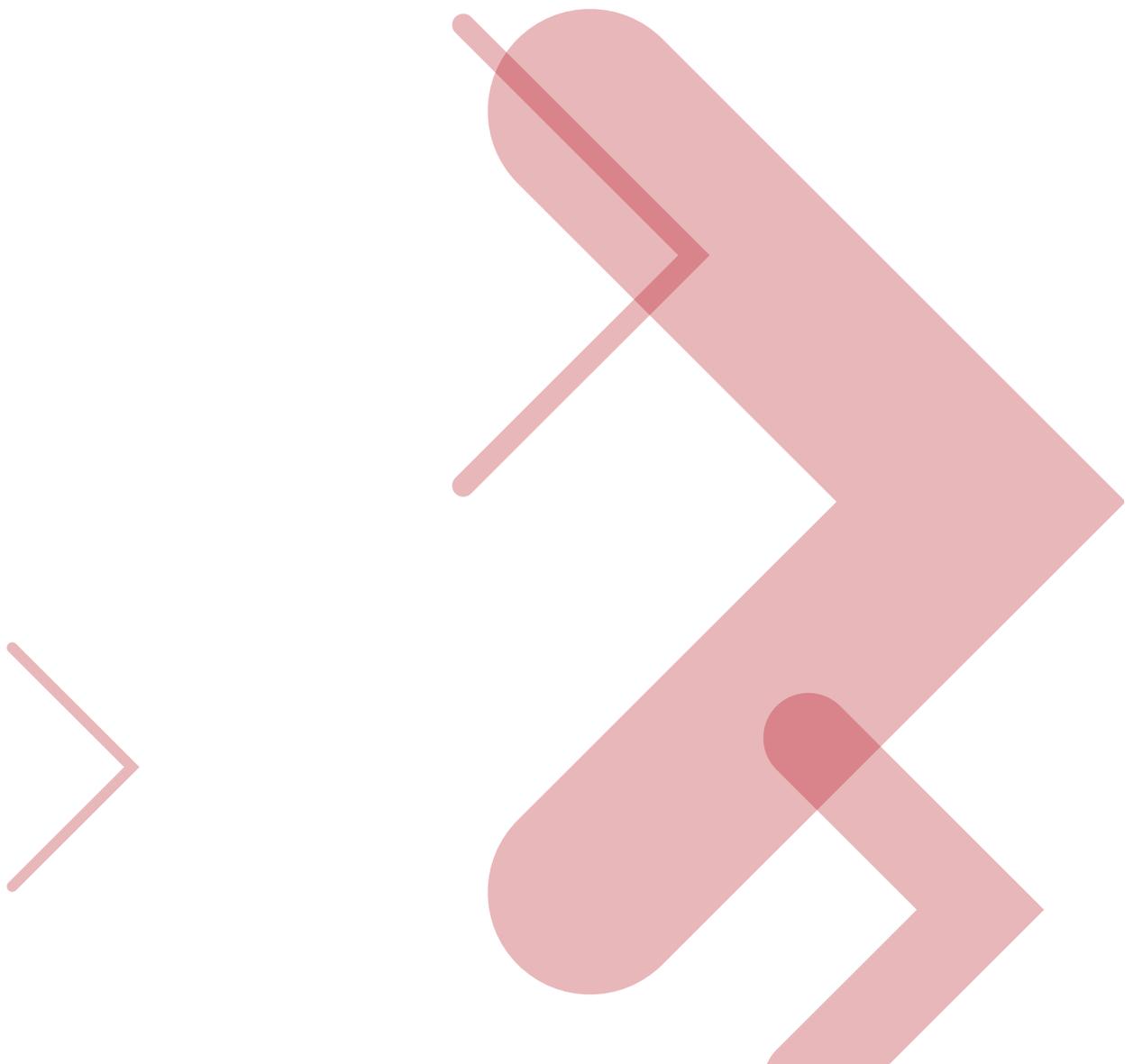




Ensuring Resilience and Availability in a TETRA System

Key steps to help ensure critical communication networks are 'always available'



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Introduction

Critical Networks are created to provide the information security and reliability that responders require, especially during a crisis. Unlike commercial carrier systems, which are designed for the general public's use, critical communication networks are created specifically for public safety and other critical communication situations. From providing "man-down" notification of an oil worker to ensuring the rapid response of the emergency services to an accident, they are an 'always available' lifeline for responders that provide real time information when needed.

This paper looks at the key issues and requirements for ensuring that a critical communications network is "always available," and how Motorola's solution addresses these points. It considers not just how resilience and availability can be built in during normal operation but also the steps that can be taken to cost effectively ensure communications during a crisis.

When considering the availability of a TETRA network, it is important to look at the complete solution from core network to base stations to the devices being used in the field.



Requirements for Ensuring Resilience and Overall System Availability

Availability measures the percentage of time that a system is working. This is the key requirement from the end users point of view. Specifically, if a user makes a call, for example to request emergency back up, how likely that call is to be successful is the user's key consideration.

A key requirement in ensuring system availability is enhancing the reliability of individual components or, put another way, minimising the chance a component will fail. Given that components can fail, albeit rarely, another important factor is maintainability, or how quickly an item can be repaired once it has failed. To ensure maximum availability, a system should also be resilient. A resilient system will continue to offer service even in the presence of faults. This can be achieved through the use of duplicated modules, subsystems, devices and even entire Mobile Switching Offices (MSO). Fallback solutions can also be invoked that in the event of a failure, enable operations to continue.

A TETRA system must be able to maintain its availability in a variety of circumstances. These include when there is abnormally high traffic on the network, maybe as a result of a major accident or event. Indeed, this is often when the need for communications is most critical. Mechanisms should also be available to make sure high priority calls get through at all times as some calls are more critical

than others. Availability should also be maintained as a network grows, both in terms of geographic area (coverage) and network traffic (capacity).

Disasters such as earthquakes, floods or acts of terrorism present a further challenge. Such events can result in major losses in network equipment just at a time when it is needed most. A well planned recovery strategy is therefore required to ensure that any reduction in service is kept to an absolute minimum.

When considering the availability of a TETRA network, it is important to look at the complete solution from core network to base stations to the devices being used in the field. In designing a system, a balance must also be drawn between the system availability, the impact on the system if communications are lost, the end user's requirements and the additional costs that might be incurred. A higher Investment in core network availability, for example, can often be justified because a core network failure could potentially impact the entire system.

The rest of this paper looks at how Motorola has developed its highly available TETRA solution to address the many challenges identified.

IP Architecture Design

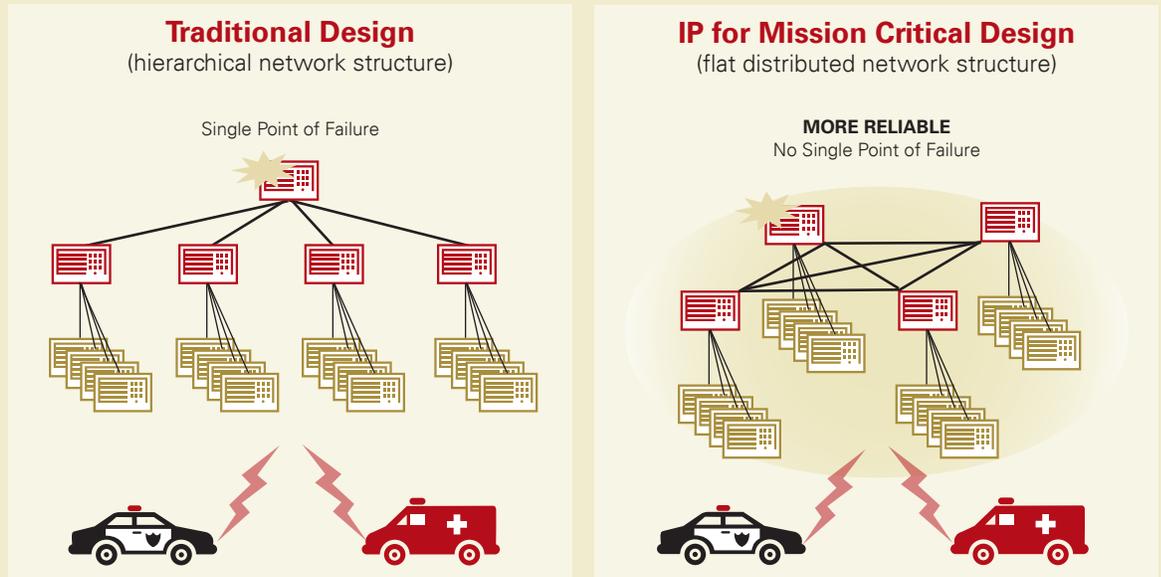


Figure 1

Motorola's TETRA Solution: Ensuring High Availability

Motorola is very conscious of the importance of system availability. A great deal of effort has been invested in ensuring that we offer a complete solution from the resilience of key components to providing effective solutions in the event of a disaster.

System Resilience

The purpose of providing resilience is to safeguard critical communications against circumstances which potentially could result in a network failure. A resilient network will continue to operate even in the presence of faults.

Core Network Resilience

In designing Motorola's solution, each component was analysed in terms of its likelihood to fail and, if it were to fail, what the consequences would be. As a result, Motorola has built in redundancy for all its key elements. With this approach, multiple equipment failures can be withstood whilst maintaining operations. For example, the Zone Controller has a redundant configuration with an active and a standby computer unit. Automatic switchover is triggered by detection of a critical hardware failure, for example a CPU card failure or a loss of power. The switchover is very fast because all configuration and subscriber databases are mirrored at all times. This redundancy not only guards against faults, but also allows software upgrades to be performed on-line, thus improving planned as well as unplanned down-time. Other critical core network components provided in redundant configurations include:

- Transport Network Subsystem (including Gateway, Core and Exit Routers)

- Mobility and Call Processing Subsystem (including Zone Controllers, Dispatchers and Domain Controllers)
- Security Subsystem (including Authentication Centre Servers)
- Packet Data Subsystem (including Gateways and GGSN)
- Short Data Subsystem
- Site Link Connections

Another key factor that can impact the resilience of the core network is its architecture or, in other words, how the different switches are linked together. Motorola's TETRA solution uses a distributed IP architecture. The IP protocol has many proven advantages associated with performance and reliability. It was developed by the US military (DARPA Net – Defence Advanced Research Projects Administration Network) because of its distributed and resilient nature and is now being adopted worldwide for all new next generation communication solutions. Consequently, enormous resources are being invested in the R&D of IP solutions with traditional processor controlled circuit switching solutions increasingly being replaced. Circuit switched networks traditionally use a centralised/hierarchical architecture, where each switch represents a potential point of failure. If such a network has one single switch or a few large switches it is by definition very vulnerable. Figure 1 illustrates the benefits of the distributed IP packet based approach compared with the traditional hierarchical circuit based approach.

The Advantage of Distributed IP Networks

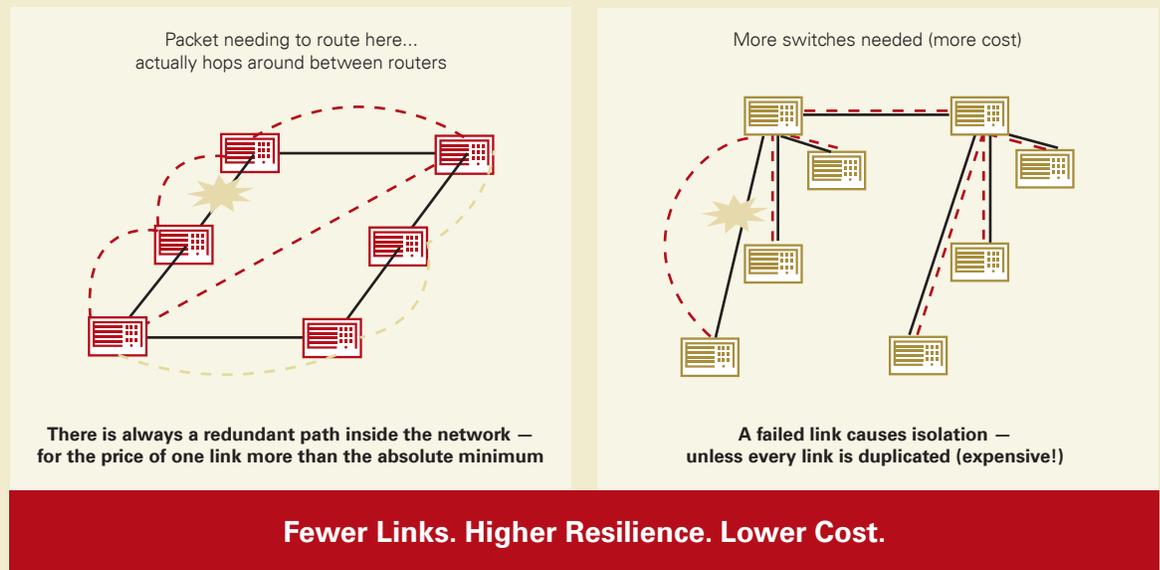


Figure 2

In a circuit switched network, if a switch (or a link to a switch) becomes non-operational, the entire network or network area dependant on the switch dies. It does not take much to imagine the potential consequences of a “dead network” in a critical situation. This vulnerability can be reduced by adding redundant links to the network, but the operational costs of the system will then suffer. By contrast, in a packet switched IP network, voice and data are “packetized” and can take many routes through the network to reach a destination. If one route is blocked, the network intelligently selects another. In addition, as an IP network principally operates in a decentralised switching architecture with duplication of networking elements, it possesses the inherent ability to compensate for component breakdown or loss of individual links. In other words, Dimetra IP is a self healing network. Figure 2 illustrates how a distributed IP solution can provide a highly resilient solution with fewer links and at a lower cost.

Motorola has further enhanced the standard IP solution to ensure its suitability for critical communications. For example, Motorola has developed faster, more reliable routing algorithms to ensure calls are re-routed quickly and efficiently in the event of any conceivable network failure.

Base Station Resilience

Motorola’s base stations can be optionally fitted with redundant base radios (BRs) and a redundant TETRA Site Controller (TSC) unit operating in a state of constant readiness should any active device fail. When not active the standby base radio (BR) is powered up but not transmitting. When the system detects that one of the active BRs has failed the back-up BR is switched into service at the same frequency as the failed BR. If the fault occurs on the radio supporting the Main Control Channel (MCCH) the MCCH is automatically switched to another radio. Similarly, failure of the active TSC in a BTS will

lead to the standby unit being automatically brought into service. An important aspect of Motorola’s solution is that the redundant TSC provides complete functionality to the base station.

Motorola supports a variety of solutions to ensure base site connectivity, including ring and star deployment options as well the ability to connect to more than one switch. These solutions can reduce leased line costs and offers true redundancy on sites without the need for third party equipment.

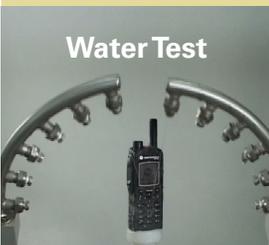
Fallback Solutions

Fallback modes provide alternative means of maintaining service in the event of failure. An example of a fallback operation is Local Site Trunking (LST), whereby each base station continues to act as a TETRA compliant trunking system should communication with the master site be lost. Local Site Trunking is in fact a very comprehensive service. Trunked group calls continue to be supported with a call set up time of less than 200ms. With Motorola’s solution there is also no need for the end-user to change channels to continue communications. The implementation of group calls in LST includes air interface encryption, end-to-end encryption, call queuing, emergency calls, recent user priority, late entry, and notification of calling party identification.

Motorola also provides additional fallback solutions. If a switch becomes isolated from other switches for example, it can still provide full functionality (authentication, encryption etc.) to the area that it serves. Similarly, Motorola provides a dispatch fallback solution of an equivalent nature. Finally, the radios themselves can fallback to secure DMO mode with air interface encryption and/or end-to-end encryption, enabling direct terminal-to-terminal style communication with other users in the unlikely event of coverage being lost.

Figure 3

Quality and Reliability Testing



Quality and Reliability

Motorola has established processes and relationships to ensure the reliability and quality of its products, features and services. For example, all Motorola radios and accessories undergo Military Standard 810F (MIL810) testing in 11 different categories: low pressure; high temperature; low temperature; temperature shock; solar radiation; rain; humidity; salt fog; dust; vibration and shock. Military Standard 810F testing was originally developed by Motorola to ensure suitability of equipment to the toughest military conditions. Products genuinely meeting and exceeding all 11 categories will stand up better to the rigours of a tough working environment.

Motorola however go beyond testing to MIL810 specifications. Motorola also conducts Accelerated Life Testing (ALT) on all its devices and accessories, as illustrated in Figure 3. This simulates six years hard usage in the field and is completed during early development to improve design and quality levels as well as at final approvals to ensure that the radio will function in even the harshest of outdoor environments. The tests are designed to give peace of mind for customers that radios and accessories will survive the inevitable knocks and drops, yet still continue working in the harshest of outdoor environments. No other manufacturer voluntarily tests their products to these extremes.

Supporting Services

Services play a key part in ensuring overall network availability, from designing the optimal resilient solution to providing full system support.

Motorola's comprehensive Network Planning Service can design a solution customised to meet each users' specific availability needs. Whether it is prior to network launch or before an event or major

expansion, Motorola has extensive experience in designing cost effective and resilient solutions (see Figure 4).

Motorola also provide a variety of services to ensure full availability is maintained. Motorola's alarm correlation service for example undertakes root cause analysis to evaluate incoming alarms and nest them under one single meaningful alarm. This helps diagnose network faults more quickly and leads to their speedier resolution. Motorola also provides an alarm management solution that delivers a regular report to highlight measures that can be taken to improve system availability.

To maximise the availability of critical communication networks, Motorola also includes a remote network monitoring solution that can continuously monitor a customer's network (24x7x365). The service is fully proven with many hundreds of customers being individually monitored by a customised solution designed to meet their requirements. Motorola also maintains a remote Network Operations Centre and therefore a potential disaster recovery solution.

Motorola offers a portfolio of Total Network Care solutions. Among the services included are: Network Support Program; Network Management; Operations & Maintenance and Training and Technical Information. The solutions are fully flexible and allow multiple service options and service level commitments to be supported. Motorola's full Performance Management Reporting Service enables effective decisions to be made to ensure the availability of your network.

In addition to services for effective network monitoring and support, Motorola also offers a range of services that proactively ensure the smooth running of the network. For example, Motorola's RF Coverage and Capacity Optimisation service optimises system availability and performance.

Comprehensive Network Planning Process

Your Unique Requirements

- Where is coverage required?
- Which terminals will they use?
- How many users?
- What traffic will they generate?
- Availability and Disaster Recovery needs?
- Custom applications?
- Integration with IT systems?

Motorola Network Planning

Network Dimensioning

Network Functionality

Solution Customized to Your Needs!



Extensive Experience in Designing Resilient Solutions

Figure 4

Maintaining Availability in Different Circumstances

A TETRA system must be able to maintain its availability in a variety of circumstances. These include when there is abnormally high traffic on the network, maybe as a result of a major event or accident. Indeed, this is often when the need for communications is most critical. Mechanisms should also be available to make sure high priority calls get through at all times, as some calls are more critical than others!

Motorola's solution incorporates a number of features designed to ensure effective operation under load. For example, Motorola's solution supports the effective prioritisation of voice and data calls, thereby ensuring that high priority calls get through. Data capacity can also be re-allocated to support priority voice calls through Motorola's bandwidth management and pre-emption capabilities.

For special events, Motorola offer a full event management service to ensure availability is maintained. This service can also be used to ensure availability when temporarily adding large numbers of users or for emergency simulations. Motorola's capability at special events is fully proven. For example, at the 2004 Olympics in Athens, Motorola provided a complete package of support including additional equipment and in-country teams. We successfully supported over 16,500 users and over 2.3 million groups calls. More recently, Motorola provided support at the 2007 G8 summit in Germany.

Availability is also maintained during periods of system expansion. Motorola's Dimetra IP solution can be expanded whilst minimising any impact to the availability of the existing system. This is an important benefit because it allows the system to grow as usage and traffic increases. New base sites can be added to the system without interrupting the service to existing sites. New base radios can also be added by simply slotting in additional base radios as and when required.

Disaster Recovery

Disasters such as earthquakes, floods or acts of terrorism can result in major losses in network functionality just when it is needed most. A well planned recovery strategy is therefore required to ensure that any loss or reduction in service is kept to an absolute minimum. Motorola offers a range of disaster recovery solutions to meet the requirements of individual operators. Options include:

- **Synchronised Standby.** This is Motorola's premium solution. This provides a complete, no compromise, full functionality 1+1 (one backup switch for every operational switch) hot redundancy solution. It also provides best in class service restoration times.

- **Automated Back Up and Restore.** This N+1 redundancy solution can provide cost effective protection against the loss of one switch. For many networks this is likely to be sufficient as the chances of a disaster impacting two switches concurrently are relatively low. The services made resilient can thus be traded-off to meet budget constraints.
- **Geographic Redundancy.** This solution distributes the existing state-of-the-art switch redundancy mechanisms to provide geographical redundancy, thereby minimising additional CAPEX and OPEX. The fully automated solution provides exceptionally fast service restoration times. It also enables the flexible tailoring of redundancy services to meet budget constraints.

Motorola's disaster recovery capability is fully proven in the field. For example, Motorola has installed a disaster recovery solution for the Airwave nationwide network in the UK that ensures that seamless, end-to-end voice and data communications are maintained for over 150,000 officers across police forces in England, Scotland and Wales as well as the British Transport Police and Ambulance Service.

"This is a great achievement for both O2 Airwave and Motorola. It reinforces our commitment to providing the emergency services with the very best communications they can get. We have been working in partnership with Motorola since its inception and successfully rolled out the Airwave network across the country. I am delighted that we are continuing our partnership to make even further improvements to the Airwave service. Completing the network was just the start; we will continue to develop the service to ensure it meets the needs of all our customers. "

Pete Richardson, Managing Director for O2 Airwave

Proven Operational Performance

Motorola's TETRA solution is the solution most widely in use in the market today and has been tested under extreme operational requirements. For example, the 2007 G8 Summit in Germany, the London bombings in 2005, the 2004 Olympic Games in Athens and the 2004 train bombing in Madrid:

"Our TETRA communication system played a critical role, unlike the cellular network which did not handle the situation due to a communication overload. It was clear to us that we needed a dedicated, secure private communication network in order to deal with life threatening situations. We are now pleased that we made the right decision back in 2001 and chose TETRA."

Javier Quiroga, Medical Services Operations Director, Madrid Municipality

Availability of Commercial Systems

Motorola's TETRA solution is fully proven in the field. Unlike commercial systems, TETRA has also shown that it can cope well with emergency situations. When disaster hits, the public reaches for their cellular phones, resulting in overloading commercial systems or taking down the network entirely. Examples have been well documented in research carried out by the independent consultancy, Mason Communications¹, of situations where commercial networks failed at times of crisis whilst critical communications networks continued to give excellent service.



Conclusions

Critical networks are created to ensure the availability of communications that responders require, especially during a crisis. A critical communications network must be resilient, reliable and maintainable. It should also maintain availability during peak times, for example as a result of a major accident or event as well as supporting proven disaster recovery scenarios.

Motorola's solution fulfils all these requirements:

- Distributed IP architecture with inherent and intrinsic resilience features;
- Resilience is also built in to all key components, subsystems and intelligent software;
- Motorola's solutions are reliable. Handsets and accessories meet and exceed MIL-STD 810 and ALT quality standards;
- Redundant site links supporting all connectivity topologies, teamed with fallback base station functionality, ensuring continued, secure and effective communications given any failure situation;

- A full range of alarms and supporting services to ensure network maintainability as well as to proactively optimise network performance and availability;
- A range of solutions to ensure availability during peak traffic periods such as major events or accidents;
- A full range of disaster recovery solutions to meet the requirements of different users.

Finally, Motorola's TETRA solution is fully proven in the field, even in the most difficult of circumstances such as the Madrid Bombing or under extreme load at the Athens Olympics.

For more information about Motorola's TETRA solution for critical networks, contact your Motorola representative.

¹ Analysis in 'The ability of Public Mobile Communications to support mission critical events for the Emergency Services' by Mason Communications Ltd., available at www.tetramou.com/catalogue



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