First Responder Solutions in the UK and Internationally

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Kable

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1 Executive Summary

1.1 Introduction

The National Audit Office (NAO) scrutinises public spending, helping Parliament to hold government to account and improve public services. It is looking to publish a report to Parliament in July 2016 on the Government's Emergency Services Mobile Communications Programme (ESMCP). The audit question the NAO is looking to use for this analysis is: "Is the proposed ESMCP solution the most advanced in the world?" Kable has carried out this study in order to answer the NAO's question by putting the Home Office's ESMCP into an international context, identifying the challenges other countries have faced in implementing similar public safety networks.

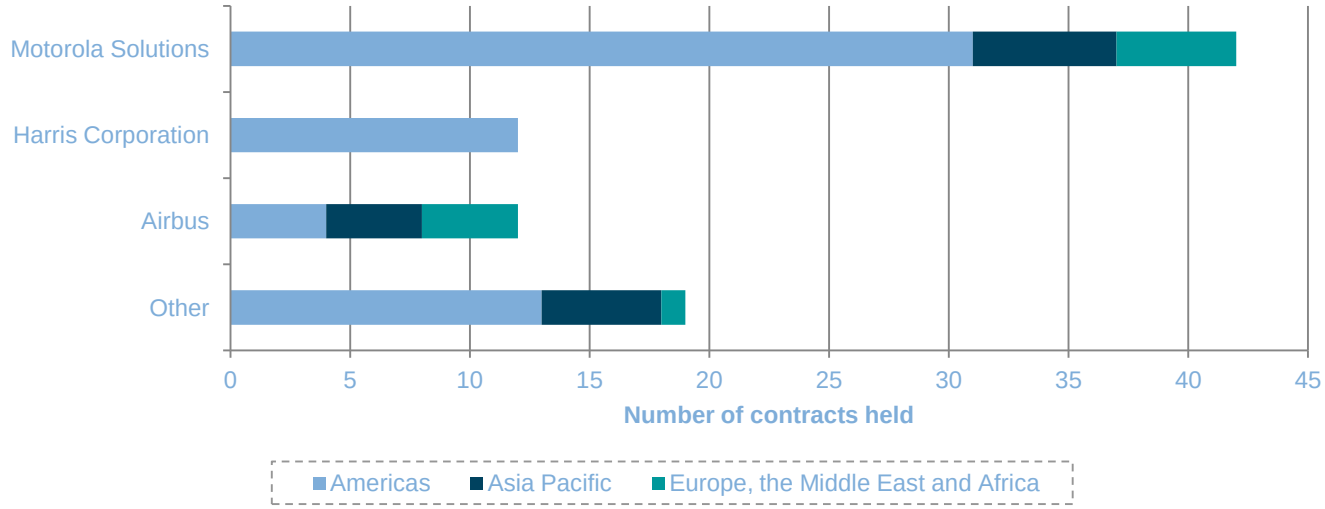
Kable has researched the provision of networks designed to carry out similar functions to the ESMCP in 26 other countries, including all members of the G20. (This information can be found in the appendix section.) Following this initial exercise, Kable selected four countries which face similar challenges to the UK. Two were selected which will use LTE technology, like the UK's ESMCP project. The other two use TETRA or a blended approach. We offer case studies of the four countries, Germany, South Korea, Australia and USA, alongside that of the UK programme. Kable also conducted research with technology vendors and other research firms to inform our analysis of the critical success factors, opportunities and risks faced by the international comparisons.

1.2 Key findings

1.2.1 Small supplier pool across public safety network market

The UK current public safety network is delivered by Airwave Solutions, who have recently been acquired by market specialist Motorola Solutions. This company will be also be delivering the User Services of ESMCP. Across the initial comparator group, Motorola Solutions is also the dominant provider. Airbus (EADS) has a strong footprint, particularly in Europe, but cannot compete with the global footprint of Motorola Solutions.

Figure 1: Public safety network key technology partners across initial comparator group

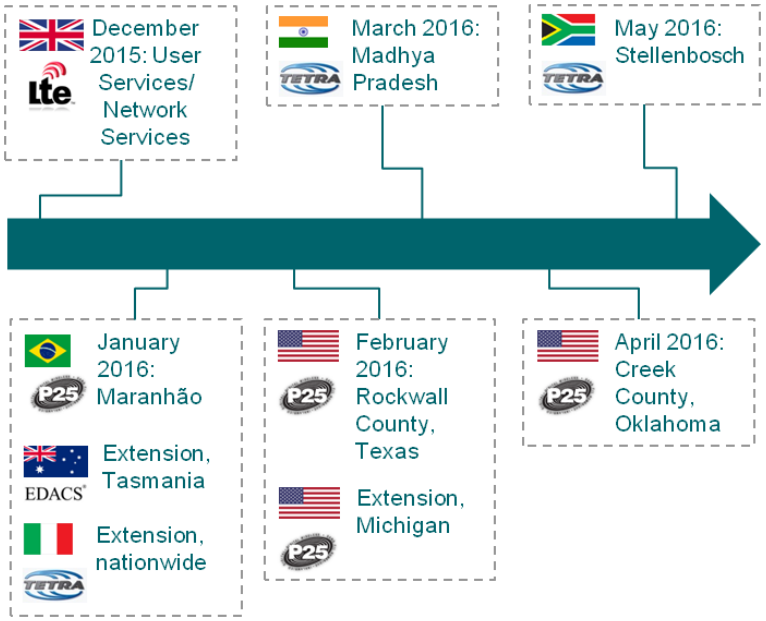


Source: Kable

Motorola Solutions' experience and footprint will support the success of Emergency Services Network (ESN). The other ESN vendors do not have Motorola Solutions experience of providing nationwide public safety networks, but are necessary given the advanced design of ESN. The South Korean Safe-Net project, which is most analogous to the proposed ESMCP solution, also uses a domestic commercial Mobile Network Operator (MNO) as the network provider. KT will provide core connectivity via its existing commercial network infrastructure, much like Everything Everywhere (EE) for the UK solution. Network provisioning in South Korea does differ from the proposed ESN solution in that Safe-Net users will utilise dedicated spectrum rather than sharing spectrum.

1.2.2 Land Mobile Radio (LMR) remains popular despite Long Term Evolution (LTE) convergence

Figure 2: Public safety network contract awards since December 2015



Source: Kable

The UK's current solution uses a Land Mobile Radio (LMR) technology using the TETRA standard. Whilst specifications differ, LMR supports the vast majority of public safety networks around the world. Furthermore, since the latest ESN contract award, amongst the international comparator group, deals have also supplied LMR technologies, although many of these contracts are far smaller than the proposed ESMCP solution or extensions to existing deals.

LMR contracts such as BOSNet (Germany), Nødnett (Norway), Las Vegas (United States) and South Australia Government Radio Network will all run far beyond 2020. These recent awards and long-term contracts indicate that LMR is still seen by many as a viable option for public safety networks over the next decade.

The proposed ESMCP solution is not based on these established public safety network LMR technologies. Instead, as an advanced solution, it will look to use Long Term Evolution (LTE) technologies, which are used to support mobile telephony and connectivity for smartphones. Across our international comparator group, there was acknowledgement that LTE does have a future role in providing public safety networks, importantly providing data communications that cannot be delivered to the same extent through LMR. It is the effective provision of these data communications that would define a network as advanced, as they would empower front-line emergency services staff.

1.2.3 Networks are first generation and focus on voice and interoperability

The UK is unique as it is the first country to fully replace its singular nationwide public safety network. Most countries do not have a singular public safety network for all emergency service users with nationwide coverage. With the incumbent Airwave network, the UK was one of the first countries to achieve interoperable voice

communications between all emergency service users through a single system. Across other countries, public safety networks are far newer and focus on achieving interoperable voice communications between emergency service users.

The proposed ESMCP solution is the most advanced – as a second generation network, incumbent usage and limitations are well understood. This has allowed the UK government to design and procure a solution relevant to public-safety agencies through the experiences of the first contract and user requirements. ESN has been designed to satisfy the data-centric communications UK emergency services demand, which they currently source through multiple end-user devices.

LTE public-safety networks have been launched but as demonstrator projects with LMR safety nets. The UK, along with South Korea, will be the first to provide a continuous LTE public-safety network nationwide. South Korea has started from a far-higher commercial coverage base and should be fully live before ESN. But the country has never had a single network, thus the priority will be interoperable voice, albeit over LTE, rather than the additional functionality offered by this technology.

1.3 Acknowledgements

First established in 1990, Kable researches and analyses UK public sector technology buying behaviour and end-user choices. In 2013, Kable expanded its research to cover an additional 36 countries. Across all the markets covered, we carry out senior-level primary research with IT decision makers, suppliers and end-users, engaging in discussion topics at a deep level and yielding penetrating insights. This project has leveraged our dedicated in-house team of analysts aligned to the UK Emergency Services IT market.

Kable would like to thank the following organisations for their assistance in producing this research:

- Airwave Solutions
- Capita
- Current Analysis
- NVIS Communications
- Pyramid Research.

2 International public safety provision and communications

Public safety provision is very different around the world. Compared to their international peers, for example, UK public safety agencies have comparatively fewer incidents to attend. This is likely to be due to a combination of socio-demographic factors and practices, such as triaging and pro-active measures, which reduce demand. A robust and secure public safety network, maintaining critical voice communications between network users, is crucial in enabling an effective response to public safety incidents and such networks show similar national variations.

No one model exists and different technologies are in place, although most networks use the proven Land Mobile Radio (LMR) over newer technologies such as Long Term Evolution (LTE). The UK is adopting the latter using commercial Mobile Network Operator (MNO) infrastructure. This option is also being explored in Australia and South Korea, where LTE coverage is more extensive than in the UK.

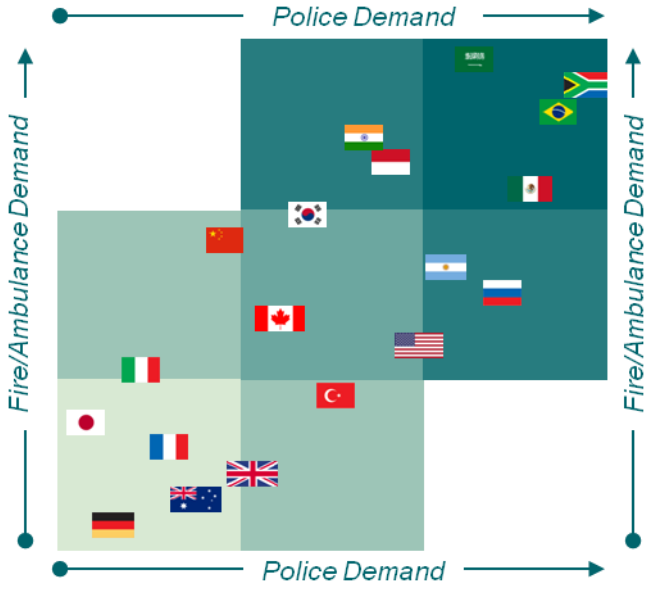
Public safety networks around the world, whether local or national, are supported by a small pool of providers – in particular Airbus and Motorola Solutions.

2.1 Provision of public safety services

Public safety encapsulates the services used to safeguard citizens. In the UK, three distinct Emergency Services provide this function through local public safety agencies, largely employing professional officers to deliver services.

Figure 3: Complexity of public safety provision

Figure 4: Public safety service demand



Source: Kable

This is by no means the norm around the world, however. For example in many countries, fire brigades are staffed by a majority volunteer workforce. The idea of three distinct services arms contrasts with paramedic and rescue services being provided by multi-function agencies in some countries. Provision at a local level can also markedly differ. For example, some emergency services are hyper-local, such as sheriff departments in the United States

compared with single agencies covering an entire country. Such service lines are typically historic, although broadly the trend is one of consolidation, such as in Scotland with the formation of national bodies for fire and police functions.

With regards to its agency structure and staffing, the UK is most similar to Brazil and France. It is worth noting that these two nations, as do many others in both developed and developing countries, also employ militarised agencies alongside civil domestic emergency services arrangements. In Brazil, each state has separate specific fire services and police forces staffed by armed services personnel. The Gendarmerie nationale and Brigade des sapeurs-pompiers de Paris in France have a military legacy and connections.

With widely different public safety provision, service demand also varies depending on socio-democratic and geographical concerns. This means that comparing the UK to other countries can prove problematic as, aside from the numbers of incidents, one must also consider the “professionalism” and maturity of each group of agencies and their staff along with what is expected from the citizens of each country. In order to investigate demand for services, one must use proxy metrics, which themselves may not be comparable due to the aforementioned factors.

When it comes to service demand, the UK is most similar to Australia, France, Germany, Japan and Italy. To be clear, this analysis does not mean that these countries with “lower” service demand have less pressure on services and agency personnel. These developed nations have optimised their public safety functions to address service demand.

2.2 International provision of public safety networks

Provision of public safety varies across the globe and so does the technology which supports these services. The UK is installing its second generation public safety network. Whilst this connectivity is key to successfully delivering emergency services, no one model exists to deliver this connectivity across the world.

2.2.1 Local versus regional networks

As a key point of comparison public safety networks can be split between those networks that cover entire countries (national) versus those that provide communications more locally (regional). Most networks around the world are the latter. This can be for multiple reasons - including the size of any given country, the complexity of public safety provisions and differing demands on emergency services providers. Networks are also by no means inter-agency and many are only used by one public safety agency group. Since 2000, the UK has had a national network across England, Scotland and Wales; national networks have also been in-place in France and Spain for the same period.

Figure 5: Examples of regional public safety network contracts

	Las Vegas (US)	Los Angeles (US)	Queensland (Australia)	South Australia	Victoria (Australia)	Western Australia
Prime contractor	Motorola Solutions	Motorola Solutions	Telstra	Motorola Solutions	Motorola Solutions	Motorola Solutions
Delivery model	Design-Build-Maintain	Design-Build-Own-Operate	Design-Build-Own-Operate	Design-Build-Maintain	Operate	Design-Build-Maintain
Public safety coverage	Police	Police, Fire, Ambulance	Police, Fire, Ambulance	Police, Fire, Ambulance	Police, Ambulance	Police, Fire
Users	3,200	34,000	15,200	20,000	21,000	9,600
Technology	LMR	LMR/LTE	LMR/LTE	LMR	LMR	LMR
Total contract value (£m)	30	280	270	90	20	30
Length (years)	11	5	15	7	2	5

Source: Kable

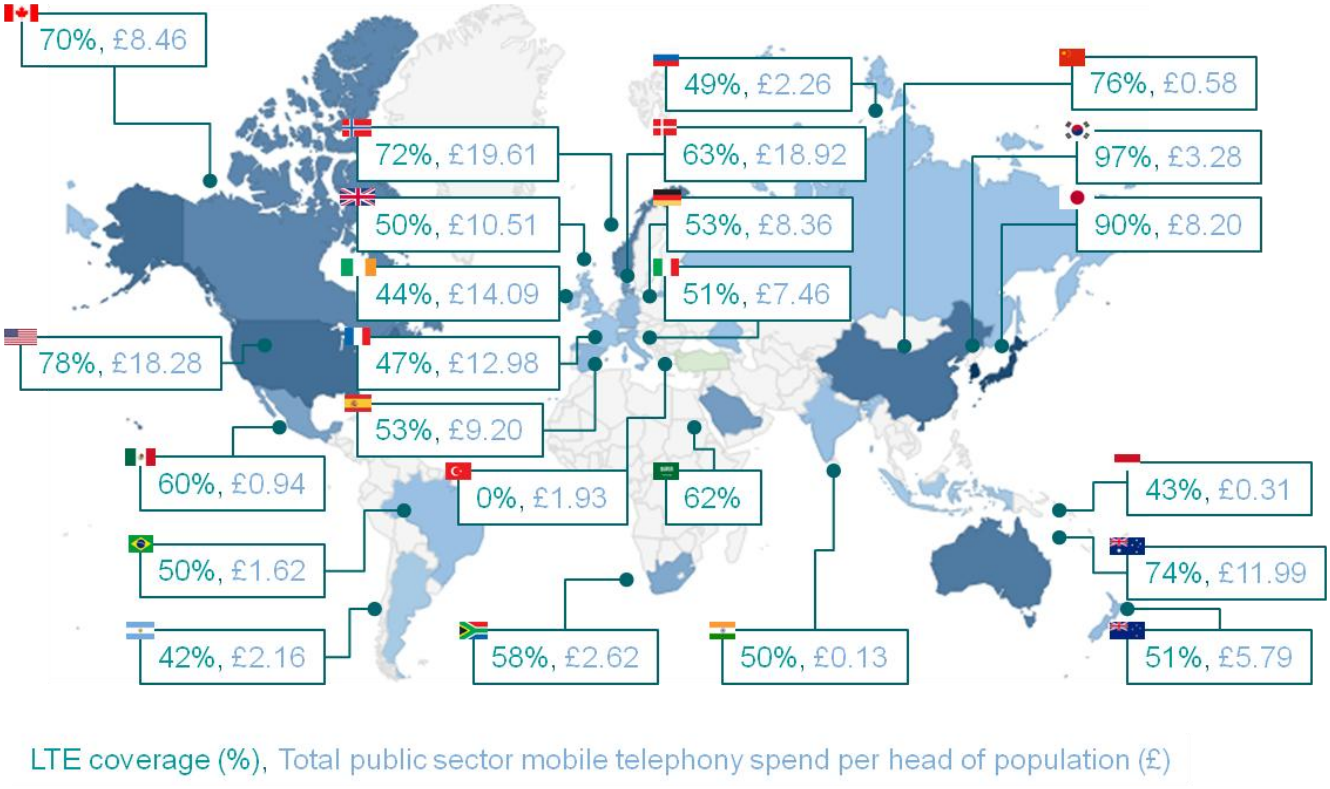
Both regional and national networks do not have to be limited to use solely by public safety agencies and aligned central government bodies. Transport and utilities are key partners. On a regional scale, such public safety networks can be installed for specific events. For example, in the run up to the 2008 Beijing Olympics, a network was installed to co-ordinate the event. This is common practice where a national or regional network does not exist.

2.2.2 Technology

Aside from differences in geographical coverage and user groups, different networks can use different technologies. By far the most common is Land Mobile Radio (LMR) which itself has multiple standards such as P25, TErrestrial TRunked RAdio (TETRA) and TETRAPOL. P25 and TETRA are open standards, in North America and Europe respectively. TETRAPOL is Airbus's proprietary technology. More recently, aside from LMR, mobile connectivity, particularly Long Term Evolution (LTE) technologies, are proving to be popular. It is this commercial technology that forms the basis of the second generation solution being installed in the UK.

The UK's Emergency Services Mobile Communications Programme (ESMCP) is using commercial Mobile Network Operator (MNO) infrastructure to supply LTE services to public safety agency users. To do this requires an existing base or an investment in MNOs to expand coverage and provide services suitable to the needs of public safety agencies.

Figure 6: Commercial LTE coverage and public sector mobile spend per head of population



Source: OpenSignal, Kable

The alternative to a state-owned LMR network or commercial infrastructure is to build a state-owned LTE public safety network. This initiative forms the basis of the US's FirstNet programme. This is an expensive alternative, with the full costs of FirstNet being estimated between £8bn and £30bn. However, the US government believes these costs can be offset through the sale of additional capacity to commercial providers who may not have the business case to deliver mobile broadband. As the core network matures, the US government will explore how to extend coverage and improve services. Future options could include expanding connectivity through commercial MNOs.

Regardless of new technologies, LMR will continue to be in use and will be procured around the world. LTE has been demonstrated for public safety adoption, through commercial and state infrastructure, but for most agencies the most critical factor is to support interoperability, and thus critical voice. LMR technologies like TETRA have been proven to provide this at scale. For the UK, this is a service that has been offered for over a decade, but LTE over commercial infrastructure offers the potential for savings and will support additional data communications. Data can be delivered over LMR, but it is slower, has less capacity and is comparatively more expensive.

2.2.3 Delivery models

A third differentiator for public safety networks is the delivery model. Some, such as the UK's incumbent contract with Airwave Solutions, provide managed services to deliver the network. This can also include financing provision, such as through vehicles similar to the Public Finance Initiative (PFI) which is used as a vehicle to spread the cost of upfront investment. Again this was used for the UK's first network. Other models look for suppliers to install and maintain network infrastructure but the delivery of communications services is provided by public safety agencies.

With such scale, prime contractors are common for public safety networks. They can be used to deliver a fully managed service or just oversee the installation of these networks. In Europe, national networks in France, Germany, Italy and Norway have prime contractors, but operating the network is largely delivered in-house.

Figure 7: Examples of national LMR public safety network contracts in Europe

	Denmark	France	Germany	Ireland	Italy	Norway	Spain	UK
Prime contractor	Motorola Solutions*	Airbus	Airbus	Motorola Solutions*	Selex ES	Motorola Solutions	Airbus*	Airwave Solutions*
Delivery model	Design-Build-Own-Operate	Design-Build-Maintain	Design-Build-Maintain	Design-Build-Own-Operate	Design-Build-Maintain	Design-Build-Maintain	Design-Build-Own-Operate	Design-Build-Own-Operate
Users	21,000	120,000	500,000	20,000	350,000	35,000	240,000	200,000
Base stations	500	1,100	4,500	600	3,100	2,100	1,500	3,400
Total contract value (£m)	200	1,000	900	350	340	530	190	1,500
Length (years)	10	20	10	8	10	26	7	19

** Contractor is Joint Venture, prime contractor represents technology supplier*

Source: Kable

3 International comparator projects

3.1 Basis for selection

The UK's ESMCP is unique as it is truly a second generation network, switching out architecture, technology and providers. Regardless of not being second generation, four countries can be identified as international comparator projects facing similar challenges to public safety agencies and the public safety network projects to support them.

Figure 8: International comparator characteristics versus UK

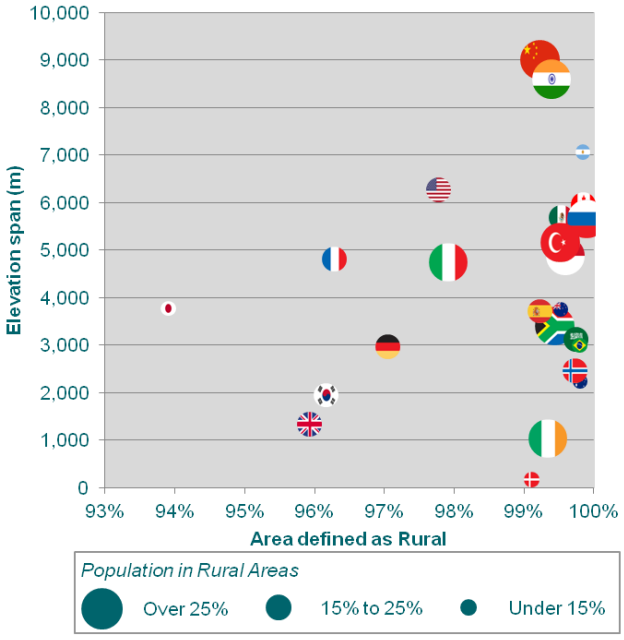
Country	Similar geography & topography?	Similar commercial LTE coverage?	Agencies facing similar pressures to UK?	Network projects uses LTE?
Australia			✔	✔
Germany	✔	✔	✔	
South Korea	✔		✔	✔
United States				✔

Source: Kable

Australia has similar contractual arrangements in place to the UK's current Airwave contract, albeit at a state-by-state level. These deals are working within the confines of existing agreements to explore LTE to complement LMR communications. Additional data communications are using commercial MNO networks. Although Australian public safety agencies face specific emergency challenges such as wildfires, service demand is similar to the UK.

German agencies also face similar service demand to those in Australia and the UK. The country has chosen to install a national TErrestrial TRunked RAdio (TETRA) system, akin to the UK's current provision. The network went live in 2015, and showcases the latest advancements in this technology. Commercial LTE coverage is similar to the UK.

Figure 9: Geographical factors



Source: Kable

South Korea starts from a far higher LTE coverage of 97%. It is also installing its first public safety network, but like ESMCP will look to deliver services to agencies over current commercial LTE infrastructure, albeit using dedicated spectrum. The UK has a similar rural area to South Korea and Germany, along with elevation span.

Lastly, the United States and its FirstNet programme are also profiled as an international comparator project, with

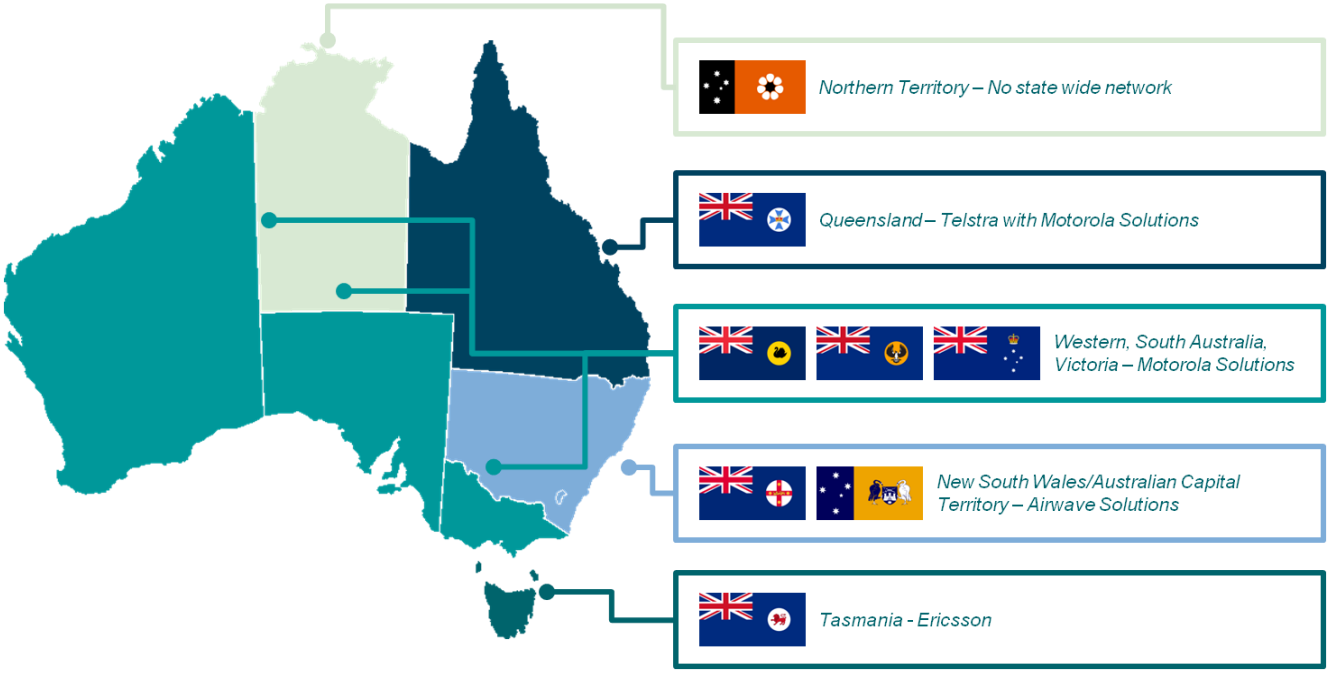
specific focus on the Motorola Solutions-led Los Angeles Regional Interoperable Communications System (LA-RICS). The US is also installing its first national public safety network and will use LTE. Unlike South Korea and the UK, FirstNet will install public sector-owned infrastructure but network reach could be expanded with commercial MNOs as the network is installed and matures. Public safety agency provision and demand, along with LTE coverage, is higher in the US and geographically is different to the UK.

3.2 Australia

Australia has several public safety networks deployed on a state-by-state basis. The most popular delivery model is LMR Design-Build-Operate (DBO) contracts similar to the UK's incumbent contract with Airwave Solutions. Northern Territory has yet to fully commit to digital radio across the state.

Core to these deployments is voice-to-voice networks shared by public safety agencies. Additional data capabilities are a secondary concern, although as networks mature this is being explored. These additional capabilities can take numerous forms: in New South Wales data is delivered in-vehicle through a separate device over commercial networks. This model is similar to how this capability has been delivered in the UK, with UK services signing additional contracts with MNOs to roll out smartphone and mobile data terminals across their workforces and vehicle fleets. Whilst there are limitations of using commercial networks to deliver these capabilities, suppliers can be recruited to provide encrypted communications and gateways to deliver secure services.

Figure 10: State-wide Australian public safety networks



Source: Kable

For most state-wide contracts the immediate concern is to consolidate legacy networks. Given the vast landmass of Australia, countless networks had been installed to connect agency personnel based in rural locations with central services. As core network coverage increases these will be retired and replaced with LMR connectivity. The largest emergency services in Australia are the volunteer brigades responding to the massive wildfires which occur. This includes pragmatic activity such as digging ditches and other fire breaking exercises. Without LMR network or

mobile coverage, for these personnel, using satellite telephony is often the only reliable form of communications.

Queensland is the exception to much of the above. In 2013, the state awarded its £270m Government Wireless Network (GWN) contract to Telstra. Under the 15-year deal, Telstra and its partner Motorola Solutions have been contracted to design, build, operate and maintain a public safety network providing a digital radio voice and narrowband data communications network. To this end, Telstra, which is Australia's largest communications provider, has been installing radio units onto its existing masts and setting aside its own LTE spectrum for its GWN customers. The 2014 G20 Summit in Brisbane saw the latter piloted with additional funding and support from the Australian Federal Government. This capability will be rolled out further by 2018 for the Gold Coast Commonwealth Games.

3.2.1 Strengths and opportunities

Through having multiple networks across the country, public safety network provision can be effectively benchmarked and maintains a healthy competitive environment, which is important with such a small pool of potential providers. Provision is also adaptive to the specific needs of each state and allows public safety agencies to specify requirements most suitable to their needs.

Australia has a very low population density, with the majority of citizens living in urban areas. Through procuring networks at a state level, local government arrangement can prioritise investments which best suit their residents. Total coverage, whilst important in the long term, does not represent a good use of public sector funding in a country where 90% of the population lives in urban areas but 99.8% of the land mass is rural.

Like the UK's current provision of the Airwave network, PFI has been used to limit upfront investment. Twinned with the popularity of managed service operating models, this has allowed state networks to limit upfront investment and adopt the expertise of industry. The former is particularly important as networks in Australia use infrastructure installed solely for state use.

The GWN in Queensland shows that the additional capabilities offered by LTE standards can be installed working within the confines of existing contractual agreements. It also allows different states to prioritise investment to best match their needs. For Queensland, the move to an LTE network does offer benefits which will improve Australian public safety. Public safety provision is tied to Australia's geography which increases agency costs significantly as well as processing and response times, particularly in rural areas.

Moving to a data centric model, Australian states will be able to make use of mobile working technologies to deploy resources smarter. This will produce efficiencies and lower the costs of Australian public safety agencies, whilst increasing their ability to deliver services.

3.2.2 Threats and weaknesses

Reflecting the large landmass of the country, state-wide contracts mean that the nature of services provided differs from state-to-state. This is further complicated by contractual terms and models which limit the country's ability to roll out common services as a whole across the nation.

National standards do exist, particularly with regards to cross state connectivity. However, interfaces between intra-state public safety agencies are not mandated. This has resulted in operational difficulties, such as in Tasmania

during the 2012/13 brush fire season. Tasmania required additional state-wide investment to deliver interoperability to address co-ordination concerns.

Public safety agencies' response to wildfires highlights the geographical challenge of delivering a public safety network over vast state-wide areas. In December 2015, agencies' emergency reactions to a large bushfire in South Australia were hindered by limited coverage and network black spots in rural locations, and further stretched by masts affected by the incident.

In extremely rural locations, public safety agencies will continue to rely on satellite telephones and legacy channels unless networks can become more robust. For these locations, satellite telephones will continue to be key for agency staff and volunteer auxiliary services. Whilst the cost of voice through satellite communications will largely remain the same, developments in data packaging is lowering the cost of these services which could mean that the expansion of public safety networks is not financially viable for these locations.

3.3 Germany

Germany is one of the last countries in the European Union (EU) to establish a single national network for its public safety agency users. The LMR network, Digitalfunk der Behörden und Organisationen mit Sicherheitsaufgaben (BOSNet) utilises TETRA and is a national contract. Unlike the ESMCP model, the contract does not use outsourced contracting models, but does use multiple suppliers, as well as an accreditation model for End User Devices (EUD).

Figure 11: BOSNet technology partners

1. Airbus:
   - Prime contractor
   - Accredited EUD provider
2. Alcatel-Lucent:
   - Network operator
3. Cleartone:
   - Accredited EUD provider
4. Motorola Solutions:
   - Accredited EUD provider
5. Sepura
   - Accredited EUD provider
6. Rohill
   - Infrastructure provision

Source: Kable

BOSNet is the world's largest and latest TETRA network. The option pursued is akin to the "Do Nothing" option for ESMCP and highlights the current capabilities of TETRA technology as well as Germany's long term plans to evolve its network LTE using an agile methodology. As the first German public safety network, data capabilities are not the predominant driver for BOSNet. Instead, the network rollout prioritises on-boarding the 800+ agencies and their users. This will enable inter-agency working and the benefits this provides.

The full cost of the ten-year project is estimated to be £3.6bn. £900m of contracts were first signed in 2007, and the network is currently operating at 97% coverage and supporting 500,000 registered users. The full cost includes estimated in-house expenditure.

3.3.1 Strengths and opportunities

> *It is a technology specific to use and has been proven to run out of scale, which is the reason why it has been chosen.*
>
> **Airwave Solutions**

The German government has taken a measured approach to acquiring a public safety network. Germany had delayed procuring this network. This has allowed the country to learn from best practice across the market. Airbus, the prime contractor, has experience in France and Spain installing national networks, whilst through TETRA it can use a proven secure technology. TETRA is designed for public safety agency users with all of the benefits this entails.

Despite the maturity of the technology, BOSNet is a long term project which allows for a controlled, agile rollout with agencies learning from one another. It has been a cultural challenge, because given the distributed nature of German public safety agencies, there was historically limited interoperability between states and services. BOSNet will realise savings as legacy systems across Germany are retired as well as offer benefits through interoperability.

Regardless of its inaugural TETRA network, public safety agencies are aware of the additional capabilities that can be provided through commercial LTE infrastructure. BOSNet's critical role is to ensure secure voice communications between Germany's various agencies.

LTE communications are unlikely to be adopted across the core user base in the medium term. Once the network users fully grasp BOSNet, early adopters may explore commercial LTE to deliver advanced capabilities. With a framework delivering end user devices, suppliers have the option to provide Dual Mode Devices (DMDs) in the future should users be open to adopting this technology.

3.3.2 Threats and weaknesses

The complexity of public safety provision in Germany has caused significant delays in rollout as approval is sought from the various stakeholders. Furthermore, regardless of TETRA networks' successes around the world, how agencies chose to most effectively utilise the new network is a cause of consternation for user groups. A significant learning curve faces public safety agencies, which took a decade for UK organisations to overcome and realise the benefits.

> *Testing the network in places where you don't know what the challenges are going to be will be the real test to see if you have got the design right.*
>
> **Airwave Solutions**

Installing the network is only the first challenge for BOSNet. Both users and operators have to understand how to optimise the network for Germany and its public safety agencies. Until the network is rolled out, the infrastructure stresses are unknown. This includes climatic and meteorological factors that affect all communications infrastructure, but which stakeholders do not have experience of.

Threats to the network of this nature can be overcome if the response is planned, but require significant expenditure to ensure that services are maintained when needed. Much like Queensland, Bavaria played host to the G20 summit. In order to successful deliver the 2015 meeting, considerable investment was required. Unplanned events, such as flooding, are far more difficult to contend with when a network is newly installed.

With regards to users understanding how best to work with the network, without sufficient time being set aside for

training requirements, the network is wasted. Whilst Germany faces a lower service demand, akin to the UK, public safety provision is optimised to best and cost-effectively deliver services. This can leave little time for users to be educated on the networks' use and its benefits.

Despite the maturity of TETRA as a public safety network technology, the project has been delayed and is currently overbudget. Using an established technology can mean that commissioners expect delivery to be less complex and can breed complacency. The complexity of the federation and local public safety agencies is a significant factor for this. With multiple stakeholders, the federal government has had to gain approval from many parties. Single leadership and agency, akin to the Home Office for ESCMP, would have streamlined the process to overcome bureaucratic speed bumps.

3.4 South Korea

The SafeNet project has been driven by the lack of agency interoperability, in response to recent disasters. South Korea has the ambition to rapidly establish a public safety network over commercial LTE infrastructure, with nationwide coverage by 2017. Users in Seoul, where the main control centre and core equipment is located, along with those in the Gangwon province, will be the first to transition onto SafeNet in early 2016. Prior to SafeNet, network provision was delivered through a patchwork of separate LMR networks. The SafeNet programme will prioritise rollout in rural districts over urban as metropolitan areas already have these legacy local LMR networks.

SafeNet's £18m infrastructure contract was awarded to KT, South Korea's second largest MNO, in 2015. Under the contract, KT is tasked with providing coverage and capacity to support 200,000 users from 324 agencies and partner organisations. Unlike the network projects in Los Angeles and Queensland, SafeNet is delivering data and voice over LTE. This includes PTT applications for critical voice along with multi-media communications functionality. Whilst technologically similar to the proposed ESN solution, Safe-Net utilises dedicated spectrum rather than sharing spectrum with the wider user base.

SafeNet is managed in-house by the Ministry of Public Safety and Security, working in collaboration with the Third Generation Partnership Project (3GPP). Samsung has been contracted to deliver end-to-end services including additional networking equipment, mobile cells and rugged smartphones. This includes core hardware supporting the PTT and data rich infrastructure equipment. 3GPP, the international standards body's Release 13 has introduced Mission Critical Push-to-Talk (MCPTT) criteria and it will be public safety agency users in Seoul and Gangwon who will be the first in the world to use these capabilities at scale.

3.4.1 Strengths and opportunities

By working in concert with industry, despite awarding two core contracts, SafeNet can interface with other partners to increase its resilience. Outside of its heavy technology industrial base, South Korea also has a large workforce associated with deep sea fishing. Accordingly, public safety agencies must be able to respond to maritime incidents. The incident which really drove South Korea to pursue its first national inter-agency public safety network was the sinking of MV Sewol.

Despite losing out to KT for the SafeNet contract, the country's largest mobile network operator SK Telecom has delivered LTE high speed data communications for ships 100km offshore. This equipment is aligned to SafeNet,

and is thus interoperable with the network. Whilst South Korea's LTE coverage is world leading, it is incidents in low coverage areas which most tax public safety agency response.

Such developments are driven by a highly competitive, oversaturated South Korean MNO market. This breeds innovation to establish market differentiation. South Korea's industrial base and heavily technological population means economically and culturally SafeNet can source best of breed commercial solutions and access market innovation. For example, KT has launched a private LTE network service for enterprise, which is remarkably similar to the SafeNet concept. With stagnation in the commercial market, SafeNet suppliers and interested parties know the only way to increase revenues is to sell similar systems abroad and thus are driven to ensure the network succeeds.

3.4.2 Threats and weaknesses

Lack of coverage, although potentially disastrous, is not the key concern for SafeNet, as this is largely mitigated by very high commercial provision. Instead, the main worry is network capacity, particular given critical PTT voice application commanding high bandwidth.

Innovative back-up solutions are being designed to expand coverage and supply capacity in low connection areas. This includes a transportable base station within a "back pack" unit and Unmanned Aerial Vehicle (UAVs) fitted with networking modules and camera equipment to maintain connectivity. The effectiveness of this equipment will be dependent on agency staff. The networks roll out is prioritising rural areas over urban, which already have LMR networks. This relies on these staff being capable enough to establish the back haul infrastructure to be shared with other users, who they have had little experience of working in conjunction with.

Working in collaboration with 3GPP means that SafeNet can benefit from commercial standards resulting in cheaper costs than a more specialised solution. However, it also means that the network may not be optimised for public safety users.

3.5 United States

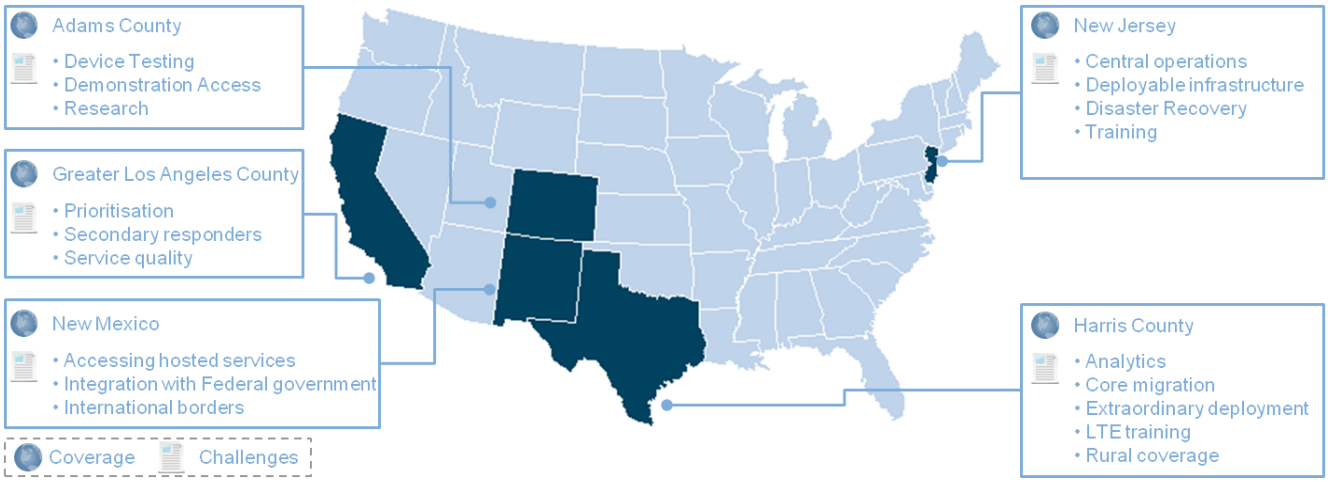
The United States' (US) does not currently have a network and LMR networks are delivered via a patchwork of local contracts. In response to major man-made and environmental incidents, the US has launched its First Responder Network Authority (FirstNet) project which will install a private LTE network for use by 60,000 public safety agencies. After core network installation, the network operators will explore how the asset could be expanded and improved. The current focus is to provide an inter-agency network for responders, but the future could potentially include interfacing with commercial MNO networks.

The US Congress has earmarked £5bn for the project along with over £90m in grants to support the states with plans to access the data broadband network to be offered under FirstNet. Regardless of this incentive funding, FirstNet is mandated through the Middle Class Tax Relief and Job Creation Act and requires all states and territories to establish connections to a core network based on the minimum technical requirements on the commercial standards for LTE service. Whilst a significant figure, other sources have indicated that the full cost of building and operating FirstNet could be between £8bn and £30bn.

The programme is currently in a pilot stage with five match-funded pathfinders known as 'Early Builders'. These

pathfinders are as follows: Adams County (Colorado), Greater Los Angeles County (California), New Jersey, New Mexico, and Harris County (Texas). The early builders have specific challenges to investigate. By building state-owned infrastructure, FirstNet is akin to the Home Office's option to build a private LTE network rather than use commercial Mobile Network Operator (MNO) networks.

Figure 12: FirstNet Early Builder Projects



Source: Kable

Motorola Solutions was awarded the Los Angeles Regional Interoperable Communications System (LA-RICS) contracts, which operates a communication network over both LTE and P25, the US-equivalent of the TETRA standard. The LA-RICS project delivers data communications via LTE, with data resilience and day-to-day communications delivered via P25. Although covering a far smaller geography (the Los Angeles County is 4,100 square miles), 90 albeit smaller agencies are attached to the project, mirroring the stakeholder complexity of ESMCP. There are far fewer users planned for LA-RICS (34,000) but it is also a network which will be used by ambulance, fire and police staff.

The two contracts awarded to Motorola Solutions cover voice and data separately. In 2013, the vendor was awarded a £112m contract to design, construct, implement and maintain voice services and infrastructure with an initial five year term. Data, to be supplied over a private LTE network, where available, was awarded a year later valued at £167m over the same term.

3.5.1 Strengths and opportunities

It is coverage if you need it, where you need it, when you need it

NVIS Communications

FirstNet's proposed approach should guarantee an LTE network will be in place for all US agencies. One of the limitations of using commercial networks is that coverage and capability is largely dependent on their existing and planned services and subscribers. Public safety networks must cover an entire country's landmass but MNO providers have little impetus to do this unless they find the potential for business. To deliver a network using existing commercial infrastructure requires funding operators to provide these services, which historically they may not have done. Furthermore, upgrade work and its prioritisation is dependent on the existing programmes and planned resources earmarked by the MNO. This specific issue could emerge as the network matures and it

potentially interfaces with commercial MNO infrastructure.

By building its own LTE network, the US can ensure appropriate coverage and guarantee that the network is solely built to provide the correct security and capabilities for public safety agency users. Full coverage can also be applied dynamically through mobile units reducing the cost of full coverage without being tied to the provision designed by a commercial MNO network to accommodate its larger, non- public safety agency subscriber base.

As with other inaugural agencies around the world, FirstNet and its pathfinder project are providing the technology to facilitate inter-agency working. It is also providing data capabilities for the first time for many users, but importantly without compromising critical voice.

For LA-RICS, agencies are exploring voice over LTE as the network evolves and there have been demonstrations of Push-To-Talk (PTT) capabilities. In the meantime, the potential latency for critical voice over LTE is a concern when compared to LMR. By taking a blended approach, for example LMR for voice and LTE for data in LA-RICS, technology provision can change as alternatives become viable.

> *Their own standalone LTE system is going to be hugely more beneficial because they are never going to have to have sag issues because there aren't private citizens using the LTE network, it is strictly public safety and first response.*
>
> **NVIS Communications**

The use of data underpinned by LTE has facilitated alternatives to traditional operations amongst LA-RICS' agency users, without being restricted by the demands placed on a shared commercial network. During the Southern Californian Rose Parade, video and images could be instantaneously shared by network users, removed from the high intensity traffic over the commercial MNO network as citizens upload content to social media, such as photos of floats and friends. This event also allowed suppliers to showcase critical voice over LTE and associated Push-To-Talk (PTT) applications.

In the wider FirstNet context, a dedicated public-sector owned LTE network means that specific applications can be built and prioritised for this network, learning and co-existing with commercial applications, but securely developed, delivered and designed for public safety. Using LTE allows commercial hardware to be used, delivering savings, and, as the network is established, the removal of legacy networks that will facilitate additional savings.

Further financial opportunities provided by FirstNet indicate that its planned excess capacity adds to telecoms infrastructure across the US, meaning that this government-owned asset will be monetised to provide additional connectivity to the MNOs. FirstNet has been designed to be over-specified and provide far more capacity than public safety agency users will need. This is because the excess capacity can be commercialised and so expand mobile broadband access to citizens. Whilst FirstNet appears to have massive cost, the US government believes it will be revenue producing and cost neutral as it provides this capacity to MNOs and citizens.

3.5.2 Threats and weaknesses

FirstNet and its Early Builder projects are dependent on the support of the 60,000 public safety agencies operating across the US, along with state sign-up. Some of these concerns will be addressed through the mandates of the Middle Class Tax Relief and Job Creation Act, but this only stipulates that minimum technical requirement connections are made to the core network. Development of the network also requires local funding and support,

albeit matched by federal spending streams.

Local stakeholders' lack of faith can cause significant problems and this has occurred in the LA-RICS project. In November 2015, members of the Los Angeles City Council unanimously voted to leave the LA-RICS partnership and instead upgrade its existing city-wide LMR network. The City Council and its network will still connect to LA-RICS and presumably FirstNet without using LTE infrastructure. Instead, the LMR network will use a "system of systems" approach to deliver interoperability.

The council was responsible for a third of the LA-RICS project costs, but despite a promise of further federal funding, the cost was too great. For the council, the total cost of LA-RICS would have been £29m versus £12m to expand its current LMR network. There are also additional financing issues complicating future costs. LA-RICS will levy connection fees on non-member users, but 21 of the network's 77 sites are on council sites and will deliver rental income to Los Angeles City Council.

Inter-agency collaboration is a new initiative for US public safety agencies and one that is core to the FirstNet project. The vast number of stakeholders with widely different needs will challenge the network rollout and its successes. FirstNet is a very technical project, dependent on a small pool of public sector staff and contractors. This is further complicated by the potential conflicts of interest between communication providers and the implication that this network would cannibalise their existing business.

With its massive cost, there is the potential that user charges may not be enough to fund FirstNet, nor may the plan sell excess capacity. Its impetus also requires political buy-in which could be challenged if the budget balloons. Blanket coverage cannot be achieved nor maintained without phenomenal and prohibitive costs. Instead coverage relies on an adaptive model and multiple access points. This means that responding to unplanned incidents could prove challenging, this may be mitigated as the network matures and its reach and bandwidth is expanded by other network infrastructure including the use of commercial MNOs.

3.6 United Kingdom

3.6.1 Current

In February 2000, a framework arrangement was established with BT for a new 'Airwave' radio service across police forces in England, Wales and Scotland within five years. The Airwave contract was sold off by BT when it divested its mobile services to form O2. The contract was subsequently separated from O2 to form the company Airwave Solutions. The network is based on TETRA technology and is a managed service agreement that also includes construction of the infrastructure.

Some 70 companies expressed an initial interest in the project and a number of these joined together to create three potential bidding consortia. These consortia passed a pre-tender assessment, but two decided to merge to produce a stronger bid. Later on, this merged consortium dropped out following the withdrawal of one of its key technical partners. This left the consortium led by O2 as the sole bidder. As existing radio systems were not meeting operational requirements, there was no 'do-nothing' option and the preferred solution had to avoid delaying implementation of a new radio service. After wide consultation, PITO concluded that continuing with O2 as a single bidder offered the least risk of delay.

Following the UK Government's decision to move emergency services communications to LTE technology, it was envisaged that migration away from the Airwave network would begin in 2015. However, the Department for Communities and Local Government has now agreed a deal that will see it used until 2020 to support the UK fire and rescue service's Firelink Project.

3.6.1.1 Strengths and opportunities

With the UK being one of the first countries to establish a national TETRA network, it has proven to be a tried-and-tested technology with multiple implementations globally. Airwave Solutions, now acquired by Motorola Solutions, has demonstrated this, providing expertise gained on this project to various other implementations around the world. The technology has not yet reached end-of-life as expected at the start of the project.

TETRA and similar LMR have been designed for public safety agency use, and will continue to be a key public-safety technology regardless of whether TETRA is in place in the UK. The network provides coverage to 99% of the UK's landmass and Airwave Solutions claims a 99.7% availability rate for its TETRA network. The Airwave TETRA network was built as a bespoke network for the UK's emergency services. It is run separately from any other communications network and is not open to 'general' usage, and is thus reliably secure.

3.6.1.2 Threats and weaknesses

The TETRA technology installed under the Airwave contract is an expensive legacy technology run on bespoke infrastructure. The current contractual agreements cannot accommodate savings and fewer vendors provide devices and solutions for TETRA than competing access technologies such as LTE, increasing the technology's base costs.

Whilst a new TETRA system could have been sought with a reduced cost versus legacy provision, communications technology has changed dramatically since 2000 as has the requirement of emergency services for data communications. Whilst LMR can deliver data, TETRA does not easily offer the same potential for integrated voice and data services as LTE.

The majority of the UK's police services are already adopting LTE technologies as part of programmes designed to allow police officers to spend more time away from police stations. Ultimately, this means that public-safety agency staff can either carry one device, such as is offered under ESMCP, or would have to have multiple devices on unconnected networks.

3.6.2 Future

The Emergency Services Mobile Communications Programme (ESMCP) is the project to replace the Airwave-provided TETRA communications used by emergency services with LTE. This transition is intended to deliver savings and allow broadband-speed data communications to support all three emergency services.

Procurement of the Emergency Services Network (ESN) was divided between three lots. The first lot of the ESMCP contract is for the delivery partner and was awarded to KBR. The delivery partner will arrange the transition from the legacy Airwave provision to an LTE-based network. This will see the contractor managing the programme,

design integration strategies, testing and assurance services, and training services across control rooms, users and vehicles.

Lot 2, 'User Services', is responsible for delivering the outsourced operation of ESMCP. Lot 2 is valued between £120m and £245m over its contract term, which is six years, with the option to extend for a further 24 months. With regards to the future of re-letting this contract between 2021 and 2023, the Home Office expects the contract to be of a smaller value and possibly delivered in-house. Initially shortlisted for the user services lot were Airwave, Airbus, CGI, HP and Motorola, of which only HP and Motorola chose to proceed to the final bidding process. Motorola was the selected vendor. The user services contract includes the need to coordinate not only the work of other lots, but also to integrate and approve related contracts, including vehicle and user devices as well as supporting control room improvements.

Lot 3, 'Mobile Services', is the largest element of ESMCP in terms of contract value. This lot also includes what was the now cancelled fourth lot, 'Extension Services'. Together this contract will deliver mobile telephony and connectivity to LTE services, both in areas with existing coverage and maintaining this connection when personnel move to areas outside coverage. For the third lot, the estimated maximum contract value over a full seven-year term will be £530m, dependent on the take-up of services beyond the emergency services market. Lot 4 had a value between £175m and £350m, although this value was sensitive to when the breakpoint would be and the number of sites requiring extended LTE coverage.

O2 and EE were selected as preferred bidders for Lot 3. However, EE was the only provider to make a final bid submission and was duly confirmed as the sole provider for Lot 3. The process has also received criticism from opposition parties for being rushed.

3.6.2.1 Strengths and opportunities

LTE connectivity combines both voice and data access allowing for a wider range of integrated services to be supported. EE's LTE connectivity currently supports data access speeds of up to 60 Mbps, with an average of around 15 Mbps. As the technology and backhaul are improved, maximum LTE access speeds are likely to exceed 100 Mbps. This offers a wealth of additional capabilities to staff, at a rate which has been negotiated for the entire public-safety sector.

Connectivity is cheaper; thus the use of LTE services offers distinct cost-saving advantages versus TETRA radio. The TETRA radio system is operated primarily for the UK's emergency services whereas EE already operates an LTE network covering a large part of the UK and accessed by a far larger number of users contributing to economies of scale. LTE connectivity is supported by a wider range of devices than TETRA and there are significantly more companies investing in LTE-enabled technologies and devices.

3.6.2.2 Threats and weaknesses

The UK's LTE commercial network does not currently have coverage to match the incumbent TETRA contract. According to Open Signal's *The State of LTE* report published in February 2016, Everything Everywhere (EE), which will be providing LTE connectivity to UK public safety agencies, has 60% coverage, which is higher than other MNO providers but far short of the 99% coverage under the legacy TETRA contract. EE has pledged to increase its UK LTE coverage to 95% by 2020, which is three years after public safety agencies begin to migrate

onto the second-generation ESN. Although solutions to establish temporary connectivity are available, for example mobile masts and backhauling in-vehicle technologies, these have not been used at scale as a stop-gap whilst fuller more permanent network connectivity is established. This connectivity will be reliant on Motorola Solutions and EE, but critics have argued that the decision to drop Lot 4 has removed an extra element of resiliency.

The UK would be one of the first countries to replace the tried and tested TETRA radio communications with an LTE-based network. It is understood that the vendors that withdrew from the bidding process did so over concerns regarding the viability of the technical solution and contractual complexity. Push-To-Talk (PTT) applications over LTE and other LTE networks have only been proven in laboratories and smaller rollouts. Whilst the Home Office wants the ESMCP system to match international standards for mission-critical voice and data applications, these standards are unlikely to be ratified until 2018, and possibly as late as 2020.

The present TETRA arrangement provides the emergency services with essentially a dedicated communications network. Although arrangements are being made to safeguard, prioritise and separate emergency services traffic from that generated by other users, there is potential for services to be disrupted in situations where there are a high number of devices utilising LTE, such as at sporting events. Alternatively, use of ESN could limit connections for citizens.

Airwave's TETRA network is now scheduled to be active until 2020, negating much of the medium-term cost saving benefit of moving to LTE. Local stakeholders who have a decade of experience using TETRA could well select to continue legacy provision up to this date.

4 Public safety network challenges for UK and others

There are numerous challenges facing the profiled international comparator projects and the UK in installing public safety networks. The technology is only one part of these projects and more pragmatic issues affect the rollout of these networks. So ESMCP will also have to overcome these problems.

Figure 13: Summary of issues and impacts on international comparator projects

Country	Number of users	Complexity of provision	Existing burdens on users	Geography	Topography	New technologies
Australia	●	●	●	●	●	●
Germany	●	●	●	●	●	✕
South Korea	●	●	✕	●	●	✕
United States	●	●	✕	●	●	●

● Significant impact and potentially disastrous

● Reasonable amount of impact affecting the scope

● Some impact but not in surmountable

✕ No impact

Source: Kable

4.1 Public safety provision

Complexity of public safety provision is a significant barrier to delivering a public safety network. Regardless of ESMCP contracts awarded, ultimately it is down to individual UK public safety agencies to sign up to this network. The core contracts should deliver savings in network operating costs versus the legacy TETRA provision and provide additional capabilities to agencies. However, there are other options for individual UK agencies. In the medium term they could look to continue with legacy provision but only up to 2020, or secure their own connectivity arrangements.

Regardless of the benefits offered, local engagement with agencies can derail larger procurements. In Germany and the US, participation has to be sought from numerous local user groups. In the former this has caused delays in rollout, whilst in the LA-RICS project in the US, City of Los Angeles Council withdrawal has reduced the resources and potential benefits for the ambitious programme. In England and Wales, signing up Police & Crime Commissioners (PCCs), who will also oversee Fire & Rescue Services (FRSs) in 2016, delayed the establishment of the Police ICT Company (PICTCo) and reduced its scope. As with the City of Los Angeles Council, individual PCCs may decide that the ESMCP programme does not offer benefits to local residents and choose to withdraw from the project and establish other provision.

The number of individual users does not appear to hinder network rollouts and the UK should be no different. Demand on users can also be overcome as long as training is succinct and targeted and does not distract from day-to-day services.

4.2 Geography and topography

Geography and maintaining coverage in rural areas is the biggest concern for public safety networks. Whilst for countries and states with a vast landmass this is perhaps obvious, even countries of a similar size to the UK find it challenging to deliver this connectivity.

> *A lot of the incidents happen in built up areas granted, but a lot of other accidents or incidents happen between those built up areas where normally there isn't commercial network coverage. But there is and does have to be PS user coverage. It is critical and you find that more and more often it is the in-betweens, the coverage black spots where the larger incidents happen, especially the ones that hit the press.*
>
> **Airwave Solutions**

For countries which are utilising commercial infrastructure, the impetus is on the contracted MNOs expanding their networks. Whilst connectivity remains high in urban areas, many public safety incidents and accordingly the complexity of their response, occur in areas without coverage. Elevation and topography can be overcome, but it still remains an issue. Infrastructure partners have expertise in optimising network coverage and can work around mountainous regions overcoming this issue, but this does require disproportionate resources.

Unplanned incidents, such as the wildfires in Australia, can also affect infrastructure. Geography has implications for the repair and maintenance of commercial and public safety masts and other network infrastructure, at a time when there will be disproportionate demand from all users for connectivity.

4.3 New technologies

New technologies such as LTE are of the least concern for public safety network projects. Users and technology providers knew what had been procured and what limitations it had.

For Germany, which has the "least advanced" technology, a national LMR network would deliver the critical cross-country inter-agency critical voice communications. With this being the primary driver, the additional capabilities which could be provided over LTE were moot. The contractual model and network architecture is flexible enough to accommodate LTE data communications in the future. But most important was secure, reliable voice shared by public safety agency user groups.

Similar priorities drive the networks installed in Australia. Despite having a longer experience with vast LMR networks, Victoria's Metropolitan Mobile Radio (MMR) went live in 2004 and new technologies cannot mitigate concerns around on boarding users in rural locations. Where data capabilities are sought, workarounds such as separate mobile telephony contracts have supplied this functionality. Where LTE is being sought such as in Queensland, Telstra has been compelled to provide additional coverage on its commercial infrastructure through government contracting akin to ESMCP.

FirstNet and SafeNet are future proofing their LTE networks by aligning them to commercial standards. Again, the driver is to install a national network to support interoperability. This means these networks can develop incrementally, sharing best practice and developments within the global MNO market. FirstNet has the potential to disrupt these vendors by providing mobile broadband, and this capability should provide the federal government with funding to develop the network in line with new technologies.

Contrasting the international comparators projects to the UK and the impact of new technologies on any of these

networks is problematic. Driving non-UK projects is a need to provide interoperability and shared voice connectivity and any other benefits offered through new technologies or otherwise are secondary. This core capability won't disappear in the UK and is something which is already offered to UK public safety agencies under the incumbent contract. Using LTE and adopting the lessons learned from a first generation network means that UK public safety agencies should gain additional data capabilities not being initially sought in the comparator projects.

There is a relatively small set of technology providers with specific public safety network expertise. Motorola Solutions, which has the key public safety agency user services contract in the UK, holds similar roles in Queensland and Los Angeles and this expertise should mitigate much of the risks associated with this project. Utilising a commercial network requires a domestic provider such as Everything Everywhere (EE) in the UK or KT in South Korea. Other providers can be domestic if the technology industrial base is high, such as Samsung in South Korea. Given the small pool of suppliers all vendors have a commercial interest in ensuring that projects are future proof and are delivered successfully to secure further business.

Consolidating networks, whether through removing the need for secondary mobile telephony contracts or removing legacy local networks, will deliver savings and this drives public safety agencies in the UK and around the world more than any disruptive, perhaps untested technologies.

5 Conclusions

The answer to the question: “Is the proposed ESMCP solution the most advanced in the world?” is ‘yes’.

This comes with some caveats. Firstly, that fully LTE demonstrator projects have occurred as part of the LA-RICS contract, and this included Push-To-Talk (PTT) applications over a LTE network. Queensland, as part of its contract with Telstra has also piloted similar functionality at planned extraordinary events. But these exemplars are specific projects designed to showcase this technology and with a safety net of LMR for critical voice communications. These are also regional projects rather than an encompassing national solution, like ESMCP.

South Korea is rapidly approaching the point when these services will be deployed in Seoul and the Gangwon province, but the real focus is voice over commercial networks between all South Korean public safety agencies as this is something which has never been offered. The lack of such a system has hindered the response to some domestic crises. The UK differs from many other solutions, as ESCMP is a second generation system, with all of the learnings that entails.

The interoperability offered by the legacy Airwave contract is taken for granted and the primary driver behind the incumbent solution. ESMCP will offer advanced capabilities and underpin additional data-rich functionality for UK public safety agencies. In a way, the fact that it is a second generation national network means that it would be the most advanced. Its incumbent usage and limitations are well understood, allowing the UK government to design and procure a solution relevant to public safety agencies through the experiences of the first contract and user demand. As a second generation contract, ESMCP has pressure to deliver savings over legacy provision. This is not a factor for most public safety network projects, whose key driver is the interoperability which is not currently in place. The impetus for these networks is in response to problems experienced during major historical incidents. To be clear, additional data capabilities do not require LTE networks, but LMR is slower and more expensive for this functionality.

The second caveat is that at the time this report has been written the Emergency Services Network (ESN) is not active and won’t be active on any scale until mid-2017 under the current plan. South Korea’s SafeNet should be fully live by this point, but may not provide the additional functionality that ESMCP will offer, particularly given the lack of experience with a national public safety network amongst users.

Through the international comparator projects it is clear that challenges lie ahead for ESMCP which risk delaying or descoping the project. South Korea is starting from a far-higher commercial coverage base (97%) versus the UK (50%). Geography is a significant hindrance, even for countries using a ‘proven’ technology and of a similar nature to the UK, such as Germany. The challenge for the UK, given its lower coverage is to ensure that network reach is maintained, as it is here where agency response is most critical. Both commercial and dedicated public safety network infrastructure can be affected by unforeseen events, particularly in rural locations.

Locally driven agency provision also complicates rollouts, as evidenced in Germany and the US. With PCCs taking on fire brigades, ESMCP’s success is dependent on local stakeholders who may disrupt the national project if they do not believe the programme is best for local residents. The success of any given public safety network relies on the support of its user groups and through effective governance arrangements. Successful projects manage to convince users of their benefits through effective engagement, messaging and training.

6 Appendix

6.1 Reference Table A: National population and geography

	Population, 2014 (m)		Geography		
Country	Urban (1)	Rural (2)	Population in Rural Areas (3)	Area defined as Rural (4)	Elevation span (m) (5)
Argentina	39.4	3.6	Under 15%	99.84%	7,065
Australia	21.0	2.5	Under 15%	99.81%	2,244
Brazil	176.1	30.0	Under 15%	99.80%	2,994
Canada	29.0	6.5	15% to 25%	99.84%	5,959
China	742.3	622.0	Over 25%	99.23%	9,004
Denmark	4.9	0.7	Under 15%	99.11%	178
France	52.5	13.7	15% to 25%	96.28%	4,809
Germany	60.7	20.1	15% to 25%	97.05%	2,967
India	419.2	876.1	Over 25%	99.40%	8,598
Indonesia	134.9	119.6	Over 25%	99.59%	4,884
Ireland	2.9	1.7	Over 25%	99.34%	1,041
Italy	42.2	19.1	Over 25%	97.91%	4,748
Japan	118.3	8.9	Under 15%	93.90%	3,780
Mexico	99.0	26.4	15% to 25%	99.53%	5,685
New Zealand	3.9	0.6	Under 15%	99.52%	3,754
Norway	4.1	1.0	15% to 25%	99.73%	2,469
Russia	106.3	37.5	Over 25%	99.90%	5,661
Saudi Arabia	25.6	5.3	15% to 25%	99.75%	3,133
South Africa	34.7	19.3	Over 25%	99.44%	3,408
South Korea	41.5	8.9	15% to 25%	96.16%	1,950
Spain	36.9	9.6	15% to 25%	99.23%	3,718
Turkey	55.3	20.6	Over 25%	99.52%	5,166
United Kingdom	53.1	11.4	15% to 25%	95.92%	1,347
United States	259.7	59.2	15% to 25%	97.77%	6,276

Source: Kable

Column descriptions and methodology

1. Population, 2014 (m) - Urban: Population in areas defined as urban, in millions (m). Urban population from The World Bank
2. Population, 2014 (m) - Rural: Population in areas defined as rural, in millions (m). Rural population from The World Bank
3. Geography - Population in Rural Areas: Column 2 divided by Column 1 + Column 2.

4. Geography - Area defined as Rural: Total urban land area in Table 2: Urban Areas By Geography (including selected under 500,000 population) of Demographia World Urban Areas (11th Annual Edition), subtracted from Total Area from CIA World Fact Book. Divided by Total Area from Total Area from CIA World Fact Book.
5. Geography - Elevation span (m): The difference between the highest point in the country and the lowest point in the country, in metres (m) from CIA World Fact Book.

6.2 Reference Table B: National public safety provision

	Public Safety Agencies		Burden of Services vs UK		
Country	Number of Agencies (6)	Number of Staff (7)	Police (8)	Ambulance (9)	Fire (10)
Argentina	10-25	25k-50k	Higher	**	Higher
Australia	10-25	50k-100k	Similar	Similar	Higher
Brazil	50-100	50k-100k	Higher	Lower	Higher
Canada	250-500	1m+	Similar	Similar	Higher
China	0-10	1m+	Similar	Similar	Higher
Denmark	10-25	50k-100k	Similar	Similar	Similar
France	100-250	100k-250k	Similar	Similar	Higher
Germany	500-1000	250k-500k	Similar	Higher	Similar
India	1000+	1m+	Higher	**	Higher
Indonesia	0-10	100k-250k	Higher	**	Higher
Ireland	0-10	50k-100k	Similar	Similar	Similar
Italy	1000+	100k-250k	Similar	Similar	Higher
Japan	500-1000	250k-500k	Lower	Similar	Higher
Mexico	1000+	500k-1m	Higher	Lower	Higher
New Zealand	0-10	50k-100k	Similar	Similar	Higher
Norway	0-10	100k-250k	Lower	Similar	Similar
Russia	0-10	1m+	Higher	Higher	Higher
Saudi Arabia	0-10	50k-100k	Higher	**	Higher
South Africa	10-25	100k-250k	Higher	Lower	Higher
South Korea	0-10	100k-250k	Similar	Similar	Higher
Spain	0-10	100k-250k	Similar	Similar	Similar
Turkey	100-250	250k-500k	Higher	Similar	Higher
United Kingdom	100-250	100k-250k	-	-	-
United States	1000+	1m+	Higher	Similar	Higher

*- indicates not applicable. ** indicates not available.*

Source: Kable

Column descriptions and methodology

6. Public Safety Agencies - Number of Agencies: The total number of civil public sector organisations responsible for public safety, which would include ambulance, fire and police services – but exclude solely military bodies.
7. Public Safety Agencies - Number of Staff: The total number of staff employed by the country's various public safety agencies, for example fire & rescue officers, police officers, paramedics etc.

8. Burden of Services vs UK – Police: A proxy metric to identify demand on police time. The number of murders per head of population compared to UK. Intentional homicides (per 100,000 people) from The World Bank.
9. Burden of Services vs UK – Ambulance: A proxy metric to identify demand on paramedic time. Hospital discharges from Organization for Economic Cooperation and Development divided by head of population compared to UK.
10. Burden of Services vs UK – Fire: A proxy metric to identify demand on fire & rescue service time. Estimated road traffic fatal injury deaths per 100 000 population from World Health Organisation compared to UK.

6.3 Reference Table C: National technology base

	Internet users in population (11)	LTE Coverage (12)	Total public sector mobile telephony spend per head of population (£) (13)
Argentina	60% to 85%	42%	2.16
Australia	60% to 85%	74%	11.99
Brazil	Below 60%	50%	1.62
Canada	Over 85%	70%	8.46
China	Below 60%	76%	0.58
Denmark	Over 85%	63%	18.92
France	60% to 85%	47%	12.98
Germany	Over 85%	53%	8.36
India	Below 60%	50%	0.13
Indonesia	Below 60%	43%	0.31
Ireland	60% to 85%	44%	14.09
Italy	60% to 85%	51%	7.46
Japan	Over 85%	90%	8.20
Mexico	Below 60%	60%	0.94
New Zealand	Over 85%	51%	5.79
Norway	Over 85%	72%	19.61
Russia	60% to 85%	49%	2.26
Saudi Arabia	60% to 85%	62%	**
South Africa	Below 60%	58%	2.62
South Korea	60% to 85%	97%	3.28
Spain	60% to 85%	53%	9.20
Turkey	Below 60%	0%	1.93
United Kingdom	Over 85%	50%	10.51
United States	Over 85%	78%	18.28

*- indicates not applicable. ** indicates not available.*

Source: Kable

Column descriptions and methodology

11. Internet users in population: Internet users (per 100 people) from The World Bank
12. LTE Coverage: LTE Coverage by country (Q4 2015) from OpenSignal's The State of LTE (February 2016)

13. Total public sector mobile telephony spend per head of population (£): Total mobile voice and mobile data expenditure in the government sector, including local, federal and central public sector bodies (2015) from Kable, divided by population.

6.4 Reference Table D: International public service network provision

Country	Geography	Name	Users	Prime contractor	Delivery model	Public safety coverage	Technology	Communications	Network Owner	Total contract value (£m)	Length (years)
Australia	Queensland	Government Wireless Network (GWN)	15,200	Telstra	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR/LTE	Voice/Data	Public Sector/Commercial	270	15
Australia	South Australia	South Australian Government Radio Network	20,000	Motorola Solutions	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	90	7
Australia	Victoria	Metropolitan Data Network (MDN) - Extension	21,000	Motorola Solutions	Operate	Police, Ambulance	LMR	Voice/Data	Public Sector	20	2
Australia	Western Australia	Community Safety Network	9,600	Motorola Solutions	Design-Build-Maintain	Police, Fire	LMR	Voice/Data	Public Sector	30	5
Brazil	Sergipe	15-site network + 2 year maintenance	3,000	Sepura	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice	Public Sector	**	**
Brazil	Maranhão	Emergency services radio system	**	Motorola Solutions	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice	Public Sector	**	**

Country	Geography	Name	Users	Prime contractor	Delivery model	Public safety coverage	Technology	Communications	Network Owner	Total contract value (£m)	Length (years)
Brazil	Brasília	Military Police (Brasília) digital radio network infrastructure	15,000	Airbus	Design-Build-Maintain	Police	LMR	Voice	Public Sector	**	**
Canada	Calgary	Public safety LTE network - demonstrator	**	Motorola Solutions	Design-Build-Own-Operate	Police	LTE	Data	Commercial	**	**
China	Beijing	Beijing Police Bureau TETRA Digital Trunked Radio Communications System	**	Motorola Solutions	Design-Build-Maintain	Police	LMR	Voice	Public Sector	**	**
China	Beijing	Beijing Government Shared TETRA Network	90,000	Airbus; Beijing JustTop Communication	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR	Voice	Public Sector	**	**
Denmark	Nationwide	SIkkerhedsNEttet (SINE)	21,000	Motorola Solutions*	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	200	10

Country	Geography	Name	Users	Prime contractor	Delivery model	Public safety coverage	Technology	Communications	Network Owner	Total contract value (£m)	Length (years)
France	Nationwide	INPT	120,000	Airbus	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	900	10
Germany	Nationwide	BOSNet	500,000	Airbus	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	1,000	20
India	Delhi	Government Radio Network	**	HCL, Motorola Solutions	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice	Public Sector	13	**
India	Andhra Pradesh	TETRA radio network contract	**	Airbus; Sanchar Telesystems	Design-Build-Maintain	Police	LMR	Voice	Public Sector	**	**
Indonesia	Jakarta	TETRA Trunked Radio Systems	**	Rohde & Schwarz, Sepura	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice	Public Sector	**	**
Ireland	Nationwide	National Digital Radio Services	20,000	Motorola Solutions*	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	350	8
Italy	Nationwide	TETRA Interpolice Programme (PIT)	350,000	Selex ES	Design-Build-Maintain	Police	LMR	Voice/Data	Public Sector	340	10

Country	Geography	Name	Users	Prime contractor	Delivery model	Public safety coverage	Technology	Communications	Network Owner	Total contract value (£m)	Length (years)
Mexico	Nationwide	Interconexión de Redes Integrales de Seguridad Pública (IRIS)	**	Airbus	Design-Build-Maintain	Police	LMR	Voice	Public Sector	**	**
New Zealand	Nationwide	National Radio Network	11,000	Tait	Design-Build-Maintain	Police	LMR	Voice	Public Sector	90	**
Norway	Nationwide	Nødnett	35,000	Motorola Solutions	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	530	26
Spain	Nationwide	SIRDEE	240,000	Airbus*	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR	Voice/Data	Public Sector	190	7
United States	Las Vegas	Las Vegas Police Communications	3,200	Motorola Solutions	Design-Build-Maintain	Police	LMR	Voice/Data	Public Sector	30	11
United States	Los Angeles	Los Angeles Interoperable Public Safety Radio System	34,000	Motorola Solutions	Design-Build-Own-Operate	Police, Fire, Ambulance	LMR	Voice	Public Sector	110	5

Country	Geography	Name	Users	Prime contractor	Delivery model	Public safety coverage	Technology	Communications	Network Owner	Total contract value (£m)	Length (years)
United States	Los Angeles	Los Angeles Regional Interoperable Communication System (LA-RICS)	34,000	Motorola Solutions	Design-Build-Own-Operate	Police, Fire, Ambulance	LTE	Data	Public Sector	170	5
United States	Texas	Harris County, Texas Public Safety LTE wide area broadband network	65,000	Motorola Solutions	Design-Build-Maintain	Police, Fire	LTE	Voice/Data	Public Sector	20	**
United States	Florida	Inter-governmental communications system	**	Motorola Solutions	Design-Build-Maintain	Police, Fire, Ambulance	LMR	Voice	Public Sector	15	**

*- indicates not applicable. ** indicates not available.*

Source: Kable

6.5 Glossary

- 3GPP: An international standards board ensuring common practice across telecommunications.
- Emergency Services Mobile Communications Programme (ESMCP): A Home Office-led project to replace the incumbent TETRA network with a new national mobile communications service.
- Emergency Services Network (ESN): The new national mobile communication network which replaces the service currently delivered by Airwave Solutions.
- Joint venture: A consortium of multiple companies.
- Land Mobile Radio (LMR): Wireless communications over radio waves. Digital encryption allows users to communicate securely with one another.
- Long Term Evolution (LTE): LTE encompassing 4G is the standard for high-speed data wireless communication for mobile phones and data terminals.
- Mobile Network Operator (MNO): A company with the infrastructure to provide mobile communications.
- Police & Crime Commissioner (PCC): Elected official in England and Wales overseeing a local police force.
- Prime contractor: Lead company on a project.
- Public Finance Initiative (PFI): State project using private finances.
- Public safety agency: Civil public sector organisations responsible for public safety, which would include ambulance, fire and police services – but exclude solely military bodies.
- Public safety agency user: Emergency services staff employed by public safety agencies.
- Public Safety Network: A communications network used by public safety agencies.
- Push-To-Talk (PTT): The ability to instantly connect to a network of established users securely.