtime of the existing TETRA service. Specific tools and procedures are available to ensure the success of such a TETRA network replacement or upgrade.

## 4.2 Roadmap to Mission-Critical Broadband

The roadmap to mission-critical broadband should be one of the most important criteria for TETRA vendor selection, whether it is for a new, replacement or upgrade of a TETRA network. A clear vision and strategy for integration and migration helps to understand how TETRA can be supplemented and possibly replaced later by LTE. This should be supported by a realistic timeline and accurate estimation of investment and maintenance needed during the lifetime of the network.

We believe a cautious approach is preferred, allowing standards to develop in order to create interoperable solutions. In the mean time, application-level integration of TETRA-like voice-over-LTE allows end-users to benefit on short term from low-cost LTE coverage for less critical communication needs, without the risks of embracing proprietary solutions that are supported by manufacturer-specific devices only.

Rohill supports the “5 steps to broadband” approach, which is also favoured by a number of critical communication experts and end-user organisations in the Public Safety sector. This 5 steps approach allows a phased introduction of LTE, whereby end-user can benefit from LTE in an early stage, while avoiding the cost and risks of a “big bang” migration to an LTE-only solution.

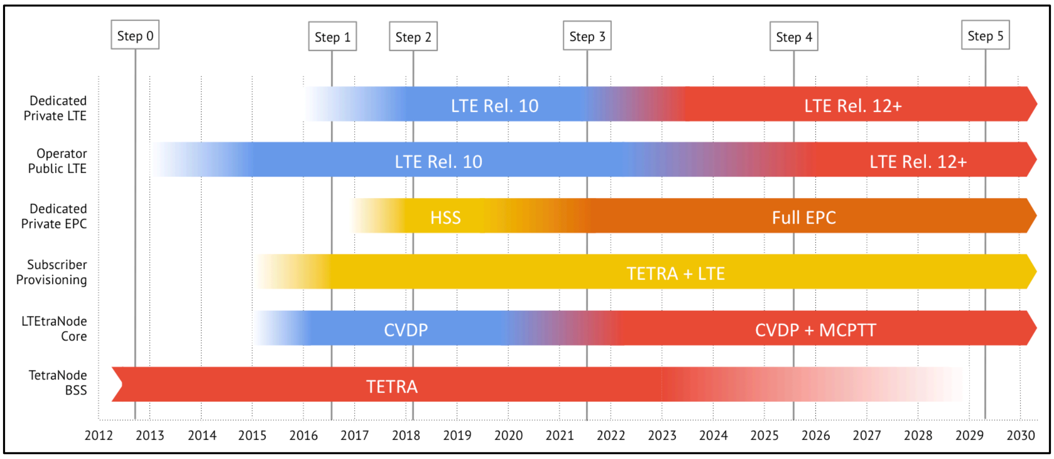


*Figure 3 - Five steps to Mission-Critical Broadband*

The colours indicate the following:

- Red indicates Mission-Critical Communications for both TETRA and LTE;
- Blue indicates Non Mission-Critical Communications for LTE as well as TETRA-over-LTE;
- Yellow indicates no specific criticality;
- Orange indicates Mission-Critical Communications support.

The roadmap to Mission-Critical Broadband consists on the following steps:

- Step 0 is the initial status, whereby Public Safety organisation use TETRA voice and data only, possibly supplemented by broadband over commercial 3G / LTE networks using standard subscriptions.
- Step 1 extends the mission-critical TETRA voice and data service with broadband data using a Mobile Virtual Network Operator (MVNO) service, allowing the Public Safety organisation to manage their own subscriptions. In addition, LTE devices can be equipped with group-oriented voice and data capabilities for less critical tasks by using the TeamLink suite of applications (refer to section 5.3).
- Step 2 introduces a private Home Subscriber Server (HSS), allowing even more control over the LTE subscriptions, for example in term of Quality of Service. The HSS is part of a private Evolved Packet Core (EPC). This EPC is interoperable with the Release 10+ based LTE network of the public LTE operator.
- Step 3 is possible after obtaining dedicated spectrum for a private LTE network. Availability of private LTE networks is important for coverage of urban areas, where overloading of public LTE networks can easily happen during events and incidents. In suburban and rural areas, public LTE networks can still serve public safety agencies while there are a limited number of large events and the density of mobile telephone users is much less in these areas.
- Step 4 enables mission-critical broadband communications by the implementation of 3GPP Release 12+ standards in both private and public LTE networks. It is expected that operators of public LTE networks are slower in adopting these 3GPP releases because of cost as well as technical and business risks (refer to section 3.4 on Challenges), but eventually then will be capable of providing these services as well. The introduction of Mission-Critical Push To Talk (MCPTT) will also enable mission-critical voice services, in addition to the Critical Voice and Data Protocol (CVDP) capabilities for voice, status, text, location, photo and video capabilities within the TeamLink suite of applications.
- Step 5 is the final stage whereby the TETRA network can be switched off and removed in order to remove the need to carry both a TETRA and LTE device, to save operational cost, and release the spectrum for other purposes. For this step it is required that all services on top of LTE are proven in terms of reliability, performance and coverage, and that specialised devices are available that are fit-of-purpose for the demanding tasks of public safety officers.

# 5 LTEtraNode features and benefits

LTEtraNode encompasses all integration and migration opportunities that exist for TETRA and LTE. It fully aligns with the previously explained roadmap to mission-critical broadband, with a commitment to support open standards for Mission Critical Push To Talk (MCPTT) when the applicable standards become available.

## 5.1 Technology

Rohill solutions are known for performance, flexibility, scalability, security and affordability. Also, the strong TetraNode system architecture, open standards-based interfaces and use of Commercial Off The Shelf (COTS) hardware and software solutions are widely recognised by the industry, our partners and end-users. Finally, the flexibility of the organisation allows for the development and supply of tailored solutions for many different market segments. These are all based on a single TetraNode platform that supports dedicated solutions, in particular for Public Safety, Public Transport and Oil & Gas.

The Rohill core technology is based on open hardware and software platforms to create a powerful IP based soft switch solution for TETRA and LTE. The adoption of Linux for all core, application server and radio access platforms delivers carrier-grade performance, stability and availability. Rohill solutions offer five-times-nine (99,999%) availability when geographic redundancy and redundant links are applied.

Our technology leadership has earned us a number of TETRA Awards that include innovations for energy efficiency, the roadmap for LTE integration and projects that emphasize the power and flexibility of the TetraNode core and applications.

## 5.2 Hybrid networks

LTEtraNode is the next step in evolution of the highly successful TetraNode product line. LTEtraNode supports hybrid networks, whereby TETRA is complemented with our private LTE network offerings, as well as gateways to public LTE networks, or even supporting both public and private LTE networks at the same time. The scenarios and benefits of using both public and private networks is highlighted in section 4.2 “Roadmap to mission-critical broadband”.

The high data throughput makes LTE the perfect complementary technology to TETRA. Whereas TETRA provides mission-critical voice and narrowband data services, LTE fulfils the requirements for broadband data, photo transfer and video streaming. In addition to broadband data, the LTEtraNode solution also supports voice, status, text and location services over LTE. The full interoperability of these services with TETRA allows seamless interoperability of these services in both domains. If operations of certain user groups are considered less critical, they may choose to deploy LTE devices only. In other cases, LTE may be used as the primary device and TETRA as a backup during critical events.

Many users of a TETRA network also have their own smartphone device for operational and administrative tasks. The mix of LTE smartphones and TETRA radios then offers several advantages:

- LTEtraNode in connection with public LTE networks offer cost-effective indoor coverage due to the ubiquitous availability of 4G coverage with backup of 3G coverage;
- TETRA is still available as a backup for critical communications during large incidents and events, but with lower capacity due to the fact that LTE can be used for voice and data communications needed for day-to-day operations.

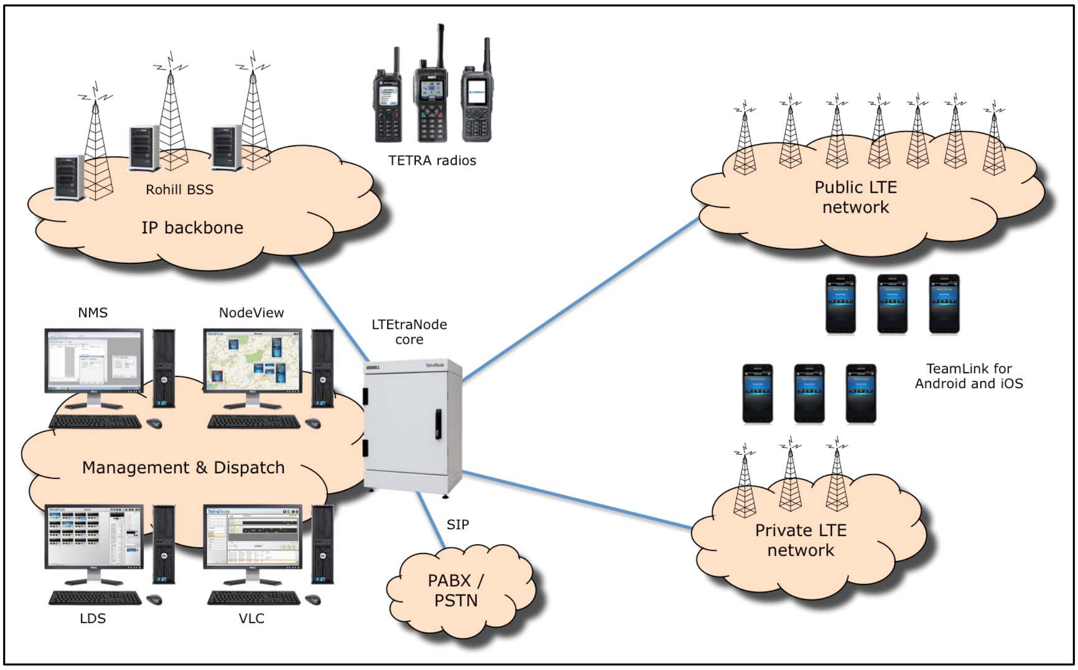


*Figure 4 - LTEtraNode Hybrid Network Architecture*

LTEtraNode offers a single platform for LTE and TETRA communications, whereby subscribers are provisioned through a single subscriber management application. Also fault, configuration, accounting, performance and security are accessible through a single set of applications, simplifying network operation.

## 5.3 TeamLink

TeamLink is the Rohill suite of applications for real-time voice, status, text, location, photo and video delivery. TeamLink is available as an app for Android and iOS smartphones as well as client software on Windows PCs, and operates as an Over-The-Top (OTT) application on top of 3G and LTE networks. OTT refers to transparent delivery of voice and data over an IP / 3G / LTE connection without the need for services in the core infrastructure in order to control and charge for this functionality.

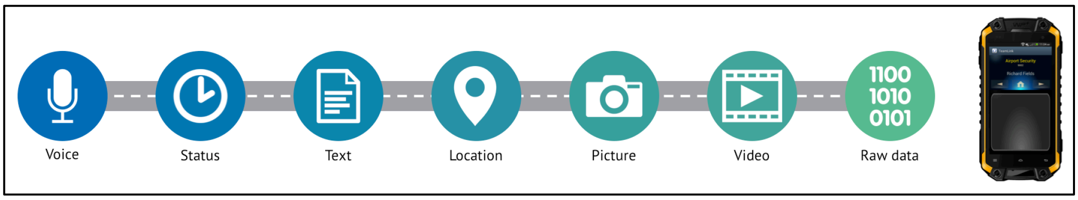


*Figure 5 - TeamLink capabilities*

At the server-side, TeamLink is supported by the LTEtraNode Core solution. The Critical Voice and Data Protocol (CVDP) is the basis for operation of TeamLink, of which the properties are explained in section 5.4. The TeamLink app can be provisioned for redundant operation of the LTEtraNode Core, allowing virtually seamless switchover when link or equipment failures occur. Operation is also much faster and more robust in comparison with PTT-over-Cellular (PoC) and proprietary solutions with a central call manager.

The TeamLink app provides an intuitive user interface; voice, status, text, photo and video capabilities are accessible by just a few buttons and gestures that are available on the main screen. Most of the functionality is invisible to the user, and only indicated when appropriate. A few functional capabilities relevant for Public Safety include:

- **Talker priority** (also referred to as "Speech Item Priority") allows certain users to interrupt a talking user. If the device or user is provisioned with pre-emptive talker priority, the user can then immediately start to talk and be heard by all group members, even if another lower-priority group member is talking. The interrupted user will hear a distinctive alert tone and show the talking party when interrupted. By default, a dispatcher is assigned talker priority.
- **Pre-emptive call priority** allows an on-going call to be pre-empted by another call with pre-emptive priority. Pre-emption is applicable to both group calls and individual calls; parties within a group call can be pre-empted by other group calls and individual calls, and likewise individual calls can be pre-empted by other individual calls and group calls. Pre-emption can be used to reach busy users, or overriding existing group calls in case of emergency.

- **Group scanning** allows a TeamLink user to monitor multiple groups at the same time. The selected group is the primary group on which communication is heard and voice is transmitted by default when pressing the PTT. Activity on scanning groups is only heard when nobody is talking on the selected group. Pre-emptive calls on a scanning group are always heard.
- **Dynamic regrouping** is a useful feature to regroup TeamLink users from the dispatcher station in order to create an interoperability team, or to reach all users in a specific geographic region.
- **End-to-End Encryption** adds 128 or 256-bit AES encryption for voice and data communication. While an application cannot control the LTE air interface encryption, the additional E2EE layer is important to protect against IP packet monitoring within the IP and LTE network. The End-to-End Encryption capability in CVDP is fully compatible and interoperable with TETRA E2EE, offering a end-to-end secure solution whereby no voice quality degradation is applicable. Existing TETRA E2EE key management tools can also be used to manage CVDP powered LTE devices.
- **Device provisioning, phonebook and group list synchronisation** are powerful capabilities that simplify the deployment of TeamLink devices. All information is stored in a central database within the LTEtraNode Core and distributed to TeamLink devices upon user authentication.

LTEtraNode provides the following interoperability and scalability figures for group calls:


*Figure 6 - Interoperability and scalability*

## 5.4 Properties of CVDP

The Rohill Critical Voice and Data Protocol (CVDP) offers advanced PMR voice and data services that are inspired by TETRA. These TETRA-like group-oriented and individual voice, status, text and location reporting functionality is supplemented by modern Presence and Instant Messaging features as well as CVDP-assisted standards-based picture transfer and video streaming capabilities. The following table provides a full overview of CVDP functional capabilities:

| Basic Services | PMR Supplementary Services | Telephony Supplementary Services | Security Services | Broadband Enabled Services |
|---|---|---|---|---|
| Group Call | Priority Call | Caller Identification | Device Authentication | Instant Messaging |
| Broadcast Call | Pre-emptive Priority Call | Call Forwarding | User Authentication | Presence Indication |
| Individual Call, simplex | Speech Item Priority | Call Waiting | Enable / Disable | Photo Transfer |
| Individual Call, duplex | Emergency Call | Call Hold | Permanent Disable | Video Transfer |
| Telephone Call | Talking Party Identification | Call Transfer | End-to-End Encryption | Discreet Viewing |
| Status Messaging | Late Entry | Include Call | | Group List Synchronisation |
| Text Messaging | Dynamic Regrouping | Call Barring | | Phonebook Synchronisation |
| Location Services | Call Authorised by Dispatcher | | | Device Provisioning |
| Mobility Management | Discreet Listening | | | User Provisioning |
| | Ambience Listening | | | |

*Figure 7 - Functional capabilities of CVDP*

These functional capabilities are enabled by a surprisingly small set of protocol messages, providing fast and robust operation of these features over 3G and LTE networks. Thanks to patented methods for streaming of voice packets during speech items (the period of talking by pressing the Push to Talk button), the typical call setup period over LTE networks is less than 200 ms for both immediate group and individual call setup.

In terms of system architecture, CVDP is very close to the proposed Mission Critical Push To Talk (MCPTT) standard. CVDP benefits from the same QoS mechanisms that are defined by the 3GPP for Mission Critical communications, but also works on top of public networks that do not support prioritisation of data packets. This makes CVDP future proof, also considering our promise to support MCPTT in parallel to CVDP when 3GPP standards are mature and being supported by LTE equipment suppliers.

Although CVDP can be considered a proprietary solution, Rohill has deliberately chosen to publish CVDP as an open specification, allowing manufacturers, application developers and system integrators to develop their own CVDP based solutions. Licensing of the patent is free of charge for third-party client applications.

The following strength and weakness analysis is comparing CVDP based TeamLink with other state-of-the-art PTT-over-Cellular (PoC) and Over-The Top (OTT), as well as upcoming standards for support of Mission-Critical Push To Talk (MCPTT) that will be eventually supported by TeamLink as well.

| Criteria | Proprietary LTE solutions | Typical PoC solutions | Typical OTT solutions | CVDP based TeamLink | MCPTT based TeamLink |
|---|---|---|---|---|---|
| Standards based PTT | Poor 1 | Good | Poor 2 | Neutral 3 | Excellent |
| Standards based LTE | Poor 1 | Good | Excellent | Excellent | Excellent |
| Carrier grade platform | Good | Good 4 | Neutral 5 | Good 4 | Excellent |
| Robustness | Good | Good | Neutral | Good 6 | Excellent |
| Latency (call setup speed) | Good | Neutral | Good | Excellent 7 | Excellent |
| Scalability (parties in group) | Excellent 8 | Neutral | Good | Good | Excellent 8 |
| Security services | Neutral 9 | Neutral 9 | Good 10 | Good 10 | Excellent 11 |
| Dispatch features | Good | Poor | Good | Excellent | Good |
| Telephony features | Neutral | Poor | Poor | Excellent | Good |
| TETRA interoperability | Poor | Poor | Good | Excellent 12 | Good |
| Video capabilities | Good | Poor | Poor | Excellent 13 | Good |
| Suitable for Private LTE | Poor 14 | Poor 15 | Excellent | Excellent | Excellent |
| Suitable for Public LTE | Bad 16 | Good 17 | Excellent | Excellent | Good 17 |
| Supports dedicated devices | Good | Excellent 18 | Good | Good | Excellent 18 |
| Supports smartphones | Poor 19 | Neutral 19 | Excellent | Excellent | Good |

| Bad | Poor | Neutral | Good | Excellent |
|---|---|---|---|---|

*Figure 8 – Comparison of solutions*

Note 1: potentially open specification, but with proprietary (manufacturer specific) aspects

Note 2: closed specification

Note 3: open specification

Note 4: carrier-grade Linux based

Note 5: Microsoft Windows Server based

Note 6: includes specific features for robust operation and redundancy

Note 7: based on Rohill IPR

Note 8: offers more effective LTE multicast support, also to be standardised by 3GPP

Note 9: relies on LTE air interface encryption

Note 10: adds AES-256 E2EE

Note 11: upgrades both air interface and E2E encryption

Note 12: fully inspired and interoperable with TETRA

Note 13: available on application level

Note 14: risk of vendor lock-in

Note 15: IMS-based PoC considered too complex for private network integration

Note 16: no public operator wants proprietary network technology

Note 17: public operators are hesitant towards new core releases

Note 18: good support of dedicated PoC devices

Note 19: smartphones do not support PoC standards - requires additional OTT layer

## 5.5 Future proof

Rohill is a strong supporter of the standardisation work within 3GPP and ETSI, and is actively participating in standardization efforts, both directly and together with end-users, research partners and industry as part of the European-funded SALUS project (Salus: **S**ecurity **A**nd Interoperabi**L**ity in Next generation PPDR Comm**U**nication Infrastructure**S**)

The LTEtraNode solution fully matches the system architecture as defined by the TCCA System Architecture work group. Rohill is committed to integrate CVDP with, and later migrate to, the emerging standard for Mission-Critical Push To Talk (MCPTT). This ensures that LTEtraNode network operators receive a guaranteed future-proof solution that works both with private and public (operated) LTE networks based on open IP and LTE standards. The TeamLink application will offer the same user interface for both CVDP and MCPTT operation, allowing seamless interoperability between TeamLink users in both domains and no need for training when switching between the domains.


Rohill has won the International TETRA Award 2014 for the "Best integration of future broadband with TETRA" with the first LTEtraNode system deployed with the public operator SETAR of Aruba in the Antilles, further acknowledging our leading role in LTE integration. The pilot project for integration of TETRA and LTE with SETAR of Aruba has been the first major achievement that proves the maturity of technology and business case of the LTEtraNode solution. The existing TetraNode network in operation for public safety and government agencies has been upgraded to LTEtraNode, and integrated with a carrier-class LTE network from Alcatel-Lucent, deployed in 2014 across the island of Aruba.