RIVADA NETWORKS

06 November 2013

Dear Sir:

Rivada Networks is pleased to offer our response to Ofcom's consultation on 'The future role of spectrum sharing for mobile and wireless data services - licensed sharing, Wi-Fi, and dynamic spectrum access.' Rivada Networks welcome the opportunity to present herein what we believe is a compelling solution to the UK's increasing demand for wireless data services, and to the supply and management of spectrum in the UK.

Rivada Networks is a leading designer, integrator and operator of wireless, interoperable Public Safety communications networks. We provide advanced communications solutions to the Public Safety community (Police, Fire, EMS and other first responders). The Rivada Networks offering is focused on delivering 4G voice, video and data through the latest in LTE infrastructure, delivering state of the art capabilities to Public Safety users, whilst serving to meet rapidly increasing demand for wireless broadband capacity across the UK.

The Rivada Networks offering compliments the approach of the Emergency Services Mobile Communications Programme (ESMCP). The ESMCP will replace the communication service delivered by Airwave with a new national mobile communication service for all three emergency services and other organisations that currently use the Airwave service. This new service, the Emergency Services Network (ESN), will take advantage of the latest mobile technologies to provide national critical voice and broadband data services to approximately 250,000 Public Safety users in the UK. The ESMCP is a cross-government programme hosted by the Home Office. Rivada Networks advocates the allocation of harmonised, dedicated spectrum for Public Safety and the Rivada Networks solution provides ESMCP and the UK with a reliable, fully interoperable, and cost-effective alternative to building expensive dedicated infrastructure.

The Rivada Networks offering also supports the aims of Ofcom in that it alleviates significant demand driven pressure on wireless broadband capacity in the UK via the creation of a dynamic, real-time market for bandwidth that is hugely beneficial for both suppliers and consumers alike.

Rivada Networks is a market leader in the provision of interoperable Public Safety communications networks. It provides advanced communications solutions to the Public Safety community, as well as communications solutions to responders in the aftermath of natural and man-made disasters, and terrorist threats. Rivada Networks' customers consist of a diverse range of federal, state, and local agencies in the United States, including U.S. Northern Command, the National Guard Bureau and the Department of Homeland Security. Rivada

Networks has provided communications solutions to almost every major disaster and civil emergency in the United States of America since 9/11. The expertise gathered during these experiences led to the development of the technology and solutions that are presented in our response to this consultation.

The solutions and approach that we present provides the UK's Public Safety services and organisations with a state of the art, fully interoperable Long Term Evolution (LTE) broadband network, and also provides a recurring revenue stream that subsidises the ongoing cost of maintaining a Public Safety network. These core goals – the highest quality Public Safety network, flexibility, and a positive revenue outcome, are unlikely to be achieved in a more efficient way.

Rivada Networks appreciates the opportunity to present our comments and share our thoughts. We would appreciate the opportunity to coordinate with Ofcom and ESMCP to define a future for Public Safety communications and place the UK at the forefront of the emerging global wireless standard for Public Safety communications, while addressing overarching demand related issues in wireless broadband capacity in the UK. We are eager to work with Ofcom, ESMCP and the Public Safety community to demonstrate that our approach presents the right solution. We look forward to further discussions with Ofcom regarding the Rivada Networks approach.

Yours sincerely,

Declan Ganley
Chairman and Chief Executive Officer
Rivada Networks

RESPONSE TO OFCOM CONSULTATION

THE FUTURE ROLE OF SPECTRUM SHARING FOR MOBILE AND WIRELESS DATA SERVICES

LICENSED SHARING, WI-FI, AND DYNAMIC SPECTRUM ACCESS

7th November, 2013

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1.0 EXECUTIVE SUMMARY

In our response to Ofcom's consultation, Rivada Networks sets out an approach that enables the UK's Public Safety services and organisations to maximise the fullest potential of a potential allocation of a proposed dedicated 20MHz of 700MHz 4G LTE spectrum, while providing a solution to rising consumer demand for wireless broadband capacity, driven largely by mobile device usage and the emergence of applications in the burgeoning M2M sector.

A number of Governments around the world are currently working toward the allocation of harmonised, dedicated spectrum, consistently within the 700MHz band, for Public Safety. 4G LTE has been unanimously accepted as the platform of choice. In the United States, Congress recently assigned the 700 MHz D Block spectrum to Public Safety and aim to fund or part fund a dedicated nationwide public safety broadband network, FirstNet. The British Association of Public-Safety Communications Officials (BAPCO) has received a mandate from Public Safety stakeholders across all emergency services, from associations and groups including the TCCA, FSC, RUSI, and from commercial providers, to lead the campaign for dedicated and harmonised spectrum for Public Safety in the UK.

Rivada Networks' approach meets the requirements of ESMCP and the Public Safety community, delivering state of the art broadband mobile communications capabilities that are able to rapidly provide for and fund essential services, leveraging existing commercial spectrum.

Under ESMCP, emergency services and other first responder organisations have been closely involved in developing an understanding of future operational needs, as well as defining requirements to provide a system appropriate for a future dominated by data communications.

ESMCP is working with the Joint Emergency Services Interoperability Programme (JESIP) to ensure that future solutions enable interoperability. ESMCP has stated that lessons learned from high-profile incidents have continuously reinforced the need for effective interoperability and also recognised that the achievement of this is only partly about communications technology.

The ESMCP aims to roll out the ESN network, stating their intention to provide users with a more cost-effective (cheaper), operationally-efficient (better) and demand-led (smarter) service.

- Cheaper - to ensure ESN is delivered cost-effectively and able to take advantage of future technological developments.
- Better - users are increasingly relying on commercial providers to provide broadband data services. ESN intends to provide this as a core service with appropriate security and availability.
- Smarter - different users will use ESN in different ways so the service will be flexible to allow users to choose only the services relevant to them.

Rivada Networks' Public Safety communications offering and innovative technologies meet all of ESMCP's aims and promise to dramatically improve public safety communications. Rivada Networks' patented Dynamic Spectrum Arbitrage system will enable the new nationwide mobile broadband public safety broadband network, ESN, to monetise a proposed 20 MHz spectrum allocation in real time to private sector users, subject to “ruthless pre-emption” when needed by Public Safety.

Rivada Networks’ DSATPA solution commoditises bandwidth. It does so at all levels, including at the most granular, a specific allocation of bandwidth, for a specific time segment, within the 24 hour time cycle in a grid as small as a subsector of an individual base station. DSATPA does all of this dynamically and competitively. In short, this is an industry game changer that will be of immense benefit to Public Safety communications.

In proposing that UK Public Safety adopt a ‘Dynamic Spectrum Arbitrage, Tiered Priority Access’ (DSA and DSATPA) model, the UK will achieve:

1. The greatest possible UK-wide control, coverage, load capacity and survivability for a mobile broadband mission-critical network, the ESN.
2. Have complete Public Safety ownership and control over the bandwidth resource & infrastructure.
3. Experience Public Safety ultra priority access (at the millisecond level) to all of the bandwidth across all the allocated spectrum (ensuring their user experience across the entire network equates to ‘clear lanes’ as though there was no other traffic on any of the network).
4. Regular refresh and updates of equipment and handsets, keeping pace with 4G and subsequent innovation and allowing such capability to be migrated quickly into the front lines of Public Safety in the UK.
5. A Public Private Partnership (PPP) model that privately funds the network deployment, operation and upgrades at no cost to the taxpayer and without compromising ongoing operation of and title to, key infrastructure or spectrum.
6. A potential source of significant surplus revenue to fund the UK's Public Safety communications mission.
7. A ‘carrier agnostic’ mobile broadband LTE footprint allowing for real-time competitive wholesale access which can reasonably be expected to benefit from the ever increasing ‘scarcity’ value of bandwidth, without surrendering that upside potential to an individual entity, or group of commercial entities.
8. A resource that will help further catalyse new business models, innovation and job creation in the UK.
9. A standards-based network that will be fully interoperable with the nationwide LTE rollout.

Please see link below to Rivada Networks' DSATPA overview video:

http://rivada.com/rivadas-board-discuss-their-patented-dsatpa-technology/

Rivada Networks meets ESMCP requirements for a dedicated, high-quality, secure network for frontline Public Safety workers and first responders, while our patented technology has the potential to utterly transform the way in which spectrum is prioritised, managed, shared, competitively priced, and used across the UK.

Rivada Networks' DSA model was developed specifically for the Public Safety mission in order to provide for the best possible Public Safety communications networks, solutions and coverage while also providing for the relief, and in cases, elimination of the requirement to tap taxpayer resources to fund the building and operation of those networks.

Rivada Networks recognises the absolute necessity for Public Safety to own and control its radio spectrum resources. We also understand that Public Safety can never compromise or lower their capabilities or standards to accommodate the needs of commercial/market requirements. We believe that in adopting a DSATPA approach as outlined in this RFI, the UK can achieve those goals and set a 'gold-standard' for next generation Public Safety broadband, whilst alleviating wireless broadband capacity constraints.

Dynamic Spectrum Arbitrage Tiered-Priority-Access (DSATPA) for the first time allows bandwidth to be allocated on the basis of priority use – meaning that in an emergency, police, fire service, ambulance service and other first responders are guaranteed access to available bandwidth. This ability to prioritise access to bandwidth for some users ahead of others will save lives in disaster situations, while allowing Public Safety to take a fixed asset and monetise it at all times – providing essential and marketable options for commercial carriers that allow them to reduce costs to consumers and relieve the stress on their own networks.

By enabling commercial carriers and others to buy blocks of bandwidth during fallow periods when demand is low, Public Safety can both increase the efficiency of its spectrum and generate a significant stream of revenue to fund itself. While dynamic spectrum access will play an important future role in enabling better quality of service and lowering barriers to spectrum access, handsets are not capable of routing packets through different gateways. Dynamic Spectrum Arbitrage, on the other hand, takes place at the network level, uses current off-the-shelf technology, and is readily controllable. Rivada Networks' solution creates the financial model and coordination necessary to enable aggregation of diverse carriers. Enabling DSA in the network offers an immediate solution to wireless broadband capacity demand pressures, leveraging existing specifications and standards, as opposed to waiting for solutions, capabilities and functionality at the device level, which may take up to a decade to emerge.

Access to dedicated spectrum is best realised through licensing as it creates an accountable 'broker' for spectrum supply and management, allows for better frequency coordination, while the associated economics would drive better spectral efficiency. Unlicensed access creates a

'free for all' scenario, thus compromising the QoS benefit whereby the consumer is offered true differential services.

Rivada Networks believe that Ofcom could play a significant role in supporting the development of DSA and relevant technologies by advocating the allocation of harmonised, dedicated spectrum to UK Public Safety. As illustrated in Real Wireless' analysis on behalf of Ofcom, expediting the availability of the 700MHz band significantly reduces the cost of delivering wireless broadband in the UK - by greater than 40% in the case of suburban areas. Real Wireless estimate that in the absence of 700MHz availability, a spectrum 'crunch' in the UK is encountered between 2022 and 2025. Ofcom can encourage network sharing and equal access, encouraging new entrants into the market to aggregate capacity, thus enhancing the user experience, allowing for diversity, and driving down costs to the consumer.

Rivada Networks can provide a full operating demonstration of DSATPA enabled LTE on request.

2.0 INTRODUCTION

We live in an era where natural disasters, terrorist incidents, or other unforeseen emergencies can take place anytime, anywhere, and compromise the ability of those engaged in life-saving work to communicate with each other. The challenge of providing secure, cost-effective, reliable, and high quality access to communications bandwidth for the UK's Public Safety and first responders is of paramount concern.

Many Governments across the world are working toward harmonised, dedicated spectrum for Public Safety. Public Safety in the United States was recently allocated the new 'D-Block' of Spectrum by Congress, providing dedicated 2 x 10MHz spectrum in the 700MHz band. The Public Safety community in the UK, Europe, Australia, Canada, and others support and recognise the benefits of allocated spectrum being harmonised within the 700MHz band, worldwide. The distinctive physical properties of the 700MHz band are advantageous in terms of coverage and spectrum efficiency. A harmonised band enables commonality of equipment and chipsets worldwide, thus driving down the cost of handsets and equipment for Public Safety. There is consensus across the international Public Safety community that 4G LTE is the optimal platform, supporting data rich, mission critical applications.

In recent years, the United States has made tremendous progress towards the goal of a nationwide Public Safety broadband wireless network. Public Safety agencies and practitioners have worked closely with federal agencies in a cooperative effort to develop a plan for the deployment of a nationwide interoperable Public Safety broadband wireless network. Wireless industry groups have formed task forces and committees to endorse existing wireless standards and develop additional Public Safety specific standards and operating procedures. APCO and

British APCO were heavily involved in this effort and continue to be strong advocates for a technically advanced fourth generation interoperable Public Safety broadband wireless network.

The solution that UK Public Safety chooses must have the ability to seamlessly roam between Public Safety and commercial 4G LTE networks. While doing so, the Public Safety network must provide unprecedented support for priority access and quality of service (QoS) settings to ensure the most critical Public Safety users receive the highest priority, and incorporate security mechanisms that work to ensure the Public Safety communications solution is secure, end-to-end, every time. This network must allow UK Public Safety to leverage its investments in existing broadband infrastructure, while taking full advantage of the favourable propagation characteristics of the 700 MHz band. Deployment of the network under broadly accepted industry standards will allow the UK's first responders to become fully interoperable with other local, regional and national services and organisations.

One of the main obstacles to achieving UK Public Safety's desired future is the cost of building and operating a state of the art LTE network that meets demanding Public Safety communications requirements. With this in mind, Rivada Networks proposes an approach that meets technical requirements, while putting in place an innovative financial solution that greatly reduces the overall cost of the network.

Commercial wireless operators are currently in the process of deploying 4G LTE networks to meet increasing bandwidth requirements for their customers. However, as demand for bandwidth continues to exponentially increase; further pressure will be applied to operators to provide the necessary radio capacity.

It is widely acknowledged that Public Safety services need access to dedicated spectrum to ensure that they have the necessary and sufficient bandwidth for the capabilities they need for comprehensive emergency response situations. However, emergencies on this scale do not happen every day, week, or month, and therefore not all of this spectrum will be needed all of the time – the requirement is simply that bandwidth on this scale can be accessed immediately should the need arise.

Having access to this highly-prized spectrum is useless without the funding in place to build and operate the network. In order to greatly reduce the cost to Government, and provide on-going funding for the maintenance and expansion of a first-rate Public Safety communications network, Rivada Networks proposes the following innovative approach:

- The development of a licensed, purpose built, state of the art broadband LTE network dedicated to, and controlled by, Public Safety services and organisations
- Network build and operation funding by private investment
- Leverages existing communications assets owned by Public Safety services (tower sites, backhaul capacity, network operations centres, etc).

- The on-going real-time auctioning of excess bandwidth, when not being utilised by Public Safety services, to private commercial operators on a dynamic basis, providing on-going funding to those services for maintenance and expansion of the network.
- Under such a proposal, the Public Safety operator would not act as a competitor to commercial carriers, but instead would operate as a licensed service provider to all carriers, providing excess Public Safety bandwidth to existing carriers and new entrants who will now be able to compete as a result of reduced barriers to entry provided by surplus Public Safety infrastructure capacity.

The benefits of this approach are significant. For starters, it can completely eliminate the requirement for Government funding for the initial build-out, and provides a recurring stream of funding for the annual operation and maintenance of the ESN. In turn, this allows Government to allocate funding to do more outside of the initial network build.

This approach also allocates control of the network directly into the hands of the Public Safety services and organisations, allowing them absolute priority access to their bandwidth controlled by the services themselves.

By reducing the barriers to entry to the commercial market for new entrants, (as it allows them to purchase bandwidth as needed, without the investment in a national mobile network), this proposal also fosters the creation of an entirely new marketplace that will result in countless new innovations in cellular communications. This will create thousands of jobs in mobile broadband communications, increase the revenue available to fund Public Safety communications, and improve the sustainability of the ESN long into the future.

3.0 CHALLENGES

For a public-private partnership to function effectively Public Safety must understand exactly what they can expect out of the partnership, how collaboration between them and the private partner will work and to what extent Public Safety will have influence or control over the implementation and operation of the network. If the goals of the private partner are substantially different than the goals of Public Safety, one can only expect friction throughout the ongoing relationship, as each party works toward differing objectives.

Rivada Networks hopes to overcome this potential obstacle by allowing Public Safety operators to become a key part of the planning and operations team, working side by side with Rivada Networks staff. This approach is a key differentiator in what Rivada is delivering and serves to demonstrate Rivada Networks' level of commitment to a true partnership with Public Safety. In addition, Rivada Networks will implement a revenue sharing plan with Public Safety services and organisations that will allow these entities to share substantially in the benefits of revenue generated from the wholesale of excess network capacity to third parties.

Some of the more obvious challenges and concerns are presented below:

3.1 Pace of Change

Communication technology is evolving quickly. Public Safety communications has traditionally been behind the curve since they have been forced to deal with inefficient spectrum, specialised infrastructure and costly devices. With more efficient spectrum allocation and the adoption of LTE technology as the wireless broadband communication standard, Public Safety can join the ranks of the commercial carriers and have access to scalable and affordable technology as it becomes available. This is not to say that Public Safety can afford to simply let the technology options evolve without their active participation. It does however; supply a platform, ecosystem, standard and a global community of users that will share many common interests and concerns.

3.2 Capital Funding

Significant funding will be required to meet the needs of a national interoperable Public Safety broadband communications network. Out of the box thinking and unconventional approaches are required to get the cost of the network infrastructure down without sacrificing the expected network quality.

3.3 Cost of Operations

There will simply not be enough revenue generated by up to 250,000 Public Safety users paying fees to support ongoing network operations. External, non-Public Safety customers will need to leverage network resources and pay ongoing fees in order to supplement the cost of network operations.

Bringing on outside users to supplement operating costs has challenges related to network priority for Public Safety that can only be solved through innovative business models and technologies, that can guarantee on-demand priority access to network resources to first responders. These technologies must also efficiently manage the access to the network for secondary users supporting first responders, with a system that can deal with changing access priorities as new resources are required to assist in an incident.

3.4 Local Control

The operational requirements of a commercial wireless network are not the same as the requirements of Public Safety communications. The involvement of local Public Safety experts is essential to meet the needs of first responders. Any business model that integrates local control is challenging to implement and manage if the network is not a Public Safety First implementation.

Enabling technology that allows for Tiered Priority Access and collaborative administrative control is needed for successful integration of local control by experienced Public Safety personnel into daily network operations.

3.5 Meeting Public Safety Grade Requirements

Meeting the need for quality, availability, reliability, and survivability makes implementing such a network a significant challenge for any operator. None of the commercial wireless broadband service providers meet these requirements today.

Integrating existing hardened assets is a significant step toward meeting these expectations. Rivada Networks believes wholeheartedly in building and maintaining to Public Safety grade quality standards and proposes fully leveraging existing Public Safety communication infrastructure toward realising that objective.

3.6 The Rivada Networks Solution

Rivada Networks' DSATPA technology is a vehicle for substantially resolving the aforementioned challenges in an elegant way and provides a foundation for rapid evolution of the proposed ESN.

- Rivada Networks' model will fund the development of the national interoperable Public Safety network and substantially subsidise operating costs.
- Rivada Networks effectively leverages leading edge technology to deliver the highest Return on Investment (ROI) for Public Safety communications by efficiently selling the unused network capacity and returning profits to Public Safety for funding ongoing operations of the network.
- Rivada Networks is delivering the only end-to-end, Public Safety grade, UK-wide interoperable broadband solution in the industry: leveraging existing Public Safety assets, developing to Public Safety standards, and utilising local Public Safety industry experts for network development and ongoing operations.
- By engaging with the commercial carriers as wholesale customers, Rivada Networks maintains significant influence over cross-network compatible devices for all network operators and their device manufacturers. The Rivada Networks approach can therefore guarantee that device costs are kept low and ensure that the Public Safety community has access to the same latest devices as the commercial world.

4.0 FUNDING

UK Public Safety has an unprecedented opportunity for an historic improvement and modernisation of its communications solutions through the allocation of dedicated spectrum for Public Safety use, coupled with ESMCP's initiative toward the deployment of a nationwide Public Safety broadband network, ESN. In order to benefit from this opportunity, the broadband communications solution must affordably meet the needs of the UK's first responders. In an era where government budgets are contracting, it is critical that we aim to do more with less. It is also critical that Public Safety organisations across the country become an integral partner in the planning and development of this UK-wide network.

The prohibitive cost of building Public Safety networks that leverage heavily on existing commercial infrastructure or building all new, dedicated nationwide Public Safety networks is forcing Governments across the world to look to innovative business models to accomplish their objectives. Public Safety in the UK has the opportunity to circumvent economic challenges and to leverage a two trillion dollar per annum global wireless ecosystem. This unique opportunity will place the UK at the forefront of what we expect will be a global paradigm shift for Public Safety communications. Rivada Networks has an innovative approach to this opportunity, one that addresses all of the fundamental success criteria.

It is widely acknowledged that UK Public Safety will need access to dedicated spectrum to ensure they have sufficient bandwidth for the capabilities they need to respond to emergencies and incidents. Public Safety services and organisations also need to have absolute control of the networks they use for mission-critical communications. However, it is also widely accepted that the Public Safety community will not need the full allocation of spectrum all of the time.

In addition to state of the art technology, and sufficient spectrum to use those networks, the UK's Public Safety services require access to funding to build, operate and maintain the necessary capabilities. In order to reduce the overall cost of the project to Government, Rivada proposes an innovative approach whereby the cost of network development is privately financed and all costs, including build and ongoing operation, are subsidised by allowing fee-paying commercial users to access the Public Safety network. In this scenario, Public Safety will have absolute priority on the network, and will have permanent access to the entire allocation of spectrum and network capacity when needed. However, when the entire capacity of the network is not required by Public Safety, the network will allow commercial subscribers to use the network by dynamically leasing any excess capacity on a wholesale basis to all carriers and other broadband capacity purchasers. The revenue generated by the selling of capacity to wholesale buyers will be used to pay for the build out and the annual operational costs associated with the network. Rivada will not be a competitor to the carriers, but will instead be a service provider for all carriers, as well as providing capacity for new entrants who can now compete as a result of the decreased barriers to entry.

The ESN should re-use existing communications assets owned by Public Safety services and organisations wherever and whenever possible, including tower sites, backhaul capacity, network operations centres, human resources, and other relevant assets. These Public Safety infrastructure assets generally come with the additional benefit of hardened attributes such as the ability to support substantial generator power, high wind loads, and other important features. Where Public Safety assets are not available, the network should utilise commercial assets to speed deployment and minimise capital costs.

Rivada will provide the ESMCP with the funds to build and operate the network, with no repayments being made until the network is complete and commercial services have begun to flow from the project. Revenues generated from the UK's Public Safety network will essentially

pay for the network with the net effect that Home Office ESMCP does not commit any taxpayers' money to the network.

4.1 Cost Considerations

If ESMCP's plan is to use multiple networks to ensure reliability within the Public Safety spectrum, it most likely means outfitting a large number of the existing Mobile Network Operator (MNO) cell sites with LTE Band 14 equipment. In the United States, the $7B that FirstNet has been allocated is simply inadequate to upgrade all but a fraction of sites to LTE Band 14 capability. It is to be expected that the UK would encounter similar difficulties. Alternatively, if a single MNO is upgraded with Band 14 equipment and commercial out-of-band networks used as backup, there are simply no commercial carrier incentives or mechanism to ensure Public Safety priority or access to backend systems from across all redundant networks.

While a carrier led deployment of Band Class 14 service has the potential to save money, it is certainly not guaranteed. For example, if the vendor implementations prevent adding Band Class 14 to existing base stations due to lack of scalability or security concerns, new eNodeB's may be required. Furthermore, additional antennas on the towers may not be feasible and add expense: installation, tower loading, backhaul provisioning, and additional lease costs are among the many additional costs that will be incurred as part of layering the Public Safety network on the commercial network, even if done in a cost conscious manner. Ultimately, Rivada believes that these costs will most likely exceed the available funding and that the cost to operate the incremental network will exceed Public Safety's ability to pay for it with user fees. Therefore, in order for a carrier to justify the business case, it must judiciously leverage the Public Safety spectrum for consumers and other users who are not first responders.

This dynamic creates an incentive for the commercial carrier to minimise the differences in how it operates the incremental network and ultimately dilutes the effectiveness of the Public Safety offering. For example, the carrier is unlikely to provide detailed system performance information to Public Safety, nor will it allow Public Safety to control the system configurations to its benefit. In the case that the infrastructure vendor cannot separate the performance information between the commercial and Public Safety base station, Public Safety may not receive useful information from a commercial carrier network.

As with FirstNet in the United States, the financial limitations placed on the ESN require innovative business models in order to minimise the cost to Public Safety users and ensure that the network will be highly available for the intended audience. The network must not only provide advanced LTE broadband services - it must also ensure that services and organisations have genuine priority access on the network while at the same time providing a recurring revenue source that can be used to finance the continuing costs of running the network.

In order to benefit from this unique opportunity, Public Safety must be able to afford the devices, service, and applications needed for their mission. The next generation devices may be more expensive than current commercial devices and that expense may impede adoption of

the service. This in turn would require subsidising of devices beyond the level carriers do today, and further challenge a MNO dependent business model.

The need to have the Public Safety network stay within budget while delivering all of their unique performance requirements demands a radical shift in thinking. The new broadband network that Public Safety proposes to deploy must be used to offer services to non Public Safety entities in order to be viable. Public Safety, however, needs to have access to all available radio resources when required to ensure vital communication is achieved either for routine operations or critical incidents.

Ultimately, it is our view that a carrier led model is not sustainable or cost efficient. Public Safety does not simply require a dedicated network – it will, in time, require new devices, services, and applications needed for its mission, and a network that drains costs rather than adds revenue is simply not desirable. Our model of a dedicated network that generates revenue, rather than an essentially hired out network that guarantees neither access nor control nor cost control, is much more advantageous and allows the allocation of revenues to the modernisation of other areas of Public Safety communications.

4.2 Concerns surrounding the Commercial MNOs

Civilian commercial communications networks are built for peacetime and periods of calm – they are designed to handle a steady volume of commercial civilian traffic, and rely heavily on the availability of electricity, a lack of network congestion, and conditions of general normality that frankly do not exist in those moments when Public Safety services and organisations are called into action en masse. Although there is an essential role to be played by civilian commercial carriers and networks in interacting with the Public Safety network, it would be unwise to become overly reliant on them.

Rivada Networks has been involved in Public Safety communications on an exclusive basis for over a decade. In that time we have provided assistance in the United States during Hurricanes Katrina, Gustav, and Ike, as well as during disasters such as the California Wildfires and the collapse of the Mississippi River bridge in Minnesota. In all of these disasters we have seen the same pattern of events.

The catastrophic physical damage suffered by the network, combined with a surge in civilian mobile phone usage during the incident, as concerned people attempted to call their loved ones, meant that Public Safety officials could not access mobile networks, leading to sub-optimal performance and confusion between agencies and responding units. In other cases, the disaster affected rural or remote areas with limited commercial network coverage to begin with.

In all of these cases, the limitations of relying on a commercially provided mobile communications network, designed for mass public use, became distressingly apparent.

Commercial mobile companies are simply not programmed to respond to major civil emergencies and as such cannot be relied upon to immediately restore access to the networks in the immediate aftermath of a major incident:

- In Hurricane Gustav, it took the commercial networks over a week to get repair teams on the ground before they could begin to restore the networks. In Katrina, it took considerably longer.
- During Hurricane Sandy, almost 25% of the entire commercial network was unavailable, and was not restored for several weeks in some places.

The first minutes and hours after a disastrous incident of this nature are absolutely critical to emergency response teams, and it is during this period that they most urgently require access to a telecommunications infrastructure built on hardened sites and supported by backup power in the event of electricity becoming unavailable. As such, reliance on commercial carriers for this kind of emergency situation is not a valid option for Public Safety, as it simply is not designed to provide for the unique requirements of modern Public Safety.

The destruction caused by Hurricane Sandy serves to clearly illustrate that commercial networks, in their current capacity, are not a reliable communications option for Public Safety. It is our consensus that relying on commercial networks is not yet an optimal Public Safety solution for the following reasons:

1. Reliance on existing commercial networks is unlikely to meet the requirements of the Public Safety community from both a network reliability and capacity availability perspective. As much as 25% of the entire commercial network was unavailable across the ten US States affected by Hurricane Sandy – there was little or no commercial coverage available from any carrier in the areas worst affected.
2. Reliance on existing commercial solutions is unlikely to give Public Safety an acceptable level of local control of the network (Rivada Networks has hands-on experience with these challenges dating back to our Hurricane Katrina experience in 2005).
3. The cost of the proposed solution may far exceed the initial funding allocated and the operational costs will likely exceed the ability of the Public Safety community to fund it.
4. The proposed solution is unlikely to invoke high levels of Public Safety adoption due to the lack of Public Safety involvement in the planning and operations process.
5. A commercial carrier based solution creates a Government funded competitive advantage for the selected commercial operator(s), and may create the perception that the Government is 'picking winners' – thereby restricting competition and driving up costs.

A much more desirable solution is the provision of dedicated spectrum and a network dedicated to Public Safety, guaranteeing priority access to Public Safety when it is most needed. Up to now, however, the ability to fund the build out and operation of a cutting edge Public

Safety broadband network has been a major issue for most cash-strapped governments and jurisdictions across the world. Allocating billions of pounds to such an effort is just not a realistic option for the majority of Governments.

ESN should allow commercial services on a 700MHz network, through a Public Private Partnership. Revenues generated can be used for the construction, maintenance, operation, or improvement of the Public Safety broadband network. Given the spectrum crunch that the UK and commercial carriers currently face, a Public Safety network has the potential to circumvent the ensuing crunch and generate significant revenues through the wholesale of any excess capacity on the network.

Rivada Networks has developed the world's first technology that seamlessly allocates excess spectrum to where it is most needed. It combines prioritisation of users on the network with a real-time auctioning process. It is capable of allocating previously unused bandwidth to other networks and users, thereby minimising unused resources on the network and providing a source of funds for the build out and operation of the Public Safety network. Rivada's approach is to privately fund the network build and operation, (built to both Public Safety and commercial requirements), and dynamically offer surplus capacity on the Public Safety network on a competitive basis, thereby generating a recurring revenue stream that funds the build and ongoing operation of the Public Safety network.

Rivada Networks proposes a solution that:

- meets Public Safety requirements, including on-demand 'ruthless' pre-emption
- gives Public Safety adequate control of the network
- does not require a single penny of taxpayers' money
- competitively sells surplus capacity on the Public Safety network.

4.3 Public Safety Requirements

An approach that would rely on commercial carrier networks is not an optimal solution for the Public Safety community, as it does not address their unique requirements in several key areas.

1. **Network Availability –** Commercial networks are not built to Public Safety standards and are regularly compromised during emergencies and major incidents.
2. **Coverage –** Commercial networks do not provide ubiquitous coverage, especially in rural areas where subscriber numbers are low and the business case may not be viable.
3. **Guaranteed Access –** Commercial networks, by their very nature, are responsible primarily to their shareholders and commercial customers, and may never offer genuine priority access as defined and understood by the Public Safety community.
4. **Local Control –** Commercial carriers are unlikely to provide Public Safety any significant level of local control in the planning and operations process. Due to its relative small size in the marketplace, Public Safety will always lose out to commercial interests whenever there is a conflict of interest.

5. **Adoption –** It is unclear what carriers would charge for such a service. Currently, service costs charged by the carriers are beyond the means of many Public Safety services and organisations. It is likely that this cost would increase if the carriers have to offer additional capabilities such as priority service. Additionally, use of Government funds to augment the carrier networks will leave little or no funding for other factors impacting adoption of such a service.

In the immediate aftermath of recent major US disasters, each and every one of the commercial mobile networks were simply not available. The lack of availability was as a result of one or more of the following causes:

- the network infrastructure suffered catastrophic physical damage and was rendered useless
- the incident occurred in an area with limited or no mobile coverage
- a huge surge in mobile phone use during the incident congested the commercial network, meaning Public Safety could not access mobile networks.

All commercial carriers suffered loss of network availability during these incidents, since none were built to the necessary robustness standards. This partially debunks the idea that redundancy of MNOs will increase network reliability. If all of these backups are unavailable at the same time, there is no redundancy. While the use of satellite systems as final backup would provide redundancy in some areas, these systems cannot fully meet the Public Safety need for control, throughput, user devices, and cost.

Public, commercial mobile networks are simply not programmed to respond to major emergencies and as such cannot be relied on to restore the networks in the immediate aftermath of a major incident. The minutes and hours immediately after the impact of a major civil emergency are the most crucial time for first responders and Public Safety users. Access to reliable communications is crucial in order to coordinate the response and minimise loss and damage. Public Safety needs to have access to sites that are hardened to survive these types of incidents, as well as a sufficient level of backup power in the event of electricity not being available. As such, reliance on commercial carriers for emergency use is not a valid option for Public Safety. It simply will not meet Public Safety's unique requirements.

MNOs are deploying 4G LTE networks but have little by way of plans to add base stations in rural areas where demand from subscribers for broadband technology is low. Therefore, the Public Safety network operated under existing MNOs will suffer from unserved areas. It is also widely understood that Public Safety needs broadband wireless service in rural areas and low traffic areas where incidents will arise. While the cost justification for a single operator may be difficult, there are many rural areas where a business case for several rural operators sharing the same RAN makes perfect sense and even more sense if it is the shared RAN designed for Public Safety communications coverage first and foremost.

It is especially unlikely that Public Safety will get true priority in a failover scenario, especially if Public Safety applications consume bandwidth at an unprecedented rate due to heavy use of streaming video, multi-cast communications, high density incident use, etc. Under these scenarios the MNOs fiduciary responsibility is to their shareholders and commercial customers - it seems clear that there is little incentive for MNOs to give genuine priority access or proper support resources to the Public Safety users.

4.4 Benefits of the Rivada Networks Approach

- It eliminates the funding required from Government for the initial build out and provides a recurring funding stream for the annual operation of the Public Safety network.
- It allocates resource control into the hands of those best positioned to use them – namely Public Safety services and organisations – thereby reducing the risk of Public Safety not using the network.
- It creates the greatest likelihood of successful adoption due to the cost efficient availability of service for most Public Safety users and freeing up Government funding for other critical elements of the solution such as devices, training, integration, and applications.
- It creates the environment for the private sector to develop new and innovative business models, thereby fostering the creation of an entirely new marketplace that will result in the creation of thousands of UK jobs and spur countless technological innovations, all of which result in increased revenue on the Public Safety network thereby improving the sustainability of the network for the Public Safety community.

Figure 4.4-1: Self Sustaining Model: *Rivada Networks' approach provides a unique operating and funding model.*

DSATPA is being pioneered by Rivada Networks to deliver and allocate Public Safety spectrum to users dynamically, and effectively manage a frequency band to ensure end users have access to the communications capabilities they require on an as-needed basis. Rivada Networks' approach has been mirrored by a recent Presidential Panel in the United States, which advocated the technology approach pioneered by Rivada Networks.

"The report calls for a tiered system in which different users would have different priority, possibly based on whether they were a government user, a user who was prepared to pay more for a higher quality-of-service, or a casual user who might be assigned the lowest priority and pay the lowest rate".

New York Times, May 25, 2012

Forbes · New Posts

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The Future Of Wireless: The Case For Spectrum Sharing

Eric Savitz, Forbes Staff

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Guest post written by Rick Rotondo

Rick Rotondo is VP of marketing and publication relations at xG Technology, a provider of radio spectrum technology.

The New York Times

By JOHN MARKOFF
Published: May 25, 2012

Presidential Panel Urges More Flexible Use of Spectrum

SAN FRANCISCO — A just-completed report from a presidential advisory committee urges President Obama to adopt new computer technologies to make better use of a huge swath of the radio spectrum now controlled by federal agencies.

The shift, which could be accomplished by presidential signature — and without Congressional involvement — would relieve spectrum congestion caused by the popularity of smartphones, and generate far more revenue for the federal government than auctioning spectrum to wireless carriers, according to the authors of the report.

Making better use of the spectrum for cellphones would allow for more services, more competition and possibly lower prices for consumers using cellphone data services.

The suggested Rivada Networks approach assumes an independent Public Safety controlled network that is privately financed (i.e. without the use of taxpayers' money). This independent plan will not rely upon any single commercial mobile network operator. The cost of financing along with the cost of continued operation, expansion and enhancement of the network can be sustained from revenues derived from the lease of excess Public Safety network capacity.

Rivada Networks believes that its approach delivers the collective benefits sought by Ofcom, Public Safety, and Home Office/ESMCP. It is also an approach that will be embraced by the business community since it stimulates the competitive environment by providing opportunities for new entrants and at the same time it avoids the perception that the government is distorting competition by selecting specific carriers.

5.0 RIVADA TECHNOLOGY

During Hurricane Katrina, Rivada Networks deployed emergency cellular base stations in Louisiana with satellite backup. While able to provide emergency communications to first responders, we found that when usage capacity was at maximum, we were unable to provide prioritised access to key users who needed it.

As a result of that experience, Rivada spent a number of years developing Tiered Priority Access (TPA), allowing us to allocate access to bandwidth based on prioritisation of the user. Having developed TPA, we realised that if we could tier priority access at a local level, we could do it at

any scale, allowing bandwidth to be commoditised and allocated to users based on real time valuation, dynamic allocation of, and access to, that bandwidth.

TPA allows Public Safety control over its own permanent, dedicated network, granting full and absolute priority when needed through a throttling mechanism, while making the surplus bandwidth dynamically available to wholesale commercial users during the significant periods of fallow time when the Public Safety bandwidth is not being used by emergency services and other first responders.

5.1 Commercial Services - DSATPA

Dynamic Spectrum Arbitrage (DSA) enables Public Safety to lease on a temporary basis excess capacity to commercial mobile network operators. Specifically DSA can be used by Public Safety to subsidise the cost of LTE broadband networks in their local area. In order to reduce the overall cost of the ESN project, Rivada Networks proposes an innovative approach whereby the cost of the network is subsidised by allowing commercial users to access the network when Public Safety does not need the full capacity of the network in specific geographic segments. Under this approach, Public Safety will have absolute priority on the network, and will have permanent access to a proposed dedicated 20 MHz of spectrum and network capacity when needed. However, when the entire capacity of the network is not required by Public Safety, the network will allow commercial subscribers to use the network by leasing capacity on a wholesale basis to carriers and other broadband capacity purchasers. The revenue generated by the wholesaling of capacity to wholesale buyers will be used to pay for the build out and the annual operational costs associated with the network.

5.1.1 Capacity leasing based on a Network Sharing Approach

The proposed LTE solution is capable of enabling the ESN Public Safety LTE network to lease excess capacity with commercial operators based on RAN sharing under a multi operator network approach.

Under this approach the Public Safety LTE solution core network will be owned and operated by a Government mandated neutral wholesale operator. The RAN and capacity will be capable of being shared with commercial operators who wish to lease capacity. In order to facilitate RAN sharing, interconnection between the ESN and the commercial operator(s) core networks will need to be accomplished. This is depicted in figure 5.1.4-1. Once the interconnects are in place, the networks will use roaming/sharing features to allow the capacity to be shared. Monitoring will be carried out on any core nodes through the Core and Network Operating Centre (NOC). Traffic separation and signalling between the ESN and commercial wireless operators in the DSA architecture is guaranteed, as are the requisite authentication and security processes.

Any capacity leasing arrangements will be subject to terms and conditions laid down by the ESMCP or relevant governing body. Under these potential scenarios UK Public Safety can decide what level of capacity and radio spectrum resources they wish to have available for normal, day-to-day operations. In addition, there may be certain times when UK Public Safety wants additional radio spectrum resources available. The mechanisms to configure capacity and radio

spectrum resources are defined under 3GPP standards. As part of the capacity leasing arrangement, DSA enables Public Safety not only to manage and control user access to the LTE radio network, but also to provide a robust and user configurable method to restrict access and or shutdown access to specific users of the LTE network at set pre-arranged times or dynamically, based on local congestion conditions, thus making available the required radio spectrum resources for Public Safety.

In utilising DSA, excess capacity leased on a temporary basis will revert back to Public Safety in the event of emergency. The DSA process for tiered shedding of non Public Safety traffic enables Public Safety to always have full access to the radio resources of the ESN. The tiered shedding of non-Public Safety traffic in DSA is done via automatically based congestion triggers which are definable by Public Safety. With DSA, public shutdown of the access classes will be instant and ruthless on pre-agreed triggers, and network operators leasing capacity understand that they are doing so on an interruptible basis.

5.1.2 Capacity leasing based on Dynamic Spectrum Arbitrage Tiered Priority Access

The need to have Public Safety broadband networks cover their costs requires a paradigm shift in thinking. The new broadband networks that Public Safety services and organisations need to deploy must be used to offer services to non Public Safety entities in order to reduce total cost of ownership. However Public Safety needs to have access to all available radio resources to ensure communication is achieved either for routine operation or incidents. Using the Rivada Networks approach, capacity can be leased to commercial operators based on a network sharing approach inherent in the LTE standards. Rivada Networks has developed a more sophisticated approach, known as Dynamic Spectrum Arbitrage (DSA), which can allow capacity on-demand services in a given geographic area through assignment of short term spectrum leases, de facto leases or dynamic roaming for complimentary or competing wireless service providers and/or end users.

5.1.3 System Requirements

The Public Safety network should employ the positive attributes of both network sharing and managed services with a tiered shedding or back-off process. This ensures that Public Safety users will have guaranteed access to the radio resources when they are needed. The network should enable spectrum and resource leases for various geographical areas, including very small regions (e.g. per user, per sector, per base station, per cell cluster, per licence area or any sub-multiple or multiple of them). The resources should be made available on a time, usage, geodetic, or any combination of the three, for short durations as defined by the arbitrage process. All of these attributes should be policy based. This will improve spectrum efficiency and utilisation, as it allows the use of spectrum by alternative users.

5.1.4 Governance

Currently, spectrum allocation and traffic usage schemes are handled in a mutually exclusive fashion. They are mutually exclusive since spectrum allocation is static and wireless traffic usage is dynamic. Wireless traffic usage is dynamic because it is both time and geographically dependent. Wireless traffic usage is time dependent since usage varies with increased usage in

peak hours, followed by lulls in usage in off-peak times. Wireless traffic is also geographically based since the location where subscribers use the network is also fluid and is correlated to the time. For instance, during the day a subscriber may use their mobile device while travelling to work, while at work, travelling back and off hour usage. The subscriber is not using the service 100% of the time and depending on what part of the day the geographic location where service is being used is different.

In most commercial mobile broadband networks, access for visiting subscribers is achieved through roaming agreements which enable a visiting subscriber to access the wireless network. The subscriber that accesses the wireless network has the same access privileges as home network subscribers. However, Public Safety network spectrum resources should be managed and allocated dynamically thereby achieving better utilisation of the spectrum. The Public Safety network should allow a commercial wireless subscriber to roam onto a Public Safety broadband network - however the roaming subscribers must be treated as secondary users under a policy based decision set thereby offering differential service offerings.

This spectrum sharing model should be based on existing traffic used by the node or geo-defined area. The model should use both stateless and stateful methods for dynamic RF resource allocations. The stateless method would involve coordinating resource usage between networks on a real time basis. The stateful process would be a store and forward approach following defined intervals. The Public Safety network should support both methods allowing for a more tailored resource allocation and utilisation method.

The implementation of this model needs to be transparent to the commercial network operator and their subscribers. The Public Safety network achieves network resource allocation transparency through active real time traffic monitoring and policy enforcement. In any such Public Safety network, the secondary user's access to the primary operator's RF resources is managed through a Dynamic Spectrum Controller (DSC) and Dynamic Spectrum Policy Controller (DPC), affording both stateless and stateful decisions. Spectrum access should be implemented either through temporary allocation of defined spectrum or through shared traffic throughput for a radio access technique.

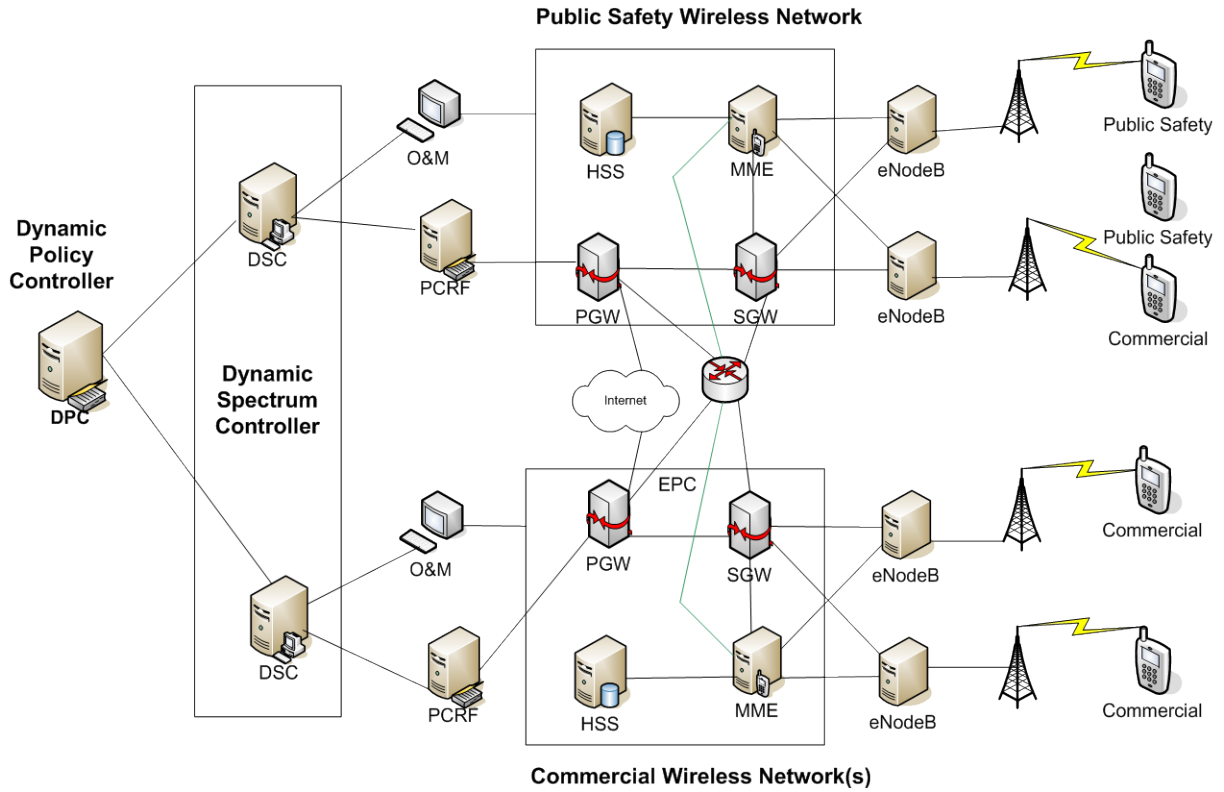

Figure 5.1.4-1: DSA architecture. *DSA allows dynamic leasing of spectrum.*

The DSC performs policy based QoS decisions, with rule sets driven by the existing traffic, projected traffic margins and the DPC governance. The DSC will facilitate the dynamic spectrum arbitrage for the mobile broadband network or sub network. The Dynamic Spectrum Lease policy controller defines the dynamic spectrum lease (DSL) parameters or SLA that is pre-agreed upon, based on the bidding agreement between the lease parties and network resources that are available. The DSC's primary role is resource request management for secondary usage. The DSC will communicate with the DPC and relay to the DPC excess capacity and projected excesses using capacity policy criteria. The home network DSC will also inform the DPC that it has a spectrum off-load request. The DPC will then allocate resources based on the DSC and inform the target and home DSC that resources are available.

Wireless traffic and resources are continuously monitored by the DSC allowing for detailed status of the various network elements and is infrastructure vendor agnostic.

A key issue with spectrum allocation is the ability to shed or reallocate secondary users based on policy rules, so that the maximum amount of resources are available to Public Safety users when needed. Such a back-off process is unique, in that it enables a Public Safety wireless network to share its under-utilised resources until such a time that they are needed.

Available resources can be dynamically allocated and de-allocated. The resource information is controlled by the DSC and relayed to the DPC for central coordination. However, based on rule

sets in the process, the DSC will identify resources available for secondary use on a system level and cluster level. As traffic in the system increases and decreases, the resource pool for secondary usage will increase and decrease and will be reported to the DPC via the DSC.

Using this approach, it will be possible to have a secondary user use the primary operator's spectrum either as a dynamic roamer or using a coordinated spectrum scheme with compatible access techniques. The scheme allocates capacity and spectrum resources using a back-off mechanism to address when the primary network requires the capacity.

Public Safety network spectrum allocation provides a tiered response to network capacity requirements providing an escalation and de-escalation process based upon the volume, type of traffic and any policy based prioritisations. During normal operation, wireless traffic through particular cell sites is monitored to determine the unused capacity available for assignment. All available capacity will be made available for potential secondary users. Once secondary users are assigned capacity/spectrum their use is on a secondary basis and once traffic thresholds are reached on the primary network, capacity is dynamically adjusted following a tiered shedding/backoff process to accommodate the primary users.

However, in the event that capacity is required for Public Safety's use and a Public Safety user, or a 999 emergency call is in place using the temporary leased radio capacity, then radio resources will still be made available for that user even if they are secondary users.

In the DSA architecture, the DSC will constantly monitor the nodes for capacity constraints. When a capacity constraint trigger is met, the scheme will seek alternative paths for traffic though coordination with the DPC and DSC. The alternative paths include handovers to adjacent cell sites or inter system handovers to mention to logical paths. The alternative path based on policy decisions will enable the operator to offer service to its customers while improving the spectrum and capacity utilisation of the other wireless carrier.

Because it is a policy-driven resource-allocation scheme, the system must be able to facilitate spectrum and capacity assignments for secondary use in the most efficient and cost effective method. The determination of the resource allocation is driven by the available resources, the services delivered and the policies that are associated with those services.

Some of the key policy criteria include:

- Radio access selection
- Capacity augmentation
- QoS (bearer service)
- Congestion control
- Routing
- Security
- Rating

5.1.5 Network Resource Bidding

This approach will enable UK Public Safety to operate their broadband network as a revenue source through a process where the network operators will pay for available resources to use on a real time basis. The spectrum sharing policy, spectrum usage, and traffic data should be processed by a third party or spectrum clearing house function. Figure 5.1.5-1 is a high level depiction of the bidding architecture.

The resources available for bid will be based on the host network operator's policy and use criteria for those resources. The criteria can include both Radio Access and Core Network Resources.

Some of the policy and resource criteria imposed by the host network operator will include:

- Spectrum available (separate or co-existence)
- Capacity/Bandwidth available (RF and Core)
- Overhead criteria (% total available capacity vs. used capacity)
- Back-off criteria (reselection, handover (intra-system and inter-system), termination)
- Treatment (how specific services/applications are treated/routed)
- Barred treatments (which services/applications are barred for use)
- Rating (how services are rated, i.e. possible special discount for off-peak usage)
- Geographic boundary (define zones or cells for inclusion)
- Time (define time and day(s) for inclusion including)
- Duration (define incremental allocation based on time and geographic boundary)
- User Equipment types

The bidder will have the ability to request resources based on time, day, and other criteria:

- Capacity/bandwidth desired
- Treatment (what services are desired, including QoS)
- Geographic boundary (where services are requested)
- Time (when are resources requested)
- Duration (how long are resources requested)

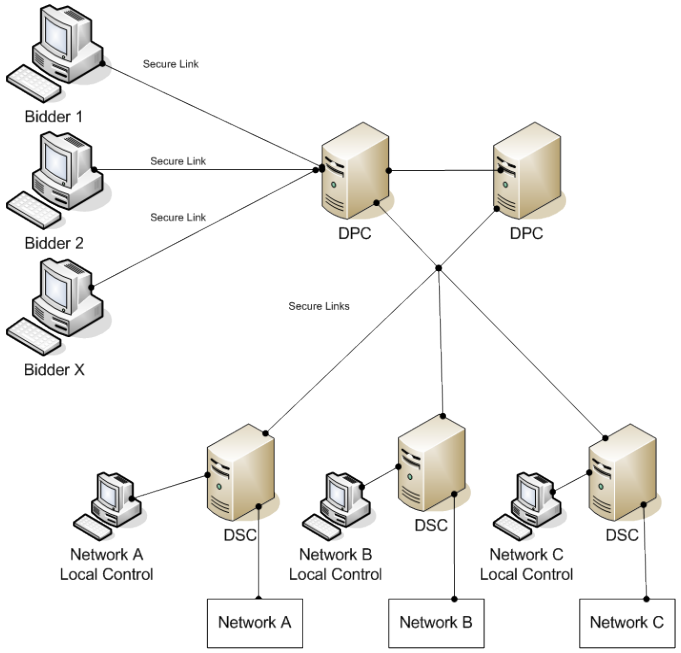

Figure 5.1.5-1: Rivada Networks DSA Bidding Architecture. *Dynamic bidding architecture allows a revenue model for spectrum leasing.*

This approach enables wireless carriers to obtain additional wholesale resources on a pay as you go basis. This is different than defining or allocating available or unused resources. In the resource access method, the access bidder will be granted capacity or resources from the host network to utilise existing unused or under-utilised capacity that may be available. The dynamic bidding process allowed will enable unique revenue opportunities to take place.

6.0 CONCLUSIONS

The Rivada Networks approach outlined in this document can be enabled through new dynamic spectrum allocation technologies compatible with the latest 3GPP LTE specifications and specifically designed for the benefit of an independent Public Safety network. Dynamic Spectrum Arbitrage-Tiered Priority Access (DSATPA) technology will enable the network to allow non-priority commercial access to network capacity on demand, thus generating a source of revenue. The approach delivers the following benefits:

1) Rivada Networks will fund the development of the UK's interoperable Public Safety network and substantially subsidise operating costs.

The Rivada Networks approach provides for substantial private investment, generating an ongoing revenue stream which allows Public Safety to strengthen and maintain a world-leading infrastructure, while potentially saving the UK taxpayer billions of pounds.

2) Rivada Networks effectively leverages leading edge technology to deliver the highest ROI for Public Safety communications by efficiently selling the unused network capacity and returning profits to Public Safety.

Rivada Networks' investment in enabling technology allows us to deliver the most cost effective solution for Public Safety communications. Our DSATPA technology will give Public Safety the full benefit of a private network while monetising surplus network capacity at the highest competitive rates, thus maximising revenue to fund the ongoing operating costs of Public Safety communications.

For the general public, this extends high quality bandwidth UK-wide and provides greater access to emergency 999 and other critical calls. It provides increased commercial service, and competition in the mobile broadband market.

3) Rivada Networks is delivering the only end-to-end Public Safety grade interoperable broadband solution in the industry: leveraging existing Public Safety assets, developing to Public Safety standards, and utilising local Public Safety industry experts for network development and ongoing operations.

For UK Public Safety: The Rivada Networks approach delivers a sustainable and affordable solution, and places the control of a dedicated disaster-resistant network into the hands of Public Safety officials, guaranteeing availability to them when circumstances require. It also provides the maximum benefit from this tremendous opportunity with the required network, devices, applications, and operations to ensure success.

For ESMCP/ESN: It reduces the risk of low Public Safety adoption by involving Public Safety to a greater extent in the delivery of the solution. It also enables greater investment in Public Safety differentiators at the lowest overall cost of adoption. It allows the ESMCP to focus on critical Public Safety capabilities such as devices, applications and emergency satellite communications backups.

For The Taxpayer: It enables their chosen mobile broadband carrier to provide access to more areas and provides greater availability for emergency 999 and other critical calls. It also provides for new services and job creation from innovative business models. It minimises the risk that the taxpayer will need to fund network operations moving forward. And finally, allowing forward-looking business models such as ours, provides taxpayer confidence that the Government is using its resources wisely without giving unfair competitive advantages to specific mobile network operators.

7.0 APPENDIX A

Responses to Questions listed in Annex 4 of the Consultation

The future role of Wi-Fi in helping to meet the demand for wireless data services

Question 1: How is demand for indoor wireless data connection speeds and capacity likely to develop over the next 5–10 years?
We expect that Wi-Fi will have a significant role to play over this timeframe, particularly with regard to in-building and small cell coverage, and the continued ability to offload commercial carrier traffic via Wi-Fi. Additionally, the use of Wi-Fi carrier aggregation with small cells will allow carriers to aggregate Wi-Fi with licensed and unlicensed spectrum for given geographical areas. It is to be expected that, over this period, some level of QoS must be introduced with carrier aggregation due to differences in propagation performance alone.

Question 2: Will an extension of the 5 GHz band be required if Wi-Fi is to play a sustainable role in meeting the growing demand for indoor wireless connectivity?
An extension of the 5GHz band will be required, especially given that this higher band is particularly suited to streaming video.

Question 3: Are there other types of indoor wireless applications that will require access to alternative spectrum other than that provided by the licence exempt 2.4 and 5 GHz bands used by Wi-Fi?
Nearfield communication and, potentially, White Space applications are two other types of communication methods which will require access to alternative spectrum solutions.

Question 4: What role do you think Wi-Fi will play in providing wireless broadband connectivity outdoors over the coming 5-10 years?
Outdoor Wi-Fi is more suited to urban environments and very small coverage areas and may be expected to continue to play a role in serving pedestrian traffic, outdoor retail and other users. However, there are a limited number of usable Wi-Fi channels. For example, the 2.4GHz band provides for only three non-overlapping channels. Therefore, as more hotspots are deployed in an area, user experience faces diminishing returns in speed and overall quality of data transmission as the density of hotspots increases. Wi-Fi is currently a non-mobility solution, best suited to providing coverage of limited geographical areas and offloading commercial wireless carriers.

Question 5: Will the increased deployment of Wi-Fi access points outdoors create a risk of reduced quality of service performance over the longer term and, if so, will approaches to co-ordinate access point performance be able to mitigate this risk?
Per our response to question 4, reduced quality of service is to be expected, leading to a 'tragedy of the commons' whereby each additional hotspot reduces the performance of adjacent hotspots. Approaches to coordinate access point performance will only relieve

performance constraints for part of the time, until users and density of sites achieve a negative return.

Question 6: Will improved approaches to accessing spectrum in licence exempt bands be needed in the longer term to maintain the quality of service achievable for outdoor public mobile broadband and/or M2M services? If so, which approaches are most likely to be adopted and how likely do you think they are to be successful in improving access to spectrum?
Improved approaches in making spectrum available are required in order to achieve long term solutions for public mobile broadband and/or M2M services. However, simply increasing the number of non-overlapping channels for unlicensed bands may not offer a complete solution, as license exempt services such as Wi-Fi are not designed for mobility. However, congestion can be reduced through offloading via creative solutions, which can offer underutilised capacity in licensed bands for mobile operators. However, to make this viable, the subscriber devices must have the necessary capabilities to take advantage of these alternative frequency bands.

Increasing spectrum supply and better managing its use

Question 7: Which frequency bands are most likely to be best suited to providing geographical shared access, including via a geo-location database approach, for use by mobile broadband, for example small cells and M2M applications?
The desired frequency bands for provision of geographical shared access are in the Lower frequency bands because they cover a broader geographical area due to superior propagation and in-building penetration. However, higher frequency bands are best suited to smaller geographical areas as they attenuate faster. Additionally, small cell and M2M applications work best with low mobility, at low power. A combination of both lower frequency bands to cover a large geographic area, coupled with high frequency bands for small cells and M2M applications would be preferable.

Question 8: Would access to these bands best be realised through licensing or licence exemption?
Access to these bands is best realised through licensing as it creates an accountable 'broker' for spectrum supply and management, and allows for better frequency coordination, while the associated economics would drive better spectral efficiency. Unlicensed access creates a 'free for all' scenario, thus losing the QoS benefit whereby the consumer is offered true differential services.

Question 9: Do you believe that tiered shared access to a range of spectrum bands has a role in meeting demand for mobile and wireless data and, if so, which applications and devices do you think will be particularly suited to this access model?
Yes, we believe that tiered shared access will play a very important role in allowing for aggregation of streaming video and multiple services to wireless handsets and tablets. Per our earlier explanation of the Rivada Networks offering, tying in Public Safety LTE with carrier aggregation to increase throughput is one of the applications best suited to this access model.

Question 10: Do you believe DSA could play an important future role in the future in enabling a better quality of service and low barriers to spectrum access alongside conventional licensed and LE spectrum approaches?
Dynamic Spectrum Access/Cognitive radio will offer a viable solution. While dynamic spectrum access will play an important future role in enabling better quality of service and low barriers to spectrum access, it must be noted that handsets sit at the edge of the network and are not capable of routing packets through different gateways. Dynamic Spectrum Arbitrage, on the other hand, takes place at the network level, uses current off-the-shelf technology, and is readily controllable. Rivada Networks' solution creates the financial model and the level of control and coordination necessary to enable aggregation of diverse carriers. Enabling DSA in the network offers an immediate solution to wireless broadband capacity demand pressures, leveraging existing specifications and standards - as opposed to waiting for solutions, capabilities and functionality at the device level, which may take up to a decade to emerge.

Question 11: What barriers still remain to the realisation of cost-effective sensing appropriate for low-cost consumer devices and what activities are ongoing to try to address them?
Barriers include handset battery life and the power consumption required to scan too many diverse bands. There are limits to the number of bands that handsets can operate in without suffering from performance degradation and band interference. A rational rule set or defined rule set in this scenario is also a barrier.

Question 12: Over what timescales could DSA become a mass market proposition?
Dynamic spectrum access handsets and associated transmitters are not currently a mass market proposition and will take a number of years to develop. Dynamic Spectrum Arbitrage, on the other hand, is a mass market proposition today as it leverages existing specifications and utilises current handset technology and transmission equipment. Dynamic Spectrum Arbitrage helps to enable and bridge into future dynamic spectrum access.

Question 13: What role should Ofcom play, if any, to support the development of DSA and relevant technologies?
We believe that Ofcom should advocate the allocation of harmonised, dedicated spectrum for Public Safety in the 700MHz band for the many reasons detailed earlier in this document. Ofcom should promote network sharing and provision to allow equal access to spectrum, thus encouraging new entrants into the market to aggregate capacity and enhance user experience. Allowing for diversity drives telecoms costs down and encourages fair market pricing.

Question 14: Do you have any other views on any of the issues discussed in this consultation?
Rivada Networks' views are expressed in some detail in our broader response to consultation.

Supporting innovation through short-term access to shared spectrum

Question 15: What are the frequency bands that would be of most value for R&D purposes?

Lower frequency bands are, we believe, best suited to R&D purposes. It is important that available handsets are compatible with these bands.

Question 16: What are the potential benefits of using a geolocation database approach for short-term access to spectrum for R&D and how would you see this working from a practical perspective? Are there alternative approaches that could deliver similar benefits?
A geo-location database approach for short-term access to spectrum for R&D would, in our view, be extremely beneficial. It would allow for frequency reuse, maximum interference mitigation, forward prediction on QoS, and improved coverage in outer areas. It would also enable dynamic steering of traffic in a geographic area to benefit the user.

Question 17: What characteristics do you view as important to researchers in arrangements to facilitate temporary access to spectrum for research and development purposes?
Handset availability and capabilities on a radio access and power consumption level are perhaps the most important factors to consider.