Development Model of a Public Safety Broadband Communications Network in Indonesia

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***Abstract* — The Public and Private Partnership (PPP) development model of a public safety broadband network between cellular operators and public safety agencies, such as the National Disaster Management Agency, is a challenge for the government of Indonesia to provide broadband access. Public safety agencies are local governments, police agency, health agency, fire brigades. Each agency built their networks independently. In this study, the public safety broadband network model in Indonesia is developed by using an investment budget to build a broadband network of each agency. The budget of each agency is a function of compensation for the public safety, because they do not build their own network separately, but they rather share it with the cellular network. Public safety users are included as cellular users who will be given priority access or Quality of Service (QoS), but they are not profitable users for cellular operators. So, a cellular operator only receives infrastructure compensation budget due to the addition of user traffic for public safety, because this is part of the responsibilities of the government. The feasibility of this model will be measured by Net Present Value (NPV) calculations. From a cellular operator perspective, it is concluded that operators choose the 2x25 MHz option, which must share bandwidth and network infrastructure with public safety agencies. It has a higher NPV than the 2x20 MHz option, which is only for commercial Long Term Evilution (LTE). From a government perspective, the NPV always has a positive value. So, it indicates that the government needs to consider implementing a development model of a public safety broadband network with a sharing scheme between cellular operators and public safety agencies.**

Keywords* — *public safety broadband network, sharing scheme, NPV, LTE

I. INTRODUCTION

Public safety is an activity comprised of prevention, treatment, and protection against things that harm other people who may be significantly affected or injured, or experience a loss or damage, such as a crime or disaster. It can be caused by human actions or a natural occurrence, which is why it is important to create a secure and comfortable condition in the community. By doing so, it can support national stability [1].

Today, communication systems supporting public safety agencies have different standards, such as using different frequency ranges of 300 MHz – 800 MHz and using different kinds of technology. The most widely used types of technology are the conventional systems, trunking systems, Public Switched Telephone Network (PSTN), and commercial cellular networks. In fact, the condition of public safety in Indonesia is still independent, which does not support interoperability among agencies. It causes coordination difficulties between agencies responding to disaster. In addition, the public safety network in Indonesia is still based on a narrowband system. The capital expenditures (capex) and operational expenditures (opex) will necessitate high investment costs when each of the public safety agencies build their own broadband networks independently. So, it will burden the government's budget while the public safety traffic is only used in emergency conditions based on operational statistic data [2] and traffic site summary information [3]. The average communication channel occupation during emergencies or disasters is 31.32 percent from the total capacity or 7.52 hours/day [4].

Consistent with the issue of broadband public safety, based on Ministerial Decree No. 22 of 2011, the Ministry of Communications and Information Technology of Indonesia has planned a migration of analog terrestrial television to digital television services, which is targeted by 2018 [5]. In Article 4 of Ministerial Decree No. 18 of 2005, it is declared that in the case where government entities desire to use a telecommunications network, they can lease it from the network provider. On the other hand, especially in Article 7 of Ministerial Decree No. 18 of 2005, it is declared that government entities networks are prohibited to collect payments [6].

Based on the explanation above, a public safety broadband network has the opportunity to integrate public safety networks, in which some portions of the Asia Pacific Telecommunity (APT) 700 MHz digital dividend bandwidth can be allocated for LTE based technology to serve public safety agencies [7]. In this study, public and private partnerships are developed to deploy a public safety broadband network in Indonesia based on the previous model [8] [9], and it has been changed according to Indonesia's condition, based on Ministerial Decree No. 22 of 2011 and Ministerial Decree No. 18 of 2005. The model is still being developed by using the existing public safety

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network. First, it will be deployed in the greater Jakarta area and its satellite area because Jakarta, as the capital city of Indonesia, serves the central government and economy with a high population density, so it needs to have a public safety broadband system.

II. METHODOLOGY

Based on previous experiences in other countries, the Federal Communications Commission-United States (FCC-US) adopted an order to create a nationwide broadband network with a 2x10 MHz bandwidth for the Frequency Division Duplex (FDD) that consists of 758-768 MHz for an uplink and 788-798 MHz for a downlink, which is called “D Block”. In America, the public safety spectrum is allocated at 763-775 MHz for an uplink and 793-805 MHz for a downlink, which consists of 2x5 MHz (763-768 MHz and 793-798 MHz) for a public safety broadband network using a bandwidth shared with an LTE network and the other spectrum allocated for a public safety narrowband network. In March of 2008, the FCC attempted to auction the D Block with public safety encumbrances but failed to attract a winning commercial bidder [10]. This is caused by several reasons, some of which include [11] [12]:

a. The 2x10 MHz bandwidth allocation in the D Block was claimed to be too small to overcome the LTE user traffic.

b. The issue has been framed in such a way as to suggest that allocations to the public safety community are at the expense of commercial wireless providers.

c. Some of the business entities collapsed and the United States (US) needs more commercial broadband network capacity to remain competitive globally.

d. The inexact time of the auction which was followed by a flurry of waiver petitions, public comments, and much debate.

Ryan Hallahan [8] improved the broadband public safety wireless communication based on the US situation, in which public safety users were reputed as being profitable users or commercial cellular customers who must pay for the use of their traffic. He devised a handover scenario whereby a handset must connect (roam) to a cellular operator if the user moves to another location which does not have public safety network coverage in Block D. In addition, APT modified 2x10 MHz of digital dividend to be allocated only for public safety communications [13].

In this research, a different method from the USA is deployed. In Indonesia, it is developed from a public partnership model between cellular operators and public safety agencies, where the public safety users are cellular users that will be given priority access or quality of service (QoS), but they are not considered as profitable users for cellular operators. Public safety user traffic on a cellular network will be converted to the additional costs (capex and opex) of cellular network deployment. In a government perspective, the investment cost payments should be managed by the government, as the Ministry of Finance should provide the budget for the public safety broadband network agencies. In this study, those payments are defined as a function of the government costs. This model developed the investment cost utilization as a budget which is canceled for each of the public safety agencies to build a public safety broadband network independently. In this study, that canceled budget is defined as a function of the government value. The government should consider the expenditure efficiency when deploying a model of a public safety broadband network, so that the feasibility will be measured from the NPV of a government perspective. From a cellular operator perspective, the government cost is a portion of the contributions to the cellular network as an operator value function of the cellular operator NPV, besides the annual revenue per user (ARPU) of commercial users. In this model, the operator costs are calculated from the total investment sharing network costs and annual spectrum fees.

III. NPV MODEL DEVELOPMENT

This model is developed from the previous studies of Ryan Hallahan [8], John Ure [9], and Administrative Incentive Pricing (AIP) recommended by Australian Communication and Media Authority (ACMA) [14] with an adoption of the conditions of Indonesia. An illustration of this model can be viewed in Figure 1.

In this study, the NPV formula is based on a government and cellular operator perspective and developed as a measure of examining the feasibility of developing a public safety broadband network based on the model proposed in this study. The cellular operator NPV during the observation is defined by t = i, as follows:

$$NPV_{Op} = \sum_{i=0}^{n} \frac{(GV_i .+ 12.\ Sub_{COMM,i} . R_{COMM}) - (C_i\ .\ Capex + C_{TOT,i}\ .\ Opex)}{(1+D)^i} - SFi \quad (1)$$

Then, the government NPV is formulated as follows:

$$NPV_{Gov} = GV_i - GC_i \quad (2)$$

Where,

GV_i	=	total investment cost utilization as a budget, which is cancelled by the year-i for each of the public safety agencies to build a public safety broadband network independently.	[USD/year]
GC_i	=	total payment of the investment costs by the i-year which should be prepared by the government, as a compensation for the public safety user traffic to the cellular operator.	[USD/year]
$Sub_{COMM,i}$	=	total number of commercial subscriptions by the year-i.	

RCOMM	=	monthly revenue from commercial subscriptions.	[USD/month]
Ci	=	amount of equipment per element developed in the i-year.	
CTOT,i	=	total amount of equipment per element operating in the i year.	
Capex	=	upfront cost to develop the network per element.	[USD]
Opex	=	annual cost to operate the network per element.	[USD/year]
SFi	=	Annual Spectrum Fee (LTE 700 MHz) in the i-year.	[USD/year]
n	=	time horizon.	[Years]
D	=	discount rate.	[%]

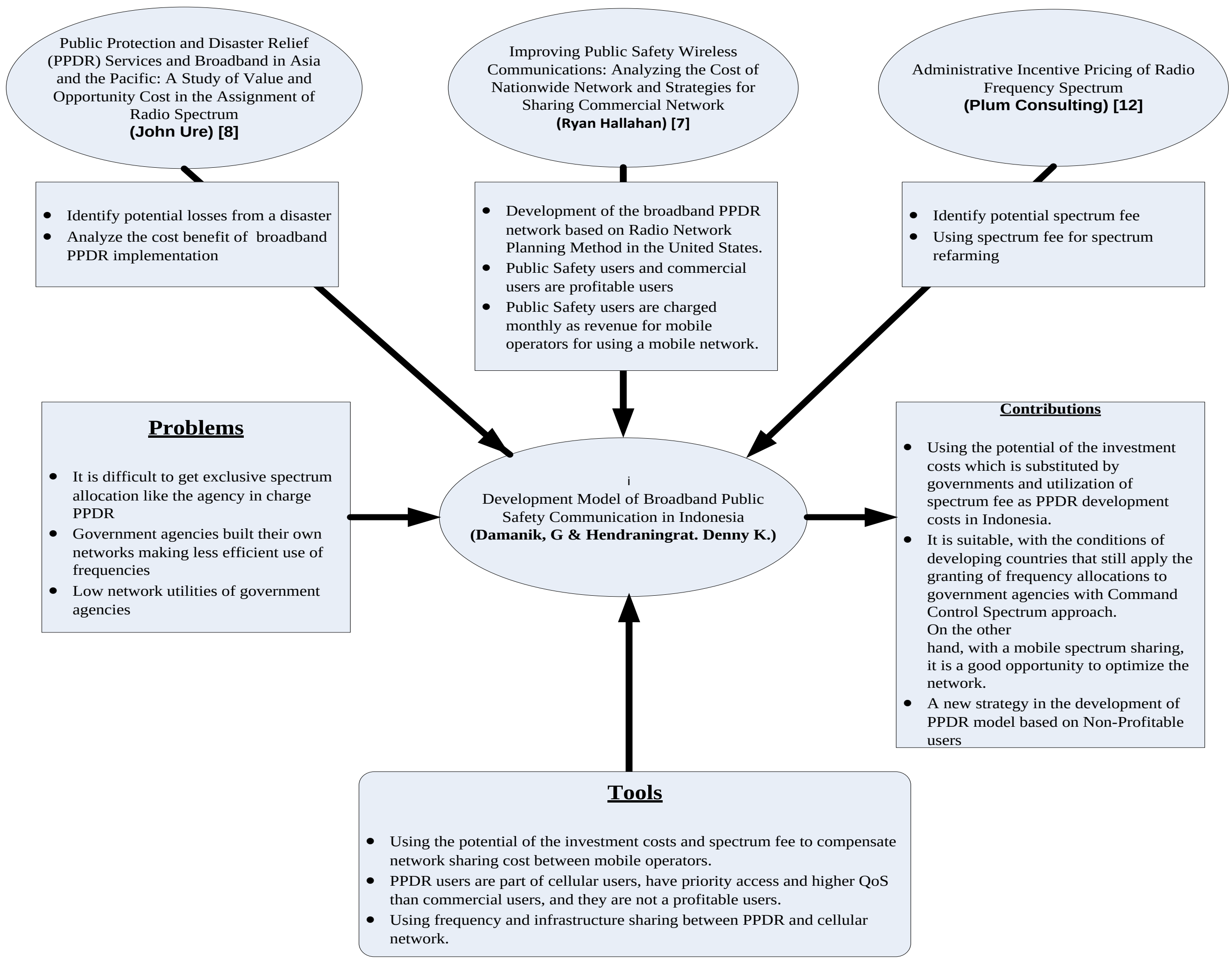

Figure 1. Development Model of a Public Safety Broadband Network

IV. RESULTS AND FEASIBILITY ANALYSIS OF PUBLIC SAFETY BROADBAND NETWORK COMMUNICATIONS IN INDONESIA

The 3rd Generation Partnership Project (3GPP) has identified a 2x45 MHz bandwidth allocation for the Asia Pacific Region as a bandwidth allocation for Evolved Universal Terrestrial Radio Access (E-UTRA) technology, such as LTE technology [15]. In this study, the digital dividend ecosystem is divided into commercial LTE and public safety. LTE is more effective than Dual Carrier of High Speed Packet Access (DC-HSPA) when using a 2x20 MHz bandwidth system [16]. This simulation is designed by using 2 Mobile Network Operators (MNOs), where the MNO that is willing to share bandwidth and network infrastructure with the public safety agencies will be given a

2x25 MHz bandwidth allocation and the other MNO will be allocated 2x20 MHz.

In this model, public safety users are cellular users who will be given priority access. The standard broadband QoS is described by 2 Mbps user throughput [17]. The services provided to the public safety broadband network include voice, two-way video, and data transfer.

In this study, the feasibility of broadband public safety communication is measured based on the NPV calculation, both from the government and cellular operator perspectives [18]. It consists of calculating the network (coverage and capacity) planning and then calculating the network cost deployment, so that the NPV can be determined.

A. *Defining Network Planning for Public Safety Communication*

1) Coverage Planning: This computation focused on performing a calculation of a maximum cell range of LTE 700 by QoS, which is outlined in Table I. In this study, it is assumed that the use of broadband LTE is in a fixed outdoor area. Based on the coverage planning method, the propagation conditions are one of the main factors to determine the cell size. In this study, link budget simulations are conducted to know the number of LTE e-Nodes B, which are needed to cover the planning area. The cell range prediction is calculated by adopting Okumura Hatta's [19] propagation model. An example of an LTE link budget calculation is shown in Table I.

TABLE I. LTE COVERAGE PLANNING

Main Parameters	Dense Urban	Urban	Suburban	Rural
Freq Operation (MHz)	700			
RF PA power (Watt)	20			
Channel BW (MHz)	20			
Cell Edge Tput DL (Kbps)	2,048			
RF Load	80%			
BTS Antenna Height (m)	30	30	40	70
Cell Range (km)	1.62	1.95	4.89	6.80
Cell Area (km2)	1.71	2.47	15.55	30.05
Site Area (km2)	5.13	7.40	46.64	90.16
Inter Site Distance (km)	2.43	2.92	7.34	10.20

2) Capacity Planning: In a cellular network, capacity planning is required for the network optimization to meet the QoS requirements [20]. The calculation of capacity planning is started with an LTE rollout plan and the user prediction of the Indonesia cellular provider which has a 43% market share. So, the number of eNodes-B is calculated using the following formula [21]:

$$Number\ of\ eNodeB = \frac{Total\ Throughput\ Offered}{Site\ Throughput} \quad (3)$$

3) Defining Network Cost Deployment: Based on data from the vendor, the network infrastructure costs were calculated for the components, as shown in Table II.[22]

TABLE II. INFRASTRUCTURE COSTS

CAPEX	Price (USD)	Notes
RAN	71,190	per unit
Core	12,000,000	per unit
Data Center and Application	714,695	per unit
OPEX		
RAN	35,171	per unit
Datacomm and Transport	16,268	per unit
Core	21,367	per unit
Data Center and Application	545	per unit

The total investment costs were calculated by multiplying the results of the network planning with the price list, which is shown in Table II. The total investment costs required to build the LTE network with a sharing system (first option) between a cellular operator and public safety is shown in Figure 2.

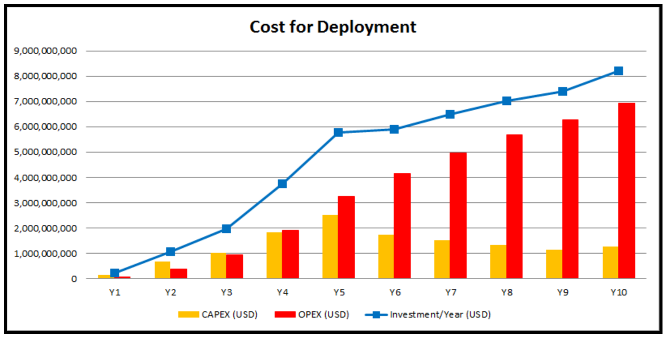

Figure 2. Total Investment Costs

B. *Defining NPV Calculation*

The NPV calculation is developed on the basis of revenues minus total expenses. From a government perspective, the revenue or government value is the total investment cost utilization as a budget which is cancelled by public safety agencies to build a public safety broadband network independently. On the other hand, the government cost is the total payment of the investment costs by the year-i which should be prepared by the government, as a compensation for public safety user traffic to the cellular operator. Figure 3 shows the calculation of government value and government costs.

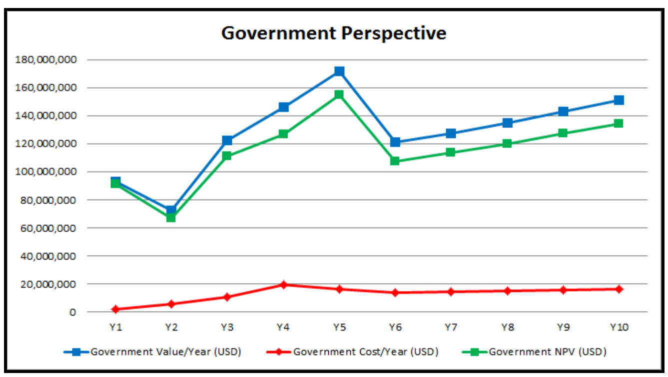

Figure 3. Government Perspective

From the cellular operator perspective, the operator revenue (operator value) is the annual revenue per user (ARPU) of commercial users plus the compensation costs from the government (government costs). On the other hand, the operator costs are calculated from the total investment sharing network costs and annual spectrum fees. In the first year, the government value has a high value obtained from the capex (core networks) of public safety agencies to build a public safety broadband network independently. In the second year, the public safety network is not required to build core networks (only towers and e-NodeB). In the sixth year, the public safety network only requires maintenance fees (opex). So, if the Ministry of Finance diverts the costs of public safety agencies to build a public safety broadband network independently to become a sharing model, then it will be advantageous for the government. Figure 4 shows the calculation of operator value and operator cost.

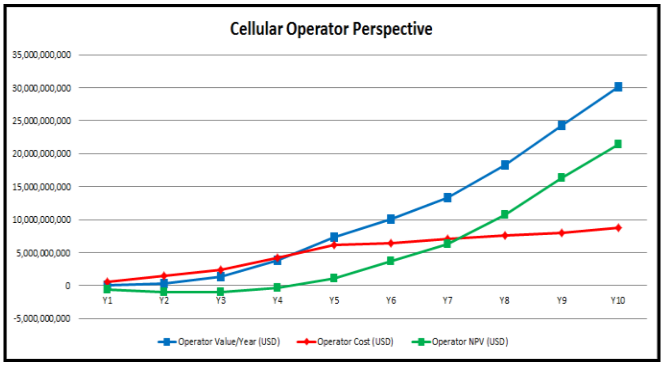

Fig 4. Cellular Operator Perspective

Figure 4 shows that the operator NPV has a positive value after the 5th year of LTE deployment. A cellular operator's revenue always increases after the 5^{th} year of LTE deployment. It is concluded that cellular operators need to consider implementing the LTE technology.

C. Simulation Results of NPV Calculations

1) Cellular Operator Perspective: In this scenario, the cellular operator is only given two options of bandwidth allocation. This simulation will compare the results of the NPV calculation between these two options. In the first option, the operator using 2x25 MHz must share the bandwidth and network infrastructure with the public safety agencies. Based on the APT recommendation [16], public safety agencies will be given 2x10 MHz dedicated only for public safety communication. However, in this development model, it is designed with 2x10 MHz for sharing between public safety and commercial LTE and 2x15 MHz only for commercial LTE. In other words, the maximum bandwidth allocation is 2x25 MHz for commercial LTE and 2x10 MHz for public safety communication. In the second option, the operator only uses 2x20 MHz for commercial LTE. Figure 5 shows the NPV results for the first option (2x25 MHz) and second option (2x20 MHz) while setting a discount rate at 5% [18].

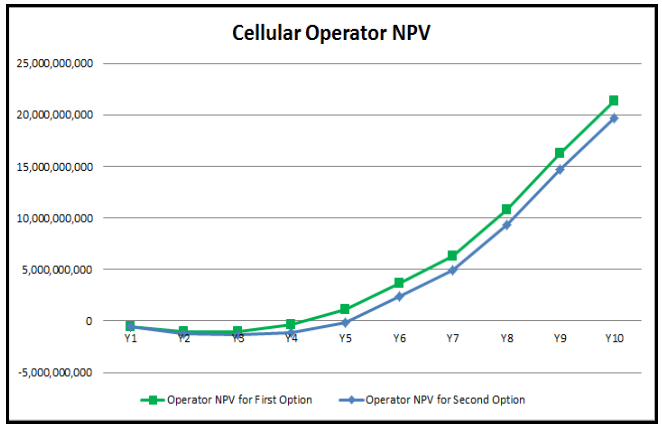

Figure 5. Cellular Operator NPV

Figure 5 shows that the NPV results for first option are higher than the second option. It is concluded that a cellular operator will obtain more benefits if the first option is taken rather than the second option.

2) Government Perspective: In this model, the Ministry of Communications and Information Technology acts as a grantor of the sharing policy between cellular operators and public safety agencies. On the other hand, the Finance Ministry acts as the owner of the budget for financing public safety broadband network implementation with a sharing concept between cellular operators and public safety agencies. Figure 6 shows the NPV results based on the government's perspective.

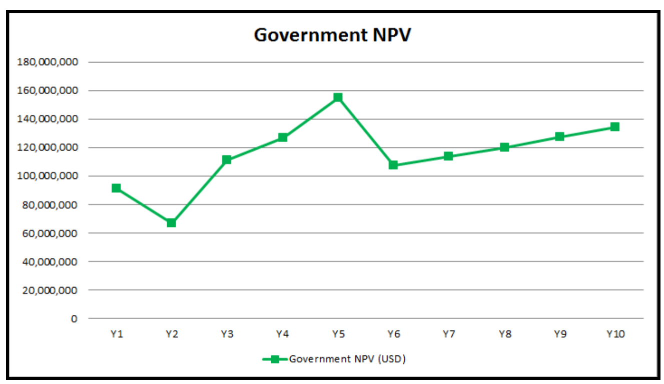

Figure 6. Government NPV

Figure 6 shows that the NPV results have a positive value with the implementation of this sharing model. This suggests that the government needs to consider implementing the development model of broadband public safety through a sharing scheme between cellular operators and public safety agencies.

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V. CONCLUSION

In this study, a public and private partnership model is developed to deploy the public safety network through a sharing model with commercial cellular operators. In this model, the investment cost utilization is a budget which is canceled for each of the public safety agencies to build a public safety broadband network independently. This study contributes to the cost savings of public safety network development.

The feasibility of this model is measured by net present value (NPV) calculations. From the cellular operator perspective, it is concluded that operators prefer the 2x25 MHz option, which must share bandwidth and network infrastructure with the public safety agencies. It has higher NPV than the 2x20 MHz option only for commercial LTE. From a government perspective, the NPV always has a positive value. So, it indicates that the government needs to consider implementing Development Model of a Public Safety Broadband Communications Network through a sharing scheme between cellular operators and public safety agencies.

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