Mission Critical Application Enabled by Operator's LTE Network

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01 Executive Summary

Mission critical applications, including Trunked Radio System (TRS) and its basic trunking service known as Push-to-Talk (PTT), have been serving public safety, utility sectors, and other vertical industries for decades. However Trunked Radio Systems mainly use Private Mobile Radio (PMR) technologies (e.g. TETRA, P25, iDEN), which are narrowband, low capacity, fragmented and non-standardized.
However, users are showing an increasing demand for broadband data applications such as push-to-video; real-time video surveillance, high-resolution photos, and location-based services. These services require TRS to upgrade from narrowband to broadband. However, traditional PMR systems cannot evolve to broadband trunking,
Meanwhile many countries across the world intend to upgrade its existing public safety networks. In which nationwide coverage is required as well as MBB transmission capabilities. However, it is too costly to build a whole new broadband TRS across the country.
In addition, operators are placing more and more importance on the exploration of B2B market by providing mission critical services over their commercial cellular network.
These causes mentioned above makes LTE as an essential option for mission critical application, because LTE technology and its natural evolvement known as 4.5G naturally support high speed connection, massive connections and low latency.

Mission critical application enabled by operator's LTE network can provide the following benefits:

- LTE brings rich services & transition from push-to-talk to push-to-video.
- Operator's LTE network enables fast and cost-efficient deployment of national mission critical service.
- It is an innovative service to boost revenue for operator

In order to realize mission critical application over LTE, there are three main drivers to be considered.

- Standardization Progress
- Ecosystem Development
- Support from Operators & Governments.

Currently UK government has started to build new emergency service network (ESN) totally based on operator's commercial LTE network.ESN gives a better understanding of how to deploy mission critical application over operator's LTE network. In addition, four different deployment options will be introduced in this white paper.

02 Differences between LTE & PMR Technologies

There are many differences between LTE and PMR. Each technology has its particular application and deployment scenarios.
Voice-centric PMR technologies such as TETRA, P25, iDEN, have been proven to be reliable and secure for critical communication after decades of operation globally. But they still have defects such as fragmented standards and limited data capability. These standalone systems based on different standards,
Frequencies and end-user devices result in close ecosystem and lack of interoperability.
On the other hand, LTE is a 3GPP-standardized and international technology, which is widely supported by the majority of mobile operators, network equipment vendors, and device manufacturers.
Nearly 500 commercial LTE networks have been launched in over 160 countries. LTE also support over 40 different standardized frequency bands from low bands (e.g. 450MHz, 700MHz, 800MHz) to high bands (e.g. 1.8GHz,2.6GHz) . Large-scale deployment results in thriving ecosystem, proven and complete interoperability.
Then TCO of deploying national public safety network can be significantly reduced by reusing commercial LTE network. For example, deploying a dedicated network in Australia is about 2.8 times more costly than relying on commercial networks, according to Public Safety Mobile Broadband (PSMB) research report published by Australian government 2016[1].

	PMR	LTE
Standard	TETRA, P25, iDEN	3GPP defined
Frequency Band	Non 3GPP-standardized bands e.g. 400Mhz, 800MHz,1400MHz,	All 3GPP-defined bands e.g. band28, band14, band20
Interoperability	Poor	Proven & Complete
Reliability	Proven & Widely Accepted	• Standardization is frozen • Need to be proven in future Practical application
Security	End-to-End Encryption	• Air Interface Encryption • Transition Encryption e.g. IPSec
Data Speed	Low Speed (e.g. 28 kbps by TETRA)	> 100 Mbps
End-user Device	Dedicated device customized for different standards	Compatible with all LTE devices •Rugged •Consumer-level
Deployment Option	New build	• Reuse operator's LTE network • New build

Table 1 Difference between LTE & PMR

In conclusion, LTE is an ideal option in the following scenarios:

- Fast & cost-effective deployment of national critical communication
- Operators want to provide mission critical services by their own commercial LTE networks.

PMR is more applicable in the following scenarios:

- Users intend to have their own private network with exclusive network resources for critical communication.
- Users have dedicated spectrum to deploy PMR.
- Mobile data applications are not the key demand for users.

03 Emerging Market for Mission Critical Application over LTE

Mission critical application over LTE can be widely utilized in various scenarios particularly in public safety. By the end of 2020, SNS Research estimates that public safety subscribers will grow to nearly 10.8 million at a CAGR of 55% in LTE cellular networks, which include commercial LTE networks and dedicated public safety LTE networks. In the mean time, public safety service revenue over LTE cellular network will increase to about $18 billion at a CAGR of 53% by 2020.

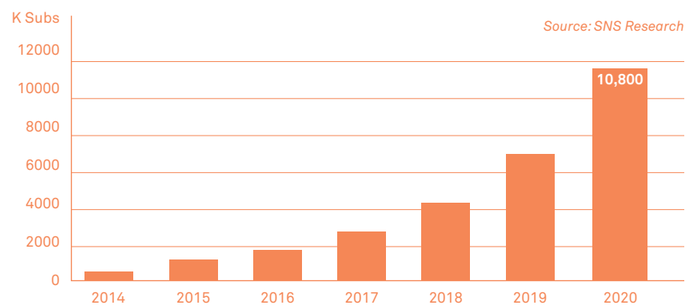

Figure 1 Public Safety LTE Subscriber Forecast 2014-2020

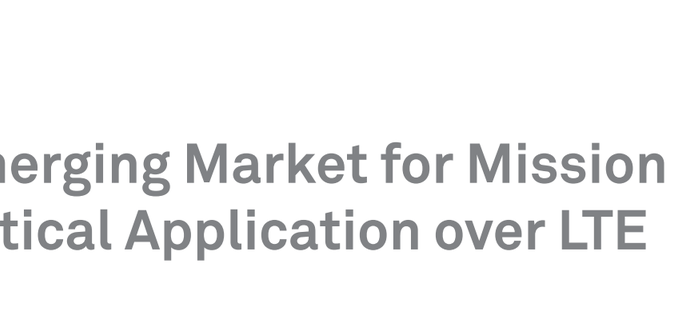

Figure 2 Public Safety LTE Service Revenue Forecast 2014-2020

SNS Research also estimates the global spending on dedicated LTE infrastructure including eNodeBs, EPC and backhaul will account for $2 billion annually by the end of 2020.

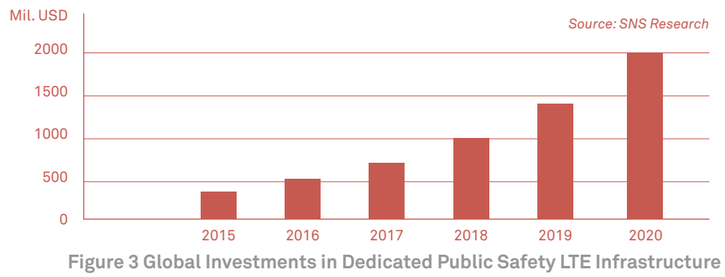

Figure 3 Global Investments in Dedicated Public Safety LTE Infrastructure

Given that mission critical application over LTE can also be applied in utility and business sectors, it brings promising market prospects for global operators.

04 Momentum of Mission Critical Application over LTE

There are three main drivers of using operator's LTE network to deploy mission critical services:

- Unified standard by 3GPP
- Ecosystem Development
- Governments & operators' Attitude

1. Frozen Standard

Obviously unified standardization will accelerate the development of the entire industry chain. Mission critical application over LTE has been standardized and covered in the latest releases thanks to 3GPP's great effort.

Since 2012, most leading standard organizations such as TCCA [2], ETSI[3], OMA[4] have established cooperation with 3GPP [5]. In 2014 3GPP created a new Working Group of WG SA6, which aims to undertake specification work for mission critical applications over LTE[6].

3GPP has initialized specific work items on application layer, network layer & terminal layer from 3GPP Release 12 onwards. These work items including MCPTT, GCSE, IOPS, ProSe cover all the scopes of mission critical communication. All of them have been frozen in 3GPP Release 12 and Release 13.In 2017, 3GPP started to standardize mission critical video and mission critical data from R14 onwards.

2. Mature & Fast-growing Ecosystem

Ecosystem is the key factor to establish business success. Two types of terminals can be provided for users:

- Consumer-level LTE Smartphone
- Rugged LTE Smartphone

Consumer-level LTE Smartphone is able to support mission critical applications after installation of mobile client as shown in Figure 5. Then operators can meet diversified user requirements with even lower CAPEX and faster TTM.

Figure 4 LTE Smartphone with Mobile Client

In addition, the most important part of ecosystem is rugged device, because public safety or industry users often work in extreme and hazardous environments, which require high reliability with physical PTT keys for the phone. Since 2015, several Android-based rugged phones have been announced as shown in the following figures, which indicate ecosystem is ready and keep growing.

Figure 5 LTE Rugged smartphones

3. Global Support from Governments & Operators

Today, mission critical application deployed in LTE cellular network is widely supported by both governments and operators globally.

1. **Government selects LTE to deploy national public safety network**
   Many countries across the world require upgrading its existing public safety networks, which are based on PMR systems such as TETRA, P25. However these obsolete trunking systems cannot smoothly evolve to broadband trunking.
   In order to realize nationwide public safety services fast and economically, governments choose to deploy broadband trunking system based on operators' LTE network.
   In UK, government started to build emergency service network (ESN) with EE, and the existing frequency band will be shared by both first responders and consumers.
   Korean government started PS LTE project in 2014. It aims to build dedicated LTE network over band 28 (APT700), and provide nationwide mission critical communication. In 2015, government started the trial with KT & SKT.
   In USA, government is also planning to use operator's LTE network, and launch nationwide mission critical services in band 14 700MHz spectrum.
   Furthermore Belgium,Mexico,Turkey,France,Australia,Belarus, are also planning to implement national public safety network over operator's LTE network.

2. **Mission critical application is an innovative Service to boost Revenue for operators**
   Mission critical application over LTE can help operator win new B2B customers and grow revenue by its own LTE network, because its application scenarios include not only public safety but utility or business sectors (e.g. transportation, construction, airport, and seaport).
   Furthermore operators can obtain new spectrum band by government-led public safety projects, because governments usually allocate specific spectrum band to deploy public safety network, and allow operator to use it for consumers' access as well.

Figure 6 Applications in Various Business Sectors

Reference Case & Deployment Options

Currently UK's ESN project is one of the most important reference cases of mission critical application over LTE, and provides a great demonstration for the other countries and operators.
In ESN, MOCN solution is applied in order to realize cost-effective and user data security.

Besides MOCN, there are another three deployment schemes to implement mission critical application over LTE as flows:

- Overlap, simplest and fastest deployment scheme
- New Build, Safest Mission Critical Network
- Combination of LTE & PMR to keep PMR for mission critical voice

1. ESN, Public Safety over Live LTE Network

UK government planned ESMCP in 2013 in order to replace obsolete TETRA network by build a new emergency service network (ESN) based on operator's commercial network as well as frequency band., because TETRA network cost government £450m every year [7] with poor broadband data capability.
U.K. mobile operator EE won the Lot 3 contract to provide mobile services by sharing its commercial E-UTRAN.
Then MOCN solution is applied here. Both Consumers and mission critical users share operator's E-UTRAN infrastructure and spectrum resources. MOCN realizes nationwide coverage with faster project delivery and lower cost, when UK government required cost reduction and 90% geographic coverage.
In order to ensure data security of mission critical users, governmental agencies will own and operate NEs (e.g. HSS, PGW) for user services.
Because RAN resources are shared, stringent mission critical requirements need to be fulfilled by features, configurations and planning in LTE network.

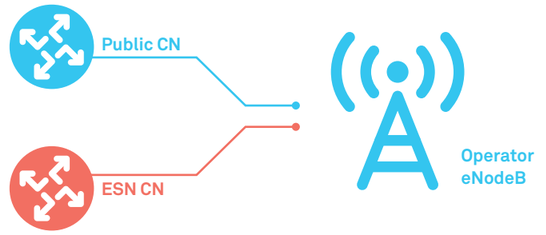

Figure 7 MOCN Network Architecture for ESN

2. Deployment Options

There are totally four options to deploy mission critical application over LTE network as follows.

	Option 1 MOCN	Option 2 New Build	Option 3 Overlap	Option 4 Combination of LTE & PMR
Frequency Band	Commercial	Dedicated	Commercial	Depend on which option(1,2 or 3) is used for LTE part
E-UTRAN	Commercial	Dedicated	Commercial	Same as above
Core Network	Dedicated	Dedicated	Commercial	Same as above
Cost	Low	High	Very Low	Same as above
Security	High	Very High	Low	"Voice: Very High Data: Depend on which option(1,2 or 3) is used for LTE part"
Delivery Cycle	Short	Long	Very Short	Very Long
Main Application Areas	UK	Korea	NULL	USA

Table 2 Deployment Options

1. MOCN, Balance Cost Efficiency & Security

MOCN scheme allows consumers and mission critical users to share operator's E-UTRAN infrastructure as well as spectrum resources, while governmental agencies own a dedicated core network to realize user data security. This dedicated core network usually includes HSS, PGW, GCS AS (Group Communication Service Application Server). In addition, software package is also required to guarantee first responders' user experience when sharing network resources with ordinary consumers.

MOCN solution is applied in most national public safety networks e.g. UK ESN, because it provides faster network deployment of national coverage, lower cost as well as user data security.

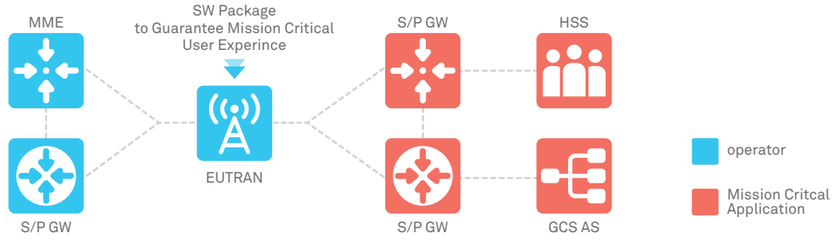

Figure 8 MOCN-based Network Architecture

2. New Build, Dedicated Mission Critical Network

Some countries prefer to build a whole new dedicated public safety network by allocating dedicated frequency band with exclusive network resources for first responders' critical communication.

For example, Korean government started PS LTE program in 2014. It aims to build dedicated LTE network over band 28 (APT700), and provide nationwide mission critical communication.

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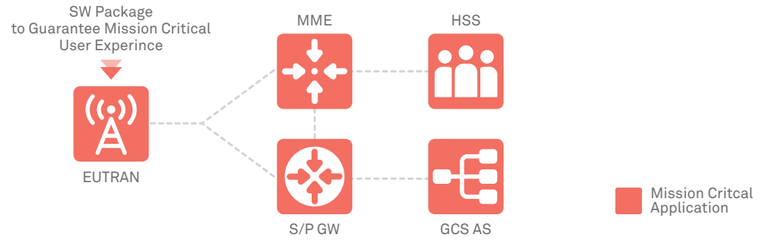

Figure 9 Dedicated Network Architecture

3. Overlap, Fast Deployment

Overlap only requires new-added GCS AS in the existing network.

In addition software package is also needed to upgrade in eNodeB in order to guarantee mission critical user experience. All users share the same core network.

Overlap is easy to deploy and help operators quickly launch services.

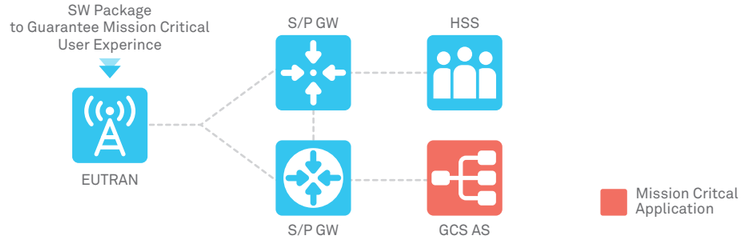

Figure 10 Overlap Deployment

4. Combination of LTE & PMR, Keep Proven

PMR networks have been proven reliable over decades of operation. In order to preserve the investment, most agencies are cautious and will continue to use PMR for mission critical voice service.

In this case, LTE network only provides data services, such as video services, location-based applications, data query. First responders need to have two handsets working in LTE and PMR mode respectively.

In 2012, US government established FirstNet, which aims to build dedicated public safety network nationwide. A dedicated LTE network using band 14 will be built for mobile broadband services. Regarding mission critical voice, first responders will continue using P25 system as they have been doing for decades.

06 Parallel Opportunity in Vertical Industry

With the Mission Critical communication over LTE is becoming reality, traditional PMR services also paving the way to LTE for entering into some vertical Industries. There is a long list of mission critical applications which could make sense for the corporate segment such as:

- Push to Talk & Push to Video
- Group Communications
- GIS

Another immediate benefit is that these applications can easily work on legacy 4G LTE smartphones. It just needs a simple software download on relevant smartphones for being ready for use.

In Latin American Region: The iDEN network is facing the challenge of evolution, also the 800MHz of iDEN is going to be clean-up and re-auctioned. Some operators want to use it as LTE band, such as 700M, in order to let iDEN users becoming true LTE subscribers and generating new revenues. In these countries, iDEN is often used by Taxi/Travel agencies and the final users also like push to talk service as being a high efficiency communication.

In Middle East: Operators want to use live LTE bands to enter into new business areas, like Public Security/Oil & Gas field/ Utility and enable revenue increase. Moreover there are opportunities to replace existing TETRA systems.

In 2017, Huawei and Kuwait's leading operator jointly launched the Middle East and Africa's first critical communication services based on live LTE network, and successfully enabled one of global leading security companies to provide broadband security services and solutions for its commercial customers.

In Europe: Operators want to use their LTE network to replace the legacy TETRA networks and would like to extend into vertical areas, such as logistic/utility, Airport. There are expectations that the rollout of mission critical applications could be faster for the vertical industry than the Government Agencies PPDR services.

In 2017, Huawei and a top operator started to deliver critical communication services to a major oil company in Spain by commercial LTE network. Video services as well as IOPS solution will be provided to improve work efficiency and network reliability.

07 Enable Mission Critical Applications over LTE

Based on 3GPP R13 standard, LTE based critical communication solution is very efficient to enable Mission Critical services into live LTE Network right now. In addition operators can take full advantages in re-using legacy LTE smartphones by a simple software applications installed. According to 3GPP standard, one optional architecture is as follow:

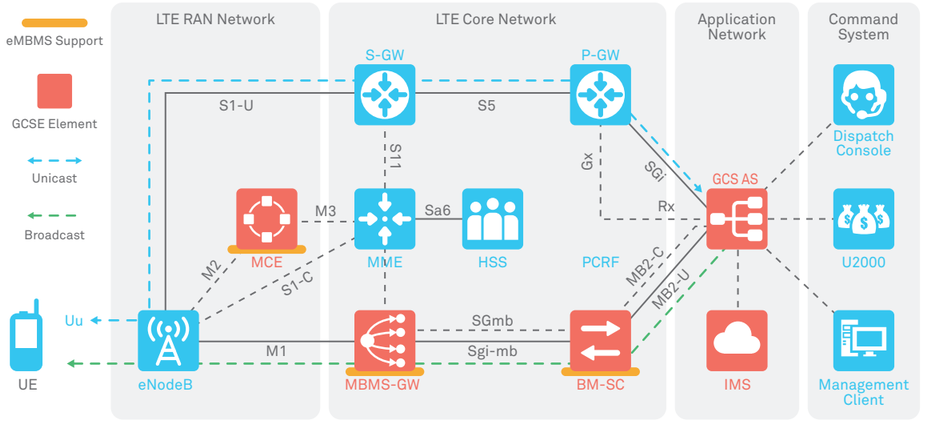

Figure 11 Optional Architecture of LTE based critical communication solution

In order to deploy LTE LTE based critical communication solution Solution in an existing LTE network, the key actions are shown in the table below.
GCS AS as the service enabler is mandatory as well as dispatch console and mobile client installed in LTE smartphone.
To ensure first respondent's user experience in commercial network, first respondent's software package is required to upgrade in eNodeB.

	New Added	Upgrade
EPC	GCS AS	
E-UTRAN		SW Package
Command Center	Dispatch Console	
Terminal	Rugged Phone (Recommended)	Mobile Client

Table 3 Key Actions to deploy LTE based critical communication solution

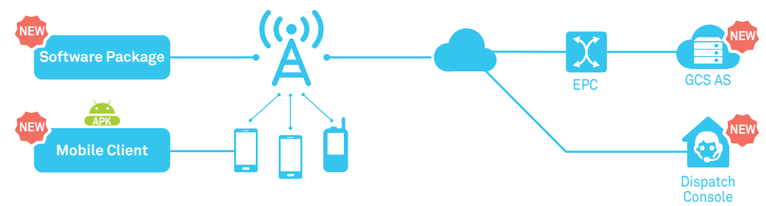

Figure 12 Network Diagram

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2. Software Package

By upgrading standard software package in eNodeB, live LTE network will be able to bring the following benefits and support mission critical service better.

- Ensure priority and preemption of mission critical services
- Guarantee service continuity under heavy-load circumstances
- Enable mission critical connection management by shorten access delay and prolong terminal's standby time
- Ensure MCPTT voice quality

3. Application Platform

In order to realize mission critical LTE services GCS AS provides group communication service application server (GCS AS) enables rich features for mission critical communication:

- Push-to-Video
- Video Surveillance
- Video dispatch service
- GIS-based dispatch service

08 Glossary

GCS AS - Group Communication Service Application Server
GCSE - Group Communication System Enabler
IOPS - Isolated E-UTRAN Operation for Public Safety
MCPTT - Mission Critical Push-to-Talk
MOCN - Multi-Operator Core Network
ProSe - Proximity-based Services
PMR - Private Mobile Radio

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