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Consolidation of public safety wireless networks: An options-based economic analysis of numerous scenarios

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ABSTRACT

The Korean National Emergency Management Agency proposed to replace existing public safety wireless networks of 46 agencies with a nation-wide consolidated network. This study compares the public–private partnership alternative of sharing a network with the conventional alternative of building a government autonomous network. Using exploratory modeling and real option analysis which compute path-dependent values (including network effects and switching costs) of all the plausible sequential incremental investments against a wide range of future states, this study has designed adaptive investment strategies ("start robust, then adapt") which start in the highest pay-off area, and then make investment decisions about whether to expand or switch to lower pay-off areas, based on an updated information of technology prospects and the previous-stage performances of inter-agency operational effectiveness and public–private partnership. This case study has demonstrated that well-designed adaptive investments will enhance long-term values and reduce downfalls arising from public–private partnership.

1. Overview of consolidated wireless communication for public safety

Public safety officials have unique and demanding communication requirements,[1] so they cannot just use cellular phones for mission-critical communications during serious accidents. Most public safety agencies operate the old analog radio systems in the very high frequency (VHF) band or the ultrahigh frequency (UHF) band. Old VHF/UHF-based systems use the wideband of spectrum resources inefficiently, and most of them are not interoperable to each other across different agencies.

The trunked radio system (TRS) greatly enhanced spectrum efficiency and improved collaboration and synchronization capabilities by allowing communications with anyone (e.g. dynamic grouping[2]), anytime (through priority access and immediate access time) and anywhere (through direct connect mode).

Enhanced connectedness enables various public safety agencies to share information in real time, and hence better respond to emergencies by rapidly mobilizing the complementary resources of several agencies. However, an inability of existing systems to communicate between public safety agencies may hinder effective disaster response or even put public safety workers in danger. On September 11, 2001, New York police helicopters relayed a message for public safety officials to evacuate the north tower of the World Trade Center, but firefighters never received it and 343 firefighters died, because their

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[1] The National Task Force on Interoperability (2005) lists public safety communication requirements as follows: reliable one-to-many broadcast capability, immediate connections, dedicated channels and priority access, highly reliable networks to withstand natural disasters, and the best possible coverage with a minimum of dead zones.

[2] Directories that allow users to opt in and out of calling groups.

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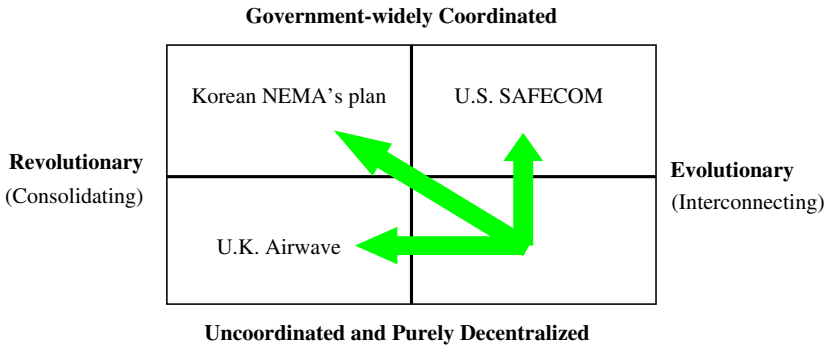

Fig. 1. Classification of migration approaches into interoperable wireless networks.

radio system was not interoperable with the police communication systems (National Task Force on Interoperability, 2005). On February 18, 2003 in Daegu, Korea, a fire in the subway rapidly turned into one of the country's worst disaster. Of about 192 people died and 148 people were injured. A stationary train caught fire, but another train traveling the opposite direction, receiving no warning message. Most people died in the second train, when it arrived at the station and stopped alongside the blazing train (MOGAHA, 2003).

Becoming aware of such problems, some governments began to pay attention to the need for improving interoperability among public safety agencies such as law enforcement, transportation, emergency medical services, fire, utilities, military, fleet management, disaster recovery and so on. The highest degree of interoperability is achieved when all the government agencies agree to migrate to a single communication system which provides coverage for all. Governments also can save money, because the fixed costs of construction and maintenance of infrastructure can be shared, and variable costs such as the prices of user equipments can be lowered, because of volume discounts (Peha, 2007). However, most public safety agencies have already built their own legacy networks redundantly (i.e. sunk costs), so the nationwide replacement of their legacy systems with a consolidated state-of-art network is very expensive.[3] Moreover functionally divided bureaucracies, fragmented planning and funding, free rider, and spillover effects discourage collective investments in shared standard services which will benefit a number of agencies and divisions.

The migration towards interoperable wireless networks can be organized by a government-wide coordination task force or by individual agencies which need it most. The migration approach can be achieved through either the switch of the entire networks all at once or incremental and backward compatible upgrades over time. Fig. 1 summarizes various types of migration approaches in quadrangle.

The U.S. SAFECOM initiative serves as the umbrella program by the President's Management Council to guide and coordinate the evolution of local wireless networks over time. SAFECOM adopts a long-term evolutionary approach to achieve an integrated system-of-systems by 2023 (Boyd & Orr, 2004). On the other hand, the U.K. AIRWAVE is the first nationwide consolidated public safety wireless network in the world, based on the most expensive technology (TETRA) to satisfy the police requirements which are the most demanding among public safety agencies. However, other agencies refused to join the Airwave, since they considered that it does not add much value to their operations, but may add significantly to the cost (NAO, 2002).

The Korean National Emergency Management Agency (NEMA), as the central leadership for disaster management, ambitiously proposed to replace the wireless networks of 46 public organizations (12 central government agencies,[4] 16 provincial and metropolitan governments and 18 public corporations[5]) over three years with a new nationwide consolidated network based on a TETRA technology which would cover 40% of the national territory.

Since a new system, based on radical innovations with wide-ranging effects on public services, will replace, rather than build on, existing systems, the value gained from it is subject to various internal and external uncertainties, and particularly interaction risk. If such investment is not matched with an inter-agency operational capability, consolidated networks will be left under-utilized. To mitigate diverse uncertainties, strategic experimentation is important. Investment managers need to periodically monitor multiple measures of internal performances and external conditions and flexibly redirect investments by adjusting the scope, timing, and scale of consolidation to capture opportunities and mitigate downside losses (Amram & Kulatilaka, 1999).

[3] Hallahan and Peha (2008) estimate the cost of a consolidated wireless public safety network in the U.S. at about $10 billion. They claim that this cost is still lower than the cost of upgrading the entire existing public safety voice infrastructure at the local, state, and federal levels ($15 –$18 billion).

[4] The 12 central agencies include Ministry of Defense, Ministry of Government Administration and Home Affairs, National Police Agency, NEMA, Coast Guard, Forest Service, National Medical Center, Red Cross, Seoul Regional Aviation Administration, Pusan Regional Aviation Administration, and Ministry of Environment.

[5] They include three railroad companies, seven subway companies, two airport companies, Korea Highway Co., National Housing Co., Korea Water Resources Co., Korea Electric Power Co., Korea Electric Safety Co., and Korea Gas Safety Co., etc.