ISSN 1985 - 0522

Suruhanjaya Komunikasi dan Multimedia Malaysia
Malaysian Communications and Multimedia Commission

Trunked Radio – Going Digital

ISSN 1985 – 0522

SKMM Industry Report 2009

Publication Date: September 2009

Published by:
Malaysian Communications and Multimedia Commission
Off Persiaran Multimedia
63000 Cyberjaya, Selangor Darul Ehsan
Tel: +60 3 86 88 80 00 Fax: +60 3 86 88 10 06
Toll Free: 1- 800-888-030
http://www.skmm.gov.my

FOREWORD

The Malaysian Communications and Multimedia Commission (SKMM) is working on a number of special industry research reports planned for the year of 2009 and it is with both honour and great pleasure, I present to our readers the industry research report on *Trunked Radio – Going Digital.*

With the existence of the latest mobile communications technologies and the explosive growth of the GSM and CDMA services worldwide, not much is said or highlighted about the trunked radio industry and its services today. Though this service is common and used widely among niche groups of users, some wireless communications users are generally not aware of its existence.

Hence, this report explores a theme that is not much discussed in the communications industry around the world today, including Malaysia. The introduction of this report is an opportune way to create awareness on the developments of the trunked radio market, including the technologies and services development in this industry of late and opportunities to move forward.

For readers desiring an understanding of the basics of radio trunking, this report features a brief overview of the concepts and basic technology involved. There are also discussions on overall trends and factors affecting the trunked radio industry, internationally and domestically. The report also offers an overview of economic and financial analysis, and business migration models of the trunked radio industry in relation to the Malaysian market.

A comparison is provided between the analogue and digital trunked radio systems featuring the different standards that have developed, and identifies the advantages and future plans for migration from analogue to digital.

The analysis in this publication is based on various sources including websites, analyst and industry reports, marketing and technical publications, and interviews with industry, technical experts, solutions and service providers. Drawing inputs from various groups, SKMM would like to thank the contributors for their invaluable insights towards writing this report.

A soft copy of this report can be obtained from the SKMM website at:

http://www.skmm.gov.my/what_we_do/Research/industry_studies.asp

I hope that this report will provide useful information and perspectives to our readers for the further development of the communications and multimedia industry in Malaysia. We look forward to hearing your feedback, which will help us improve our industry reports in the future. Please send your comments to webmaster@skmm.gov.my

Thank you.

En. Mohamed Sharil bin Mohamed Tarmizi
COO/Acting Chairman
Malaysian Communications and Multimedia Commission (SKMM)

EXECUTIVE SUMMARY

The notion of trunking came about in the early 1980s when there was increasing congestion in the airwaves. It is a concept of providing network access to many clients by sharing a set of lines or frequency channels instead of providing them individually. Unlike other common telecommunications services such as mobile cellular, trunked radio communications are not intended for the general public. It provides communication channels to a group that has strong community interest with one another. In terms of spectrum use, trunking is more efficient as it has the ability to switch between multiple radio channels. This allows less blocking and is able to accommodate a greater number of users to a number of radio channels. For example, on a 20-channel conventional system, the number of users served is between 700 – 1,000 users. In contrast, on a trunked radio system, the same number of channels can service between 2,000 – 2,500 users.

Despite the existence of sophisticated communications technology, trunked radio systems still remain the preferred communications technology for some niche users in the market. Trunked radio communications systems offer a unique combination of cost-effectiveness, reliability and features not offered by other common communications services. Users of trunked radio systems include organisations with mobile workers that require person-to-person and person-to-group radio communications to coordinate and facilitate their operations such as public safety and emergency services, transportation companies, airports, utility companies, and port authorities. Trunked radio communications systems applications are diverse for a specialised group of users and are able to fill the gaps that are not provided by other telecommunications carriers. Applications include day-to-day operational communications, safety purposes for those working in isolation or remote areas, emergency and disaster communications, including security and defence measures.

Over the years, trunked radio has evolved to serve the growing demand for better technologies offering efficient usage and more services. Efforts on standardisation have resulted in multiple standards and technologies to also meet the various radio communications needs in the market. In terms of transmission, trunked radio has progressed from analogue to digital transmission, albeit at a slow rate although digital is able to deliver more advantages. At the same time, the innovation for analogue trunked radio appears to have now reached its maximum.

Although majority of trunked radio systems today still operate in analogue mode, the demand for better performance and reliable system has shifted the strategic direction of vendors, service providers and users towards migration to digital systems. Comparatively, digital trunked radio systems are able to transmit better and offer consistent voice quality; support integration of data and voice; provide enhanced encrypted voice; is more spectrum efficient and interoperable; and can support advanced applications such as GPS. Standards for trunked radio systems have also evolved. As noted by a manufacturer, Motorola, the availability of standards helps the development of defined migration path and technological progress for trunked radio systems. It also ensures multi-vendor interoperability and compatibility. There are two categories of standards – open standards and proprietary standards. In open standards, the components in an existing system can be easily substituted with that from another vendor, meaning that end users purchase or replacement parts are not controlled by a single vendor. An example is the Terrestrial Trunked Radio (TETRA) developed by the European Telecommunications Standards Institute (ETSI). However, the contrary is true for users of proprietary standards such as iDEN by Motorola.

The market for trunked radio is relatively small with unique market segmentation. In fact, it is a niche market with relatively no direct competition from other services. Though the mobile cellular service may seem to offer similar services, it is nevertheless designed to meet the needs of the mass market. The cellular mobile service provides

the mass market with one-to-one communication where a mobile unit can connect to another mobile unit or fixed line through interconnection using the public switched telephone network (PSTN). With technological developments, trunked radio in recent years also has the capability to interconnect with the fixed line telephone network and offers the sending of short messages directly to a handset. This is an overlap to the mobile cellular service. But, the mobile cellular handset is not designed for that high level of durability and robustness in contrast to trunked radio handhelds used in challenging work environment as well as the responsive push-to-talk communications application.

Despite the small trunked radio market share in telecommunications, market research firm, Venture Development Corporation (VDC) estimates the global market stands at about USD8.4 billion in 2008 with an installed base of mobile and portable radios nearing 20 million units. VDC predicts a continued and consistent growth during the next several years for the digital trunked radio systems. Further to that, VDC's findings have also shown that 70% of the system installed remained analogue, but by 2012, the total installed base of digital system would reach 66%.

In Malaysia, the developments of trunked radio services have reached a stable stage due to the rapid growth in coverage of mobile cellular services. There are two key players in the Malaysian market – the Government and the commercial sectors, with their own subscriber segments serving different needs. The Malaysian Government has set up an integrated digital radio network solely for the use of Government agencies known as the Government Integrated Radio Network (GIRN) which operates on the 380MHz to 400MHz frequency band. In the commercial sectors, there are four main consortiums that provide trunked radio services in Malaysia – Electcoms Wireless Sdn Bhd, DTRS Consortium, Hasyon Technologies Sdn Bhd and Segi Maju Consortium. At present, the majority of the consortiums are operating on 100% analogue system. Only Electcoms Wireless Sdn Bhd is offering digital trunked radio services while Segi Maju has done a soft launch of its digital services in May 2009. Compared to other communications services, the trunked radio subscriber base is low. Today, there are approximately 50,000 trunked radio subscribers nationwide.

In terms of tariffs and pricing in Malaysia, it is not regulated and service providers are free to set the price to be attractive and competitive. Findings have shown that most service providers are charging a flat tariff for the use of trunked radio services and associated equipment. Charges are also dependent on other factors such as payment period, quantity, packages subscribed and areas of coverage. The cost of trunked radio handsets and equipment also varies. In general, the cost of digital trunked radio handset is much higher than that of the analogue, averaging between RM2,500 to RM3,500, while the digital trunked radio terminal is priced at about RM6,000. A schematic estimation on the infrastructure cost to conduct a trial for digital trunked radio with one site base is about RM230,000.

Additionally, a review of the economics and financial performances of the trunked radio service providers in Malaysia have shown that while there are a few larger players who are financially sound with the capabilities to upgrade and migrate to digital, many of the smaller trunked radio service providers are unable to do so due to lack of resources and financial capital. Therefore, in order to migrate and rejuvenate their operations, there are three business migration models options that these analogue trunked radio providers can implement to ensure continuous operational efficiency in the future – consolidation to form a consortium, forming a wholly-owned subsidiary or operating in MVNO model-like market, taking into account other considerations and issues too.

Though digital deployment in Malaysia has not been fully implemented, SKMM is strongly encouraging the migration to digital for better spectrum utilisation. Currently, all trunked radio system services operating in Malaysia are using the 800MHz frequency band (806MHz to 821MHz and 851MHz to 866MHz). This frequency band for the

operation of trunked radio systems was first introduced in Malaysia in 1990. However, the decision from the World Radiocommunication Conference (WRC) 2000 and 2007 identifies the 800/900MHz band to be allocated for the International Mobile Telecommunications (IMT) future mobile service. In this case, there is a need to consider migrating the operations of trunked radio services to the 380/400MHz band in Malaysia. We also have a complementary set of system technologies operating in the Malaysian market, such as TETRA, APCO25 and GoTa. This is facilitated from a regulatory perspective as SKMM adopts a technology neutral environment where the demand and market forces will determine the technology of choice.

Under the Communications and Multimedia Act 1998 licensing regime, trunked radio network service providers were previously classified under the class licence category where less or minimal regulation is required due to the small and niche market served. As network service providers are required to migrate from analogue to digital which provides wider, new applications and can serve a potentially larger market base as compared to analogue trunked radio, SKMM now requires companies to apply for the individual licence to continue operations. Under the individual licence category, network service providers will have to undergo heavier regulatory supervision in particular, in providing fair and non discriminatory access and interconnection offerings for trunk radio applications service providers who will reside on their network operating under a class applications service licence.

No doubt, at the end of the day, the shift towards digital is inevitable worldwide, including Malaysia. Hence, in the quest for migration, trunked radio vendors and even service providers have to ensure that their technical blueprint and commercial roadmap are ready for the change in moving forward to digital. Service providers should also look into consolidation as a strategic option in order to collaborate and build a strong platform to compete and also to develop and support applications that can provide better solutions to customers. With the spread of cellular wireless creating a more competitive environment, trunked radio service providers require innovativeness and new applications to sustain market share and drive the market forward in the future towards digital. Service providers must review for change in their strategies and build sustainable business models outside traditional areas. They must also continuously observe the international scenes, developments and industry demand for an indication on where the industry is moving towards and adopt or adapt accordingly.

However, creating public awareness on the benefits of trunked radio services will also remain one of the biggest challenges for service providers. Regulators such as SKMM will continue to work with various parties involved to improve the local regulatory environment to enable the industry to grow.

TRUNKED RADIO: A LASTING LEGACY

The past few decades have seen rapid advancement in communications technology. The industry itself can easily be ranked as one of the most dynamic and fastest growing. Driving the growth are also factors such as the need for instantaneous and constant connectivity, and the need for practicality, efficiency, and capacity. Connectivity has also evolved from one-to-one, one-to-many and any-to-any.

Source: Radio Pioneers and Core Technologies, Federal Communications Commission

Today, wireless communications using radio frequencies of the electromagnetic spectrum is widely used as opposed to wired communications and this includes the two-way radio. As early as 1890s, two-way radio communications were already available when Gugliemo Marconi and Alexander Popov experimented with ship-to-shore communications. Since then, radio technology plays a major role in communications, with two-way radio becoming a key tool in all public, private and business use and this includes conventional and trunked radio.

Though conventional radio systems were previously the main way of communications, the increasing crowding of radio spectrum bands have caused the introduction of trunked radio techniques. The central idea of trunked radio systems also came about with the need to provide communications to be specialised by large and diverse fields of organisations for various critical purposes.

The trunked radio systems differ from the conventional radio systems. Trunked radios are much more complex controlled radio systems where the use of a pool of channels is made available for different groups of users known as talk groups. In contrast, conventional radio system provides communications between users within a given geographic coverage area[1].

Trunking Analogy

The notion of trunking was developed in the early 1980s when there was an increasing congestion on the airwaves[2]. As spectrum is considered a limited resource and costly to obtain, manufacturers developed trunking systems to optimise the use of available frequency. It is a concept by which a communications system provides network access to many clients by sharing a set of lines or frequency channels instead of providing them individually. This is comparable to the structure of a tree with one trunk and many branches.

In simple explanation, the operation of a trunked radio system can be likened to the operation of tellers in a bank. A bank may have four teller windows to serve customers but there will only be one waiting line for customers in a bank. Customers entering the bank can proceed immediately to any four available tellers if the bank is not busy and has no queue. However, if traffic begins to pick up with all teller windows fully utilised, only one queue is created and customers have to wait in line for the next available teller to carry out their banking transaction.

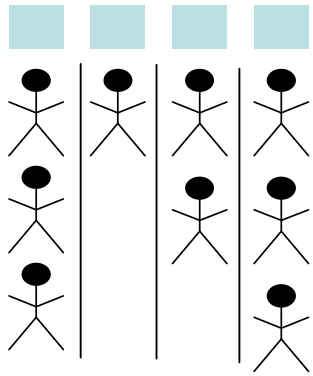
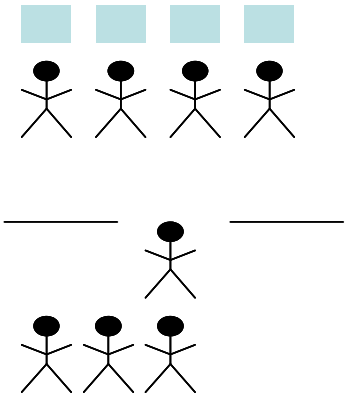
Comparatively, conventional radio system operates like lines in a supermarket cashier counter. Each cashier counter will have its own queue. For example, if there are four

[1] *Guide for the Selection of Communication Equipment for Emergency First Responders Volume 1, February 2002, National Institute of Justice.*

[2] *Airwaves are the medium of radio and television transmission.*

cashier counters, there will be four waiting lines and customers are allowed to select whichever queue they would like to stand in.

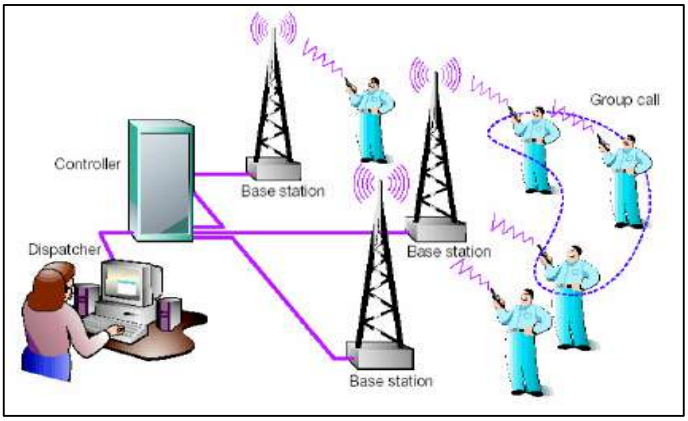
Conventional Radio System Versus Trunked Radio System

	
Concept of Conventional Radio System (Similar to a queue system in a supermarket)	**Concept of Trunked Radio System (Similar to a queue system in a bank)**

Source: Trunking Radio Explained, Flyed Micro

The Trunking Process

How Trunking Works



Source: Introduction to Wireless Communication System, UPM http://eng.upm.edu.my/~barirah/KKK4615/notes/lecture1a.pdf

A trunked radio system is a computer-controlled radio system and is technically more complex than conventional radio. For instance, trunked radio allocates 20 or more talk groups to a particular radio frequency channel. The radio system computer assigns a user and the user group to a frequency when the push-to-talk (PTT) button is pressed. The radio then sends a digital message to the system controller requesting a channel assignment.

The message contains your identification (ID), talk group, and a request for assignment of a voice channel. If a channel is available, the system controller sends a message back to the mobile radio with the channel assignment information and, also broadcasts a similar message to other radios in the fleet so that they can tune to the designated channel, if necessary. A voice conversation occurs after the channel assignment process is completed.

In terms of spectrum used, trunking is more efficient than the conventional system as it has the ability to switch between multiple radio channels. This allows less congestion and can accommodate greater number of users to a number of radio channels. An example would be that a 20-channel conventional system can serve between 700 to 1,000 users. In contrast, on a trunked system, the same number of channels can service between 2,000 to 2,500 users[3].

[3] *Introduction to Land Mobile Radio*

Types of Trunked Radio Users and Applications

Source: Zenitel

Despite the existence of more sophisticated mobile communications technology, trunked radio systems still remain as the preferred technology for some users in the market as it offers a unique combination of cost-effectiveness, reliability and features that is not offered by other common communications[4] services. Trunked radio is also able to serve a broad spectrum of users including organisations with mostly mobile workers that require person-to-person and person-to-group radio communications to coordinate and facilitate their operations.

Both the private and public sectors are amongst user groups of trunked radio systems. According to Motorola, trunked radio users can be categorised into three distinct groups – Commercial and Light Industrial, Professional/Business Critical and Public Safety/Mission Critical, each with their own needs and expectations from the systems and services provided. At one end of the continuum are organisations that require fast, convenient and low-cost communications over a limited range which meets their needs quite adequately. These include users who work in a variety of industries such as retail, hospitality, and property management.

On the opposite end are organisations with mission-critical communications need which demands high functionality such as top-level reliability, security and vast geographic coverage, mostly those in the emergency, security and safety services.

In between this two ends of the continuum lies the largest group in the market that needs to communicate efficiently and cost effectively with their mobile workforce who travels across large geographic areas. These groups of users include those from the manufacturing industry, transportation and taxi service providers, petrochemical, public utilities and mining.

Trunked Radio User Groups and Their Communications Needs

Source: Adapted from Standards for Professional Mobile Radio – Making a Business Critical Choice for the Future, Motorola, 2008

[4] *Common communications refers to those of wired and wireless means of communications such as the fixed line and mobile cellular where end users are usually the mass market.*

With the development of better technology in trunked radio systems, the number of end users has increased. The following shows groups of some trunked radio users that are in existence:

Trunked Radio Users

Users	Details
Public Safety and Emergency Services	Reliable communications during emergency situation is critical for public safety and emergency service providers such as police, fire departments and ambulance services. Trunked radio is able to support these users as it offers reliability and support multiple, instant group calls.
Transportation	Rail, bus, trucks and fleet management companies use trunked radios for their communications and tracking needs. Workers in this market segment are always on the move and by using trunked radio, organisations can coordinate their operations effectively.
Airports	An airport has a unique environment with numerous groups of mobile workers who must work cooperatively to carry out the airport functions. Trunked radios are an ideal communications platform in this situation as public cellular systems are insufficient to support airport use due to unreliable coverage during busy times and lack of functionality such as group call. Usually airports function on private trunk radio network for their internal use.
Utilities	Utility companies and their maintenance crew usually use trunked radio communications as their field workers are mobile and out on the move coordinating maintenance work and remote monitoring.
Business and Industry	Local government, municipal councils, public work companies, security firms and service/maintenance companies are some of the users for trunked radio systems.
Others	Other users of trunked radios include agricultural industry, forestry, port authorities that use trunked radio to support their daily operations.

Source: PMR Market Appendix, Digital Project Report by Radiocommunications Agency, 2002

Today, the applications of trunked radios are quite diverse. The table below summarises some of the use of trunked radio.

Trunked Radio Applications

Applications	Details
Operational communications	Most trunked radio users use their systems to: • manage their business operations like coordinating the activities of employees and supervisors, e.g. loggers, field workers, taxi drivers, and public safety and service personnel • communicate information and coordinate a variety of day-to-day as well as emergency activities Example, trunked radios are used extensively in transportation of raw materials and finished products. Companies use radio to coordinate delivery of products and to dispatch drivers for pickups. This enhances efficiency and ensures timely delivery of products.
Safety	Some personnel often work in isolation or remote areas and work itself can be potentially hazardous (e.g. loggers and oil riggers). Trunked radio provides an important connection in case of emergency. In addition, trunked radios are often used in large scale emergencies, such as flood and earthquake where all other means of common communications are impossible such as fixed line.
Emergency and disaster communications	Trunked radios are critical tools for emergency responses and are used for immediate communications during repair, rescue and disaster-relief efforts. Immediate communications are vital to save lives, protect property, and coordinate relief efforts as common commercial communications services may be damaged or too congested to be used. For example, air rescue personnel must be able to quickly coordinate its personnel and equipment to respond to emergency landings at areas of incident.
Security	Many companies have internal security measures that include security officers that protect the property and screen visitors. Here, security officers

	are equipped with radio communications to dispatch emergency response personnel when in need such as in the case of fire, intrusions and other emergencies. For example, airports require tight security to safeguard its large surrounding area. To monitor the area and communicate with one another, trunked radios help airport workers carry out security function effectively.

Source: Private Land Mobile Radio Services: Background by Federal Communications Commission, 18 December 1996

DEVELOPMENT OF TRUNKED RADIO

Evolution of Trunked Radio – From Transmission Systems to Technology Standards

Since the first introduction of two-way radio communications systems, trunked radio has undergone a lot of changes over time to serve the growing demand for better technologies and greater usage. Efforts on standardisation have resulted in the creation of multiple standards and technologies to meet the needs of various radio communications in the market.

Transmission Systems

Today, trunked radio has evolved from analogue to digital transmission due to more advantages from digital technology. This is similar in concept to the transition of digital technology in broadcasting where digital broadcast offers many benefits over traditional broadcast using analogue systems, especially in highly efficient usage of spectrum.

Analogue Trunked Radio Systems

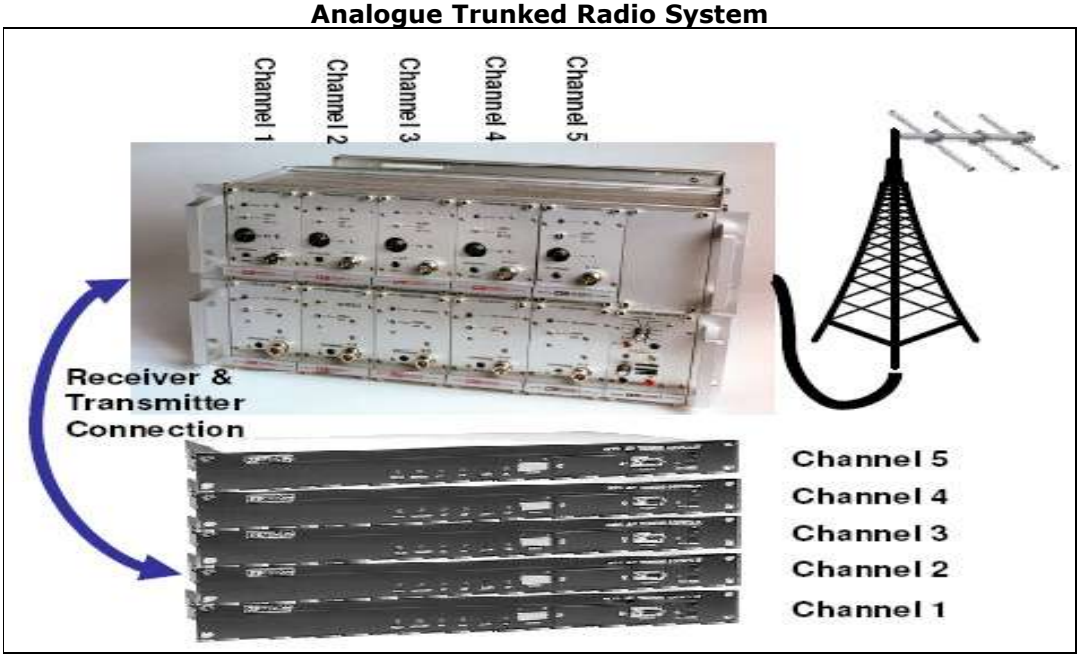
Commercial trunked radio industry has existed in Asia-Pacific since 1982 with New Zealand[5] being the first country to have the system in operation. As analogue systems were always used as the key platform for trunked radio communications and have been around for a long time, the innovation for analogue trunked radio has now reached its maximum.

Basically, analogue radios transmit analogue signals over-the-air where radio waves[6] that are usually modulated by a voice are continuously broadcast. At the same time, there is no additional computer processing (e.g., digitisation) for analogue radio. A traditional two-way radio with an analogue signal is also not feature-rich. Standard analogue radios usually offer push-to-talk, scanning, simple group conversations (one-to-many), and limited encryption capabilities.

A typical analogue trunked radio system is shown below. Trunking controllers are allocated on a per channel basis (for example, five channels shown in the diagram below) and then linked to the radio system on a channel for channel basis. The output of the radio system is then combined and transmitted to the antenna.

[5] *Introduction to Land Mobile Radio – Public and Private Land Mobile Radio Telephone and System, 4 December 2000*
[6] *Radio waves are electromagnetic waves occurring on the radio frequency portion of the electromagnetic spectrum.*

Analogue Trunked Radio System



Source: Application Note – Analogue Trunking by Daniels Electronics Ltd., February 2007

Common analogue trunked radio systems include: Motorola Type I, Motorola Type II, Motorola Type I/II hybrid, General Electric EDACS, and EF Johnson Logic Trunked Radio (LTR) systems[7].

While analogue systems are very cost-effective in areas outside major population centres, with easy-to-use dispatch features and low-cost service today, it is not as efficient in its use of spectrum as digital.

Digital Trunked Radio Systems

Source: Zenitel

Although the majority of global trunked radio systems users today still operates in analogue, the increasing demand for better performance and reliable system has shifted the direction for vendors, service providers, and users to move from analogue systems to digital trunked radio systems. Unlike analogue systems, data and voice conversation transmitted using digital systems are encrypted and converted into digital format before it is transmitted over-the-air. The radio signal is converted into binary code using electronic or electromagnetic signals. The binary code is then decoded by mathematical algorithms in the receiving radio so that the user at the end point can understand the information conveyed on the assigned working channel. When the transmission is completed, the assigned working channel will be released and is then available for another transmission.

Source: Zenitel

[7] *Trunked Radio Systems, Radio Scanner Guide, http://radio-scanner-guide.com/RadioScannerGuidePart3A-Trunked.htm*

Since transmission of conversation can be sent through different working channels, it is difficult for any unauthorised listener to eavesdrop the conversation. Digital systems offer users enhanced signalling options, more consistent audio quality, higher radio spectrum efficiency, fast Internet connection and wider range of encryption features. Some of the general characteristics comparison is shown in the table below:

General Comparison between Analogue and Digital Trunked Radio Systems

Analogue Trunked Radio Systems	Digital Trunked Radio Systems
Voice quality decreases gradually and noise level increases when users move far away from the analogue transmission site.	Better and consistent voice quality as it can reduce environmental noise levels during transmission. Background noises with no recognisable voice characteristics are not usually encoded.
Less functionality and features can be embedded in analogue systems.	Because voice transmissions are treated as data, digital systems can support improved integration of data and voice. The latter is one of the gripping reasons why users and service providers are migrating from analogue to digital systems.
Less secure since analogue systems do not have full encryption feature.	Enhanced encrypted voice quality. Encryption prevents any voice or data transmitted from interception by unwanted listeners.
No software-driven business applications can be supported by this system.	Better compression makes digital system more spectrum-efficient to support advanced applications such as GPS location and high speed messages.
Analogue devices can be upgraded but will not be capable to cope with advancing technology.	Interoperability among neighbouring systems. Digital platform provides a migration path that allows for use of both digital and analogue radios. Digital systems also provide Internet connectivity.
Maintenance costs are high.	Lower total cost of ownership.

Source: www.BearCom.com, www.about2wayradio.com, TETRA Association, The Future of Professional Two-Way Radio: Digital and various websites

The Digital Advantage Summary

Performance Factor	Analogue	Digital	Advantage Today	Advantage Tomorrow
Voice Quality	Degrades as RF signal strength reduces	Constant throughout RF coverage area	Digital	Digital
Non-Voice Services	Limited data throughput	Higher data throughput	Digital	Digital
Security	Limited level of protection against eavesdropping	Easily adapted to support digital voice encryption	Digital	Digital
Cost	Very mature low complexity products with development investment already recovered means lower costs	High complexity and sophistication products with future capability	Analogue	Digital
Other	Limited inherent protection of voice signals in high noise environments	Good inherent protection of voice signals in high noise environment	Digital	Digital

Source: TETRA Experience 2006

The Role of Standards in Trunked Radio

Standards provide a platform for evolution and development of trunked radio as there is clearly define technological progress towards specific industry-shared goals. The absence of standards will lead to the development and production of equipment which are incompatible with other systems; produced by different manufacturers and vendors.

According to Motorola, the goal of standards is to aid the development of defined migration paths and documented upgrades to the technology. Standards bodies usually collaborate to develop a timeline for feature introductions due to regulatory mandates, while balancing value proposition to users. At the same time, standards help ensure a robust, realistic and cost-effective future progression for the defined technology.

Standards also ensure multi-vendor interoperability and compatibility. When standards on interoperability are developed, it ensures greater sustainability of technology solutions over time, thus decreasing risk of obsolescence and increased cost savings. Such standards also allow users to have access to multi-vendor alternatives for technology and equipment adoption or replacement.

Although there are several international standards developed for trunked radios worldwide, there is no universal standard with global appeal. The industry carries a mixture of standards by manufacturers in collaboration with associations and agencies. Generally, there are two categories of standards for trunked radio systems as summarised in the table below:

Standards for Trunked Radio Systems

Standards	Details	Examples
Open standards	Open standards are also known as "open system". According to ITU, open standards are "standards that are made available to the general public and are developed (or approved) and maintained through a collaborative and consensus-driven process. 'Open Standards' facilitate interoperability and data exchange among different products or services and are intended for widespread adoption". Using open standards also means that the component in an existing system can be easily substituted with that from another vendor. Hence, an open standard is not controlled by a single vendor. With open standards, equipment often benefit from price and performance advantages arising from multi-vendor competition.	• Terrestrial Trunked Radio (TETRA) developed by the European Telecommunications Standards Institute (ETSI) • APCO-25 or Project 25, developed through a joint effort of the Association of Public-Safety Communication Officials International (APCO), the National Association of State Telecommunications Directors (NASTD), some Federal Agencies and the National Communication System (NCS) and was standardised under Telecommunications Industry Association's (TIA), USA.
Proprietary standards	Proprietary standards are standards that are developed and controlled by one or a closed group of companies and do operate in the same band as existing system. Such standards can also be advantageous as they will speed up the development and roll-out of new equipment into the market. Each equipment specification will follow the proprietary standard. On the other hand, the adoption of such standards will lead to technology "lock-in". Adopters of the standard can only source equipment from usually one vendor that develops it.	• Integrated Digital Enhanced Network (iDEN) developed by Motorola that uses Time Division Multiple Access (TDMA) • Enhanced Digital Access Communication System (EDACS) by Ericsson Inc. (initially invented by General Corporation before being taken over by Ericsson Inc) • Global Open Architecture Trunking (GoTa) developed by ZTE Corporation, China*

**GoTa is a CDMA-based trunking system. Currently, the only company that manufactures the GoTa system is ZTE Corporation in China.*

Source: Digital Trunked Land Mobile in the 800MHz Band – An Engineering Discussion Paper by Radio Spectrum Policy and Planning Group, Energy and Communications Branch, Ministry of Economic Development, New Zealand, May 2007 and other various websites.

Analogue Trunked Radio Standards

The first trunked radio standard introduced was the analogue MPT 1327 from Rohde and Schwarz. At present, analogue trunked radio systems rely on a few standards such as the following:

Analogue Standards of Trunked Radio Systems

Analogue Standards	Summary of Standards
APCO – 16 (Association of Public Safety Communications Officials – Project 16)	• Developed by the Association of Public Safety Communication Officials – International in 1979 • APCO-16 products follow 25 or 30 KHz radio channel utilisation • Examples of products complying with the standard are SmartNet and SmartZone trunked system developed by Motorola
MPT1327 (Ministry of Post and Telegraph 1327)	• Developed by the British Department of Trade and Industry in 1988 • Used primarily in countries like UK, Europe, South Africa and Australia • MPT1327 utilises Frequency Division Multiple Access (FDMA) technique to utilise spectrum
LTR (Logic Trunked Radio)	• Developed by E.F. Johnson Company 1978 • LTR utilises Frequency Division Multiple Access (FDMA) technique to utilise spectrum on 25 KHz bandwidths • It is distinguished from other common trunked radio systems by not having a dedicated control channel.

Source: Understanding Two Way Radio Technology, http://about2wayradio.com/index.htm and other various websites.

Digital Trunked Radio Standards

The move towards digital trunked radio systems over the last few years, together with digital standards, has increased acceptance leading to the accelerating trend of migrating to digital. Vendors and service providers are now more willing to move from their legacy systems in order to stay ahead or still be in the business of trunking communications services.

Proprietary system standards are giving way to open standards as well. Previously, most trunked radio systems relied very much on proprietary standards containing software licensed exclusively to a manufacturer. For most part, relying on proprietary standards would make interoperability between radio systems very complex if not impossible. This is due to the usage of different trunking technologies, with different brands of hardware and software. TETRA and APCO-25 are examples of open standards and iDEN is one of the models for proprietary standard. As more standards are developed to be an open standard, compatibility and interoperability issues are no longer a major crisis.

There are few standards which can support digital trunking systems. However, in this report, only TETRA, APCO-25, iDEN, GoTa and DMR are discussed briefly.

Digital Standards for Trunked Radio Systems

Digital Standards	Summary of Standards
TETRA (Terrestrial Trunked Radio)	• Developed by European Telecommunications Standards Institute (ETSI) in 1995 • TETRA is based on 4-slot Time Division Multiple Access (TDMA)on 25kHz bandwidth • TETRA Release 2 standards was released in 2005, an upgrade version of TETRA release 1

APCO – 25 (Association of Public Safety Communications Officials – Project 25)	• Developed by the Association of Public Safety Communication Officials International (APCO), the National Association of State Telecommunications Directors (NASTD), some Federal Agencies and the National Communication System (NCS) • APCO-25 operates on Frequency Division Multiple Access (FDMA) on 12.5 kHz and/or 25kHz bandwidth
iDEN (Integrated Digital Enhanced Network)	• Developed by Motorola in 1994 • Provides users the advantage of a trunked system and cellular-like services integrating voice and data and uses a SIM card just like GSM-based phones • iDEN operates on TDM technologies for multiple access operating in 800MHz
GoTA (Global Open Trunking Architecture)	• Developed by ZTE Corporation • GoTA operates on CDMA technologies and allows deployment

Source: TETRA Association (www.tetramou.com), P25 Radio Systems Training Guide (www.danelec.com) Motorola Worldwide – iDEN MD (www.idenphones.motorola.com), ZTE GoTA (www.zte.com.cn), Understanding Two Way Radio Technology (http://about2wayradio.com/index.htm) and other various websites.

As the digital trunked radio system market shows bright prospect, the trunking equipment providers, network carriers, and terminal users consistently ride on this new wave of transformation so that their existing business model is still applicable. Aligned with the global movement towards digitalisation in this sector, Malaysia is not left behind. SKMM has been strategising a smooth migration plan from analogue to digital system in the local scene over requisite timeline.

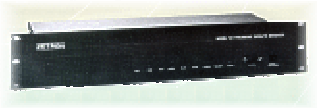
Trunked Radio Equipment – Analogue and Digital Systems

In order to create radio trunking communications, there are some components of equipment needed to make the connection. Currently, we are now witnessing the fast growth of radio trunking equipment manufacturers around the world, resulting in an increase in applicable equipment today. With the advancement of technology, equipment for radio trunking has improved tremendously including the availability of digital systems.

In this report, the trunked radio system equipment explained includes base stations/repeaters, mobile radio, portable radio, controller and other accessories used, and brief description of their function.

Some of the equipment used in the analogue and digital systems are:

ANALOGUE  **DIGITAL** 	**BASE STATION / REPEATER** **Base Station** is also known as a fixed station, comprising a receiver and a transmitter. The radio is powered by an external electrical system connected to the antenna. Due to this, the base station has the most powerful transmitters compared to mobile and portable radios, including the most sensitive receivers. Microphones can be handheld or desktop models and the speaker can be an external or internal type. **Repeater** refers to a transceiver that receives and re-transmits signals. The key purpose of repeaters is to extend communications coverage for portable, mobile and base stations. The signal received is rebroadcast to the radio network, often with a higher power and from a better location. Nowadays, the term base station and repeater are usually mixed to refer to a network

	component that provides RF coverage.
ANALOGUE  **DIGITAL** 	**MOBILE RADIO** This device is typically installed in a vehicle or a car. The size and weight of the mobile radio is larger and heavier than a portable radio. This is of no matter to the user because the mobile radio is fixed in the vehicle. Generally, mobile radio has higher power output than portable radio due to its form factor which facilitates more components to produce higher power. There is no issue on battery life as it uses the vehicle battery for power. Thus, the range of a mobile radio is usually superior to portable radio.
ANALOGUE **DIGITAL**  	**PORTABLE RADIO** Portable radios are small and lightweight handheld wireless devices that contain a microphone and speaker, rechargeable battery for power supply and an antenna. Since users carry this device most of the time, the ergonomics of portable radio (that is, its size and weight) is an important factor for users. Portable radios regularly have lower power output compared to mobile or fixed-station radio due to the above limitation factors. Thus, the range of portable radio is typically smaller than mobile or fixed-station radio.
	**CONTROLLER** This is a network component that manages the entire network. The switching system, for example, manages the incoming and outgoing traffic and routes the communications to and from base stations. The switching system is the kernel of the network as without it the network will not be able to handle wide area network calls.

Note: All products mentioned above are from EFJohnson, TAIT Communication, Zetron, Sepura, and Motorola iDEN.
Source: Guide for the Selection of Communication Equipment for Emergency First Responders Volume 1, February 2002, National Institute of Justice

Signal Quality for Digital Trunked Radio

For any communications, signal quality is an important aspect as it ensures reliable communications transmission. In trunked radio, it is essential to have good signal audio quality especially during critical incidents as safety personnel frequently depend solely on trunked radio communications to effectively relay information and coordinate emergency situations. However, the presence of other noise interference in the surrounding environment such as wind, traffic, sirens and large crowd noises is inevitable. In digital trunked radio, the signal quality or more often known as Delivered Audio Quality (DAQ) is often rated between 1 to 5 as shown in the table below:

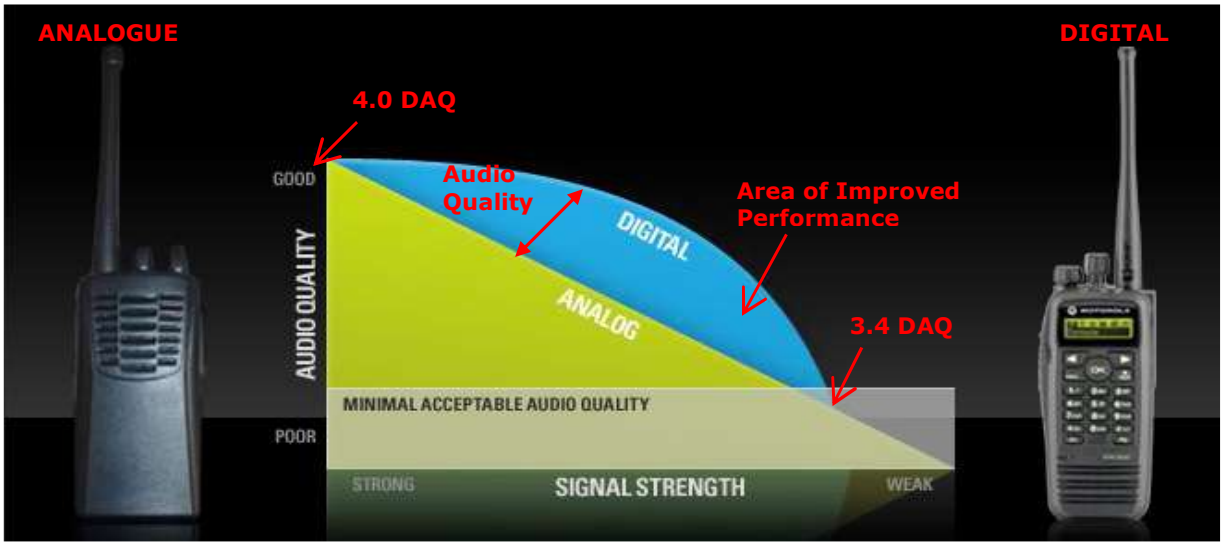
Trunked Radio Audio Quality

Delivered Audio Quality (DAQ) Rates	Details
DAQ 1	Unusable. Speech present but not understandable
DAQ 2	Speech understandable with considerable effort. Requires frequent repetition due to noise/distortion
DAQ 3	Speech understandable with slight effort. Requires occasional repetition due to noise/distortion
DAQ 3.4	Speech understandable without repetition. Some noise/distortion present
DAQ 4	Speech easily understood. Occasional noise/distortion present
DAQ 5	Speech easily understood. No noise/distortion present

Source: Commentary on Public Safety Technology – and other things by Daryl Jones, 11 May 2008

For most digital trunked radio system, a minimum Delivered Audio Quality of 3.4 is required, where speech is understandable without repetition, with some noise or distortion present. As a comparison, digital trunked radio will provide clearer voice communications over a greater range than comparable analogue trunked radios, rejecting static and noise[8].

Analogue versus Digital Trunked Radio Audio Quality



Source: Adapted from Hear the Difference Motorola Website, http://ap1.motorola.com/mototrbo/hear-the-difference.html

As radio users move further away from the transmitting radio, the signal strength decreases and this will directly affect the ability of the radio to produce intelligible sound.

[8] *Hear the Difference, Motorola website, http://ap1.motorola.com/mototrbo/hear-the-difference.html*

For an analogue system, the clarity and intelligibility of the transmission received by the users will decrease directly as the signal level decreases. Contrary to this, while the desired signal decreases, the noise or static in the signal progressively increases with strength until the user's voice cannot be heard over the noise. In a digital system, the transmitted signal decreases just as an analogue system, as signal level decreases. However, the error correction in the digital transmission that contains extra information, allows audio information to be heard even with a large decrease in signal level.

In summary therefore, the digital trunked radio system offers benefits over the analogue system in many aspects from the potential to ride on new technology wave to enhance existing business models into time for service providers to greater and more reliable services offered to end users. Nevertheless as a market segment, the trunked radio market is relatively small compared to the cellular mobile phone market.

TRUNKED RADIO MARKET: OVERVIEW AND GROWTH

The cellular based GSM and CDMA services have grown phenomenally worldwide, while the trunked radio services, which started the very concept of being connected on the move, go almost unnoticed. Today, trunked radio services still supply the much needed communications support for critical and specialised services in unique niche markets. Noteworthy is that the transition to digital has caught the still analogue system service providers in a "time space" fix where they need to invest more before the competition catches up with them. Additionally, the small market size, limited resources amidst more demanding end users are making it difficult for service providers to create a bigger market for themselves and to modernise their system in sync.

As it is a push market in this industry, it is observed that it will take a longer time for customers or end users to approach service providers for this service as compared to other commercial communications services. On the marketing front, cellular service providers are aggressively marketing their services to the masses, while radio trunking service providers tend to spend significantly less on marketing campaigns. This does lend to some disparity in an increasingly digitising environment then for customers to inform the service providers what they need so that service providers can cater to customer needs. To some extent, this slows down the development of digital applications features going forward, especially those localised to a particular user group or user geographic region where end user awareness on the benefits of the switch to digital is lacking.

Interestingly, as of today, there has also not been a universal name to label this industry. In different countries, trunked radio is assigned a different term or name as shown in the table below. However, no matter what name is used, all fall within what is generally referred to as trunked radio.

Different Terms for Trunked Radio

Country	Term
United States	Specialised Mobile Radio (SMR) or Land Mobile Radio (LMR)
Asia	Trunked Radio Service (TRS)
United Kingdom	Private Mobile Radio (PMR)
Europe	Public Access Mobile Radio (PAMR)
India	Public Mobile Radio Trunking Service (PMRTS)
Japan	Multi Channel Access System (MACS)

Source: Consultation Paper on Licensing Issues Relating to Public Mobile Radio Trunking Service Providers, Telecom Regulatory Authority of India, 25 August 2000

Competition in the Trunked Radio Market

As trunked radio offers services to a unique and specific set of industry segments that require one-to-many and one-to-one communications, there is relatively no direct competition from other wireless communications services. Mobile cellular services may seem to offer similar services but is considered not yet a direct competitor as the cellular mobile phone does not provide similar capabilities and is designed to meet the needs of a different end-user group – the mass market. Unlike trunked radio services, the cellular mobile provides the mass market with one-to-one communications whereby a mobile unit can call another mobile unit or a fixed line through interconnection with public switched telephone network (PSTN).

With technological developments in trunked radio in recent years, the availability to interconnect to PSTN is also available. Additionally, coupled with the ability to send short messages directly to a handset, there is now some overlap with the mobile cellular services. However, in terms of equipment design, the mobile cellular is not designed to the extent of robustness that trunked radios offer which is an important factor for end users who are operating in challenging work environment. Hence, the trunked radio market is still much more of a niche market where competition is limited.

Factors Affecting the Trends and Demands for Trunked Radio Services

As the market for trunked radio grows, findings have shown that there are a few factors affecting the trends and demand for trunked radio services. This is summarised in the table below:

Factors Affecting the Trends and Demands for Trunked Radio Services

Needs	The need for communications services by users is increasing dramatically and driven primarily by changes in demography and increasing population. However, the demand for trunked radio services is affected by the needs of its users. When common commercial communications services such as cellular mobile are not able to meet the demands of users, the trunked radio services are able to fill this gap. For example, though common mobile cellular services and equipment are able to provide majority of the needs of users in the marketplace, it is not able to do so for the needs of the public safety communications markets like the fire fighters. In many instances, fire fighters operate in extreme environments, markedly different from common communications users - operate lying on the floor, in zero visibility, high heat, high moisture and wearing self-contained breathing apparatus face pieces that distort voices. This is further challenged by their bulky protective clothing that eliminates manual dexterity. They also operate inside structures of varying sizes and construction types. All these factors are to be considered in order to communicate in a safe and effective manner. Hence, trunked radio equipment will provide a better communications tool, offering durability in a harsh environment, with better performance and coverage.
Technology	The need to use spectrum more efficiently and advances in technology are factors that will affect the trends and future demands of trunked radio. As spectrum is a finite resource, radio trunking systems were developed because of its dynamism to optimise channel usage and improve spectral efficiency. Trunking of groups of radio channels allows operation at a much higher loading level than single channels can handle with acceptable access delay[9]. Hence, trunking remains the preferred technology especially in public safety agencies as the system provides better control over the network during emergency situations - avoiding congestion which will usually occur over a common cellular network. Additionally, transformation of technology such as digitisation of information and the quickening pace of digital communications systems have also shaped the demands of trunked radio services and systems. The switch to digital promises greater capacity and more efficient transmission including better security and voice quality. Digital transmission has also paved the way for convergence of voice and data networks. The seamless integration of such networks allows

[9] *Comparisons of Conventional and Trunked Systems, Public Safety Wireless Network, May 1999*

	efficient interconnection capabilities. However, there are also difficulties arising in the transition to using new technologies. Users and service providers would have to take into account factors in terms of cost and availability of equipment.
Regulatory	The changes in regulatory landscape also affect the trends and demands in trunked radio services. For example, over the years, Asia has had many regulatory successes that have created a more positive environment for the industry. Many regulators are responding to industry needs and have lifted many restrictions in order for this industry to develop further. These include countries like India and Japan where regulators have made it easier for service providers to offer trunked radio services and increase the demand. For instance, in India, operators can now get a tax break for five years[10]. Regulatory changes such as spectrum refarming seeking to increase the capacity and efficiency of trunked radio services have an impact in changing the trend for radio trunking.

Source: Private Land Mobile Radio Service: Background by Federal Communications Commission, Wireless Telecommunications Bureau, 18 December 1996. PMR Market by Radiocommunications Agency, November 2002

Worldwide Developments of Trunked Radio – Then

The largest markets in the world for trunked radio are in United States (US), Canada, United Kingdom (UK), Japan and China. However, there are also subscribers found in countries like Australia, Argentina, Brazil, France, South Korea, India and Malaysia. Between 1994 and 1998, the International Mobile Telecommunications Association (IMTA) research indicated worldwide commercial trunked radio market grew by approximately 4.5 million units. At the end of 1997, it was estimated that there were at least 55 countries with commercial trunked radio systems in place. This includes Europe, Latin America and Asia-Pacific region, serving an estimated 6.8 million users. In 1998, IMTA estimates that 3.4 million of the 8.6 million subscribers were of digital units. Whereas Asia-Pacific region represents the largest regional commercial trunked radio market with more than 4.04 million units in service at the end of 1998. By 2001, a study by a research company, IMS Research, estimated that the number of Private/Professional/Personal Mobile Radio (PMR) users worldwide was 33.1 million with US capturing 57% of the market share, followed by Asia at 22%, Europe at 19% and Middle East and Africa, 2%. However, approximately 77% of the users relied on analogue systems with the balance 23% using digital technologies.

North America

In North America, the first country to introduce the commercial trunked radio industry was US in 1974, followed by the launch of the first commercial trunked radio network in 1977. A decade later, there were approximately 3,000 service providers with 628,000 units in service and by the end of 1997, the number of subscribers exceeded 2.68 million. However, in other North American countries like Mexico and Canada, commercial trunked radio industry took place much later in the 1980s. Like Canada, the industry became active in 1984. In Mexico, there were 45 companies operating commercial trunked radio systems with an estimation of 73,000 units in service. [11]

Europe/Eurasia

The introduction of trunked radio services in European and Eurasian countries began in late 1980s and early 1990s, respectively. In UK, the first system was introduced in 1987, and in 1990, France issued its first commercial trunked radio licence. In 1992, it is reported that there were about 100,000 commercial trunked subscribers in Europe and the number grew to 5,567,000 in 1997. By 2000, there were more than 175 companies operating commercial trunked radio systems in Belarus, Belgium, Czech Republic, Estonia, Finland, France, Germany, Latvia, Lithuania, Moldova, Poland,

[10] *Asia Trunking Operators Report Regulatory Successes, http://www.itu.int/itunews/issue/1999/07/perspect.html, 1999*
[11] *Public and Private Land Mobile Radio Telephones and Systems by Lawrence Harte, Alan Shark, Robyn Shalhoub, and Tom Steiner*

Portugal, Romania, Russia, Spain, Sweden, Tajikistan, Turkey, Ukraine and UK. The biggest markets are in France, Germany and UK.

Asia-Pacific

Commercial trunked radio services were also introduced in Asia-Pacific during the early 1980s. The first system was implemented in New Zealand in 1982, followed soon thereafter by countries like Japan and Australia. For example, in Japan, the trunked radio system or known as Multi Channel Access System started in 1982. The service was provided in Tokyo district using the 800MHz band. However, despite its success as one of the largest markets for commercial trunked radio in the world, service providers have faced numerous regulatory challenges. However, over the years, by working with the then Japan Ministry of Posts and Telecommunications (now known as the Ministry of Internal Affairs and Communications), many of the challenges have been removed. In Korea, the first company to initiate the trunked radio system was Korea TRS in 1988. In India, trunked radio service or better known as Public Mobile Radio Trunked Service (PMRTS) was opened to the private sector in the year 1995. As of 31 March 2007, PMRTS was provided by 12 service providers. Its subscriber base increased from 29,950 at the end of March 2006 to 31,501 at the end of March 2007.

Worldwide Developments of Trunked Radio – Now

Findings by VDC Research Group

Market research firm, Venture Development Corporation (VDC) estimates that the global market for PMR solutions – hardware, software and services – is at about USD8.4 billion in 2008 with an installed base of mobile and portable radios close to 20 million units. Although the market has clearly matured over the years, VDC predicts a continued and consistent growth for the PMR solutions during the next several years, much of which will be replacement sales as users migrate to next-generation platforms[12]. VDC expects the market is to reach USD11.3 billion by 2012.

VDC also recently conducted research among more than 650 current and future global PMR users. Respondents from all of the major geographic markets predicted a strong shift to digital technology during the next five years. Findings showed that about 70% of the current installed base of PMR radios remained analogue. Further to that, VDC also indicates that by 2012, the totalled installed base of digital PMR radios should reach 66%, with transition taking longer than expected, largely due to the factor of the long shelf life and replacement cycle of PMR solution and the lack of clear investment drivers.

Findings by EADS[13]

Meanwhile, EADS reported that the total global PMR market size is estimated at about five billion Euros, most of which comes from digital PMR systems and terminals, and command and control systems. Over the next five years, the market is expected to grow by 20% with continuous, steady growth in digital PMR systems and terminals, and an increase in the relative share of applications and services[14].

---

[12] Article from RadioResource International - Data Applications Could Drive Digital Shift, Venture Development Corporation

[13] EADS is a global leader in aerospace, defence and related services and is the only company in the world that can offer mission critical network solutions based on TETRA, TETRAPOL and P25 technologies.

[14] Global PMR market reaches five billion Euros, Key Touch Customer Newsletter 2008 by EADS.

Findings by ABI Research

According to ABI Research, the market for terminals used by emergency first responders[15] looks set to grow significantly over the next five years. The market is expected to grow slightly from USD1 billion in 2007 to more than USD3.6 billion in 2013 as agencies such as the Association of Public Safety Communications Officials International (APCO)/Telecommunications Industry Association (TIA) Project 25 (P25) and European Telecommunications Standardisation Institute (ETSI) Terrestrial Trunked Radio (TETRA) standardise on digital technologies[16].

Global Case Studies

Case studies below are some examples that indicate the growth of trunked radio worldwide.

Case Study of a Country: China

China is one of the world's largest manufacturers for two-way radios. Findings have shown that China itself produces 11 million two-way radios in 2006. For China, its market for handheld two-way radios has reached a mature stage with active makers producing a capacity between 20,000 to 30,000 handheld two-way radios. The average monthly output is about 20,000 units and 60% is shipped overseas. The analogue handheld two-way radio still dominates the supply in China though makers feel that it is also nearing its maturity stage and will gradually be replaced with digital radios. Many companies are already focusing on digital trunking system which has more extensive applications with brighter growth prospect.

An example of a leading maker in China, which has evolved into an active digital trunking system solution and terminal provider, is HYT Science and Technology Co. Ltd (HYT). HYT started R&D on digital trunked two-way radios since 2002 and has over the years developed APCO and TETRA products. In 2006, the company produced one million handheld two-way radios. Out of this, 60% of HYT output was exported to more than 70 countries worldwide such as Russia, United States, Japan, India and Indonesia. Most of the companies in China also export their products to the Euro-American market with the United States as the lead importer.

Case Study of a Technology Standard: TETRA

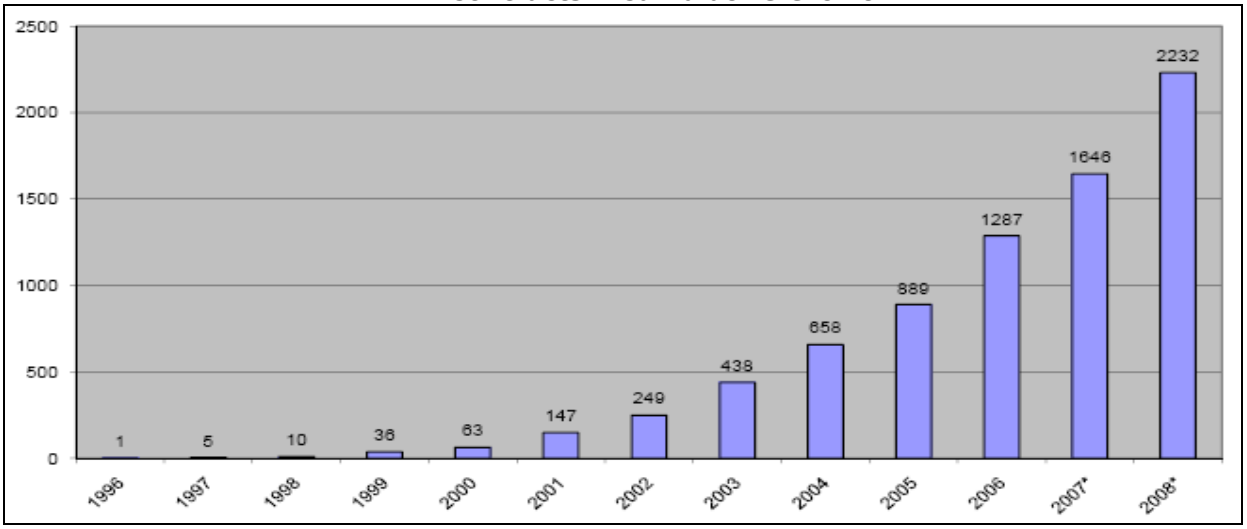
The evidence in the growth of trunked radio can also be seen through the development status of the standards in the trunked radio systems. This is especially shown from the worldwide growth in the implementation of standards over the networks in both the public and private sectors. The data below shows the cumulative growth of global TETRA contract over the years. As of third quarter 2008, TETRA reported having secured 2,232 contracts globally and the standards are now used in 102 countries worldwide, of which 63 are outside of Europe. According to TETRA, the fastest growing markets regionally are the Asia-Pacific and South America, whereas according to sectors, the fastest growing markets for TETRA are those in the Oil and Gas, and Commerce and Industry.

---

[15] First-responder terminals are used by public safety personnel as part of their communication system. These terminals use the trunked radio technology with standards such as TETRA and APCO25.

[16] First Responder Terminal Market to Reach USD3.5 billion by 2013, ABI Research, 5 November 2008.

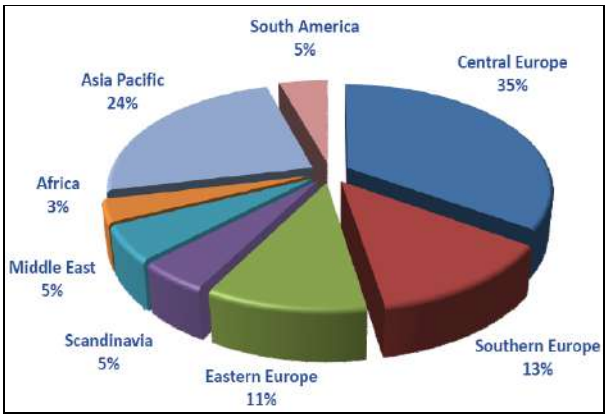
TETRA Contracts – Cumulative Growth



** until Q3*
Source: Introduction to TETRA, TETRA Association, 2009

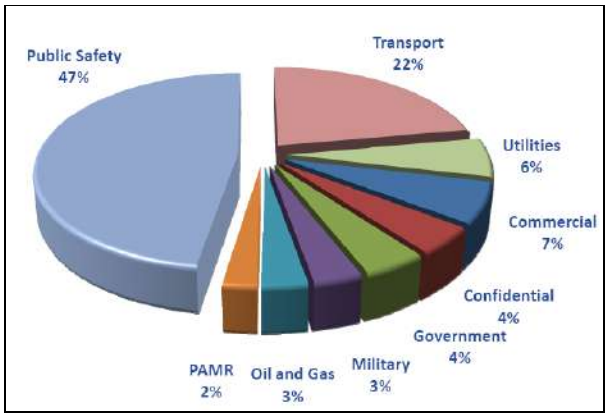
As of 2009, the largest market for TETRA is Central Europe at 35%, followed by Asia-Pacific at 24%. Asia-Pacific TETRA market has doubled in the last 12 months. With an increase of 98%[17] in awarded contracts, the region is the fastest-growing critical communications market in the world[18]. While public safety remains the largest global user base at 47%, in Asia-Pacific the Transportation sector is extremely strong with almost 40% of the market[19]. Globally, non-public safety sectors are also showing potential such as the Oil and Gas industry, and general commerce and industry**.**

TETRA Contracts by Region in 2009



Source: TETRA Market Worldwide, TETRA Association, 2009

TETRA Contracts by Sector 2009



Source: TETRA Market Worldwide, TETRA Association, 2009

Case Study of a Manufacturer: Motorola Inc.

Motorola Inc., a provider in development and deployment of TETRA communications solutions, announced at the end of March 2009, the shipments of its one millionth TETRA terminal. The customer receiving these terminals is the Jordan Armed Forces (JAF). TETRA has also recently won contracts to build digital trunked radio communications network (TETRA) for Delhi, Bangalore and Hyderabad International Airports to serve their round-the-clock mission-critical communications needs[20]. Such growth and developments show that the global market for trunked radio services is still growing as there are still demands from end users for various operations.

[17] *Figures refer to notified contracts June 2007 – May 2008, compared to figures from previous 12 months.*
[18] *TETRA markets doubles in Asia Pacific, TETRA Association Press Release, 26 May 2008.*
[19] *TETRA markets doubles in Asia Pacific, TETRA Association Press Release, 26 May 2008.*
[20] *Motorola shipped one million TETRA terminals*

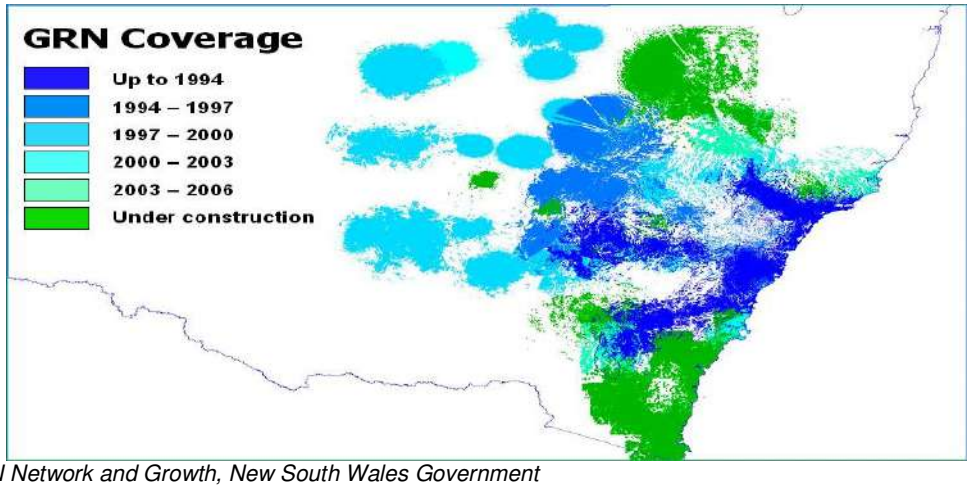
Case Study of a Government Radio Network: Government Radio Network Services, Department of Commerce, New South Wales Government, Australia

In New South Wales, Australia, the Government Radio Network Services (GRN) is one of the larger trunked radio networks in the world. Established in 1993, it brings the latest radio communications technology to the New South Wales (NSW) Government Agencies and Departments and provides a common platform for over 40 government agencies and authorities who use mobile radio communications. Established in 1993, the GRN covers the three most densely populated areas of NSW - Greater Metropolitan Sydney, Newcastle and Wollongong. Over the last 15 years, the GRN has expanded significantly. New sites are being added all the time, as well as offering enhanced (fill-in) coverage to enable portable activities[21]. Currently, the NSW GRN covers over one-third of the state of NSW. This equates to a geographic area of some 150,000 square kilometers, making the NSW GRN one of the largest trunked radio networks in the world.

The Network extends to the regions as follows:

Region	Area
***North Coast*:**	Forster/Tuncurry
***New England*:**	Murrurundi, along the Castlereagh Highway
***North West*:**	Mitchell and Barrier Highways to Lightning Ridge and Bourke
***West*:**	Cobar, Lake Cargellico and along the Newell to West Wyalong
South West:	Along the Hume and Federal Highways to and including Yass and the ACT
South:	Nowra

Source: GRN Network and Growth, New South Wales Government Website, 12 October 2007, http://www.grn.nsw.gov.au/about-the-nsw-grn/network-development-and-growth



Source: GRN Network and Growth, New South Wales Government

DOMESTIC TRUNKED RADIO MARKET: OVERVIEW AND GROWTH IN MALAYSIA

In Malaysia, according to Mindbranch[22], the growth of trunked radio services appeared to have reached a stable stage. This is mostly due to the rapid growth coverage of cellular services where indirect competition for this service has taken away most of the substitutable trunked radio market share. Like others, the market for trunked radio services in Malaysia covers a wide range of users in the specialised user groups.

Key Players in Malaysia

There are basically two groups of key market players in the Malaysian market, which are the Government and the commercial sectors. Both sectors have their own subscriber segments serving different needs.

---

[21] *GRN Network and Growth, New South Wales Government Website, 12 October 2007, http://www.grn.nsw.gov.au/about-the-nsw- grn/network-development-and-growth*

[22] *Mindbranch is a leading source for market research covering over 130 sectors with in-depth industry research, global businesses information and independent equity analysis.*

Government Sector

The Malaysian Government has set up an integrated nationwide digital radio network solely for the use of Government agencies known as the Government Integrated Radio Network (GIRN). This network operates on the frequency band 380MHz to 400MHz for the Public Safety Radiocommunications Services and the Military, Ministry of Defence. The agencies involved are the Royal Malaysian Customs, Malaysian Maritime Enforcement Agency, Royal Malaysian Police, Malaysian Fire and Rescue Department, Immigration Department and Ministry of Domestic Trade and Consumer Affairs. Though the users of GIRN network share infrastructure, they remain autonomous. The leading technology provider in Malaysia for the integrated secured radio communications is the Sapura Group.

For example, the Royal Malaysian Customs are using the Sepura[23] Handheld Terminals provided by Sapura[24]. The equipment is able to conduct communications or calls through a talk group using a Direct Mode Operation (DMO) or Trunked Mode Operation (TMO). The equipment is provided to all the Royal Malaysian Customs officers in the Preventive, Narcotics, Marine and Internal Tax Division. Also, all their vehicles and department boats are equipped with mobile trunked radio equipment.

Commercial Sector

In the commercial sector, there are four main consortiums that operate the trunked radio services in Malaysia. These consortiums consist of a few smaller companies to form a group to manage and roll out the digital trunked radio services in the country. The consortiums are listed in the table below:

Trunked Radio Consortiums in Malaysia

Consortium	Companies
Electcoms Wireless Sdn Bhd	• Electcoms Bhd • CMRS Trunk Radio Sdn Bhd • Syarikat Pelatus Sdn Bhd • Saturn Holdings Sdn Bhd • Push-To-Talk Sdn Bhd
DTRS Consortium	• Mal-Tel Communication Sdn Bhd • STR Communication Sdn Bhd • Widenet Distributor Sdn Bhd • Asiaspace Dotcom Sdn Bhd
Hasyon Technologies Sdn Bhd	• Hasyon Teknik Sdn Bhd, • Cometron Sdn Bhd • Pager Communications Sdn Bhd • Samen Trunk Radio Sdn Bhd • Textphon Sdn Bhd
Segi Maju Consortium	• Segi Maju Sdn Bhd • Stars Associated Sdn Bhd

Source: Malaysian Communications and Multimedia Commission, SKMM

However, Telekom Malaysia Berhad (TM) also offers trunked radio services, namely VHF Nationwide and UHF Klang Valley.

At present, majority of the consortiums is operating on 100% analogue trunked radio aside from Electcoms Wireless which is the sole digital trunked radio operator in the country. Although there are signs that migration to digital trunked radio in Malaysia is underway, the transition in upgrading to a digital infrastructure and system is still at a slow pace due to the high cost involved. For example, Electcoms Wireless has 90% of subscribers on analogue trunked radio and 10% subscribers on digital trunked radio from the total of about 30,000 subscribers. Despite the emergence and availability of

---

[23] *Sepura is a leading network-independent TETRA radio supplier based in Cambridge UK. It also designs and develops digital radios for the Emergency Services, the Military and the commercial sector*

[24] *"Pegawai Pencegah dan Cukai Dalaman Didedahkan Tatacara Penggunaan Handheld Terminal" from Kastam Diraja Malaysia Perlis' website, 6 September 2008*

digital technology, according to Electcoms Wireless, the migration of their subscribers from analogue to digital is less than 5% as the existing analogue customers are unwilling to migrate to digital trunked radio due to the high price of user equipment.

Another trunked radio operator, SLW Group has invested more than RM5 million to bring the open standard TETRA digital trunked radio system to Malaysia. Segi Maju Consortium (Segi Maju), a member of the SLW Group of Companies, recently conducted a soft launch of its digital trunked radio services known as DART in May 2009. Another RM15 million is expected to be invested over the next five years to upgrade the current digital trunked radio service infrastructure[25]. After a year of its introduction, Segi Maju expects 20% of its customers will migrate to digital trunked radio services[26].

Market Growth

Compared to common communications services, the subscriber base for trunked radio services in Malaysia is considered low. Among the large scale users in the market served in Malaysia are from the emergency medical and transport services sectors, security companies, freight and logistic companies, taxi service providers, including mining and petrochemical companies. Today, there are approximately 50,000 trunked radio subscribers nationwide[27] with Electcoms Wireless having the largest number of subscribers at 30,000. However, over the last five years, there appears no growth in the number of trunked radio subscribers. This is also evident in the number of base stations over the last four years since 2005 to 2008. Over the years, the numbers for the 800MHz trunked radio base stations owned by the commercial service providers have not grown with the figure remaining at 190. For the 380/400MHz trunked radio base stations, the number stands at 454 as of 30 June 2009. Majority of the trunked radio base stations in the 380/400MHz is owned by the National Security Council. Others include the oil and gas, and transportation industry that require specific private networks.

Fundamentally, there are three groups of trunked radio service providers in the Malaysian market. These service providers are:

Groups of Trunked Radio Service Providers in Malaysia

Types of Group	Frequency Band	Purpose/Description	Number of Service Providers*	Number of Base Stations*
Government Infrastructure Radio Network (GIRN)	380 – 400 MHz	Service provider is Sapura Group, servicing the Government enforcement bodies such as the National Security Council, enforcement agencies, immigration and customs departments with exclusive use of network and the need for integrated secured radio communications for public safety purposes.	1	430
Public Mobile Radio Network	806 – 821 MHz & 851 – 866 MHz	Service providers consist of companies that provide radio communications for commercial use such public radio taxi service, tow trucks service providers, city council, transport/logistics operators	12	153 (including 28 base stations for digital trunked radio)
Private Network	806 – 821 MHz/ 851 – 866 MHz	Service providers are organisations or corporate entities that require radio communications for their	19	37

[25] *Government to Continue to Push for Improvement for Telcos, Bernama, 21 May 2009.*
[26] *Segi Maju sedia labur RM15 juta lagi, Utusan Online, 21 Mei 2009*
[27] *SKMM's estimation(figures not including subscribers from the 380 – 400 MHz Government Integrated Radio Network, GIRN)*

	& 380 – 400MHz	internal use only with no connectivity to the public such as airports operators, petrochemical companies, seaports and mining companies	8	28

** Note: Figures as of 2008*
Source: Malaysian Communications and Multimedia Commission, SKMM

Tariff/Pricing

In Malaysia, tariffs are not regulated and service providers are free to set the price to be as attractive and competitive as they like. Findings show that most of the service providers in the country are charging a monthly flat tariff for the use of trunked radio services for unlimited airtime. The average monthly network access tariff per unit for both the portable and mobile radio is between RM20 – RM40 per month. Fees charged are also dependent on payment period, quantity, packages subscribed and areas of coverage. For example, the table below shows a sample of tariff charged by, Telekom Malaysia (TM) over a private network:

Examples of Trunked Radio Service Tariff by, TM Over a Private Network

		Charges/Unit/Monthly
1. Charges for Voice or Data:		
1.1	**1 Region** **2 Regions** **3 Regions** **4 Regions** ***Regions Consist of Central, Northern, Southern & Eastern**	RM40 RM55 RM65 RM70
1.2	**Sabah or Sarawak** **Sabah & Sarawak**	RM40 RM55
2.	**Reconnection Charges** **Reconnection after Temporary Disconnection Due to Unpaid Bill**	RM10/per unit
3	**Stamp Duty for New Registration**	RM10/application

Source: TM's website, http://www.tm.com.my/business/corporate-government/satellite-maritime-radio/trunked-radio-services/

Access Package Models/Service Business Models

Service providers in Malaysia also provide different access packages. Findings have shown that the following are the three generic types of access package models provided by the service providers in the country:

Types of Generic Access Package Models in Malaysia

Access Package Models	Remarks
Network access only	Equipment is customer's own
Network access + rental/lease of equipment	Cost of rental/lease varies from RM90 to RM300 depending on radio-equipment/accessories/rental-period/quantity and packages
Use of spectrum through authorisation	Provide total solution inclusive of spectrum packaged with initial System Integration and on-going System Servicing, Maintenance, Repair and Upgrade if necessary. Charges based on total package/services required.

Source: Industry

There are also other access package models known as service business models provided by a service provider[28]:

Types of Service Business Models in Malaysia

Service Business Models	Remarks
Shared Service Solutions (Talk group rental)	Provides shared airtime or repeater services inclusive of system maintenance
Outsourcing Solution	Provides service solution inclusive of maintenance and investment of all hardware and software
System Choice	Designs, supplies, installs to commission of communications systems as specified by customer
MVNO Solution	Provides MVNO services. Customers may re-configure and partition services according to their requirement

Source: Segi Maju Consortium

Equipment Cost

While there are many types of mobile and portable radios as well as console equipment that are available in the market, findings have shown that the service providers in Malaysia are more inclined to using equipment and systems from manufacturers such as Motorola, Kenwood, EF Johnson, Zetron and AirTech.

The cost of trunked radio handsets or walkie-talkies available in the country also varies. In general, the cost of digital trunking handsets is much higher than analogue as shown in the table below. On average, a digital trunking handset is currently priced between RM2,500 and RM3,500. The cost is more than double the cost for analogue trunking handset. The current high cost of handsets is one of the impediments to market penetration.

Given this, Kenwood, has indicated recently that the cost of digital radio hardware is still 30% to 40% more expensive than analogue and they, as manufacturers, have invested much in software development. From Kenwood's opinion, the hardware cost will only decline depending on market trend and as the market size for trunked radio is not as large as cellular mobile or wireless, Kenwood does not expect the digital trunked radio hardware cost will decline much like the cellular.

Additionally, handsets operating on digital standard, TETRA, are currently priced higher at RM2,800 to RM3,500 as compared to others like iDEN and GoTA.

Cost of Trunked Radio Handset in Malaysia: Analogue Versus Digital

System	Analogue		
	Conventional	Trunking	Digital trunking
Walkie-talkie	RM80-900	RM1300-1600	RM2500-3500
Intrinsically Safe walkie-talkie[29]*	RM700-1600	RM2500-3000	RM5000-9000
Mobile radio	RM700-1400	RM2200-2700	RM3000-5000

**more than 50% of market is oil and gas sector*
Source: Various industries

[28] *Operator here is referred to Segi Maju Consortium*
[29] *Intrinsically safe walkie talkies are often used in heavy industrial environment where the radio may be used around flammable vapours. This means that the knobs and switches in the radios are engineered to avoid producing sparks as they are operated.*

Cost of Trunked Radio Handset Based on Standards in Malaysia

Digital Standard	Handset Cost
TETRA	RM2800 – 3500
iDEN	RM455 – 1225
GoTA	RM455 – 1225
NXDN	Not available

Source: Various industries

With a relatively small subscriber base in the market, the service providers in the industry are striving to obtain reasonable revenue. New investments are also limited due to the high cost of infrastructure in radio trunking. For service providers, the digital trunked radio terminal is currently priced at RM6,000 whereas the analogue terminal is priced RM1,300. In the long run however, equipment and maintenance price for analogue equipment will increase whereas digital equipment price will decrease eventually.

Estimated Infrastructure Cost for Digital Trunked Radio

As the number of subscriber base and base stations required by each service provider varies, we have not attempted to estimate the cost for deploying the entire digital trunked radio system network and infrastructure.

However, to set up a digital trial radio infrastructure with one base site, the rough estimation for the infrastructure cost is RM200,000. Note that this does not include the provision for cabling and other services provided by the vendor. Normally, the cost of installation is expected to be about 15% of the cost of equipment[30]. Thus, the best estimates for a trial digital trunked radio with one base site including provision for installation is approximately RM230,000.

Digital deployment is at an early stage in Malaysia, with SKMM strongly encouraging the migration to digital. With the advent of digital trunked radio system, Malaysia now has a complementary set of public system technologies, from single-frequency repeaters to digital trunking, such as TETRA, APCO25 and GoTa CDMA. Though popular technologies are emerging, TETRA seems to be the most preferred technology standard among service providers here to support their system as it has been used extensively around the world. Currently, SKMM adopts a technology-neutral environment. This creates a flexible environment where demand and market forces will determine the technology of choice.

SKMM also expects the service providers to migrate towards digital solutions, particularly in the congested areas in order to increase efficiency and capacity. The older technologies can be re-deployed to provide niche market service and service in the sub-urban or less dense areas that might not otherwise receive adequate TRS coverage.

The Issue of Unauthorised Cloning of Trunked Radio

Though the subscription tariff for trunked radio in Malaysia is relatively inexpensive in comparison with other common communications systems, unauthorised cloning of analogue trunked radio is an issue in Malaysia. For example, a dealer offering trunked radio sets can charge cheaper fees as compared to other authorised dealers. Recently, SKMM together with the Federal Commercial Crime Investigation Department and SIRIM was able to trace a trunked radio cloning syndicate that was responsible for a licensed trunked radio company losing some RM2.4 million yearly. However, with the migration to digital trunked radio in the future, the issue of unauthorised cloning will decrease with better security features in digital systems. At the moment, service providers are working to improve the security of analogue trunked radio systems to

[30] *East Bay Radiocommunications Systems Design Evaluation Report*

curb cloning. Also, SKMM will continue to monitor and work to arrest unauthorised cloning activities in the country.

ECONOMICS AND FINANCIAL ANALYSIS FOR TRUNKED RADIO MARKET IN MALAYSIA

Although the move towards digital trunked radio started over a decade ago, the trend has yet to take off rapidly as compared to other communications devices. As mentioned earlier, the percentage of migration to digital for trunked radio worldwide is expected as in the industry forecast below:

Year	Analogue	Digital
2009	70%	30%
2012	34%	66%

Source: VDC Research Group

Therefore, it is necessary to understand what are the forces behind the demand and supply for trunked radio in the market. In order to gain a clearer picture of the trunked radio market in Malaysia, we have reviewed the economics concerned and examined the state of financial performances of this segment.

Life Expectancy of Trunked Radio Network

According to TETRA, a typical trunked radio network is expected to have a life cycle of around 15 to 20 years before replacement. This is also the current industry average. Usually, a radio system infrastructure has a mix component of technologies that are integrated together. Most of these components have technology life cycles of the IT industry. Thus, parts or components availability is a limiting factor over time especially for systems with mix technology as they become increasingly difficult to sustain as they age.

At present, some current analogue trunked radio equipment is no longer being manufactured or shipped while some are being phased out over the coming years. However, it is found that the life cycles of these systems are being stretched for at least another six to ten years from the end-of-life date or serviceable life of the infrastructure[31]. The life cycle of equipment is determined by the suppliers and manufacturers who provide extended support. The strategy employed by manufacturers is to enter into a special contractual agreement to support products or equipment past its commercial life. Manufacturers of trunked radio equipment will make bulk purchases of parts and components when suppliers of the components used in trunked radio manufacturing are phasing them out so that sufficient inventories can appear to be maintained for the next seven to ten years. For example, if the end-of-life of a component is announced to be in 2008, the equipment would likely be maintainable and supportable until at most 2015. This strategy is currently being used with, for example the Motorola MTX838 and MTX900 series of portable radios where they are no longer manufactured, but, accessories and replacement parts are still available.

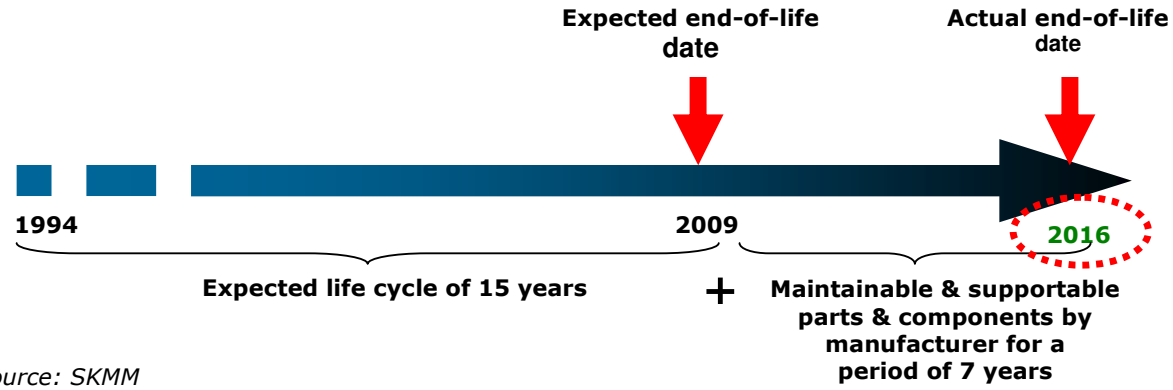
Thus, the life cycle of the analogue trunking equipment and components will be the primary factor driving the need to migrate to digital system. Though this strategy employed by the manufacturers seemed relevant, service providers should not count on this for long-term sustainability of their systems equipment that they are offering to end-users. They must ensure that there are careful planning and appropriate business models established to cater and support the intended life cycles and technology replacement process.

Now given that some of the current system infrastructure owned by service providers in Malaysia were originally installed as far back as in 1994, the overall system life cycle of

[31] *Benton County Emergency Service Radio System Upgrade Review, 9 January 2007*

the current infrastructure would be 15 years old (1994 – 2009) today. With the reality that the manufacturers are able to support and extend the life of the analogue system for at most another seven years, it will bring to the actual total end-of-life date for the system to 2016. However, service providers must also be aware that even with recent acquisitions of spare parts, it is unlikely that the system can be maintained to provide much reliable service past the 20 years. Trying to sustain the serviceable life beyond the 20 years is a risky proposition in respect of critical services supported.

Example of Life Cycle Timeline for Analogue Trunked Radio System and Infrastructure



Source: SKMM

Examples:

Calculation on the Actual Estimated End-of-life Cycle for Analogue Trunked Radio Systems of Service Providers in Malaysia

Companies	Established	System Life Cycle (Years)	Estimated End-of-Life*	Support Period (years)	Actual End-Of-Life **
SLW CORPORATION SDN BHD	1987	15	2002	7 years	**2009**
ELECTCOMS SDN BHD	1989	15	2004	7	**2011**
SEGI MAJU CONSORTIUM SDN BHD	1993	15	2008	7	**2015**
STR COMMUNICATIONS SDN BHD	1994	15	2009	7	**2016**
WIDENET DISTRIBUTOR SDN BHD	1995	15	2010	7	**2017**
MAL TEL COMMUNICATIONS SDN BHD	1997	15	2012	7	**2019**

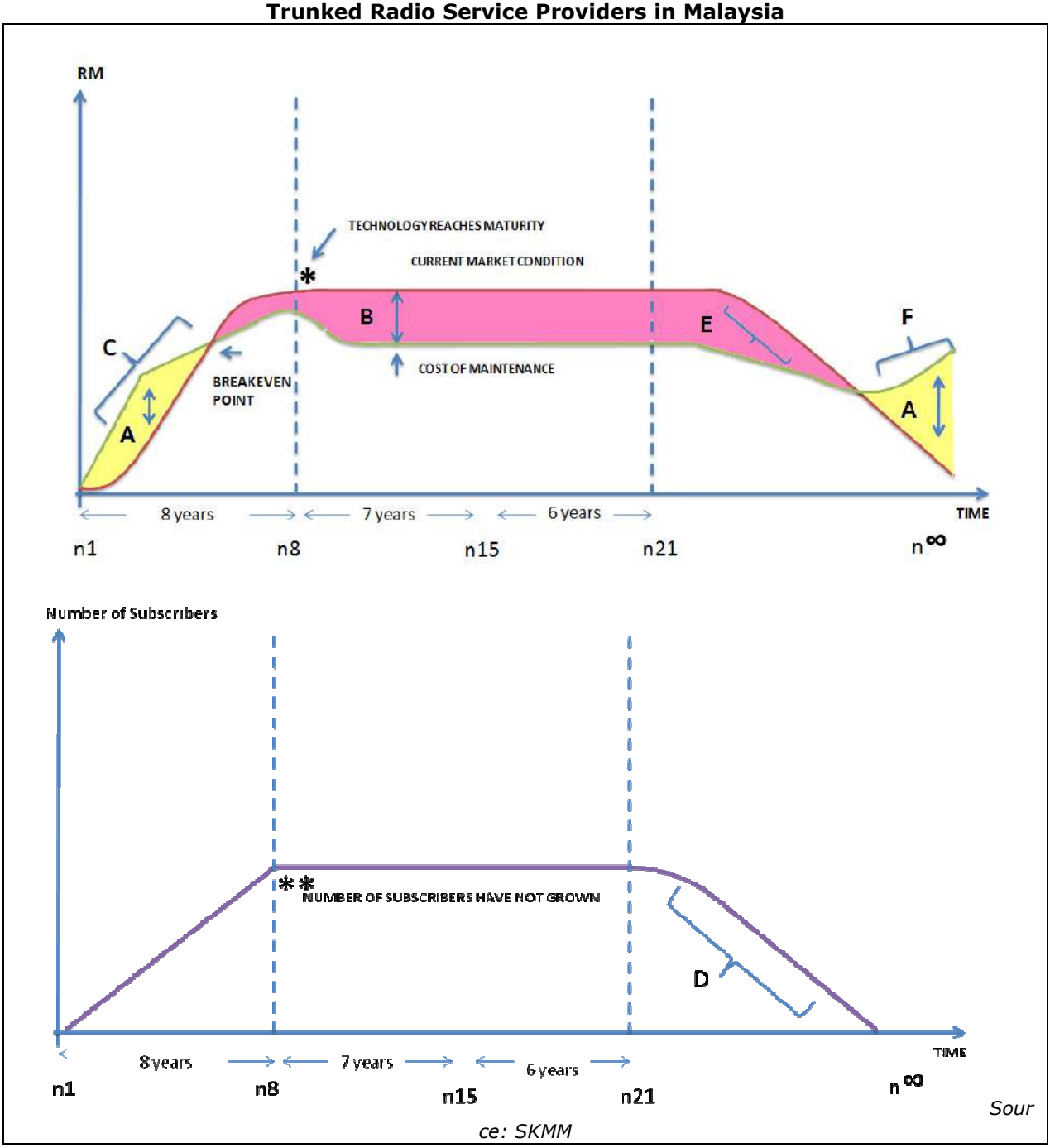
Footnote:
**Calculated by adding 15 years of system life cycle to year in which the network was established.*
***Calculated by adding 15 years of system life cycle and 7 years of support period to year in which the network was established.*
Source: Industry, SKMM

From the sample estimation above, we can concur that the actual end-of-life of analogue trunked radio systems and infrastructure of service providers in Malaysia is likely between the periods of 2010 and 2019. Therefore, pursuing an upgrade to digital, on average before 2015 is a reasonable time period for Malaysia. We can also conclude that failure to migrate before this time would result in a system that is not maintainable or be expensive to maintain and unable to adequately support critical services. This approach is also aligned to the industry norm where current market conditions are

moving away from analogue technologies to digital. As reported by VDC Research, in all major markets such as North America, European Union and Oceania, all interviewees reported a shift to digital technology. Suppliers reported in the study that the majority of new equipment sold is digital. End users data also indicates the same result. However, the decision to migrate latest by 2015 must also take into account other factors such as the financial capabilities of the trunked radio service providers.

Return on Investment (ROI) for Analogue Trunked Radio Service Providers

An Example of Return on Investment (ROI) and Subscribers Growth for Analogue Trunked Radio Service Providers in Malaysia



Source: SKMM

Legends to ROI graphs

	Number of subscribers Investment cost Return	**C**	Initial investment ▪ Install new base stations ▪ Buying new systems ▪ Purchase of stocks, handsets, terminals and other equipment ▪ Purchase of software ▪ Licence fees, etc
* **	Technology reaches the point of maturity after 8 years Market reaches the point of maturity (No growth and number of subscribers remains)	**D**	Losing number of subscribers as some have migrated to using digital trunked radio
A	Negative ROI (Investment cost > Return)	**E**	Return decreases as number of subscribers decreases and cost of analogue trunked increases
B	Positive ROI (Investment cost < Return)	**F**	Cost of investment gradually increases ▪ Cost of maintenance for analogue trunked radio gets more expensive ▪ Analogue trunked radio equipment becoming more expensive as supply decreases and analogue equipment phases out

Source: SKMM

The graph illustrates a hypothetical example of a return on investment (ROI) for an analogue trunked radio service provider over a period of time and the subscribers growth trend. At the beginning, the initial investment cost of the service provider is substantially high as large amount of capital is required in setting up the infrastructure, installing new systems, acquiring new stocks (e.g. handsets and terminals), purchasing software and paying for licensing fee. The cost of investment is represented by the green line which is rather steep at the beginning of the graph but tapers off slightly subsequently as investment cost decreases when most of the implementation or roll-out cost is disbursed; leaving a recurring maintenance cost as represented by the flat portion of this line. After a period of time, as heavier replacement costs are necessary, the line curves up again. The return for the service provider is depicted by the red line here. Initially, the return obtained will be minimal and is not able to compensate for the high initial cost of investment. This is illustrated by the return line located lower than the investment cost line whereby the overall ROI of the service provider is negative at this early phase. However, the service provider will attain a point of breakeven and the return line will intersect with the investment cost line. This also denotes the starting point of a positive ROI where the service provider will be attaining a higher return than the cost of investment afterwards.

Aligning to this, in terms of subscribers growth, the number of subscribers shows an increasing trend at the initial stage and the few years after as early adopters filled up the market and there is still demand for analogue trunked radio technology to fulfil the needs of end-users in the market. The size of the subscribers in the market continues to grow till it reaches a maturity stage where there is no growth and the number of subscribers remains the same as in what the trunked radio Malaysian market is facing at the moment with a stagnant subscribers size of 50,000.

However, if a trunked radio service provider whose analogue system has an actual end-of-life by 2015, does not migrate to digital by then, they will risk the following:

- Shrinking subscribers market as the analogue trunked radio subscriber will eventually migrate over to digital that provides wider applications, better security and clearer voice quality.

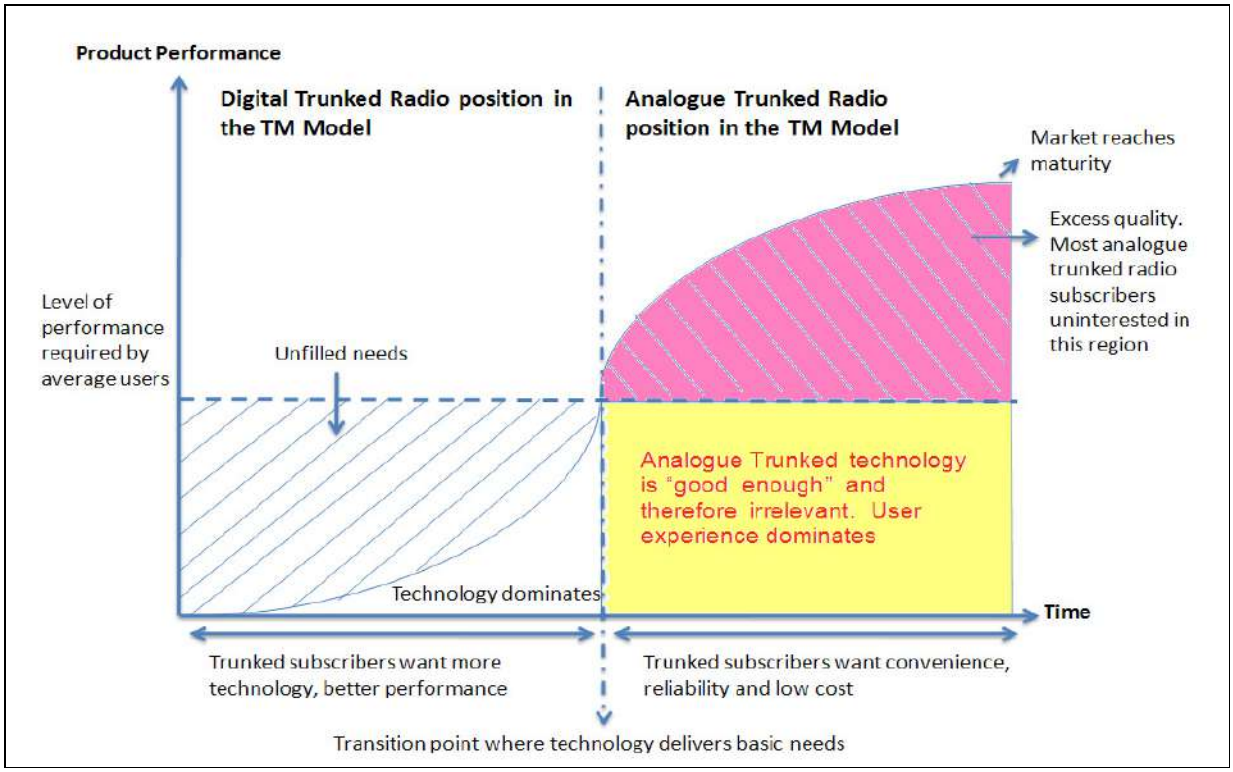
- As the serviceable life of the analogue trunked radio systems comes to an end, the analogue system maintenance and operating costs will increase as replacement parts and support for the systems are harder to find.

In many cases, this will lead to a decreasing ROI and eventually followed by a negative ROI where the return line is unable to sustain above the cost line.

Technology Maturity Model

The current trunked radio market offers two types of systems – the analogue trunked radio and the digital trunked radio. Looking at the present market situation, the market size for the analogue trunked radio is larger than the digital trunked radio market. At present, the analogue trunked radio market has already reached a maturity including the analogue technology. In this phase, looking on the demand side, the system has already satisfied the basic needs of the end-users. When this happens, end-users now seek efficiency, reliability, low cost and convenience or ease of use. These are the existing offerings of the analogue trunked radio system. Once the level of performance has met the requirements of the average end users, improvements in technology have lost its value for end users thus, they tend not to buy new technologies. This is illustrated in the analogue and digital technology maturity model graph below.

Technology Maturity Model (TM Model)



Source: Adapted from Growing Up: Moving Technology-Centered to Human-Centered Products and SKMM

On the supply side, as marketplace matures, other pressures start to build up. In this phase, there are now either multiple competitors or high competitive pressures within the industry itself and each is able to satisfy the customers' technical requirements. The analogue trunked radio products and equipment can no longer be differentiated by features and each and every competitor within the industry has comparable technology with equivalent performance, so other dimensions of the analogue trunked radio products now take on added relevance such as reliability. The service providers of analogue trunked radio are no longer technology-driven companies – they are considered as a service-driven company. For example, all analogue trunked radios provide the basic voice applications, one-to-one and one-to-many talk features. Now, the importance of ease of use, reliability and convenience takes centre stage.

Eventually, with multiple competitors within the industry and cost-sensitive buyers in the market, profit margins of the service providers drop due to decreasing prices and shrinking market share – a current reflection of the situation faced by analogue trunked radio service providers in Malaysia.

In this situation, the analogue trunked radio service providers need to step back and make a careful assessment of the market situation and trends. If service providers want to grow, they must change the way things are done and change their product offerings**.** Growth here will only be fuelled by technology enhancements and service providers must transform themselves back into a technology-driven company where products are marketed on the basis of their features, technological claims and superiority to capture the early adopters[32] who want better technology advantages and better performance. Given time and the right marketing strategy, users will demand better technology and more features, regardless of cost or inconvenience. Here is where the digital trunked radio is currently positioned in Malaysia, at the point of the curve where technology dominates, offering many new or added advantages in use and applications. At this position, early users are relatively few as in the case of digital trunked radio systems market in Malaysia. Over the years, the number of users will grow until it reaches a maturity just like the analogue trunked radio systems.

Company Financials

Source of Financial Accounts

The financial analysis in this report is based on individual accounts of the trunked radio service providers available to SKMM. The financial status of eight trunked radio service providers out of the 17 between the years 2003 and 2008 could be analysed in time series. This is as a result of incomplete accounts or no submissions of accounts and data that is available for comparisons.

Size of Market by Revenue

The overall market for trunked radio in Malaysia is indicated to be about RM68 million by revenue, with retained earnings available for future investments by this segment to be between RM20 and RM25 million[33]. Over the past four to five years, the overall trunked radio industry in Malaysia has not grown.

Size of Companies

In Malaysia the trunked radio industry in Malaysia comprise a mixed group of companies that range from big organisations with share capitals ranging between RM30 million and RM1 million to some smaller firms with share capitals between RM50,000 and RM200,000.

Financial Performance

Based on the financials, the larger analogue trunked radio service providers are seen able to sustain a positive financial standing over the years with their revenues and net profits increasing and remaining stable. There are also smaller analogue trunked radio service providers who continue to experience financial difficulties with significant decline in revenues and net income or experiencing serious net losses over the years. Noteworthy, the service providers that are currently or recently providing the digital trunked radio services are also undergoing operating and net losses. This is noted as a temporary setback to eventual better ROI.

In terms of operating margin, the impact of margin varies for each service provider. For service providers with stable operations and a larger subscriber base, they maintain a

---

[32] Early adopters are people who buy new products because they love the technology and are willing to take risks on the products and pay high costs to obtain them.

[33] Estimation derived from the accumulated profits or retained earnings of as available data from the service providers based on the financial accounts with SKMM. This will indicate how much money the industry has for future investments and developments to digital.

higher operating margin whereas the smaller service providers show negative operating margin. Nevertheless, the overall operating margins across the industry have contracted and are expected to contract even further, due to continuous decrease in revenue and operating income if they remain in the analogue segment which is already experiencing limited growth.

The service providers within the industry in Malaysia are in fact reporting decreasing profit margins where some are experiencing negative profit margin. Moreover, there are also service providers, especially many smaller players who post losses. The pressure on margins and loss positions are the result of heavy competition within the market itself as service providers are lowering prices of the analogue trunked radio services due to market pressures and maturity. However, a larger service provider like Electcoms Berhad did post profit margin ranging from 10% to 67% over financial year ending 31 January for years 2004 to 2007 respectively. In contrast, service providers like Segi Maju Sdn Bhd and Electcoms Wireless Sdn Bhd post fluctuating negative and positive margins likely due to investments in digital infrastructures.

Summary and Observations

Overall, the financials of these service providers offer an overview of how the trunked radio industry is performing in Malaysia. Based on the earnings as well as the operating and profit margins, we can infer that the trunked radio market and industry are not as financially sound as we would like them to be, with only three to four companies seen as being able to sustain their business on stronger financial performance. These are the service providers that will be able to outdistance the others in terms of earnings in a longer run and are most likely able to migrate to digital trunked radio systems in the immediate future.

It appears now that perhaps the greatest challenge for all trunked radio service providers in Malaysia at the moment is maintaining favourable revenue and long term survival. In solidifying the future of the market and the industry and upon examining the financial performances of the trunked radio service providers, consolidation among trunked service providers can be at their advantage. Such an approach is technically and financially feasible. In our opinion, it will offer significant improvements for operational efficiency and increase the availability of resources as well as capital to expand the industry. This is not only to reinforce the profitability of the better performance larger companies, but also to offer the smaller trunked radio service providers a chance to continue to be in the market and a profitable status at that.

Conclusion Based on Both the Economics and Financial Trend Analysis

When analysing both the economic, financial and cost perspectives of the trunked radio service providers collectively, we can further conclude the following for the trunked radio service providers in Malaysia:

1. ***The business life cycles of the analogue trunked radio service providers have been shortened***

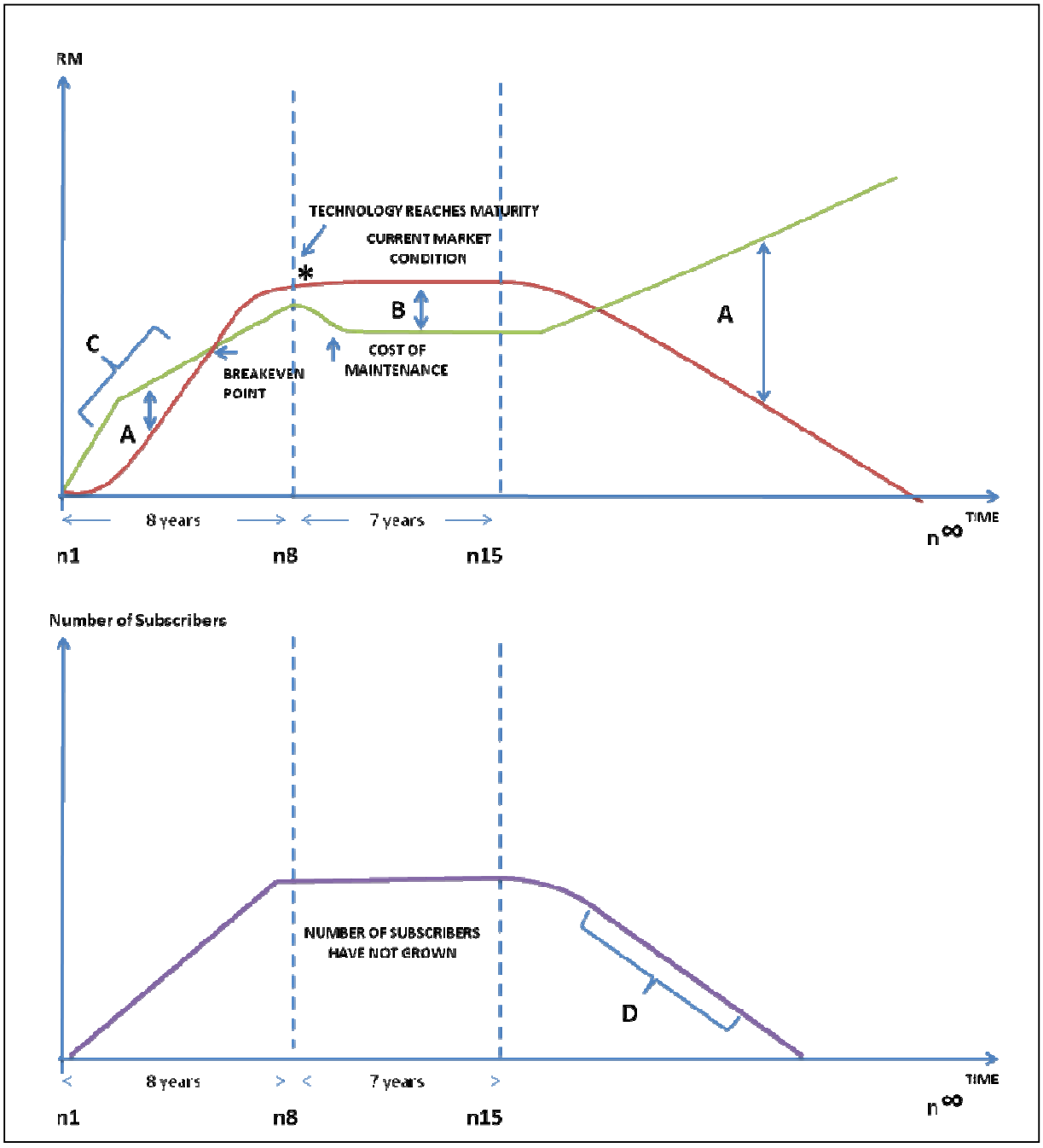
   Theoretically, it can generally be deduced that it takes 21 years to reach the actual end-of-life for trunked radio systems infrastructure and before its ROI begins to decline. However, the observation from the analysis on the financial performances of these analogue trunked radio service providers in Malaysia indicates otherwise. Although the infrastructure that they own may still have a few more years of serviceable life, most analogue trunked radio service providers in Malaysia are already experiencing a loss with either a declining or a negative ROI over the last few years. Hence, under these two circumstances, the business life cycles of the analogue trunked radio service providers have in fact reduced to less than the 21 years as indicated from the few companies that only have profit margins at all.

   In the Malaysian market, there are two scenarios. The market for scenario 1 refers to service providers who are still able to sustain their operation with positive revenues and profits and the market for scenario 2 reveals that there are some service providers who are already unable to sustain their operations as revenues are decreasing with losses incurred over the last few years. These scenarios are depicted by the graphs below, which is an adaptation to the earlier graph that shows that it takes about 21 years before an analogue trunked radio service provider sees a decline in ROI.

Scenario 1

Scenario 1 depicts the current situation faced by some of the larger analogue trunked radio service providers in Malaysia. Observation of their financial performances shows that these service providers have sound financial background that will enable them to sustain their operations in the next few years but risk facing further decline in profits and revenues soon. Service providers such as these are most likely to be able to migrate to digital trunk radio system when required. Granting this, these service providers should give serious consideration to upgrade and migrate to digital now. If an upgrade is delayed any further, the potential for its financial resource capability to upgrade to digital will likely cease.

Scenario 1: Actual Business Life Cycle of Larger Analogue Trunked Radio Service Providers in Malaysia



Source: SKMM

Legend for Graph in Scenario 1

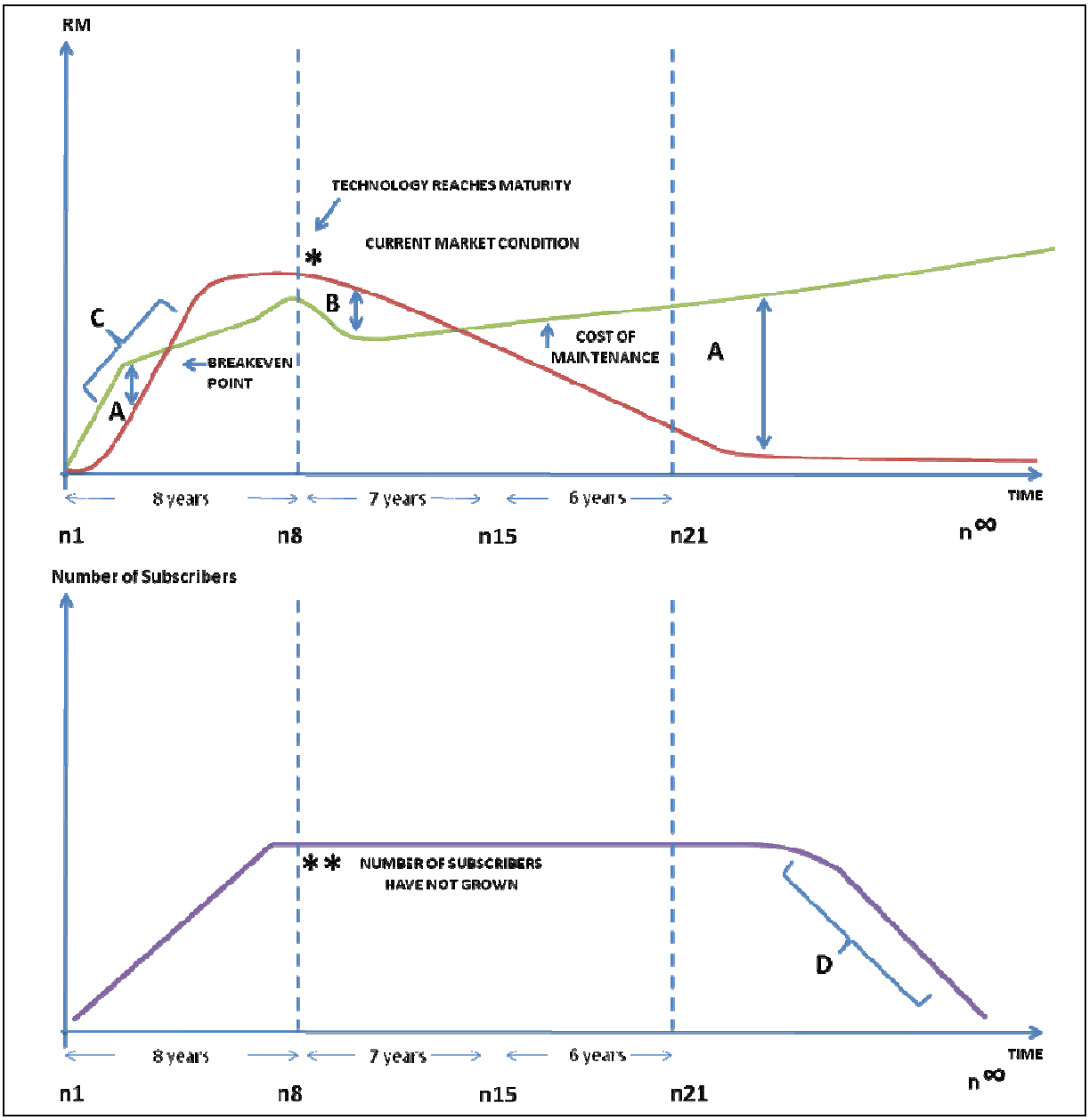
	Number of subscribers Investment cost Return	**B**	Positive ROI (Return > Investment cost)
* **	Technology reaches the point of maturity after 8 years. Market reaches the point of maturity (No growth and number of subscribers remain)	**C**	Initial investment ▪ Install new base stations ▪ Buying new systems ▪ Purchase of stocks, handsets, terminals and other equipments ▪ Purchase of software ▪ License fees and the like
A	Negative ROI (Investment cost > Return)	**D**	Losing number of subscribers as some have migrated to using digital trunked radio

Source: SKMM

Scenario 2

The graph in scenario 2 shows the situation of some of the smaller analogue trunked service providers who are facing financial difficulties. The business life cycle of these service providers have been reduced even further as they are already incurring serious losses in the past few years and can barely sustain their operations. From their financial performances, revenues are showing a decline, and their operating and profit margins have contracted to a loss. Hence, it will be challenging for these analogue service providers to migrate to digital now and in the future as they barely have the resources and financial capital to do so.

Scenario 2: Actual Business Life Cycle of Smaller Analogue Trunked Radio Service Providers in Malaysia



Source: SKMM

Legend for Graph in Scenario 2

	Number of subscribers Investment cost Return	**B**	Positive ROI (Return > Investment cost)
* **	Technology reaches the point of maturity after 8 years. Market reaches the point of maturity (No growth and number of subscribers remain)	**C**	Initial investment ▪ Install new base stations ▪ Buying new systems ▪ Purchase of stocks, handsets, terminals and other equipments ▪ Purchase of software ▪ License fees and the like
A	Negative ROI (Investment cost > Return)	**D**	Losing number of subscribers as some have migrated to using digital trunked radio

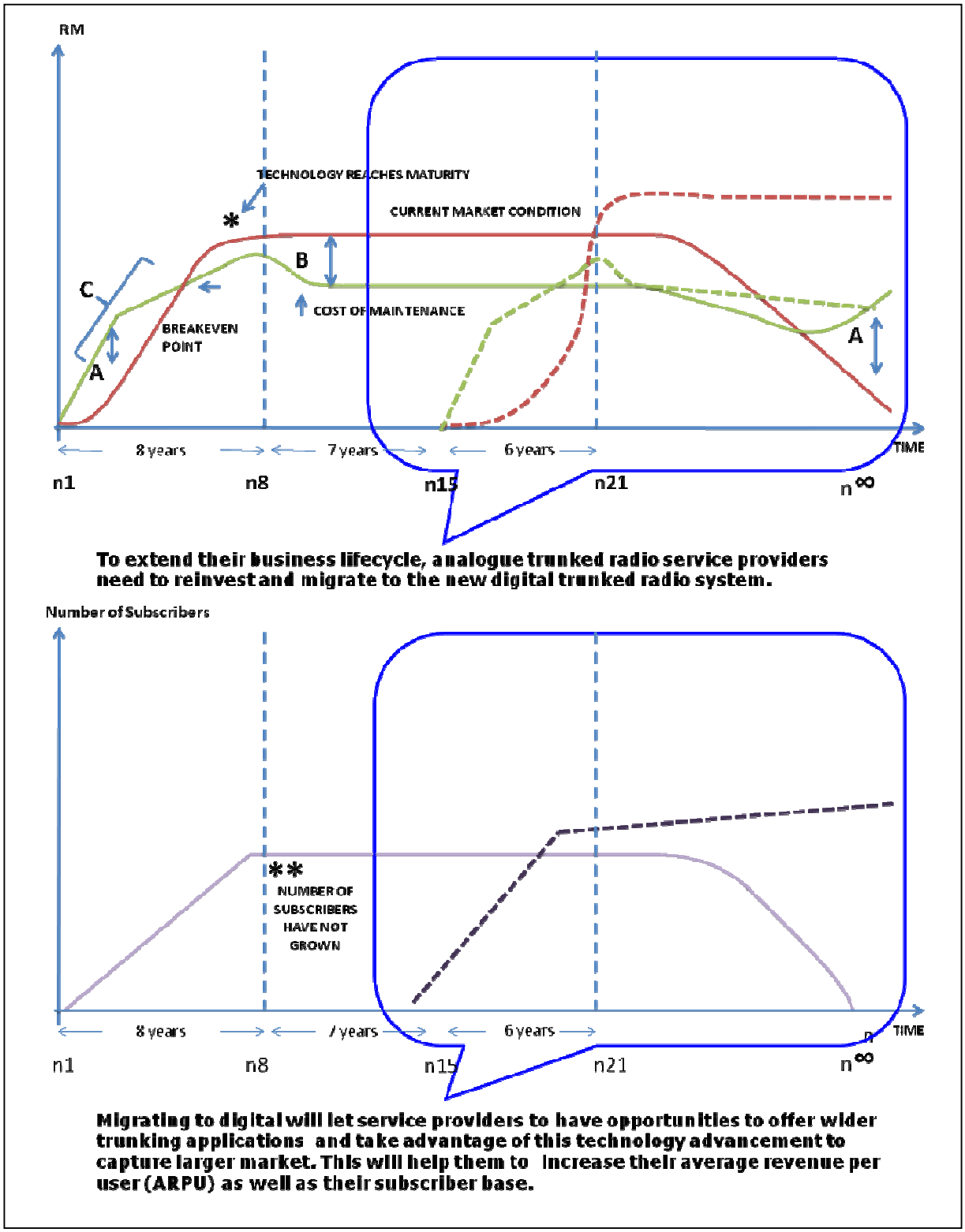
Source: SKMM

2. Analogue trunked radio service providers need to invest in digital trunked radio to rejuvenate their business.

As mentioned previously in the technology maturity model, growth will only be fuelled by technology enhancements and service providers must transform themselves back into a technology driven company to reap the advantages of technology. Thus, to rejuvenate their business life cycle and grow, analogue trunked radio service providers need to invest in digital. By investing in digital, they are able to improve revenues, and sustain and expand their operations as digital trunked radio systems are able to offer more applications to a wider subscriber market as compared to analogue. This in turn will increase ARPU and decrease customer churn for the service providers.

The graph below illustrates this. Although at the beginning, trunked radio service providers may endure a period of losses as they ramp up their operations, they will be able to sustain or rejuvenate their business again with improved revenues as compared to the basis of continuing their analogue trunked radio operations only.

Trunked Radio Business Life Cycle: Rejuvenation through Digital



Source: SKMM

Legend for Graph on Trunked Radio Business Life Cycle

	Number of analogue subscribers		Number of digital subscribers
	Investment cost for analogue trunked radio		Investment cost for digital trunked radio
	Return for analogue trunked radio		Return for digital trunked radio
*	Technology reaches the point of maturity after 8 years.	B	Positive ROI (Return > Investment cost)
**	Market reaches the point of maturity (No growth and number of subscribers remains)		
A	Negative ROI (Investment cost > Return)	C	Initial investment ▪ Install new base stations ▪ Buying new systems ▪ Purchase of stocks, handsets, terminals and other equipment ▪ Purchase of software ▪ Licence fees and the like

Source: SKMM

3. ***Consolidation is an obvious choice especially for smaller analogue trunked radio service providers for sustainability***
   With deteriorating revenues and increasing losses, migration to digital trunked radio system is far from possible especially for the smaller service providers. Today, those who have been able to migrate have sound financial background. Even then, the initial investment costs have taken a toll on their preliminary financial status, as is expected when investing in digital technology. As such, in order to sustain their businesses and ensure that there are enough resources and capital, consolidation would be a viable option for business viability.

BUSINESS MIGRATION MODELS FOR TRUNKED RADIO SERVICE PROVIDERS

Financial capability is indeed the central element to be focused at for every company that wants to pursue the migration towards digitalisation. Shifting from its analogue legacy system to digital means they need to spend huge capital investment for the deployment of this new system. Some companies face no major hindrance in their migration process to digital due to their solid financials records.

However, for some other companies, they may need to work on a new different business migration model in order to make the migration plan successful for their companies. Different companies need different business model. Suitability evaluation based on financial aspects and business plan are key points to facilitate the process of building up a new business model.

Here, we have put together three possible business migration models that may be suitable and feasible for trunked radio service providers in Malaysia to embark on a migration based on the current state of the industry and present financial strength of each company.

Business Migration Model 1: Companies Consolidate Into a Consortium
In this business migration model, analogue trunked radio service providers consolidate to form a consortium which will represent the best interest for all companies involved. This consolidation will help companies to combine their economic capacity in order to prolong their business and uphold their operations. As a result of this consolidation, the newly-formed consortium will eventually have enough financial resources to carry out the most crucial part, which is the investment for the new digitalised infrastructure,

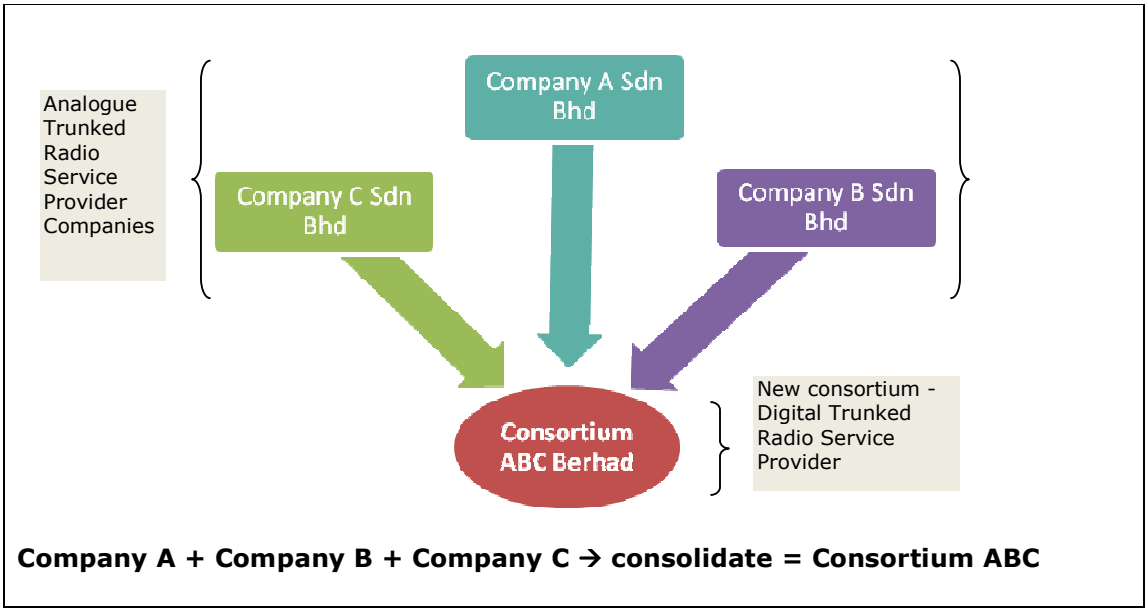
where initially that investment cost seemed to be too much to be borne by one analogue trunked radio service provider.

This model is suitable for companies that do not want or have the capabilities to entirely transform as a digital trunked radio service provider on an immediate basis and as a single entity due to many reasons, including weak financial status.

In terms of subscriber base, the number of subscribers will come from each of the companies where it will then be shared and slowly migrated to be placed under the new consortium. This is another advantage of consolidation, where not only financial capital is now shared as joint inputs, but companies involved can also take advantage if subscribers migration is combined and planned strategically.

This business migration model can be illustrated in the diagram below, Company A, Company B and Company C which originally operate as different analogue trunked radio service providers, consolidate and pool money and resources to be Consortium ABC, where it will then operate as a new consortium, providing fully digital trunked radio service in the allocated spectrum band and required licence.

Consolidation of Companies to be a Consortium



Source: SKMM

Business Migration Model 2: Wholly-owned Subsidiary

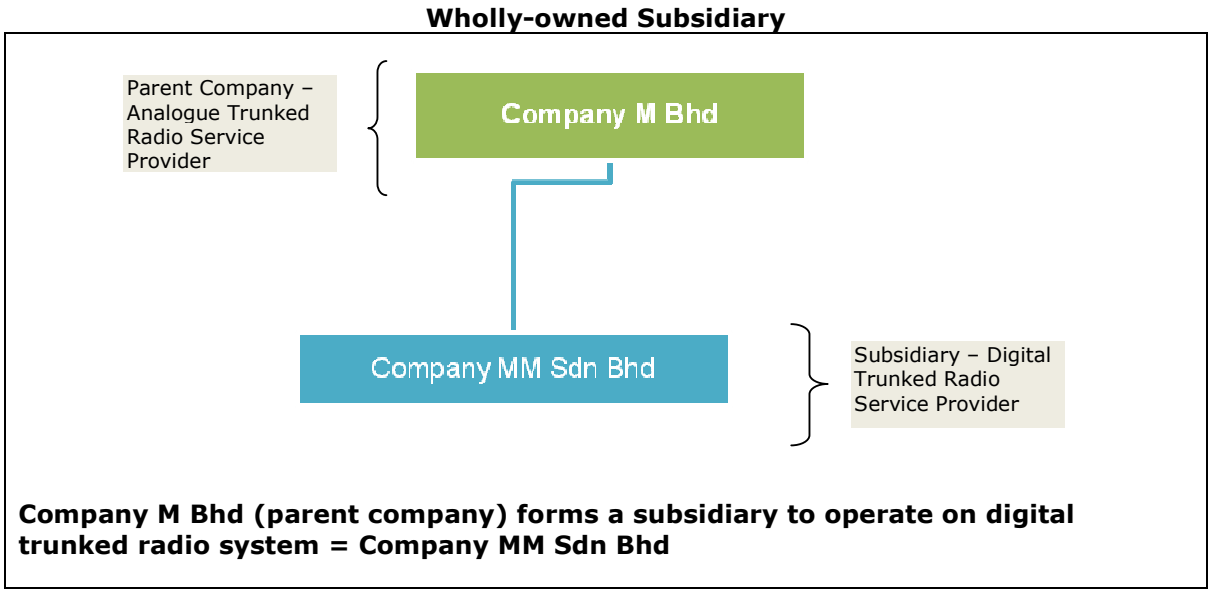
This model is a contrast to the first model whereby the company does not combine with other companies to be a new consortium but instead form a subsidiary, wholly owned by the parent company, but operate differently at the same time.

The parent company, which is an analogue trunked radio service provider, constructs its subsidiary to operate as a digital trunked radio service provider. Both will operate in parallel with different types of service orientation (one is analogue and the other is digital) but are meant to support each other at any time when it is needed. Operating upgraded and legacy systems in parallel is a common transition strategy for systems of this type.

The initial investment outlay also comes from the parent company with most of the initial cost for operation will be pumped in by the parent company. The parent company will gradually discontinue its analogue trunked radio services and operate together with its subsidiary as a digital trunked radio service provider later on.

This model is an ideal option for a company with steady financial performances and has immense excess in revenue and retained earnings over a long period of time. Although, the number of subscribers would not be a combination of subscriber's base of many different companies as in the previous model, the parent company will migrate its analogue subscribers to their new subsidiary which operates for digital trunked radio services in phases.

Diagram below shows Company M as the parent company forming a new subsidiary, Company MM to operate as a digital trunked radio service provider in parallel to its analogue trunked radio services.



Source: SKMM

Business Migration Model 3: MVNO Model

This model is based on Mobile Virtual Networking Operator (MVNO) which exists in the mobile cellular industry and has been practised by many large and small companies globally. In the mobile cellular industry, MVNOs need not build up their own infrastructures, but instead, they rent the network from Mobile Network Operator (MNO), which usually is the major and key mobile operator in the country that owns the complete infrastructure needed for full deployment of cellular network communications. MVNOs are able to save money from renting the network from MNOs since they are not spending any cost in building base stations or any other expensive core infrastructure.

Based on this model, it is feasible for analogue trunked radio service provider which does not have financial capability to build such costly infrastructure, to rent the capacity from an established digital trunked radio service provider. This model, however, will be feasible, if only there is an established company which wants to rent out their capacity to the smaller company.

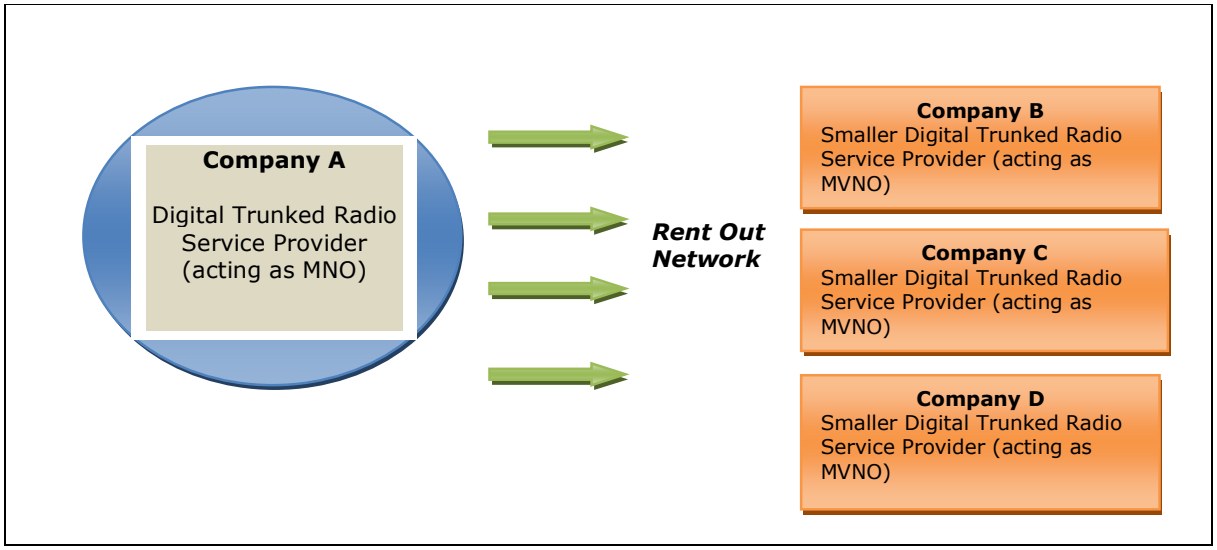
This report does not explain in detail the costing of renting out the capacity, but through industry observation both companies are capable to make good working returns using this model, giving that both are doing business on an agreed wholesale rate of charges which is based on bilateral agreement. Depending on their needs, they can operate as thin or thick MVNOs[34].

[34] *Perspective on MVNO is based from the cellular mobile market and Guideline on Regulatory Framework for 3G Mobile Virtual Network Operators, February 2005. MVNO is an organisation that does not have assignment of 3G spectrum but is capable of providing public cellular services to end users by accessing radio networks of one or more 3G spectrum holders.*

This model also provides opportunity for smaller companies to follow suit the transition trend without jeopardising their business life-cycles. They can also take some time to draw enough financial resources as well as operational exposure before going for full deployment of digital system.

Diagram below shows how the 'MVNO' model takes place.

MVNO Model for Trunked Radio Service Providers



Source: SKMM

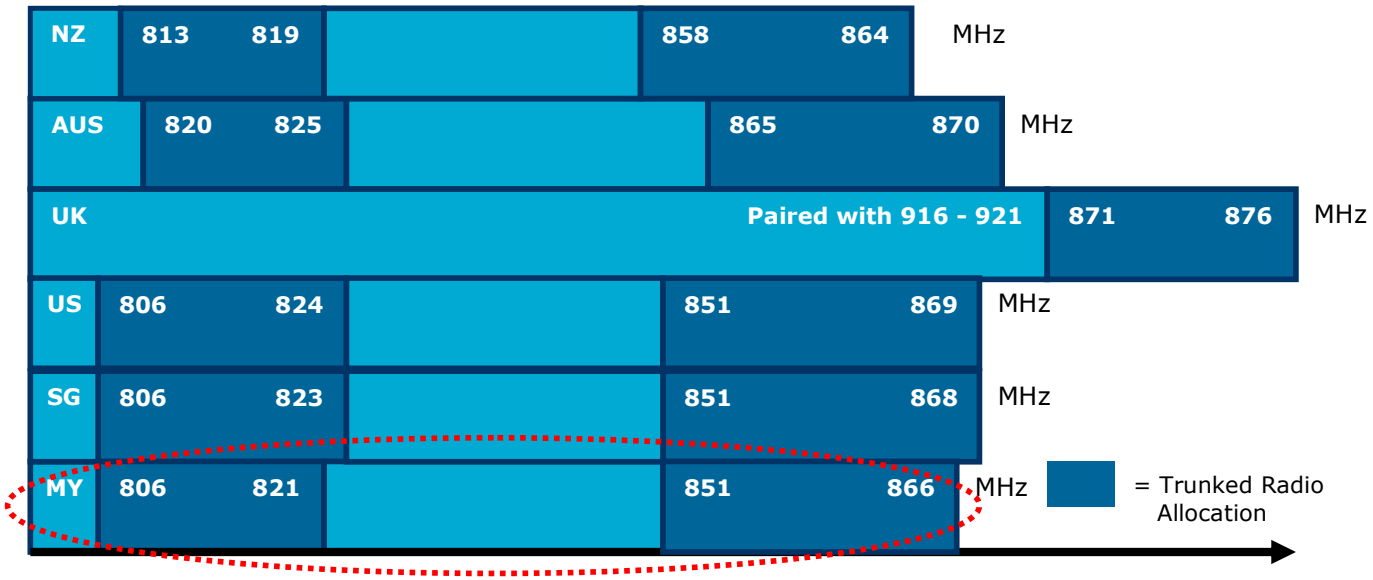
MIGRATION PLAN IN MALAYSIA: FROM ANALOGUE TO DIGITAL TRUNKED RADIO PLATFORM

Globally, the market for trunked radio systems operating on 800MHz bands has existed for some time. However, as a result of the last World Radio Communication Conference (WRC) decision in 2007 which included the 800MHz band in the IMT band, studies are being carried out to consider the migration of the trunked radio services in Malaysia to other bands in the near future.

The 800MHz Trunked Radio Services in Malaysia

In many countries such as US, UK, Australia, and New Zealand, the frequency band, 800MHz has been allocated for the general or commercial market for trunked radio systems as summarised in the diagram below:

Summary of 800MHz Private Trunked Mobile Radio Bands in Malaysia, Singapore, US, UK, Australia and New Zealand



Source: Adapted from Digital Trunked Land Mobile in the 800MHz Band: An Engineering Discussion Paper, Radio Spectrum Policy and Planning Group, Energy and Communications Branch, Ministry of Economic Development, May 2007

The diagram shows that US, Australia and New Zealand have significantly harmonised spectrum arrangements in the 800MHz band. This also includes Singapore and Malaysia.

Currently, all trunked radio system services operating in Malaysia are using frequency bands between 806MHz to 821MHz and 851MHz to 866MHz with a total bandwidth of 2 x 15MHz. This frequency band is divided into three blocks which are Block A, Block B and Block C. The frequency bands for operation of trunked radio systems were first introduced in Malaysia in 1990 and have been used for the same purpose so far. In 2006, SKMM approved an inband migration plan from analogue to digital with a target completion by December 2008. However, this target could not be achieved and is currently under review.

The frequency allocations for trunked radio system for Public Network and Private Network are shown below:

Frequency Band 806MHz to 821MHz and 851MHz to 866MHz

BLOCK	Transmit Frequency (MHz)		Receive Frequency (MHz)	
	From	To	To	From
A	851	856	806	811
B	856	861	811	816
C	861	866	816	821

Source: SKMM

Based on a study on the market and technology trends of the digital trunked radio systems in the 800MHz bands, SKMM finds that there is no lack of equipment availability for digital trunked systems using 800MHz band in the Malaysian market today. There are many choices of equipment that can support digital system and use digital technology standards.

Nevertheless, it is well understood that presently, digital trunked radio systems cost much higher than the analogue systems mostly on the user terminal side. Prices may vary from one technology to another depending on the technology or standards used.

It is also recognised that the analogue market is now mature while the digital market is inevitably replacing the existing analogue system. When this happens, within the next three to five years, digital systems will be considered mature with price levels finally becoming comparable to the analogue systems.

Migration Status and Future Plan: 400MHz Frequency Band

As at second quarter of 2009, there has been some migration of analogue to digital by service providers although others have yet to migrate. Some of the service providers like Electcoms Wireless have already begun the migration to digital and currently have 42 sites operating on digital systems. Segi Maju Consortium on the other hand, has obtained their digital system in early 2009 and will be deploying their phase one by third quarter 2009, covering three sites in the Klang Valley. Electcoms Wireless is operating using GoTa system from ZTE while Segi Maju Consortium is using TETRA system. The other consortiums have yet to make any significant move to migrate to digital.

At present, SKMM is studying the proposal to move the 800MHz trunked radio systems to the frequency band of 410MHz to 430MHz. This proposal is driven by the decision from the WRC. The WRC 2000 and 2007 have identified for the 800/900MHz band (790 to 960MHz) to be allocated for IMT future mobile service. The digital dividend band (790 to 862MHz) is likely to be re-farmed by 2012 in Europe and 2015 in Asia Pacific. As such, SKMM is also planning to prepare this 800/900MHz band to be used for future mobile services (IMT), which might need a re-farming on the spectrum in order to allow IMT to be introduced.

If the plan is approved, the proposed move will make the 400MHz band, which is the 380 to 400MHz and 410 to 430MHz, the primary band for radio trunking. The propagation characteristics of the band is ideal for large area coverage with a small number of base stations, giving rise to lower infrastructure cost as compared to the 800MHz band. Some service providers have already shown keen interest to perform trial for their digital trunking system to operate in 410 to 430MHz frequency band.

LICENSING REGIME FOR TRUNKED RADIO SERVICE PROVIDERS IN MALAYSIA

In Malaysia, the trunked radio service providers are regulated by the Malaysian Communications and Multimedia Commission (SKMM). Under the Communications and Multimedia Act 1998 licensing regime, as the trunked radio services in Malaysia are serving a niche market, the service providers were previously classified under the class licence category where it requires less or minimal regulation.

However, as service providers are now required to migrate from analogue to digital in the near future, SKMM now requires the consortiums to apply for the individual licence category. With much wider new applications, the digital trunked radio technology will be able to serve a potentially larger market base as compared to analogue trunked radio.

Currently, three Consortiums in Malaysia have been placed under the individual licence category as they have or in the process of rolling out digital trunked radio service soon. These Consortiums are Electcoms Wireless Sdn Bhd, Segi Maju Consortium and DTRS Consortium.

THE WAY FORWARD FOR TRUNKED RADIO: WHAT WILL THE FUTURE BRING?

In order to meet the challenges of the future, users and service providers must act now to ensure that future systems and technologies are capable of providing the required critical services.

Going Digital

No doubt that at the end of the day, the shift towards digital is eminent in most parts of the world including Malaysia. Hence, in the quest to take advantage of the many benefits of digital services upon migration, trunked radio vendors and even service providers have to ensure that their technical blueprint and commercial roadmap are ready for the change. These should include the following as suggested by VDC:

Suggestions by VDC for Digital Migration

• **Availability of multimode (analogue and digital) radios to enable a more seamless transition and support backward compatibility with legacy analogue systems**
• Competitive pricing with existing analogue solutions with premium not to exceed 20 – 30%
• Development of form factors that better support wireless data applications, especially improved user interfaces and intuitiveness
• Improved leverage of the security capabilities of digital technologies

Source: Venture Development Corp.

In fact, according to Analysys Mason, when end users and service providers fail to embrace change, there are different effects for both as illustrated below:

Effects When Fail to Embrace Change

Operators	End Users
• Loss of customers as they migrate to other networks that can offer advanced features, such as high-speed data, potentially resulting in costly sunk investment • Increasing risk of obsolescence as the network matures up to the point where current equipment is no longer supported and retrospective work is required to implement alternative solutions possibly leading to disruption to end users and additional costs	• For managed services, the end user may be put in a weak negotiating position, where the operator can 'hold them to ransom' knowing that any migration will be difficult • If the network is not meeting new business requirements, additional expensive short-term solution is necessary • As a network comes towards end of contract/network life, the operator is likely to be less focused if it anticipates that the end user will migrate

Source: Analysys Mason

According to VDC, the following are developments that will drive the trunked radio market towards digital:

New Applications That Will Drive Market towards Digital

New Developments	Details
Wireless data applications	Wireless data applications may represent the key missing ingredients. Wireless data opportunities are expected to be a critical factor driving next-generation PMR adoption, especially among emerging user segments.
Broader sets of applications	Users are not looking for improved performance in terms of solutions, but they are looking to support a broader set of applications.
Digital standards	The emergence of several accepted global digital standards and critical factors accelerating the transition.
Voice	Voice will remain the killer applications especially among traditional users such as public safety. Enhancement of voice capabilities and quality are significant investment drivers themselves.
Complex applications	While standard and data application such as messaging are fairly common, requirements for more complex applications that improve worker productivity and field-based communications at the point of interactions are emerging.
GPS and LBS	Core users are increasingly leveraging on GPS and LBS such as automatic vehicle location
Video support	Support of video for remote monitoring and surveillance represents critical growth segments.

Source: Venture Development Corporation, RadioResource International. 2009

Consolidation of Service Providers

Service providers should also look into consolidation to build a strong platform to compete. Although the industry has not grown much in size, but a strong consolidation in the market will help increase shared resources that will lead to market growth and enable scalability. Through consolidation, service providers can earn economies of scale to enable them to even compete with similar offerings in the market and fund the increased technology investment needed due to market growth and increased client and product sophistication. At the moment, the trunked radio services industry in Malaysia is currently made up of a small number of relatively large players. However, in the coming years, there is an indication that the industry and its players will face crossroads. As the analogue trunked radio market reaches maturity, service providers need to identify future growth opportunities which can be done more effectively through

consolidation. Following this, a post-market consolidation will see service providers focusing on developments of new products and service offerings.

Overall there are many good reasons for consolidation:

- There is a slowdown in market growth as seen in the analogue trunked radio market globally.
- New entrants into the trunked radio industry in the future will create price pressures for incumbents, especially when the price levels for digital trunked radio equipment fall.
- Leveraging on economies of scale to improve operational efficiencies in terms of infrastructure, integration, standardisation and customer base.
- Continuous regulatory evolution in the communications industry and technology standardisation will enable service providers to integrate their solutions easily.

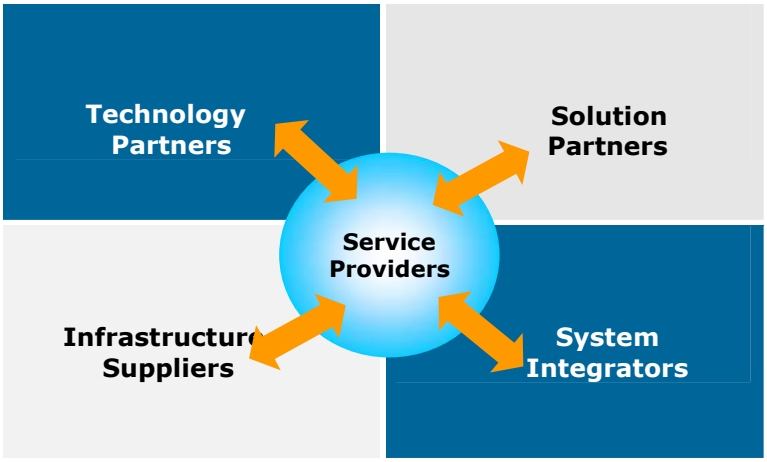
Such strategy of consolidation is employed by service providers and dealers in the US for operational efficiency[35].

Cross Collaboration and Strategic Partnerships with Manufacturers and Developers

With the spread of cellular wireless trying to capture the wireless business market share and creating a more competitive environment, trunked radio service providers in general are losing out in the communications industry. Under these circumstances, to survive the competition, service providers in Malaysia not only need to consolidate as a viable option but also need to go into cross collaboration or strategic partnerships with manufacturers and developers. Such strategic move to work together as one to develop and support applications can drive the development of better solutions to customers in terms of nationwide network on seamless system, with better quality of service.

Faced with the changing industry trends, innovativeness and new applications for trunked radios will soon drive the market forward in the future towards digital. So is the requirement for a sustainable business ecosystem. Operators who can adapt or adopt changes to their strategy can build sustainable business models outside of traditional service areas. This is no longer the time to work in silos as it is not sustainable in view of the intense competition existing in the communications markets today. Strategic partnerships also enable customisation of products according to the needs of a wider range of end-users, which opens new market opportunities within the industry. This cannot be done if service providers work only on their own.

Sustainable Business Models for Trunked Radio Industry Ecosystem



A sustainable business model for the trunked radio industry in Malaysia encompasses players working together in a strategic partnership as shown in the diagram below. A suitable ecosystem enabling discussion and forum to solve problems and develop solutions will stimulate the growth of new innovative applications leading to new radio trunking products, solutions and services.

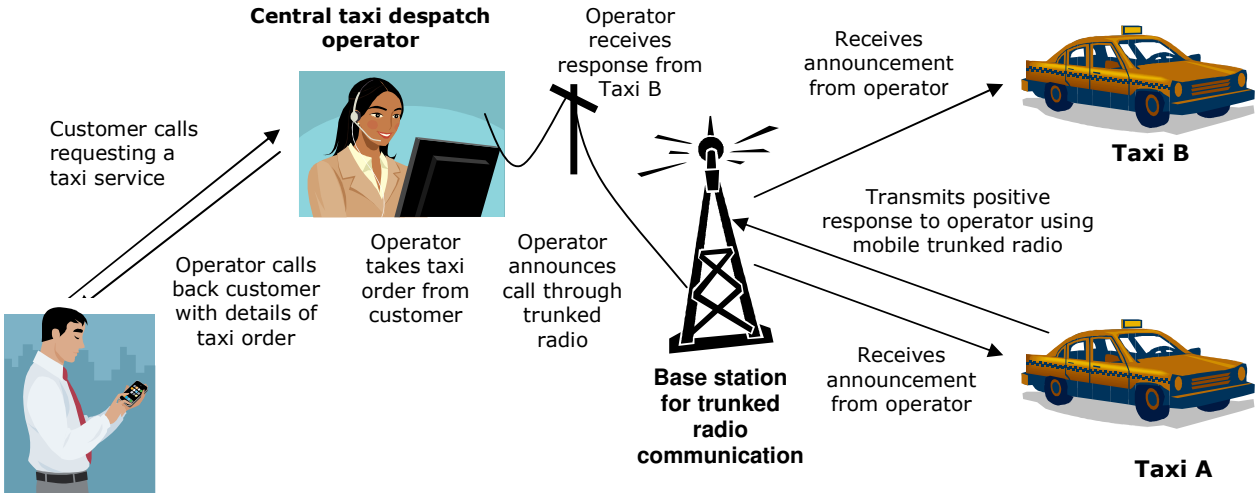
Source: Adapted from various websites.

[35] *An example of US dealers banding together for operational efficiency can be found in the article, Dealers Form Digital SMR Consortium, 27 May 2008, http://www.radioresourcemag.com/onlyonline.cfm?OnlyOnlineID=97*

Case Study on Convergence in a Taxi - The Integration of Innovativeness and New Applications: Taxi Fleet Management

An example of collaboration for innovativeness and new applications in radio trunking is the taxi fleet management system. Currently, the taxi fleet management systems in Malaysia consist of simple two-way voice radio communications using radio trunking as shown in the diagram below. Sophisticated fleet management system as in Europe is not in place at the moment in Malaysia.

Taxi Fleet Management in Malaysia



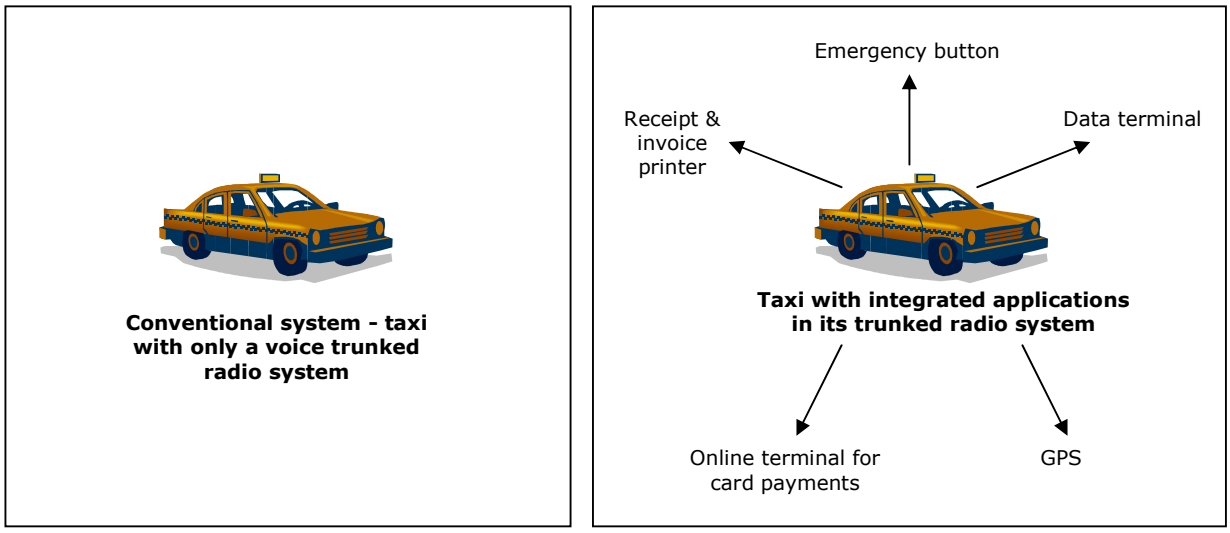
Source: Adapted from various websites.

Relying solely on radio trunking communications through a central despatch centre, efficiency in taxi fleet management is not optimised. The use of trunked radio system can be extended not only to communications but there are other new application areas that can be explored as well.

IndelcoStar, a company in Europe, uses innovation to integrate new applications into the trunked radio systems of taxis in Europe. The company has developed a dynamic taxi dispatch and management system for use in cities throughout Europe. The system developed by IndelcoStar is available in two modes – mixed and trunking. The trunking mode is used in crowded cities with many vehicles (taxis) located in a small area. In certain areas, there will be at least two base stations, one for data and one for voice. According to IndelcoStar, all taxis are connected over the data channels to the host. For voice connection, the selected taxi will be switched to the voice channel with all other taxis remaining on the data channels. At the end of the voice transmission, a control message switches the taxi back to the data channel. The host is responsible for the traffic on each channel. The layout of the system (number of base stations) is calculated from the expected load of the busiest hour of the year. Note that when one base station fails, the system will still work.

Furthermore, IndelcoStar has integrated additional applications into their radio communications systems as shown in the diagram below:

Examples of Integrated Applications in Trunked Radio Communications



Source: Adapted from various websites

The system integrates various innovative applications into the trunked radio system that requires the development of new hardware and software applications as well as collaboration across various manufacturers. In terms of hardware (equipment) and software, IndelcoStar collaborates with the following types of manufacturers and developers:

IndelcoStar Strategic Collaboration with Hardware Manufacturers and Software Developers for Integrated Trunked Radio System

Types of Hardware Manufactures/Makers	Types of Interconnect Software Developers
Data terminal	Auto booking software – to book taxi in fully automatic way without any human intervention
GPS receiver (antenna)	GPS software – to monitor the location of the vehicles of its fleet
Mobile trunked radio set	Computer Telephony Integration or CTI software – intelligent interconnection between the telephone workplace and the work station of the dispatcher. Dispatcher is provided with all the relevant information about the caller
Chipcard/smartcard/ magnetic card/credit card reader	Clearance of credit and cliental cards software – enables customers to pay by a payment card right in the tax and provides complete billing and administration of credit cards
Intelligent interface box that connects various equipment	Internet software – to book a taxi through web pages in fully automatic way
Emergency button	Invoicing software – enables invoice to be created directly for customers
Online server	Online optimising routes software – provides quick and exact meter of the price of routes

Source: fms Datenfunk Ltd. And Optimising taxi fleet management by Gunter Holpfer, Kapsch Fleet Management Austria

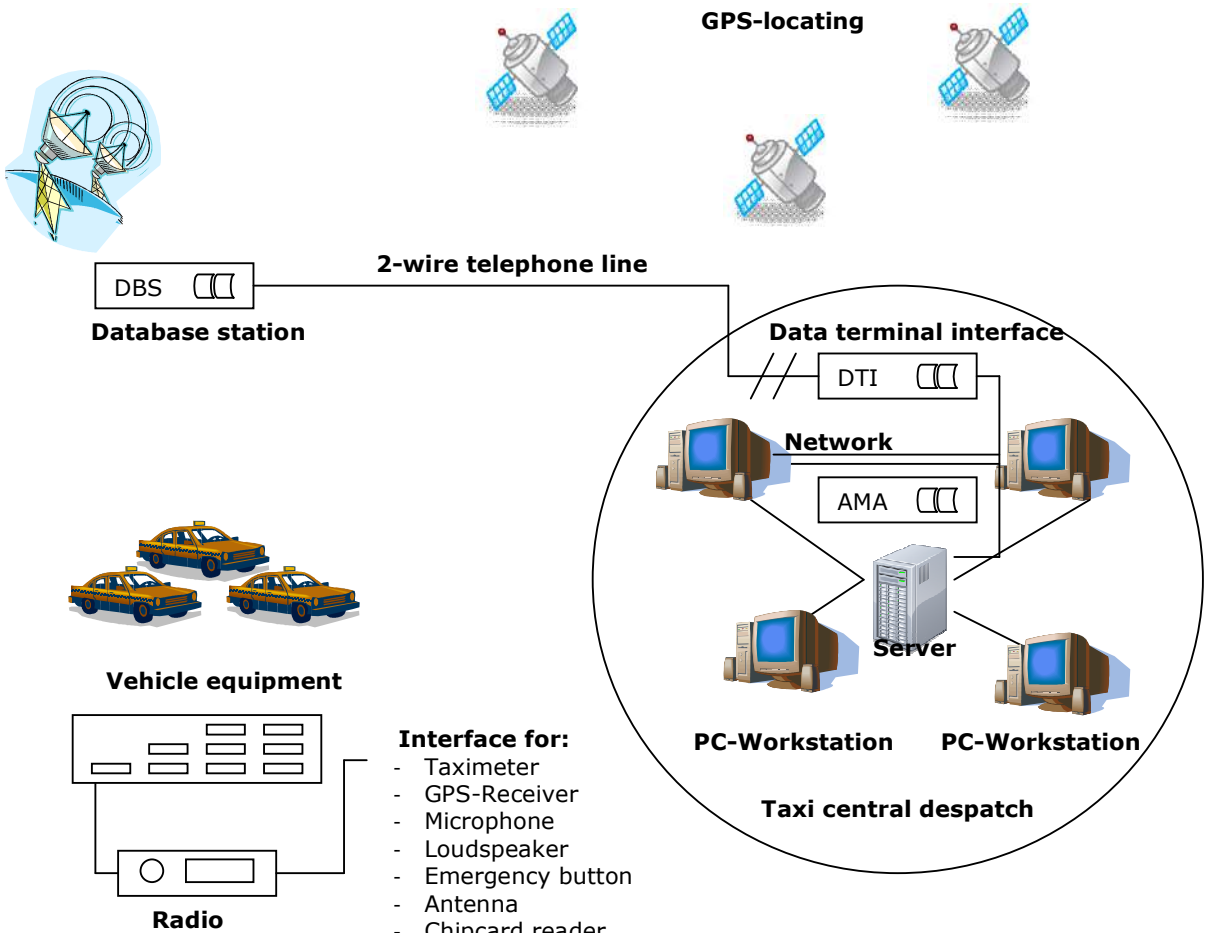
When a customer calls and orders a taxi service, this is received by the taxi despatch centre (TDC) and recorded by the operator at the workstation. Information on the address, alternative routes for getting there or the page in the road map are automatically taken. As soon as the address is logged, the nearest taxi with the shortest time of arrival is contacted by the computer. Once the driver accepts the order (all done within an acceptable time limit of, for example, 10 seconds), the computer will show the details of car number, current taxi status and driving time to the destination

in minutes to the telephone operator. This information is then passed on to the customers. For the driver, after accepting the trip, all relevant order information is sent to the taxi. Information is stored in the onboard computer until the order is completed by the driver. This information can be accessed at any time.

If the driver does not accept the order, the computer will immediately search for and contact the next nearest taxi. The TDC does not need to undertake additional work, as all this is done automatically through the computer system, which means that more calls can be received by the operator.

Upon servicing the customer, the driver logs in the time of pick-up and drop-off on the computer and this is recorded at the TDC. A customer can also immediately obtain the estimated waiting time of pick up through a synthesised voice message. All this is done through integration of applications with the trunked radio system by an intelligent interface box that controls the triggering of the interface. The system architecture is shown below:

Convergence in a Taxi: Integrated Taxi Fleet Management System



Source: Optimising taxi fleet management by Gunter Holpfer, Kapsch Fleet Management Austria

Examples of other applications that can also be integrated into the same system are security cameras, turn-by-turn navigation monitoring and fuel analysis. Integration of other applications into trunked radio systems can also be done for other operations.

CONCLUSION – SUMMARY OF KEY FINDINGS

In conclusion, key findings from this study have shown that:

1. There is a need for digital deployment for trunked radio as global trends have shown a shift in demand from analogue system to digital trunked radio. Migrating to digital can also enable service providers to rejuvenate their business life cycles.

2. There is a need to consider migration of the trunked radio operations in Malaysia to the 380/400MHz due to the decision made by the WRC to use the 800/900MHz band for IMT future mobile service in the near future.

3. Although the number of subscriber base is small and has not increased extensively, trunked radio service is an important communications system as it supports the critical industry needs including the security and emergency services that have significant economic and social impact. In the advent of going digital, service providers will be able to offer wider applications and serve potentially larger market. Hence, the earlier decision by SKMM to have service providers to operate under the individual licence category is in the right direction.

4. As digital trunked radio is able to offer wider applications, service providers can take the advantage of this to increase revenue through the creation of new services offered for a fee, thus increasing average revenue per user (ARPU). Through newer applications and services offered, customer churn for trunked radio services can also be reduced.

5. There is a need for service providers to also consolidate for business survival in the long term, let alone operational efficiency. Consolidation will help increase the availability of resources as well as capital to stay in business.

6. Therefore, there is a need for service providers to get into smart partnerships and strategic cross collaboration with manufacturers and developers for a sustainable business ecosystem today.

Overall, service providers, manufacturers and developers must continue to strive to be competitive by taking advantage of improved technologies, developing new applications through smart partnerships and technology transfers as well as implementing better marketing strategies as trunked radio offers end-users features not available from other wireless services. They must also continuously observe the international scenes, developments and industry demand for an indication on where the industry is moving towards and work to adopt or adapt accordingly for sustained viable business models.

However, creating public awareness about the benefits of these services remains one of the biggest challenges for service providers. Hence, regulators such as SKMM will also continue to work with service providers to improve the local regulatory environment so that trunked radio service providers can sustain and provide the much needed services to their clients.

ACRONYMS

3G	THIRD GENERATION	**LTR**	LOGIC TRUNKED RADIO
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE	**MCAS**	MULTIPLE CHANNEL ACCESS SYSTEM
AMR	ADAPTIVE MULTIPLE RATE	**MELPe**	MIXED EXCITATION LINER PREDICTIVE, ENHANCED
APCO	ASSOCIATION OF PUBLIC-SAFETY COMMUNICATION OFFICIALS	**MHz**	MEGA HERTZ
AVL	AUTOMATIC VEHICLE LOCATION	**MMS**	MULTIMEDIA MESSAGING SERVICE
CAI	COMMON AIR INTERFACE	**NASTD**	NATIONAL ASSOCIATION OF STATE TELECOMMUNICATIONS DIRECTORS
CC	CONTROL CHANNEL	**NATO**	NORTH ATLANTIC TREATY ORGANISATIONS
CUG	CLOSED USER GROUP	**NCS**	NATIONAL COMMUNICATION SYSTEM
CDMA	CODE DIVISION MULTIPLE ACCESS	**PABX**	PRIVATE AUTOMATIC BRANCH EXCHANGE
DAQ	DELIVERED AUDIO QUALITY	**PMR**	PUBLIC/PRIVATE MOBILE RADIO
DMO	DIRECT MODE OPERATION	**PMRTS**	PUBLIC MOBILE RADIO TRUNKING SERVICE
DMR	DIGITAL MODE RADIO	**PTT**	PUSH-TO-TALK
DQPSK	DIGITAL QUADRATURE PHASE-SHIFT KEYING	**QAM**	QUADRATURE AMPLITUDE MODULATION
EDACS	ENHANCED DIGITAL ACCESS COMMUNICATION SYSTEM	**SCADA**	SUPERVISORY CONTROL AND DATA ACQUISITION
ETSI	EUROPEAN TELECOMMUNICATIONS STANDARDS INSTITUTE	**SMR**	SPECIALISED MOBILE RADIO
FCC	FEDERAL COMMUNICATIONS COMMISSION	**STANAGS**	STANDARDIZATION AGREEMENTS
FDMA	FREQUENCY DIVISION MULTIPLE ACCESS	**SWOT**	STRENGTH, WEAKNESS, OPPORTUNITIES AND THREATS
GIRN	GOVERNMENT INTEGRATED RADIO NETWORK	**TDMA**	TIME DIVISION MULTIPLE ACCESS
GoTa	GLOBAL OPEN TRUNKING ARCHITECTURE	**TEDS**	TETRA ENHANCED DATA SERVICE
GPS	GLOBAL POSITIONING SYSTEM	**TETRA**	TERRESTRIAL TRUNKED RADIIO
GSM	GLOBAL SYSTEM FOR MOBILE	**TDC**	TAXI DESPATCH CENTRE
GRN	GOVERNMENT RADIO NETWORK	**TIA**	TELECOMMUNICATIONS INDUSTRY ASSOCIATION'S
HSD	HIGH SPEED DATA	**TMO**	TRUNKED MODE OPERATION
iDEN	INTEGRATED DIGITAL ENHANCED NETWORK	**TRS**	TRUNKED RADIO SERVICE
IMT	INTERNATIONAL MOBILE TELECOMMUNICATIONS	**TSC**	TRUNKING SYSTEM CONTROLLER
ITU	INTERNATIONAL TELECOMMUNICATIONS UNION	**UHF**	ULTRA HIGH FREQUENCY
JAF	JORDAN ARMED FORCES	**VHF**	VERY HIGH FREQUENCY
KBit/s	KILO BIT PER SECOND	**W**	WATT
KHz	KILO HERTZ	**WRC**	WORLD RADIOCOMMUNICATION CONFERENCE
LMR	LAND MOBILE RADIO		

CONTACT US

HEAD OFFICE

MALAYSIAN COMMUNICATIONS AND MULTIMEDIA COMMISSION
63000 Cyberjaya
Selangor
Telephone: +60 3 86 88 80 00
Facsimile: +60 3 86 88 10 00
E-mail: ccd@cmc.gov.my
Website: www.skmm.gov.my
Aduan SKMM: 1-800-888-030
Aduan SKMM SMS: 15888

REGIONAL OFFICES

NORTHERN REGIONAL OFFICE
Tingkat 1, Bangunan Tabung Haji
Jalan Bagan Luar
12000 Butterworth
Penang
Tel: +60 4 32 38 22 8
Fax: +60 4 32 39 44 8

SANDAKAN BRANCH OFFICE
Lot No.7, Block 30
Bandar Indah Phase 6
Batu 4, Jalan Utara
90000 Sandakan
Sabah
Tel: +60 8 92 27 35 0
Fax: +60 8 92 27 35 2

EASTERN REGIONAL OFFICE
B8004 Tingkat 1
Sri Kuantan Square
Jalan Telok Sisek
25200 Kuantan
Pahang
Tel: +60 9 51 21 10 0
Fax: +60 9 51 57 56 6

SARAWAK REGIONAL OFFICE
Level 5 (North), Wisma STA
26, Jalan Datuk Abang Abdul Rahim
93450 Kuching
Sarawak
Tel: +60 8 23 31 90 0
Fax: +60 8 23 31 90 1

SOUTHERN REGIONAL OFFICE
Suite 7A, Level 7
Menara Ansar
Jalan Trus
80000 Johor Bahru
Johor
Tel: +60 7 22 66 70 0
Fax: +60 7 22 78 70 0

MIRI BRANCH OF THE SARAWAK REGIONAL OFFICE
Lot 1385 (1st Floor), Block 10
Centre Point Commercial Centre
Phase II
98000 Miri
Sarawak
Tel: +60 8 54 17 90 0/60 0
Fax: +60 8 54 17 40 0

SABAH REGIONAL OFFICE
6-10-10, 10th Floor
No. 6 Menara MAA
Lorong Api-Api 1, Api Api Centre
88000 Kota Kinabalu
Sabah
Tel: +60 8 82 70 55 0
Fax: +60 8 82 53 20 5

CENTRAL REGIONAL OFFICE
Level 17, Wisma SunwayMas
1, Jalan Tengku Ampuan Zabedah C9/C
Section 9
40100 Shah Alam
Selangor Darul Ehsan
Tel: +60 3 55 18 77 01
Fax: +60 3 55 18 77 10

ENQUIRIES

For any details and enquiries please contact the Market Research team:

Yee Sye Chung (Head)
Fiona Lim Ai Suan
Sharmila Manoharan
Azrita Abdul Kadir
Nadzrah Mazuriah Mohamed
Siti Na'ilah Kamarudin
Nurul Izza Saaman
Ramziyah Mohamad
Nor Hayati Muhd Nor