

PPDR Network Implementation Options

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Abstract – Public Protection and Disaster Relief (PPDR) systems are one of the crucial national matters. Currently, several frequency bands have been discussed for PPDR, as well as several scenarios that can be applied for their implementation. This paper provides an overview of different PPDR network implementation options and discusses their advantages and drawbacks. Network implementation options that are analysed in this paper are: dedicated networks for PPDR, commercial networks used by PPDR agency under special terms and hybrid solution that is combination of the two.

Keywords - PPDR; network; hybrid PPDR; dedicated PPDR; operator; commercial

I. INTRODUCTION

PPDR sector as well as correlated radio communications are sovereign national matter and PPDR needs of different European countries may differ to a significant extent. Therefore, harmonization process of the PPDR sector in Europe should be flexible enough to take into account different implementation options, such as the use of commercial networks and the amount of available spectrum, while simultaneously ensuring interoperability between the different countries as well as maximizing the economics of scale [1]. For this reason, ECC¹ deliverables are not trying to specify detailed regulatory and technical aspects of PPDR harmonization in Europe but to help with creation of European regulatory and technical framework for broadband PPDR (BB PPDR).

For economies of scale a technical solution for BB PPDR network should be based on a commonly used technology so the LTE is selected as technology of choice for BB PPDR. Benefit of widely used technology is easiness of international cooperation. BB PPDR based on LTE technology as a global interoperable solution, could be very useful in disaster relief situations as interoperable communication system for the delivery of mutual aid [1].

Future European BB PPDR Wide Area Networks (WAN) will need the amount of 2x10 MHz of spectrum range. However, voice communications over the WAN, Air-Ground-Air (AGA), Direct Mode Operations (DMO) and ad-hoc networks could demand additional spectrum [1].

Currently, frequency bands at 400 MHz (410-430 MHz and 450-470 MHz) and 700 MHz are allocated for PPDR. Frequency band at 400 MHz cannot be considered as a stand-alone solution for countries requiring 2x10 MHz for BB PPDR as calculated in ECC Report 199 [1] as minimum requirement

provided through dedicated networks or hybrid solution, but 400 MHz options can offer national flexibility in the context of additional spectrum beside the 700 MHz range. Tuning Ranges and associated Least Restrictive Technical Conditions should be included in an ECC harmonization deliverable. Due to the very good propagation characteristics in the 400 MHz band, the number of sites needed to provide the necessary coverage (rural areas) could be reduced.

The 700 MHz band provides the possibilities to accommodate BB PPDR by designating several spectrum blocks for dedicated BB PPDR use as well as MFCN² which can be used to fulfil national PPDR requirements, and at the same time allowing for realistic and affordable technology developments. Therefore, the 700 MHz band can be considered as a stand-alone solution for the full 2x10 MHz need for BB PPDR as calculated in ECC Report 199 [1] as minimum requirement provided through dedicated networks or hybrid solution. Further option is to use a commercial MFCN network(s) operating within the 700 MHz band to provide BB PPDR services.

The paper provides an overview of different approaches for PPDR network implementation, focusing on hybrid solution which could be a compromise with regard to building a dedicated infrastructure and assuring appropriate priority level for PPDR systems. The paper also discusses the possibility of using 700 MHz for PPDR, since its allocation will directly influence the future second digital dividend.

II. PPDR NETWORK IMPLEMENTATION OPTIONS

Broadband PPDR services can be realized through several types of network implementation options:

- commercial – special mobile broadband service provided by one or more mobile operators;
- dedicated – a special network designed for PPDR, fully in compliance with all PPDR requirements;
- hybrid – the combination of the two aforementioned models.

Frequency bands used for BB PPDR services are the same frequencies that are dedicated for LTE (Long Term Evolution). The option of using commercial equipment could significantly scale down the costs for network infrastructure (e.g. base stations) and user equipment (e.g. terminals) [2].

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² Mobile/fixed communications network

Interoperability is rather important feature during PPDR operations. It ensures that different agencies communicate through radio network in real time. This also implies interoperability of user equipment for agency that require cross-border cooperation with other PPDR agencies [3].

Because of low cost, commercial solutions are financially most suitable and cost-effective way to implement PPDR systems. But despite the favorable price, they have certain drawbacks which will be discussed later in the article.

A. *Dedicated network infrastructure for PPDR*

A dedicated mobile broadband PPDR network, owned by the government or contracted operator, will have to meet PPDR requirements such as security, coverage, resilience, etc. Spectrum for broadband network that will be used in BB PPDR purposes is specified on a national level. In ECC Report 199 a minimum of 2x10MHz is mentioned.

Dedicated network infrastructure for PPDR can be realized in two ways [2].

1) *Dedicated PPDR network owned and operated by PPDR agency*

In that type of arrangement, PP organization would have their own dedicated infrastructure and would have full control over PPDR network during times of emergencies. PP organization will be able to dynamically change network system settings, influence the performance of the service considering the demands of the situation so that PP personnel can make proper decisions based on the available information. Furthermore, PP organization will also be able to determine the level of reliability, security, robustness, and other system characteristics regarding the requirements of the mission [1], [2].

2) *Dedicated PPDR network owned and operated by commercial operator*

Under such arrangements the PPDR network is owned and operated by a commercial body. Benefits of this type of scheme is favorable funding of network development and maintenance [2].

B. *PPDR agency using commercial networks as a special subscriber*

Alternative to previous types of deployment arrangements of a dedicated PPDR network is the use of commercial services as a 'special' subscriber group.

Problem that could appear when using network owned by commercial operator is the trust issue towards the operators in providing resilient networks for mission-critical and business-critical services. In order to be given PPDR contracts, network operators would have to fulfil certain conditions.

Mobile network operators (MNOs) should be obligated to provide PPDR network services. This could be done by modifying operating or spectrum licenses. Regulators obligations would have to be bolstered to the degree where they would be supervisor of whether MNOs implement the provisions required of them as providers of PPDR network services. MNOs would have to be obliged to prioritize mission-

critical traffic. Prices of PPDR services would have to be based on costs which should be periodically inspected. It would have to be defined by government that mission-critical services also include utilities and transport management [2].

To meet the needs of PPDR operational services in the case of using commercial networks it may be necessary to negotiate special commercial terms with operators that would secure features like [3]:

- priority access privileges – especially in case of emergency and disaster events;
- expanded network coverage to areas that are not viable for commercial services;
- enhanced minimum network Grade of Service (GoS), reliability and robustness, in the event of possible equipment failure, power failure and natural disaster;
- dynamically reconfigurable push-to-talk 'group calling' functions, to facilitate efficient and effective multi-agency co-ordination and response to events;
- encryption and authentication/security features, to ensure an appropriate level of network traffic integrity to protect PPDR operational communications.

At the state level, using commercial networks as a special subscriber would result in a certain level of natural spectrum harmonization as well as technological compliance between PPDR agencies. This would not necessarily ensure international interoperability because harmonization between administrations would be undergoing a sovereign decision of each country on the adoption of a common spectrum and technology [3].

The expense of paying for features mentioned earlier could be less than the cost of deploying a dedicated PPDR network because larger part of the commercial network and its functionality that is used for PPDR services will be subsidized by commercial users.

For example, additional costs, like the cost of coverage for areas that are not considered viable for commercial services may provide indirect benefits for the operator through the expansion of customer base. For that reason PPDR agency may not bear full expense for services that are necessary for PPDR networks but not viable enough for commercial services to justify their implementation in commercial network. Therefore, this kind of arrangement could mean lower capital and operational cost for government agencies in regard to building their own dedicated network. With lower costs, relevant savings could be directed into increasing functionality and expanding the network coverage in much larger degree than it would be possible if dedicated networks scheme was chosen as PPDR network solution. Consequently, commercial network approach could mean that dedicated spectrum for PPDR network is not needed and therefore it would result in a reduction of total costs for PPDR agency [3].

Devices which would be used by PPDR agency should be robust and resistant to adverse conditions. Acquisition of such devices can be either provided by commercial network operator in which case operator retains User Equipment (UE)

authentication responsibility or PPDR agency can purchase necessary equipment but UE authentication setup procedures may require additional arrangements with commercial operator.

On the premise that the coverage, priority access, functionality and security requirements are fulfilled, there may still be question of the degree of control over the network resources that PPDR agency can administer.

The approach of sharing commercial network for PPDR services could provide several benefits:

- expanded network coverage;
- access to new capabilities when required either by commercial or by PPDR users;
- enhanced access to more radio communication resources;
- provision of better services and applications to the consumers by the commercial operators.

When using commercial networks for mission critical purposes, the government would have to place specific legal requirements on the operator in a contract.

C. Hybrid solution

In hybrid solution models with partly dedicated and partly commercial network infrastructure the goal is to find a balance between the services that are offered by a commercial mobile broadband network and the requirement for availability and capacity of PPDR agency.

Sharing network infrastructure with commercial network operator could be a viable option of providing broadband PPDR services especially for rural areas with low population density where building of dedicated PPDR network may be considered too expensive. There are several different models of shared network infrastructure:

- geographical split between dedicated and commercial network infrastructure;
- mobile virtual network operator (MVNO) model where PPDR users share RAN with the public users;
- MVNO model combined with a geographical split;
- extended MVNO model

A MVNO is a wireless communications services provider that does not have to own radio access network (RAN) to provide services to its customers. Instead of having its own dedicated network it enters into a business agreement with one or more mobile network operators and uses their network infrastructure.

If MVNO is used as a service provider for PPDR agency, there can be several arrangement methods with commercial operator. MVNO could use the core network from the commercial operator, control elements of the core network or have dedicated PPDR core network.

1) Geographical split between dedicated and commercial network infrastructure

In this model dedicated PPDR network is built in certain areas of a country while other parts that are not covered by dedicated PPDR network are served by one or more commercial mobile operators. This kind of arrangement can have completely separated dedicated part of PPDR network from commercial part of the network or it could share, with commercial operator, core network and service nodes while having some dedicated elements and also have dedicated RAN in some areas [4].

For this model it is necessary to have dedicated spectrum in the network part that serves only PPDR users. A roaming agreement will be also required between PPDR network and the relevant commercial networks.

2) Sharing the public operator's infrastructure

In this arrangement, PPDR agency as a mobile virtual network operator (MVNO) would share the common radio access network (RAN) with a commercial operator but would own some elements of the core network. PPDR agency would own and be responsible for switching nodes, authentication nodes, gateways, and user management facilities. This solution provides avoiding duplication of the radio network portion of commercial systems resulting in cost reduction and shared use of the radio spectrum [3], [4].

As owner and operator of core network elements, PPDR agency would have higher operational control over the network which would give them necessary level of control over the system in times of crisis. This type of arrangement would require implementation of functions and features that PPDR organization demands and needs for own activities into shared system infrastructure [3].

There will probably still be the need for agreements with commercial operators for covering some additional requirements like extended coverage, network reliability and robustness, priority access in times of crisis and security. Sharing the public operator's infrastructure could ensure improved area coverage, enhance capacity and increase functionality due usage of modern all-IP networks [4].

At the times of emergency, when the traffic over PPDR network will probably get higher than on a regular bases, PPDR network deployment options, whether it is over commercial networks as a special subscriber or hybrid solution where commercial operator's infrastructure is being shared with PPDR agency, may provide to PPDR networks access to additional commercial channels or extra capacity which could ensure temporary boost in network performance during emergency situations but not on the permanent bases [3].

3) MVNO model combined with a geographical split

In this models PPDR network has dedicated core and service node elements and in some areas, e.g. in urban areas and along critical transport corridors dedicated RAN infrastructure. RAN infrastructure in other areas is shared with

commercial network. Dedicated PPDR spectrum is requires in areas where dedicated RAN exists [4].

This model combines MVNO functionality and geographical split solution.

4) *Extended MVNO model*

This variant of PPDR network also has dedicated core and service node elements. The difference to the previous model of PPDR network is in radio transmitters and receivers in the commercial mobile base that are dedicated for PPDR network. The idea behind it is to have dedicated radio resources in the Tx/Rx of the RAN part of a commercial network. In this case PPDR agency will have dedicated communication capacity but will be dependent of the RAN of the commercial networks.

This variant requires dedicated PPDR spectrum nationwide [4].

III. CONCLUSION

PPDR agency needs a communication network for own operational services. PPDR networks require some special features in comparison to commercial networks to ensure the needs of PPDR operational services. There are several PPDR network implementation options that would meet the needs of PPDR agency, dedicated networks for PPDR, commercial networks used by PPDR agency under special terms in regard to commercial users and hybrid solution that is combination of the two.

Regarding the cost, the most suitable solution would be commercial network where commercial operators defray maintenance costs. The downside of such solutions is that PPDR agencies have no control over the communications network and must rely on the service provider to deliver arranged service.

Dedicated network is the most expensive solution because country or PPDR agency must build their own communication network and bear the costs of its maintenance. On the other hand, such a solution provides complete control over the network which contributes to system reliability and

availability of the services provided by dedicated PPDR network.

The compromise of the two previous solutions is a hybrid network which is based on a combination of dedicated and commercial network. Therefore, the costs of building and maintaining the network are reduced as part of the network and maintenance is shared with the commercial operator. This increases the reliability and availability of the network in relation to the commercial solution because the individual elements of the network are dedicated to PPDR network and controlled by PPDR agency.

The concept of "flexible harmonization" has been designed as regulatory model for PPDR. It includes common technical standard (i.e. LTE) on European level, but the flexibility on national level on how much spectrum should be designated for PPDR (within harmonized tuning range(s)) and which PPDR network implementation model (dedicated, commercial or hybrid) will be implemented. This regulatory model has been adopted to enable an efficient implementation of BB PPDR and to ensure sovereign right of a country to choose the most suitable solution for broadband PPDR according to national needs and capacity.

Countries will decide for themselves what the most suitable solution is for broadband PPDR according to their national needs. Due to that ECC deliverables attempt to aid the creation of a high level European regulatory and technical framework for BB PPDR rather than to define the detailed regulatory and technical aspects.

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