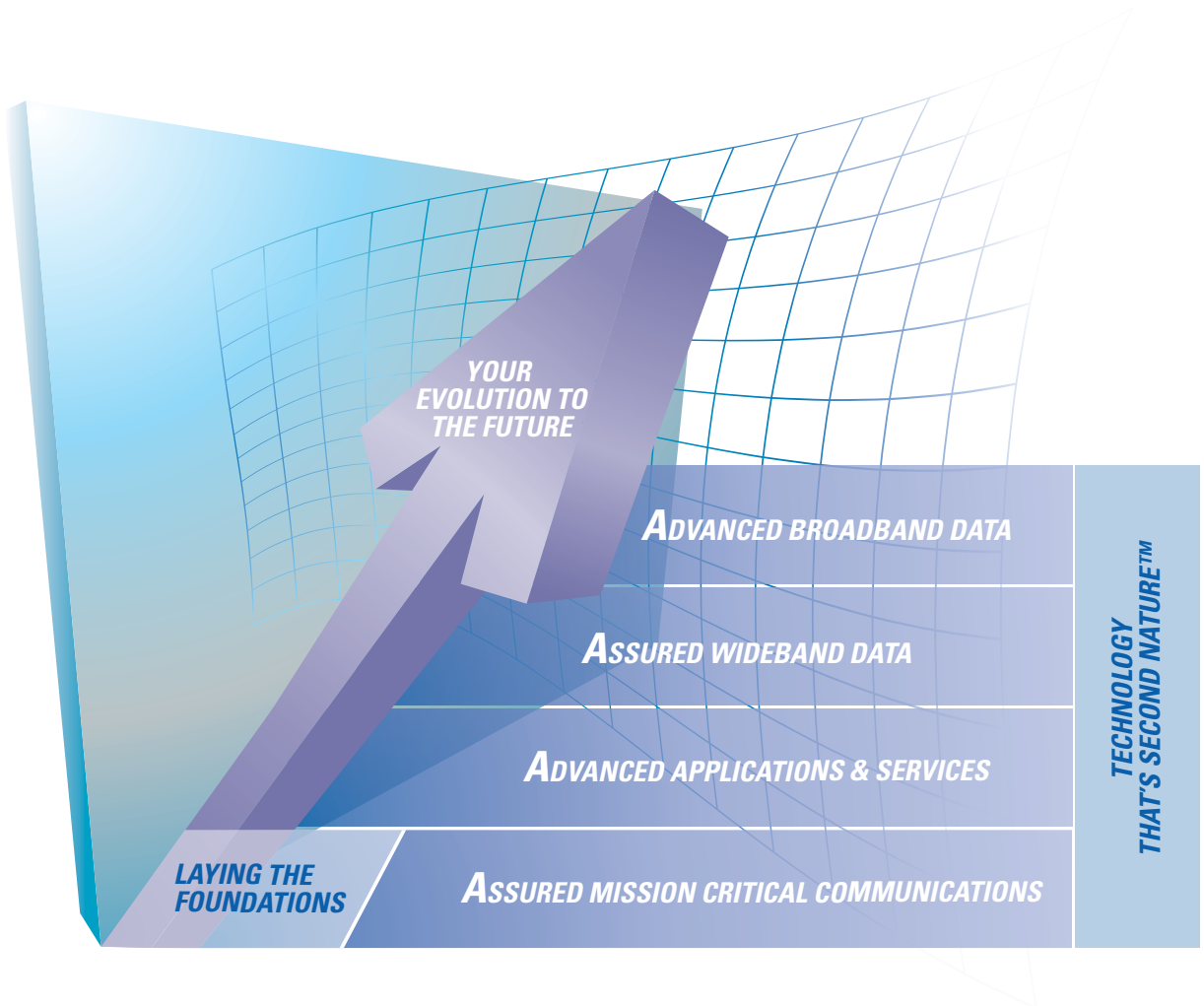
WHITE PAPER

TEDS:
Enabling the Next Evolution of Mission Critical Data Applications

EXECUTIVE SUMMARY

To date, voice services have provided the foundation of critical communications within public safety bodies and commercial organisations. A new picture, however, is emerging, that elevates the importance of data applications for accomplishing critical operational tasks and achieving strategic objectives. The increasing importance of these data applications means that there is now an expectation on them to be continually available. This need for high availability demands a high level of resilience in the communications infrastructure. Such resilience has been provided by TETRA for voice and low data rate services and has made this technology indispensable for public safety agencies and commercial businesses with critical operations.

In this whitepaper, the increasing importance of new data applications is examined with respect to the benefits they offer to public safety and commercial organisations. The importance of these data applications, it is argued, demands as reliable and robust a communications infrastructure as provided by TETRA for existing voice and data services. Furthermore, given the resilience it derives from TETRA, it is argued that the capabilities of TETRA Enhanced Data Service (TEDS), make it the most suitable technology for meeting the needs of the next evolution of critical data applications.



MISSION CRITICAL DATA APPLICATIONS ARE EMERGING

On the night of 7 January 2005, Carlisle, a city in the North East of England, experienced unprecedented levels of rainfall and severe storms. By the mid-morning, mains power to the city and surrounding areas had been lost due to the flooding. As Mike Coward, the Emergency Planning Officer for Cumbria County Council recalls, "This meant that a number of cellphone systems dropped back to standby power and a combination of problems with standby arrangements resulted in the loss of most mobile phone coverage in the city centre by the afternoon."

On August 1, 2007 a few minutes after 6:00 pm, the forty year old I-35W bridge collapsed into the Mississippi river in the US state of Minnesota. In the immediate aftermath, at the disaster scene, cell phone systems were often unavailable due to the intense traffic loads.

Those two episodes highlight the vulnerabilities of public mobile phone networks and serve as a reminder that the availability of reliable communications cannot be taken for granted. To understand the criticality of communications to public safety agencies and commercial organisations, a definition is helpful:

Mission critical communications is a term used to describe networks specifically designed for public safety teams to guarantee robust, fail-safe, and secure voice and data communications. The term is also applied to business critical communications infrastructure that has been developed to oversee the safety of field workers, increase productivity, and maintain business continuity should unforeseen incidents occur.

In mission critical situations, public safety and security (PSS) organisations cannot afford the risk of having transmission failures or unlawful unauthorised interceptions of their voice and data communications. Similarly, for many businesses, such as those related to the provision of public transportation services, communications failures could compromise the safety of both the public and personnel or result in the loss of significant revenue. The lack of resilience in public cellular networks is therefore a significant contributory factor in the adoption of private radio networks by mission critical users.

To date, private radio networks used by PSS organisations have carried predominantly voice traffic. PSS organisations needs, however, are continuing to evolve and the services they provide are becoming increasingly dependent on wireless data communications. For example in both the US and the UK, Automatic Number Plate Recognition (ANPR) has evolved from being an add-on project to becoming a mainstream policing tool that is integrated into police force strategies, tactics and processes.

Wireless data technologies have also become critical in enabling the rapid dissemination, to officers in the field of detailed photographic images of lost children or wanted people. Ian Latimer, the Chief Constable of the Joint Police Board in the UK, reinforces this view when he states that 'the benefits in terms of officer safety cannot be overestimated and our ability to locate missing persons or track down criminals more quickly will only assist us in ensuring we continue to make the Highlands and Islands a safer place to live, work and invest.'

The trends are clear. The increasing use and success of individual data applications within PSS organisations has meant that they are increasingly an integral part of their processes and as such, critical to delivering on strategic objectives.

Today's digital private radio networks are based on narrow-band interfaces which are optimised for voice communications and data communication at low transmission speeds. With the growth in data usage, PSS organisations and businesses with critical communications requirements will look to maximising the usage of their frequency allocation. With restricted financial resources, these organisations will demand that any radio technologies used are cost effective when compared with alternatives. How can organisations with critical requirements meet these challenges?

The adoption of any new radio communications technology for mission critical data will depend on the extent to which it meets and exceeds the unique requirements of its users compared with alternatives. Motorola's implementation of TETRA Enhanced Data Service (TEDS), with its high spectrum efficiency, is the most suited solution for addressing the evolving critical data needs.

UNIQUE REQUIREMENT OF MISSION CRITICAL USERS AND PROVIDERS

In recent years, many of Europe's national agencies have invested in dedicated narrowband digital mobile networks in order to provide multi-agency voice and data communications. This growth in multi-agency networks has created two important actors, namely the User and the Network Provider.

Mission critical users in PSS organisations have unique operational requirements based on the expectation placed upon them to save lives and protect property. Likewise, in industrial and commercial settings, the need to ensure the continuity of operations places certain demands on the communications infrastructure. To align with these needs, radio communications systems must provide:

- **Reliability:** the system must be available at all times.
- **Tailored service coverage:** the system must operate in all geographical locations where there is need for the service.
- **Guaranteed network access:** a high grade of service must be offered to ensure instant network access when required.

Network Providers, be they private or public owned, must ensure that agreed service levels are met for all users, cost effectively. With the growth of mission critical data services, it will also become necessary for Network Providers to be able to guarantee a Grade of Service for a mix of voice and data-centric services for end-users.

Conversely, public cellular networks do not provide users with a guaranteed grade of service, focussing only on best-effort. Indeed, when matched against the spectrum of needs for providing mission critical services, commercially based cellular networks fall short. There are real life examples that illustrate this inadequacy.

A report by the London Assembly cited the reliance on cellular networks as a contributor to communication difficulties amongst first responders. During this tragic event, it has been reported that some mobile networks experienced a 250% increase in call volume and that the unprecedented levels of congestion hampered the ability of some of the emergency services to communicate. Significantly, the report highlighted the importance of guaranteed access to communications networks by the emergency services.

DEDICATED VS NON-DEDICATED NETWORKS

To meet the need for guaranteed access, cellular networks in some countries have employed technologies that can be used to provide priority network access to PSS users by locking out or switching off access to non-priority users. There are, however, difficult decisions to be made when balancing the needs of the public versus PSS operational requirements and invoking a priority access scheme may have an impact on the operation of other services involved in an emergency.

Given the myriad of considerations involved, decisions to activate access priority schemes are only taken at the highest level of command during an emergency. For example, in the UK, the decision to activate the access priority scheme ACCOLC is performed only at Gold command, the level at which strategic decisions are taken during an emergency. Consequently PSS services may have restricted access to cellular networks during periods of traffic congestion arising from non-emergency situations such as large public events. This is not an acceptable option for PSS services.

The need for high availability, dedicated networks is not restricted to PSS services. Indeed, commercial organisations such as deregulated utilities have to compete on quality of service as well as on price. Here, quality of service is directly related to the ability of utilities to deliver a rapid response to high impact events such as power outages, unsafe water quality or service interruptions.

Within the commercial sector, there is an increasing reliance on monitoring and telemetry applications such as SCADA in order to enable rapid response capabilities and typically, these systems require the transmission of significant volumes of data. While not life-threatening, these telemetry applications are absolutely critical and demand a high level of robustness and availability. These are characteristics that are inherent in mission critical dedicated networks.

FROM TETRA TO TEDS

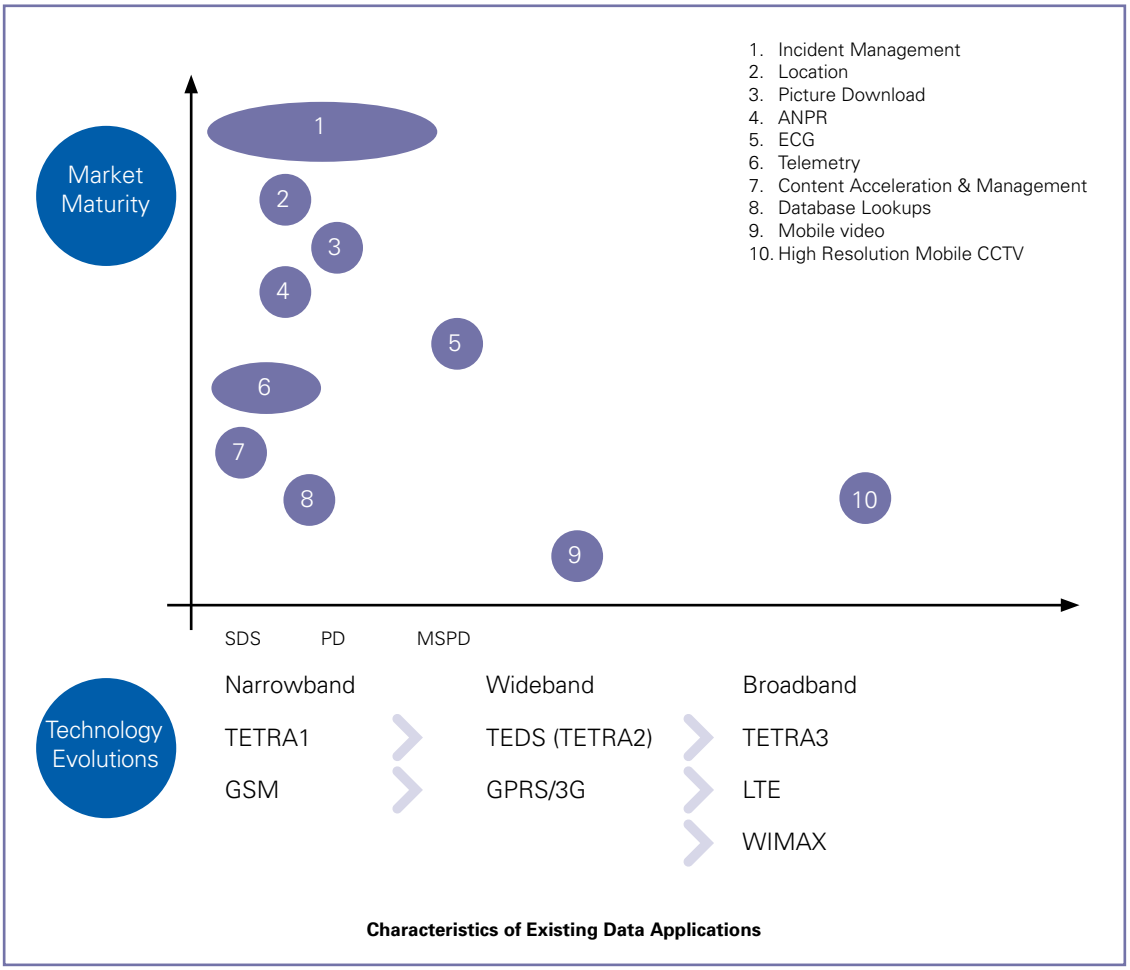
Today, many PSS and commercial organisations across Europe have come to rely on dedicated TETRA networks for mission critical voice communications. TETRA was developed by the European Telecommunications Standards Institute (ETSI) to carry data as well as voice in order to address the unique needs of public safety agencies.

The success of TETRA is reflected in the fact that it has now been adopted by more than 80 countries worldwide. The use of TETRA encompasses public safety and commercial industries, underlying its capability to support critical communications requirements.

In its initial release, TETRA was designed as a voice priority service, with capacity to support status messaging, text messaging and packet data. These data services are sufficient to support mission critical services such as database queries, AVL (Automatic Vehicle Location) and resource management. With the introduction of MSPD (Multislot Packet Data) in 2005, which increased the throughput for packet data by nearly a factor of 4, applications like image transfer have started to become more widely used.

As users became interested in developing richer applications, the TETRA Association responded by working with ETSI to develop the TEDS standard, a wideband data solution which enhances TETRA with a much higher capacity and throughput for data.

Today, there is a high concentration of mature data applications within the capabilities of narrowband and wideband radio bearers. Indeed, public safety agencies and commercial organisations are leveraging the capabilities of SDS (short data service), PD (Packet Data) and MSPD to support applications ranging from telemetry to incident management. Significantly, the bandwidth requirements of most of these applications are within the capabilities of TEDS.



Characteristics of Existing Data Applications

INTEREST IN NEW DATA APPLICATIONS IS GROWING

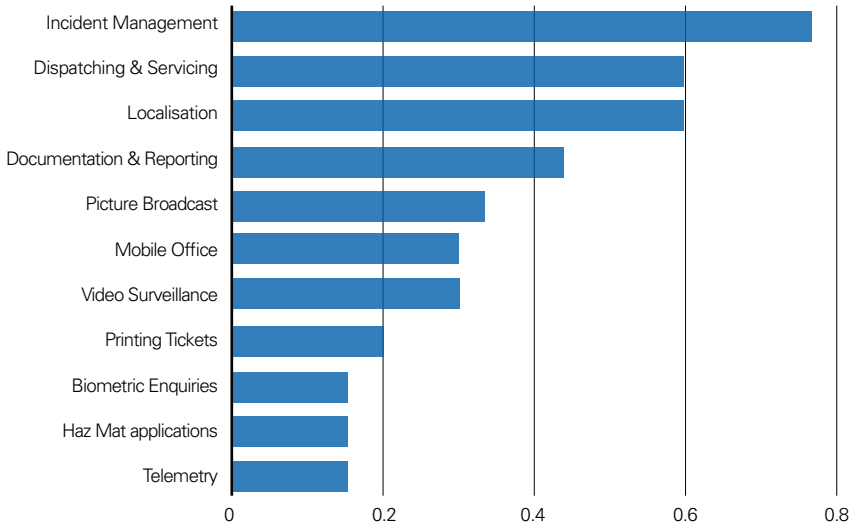
In reviewing the maturity of data applications, it is apparent that the most successful applications are those that enable an efficient mobilisation of resources or are critical to saving lives. For example, pre-hospital ECG's which require wireless transmission from an ambulance are seen as critical to meeting the 90 minute door-to-balloon time window in the treatment of cardiac conditions.

The door-to-balloon time window measures the time interval between a patient's arrival at the hospital and intracoronary balloon inflation. Medical studies have shown that achieving a door-to-balloon time of less than 90 minutes is associated with a reduction in mortality rate. These studies also suggest that the transmission of an ECG while the patient is en-route to the hospital can achieve a 15-20 minute improvement in the door-to-balloon time[1].

"At Royal Berkshire Fire and Rescue Service, we are becoming more reliant on wireless data. By transmitting data en-route to the fire ground, we are able to deploy resources faster, saving as much as 3 minutes per appliance. This translates to greater operational effectiveness in our goal of saving lives and protecting property. "

Alan Newcombe, Information Systems Officer, Royal Berkshire Fire and Rescue Service, UK.

Remote access to back-office database systems is a growing application area, and one that has shown economic benefits to PSS organisations. A proof point is provided by the North Wales Police force's pilot project which showed that remote access via mobile terminals to their internal records management system delivered savings of 29,000 productive hours. As well as productivity improvements, remote access to internal systems enabled an increase in police visibility in the community and higher crime solving rates[2].



Relative Popularity of Data Applications

The advantages of mobile data services are also evident in surveillance applications where wireless video solutions are helping PSS organisations improve their situational awareness and reduce crime rates. At the same time, these systems are also proving remarkably successful at maximising available resources and budgets.

[1] Source: Ting, H et al, (2008), 'Implementation and Integration of Prehospital ECG's Into Systems of Care for Acute Coronary Syndrome', Statement from AHA. Circulation 118:1066-1079.

[2] Source: BAPCO Journal, May 2007.

WIRELESS VIDEO HELPS TO REDUCE CRIME IN A LOS ANGELES NEIGHBOURHOOD

The Los Angeles police department (LAPD) sees wireless video technology as a critical policing tool. Even with no headcount increase in officer staffing, the technology has had a significant impact on crime in Jordan Downs neighbourhood in Los Angeles. "People act differently when they're on camera and that's good for both the community and the police," says LAPD sergeant, Dan Gomez. In 2006, crime in Jordan Downs decreased by 40%, and was down another 32% in the first 3 months of 2007.

IMAGIN: A COMPLETE PORTFOLIO OF IMAGES IN THE FIELD

Scotland's Northern Constabulary provides all its officers with on-the-street access to a wide range of images and CCTV footage. The scheme delivers images across the Airwave network to Motorola's WAP-browser-equipped MTH800 Airwave radio.

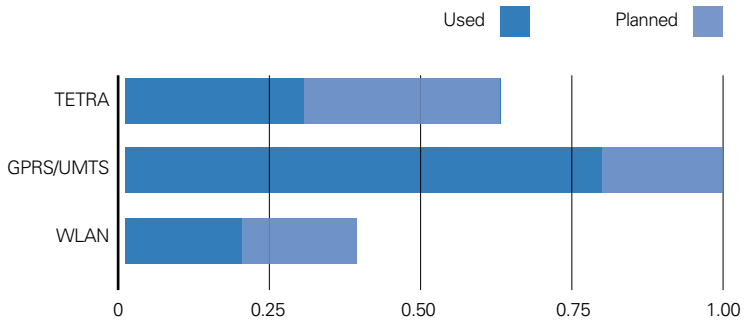
The handset's large, clear, coloured screen provides excellent detail of the range of images available to officers under the IMAGIN (Images Made Available to Groups or Individuals over Networks) concept, developed by the force. Officers can view images of missing persons, suspects and CCTV, as well as call up maps while on patrol. They can also access the electoral roll for the Highlands and Islands region to verify names and addresses (freeing up Force Operations Centre staff), and the driver database to check drivers' identities.

IMAGIN enables officers to spend more time on the streets (information on persons can be distributed without the need to return to the station), their safety is enhanced as they approach incidents armed with information about individuals and missing persons can be traced more quickly which has the potential to save lives.

THE REQUIREMENTS OF DIFFERENT TIERS OF APPLICATIONS

Research conducted by Motorola has suggested that PSS organisations are leveraging the data capabilities of commercial cellular networks for a variety of applications. Whilst in some cases the applications being used over cellular networks are not mission critical, these arrangements will not be sufficient as a longer term solution, as data usage evolves to mission critical applications and minimum quality of service obligations must be met.

Motorola recently conducted research based on respondents from 18 organisations spanning public safety and commercial industries. The aim of this research was to understand the use of different radio bearers for data applications used by these organisations. The results, though not conclusive, indicate relatively high usage of commercial networks for data applications when compared with narrow-band TETRA and reflect the growing interest in data applications across public safety and commercial sectors.



Proportion of respondents using or planning to use specific data services

Mission critical data application throughput requirements can be classified into three tiers:

- Tier 1 consists of applications that can operate in narrow-band channels such as TETRA and MSPD. Such applications include AVL, text messaging, web browsing, still image transfer and also slow-scan video applications.
- Tier 2 applications support higher resolution images and video. These applications require wideband radio bearers such as TEDS and 3G.
- Tier 3 includes rich multimedia applications requiring the transmission of high resolution live video and requires broadband channels.

Mission critical network operators will, amongst other factors, base the selection of individual communications technologies on their cost effectiveness. With the introduction of TEDS, network operators now have an alternative technology to compare against when making investment decisions. For this, a head to head cost comparison of the alternative technologies will be helpful.

ABOUT TEDS

Advances in DSP technology have led to the introduction of multi-carrier transmission standards employing QAM modulation. WiMAX, Wi-Fi and TEDS standards are part of this family

TEDS performance is optimised for wideband data rates, wide area coverage and spectrum efficiency

Adaptive Modulation
In addition to those provided by TETRA, TEDS uses a range of adaptive modulation schemes and a number of different carrier sizes from 25 kHz to 150 kHz. Initial implementations of TEDS will be in the existing TETRA radio spectrum, and will likely employ 50 kHz channel bandwidths as this enables an equivalent coverage footprint for voice and TEDS service, avoiding the need for "fill-in" sites dedicated to TEDS.

Data Throughput
A high protection mechanism is typically used to ensure the resilience of the data transmission, giving an effective data rate of up to 80kbps, available to applications, once overheads are considered.

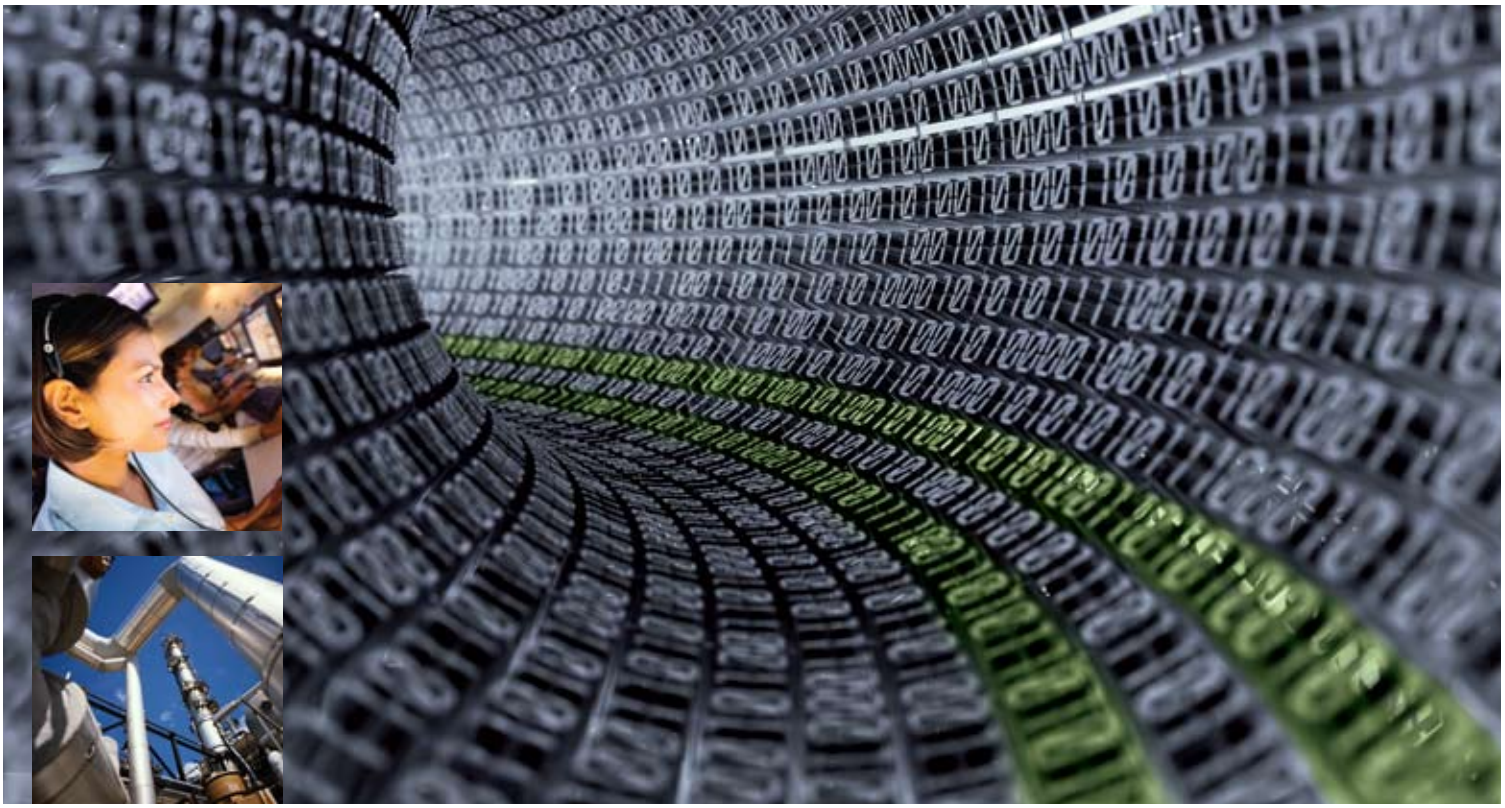
SIMULATING A DATA MIGRATION CHOICE

Consider the situation of an incumbent TETRA network operator based in the UK that is evaluating alternative data technologies. In this simulation model, the following assumptions are made:

- **Alternative Data Technologies:** Public 3G or GPRS cellular network
- **Implementation:**
  - The model assumes that bandwidth can be leased from public cellular network operators and therefore no infrastructure build is required.
  - TEDS is activated through the installation of TEDS capable transceiver equipment and a network software upgrade. TEDS carriers use 50 kHz channel bandwidths.
- **Deriving the total cost of ownership for TEDS:**
  - The model derives the network costs by determining the number of basestations required for a defined level of coverage and traffic capacity.
  - The level of coverage is dependent on the type of terrain and these are categorised as Dense Urban, Urban and Rural. All terrain data has been based on the UK.
  - Also included in the model are costs related to end-user devices, TEDS capable network infrastructure and integration costs.
- **Costs for commercial networks:** costs of ownership per end-user are compared against indicative market prices for mobile data including end-user device costs.
- **Applications:** The model is based on the use of Tier 1 and Tier 2 applications.
- **Time Horizon:** 7 years has been selected as the amortisation period. This is a representative investment period for mission-critical network infrastructure.

User Profile	Application Tiers Served	Technologies	Indicative cost $/user/month: Dense Urban High Capacity	Urban Medium Capacity	Rural Low Capacity
Tier &2 35MB/user/month	1.2	TEDS Upgrade	10	14	12
	1.2	GPRS/3G for Tier 2	52	52	52

Costs are based on indicative market prices across the Europe, Middle East and Africa region and are quoted in US dollars



70 PERCENT SAVINGS

When the numbers are compared, it is clear that TEDS provides network operators with opportunities for significant cost savings. Indeed, a TEDS software upgrade proves to be the most cost effective solution for Tier 1 and Tier 2 applications with incumbent TETRA operators. The cost differentials between TEDS and leased bandwidth from cellular operators suggest savings of up to 70% savings in dense urban environments. In less dense rural environments, the cost savings are even greater. The hypothetical case study therefore suggests that network operators have a compelling economic justification for porting existing GPRS and 3G data applications to TEDS. Does this mean that all existing GPRS and 3G applications should be ported to TEDS? The answer lies in the service level agreements between network operators and users.

As data services become mission critical, users will demand that application quality of service requirements are strictly adhered to by network providers. Given the limited capacity available on networks, the focus of service level agreements will be on the provision of mission critical data applications.

SOME APPLICATIONS ARE CRITICAL. SOME ARE NOT…AT THE MOMENT

PSS organisations can be viewed as social entities within which new processes and procedures are continually evolving. When applications enable strategic outcomes, PSS organisations are motivated to adapt existing processes so that aligned operational goals can be achieved. Such applications are viewed by PSS organisations as mission critical – they are critical to their ability to achieving strategic aims.

For end users, the importance of applications could therefore be based on the criticality of the operational tasks they enable. This means that the transition from non-mission critical to mission critical status will have a number of evolutionary paths based on the characteristics of the operational task being enabled.

For TETRA network operators and user agencies, there will be an economic motive to drive mission critical applications onto their TEDS networks. Non-mission critical applications, however, are more likely to remain on public networks in order preserve sufficient access capacity for mission critical services.

SERVING THE EVOLVING BROADBAND REQUIREMENTS

The analysis also illustrates the cost benefits to network operators and user agencies that can be achieved from leveraging their existing TETRA investments. Given the high costs of deploying a separate network with ubiquitous coverage, it is likely that initial requirements for Tier 3 applications will be fulfilled using localised broadband solutions. For Tier 3 applications requiring low levels of resilience, public networks such as WiFi and WiMAX could be used in the short term.

The TETRA industry is now investigating the evolutionary path through which TETRA network operators can offer broadband wireless services to mission critical users. In the short term, the proposal is for operators to enable inter-connection between TETRA and complementary networks (e.g. broadband networks based on WiMAX or Wi-Fi). This requires users to have separate radios for each network and operators to provide gateways to support the required degree of inter-connection between these networks. In the longer term, there is a proposal to evolve TETRA towards a "Broadband TETRA" solution. As leaders in wireless broadband, enterprise and public safety solutions, Motorola is uniquely positioned to deliver a complete mission critical data solution to customers as they evolve their existing networks for more advanced services.

INVESTIGATE FURTHER

Existing TETRA network operators stand to reap 70% cost savings from an investment in TEDS compared with leasing capacity from commercial cellular network providers for narrowband and wideband data applications. There is therefore a compelling economic reason for network operators to port existing GPRS and 3G applications which can be supported on TEDS radio bearers. User agencies stand to gain too, as the reduced costs of ownership will give rise to lower costs for end-user data access.

There is a wide variety of data applications in use by PSS and commercial organisations, with equally diverse importance to their strategic and operational goals. By understanding the criticality of the tasks these applications enable, network operators have the opportunity to develop service level agreements based on Grade of Service. For network operators with private ownership, this could translate to opportunities for new revenue streams based on the additional services enabled by the TEDS implementation.

Critical applications with broadband data speed requirements are also evolving towards mission critical status. Where the investment makes economic sense, dedicated and private broadband networks could be implemented to meet the quality of service requirements of these higher speed data applications.

To address broadband mission critical data requirements, the TETRA industry aims to harness the resilience inherent in TETRA in order to deliver broadband capabilities to mission-critical users. There are however alternative broadband radio bearer options depending on the nature and criticality of applications that need to be supported. For this reason, it's important to partner with a provider that knows wireless technology inside and out.

For nearly 80 years, Motorola has been recognized as the leading provider of wireless communications systems, networks, devices and services. To learn more - and actually see in action - how Motorola can help government and public safety agencies can realize benefits from wideband and broadband wireless networks, please visit us at **www.motorola.com/secondnature**

MINI-GLOSSARY

Term / Acronym	Description / Complete Name
3G	Third Generation Mobile Telecommunications
ANPR	Automatic Number Plate Recognition
AVL	Automatic Vehicle Location
DSP	Digital Signal Processor
ECG	Electrocardiogram
ETSI	European Telecommunications Standards Institute
GPS	General Packet Radio Service
MSPD	Multi Slot Packet data
PD	Packet Data service
PSS	Public Safety and Security
SCADA	Supervisory Control and Data Acquisition
SDS	Short Data Service
TEDS	TETRA Enhanced Data Service
TETRA	TErrestrial Trunked RAdio
TETRA1	Release 1 of the TETRA Standard
TETRA2	Release 2 of the TETRA Standard
TETRA3	Release 3 of the TETRA Standard
WiFi	Wireless Fidelity, a local area network (LAN) that communicates via radio waves on the 802.11 standard instead of wires.
WiMAX	Worldwide Interoperability for Microwave Access, based on IEEE 802.16

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