European Commission

Is Commercial Cellular Suitable for Mission Critical Broadband?

Study on use of commercial mobile networks and equipment for "mission-critical" high-speed broadband communications in specific sectors

EXECUTIVE SUMMARY

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Executive Summary

The aim of this study is to evaluate the options for mission critical communications utilising mobile broadband in three sectors – public protection and disaster relief (PPDR, principally police, fire and emergency medical services), utilities (electricity, gas and water) and the intelligent transport systems (ITS) now entering service, with a focus on road and rail. The two main options considered are the public land mobile networks (PLMNs) run by commercial operators and the dedicated networks created specifically for use in these sectors.

European society depends on mission critical services

Public safety, the assurance of working utilities and reliably operating transport systems are essential for modern European society. Such services cannot function without radio networks and increasingly they require wide-area wireless broadband support. This study examines the past, present and future of mobile communication for mission critical services in the three sectors. Traditionally, each sector has had its own dedicated networks, often with exclusive spectrum allocations.

To cite just one example, PPDR in the EU Member States (MS) has benefitted from significant capital investment (capex) of at least €19 billion. (The total may be higher as public accounts differ in transparency and completeness.) Most of the investment has been in TETRA and TETRAPOL technologies, with limited potential to support new data services, even though the voice channels might well be useful for another decade or more and so will form the basis for certain PPDR networks until a replacement technology is available. Moreover, the suppliers of mission critical technologies are specialised and few in number, with limited potential markets in Europe and globally. So economies of scale from the mass production of equipment cannot be attained and the small number of suppliers restricts competition. Furthermore, while international cooperation between PPDR and other vital services is growing in importance, interworking different manufacturers' implementations of TETRA and TETRAPOL has proven difficult. PPDR users are effectively locked in to specific implementations of the standards that interfere with cooperation across borders, jurisdictions and sectors.

European rail networks are currently deploying a 900 MHz service based on their own private communications networks, using a variant of GSM which could ultimately cost over €25 billion (our estimate). GSM is still the most widely supported cellular technology and it is well suited to the railways' needs. But it is similar to TETRA and TETRAPOL in having a limited number of sources of mission critical equipment designed specifically for railway use, and a very uncertain future, as the cellular industry wants to phase out GSM in favour of 3G and 4G. Thus, just how future support for the railways' new wireless networks would be provided is quite unclear.

Meanwhile, mission critical applications are now developing rapidly. Smart grids for utilities, video for road traffic management and medical imaging for ambulance teams require broadband data channels accessible across wide geographic areas. Broadband is becoming increasingly important for saving lives, keeping the lights on, preventing accidents and maintaining public order.

In this context, Europe's mission critical services are undergoing a major change as dependence on digital technology rises. Furthermore, the concept of "mission critical" communications is spreading from PPDR into other sectors as the European economy's interconnectedness and dependence on information-rich capabilities grows. As a result, the definition of "mission critical" is being extended

from the key functions which protect safety of life to include maintenance of the macro-economy's smooth functioning (practical definitions for the future are explored in Section 2.4.).

More efficient mobile broadband networks are appearing, but there is a complication

In this context it appears fortunate that Europe's mobile network operators (MNOs) are currently rolling out high-speed mobile broadband. However, the mission critical sectors have reasonable apprehensions about relying exclusively on commercial mobile services, with two major reservations:

- Can commercial operators be trusted to provide reliable services under fixed-price contracts over long periods of time?
- Will they provide the needed level of network availability, resilience, service quality, security and coverage, particularly in emergencies?

Each of the three sectors considered here is closely allied with governments and the public sector as a whole. The emergency services expect government grants of priority resources, such as free spectrum and rights of way. But all EU Member States face budgetary constraints resulting from the financial crisis of 2008 and rising long-term debts. The squeeze on public services is expected to continue for a decade or more, leading to a contradiction: public services must reign in their spending even though citizens always expect them to do more.

Are commercial mobile networks a viable mission critical solution?

In an age of persistent austerity the question is increasingly asked: can commercial mobile networks adequately support mission critical communications, for broadband and voice? The economic advantages of using the same broadband technology base, infrastructure and spectrum bands for mission critical users as well as the mass market seem clear. But the question is whether the cost savings come with sufficient resilience and performance.

In response to the pressure on public budgets and the introduction of a new more efficient generation of mobile broadband technology, the European Commission requested an in-depth independent study of the costs and benefits of using commercial networks for mission critical purposes. SCF Associates Ltd. was asked to explore the communication requirements and options in three sectors – PPDR, utilities, and ITS – through a close examination of five scenarios.

It should be emphasised that the objective of this study is to examine the introduction of mobile *broadband* to mission critical services via commercial MNO networks. Moreover this study should examine the needs of *all three* sectors (utilities, ITS – road and rail – and PPDR).

These five scenarios explore the options on a cost basis among dedicated networks, commercial networks from the MNOs and new LTE commercial equipment hardened for use on a dedicated network. Our conclusions are that in general, the capex per user for commercial LTE networks, hardened and with geographic coverage extended to 99% of national territories, would be less than the capex per user for dedicated LTE networks. This is also the most attractive option in terms of value for money when capex and opex are combined, although the cost advantages vary according to which frequency bands are used. At 450 MHz, the cost per user of a dedicated network is cheaper in capex by over 40% compared to the commercial mobile broadband network at 800MHz. But when 10 years of opex is taken into account, the sharing of infrastructure costs favours the commercial networks, whether operating at 450, 700 or 800 MHz. A commercial LTE network operating at 800 MHz can

give a capex cost per user that is lower by some 40% than a dedicated LTE network at 700 MHz. (If MNOs decide to operate commercial mission critical networks in the 700 MHz band, the capex costs could be up to 20% less than a similar network at 800 MHz.)

But cost is not the only consideration. Our overall conclusion is that it could be possible for commercial mobile broadband networks to be used for mission critical purposes but only ***if five conditions are met***.

The five conditions – which must be met in full – are these:

1. First the behaviour of commercial MNOs must be constrained to provide the services needed by mission critical users while preventing the use of "lock in" techniques to take unfair advantage of this expansion of the MNOs' market power and social responsibility. Such changes include not just stronger commitments to network resilience, but the acceptance of limits on price increases and contract condition revisions, ownership continuity assurances, and a focus on quality of service for priority mission critical traffic. Equally important for long-term relationships will be the mission critical services' *perception* of MNO behaviour and performance. For that, measures will be needed that go beyond service level agreements (SLAs) at a commercial contract level: new regulations regarding commercial MNOs services must be enforced by each Member State's national regulatory agency (NRA).
2. Commercial networks have to be "hardened" from RAN to core and modified to provide over 99% availability – with a target of "five nines". Geographic coverage must also be extended as needed for mission critical purposes and indoor signal penetration improved at agreed locations.
3. All this network hardening and extended coverage, along with the addition of essential mission critical functions and resilience, must be accomplished at reasonable cost. No more should be spent on the selective expansion and hardening of commercial networks for mission critical use than it would cost to build a dedicated national LTE network for that purpose.
4. Hardened LTE networks must be able provide the different types of service required by each of the three sectors. Each sector uses broadband in quite different ways. That is, not just for streaming video, image services and database access, as in PPDR, but for very low-latency telemetry and real-time control for utilities and transport. In the five network options examined in Chapter 4, accommodating the needs of the different sectors becomes easier as one moves from existing dedicated networks to LTE and then to more complex hybrid configurations.
5. However, there is a further high barrier: will commercial mobile networks be able to overcome ingrained Member State preferences for state controlled networks for applications that implicate public safety? This is not simply a legal, regulatory or economic question. Some Member States have specific histories of state control as part of their culture, traditions and politics, not to mention investments in current technologies with long payback cycles. Thus some Member States may want to continue using dedicated networks in the short and medium term even if they cost more – examples are Germany, Italy and France for PPDR. However, it cannot be said that they will always ignore cheaper alternatives. The MNOs may need to be more persuasive in putting forward their advantages. In the meantime, it must be left to Member States to choose.

These obstacles to commercial use cannot be removed immediately. But for the medium and long term, sharing commercial MNO infrastructures for both public and mission critical purposes makes economic sense. The crucial barrier is the current MNO mass-market business model, which needs to be suitably amended to provide appropriate levels of service to priority clients with special needs. But *perceptions* of the MNOs will take some time to change. Hence, as mission critical networks are the responsibility of national administrations, it is likely that dedicated state-owned networks will continue to be the preferred model in the near term. But at least for budgetary reasons, each Member State may consider moving from dedicated closed networks to shared commercial networks as the five conditions above are satisfied.

What measures are needed to meet these conditions?

Costing the scenarios in Chapter 4 for commercial, dedicated, shared and hybrid networks, it appears that budgetary requirements can be satisfied in several different ways. Moreover, our investigation of LTE in Chapter 3 shows that its capabilities can be brought up to mission critical levels if the standards organisations deliver what they promise, on time.

To perform this study, the requirements shaping the wireless communications needs of the three sectors were explored in depth (see Chapter 2 and the Appendixes, which are an integral part of this report). The PPDR community's requirements are well articulated by organisations such as the Law Enforcement Working Party (LEWP) and the TETRA and Critical Communications Association (TCCA). However, police perspectives tend to dominate those articulations. Fire fighters, emergency medical personnel and disaster relief organisations have somewhat different needs and these must be taken into account as well. So we give more attention to their requirements than is often the case (see Appendix A).

For the utilities, industry associations including the EUTC (European Utilities Telecommunication Council) and Eurelectric as well as specific utilities (Iberdrola, Alliander and others) gave us detailed input. The European Railway Agency (ERA) provided essential information and further study revealed the emerging requirements of roadway transportation. Across the three sectors we found diverse requirements:

- PPDR users expect to use mobile broadband much more extensively in the future, although each subsector has a different agenda: video and high-resolution images are of growing importance to law enforcement, while real-time sensors (including infrared cameras and through-the-wall motion detectors) are increasingly sought by fire fighters. Emergency medical services need high-resolution images for remote assistance in making accurate onsite injury assessments and diagnoses, while search and rescue teams find video-equipped drones enable a few people to survey large areas efficiently.

- Utilities are less interested in broadband than in reliable wide-area collection of brief machine-to-machine (M2M) data bursts from millions of meters and substations. Variable inputs from solar cells and wind turbines are changing the architecture of power generation today and posing new challenges for voltage regulation and network stability. Smart grids will add two-way communication requirements and new services beyond resource distribution. Many utilities insist on direct control of communications networks since they are legally obliged to provide reliable services. They cannot shift responsibility to their suppliers so they are loath to depend on third parties, such as MNOs, for support of real-time operational control.

- Narrowband data communication over circuit switched voice links are the new norm for train control in Europe. But in the sphere of non-operational/non-mission-critical wireless,

passenger access to the Internet via Wi-Fi may be essential to achieving the growth in train passenger numbers sought by the European Commission to meet reduction targets for greenhouse gas emissions. Road vehicle bandwidth demands are more diverse and harder to predict. They range from vehicle-to-vehicle communications at 5.9 GHz to eCall accident reporting via cellular, to roadside cameras automatically reading vehicle license plate numbers to enforce speed limits and collect tolls.

Identifying the different requirements, then seeing if network sharing across sectors is still feasible and pricing the different ways to satisfy the requirements – these were the main challenges of this study.

Looking at the supply side, the current and foreseeable capabilities of commercial mobile networks are examined in Chapter 3. The key arena for evolving these capabilities is the ETSI/3GPP partnership for LTE standards development. The study looked at the process of adding mission critical capabilities to LTE, specifically in Releases 12, 13 and 14, to understand the probable timetable for delivering equipment with functions like Direct Mode Operation, Push-To-Talk and priority calling. We also looked at LTE equipment deployment patterns among the MNOs in the Member States, since the availability of new equipment does not in itself force the replacement of older equipment. The implication of the current roadmap for LTE is that hardly any mission critical functionality will be available in the field before 2016, some might be available in some places by 2018 and much more by 2020. Thus, before 2020, the LTE technology available for mission critical networks may be not be fully standardised.

The other major requirement for the introduction of new mission critical broadband networks is the availability of UHF frequencies. For cost effective equipment, a crucial parameter is the size of the market at each frequency, in terms of volume production. According to chipset manufacturers (on which the equipment suppliers depend), the 450 MHz band will be a fairly large market, led by rollouts in Brazil, Bangladesh and Finland. The 700 MHz market will also be economically viable globally and could well exceed the 450 MHz market in volume.

The capability of handsets to be multi-mode in several different frequency bands will depend on the antenna design and size as software-defined RF front ends are flexible, while MIMO provides superior throughput and signal strength. The aggregation of different frequency bands into “virtual channels” to supply greater bandwidth and thus faster data transfers is also possible with LTE.

Five scenarios were examined and commercial mobile LTE is the lowest cost *broadband* solution

Having understood the technical and spectrum possibilities, the study built five scenarios based on different types of deployments:

1. Dedicated networks and dedicated specialised equipment
2. Commercial MNO networks and commercial equipment
3. Dedicated networks with commercial networking equipment
4. Hybrid networks
5. A common multi-purpose network, perhaps regional in scale

Costs were the basis for comparing these options. The basic tenet of this comparison was the use of mobile broadband to add capabilities and thus increase the value of the network to its users and to society in general.

The first scenario looks at continuing with current dedicated networks and dedicated equipment – essentially the costs and benefits of continuing with TETRA/TETRAPOL. It shows that although the costs are high, they can be less than other options – but not when the value of the capabilities and benefits are factored in.

This is highlighted in scenario 3, a further configuration of a dedicated network, but with commercial LTE equipment, hardened. As we do not yet know the outcome of European discussions about possible re-allocations of frequencies, our modelling was calibrated to 800 MHz as a commercial band for LTE, with cost comparisons for lower and higher frequencies. As lower UHF bands might become available eventually, sensitivity analysis compared costs for the major cost driver, the number of base stations needed at various frequencies.

Scenario 2 is perhaps the key option, as it focuses on the use of commercial networks. A crucial cost is that of hardening for resilience, for both the radio access network (RAN) and the core network. (We assumed that government would pay for hardening but of course this is open to debate.) However, the main issue arising from this scenario is not the technology challenge of building a resilient network, but the regulatory, legal and contractual context. From the case study in Chapter 5 on the UK government's orchestration of a new PPDR network to replace the existing Airwave TETRA network, using commercial MNOs, a pragmatic contractual structure was defined, for use with scenarios 2 and 4. This was applied as a set of four contracts between a central government and commercial suppliers to fulfil four basic roles:

1. *Programme manager* – responsible for managing network services long term and the fulfilment of the other three contracts (termed the "Delivery Partner" by the UK government).

2. *Systems and network integrator* – may handle sales of handsets, apps and other equipment to the end user services (a role which can be separated from systems integration).

3. *Multiple MNOs offering mobile services at wholesale rates over hardened networks*. Interestingly, MNOs seem to see the mission critical market as a new revenue stream with a bright future, especially if government pays to harden the networks to meet PPDR standards. It is assumed that the government could buy capacity at wholesale rates for its PPDR services at much lower prices than individual subscribers. Also the bidding framework requires tenders from multiple MNOs, introducing competition into the price offers.

4. *Extension services for extra coverage* – since most commercial MNOs typically achieve 90% coverage while the PPDR community seeks 99% coverage including tunnels, underground garages and other enclosed public spaces.

Such contracts include clauses on everything from government step-in upon failure, SLAs on minimum availability, contract transfer limits, limits on *force majeure* claims, and so on. But more is needed to reassure the mission critical services, as we explore below.

Naturally this framework could be applied in the way favoured by the UK government, through direct contracts between the tenderers and the ministry of the interior (Home Office). Another approach may be more effective in the long term, with an MVNO as programme manager or above the programme manager. The Belgian network ASTRID is a case in point, with their Blue Light Mobile MVNO illustrating how such an approach could work (see Chapter 5).

In analysing the costs, the study found commercial LTE operation was the cheapest in simple financial terms (see Chapter 4). But other factors must be taken into account to assess the real value of any

option, including network reliability as well as the degree of support for all three sectors, especially for M2M data.

In that vein, although the hybrid network in scenario 4 is much more expensive than the other options because of its complex architecture (given the implementation put forward here), it would unite utility and ITS networks better than either a purely commercial or dedicated network. It also offers greater flexibility for integrating existing networks and enabling a gradual migration.

More is needed than a good contract to attract and reassure users

However, in addition to contractual structures specific regulatory measures may be needed to reassure the three sectors (particularly those with regulatory obligations on continuity of service, such as the utilities) and ensure that MNO performance levels are maintained over decades. These measures are necessary to gain the trust of the user communities that MNO commercial behaviour will never disrupt mission critical services. Measures in specific areas are needed to build the confidence of these users in the MNOs:

1. Being prepared to upgrade to high standards of reliability and correct service failures as quickly as possible, without any degradation in that commitment over several decades
2. Acceptance of long-term (15 to 30 year) contract commitments to mission critical customers, with stable conditions and agreed rates
3. Providing priority access to mission critical services, especially when emergencies create a risk of network overload
4 Providing geographic coverage to meet the needs of mission critical users
5. Willingness to cooperate with other MNOs and MVNOs – for instance, in handing over a mission critical call to another operator with a better local signal
6. Keeping to the spirit and letter of long-term contracts for mission critical services without arbitrary changes in technical features, tariffs or service conditions
7. Readiness to submit cost-based pricing analyses of tariffs with full open book accounting for NRAs and government clients
8. Willingness to offer new charging regimes and metering procedures
9. Removal of excessive charges for international roaming across the EU and avoidance of "surprise charges" for previously agreed services.

Such measures are needed in light of the fact that today's MNOs have become the incumbents, much like their fixed line predecessors. They have evolved from being small upstarts and challengers of the status quo to being the dominant forces in the telecommunications market, with at least five times as many subscribers as fixed line carriers ever achieved. Mission critical mobile broadband will further extend their dominance.

In response, as emphasised in Chapter 6, it is essential to consider new measures that give national regulatory authorities (NRAs) specific new powers to cope with this situation on behalf of mission critical services:

1. MNOs should be mandated to support mission critical services. There seem to be two possible ways to do this:

- To operate as an MNO or an MVNO, licensees must agree to provide mission critical services. That may entail extended geographic coverage, hardening to meet minimum standards of availability and resilience, and designating an overall programme manager for mission critical services. It is effectively an additional set of licence conditions to operate a public mobile service.

- An alternative is that any purchase or exercise of a mobile spectrum licence brings with it the obligation to support mission critical services for as long as the licence is valid. Note that the grant of spectrum conditioned on mission critical provisions offers NRAs the power to re-assign the spectrum to a new operator, if the original one fails to perform. This mechanism gives effective control to the NRA through the potential for spectrum re-assignment, such that the spectrum is not 'lost'.

The first alternative would begin with new licences; the second would begin with the transfer of an existing license. This is not a *universal* service obligation but a *specific* service obligation that extends MNO/MVNO responsibilities for the long term. On the positive side, it is a rare obligation that brings with it a new revenue stream, accompanied by government investment in resilience that will benefit all users of the network.

2. NRAs should have the power to introduce regulations that support and enforce the provisions of long-term MNO contracts with mission critical users.

3. NRAs should be authorised to grant priority access to commercial mobile network services for mission critical communications when justified by circumstances, including the handover of calls between MNOs when required. This may require amendment of existing guidelines, statutes or regulations.

4. NRAs should support governments in setting tariffs for mission critical services by research into true costs of MNO operation and through comparative cost studies with other NRAs and sources from outside the Member State. That may require forensic accounting and suitable preparations of the cost base declarations by MNOs.

Thus a key conclusion of this study is that commercial mobile networks could be suitable for mission critical communications within the right legal, regulatory and contractual framework. This conclusion allows each Member State to decide whether to employ MNOs for mission critical communications. No recommendation is made here to impose a common policy mandate (for example, through an EU Directive). However, Commission guidelines for Member States on NRA roles, actions, powers and responsibilities *vis-à-vis* MNO contracts with mission critical users might be desirable.

Should additional spectrum bands be reserved for mission critical services?

Since many Member State governments have statutory obligations for the provision of national mission critical communications (especially for PPDR), as well as political and cultural traditions effectively ensuring that government-owned-and-operated networks are the only viable option, dedicated spectrum will be required for them. Therefore, on the key question of whether there should be exclusive dedicated spectrum across the EU for mission critical services, a pragmatic direction is favoured. This is based on the subsidiarity principle: each Member State should choose its own direction. For those choosing to build dedicated mission critical networks, dedicated spectrum will be necessary – which is an additional financial burden, if the opportunity costs are recognised. These are not just the loss of auction revenues, i.e. the market value of the spectrum, but the loss of broadband's

economic stimulus effect on the general economy although it may be argued that the socio-economic benefit that same spectrum could give for mission critical functions might tend to compensate.

Economic circumstances may force a rethink of the affordability of a dedicated network over the next few years in some Member States. The costs might prove too much of a burden just when the LTE standards releases with mission critical functionality are transformed into new equipment and prices are reduced as the ramp-up of production volumes kick in. Should a Member State then decide to migrate from a dedicated closed to a shared commercial network, previously dedicated spectrum might be refarmed to commercial networks, either with mission critical users as the only clients, or as priority users with others sharing the network.

But which frequency band should be chosen? Overall, the debate turns on the frequency range as that sets the physical characteristics that determine cost and performance. That is at the heart of the clash between Europe's television and cellular industries, highlighted in the recent report by the Lamy High Level Group, which failed to reach consensus on the future of the UHF spectrum below 790 MHz in the short term.

Our conclusion is that because of various stakeholder interests, especially those of existing military and PMR users, the main band used today for TETRA (380-400 MHz) is unlikely to be available across the EU, particularly not for conversion to LTE. The next band up, 450 MHz, is a more promising choice for dedicated use with nearly half of the Member States being prepared to consider it. Moving further up the spectrum, the surprise proposal at WRC-12 for ITU Region 1 to allow mobile use of 694-790 MHz is provoking much discussion across the EU, as the Lamy report shows. Although the report suggested a timetable for releasing the 700 MHz band to mobile, this would not be until some time between 2018 and 2022. That would coincide with more mature generations of LTE, in Releases 12-14, with most of the mission critical features needed by PPDR.

Whether a harmonised exclusive allocation is necessary and desirable, with commercial offerings alongside, is a key question. Our conclusion is that the diversity of views among the Member States makes a dedicated mission critical allocation at 700 MHz logical only in the short term, as a subsequent migration to commercially based services is likely to occur progressively over the next decade because of increasing economic pressure on government budgets.

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