MOTOROLA'S GSM 900 & 1800 BSS SOLUTIONS

This document describes Motorola's complete BSS solution for both GSM 900 & 1800 and Dual-band networks. It includes descriptions of Motorola's BTS product range, (Macrocellular) BSC, TRAU and OMC-R. The last section provides information on Motorola's Dual Band (GSM1800/E-GSM900) cellular network.

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1 OVERVIEW OF MOTOROLA'S BTS PRODUCT RANGE

Motorola offer its customers the following comprehensive range of BTS products, including solutions for macro and micro BTS types:

- Horizon*Macro* 40 watt (GSM900) BTS -48V & +27V DC Indoor macro BTS.
- Horizon*Macro* 40 watt (GSM900) *BTS* 110/230V AC Indoor macro BTS.
- Horizon*Macro* 40 watt (GSM900) BTS – 220V a.c., 380V a.c.Outdoor macro BTS.
- Horizon*micro* 1.2 watt (GSM900) BTS
- Horizon*compact* 10 watt (GSM900) BTS 220V a.c.

Motorola's BTS products support both Baseband and Synthesised Frequency Hopping and are fully GPRS ready without any hardware changes.

1.1 THE HORIZON*MACRO* BTS

The ***Horizonmacro BTS*** has been designed for high capacity and wide area coverage. It provides a high level of flexibility.

- The Horizonmacro BTS is dramatically reduced in size and volume, approximately half the size of Motorola's previous M-Cell6 macro BTS.
- Able to stack the indoor cabinet on top of one another to give 12 carriers in the same footprint as the M-Cell6.
- Supports dual band 900/1800 in the same physical cabinet.
- The Horizonmacro BTS Indoor cabinet supports up to 6 carriers with omni or sectored configuration.
- The Horizonmacro BTS Outdoor cabinet supports up to 12 carriers with omni or sectored configuration.
- One Horizonmacro BTS cabinet supports up to 3 sectors. Two Horizonmacro BTS cabinets can support up to 6 sectors.
- Cell sites can easily be expanded or reconfigured as network requirements change.
- Expansion up to 24 carriers is achieved by cascading 4 indoor or 2 outdoor cabinets.

Horizonmacro 12 Carrier Outdoor BTS including:

- 6 carrier expandable to 12 within single enclosure

- Power Input:150V-264V ac single or three phase
- 40 minutes integral battery back up
- 6 'U' Internal customer communications equipment space/4 x customer outlets @ -48Vdc (total 4A)
- Low Voltage Disconnect x 2 enables onward linked sites to stay on air in the event of power failure
- Integral lighting lamps on each cabinet bay
- Integral fold down computer mounting tray
- AC power outlet (total 10amp @230V nom.) European style fitting x 2 IEC 320 x 2

Horizon*macro* Indoor BTS

Horizon*macro* Indoor BTS Cabinet

Two Vertically stacked Horizon Indoor BTS cabinets

Horizon*macro* 12 carrier Outdoor BTS

2 HORIZON*MACRO* BTS PRODUCT DESCRIPTION

2.1 INTRODUCTION

The quality expectation of the modern day telecommunications subscriber is high. The wireless subscriber expects to connect and complete all calls, experience high voice quality and have complete mobility, indoors or outdoors. The GSM 1800 operator must ensure that his network is comparable or better than the incumbent GSM 900 cellular operators and must strive to achieve wire line quality. The advancement in speech codes and the introduction of techniques such as Enhanced Full Rate (EFR) and Tandem Free Operation (TFO) will ensure that the subscribers continue to expect high quality service. This document will provide a brief outline of the key benefits to our customers in utilising Motorola's BSS products and services.

2.2 PRODUCT OVERVIEW

Motorola's latest Horizon*macro* BTS is designed to meet the network operator's needs for a small, flexible macrocellular BTS platform.

Building on the already successful M-Cell BTS product range, the Horizon*macro* BTS has been specifically designed to meet the requirements of network operators at all stages of network maturity and growth. This product takes account of considerable research and liaison with customers to define their requirements.

Its modular design allows operators to satisfy initial market requirements with minimal investment, then to simply and economically expand network capacity as traffic demand increases. The expansion capability of this BTS's up to 24 carriers is better than any of our competitors.

The Horizon*macro* BTS is available both as a Indoor cabinet and as a completely self-contained Outdoor cell site, suitable for operation in the most severe weather conditions.

The BTS provides network operators with the flexibility to have GSM900, GSM1800, and Dual Band heterogeneous equipment configurations. The BTS has the highest transmit power and most sensitive receive level on the market today, allowing operators to cover wide areas of their network with the minimum number of cell sites.

All the leading features are supported; e.g. EGSM, Frequency Hopping, GPRS etc.

2.3 MARKET APPLICATIONS

One major concern for all operators is the ability to provide networks, which are able to support a dense population of hand portable users. This was a key driver for the introduction of the Horizon*macro* BTS.

This BTS gives network operators the most technically advanced equipment, providing tailored growth to meet high subscriber capacity systems. The BTS can be used in dense urban, suburban and rural locations.

The advanced design of the BTS allows operators to rapidly deploy cell sites, whilst ensuring that the cost of coverage is kept to a minimum. The Horizon*macro* BTS is designed specifically for indoor and outdoor macrocellular applications where space is at a premium.

Motorola's advances in RF, digital and packaging technologies have been developed to produce significant improvements in the key parameters of size and weight over the current M-Cell product.

The BTS is approximately half the size and weight of M-Cell*6* for the same number of transceivers. The small product footprint assists operators with ease of deployment, either with provision of equipment room space, or the ability to mount the BTS on a rooftop.

It is possible to vertically stack two BTS cabinets, doubling the number of transceivers within the same footprint area – 12 carriers in the same volume as M-Cell*6*.

Configurable as a single band or multiband cabinet, it is particularly useful for operators who wish to add multiband capability to existing single band networks.

2.4 SYSTEM CONFIGURATION

The Horizon*macro* BTS is capable of supporting 3 cells within a single cabinet and can be expanded to a maximum configuration of 24 TRXs per site subject to a maximum of 12 TRXs per cell.

The Horizon*macro* base station offers operators control over their growth strategies. Omni sites can be reconfigured to provide sectored operation within the original BTS cabinet. The use of standard building blocks offers Operators the benefit of rapid cell reconfiguration and expansion and the ability to remove redundant duplicated modules. Cell sites can be expanded with very short interruption in service to meet requirements for increased capacity.

2.5 KEY BENEFITS OF OWNERSHIP

The Horizon*macro* BTS has been designed from the start with the network operator in mind.

This new BTS provides an operator with the following benefits:

- Rapid Cell deployment
- Good growth strategy
- Lowest running costs
- Future Feature Support
- High Reliability
- Highest Quality
- Range of capacity solutions

Rapid deployment of BTS sites is achieved by ease of installation, 2-man team, integrated transmission, and minimal commissioning requirements.

Motorola have designed the Horizon*macro* BTS to be the most flexible BTS platform available on the market, with ease of expansion and reconfiguration as network subscriber capacity grows.

Motorola strives to provide network operators with a product that ensures that cost of ownership is kept to the absolute minimum. The initial cost of both site acquisition and preparation, along with the ongoing running costs are substantially lower than conventional cell sites.

The Horizon*macro* BTS has been designed with an eye to the future. It will support not only multiband and multilayer architectures, but has also been designed with sufficient processing power and memory capability to support future features such as GPRS data services with only a software update (no hardware change is necessary).

The Horizon*macro* BTS has been designed using fewer boards and higher levels of integration, providing exceptionally high equipment reliability. In particularly important BTS locations, redundancy options are available for power systems and control processors, to provide even higher availability.

Motorola offers network operators a portfolio of capacity management techniques, including both directed retry and Motorola's more intelligent version, Congestion Relief, as well as multilayer, microcellular, and synthesiser/baseband frequency hopping.

Motorola's Horizon*macro* BTS product offers diversity reception and frequency hopping. Diversity reception helps to protect the transmission quality against interference and reduces the effects of multipath fading. Frequency hopping improves the performance for static or slow-moving subscribers by avoiding the co-channel interference caused by slow fades. Both of these features improve the call quality perceived by the subscriber.

High network quality implies high levels of availability and coverage. Availability is dependent on network capacity and reliability. Motorola's Horizon*macro* BTS allows precision placement for optimum coverage and interference control, thus providing the highest quality network.

Motorola is conscious of the need to minimise not only the initial cost of establishing a cell site, but also the ongoing costs throughout the lifetime of the equipment. The Horizon*macro* BTS helps to achieve this by the following features:

- Small Footprint
- Compatibility with M-Cell BTS
- Flexible Expansion
- Transmission Options
- Dual Band Flexibility
- Ease of Installation
- Reliability Improvements
- Future Feature Support

2.5.1 Small footprint

The Horizon*macro* BTS is approximately half the size and weight of M-Cell*6* (previous BTS generation) for the same number of transceivers, thus reducing transportation and costs. Site provisioning costs are substantially reduced, as the BTS cabinet requires access from the front only and the cabinet can be mounted against a wall on the three other sides.

It is possible to vertically stack two BTS cabinets, doubling the number of transceivers within the same footprint area – 12 carriers in the same volume as M-Cell*6*.

2.5.2 Flexible Expansion

Motorola has designed the Horizon*macro* BTS to be the most flexible BTS platform available on the market.

The Horizon*macro* BTS allows a graceful, phased expansion of network capacity aligned with subscriber growth. Expansion capability to 24 carriers (and beyond using co-located sites) reduces the need for additional sites, thus protecting the operator's investment.

A single indoor cabinet can house up to 6 RF carriers, which can be configured for omni-directional or up to 3-sector operation. For example a sector 2/2/2 site can be housed in a single cabinet, and a sector 4/4/4 in only two cabinets. Motorola's Horizon*macro* BTS can easily be expanded up to 24 carriers, for example sector 8/8/8 in four interconnecting cabinets.

The BTS can also support up to 12 carriers per sector - this is becoming increasingly important as larger numbers of carrier/sector are being deployed in order to realise the capacity benefits of techniques such as aggressive repeat patterns, frequency hopping, etc.

Both wideband (hybrid) combining and remote tune (cavity) combining options are supported.

As with previous generations of Motorola macrocell BTS equipment, synthesiser frequency hopping is supported on all configurations.

A single Outdoor cabinet can house up to 12 RF carriers, which can be configured for omni-directional or sector operation. The outdoor BTS cabinets provide excellent battery backup flexibility, with a variety of different options that can either be included at initial installation or added to the site at a later date if required.

2.5.3 Transmission Options

Optimising transmission costs is an important area and one in which Motorola has placed considerable emphasis.

Motorola's strategy has two dimensions:

- An efficient network architecture that minimises the required bandwidth and length of links.

- A portfolio of interconnection technologies to minimise costs in every situation.

Sites utilising the Horizon*macro* BTS product can be connected in 'Daisy Chain', 'Fork', or 'Star' topology. Additional transmission paths can be equipped over diverse routes if redundancy is required. Where possible a BTS multiplexes its own traffic with that of downstream BTSs onto a single transmission link. At each stage the transmission link becomes more fully utilised.

Motorola's architecture moves relatively more intelligence to the BTS compared to other vendors. As a result the control traffic required to the BTS on the RSL (Radio Signalling Link) is minimal. Similar concepts apply to the link between Transcoder and BSC (XBL, Transcoder-BSC Link). The RSL signalling capacity can be provided on either a 16kbps or 64kbps channel depending on TRX capacity at the site. Carrying more traffic and less signalling overhead enable very low transmission bandwidth sites. For example:

- A sub-equipped single carrier site connected over a 1 x 64kbps link (3 TCH)

- A single carrier site needing just 2 x 64kbps backhaul (7 TCH)

- A two carrier site needing just 4 x 64kbps backhaul (15 TCH)

A BTS served with a single 64kbps channel may be useful where nominal coverage is required, perhaps as part of achieving a licence condition.

The Horizon*macro* BTS outdoor cabinet has 6U x 19 inch rack space to allow Transmission equipment to be integrated within the cabinet along with power connection points, transmission jumpering and RF feeders, to form a completely self contained cell site. This integration of transmission equipment into the outdoor BTS minimises the associated costs in providing additional cabinets and onsite work is dramatically reduced.

Motorola have worked closely with the following companies to ensure ease of integration of their microwave products: Alcatel (9400UX series), DMC (Spectrum/M-Series), Harris (MicroStar), Bosch, Innove (XP4 Series), Sagem-SAT (Urbicom2 System), Siae (RTxxG family) and PCom.

2.5.4 Dual band Flexibility

For operators with access to both GSM900 and GSM1800 spectrum, Motorola's advanced BTS design delivers the ultimate in deployment flexibility.

The Horizon*macro* BTS supports any combination of 900 and 1800 carriers within a single BTS cabinet. For example, a single cabinet can support up to 3 sectors at GSM900 or 1800 (single band), or one sector at GSM900 and one sector at GSM1800 as a multiband cabinet. A single dualband BTS cabinet contains one Single Unified Receiving Filter (SURF) module which can support up to 4 sectors per module, either configured as 3 x 900 + 1 x 1800 or 3 x 1800 + 1 x 900.

In addition, converting a single band cabinet to a multiband cabinet (and vice versa) is a simple matter of exchanging one Field Replaceable Unit (FRU).

Alternatively, the BTS can be configured as a multiband BTS using single band cabinets connected together to form a single logical BTS. This configuration only requires one control link, and is managed from the OMC as a single logical entity. A 12-carrier BTS site consisting of a 3 sector GSM900 and 3 sector GSM1800 (or visa versa) i.e. 3/3/3 – 1/1/1 is achieved using two cabinets.

In conjunction with Motorola's Advanced Load Management feature, the new Macro BTS is the most powerful & flexible multiband system solution available.

2.5.5 Ease of installation

Both the Horizon*macro* Indoor BTS and Outdoor BTS are light and can easily be transported and handled by two people.

The Outdoor BTS minimises any site acquisition and planning restriction difficulties due to the low height of the outdoor enclosure (under 1.5 metres). Installation costs are further reduced, as the outdoor BTS requires minimal civil works.

Installation and maintenance requirements are simplified by the 100% front access design of the BTS. As a result, the BTS cabinet can be installed directly against walls on three sides, simplifying site acquisition by allowing far more flexibility in sitting of equipment.

Cable entry is also very flexible by allowing entry from either the left or right side, or from the top or bottom of the cabinet.

2.5.6 High Reliability

The Horizon*macro* BTS has been designed using fewer boards and higher levels of integration, providing exceptionally high equipment reliability. In particularly important BTS locations, redundancy options are available for power systems and control processors, to provide even higher availability.

As with the M-Cell BTS family, an optional memory card can be employed at the BTS to provide non-volatile storage of the operational software, significantly reducing outage times due to download following power outages. An added benefit is the ability to download software upgrades in background mode, and then change over to the new load with a minimum of disruption.

All Field Replaceable modules plug into the cabinet minimising the time taken to restore a faulty site to full operation.

Higher reliability has been achieved in the redesigned transceiver module, which uses RF chipset technology.

Up to 10 minutes of battery backup is provided within the outdoor BTS cabinet. This backup may be supplemented by an additional battery backup cabinet, which provides over 4 hours standby capability. For applications requiring greater backup duration, a second battery cabinet can be installed to give over 8 hours standby capacity.

2.5.7 Future Feature Support

Motorola's Horizon*macro* BTS has been designed with an eye to the future. It will support not only multiband and multilayer architectures, but has been designed with sufficient processing power and memory capability to support future features such as GPRS data services with only a software update (no hardware change is necessary).

Network Operators can build their networks with Motorola's Horizon*macro* BTS confident in the knowledge that the support of future features has been incorporated into the design, helping to protect an operator's investment.

2.6 PRODUCT SPECIFICATIONS

Frequency

GSM 900	Base Receive	880 – 915 MHz
	Base Transmit	925 – 960 MHz
GSM 1800	Base Receive	1710 – 1785 MHz
	Base Transmit	1930 – 1990 MHz

Configuration Limits

Up to 24 carriers per site

Up to 12 carriers per sector

Up to 6 carriers per cabinet (Indoor)

Up to 12 carriers per cabinet (Outdoor)

Up to 3 sectors per cabinet

Up to 6 sectors per site

The outdoor cabinet is capable of expansion to the full range of configurations available in the indoor product.

RF Output Power

900MHz	40 watts at antenna connector (single carrier) 20 watts at antenna connector (2 carriers hybrid combined)
1800MHz	32 watts at antenna connector (single carrier) 16 watts at antenna connector (2 carriers hybrid combined)

Air combining of carriers using Twin Duplexing Filters it is possible to achieve 40W/32W RF o/p power in multi carrier configurations

Receiver Sensitivity

107dBm for GSM900 guaranteed at BTS cabinet input (measured under all profiles).

108.5dBm for GSM1800 guaranteed at BTS cabinet input (measured under all profiles).

Motorola generally delivers receivers, which are typically 6dB more sensitive than as specified by ETSI, i.e. 110dBm.

Safety

EN60215 (radio transmitting equipment)

EN60950 (mains operated electronic apparatus)

EN41003 Equipment to be connected to telecoms equipment)

UL94VO (general flammability)

EMC

ETS 300-342 pt.2. (GSM 11.20 limits)

Physical Characteristics - Indoor

Height:	Less than 1 metre Stackable, less than 2 metres (12 carriers)
Footprint:	Approx. 400mm x 700mm.

Weight:	Less than 120 kg for fully populated cabinet Less than 255 kg for two cabinets stacked
Environmental:	-5C to +45C
Power:	AC 88-264V, 45 to 66 Hz DC +27V (+20V to +30V DC) or -48/60V (-39V to -72V DC)

Physical Characteristics – Outdoor 12 carriers

Height:	Under 1.5 metres. (non-stackable)
Footprint:	Approx 800mm (depth) x 1900mm (width)
Weight:	Less than 550 kg for a fully populated cabinet
Environmental:	-40C to +45C
Power:	AC 88-264V, 45 to 66 Hz

3 BSC & TRANSCODER PRODUCT DESCRIPTION

This section describes the main features of Motorola BSC/RXCDR. In order to improve modularity and the ability for operators to better control their costs, Motorola has established product leadership in the area of small, cost efficient BSCs. Networks, which take advantage of transmission efficiencies supported by the high granularity approach offered by a small BSC are able to benefit from substantial transmission savings when deploying a highly distributed architecture. With the launch of the Scaleable BSC in GSR 4 Motorola addresses the diverse requirements of network operators in terms of BSC size with a single platform that can be efficiently configured in small, medium or large models.

Due to the modularity and flexibility of Motorola's BSSC architecture, it is possible for the operator to configure as follows a two shelf BSSC cabinet :

- One large BSC (2 cages linked together - one logical NE)
- Two BSCs (2 separate cages - two logical NEs)
- One BSC and one Transcoder (2 separate cages - two logical NEs)
- Two Transcoders (2 separate cages - two logical NEs)
- One large Transcoder (2 cages linked together - one logical NE)

The BSSC cabinet houses all the combinations of BSU (BSC) and RXU (TC) shelves (as shown in Figure 1) allowing the network design and implementation engineers an opportunity to minimise hardware implementation whilst maintaining the required BSS functional capacity.

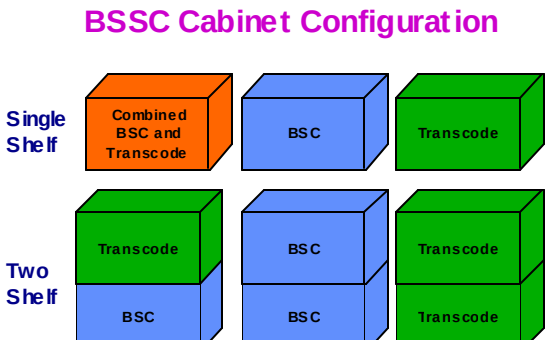


Figure 1 - BSSC Cabinet Combinations

3.1 BSC CAPACITY AND DIMENSIONING

The following table gives the BSC capacity:

SOFTWARE RELEASE	GSR4
Sites	100
Cells	250
TRX	384
Erlangs	1650

Being able to expand capacity within a BSC is appealing from an operational viewpoint because there is less time and effort involved compared to "re-parenting" sites from one BSC to another or even one OMC to another.

The Scaleable BSC also offers a substantial advantage for microcellular deployment where a single BSC will be able to support up to 192 microcellular BTSs each equipped with 2 carriers per site. At 2% blocking on the air interface this corresponds with around 1574 Erlangs of traffic – or around 63,000 subscribers (at 25mE per subscriber).

This increased capacity in the GSR4 software release is achieved through the deployment of Generic Processing Card 2 (GPROC2) for each function at the BSC including Base Station Processor and Link Control Functions.

3.2 MODULARITY OF MOTOROLA BSC

The flexible architecture of the Motorola BSS sub-system will allow the BSC functionality to be contained within a single digital shelf of the standard Motorola BSSC cabinet. This cabinet may be expanded to support two digital cages. These cages may be configured as two separate logical BSC Network Elements (NEs) or combined as a large single BSC NE.

All the BSC digital boards are modular in design, and therefore, their specific functionality and configuration is determined through the software configuration database. For instance the MSI board is designed to support 2 PCM interfaces, and the software defines whether each port drives an A-bis links or an M-link (it is even possible to connect one A-bis and one M-link on the same MSI board). This architecture makes the system very flexible, easy to configure (or reconfigure), easy to expand, and reduces the amount of spare parts.

3.3 DOWNLOADABLE SOFTWARE

With the Motorola BSS, migration between two software releases can be entirely done from the OMC. The software and the BSS database are downloaded through the OML link to the BSC and then through A-bis link to the BTSs. The processor cards automatically update their on board EEPROM with the new boot code. Therefore the Motorola system DOES NOT REQUIRE SITE VISITS for software changes.

With the CSFP feature, it is possible to download the new software version while the network is in normal operation and then swap between the two versions. This feature dramatically reduces the outage time of the network for software upgrades (typically a few minutes for the entire BSS).

3.4 REDUNDANCY

If requested, Motorola can provide a full redundancy for its BSC processor cards and switching cards. The BSC operating system allows processes to move between processors. This flexibility releases the MOTOROLA system from the necessity to have duplicated chains for redundancy. Thus whatever the number of processor boards is on the BSC, full processor redundancy is offered with only two extra boards.

3.5 MOTOROLA BSC-BTS INTERFACE

Using the Motorola A-bis system, the control of the radio and terrestrial circuits are split between the BSC and the BTS. The BSC retains the processes that control the terrestrial links up to the MSC and the final decision process concerning handovers, (switch manager, SCCP, handover request evaluator etc.) whilst the BTS contains the processes whose job is to monitor and control the radio channels (RRSM, CRM and the radio channel interface). Using the Motorola system, a BTS (Cell) does not need its own dedicated A-bis link but only the SITE on which the BTS resides requires an A-bis link. This reduction in dedicated A-bis links is achieved because far fewer control messages/signalling are required between the BSC and the BTS. This means that on sites where more than one BTS cabinet is present, the 2Mbit/s timeslots not required for the A-bis links can be utilised for traffic circuits to the BSC.

Motorola's A-bis variant signalling scheme will enable a single 2 Mbit/s transmission link to support a maximum of 14 TRXs. The Motorola BSS achieves a 50% increase in utilisation when compared with competitive A-bis schemes, which need three separate 64 kbit/s channels per transceiver.

Up to 12 TRX, only one Radio Signalling Link (RSL) is required per site. Here are some examples of the number of TS required per BTS site.

TRX per site	RSL Timeslot	RTF timeslots	Total number of timeslots
2 TRX	1	4	5
4 TRX	1	8	9
6 TRX	1	12	13
12 TRX	1	24	25

The second main advantage of the A-bis interface is the software load repartition it offers. For instance Motorola has been able to easily introduce new complex handover algorithms for microcellular without any modification and overload problem at the BSC level, as BTS are processing the measurement report and handover algorithms.

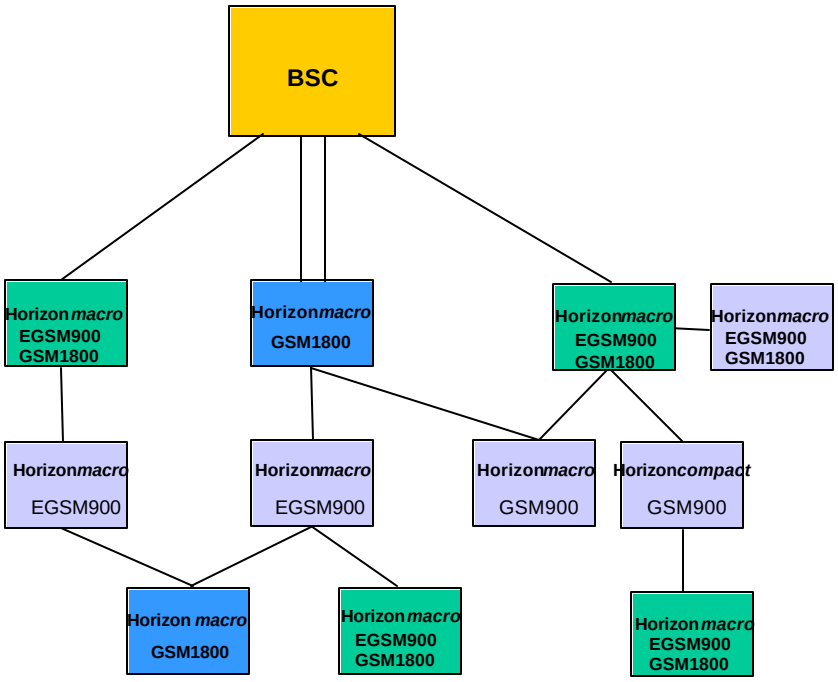
3.6 BTS - DROP AND INSERT

Conventional "Star" A-bis configurations are not cost effective in connecting a BTS to the BSC and therefore the utilisation of Motorola "Drop & Insert" techniques (or multiple logical BTS sites sharing a single 2 Mbit/s transmission medium), allows the transmission medium to be used more efficiently. All Motorola macro BTS equipment is capable of supporting open and closed chains, forks and branches of the A-bis Interface, commonly called "Drop & Insert". Micro equipment is also capable of supporting open and closed chains (loops).

The utilisation of "Drop & Insert" for BTS sites within regional areas will efficiently utilise the 2 Mbit/s transmission links available, especially when designed with a distributed BSC philosophy. The following diagram outlines some of the types of A-bis connection available with the Motorola BSS.

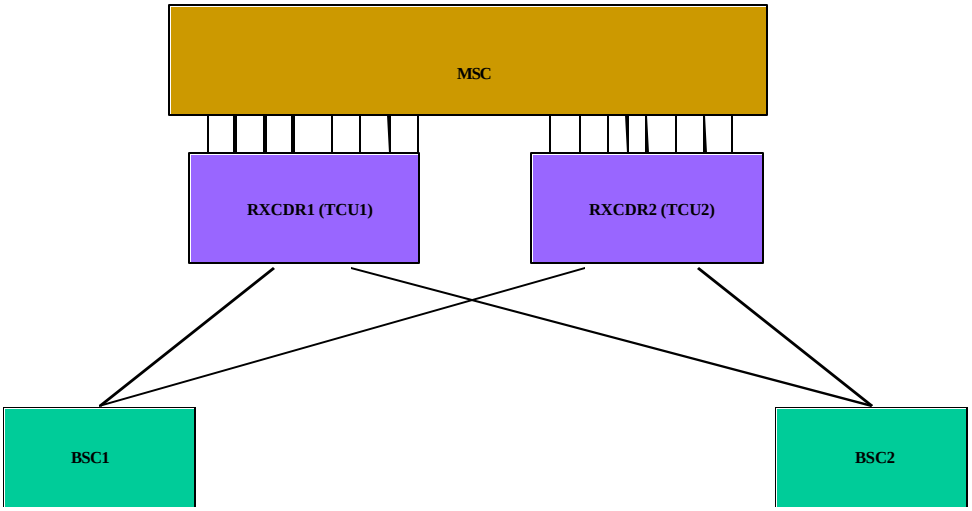
The following diagram outlines some of the types of A-bis connection available with the Motorola BSS.

MOTOROLA BTS "Drop and Insert" Example



3.7 BSC-RXCDR INTERCONNECTION

The Motorola system supports any combination of BSC and RXCDR (TCU). It is also possible to connect a BSC to several RXCDR (TCU) and to connect several BSCs to the same RXCDR (TCU) as shown in the following figure. Such a configuration offers full redundancy on the A-Ter links.



3.8 BASE STATION CONTROLLER (BSC) FUNCTIONALITY

The Motorola BSC will support and control multiple BTS's, perform call processing, dynamic switching, operations and maintenance, as well as providing the M-Interface connection between the BSC and Transcoding equipment (XCDR).

The principal functions of the Motorola BSC include managing the radio channels and transferring signalling information to and from the mobile subscribers. The Mobile Switching Centre (MSC) communicates and passes signalling and traffic data to the BSC, which provides the opportunity for remote switching, distributed control and traffic concentration.

3.9 REMOTE TRANSCODER (RXCDR) FUNCTIONALITY

In order to fully utilise the sub-multiplexing functionality of the Transcoder (XCDR), Motorola advocates that the XCDR be co-located at the MSC, remote from a distributed BSC architecture, and thus performing remote transcoding (RXCDR).

The Motorola Remote Transcoder (RXCDR) contains the digital signal processing equipment that performs GSM/DCS defined speech encoding and decoding. The Motorola RXCDR will transcode 64 kbit/s A-law PCM channels in the PSTN network and the 13 kbit/s vocoder channels used on the GSM air interface.

The Motorola RXCDR supports up to 480 TCHs per transcoder digital shelf (RXU) and the RXCDR cabinet will support up to two RXUs (960 TCHs). The two RXUs may be

configured as either two separate RXCDRs or a single 960 TCH RXCDR within a single cabinet.

The modular digital cards of the Motorola BSS infrastructure allow simple expansion of the RXCDR through the addition of Advanced Transcoder Board boards, each capable of supporting 30 TCHs.

3.10 KEY COMPONENTS OF THE MOTOROLA DESIGN

This section provides highlights of key aspects of the design and implementation of Motorola's BSC. The Motorola BSS physical implementation is based on a small set of:

- Digital boards
- Communication busses
- Radio subsystem

These elements are combined with Motorola software to form a flexible, high performance BSS product which provides superior fault tolerance, allows graceful expansion from control of a single carrier up to a large BSC supporting many distributed BTSs, and offers potential cost savings resulting from reduced 2 Mbit/s circuit terrestrial (leased) line requirements. Support for multi-cell BTS sites, operations and maintenance functions, and fault detection and management is also included.

Key elements of the Motorola design, which enable the flexible architecture include:

3.10.1 Generic Processor (GPROC2)

The new high performance, Motorola 68040-based fault tolerant processing board may be assigned different functional duties based on the required capacity and architecture. For example, two processor boards can be used to perform all BSC functions in a small BSC site. When this site grows, more processor boards are added to increase the capacity. Functions are distributed among the processor boards to achieve optimum performance. The same GPROC2 board may be used for controlling multiple cell sites.

3.10.2 Kiloport Switch (KSW)

A high speed digital switch capable of supporting 1024 64kbps ports, or 4096 16kbps ports, expandable to 4096 64kbps ports when 4 KSW boards are interconnected.

- Sub rate switching (16kbps, 32kbps, or 64kbps ports)
- Extendible to support up to 5 shelves
- Expandable to support up to 16,384 16kbps ports

3.10.3 Buses

High performance communication buses, which support inter-processor, processor-to-peripheral, and call-oriented traffic through the BSS are also implemented. A high speed (16 Mbit/s) Local Area Network (LAN) is used for inter-processor communications. The use of a LAN allows easier BSS expansion and increased fault tolerance.

An extension of the processor bus (MCAP) allows peripheral boards (e.g. kiloport switch, multiple serial interface boards, etc.) to be controlled with minimal overhead. A time division multiplexed (TDM) switch highway allows signalling and traffic (voice or data) to

be routed through the BSS. If requested, Motorola provides "hot" redundancy for TDM, LAN, and Clock buses.

3.10.4 Operating System

A unique multi-processor real-time operating system is supplied with the BSS. This operating system is based on a process-message model and utilises the memory management unit (MMU) of the 68040 to ensure process and data isolation. Motorola's extensive experience with large real-time systems has shown that unintentional process interaction leads to the majority of software-generated faults.

The operating system offers the following features:

Process and data isolation - prevents one process from writing into another process' address space. All inter-process communications are performed via messages passed by the operating system.

Logical message routing - allows the BSS application software functional units to migrate from processor board to processor board without affecting the application routines. No modifications to the routines are required when the BSS expands from a single GPROC2 to multiple GPROC2s and the high level functions may be partitioned for greatest efficiency.

3.10.5 Downloadable Software

On the MOTOROLA system, the software versions are fully downloadable. Meaning that when a software version is changed, everything can be done from the OMC-R and no on site visits are necessary. In particular, the MOTOROLA system does not need to physically change PROMs on each site. The GPROC2 boards have an EEPROM, which is automatically updated on each new software version download. This is required to activate the CSFP (Code Storage Facility Function Processor).

3.11 BSU AND RXU DIGITAL BOARDS

3.11.1 Full Size Boards

3.11.1.1 Generic Processor (GPROC2) Board

GPROC2 is a second-generation processor board. Its main purpose remains the same in that it is a generic piece of hardware supporting the various BSS software functions. GPROC2, however, has been significantly redesigned to provide a substantial increase in both processor performance and available memory - this has been driven by the specific needs at the BSC to provide support for advancing features, services and BSS capacities. GPROC2 runs with a 68040 processor and 32 Mbytes of memory (expandable to 64 Mbytes) offering a performance gain of approximately five times that of GPROC2 and a doubling (or quadrupling) of memory space. Furthermore the memory on GPROC2 uses error detection and correction circuitry to guard against failures of memory cells, this makes the GPROC2 inherently a more reliable processor board.

The GPROC2 is used throughout the Motorola BSS as a generic control processor board. The functions performed by the board are determined by the software. A single board, for example, may perform all BSS functions for a small site. As the site grows, the functions are

distributed to additional GPROC2s, which support the increased performance requirements of the larger site. Additionally, using a single physical board for all control processor functions allows a significant reduction in the number of spares, which must be maintained by the operator. Possible functional assignments for the GPROC2s in the BSS are listed below:

- Support of the MSC signalling links (CCITT SS #7)
- Support of the Layer 3 Call Processing functions
- Support of the BSC-BTS signalling links (LAP-D)
- BSC control functions (fault management, switch control, etc.)
- Support of the OMC-R interface (OSI protocols)
- Remote transcoder control functions

3.11.1.2 Switch Board (KSW)

The time division Kiloport switch (KSW) supports 1024 64 kbits/s kiloports, which is equivalent to 32 2.048 Mbit/s circuits. The KSW board is used in digital shelves within the BSS architecture (BSU and RXU digital shelves). The switch contains an MC56001 digital signal processor (DSP) as a control processor, which communicates with the GPROC2 via the MCAP bus. For redundancy, the number of KSWs at a site is doubled. The redundant KSW configuration is also controlled by the GPROC2 over the MCAP bus. In the event of a primary switch failure, the redundant KSW network at the site will pick up and continue with uninterrupted service. The KSW provides sub-rate switching of 16 and 32 kbits/s channels as well as the standard 64 kbits/s switching. The overall switching rate of a single KSW is 65.536 Mbit/s. Up to four KSW boards may be interconnected, providing a total switching capacity of 4096 64 kbits/s kiloports (16,384 16 kbit/s kiloports) and an increased switching rate of 262 Mbit/s.

3.11.1.3 Generic Clock Board (GCLK)

The Generic Clock Board (GCLK) generates all timing reference signals required at the BSS site. The master TDM clock will be normally synthesised from the on-board reference oscillator operating at 16.384 MHz, which may be phase locked to the recovered clock from the selected 2 Mbit/s circuit or may free run. The GCLK board provides 0.05 ppm reference stability as required by GSM/DCS specifications.

The GCLK is located in the first digital shelf at a site. A redundant GCLK may also be equipped in the same shelf. With the use of the clock extender (CLKX), it can support up to 18 co-located shelves.

The Multiple Serial Interface (MSI) board interfaces two 2.048 Mbit/s circuits to the TDM switch highway. An MC68000 performs the control functions required on this board. The MSI provides surge protection, clock extraction, jitter attenuation, frame alignment and support for the procedures required to synchronise multiple BSCs within a network**.**

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3.11.1.5 Advanced Transcoder Board (ATB)

The Advanced Transcoder Board (ATB) (previously code named GDP) supports Enhanced Full Rate (EFR) speech transcoding and 4:1 sub-multiplexing functions at either the MSC, BSC, or BTS sites. It also provides an interface to the 2 Mbit/s circuits and the TDM switch highway. Each ATB board can support 30 traffic channels of GSM/DCS speech transcoding.

This board also provides functionality to **adjust the audio volume at the Transcoder**.

3.11.1.6 Bus Terminator Card (BTC)

The Bus Terminator Card (BTC) provides the terminations necessary for all of the signals on the digital backplanes and is required due to the high-speed busses contained in the backplanes.

3.11.2 Half Size Interface Extension Boards

Interface extension boards are required for optical/copper interconnection of equipment shelves and for interconnecting to external alarm site alarms.

3.11.2.1 Kiloport Switch Extender (KSWX)

The Kiloport Switch Extender (KSWX) board is used to provide an optical interconnection to carry the TDM bus between digital shelves. It is required when a site grows beyond one cabinet or shelf. With the KSWX the TDM bus may be extended to other shelves, or expanded by inter connection of KSW boards. For redundancy each KSWX is duplicated.

The KSWX operates in three different modes defined as Local, Remote, and Expansion. The mode in which the KSWX operates is determined by the slot in which it is inserted. When in the local slot, the KSWX distributes the clock signals to the shelf (received from the CLKX), and if there is no KSW, drives the TDM bus. In the remote slot the KSWX bi-directionally transmits and receives information between the KSW and a KSWX operating in the local mode of an extension shelf. When inserted in the expansion slot the KSWX bi-directionally sources and receives information from another KSWX operating in the expansion mode in the expansion shelf (2nd switch shelf), which allows communication between two KSW boards.

3.11.2.2 Clock Extender (CLKX)

The Clock Extender (CLKX) board is required when a site grows beyond a single digital shelf. The function of this board is to distribute the clock and reference signals generated by the GCLK boards, via optical fibre, to the additional shelves. A CLKX (two for redundancy) is required for every six shelves of equipment at a BSC. By using three CLKX boards each GCLK can support up to 18 co-located shelves.

3.11.2.3 Local Area Network Extender (LANX)

The Local Area Network Extender (LANX) board is required for each digital shelf (if more than a single GPROC2 is present). The function of the board is to provide the extension of the LAN via fibre optic interfaces for communications between GPROC2 boards in different shelves, provide LAN arbitration between GPROC2 boards, support the removal of a GPROC2 without affecting the LAN, and to provide the active/standby redundant LAN

control within a shelf. It also provides the shelf ID Two LANX boards per shelf are required to provide redundancy.

3.11.2.4 Parallel Interface Extender (PIX)

The Parallel Interface Extender (PIX) board provides the interface between the BSC processors and the customer's site equipment (external alarms). This board provides eight sets of dry contact detect and four sets of dry contact closures, to be defined by the customer. The board contains the required interface logic to the GPROC2 for these contacts. A maximum of two PIX boards can reside in each shelf, providing 16 alarm inputs and 8 control outputs. Redundancy is provided by duplication of inputs or outputs to different PIX boards.

3.11.2.5 Battery Backup Board (BBBX)

Battery Backup Board (BBBX) provides DRAM backup for up to eight GPROC2 code loaded boards. The BBBX provides the interface and DC conversion to an externally located battery, which can be between +27VDC and -48VDC.

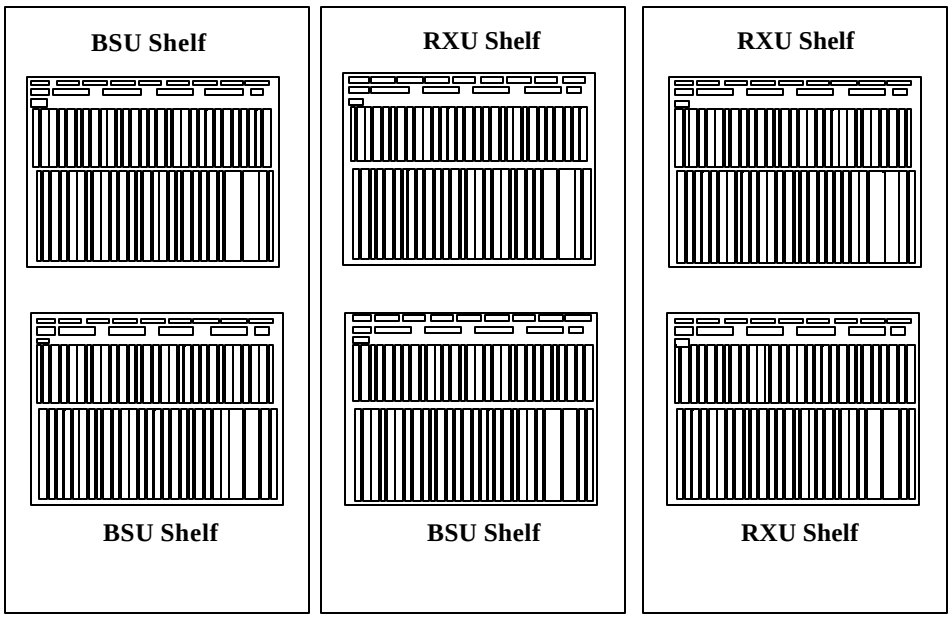
3.11.2.6 BIB and T43 2 Mbit/s Circuit Interface Boards

The purpose of the Balanced-line Interconnect Board (BIB) and the Type 43 Interconnect Board (T43) is to interface external 2 Mbit/s circuits to shelf backplanes by connecting to the top panel of the BTS and BSSC cabinets. The BIB and T43 boards provide the same function, the type used is determined by the 2 Mbit/s circuit transmission standard used (balanced or unbalanced). The BIB board provides twelve (six input, six output) balanced, 120 ohm lines, which are mass terminated in a 37 pin D-type connector. The T43 provides twelve (6 input, 6 output) unbalanced, 75 ohm lines terminated with individual T43 (coaxial), connectors. Both boards are protected against secondary lighting surges of up to 1500V.

3.12 BSS CONTROL CABINET (BSSC)

The BSS Control cabinet (BSSC) supports two shelves, which contain the digital boards. The flexible architecture of Motorola's BSS control allows customisation of the functions supported by the BSSC via different allocations of digital boards. The BSSC cabinet(s) at a site is therefore equipped to meet the requirements of the site. Both shelves may be interconnected to form a single control entity, or not connected, in order to form separate logical entities (e.g. 2 different BSCs).

The BSSC cabinet houses all the combinations of BSU and RXU shelves (as shown in Figure 1) allowing the network design and implementation engineers an opportunity to minimise hardware implementation whilst maintaining the required BSS functional capacity.



BSSC Cabinet Combinations

3.12.1 BSSC Cabinet Shelves

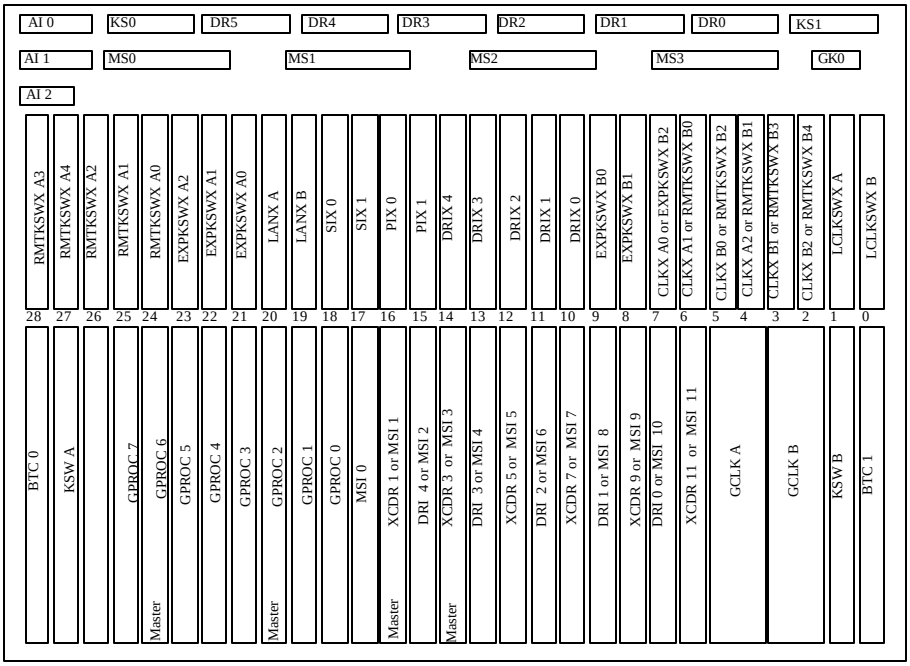
To provide even greater flexibility, either shelf may be one of two different types. One shelf, the BSU, is configured to support up to 8 GPROC2 board slots and 12 external interface board slots. The other shelf, the RXU provides 19 external interface board slots, but only 2 GPROC2 board slots.

Each shelf consists of two rows of digital boards interconnected by a common backplane. The upper row of board slots accommodates the smaller (half size) interface extension boards. The lower row of board slots provides the location for the larger (full size) digital processor boards and clock generation. Each BSU or RXU shelf supports up to 27 full-size boards and 29 half-size boards. The shelves require 48V/60 VDC for operation.

Up to three power supplies are located in the lower part of each shelf. Each shelf is initially equipped with two power supplies, with room for a redundant supply. There are two types of power supplies, one for the negative ground and one for the positive ground. The cooling fans for each shelf are located below the power supplies for that shelf. The speed of the fans for each shelf is controlled individually according to the current ambient temperature and internal power dissipation, providing the required amount of cooling while minimising the noise level. To increase system reliability, multiple fans are used so that the entire shelf is not disabled by the failure of a single fan. Each fan is individually fused and alarmed.

3.12.2 BSU Shelf

The BSU shelf is the suggested platform for the BSC function. The BSC is primarily a processing element, which provides the call processing for the BSS, transfers signalling information to and from the mobile stations, manages the BTSs, and provides switching between the radio channels and the trunks to the MSC (A-interface). As such the BSU shelf, with its greater capacity for processor boards, better enables the growth of processors to provide the BSC function.



BSU Shelf

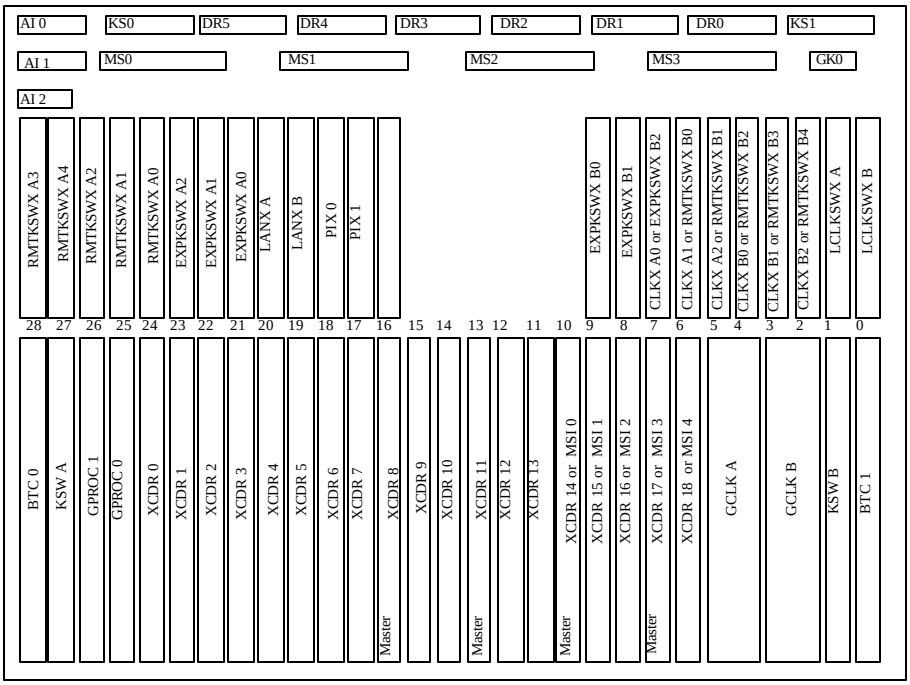
Each Multiple Serial Interface (MSI) board may interface 2 x 2Mbit/s links allowing 24 interfaces per shelf (A-bis and M-Interface). Transcoder boards may also be installed in certain full size slots if transcoding functionality is to be co-located at the BSC.

Board Name	Maximum
MSI	12
ATB	6
GPROC2	8

Maximum Number of Full-Size Boards in a BSU Shelf

3.12.3 RXU Shelf

When the transcoding function is concentrated at a location such as the MSC or BSC, the RXU shelf has the largest capacity for performing the transcoding function. Each shelf can support remote transcoding for up to 480 traffic channels plus additional 64 Kbits/s circuits for control and operations and maintenance usage. Each RXU shelf is configured to support 2 GPROC2 board slots 20 and 19 external interface board slots (16 ATB and up to 3 MSI boards).



RXU Shelf

The flexible architecture of the BSS equipment is demonstrated in the following table. The RXU shelf configuration is dependent upon the BSS network and future subscriber growth predictions. Each MSI board provides the interface for 2 x 2Mbit/s links and each transcoder card (ATB) provides the 4:1 sub-multiplexing function for 30 traffic channels.

ATB Cards	MSI Cards
16 +	3
15 +	4
14 +	5

External Shelf Interface Combinations Using the RXU Shelf

3.12.4 Alarm Notification Capability

Each digital shelf (BSU or RXU) accepts up to sixteen (8 per PIX board) external alarm or status inputs, via the Parallel Interface Extender (PIX) typically used to monitor site conditions such as fire and building entry alarms, and can control up to eight outputs (4 per PIX board) for external alarming devices (bells etc.).

Each monitoring circuit is capable of supporting a "dry" relay contact input, either normally open or normally closed. "Dry" contacts imply that no current may be injected by the customer equipment being monitored. The external alarm inputs interpret an external resistance from 0 to 1000 ohms to be a closure and any resistance greater than 10,000 ohms to be an open circuit. Each cabinet will provide the capability to control up to eight external alarming devices. Each control circuit provides a set of "dry" relay contacts, either normally open or normally closed. "Dry" contacts imply that no current will be sourced or sunk by the cabinet control equipment.

The external alarm output contacts withstand a maximum of 30 Volts /1 amp DC without damage. Typically redundancy is not provided unless the physical site alarms are duplicated, and when the transcoding is located at the MSC site, the MSC will provide for site alarms.

3.12.5 BSSC Cabinet Connections

All connections to the BSSC cabinet, including DC power, 2 Mbit/s circuits and customer-defined alarms are located on the top panel. Interconnections to external cabinets are made with fibre optic cables, which leave the top of the cabinet through a waveguide-below-cut-off filter.

The power distribution panel is mounted at the top of the BSSC cabinet. To provide the maximum amount of transient protection, the battery connections are all made at a common point at the top of the cabinet.

3.12.6 BSSC Cabinet Capacities

BSSC Cabinet Standard Equipment

1 BSSC cabinet hardware kit

1 Distribution Alarm board

BSSC Cabinet Capacities

2 total BSU and/or RXU shelves maximum

48 2 Mbit/s circuit interfaces maximum

The BSU and RXU shelves come equipped with

2 BTC

1 LANX

3.12.7 BSU Shelf Capacities

Full Size Boards

8 GPROC2
2 KSW
12 total external interface slots for MSI and/or ATB
2 GCLK

Half Size Boards

18 KSWX
6 CLKX (requires KSWX slots)
2 PIX additional
1 LANX (2 total)

Power

2 Power Supplies initially
1 additional Power Supply for redundancy (3 total)

3.12.8 RXU Shelf Capacities

Full Size Boards

2 GPROC2
2 KSW
19 total external interface slots (up to 16 ATB + 3 MSI)
2 GCLK

Half Size Boards

18 KSWX
6 CLKX (requires KSWX slots)
2 PIX
1 additional LANX (2 total)

Power

2 Power Supplies initially
1 additional Power Supply for redundancy (3 total)

3.12.9 BSSC Cabinet Environmental Specifications

Power Consumption:	2400 watts maximum
Cabinet Dimensions:	2100 mm x 712 mm x 415 mm (HxWxD)
Floor Loading:	230 kg max.(2 BSU cages), 136 kg unequipped
Storage Temperature Range:	-45 degrees to +70 degrees C (storage)
Operating Temperature Range:	-45 degrees to +45 degrees C (operating)
Humidity, Non-condensing:	20 to 80% relative humidity, not to exceed 0.024g water/g dry air

Altitude:	Up to 3 km, corresponding to an atmospheric pressure range of 648-1048 millibars. The maximum ambient temperature corresponding to an atmospheric pressure of 648 millibars is 40 deg C.

3.12.10 BSSC Cabinet Power Supply

Voltage Range:	40 to -75 Volts DC Positive Ground, 48/-60 VDC, nominal
Voltage Regulation:	1.5 %
Maximum Current:	86amps at +27V, 46 amps at –48V
Typical Current:	65 amps at -48V DC, 52 amps at 60V DC
Ripple and Noise:	less than 32 dBm C-weighting in voice band
	less than 200 mv p-p over 1 0 Hz -14 MHz
	less than 30mv rms over 10 Hz -14 MHz
Voltage Application Stabilisation:	within the specified voltage range in less than 1 sec.

4 OMC-R PRODUCT DESCRIPTION

4.1 MOTOROLA OPERATIONS AND MAINTENANCE CENTRE (OMC-R)

Motorola's Operation and Maintenance Centre (OMC-R) is used centrally to support the day-to-day management of a cellular network. It also provides data on which to base the long-term engineering and optimisation of the network. The principles of OMC-R Network Management (NM) are based on the ISO network management. For example, standardised, open communication interfaces like Ethernet and X25 are used in the OMC-R.

The OMC-R is based upon the Sun Microsystems server and workstation product line. There are two hardware configurations - one supporting up to 5,000 traffic channels and another supporting up to 45,000 traffic channels. This has the benefits of a reduced cost for an entry-level system with the 5K model, simplified systems administration with a single computer family and the computing power of the Sun platform offering greater capacity.

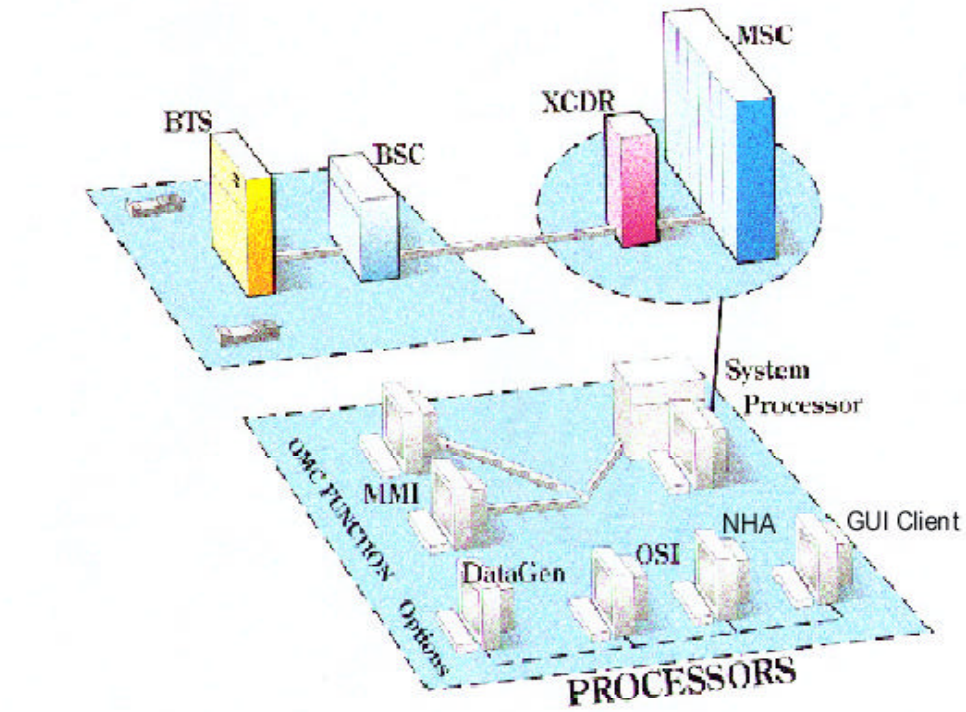


Figure 1 - Motorola O&M Architecture

The Motorola OMC-R is a Reduced Instruction Set Computer (RISC). The accurate data it provides is essential to the day-to-day management of a GSM network.

Some of the main features and benefits of using the OMC-R in a GSM network are:

- Operations and maintenance are centralised. This simplifies the network management and reduces labour costs.
- The quality of service is improved by the simplicity of locating and isolating faults.
- The user-friendly Man/Machine Interface (MMI) reduces training costs and operator errors.
- Detailed statistics are provided on a regular basis from which the network can be optimised to be more efficient and cost effective.
- Security control is improved. This protects the network against unauthorised use.
- Machine to machine connections are simplified by the standardised communications interfaces.
- Standard UNIX operating system means that third party applications can be added by the customer.
- The industry standard database provides SQL access for custom reporting.

The OMC-R conforms to the following GSM Recommendations:

- Network Status Monitoring.
- Event/Alarm Management.
- Fault Management.
- Performance Management.
- Configuration Management.

A Database Management System, Man Machine Interface and a Communications handler to meet the above recommendations are supplied in the Motorola OMC-R package.

The high quality of service which can be expected from the OMC-R ensures your cellular system will be operated and maintained in an efficient, cost-effective way and provide optimum performance.

OMC-Rs manage the Motorola BSCs, BTSs and remote transcoders. The GSM network will continue to operate if the OMC-R should happen to be off-line. It does not affect call processing in the network in any way.

The data is exchanged using X.25 as a transport mechanism between the OMC-R and the BSC. The upper layer protocols include a file transfer mechanism, event reporting and a remote access for the BSS MMI.

4.2 OPERATION

4.2.1 OMC Statistics

The OMC-R periodically collects the statistics generated at the network elements under its control. These statistics are used to support the optimisation of network performance and quality and to anticipate degradation in network availability or performance.

The OMC-R can present raw statistics in the following eight logical groups of data:

- BSS Raw Statistics
- Cell Raw Statistics
- Carrier Raw Statistics
- GPROC Raw Statistics
- MTL Raw Statistics
- OML Raw Statistics
- RSL Raw Statistics
- XBL Raw Statistics

There are over 100 raw statistics. Each group contains the raw statistics pegged at that particular device level. By selecting any one of the groups the operator can generate a report on up to seven raw statistics.

The OMC-R gathers statistic data from the network of BSCs.

The OMC-R computes key statistics from the gathered raw statistics. For all cells in the network there are 16 key statistics that can be calculated over any specified time period. These are presented in the Key Statistic Report.

The Key Statistics give the operator an overall indication of the "health" of the network.

Key Statistics are calculated for the following:

- Handover Success Rate
- Handover Failure Rate
- Handover per neighbour per cause
- Handover per cause per cell
- External neighbours Handover
- Indication of Overload Flow Control
- Handover flow between Cells Stats
- RF Loss Rate
- Paging Load
- TCH Assignment Success Rate
- TCH Mean Holding Time
- TCH Mean Arrival Rate
- TCH Traffic
- SDCCH Mean Holding Time
- SDCCH Mean Arrival Rate
- SDCCH Traffic
- TCH Congestion
- SDCCH Congestion
- SDCCH RF Loss
- TCH RF Loss
- Cell Total Calls

In the Motorola OMC-R all the above groups of statistics are standard features.

4.2.2 The OMC Man Machine Interface (MMI)

The OMC MMI is a user-friendly Graphical User Interface (GUI), based on the Open Software Foundation motif (OSF-Motif). This makes it easy for the operator to manoeuvre through the OMC functions and carry out everything in network management through a single focal point. It makes a simple job of all maintenance, network reconfiguration, trouble-shooting, diagnostics, and system administration (See figure 2 below).

A summary of the alarms present in the network can be seen directly from the GUI and access to the alarm detail window can be easily obtained.

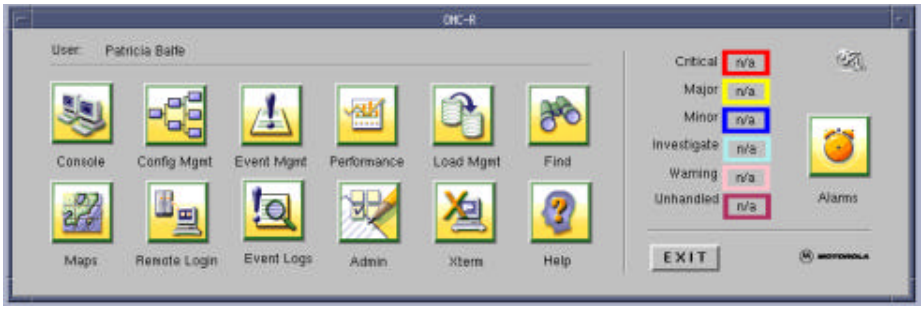


Figure 2 – Motorola OMC-R GUI

4.2.2.1 GUI support for large Networks

As the capacity of a single OMC-R increases a number of extensions have been introduced to provide functionality to assist in managing larger networks. This will reduce clutter on the map and alarm window's, speed up search in the alarm window while making it easier to find network elements in the login window. The summary information allows for quick review of the overall network status.

Functions include the following:

- BSS naming on forms.
- MIB/Network Element consistency.
- Short labels on map.
- Alphabetic display in remote login window.
- Auto-create comms links.
- Find on alarm window.
- Copy on alarm window.
- Alarm details for single alarm.
- Alarm deferral.
- Split alarm window.
- Reassign alarm.
- Auto-remove cleared alarms.
- Alarm summary (alarm window).

4.2.3 Network Status Monitoring

4.2.3.1 Map Display

At the heart of Motorola's OMC-R are the pictorial displays providing views of network equipment. The OMC-R provides hierarchical, geographical and topographical views of the network allowing the operator to quickly gain an understanding of the network status. The geographical map is displayed as a background, overlaid with nodes and links representing the RF network.

Icons are used to identify the individual network elements such as Base Station Controller (BSC) Base Transceiver Station (BTS) or Mobile Switching Centre (MSC). Network elements or links can be annotated with a name or location (See Figure 4 below).

From the map view a user can obtain further detailed operational status, or enter immediately one of the further functions for device management, configuration management, remote login to the device or performance management.

The status of each node and link is continually updated on the display with colours and icons used to graphically indicate the class and severity of any alarms occurring at that element or link. A new incoming alarm will also cause the icon of the affected element or link to be clearly identified on the screen.

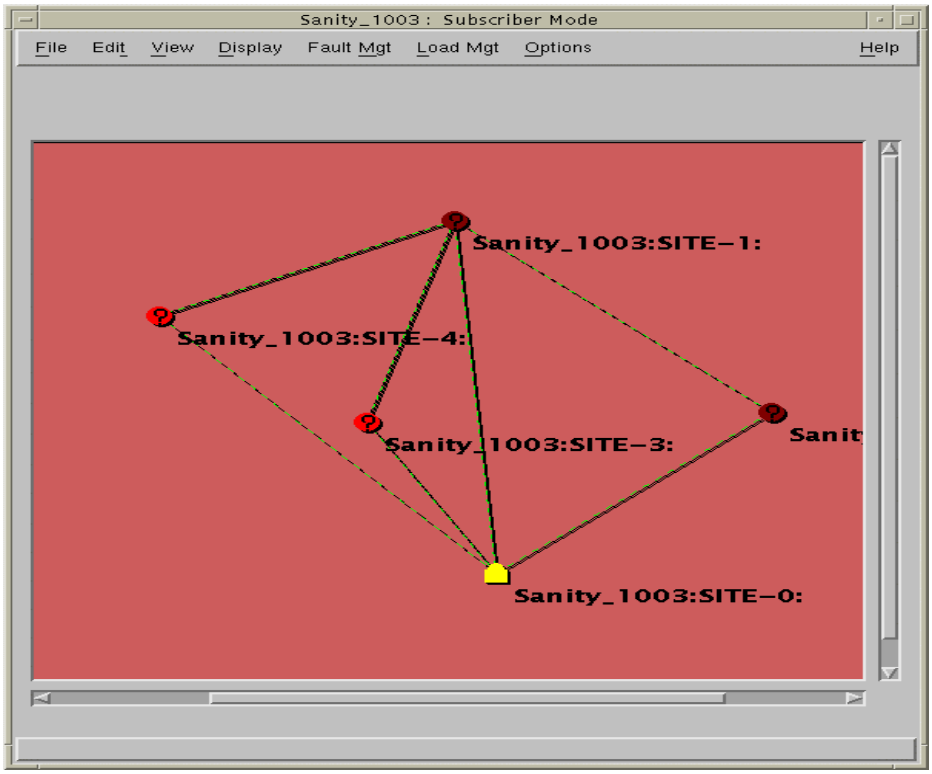


Figure 4 - Network Map Display

The standard GUI map is available on the OMC. If a detailed geographical map of the area is required it can be loaded on separately.

4.2.4 Alarms

When an alarm occurs, the operator is alerted by the main alarm icon being animated and by a warning sound. An alarm summary shows the number of outstanding alarms at each severity level. The alarm status is reflected in the map display by a colour change and flashing of the network node concerned. Maps can be specially configured to suit the monitoring requirements of each Network Operator.

Notification of a new alarm or event can also be directed to a pager to notify an engineer remote from the OMC-R workstation.

The OMC-R user can access the alarm from the map, from alarm subscription list or from an event window opened for the specific network node. The user has control over the format and sorting of alarm/event displays.

Inbound events and alarms are standardised and entered into a log with full facilities of search, recall and sort. The event log has automatic and manual rollover.

Each map has a Re-Sync capability. The OMC periodically checks the devices in the network to ensure that the map shows true representation of the health of the network.

4.2.4.1 Event /Alarm Subscription

Typically an O&M centre has a number of OMC-R operators. A subscription process allows the individual OMC-R operators to concentrate on events and alarms from a specific section of the network or on a particular type of event or alarm. Subscriptions are not exclusive therefore multiple users may have subscriptions that cover a specific event or alarm. A user can also have multiple subscriptions and therefore receive notification of new events and alarms under any of these subscriptions.

Subscription lists can be modified, deleted, renamed and displayed by the operator. Each event and alarm subscription uses the following criteria:

- Source Device
- Alarm Type

4.2.4.2 Alarm Management

Alarm management is supported using, for example, the following features:

- BSS Transient Alarm Handling
- Alarm Notification via Paging
- Alarm Handling Improvements
    - Map Event History
    - Alarm Blacklisting from Alarm Window
    - OIC Alarm Clearing at OMC

4.2.4.3 Classes of Alarms

- Communication failure – Indicates an alarm relating to a fault in the transfer of data from one point to another
- Quality of Service failure – Indicates an alarm associated with degradation in the quality of service
- Processing failure - this is an alarm associated with software or processing faults
- Equipment failure – Indicates an alarm associated with an equipment fault, transmitter failure or power problem
- Environment failure – Indicates an alarm associated with the room in which the equipment resides
- Software Alarms Messages –Indicates alarms associated with software related errors, are generated only in GPROC-based devices and are reported to the BSS Software Fault Management (SWAM) application software

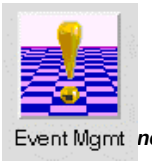
4.2.4.4 Classes of Events

- Indication of a device change of state at a N.E.
- Test result information
- Information on traffic conditions
- File transfer indication
- Measurement result indication
- Indication of a faulty device condition at a N.E. (an alarm)

4.2.4.5 Classes of severity:

- Critical - Indicates that a fault affecting the service has occurred. Immediate corrective action is required
- Major - Indicates that a fault affecting the service has occurred. Urgent corrective action is required
- Minor - Indicates the existence of a fault that does not affect the service. Corrective action should be taken to avoid a more serious problem
- Warning - Indicates the detection of a potential or impending service-affecting fault. Action should be taken to further diagnose and correct the problem to prevent it becoming more serious
- Indeterminate - Indicates that the severity of the fault cannot be determined
- Clear - Indicates the clearing of previously reported alarms

4.2.5 Event and Alarm Handling



Once a particular Alarm event has been seen the OMC-R operator can register that it is being handled. Any other OMC-R operator accessing that alarm will then see the name of the individual handling that alarm. Further a comment can

be tagged to the alarm so that users can log notes to others as the alarm is being resolved. Specific event types or nodes can also be 'blacklisted' so that reporting is barred (although the event is logged).

An alarm threshold can be set to only show an alarm after it occurs a certain number of times.
Alarms that have been subscribed to will appear on the operator's terminal. The operator can change the status of these alarms to one of the following:

- New - Indicates that the operator has not yet acknowledged the alarm
- Seen - Indicates that the alarm has been acknowledged, no further action has been taken and the fault has yet to be rectified
- Handling -Indicates that the operator is attempting to rectify the fault that caused the alarm
- Cleared -Indicates that the fault has been rectified, or cleared by the operator

4.2.5.1 Event and Alarm Thresholds

An operator may define event and alarm thresholds so that the OMC-R is notified following a pre-set number of occurrences of a particular event/alarm.

4.2.5.2 Event and Alarm Printing

Event and Alarm information may be routed to a printer.

4.2.5.3 Save Alarm Context

This allows the BSS to store any alarms and events that may occur whilst the OMC-R is inaccessible for any reason.

6.2.5.4 Network Element (NE) Device Reconfiguration Control

This feature enables the operator to change the device state and obtain the status of devices.

4.2.5.5 States

There are two types of states possible.

- Administrative -Set by the operator at the OMC using Remote Login facility or locally at the site, using a PC
- Operational -Controlled by the NE Fault Management application

4.2.5.6 Administrative State

There are five administrative states. They are as follows:

- Unlocked -Normal operation state of device
- Locked -Unavailable for normal operation
- Shutting Down -Will become locked once its current tasks have been completed
- Equipped -The device is known to the system
- Unequipped -The device is not known to the system

4.2.5.7 Operational State

There are three "operational" states. They are as follows:

- Enabled -In this state the device is not supporting user traffic

- Disabled -In this state the device cannot support user traffic
- Busy -In this state the device is supporting user traffic

4.2.5.8 Consolidated Alarms

The map area shows alarms at nodes based on device severity, so if a BSS contains an "alarming" device the BSS icon is alarmed. A problem with this approach is that a redundant device that goes critical causes the BSS that contains it to go critical. Therefore, the map is red most of the time. The operator is misled into thinking there is a critical problem at the BSS when in fact the problem may not affect the subscriber.

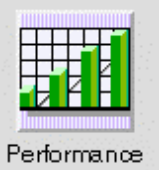
This feature displays alarms on the map in terms of the impact on the subscriber. A loss of service results in a critical severity; a loss of capacity results in a major severity; and a loss of redundancy results in a minor severity. A redundant device that goes critical causes only a minor functional unit severity (a functional unit is a BSC, BTS, RXCDR or cell), but if the last radio unit or controller associated with a cell goes critical then the displayed cell severity is critical. The map therefore enables an operator to prioritise his work according to the impact on the subscriber.

4.2.5.9 Call Trace

The call trace facility enables a PLMN operator to trace the activities of various network elements for events associated with a particular subscriber or equipment. With a single command, the operator at OMC, MSC or BSS can activate a trace. Each call trace object has certain criteria associated with it. The operator is required to specify the criteria to activate a call trace object. When a call in the BSS meets the criteria, a trace gets invoked by the BSS. The BSS collects various data as specified in the trace criteria and sends it to the OMC-R in the form of trace records. The BSS sends these trace records in ASN.1 format. The OMC-R converts the records into GSM 12.08 format and saves the data in the form of log files at the OMC-R. If the operator has call trace product he is able to analyse the data and find out solutions to improve the network performance. The operator also has the option of forwarding the records to the NMC. When all the conditions of a trace criteria are met, the BSS deletes the call trace object and informs the OMC-R. The operator may also request the BSS for a premature deactivation of a trace.

When an operator (at OMC/MSC/BSS) creates or deletes a call trace object, the BSS notifies the OMC-R and a trace criteria gets created/deleted at both BSS and OMC-R. The trace criteria are persistent over the OMC-BSS interface. That means if a trace criteria object is present in BSS, it is present in OMC-R and vice versa. The only exception is 'completed' call trace objects that exist at the OMC-R only.

4.2.6 Performance Management



Periodically the OMC-R will collect the statistics generated at the network elements under its control. The interval for collection may be set to 30 or 60 minutes.

Data production and collection for Performance Measurement is scheduled through the following functions to allow the operator to:

- Enable or disable statistics measurements for all or selected device types
- Read the interval at which statistics are reported
- Modify the reporting interval
- Read the threshold value
- Modify the threshold value
- Read individual values of measurements
- Reset the values of statistics by a cell, board or site ID

4.2.6.1 Performance Data Processing - The PM File Parser

Performance data is generated at the BSS and the RXCDR and stored as a PM data file. At set intervals the PM files are sent to the OMC that logs and stores the data.

The PM data processing software (known as the PM Parser) converts the Raw Statistics into a suitable format for storage in the Informix database.

The parser extracts the Raw Statistics from the data files and stores each in the appropriate column in the database.

4.2.6.2 Performance-Data Presentation.

The operator can create and run reports from performance data stored in the database. This data and reports are in a format that is easy to digest. Reports are available for both key and raw statistics.

Operators can generate their own reports using the command line interface with Customised Reporting by Motorola. Informix ISQL and ACE packages are also in the system for generating customised reports. These reports can be set up to run as Cron jobs.

A Cron-Job can be set to run reports, backup and remove the processed raw data files. It may be scheduled to run at night when there is low loading on the network.

4.2.6.3 Graphical Presentation of Key Statistics

It is possible to generate and display graphical reports from key statistics data (See Figure 5 below). Additional features are:

- Operator Customisation
- Multiple Selection Criteria
- GUI Stats Management
- Activation from Map

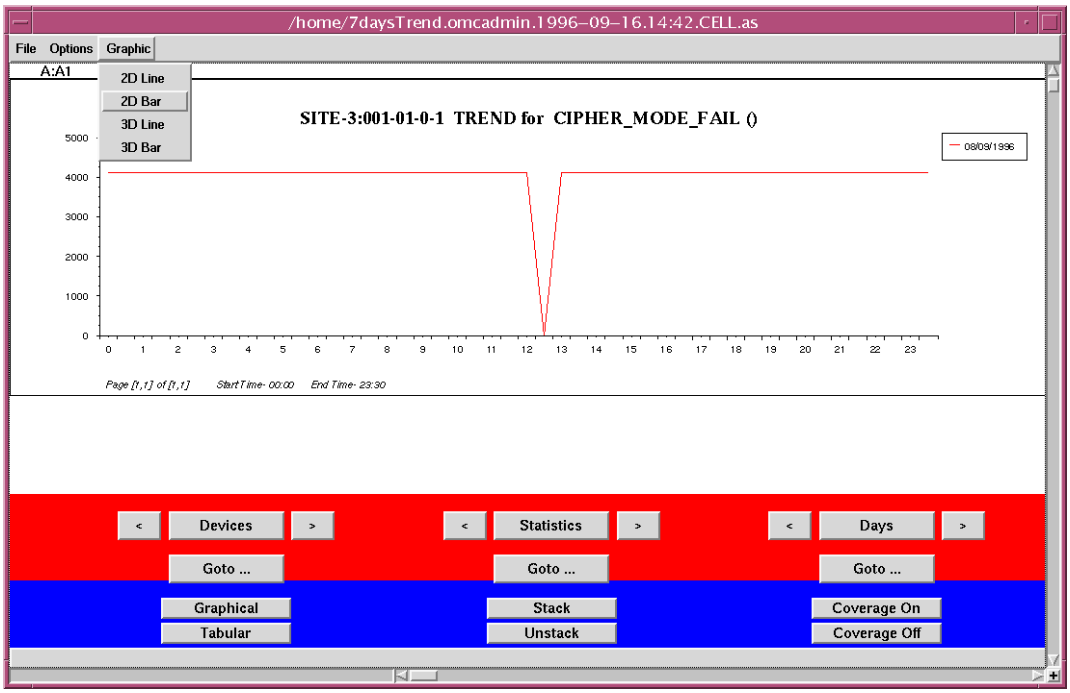


Figure 5 – Statistic Report Example

Examples of the graphical reports available are seen below:

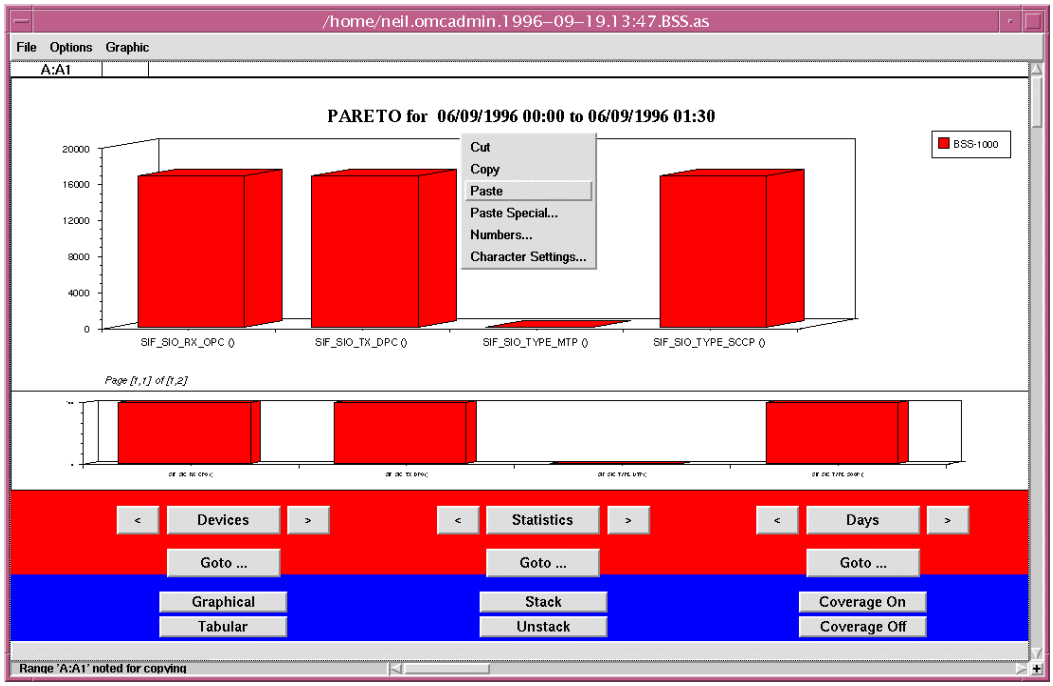
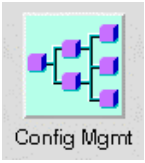


Figure 6 – Graphical Report Example

4.3 CONFIGURATION

4.3.1 Configuration management

The Configuration management is a central facility for the following tasks:



- Configuration at the OMC
- NE Software Load Management
- NE Software Download
- NE Operational Database Backup Site Reconfiguration

4.3.2 Site Reconfiguration

The OMC can add, modify, display and delete the parameters that determine the operation of the NEs using the OMC - BSS Remote Login interface.

4.3.3 NE Configuration at the OMC

The OMC maintains a configuration file to communicate with all the nodes on the network. This enables it to perform Configuration Management. The file contains details of all the nodes managed by the OMC, the software load for each NE and defines all the addresses for the OMC NE data communication protocol.

4.3.4 On Line Network Expansion

This will allow an operator to perform the following configuration operation via the navigation tree GUI:

- Copy and Paste a BTS
- Re-parent a BTS between BSS's
- Delete a BTS, including its contents (e.g. cells, RTF's RSLs etc)

4.3.5 Neighbour data synchronization for multiple OMC's

Data synchronization facilitates the synchronization of cell/neighbour data between the OMC's and between OMC's in a multi-OMC-R environment giving the following enhancements:

- Neighbour propagation after auditing a new BSS binary file
- Neighbour propagation after entering a new BCCH, radio device etc
- Enhancements to the proxy cell feature will allow automatic creation/updating of proxy cells between Motorola OMCs or via spreadsheets from non-Motorola OMCs
- Proxy cell can be automatically created from neighbour information

4.3.6 Software Load Management

This feature enables the operator to load a network element remotely to the OMC-R. Once the load has been installed on the OMC-R it can be downloaded later to the BSS under the OMC-Rs control. The OMC-R can load to the BSS an individual component or complete software.

When the OMC-R carries out a software load it transfers both the BSC and the relevant BTS loads to the BSC. Then the BSC subsequently controls the downloading of the BTSs under its control.

The OMC-R holds two versions of the software for each network element. The previous software can be restored if there are problems when loading the new version.

4.3.7 Software Download to a Network Element

Once the load has been installed on the OMC-R it can be downloaded later to the BSS under the OMC-Rs control. The OMC-R can load either an individual component or complete software to the BSS.

When the OMC-R does a software load it transfers both the BSC and the relevant BTS loads to the BSC. Then the BSC subsequently controls the downloading of the BTSs under its control.

A facility to enhance the software download function is the Code Storage Facility Processor (CSFP)

This is a GPROC device to reduce system downtime whilst propagating new software instances. A software instance is a complete set of software and firmware objects including the database object.

In the past, propagating new software meant the BSS was not available for considerable periods of time. The majority of the downtime was due to link throughput and network topology limitations. The CSFP feature downloads the software instance while the system is on-line. This reduces the time that the system is unavailable. After the software has been populated to all desired sites the BSS is reset for the new software instance. Since the new software instance exists locally it is no longer limited by link throughput and network topology so network outage time is reduced.

In addition to migrating to new software loads, the CSFP feature can also fall back easily and quickly to an existing software instance. As described above, a new software instance is dispersed to all CSFPs in the BSS. Then the network is reset. After reset, all non-CSFP GPROCs begin the new software load while the CSFP optionally retains the old software load.

6.3.8 Network Expansion

These features will further enhance the operator's ability to add elements to the network and therefore improve efficiency:

- The ability to add or delete sites or cells as complete entities will save significant operator time and reduce errors arising from elements not correctly deleted.
- Batch mode functionality will permit operators to set up a chain of events and thus provide enhanced automation of configuration.
- The use of standard configurations will save having to enter common data more than once.

4.3.9 NE Operational Database Backup

The operational database at a NE contains all its configuration and operational parameters. A binary version of each NE's Operational Database is held in the OMC. So, if there is a failure at the NE, lost data it can be recovered by downloading the backup database from the OMC. Updating the binary version of the Operational Database from the NE is known as Database Check pointing.

4.3.10 Generic RF Planning Tool Interface

After a frequency re-plan, the PlaNET and NetPlan RF planning tools produce tab-delimited ASCII files in the same agreed format. DataGen is able to import these ASCII files directly into its database. Once the correct hardware etc. has been specified, the RF planning data can be put into the BSS binary databases. If the correct hardware etc. is not specified, DataGen produces a report file detailing the hardware changes necessary so that the BSS binary databases' hardware match the RF planning data requirements.

DataGen can import RF planning data from other planning tools besides PlaNET and NetPlan once the data is in the agreed spreadsheet format.

Some parameters can be imported directly onto the OMC-R these are related to site latitude information

Motorola's position is to release the generic RF data interface format for both IMPORT and EXPORT and to make that available as part of a developer support programme to allow third party planning tool providers to integrate with the OMC-R.

4.3.11 Security & System Administration

4.3.11.1 Password Authentication of OMC-R Operators

OMC-R operators access the system through a unique login of user name and a password. This login and the defined limitations of access for each operator are set by the system administrator.

Command partitioning feature is a means of partitioning OMC users into different security areas. Options that could be used to alter OMC/BSS information at the OMC user interface will be allowed or disallowed by the access an operator has to a security area.

This level of security can be used to keep operators to work where they access only commands essential to their job role.

It also improves the OMC operation by giving users a smaller, easier and more appropriate choice of menu options.

4.3.12 Policing of Network Addresses on Inward Traffic

The OMC-R performs a validation check on all incoming X.25 source addresses.

4.4 GPRS PCU SUPPORT

The Packet Control Unit (PCU) performs radio functions and GPRS network functions. It has interfaces to the OMC-R, BSC and SGSN. The

Motorola PCU hardware is based upon proven off-the-shelf equipment that uses the compact PCI standards.

The OMC-R PCU support for GPRS is a fully integrated solution within the existing OMC-R architecture. It consists of support for the PCU as part of the BSS in the following key management areas:

- Fault management
- Configuration management
- Performance management
- Load management
- Security management
- On-line help.

Alarms associated with the PCU are shown alongside the normal BSS alarms. Alarms can be handled in the same way as the existing OMC-R - via a pop-up menu. There is also some support for the consolidation of PCU alarms as shown by the subscriber impact statement within the alarm message.

The existing OMC-R configuration management application has been updated to support GPRS BSS & PCU configuration. The various functions can be accessed from the navigation Tree.

The following OMC-R configuration management functionality will be supported for the GPRS elements:

- OMC-R GUI support for creation (with default parameter values) of PCU
- OMC-R GUI support for deletion of PCU
- OMC-R GUI support for creation/deletion of devices under the PCU
- OMC-R GUI support for view/modify of GPRS BSS & PCU parameters
- Propagation of related cell parameter values within cells

The existing OMC-R performance management application will be updated to support new GPRS BSS & PCU statistics. The OMC-R performance management application provides the following functionality:

- Background statistics sent to the OMC-R in intervals of 30 or 60 minutes
- Background statistics can be displayed in graphical format
- Background statistics can be displayed in tabular format
- Key statistics can be derived from raw statistics.
- Custom statistics can be derived from raw & key statistics.
- PM reports can be scheduled.

4.4.1 Load and Database Management

The PCU load/database will be included as part of the standard BSC load/database download from the OMC-R to the BSC. Thus the existing OMC-R load and database management functionality will apply to GPRS PCU. This consists of:

- Install of software load/database
- Delete of software load/database
- Download of software load/database
- Activate (Swap) of new software load/database
- Upload of database.

4.4.2 Security Management

The existing OMC-R access control will apply to the GPRS PCU, giving the following:

Access control shall be administerable by the security administrator.

Access control shall be on a per operation basis, e.g., operator 1 shall not be allowed to perform configuration operations.

The security management will appear exactly the same as the existing screens.

4.5 REMOTE LOGIN

4.5.1 TTY Interface

This method of entry for BSS MMI commands uses a terminal emulation window to enter the commands line by line.

4.5.2 Batch Facility

This Facility uses a command file for a sequence of BSS MMI commands. The commands use a text file, which can be sent to the BSS and executed at any convenient time.

4.6 SYSTEM ADMINISTRATION

The OMC-R provides the platform for the following tasks:

- Equipment replacement i.e. taking equipment in or out of service
- Maintenance
- Recent changes
- Troubleshooting and diagnostics
- System administration

4.6.1 Command Processing

The MMI enters commands and executes commands.

4.6.2 Help Facility

The OMC-R provides extensive on-line help.

4.6.3 Batch File

A facility for creating and executing commands in batch.

4.6.4 Command Logging

All BSS commands from the OMC-R operator are time stamped and logged with a user identity. Using the logs to review the history of an individual operator is useful when assessing OMC-R activity.

4.6.5 Additional Tools

Additional tools are available for the OMC-R system.

The event-counting tool will produce metrics based upon the number of alarms or events produced by the system. This helps to detect link failure trend, QOS degradation and so on.

Cell Analysis Tools search for potential anomalies within cells. By comparing the statistics with known thresholds and rules it gives the operator a list of cells to be investigated and a possible root cause.

Call Trace Products will enable the operator to track calls at random, or particular users, by receiving mobile report data, long trend distributions and both. Real-time graphicals are produced, not only for troubleshooting but also for optimisation purposes.

Circuit & Channel Error rate monitoring will help the day-by-day operation and maintain the quality of service by ensuring outages are reported immediately.

4.6.6 Database Management System (DBMS)

The database at the OMC Processor is primarily for storing processed statistics on the GSM/DCS network. It uses an industrial standard Relational Database Management System (RBDS) known as Informix. The DBMS features the following applications:

- Structured Query Language (SQL) for custom reporting.
- Read only access to the OMC's performance management database. This enables the customer to develop or purchase external applications for reports.
- Database backup.
- Database administration.

4.6.7 SQL

Standard SQL query language for reading of the PM database.

4.6.7.1 Read Only access to the Performance Management Database

Read-only access to the OMC-Rs PM database is a feature for the customer to extract information for further processing and analysis on other platforms.

4.6.7.2 On-line Database Backup

The system administrator may carry out on-line backup of the OMC-R database. This avoids the need to halt OMC-R operation during regular backup exercises.

Database Administration Facilities

The OMC-R has the following facilities for database administration tasks:

- Database Status information (status of users, logs, archives, etc.).
- Set-up and monitoring of database initialisation parameters.
- Query and allocation of database space.
- Database archival procedures.

4.6.8 Communications Handler

4.6.8.1 Internal OMC Communications

- TCP/IP
- Ethernet
- X11

4.6.8.2 OMC to Network Element Communication

- X.25 based

4.6.8.3 OMC-R to other NM Systems Communications Profile

- Q3/CMIS-based (optional)
- X11-based (optional)

4.7 MOTOROLA 3G INTERFACE

4.7.1 Q3 Network Alarm Management

The Q3 interface is a product comprising of software and computing hardware

The object model used on the Q3 interface is based largely on GSM 12.20 and TMN (ITU-T) X.721 and M.3100 standards. The OMC-R Q3 interface supports a fully compliant X.721 multiple event forwarding discriminator, multiple manager and log interface for forwarding and storage of manager accessible event/alarm logs.

The Motorola OMC-R is used to operate and maintain the radio network elements (BSC, BTS, RXCDR) of a PLMN and as such is a network element manager in the context of the TMN model.

For the Operator specific layers (business, services and network management), Motorola supports the use of the Q3 interface for exchange of network management information to any Q3 compliant NMC platform.

The Q3 OMC-R supports a fault management and a configuration management interface to RF network elements and parameters via the OMC-R mediation device.

The Motorola Q3 interface supports the following functions.

- Fault and event management.
- Standard EFDs and logs fully supported. (create, set, get, delete).
- Standard alarm and event format with capability of additional text.
- Configuration management reporting (create, delete, operational and administrative state change and attribute value change notifications for Q3 interface objects).
- State change information for non-Q3 interface objects and devices.

4.7.2 Configuration management:

- Capability to read from and write to all BTS object (cell) RF parameters.
- Capability to create or delete and read or write to adjacent cell (neighbour) and handover/power control algorithms.
- Read from and write to administrative state (where supported at OMC).

In addition to the specific features above, which are separately orderable software options, the Motorola interface provides the following:

- Alignment with GSM 12.20 phase 2 object model and GDMO.
- GSM 12.08 call trace support.
- Multiple manager (NMC) support.
- Link recovery mechanisms.
- Fully conformant Q3 OSI stack with X.25 (separate option) or Ethernet LAN transport layer.

4.7.3 Motorola's Q3 OMC-R interface provides:

- A standardised, open interface available to higher-level management systems.
- Ability to integrate the Motorola OMC-R into a large multi-vendor network management system.

4.8 GUI CLIENT

Motorola's solution for multiple remote OMC access is to provide a GUI server that can support a number of concurrent GUI's. This is executed locally on the server and displayed using the X11 protocol on X-terminals

or older slower equipment, while the total number of concurrent GUI's accessing the OMC-R cannot exceed 10.

The GUI client will comprise of the following features:

- Full GUI functionality as supported on Sun Ultra 5 MMI server or client platform - except:
    - no Audio sound;
    - a single CD ROM installed locally on the server only;
    - a single DAT/QIC device installed locally on the server only.
- Up to four concurrent GUI sessions executing locally and displayed remotely using the X11 protocol.
- Functionality normally accessed using the "root" menu on the Sun Ultra 5's: e.g. Database utilities will be accessed using scripts executed from the command line.

4.9 EXTERNAL COMMUNICATIONS

4.9.1 Workstation on remote LAN segment

A dedicated 64kbit/sec link to the remote LAN segment is required (for reasonable performance). No limit is specified for the number of remote UIs (except for the overall OMC limit). To reduce the network traffic on the remote link we recommended the use of an MMI Processor on the remote LAN segment. This is preferable to using X11 to display the OMC GUI on a remote X display. We recommend the installation of OMC software on the MMI Processor on the remote LAN segment (MMI Server). Remote UI Processors can then load the OMC software locally and not over the 64kbit/sec link.

For interconnecting LAN segments over a 64kbit/sec link Motorola recommends the Codex 6520 multi-peripheral router.

We recommend that a workstation at the remote site is equipped with CD ROM drive, tape drive and AnswerBook (Sun documentation on CD). This will keep traffic to the remote site to a minimum.

6.9.1.1 OMC to BSC/RXCDR Communication

The method of connecting with the OMC-R to the BSCs and RXCDRs uses an X.25 packet network to transport the X.25 data.

4.9.1.1.1 X.25 Equipment

The OMC communicates with network elements over X.25. An X.25 packet switch provides the physical connections to the OMC. A multiplexer is used to connect the 64kbit/sec X.25 traffic to a timeslot on a 2Mbit/sec link. In a future release of The Motorola Codex 6560 packet switch direct E1 connection will be supported.

Codex X.25 packet switch (model 6525 or model 6560) and multiplexer (Motorola Codex 6250) are recommended for use with the OMC by Motorola. The following packet switches (networks) are also supported:

- Datex - P (Germany)

- Netrix Packet Switch

The configuration of the X.25 equipment depends on the size of the network to be managed by the OMC.

4.10 MOTOROLA DATAGEN DATAGEN/OFFLINE MIB

DataGen is a BSS configuration Management tool designed to create and maintain the BSS database used by the Motorola GSM networks. It will allow the operator to perform the following functions:

- Validate and Insert BSS area definition files into an internal database.
- Create MMI command scripts.
- View topology maps for a given network.
- Copy BSS area and Upgrade the software version.
- Report differences between BSS areas.
- Read Configuration Management database objects into the database.

DataGen has the benefit of being able to configure a central database containing all the data for an entire network. This allows greater flexibility in system expansion and the addition or extension of new features. DataGen has a tool, which provides the creation of MMI scripts, system databases and the dis-assembling of binary databases into constitutional parameters.

DataGen is built upon the Sun UltraSparc 170 E, an identical hardware to the OMC-R. They may be deployed on a shared Ethernet LAN for the interchange of data whilst getting the best in compatibility and security from the two systems.

DataGen is intended to be used for "back office" preparation of large-scale network changes. This is a carefully planned and controlled operation, which requires the audit and approval of suggested changes before applying them in the network. Actual deployment of the changes in the network is through the OMC-R which, is then used for day-to-day small scale changes where required.

4.11 NETWORK HEALTH ANALYST

4.11.1 Alarms and Statistics Analyser

This facility encapsulates the knowledge of Motorola's experts and design engineers and makes it all available to the operator around the clock. An optional feature, it reduces the amount of effort and skill required to operate the RF infrastructure. The Network Health Analyst gathers alarms and statistics data from the OMC, analyses it and reports conclusions through the existing operator workstations.

4.12 HARDWARE

4.12.1 Equipment List for the Scaleable OMC-R

The Motorola Scaleable OMC system (See Figure 7 below) consists of a number of UNIX processes divided between the following hardware platforms:

- System Processor
- MIB Processor
- MMI Processor
- OSI Stack Processor (optional)
- Remote Login Processor (RLP) (optional)
- Expert Advisor Processor (optional)
- DataGen Processor (optional)

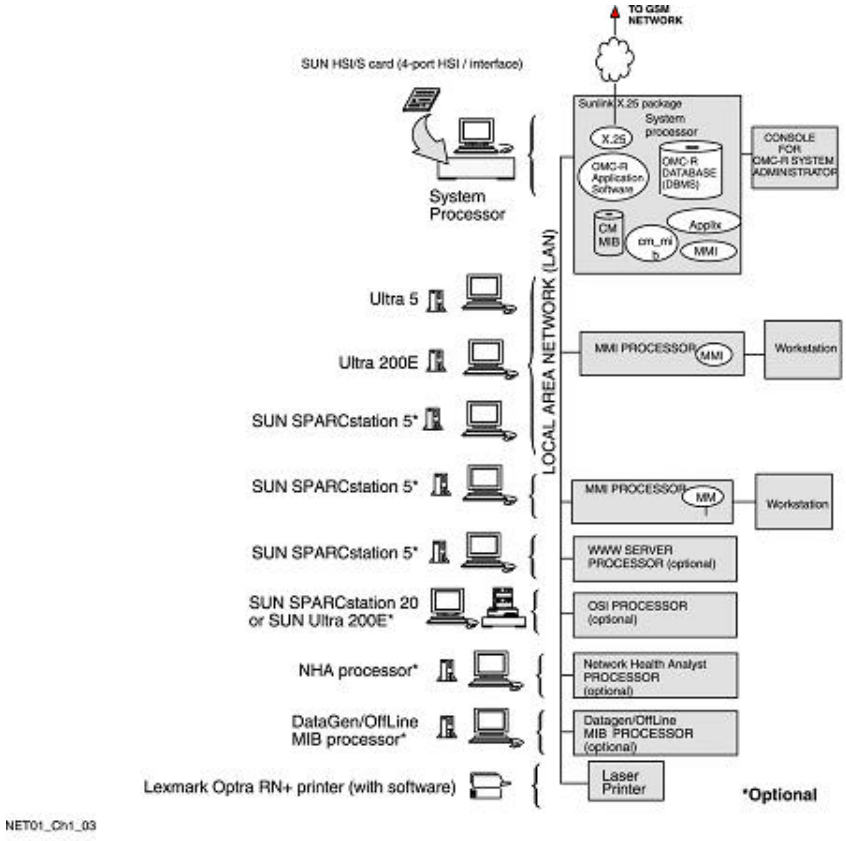


Figure 7 - Motorola Scaleable OMC Hardware Architecture

6.12.2 SCALEABLE OMC BENEFITS

The benefits of the Motorola Scaleable OMC system which is based on SUN SPARCstation hardware include:

- Reduced OMC-R costs for entry level systems
    - Lower computer platform costs

  - Eliminate Packet Switching costs for small systems

- Reduced Cost of Ownership
  - Low ongoing cost of maintenance
  - Local maintenance in many countries
- Consistent software through traffic channel growth
- Simplified System Administration
  - Single computer family
  - Reduced training costs
- SUN as strategic supplier to Motorola
  - Industry leading supplier of Client/Server
  - World-wide support organisation
  - Scaleable computer architecture with common components
  - Lower cost of ownership (purchase; post warranty support costs)

4.12.3 Motorola Scaleable OMC – Structure

The Motorola OMC Server can be configured using the following scaleable steps:

- OMC Server Hardware
  - OMC Server Hardware Up to 5 k TCH
  - OMC Server Hardware Upgrade to 10 k TCH

Software steps of 5k up to 45k TCH

4.12.3.1 System Processor

There is one System Processor in every OMC. All communication with network elements goes via the System Processor.

System Processor	Minimum Configuration
Series/Model	Sun Ultra Enterprise 3500.
Scaleable OMC CPU	
Up to 5,000 TCH *Up to 10,000 TCH*	2 of 400 MHz CPU With 500kByte cache. 4 of 400 MHz CPU With 500kByte cache.
Up to 30,000 TCH	4 of 400 MHz CPU With 500kByte cache.
Up to 45,000 TCH	4 of 400 MHz CPU With 500kByte cache.
Scaleable OMC Main Memory	1Gb
Scaleable OMC Disk Capacity	
Up to 5,000 TCH	18 GBytes external mirrored disk (total = 2 X 9 GB)
Up to 10,000 TCH	32 GBytes external mirrored disk (total = 4 X 9 GB)
Up to 30,000 TCH	32 GBytes external mirrored disk (total = 4 X 9 GB)
Up to 45,000 TCH	32 GBytes external mirrored disk (total = 4 X 9 GB)

Backup	SMCC 4-8 GB DAT tape drive
Operating System	Solaris 2.5.1
Environment	SUNprint 1.0; Sunlink X.25 9.0; Sun's Common Desktop Environment; Solstice DiskSuite 4.0; Answerbook
Database	Informix OnLine 7.13.UC4 ESQL 7.24 ISQL 6.03.UC1 All licences are run-time.

4.12.3.2 MMI Processor

One GUI session can be run on the MIB processor. Each additional GUI session requires an MMI processor to run except in the case of new 5,000 TCH systems where 2 GUIs can be run on an MMI Processor.

MMI Processor	Recommended Configuration
Series/Model	SPARCstation 5 Model 110 or Greater
Main Memory	256 MB
Disk Capacity for MMI Client	1 of 9GB internal disk drive or more
Disk Capacity for MMI Server	1 of 9GB internal disk drive or more
Operating System	Solaris 2.5.1 - Server
Environment	X11 Release 5 version 26 - IXI Motif User Pack 1.2.4d for SPARC Solaris 2.x (1 user); Gensym, TeleWindows if E.A. Option installed.
Data Presentation	I-Connect, Runtime, single user; WingZ 1.4.1 Applix Spreadsheet 4.3; ApplixData 4.3

Note: Applix Spreadsheet and ApplixData are not required when configuring as an MMI client.

4.13 MOTOROLA OMC CAPACITY AND AVAILABILITY FIGURES

4.13.1 OMC Capacity Figures

The following table provides capacity figures for the Motorola Scaleable OMC:

OMC Capacity Parameters	E3500	E3500
Maximum Network Size in TCH	5,000	45,000
Maximum Number of Network Elements managed	15	120
Maximum Simultaneous GUI sessions (Only 1 GUI session per machine except for the RLP)	5	10
Maximum Simultaneous GUI sessions per RLP	4	4
Maximum Simultaneous login to BSS sessions	6	20 (max. 8 to any given NE)
Maximum Simultaneous File Download to BSS sessions	6	12
Maximum Simultaneous File upload sessions	4	15
Maximum sustained event rate (Events per second)	10 (8 alarms and 2 state change)	15 (12 alarms and 3 state change)
Maximum event burst over 20 minute interval (Events per second)	20 (16 alarms and 4 state change)	60 (48 alarms and 12 state change)

4.13.2 OMC Availability Figures

This section attempts to set target availability for the OMC system processor concerning unplanned outages only.

4.13.2.1 Definition

Availability is the system up time expressed as a percentage of total time:

Availability = Up-Time/(Up-Time + Down-Time) = MTBF/(MTBF + MTTR)

4.13.2.2 Availability Target

An overall target of 99.99% is recommended for the E 3000 based OMC system processor. This is based on an annual downtime of about 1 hour broken down as follows:

- 2 restarts due to 1 hardware failure every 2 years: 20
- 3 restarts due to software (OS and application) every year: 30

Total (Minutes) = 50

Note: Each restart is assumed to cause an outage of 10 minutes. A hardware failure causes 2 restarts, one to recover from the failure and one to replace the faulty part. Outage due to software upgrade of the OMC is targeted at 6 hours per new release.

4.13.2.3 Availability Conditions

The OMC System processor is considered available under the following conditions:

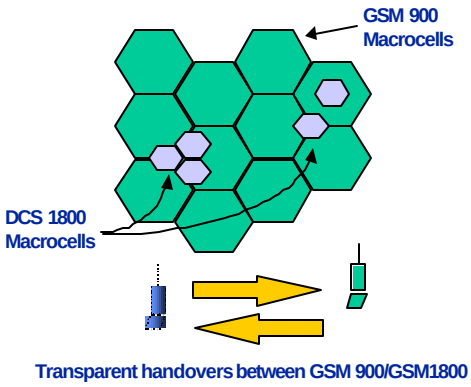
- The OMC System Processor is running the main OMC applications with at least 50% of it's maximum CPU capacity, at least 50% of it's memory capacity and at least 50% of it's I/O capacity and all of it's disk capacity (at least one side of the mirror) available to the application.

5 INTRODUCTION TO DUAL BAND

This section has been written to provide information on the use of Dual Band (GSM1800/E-GSM900) cellular networks. Mainly it covers the Implementation of Dual Band Systems, including BSS Implementation, Traffic Management of Multiband Handovers, Operations & Maintenance, and Preparation for Multiband Operation. Also included is a section covering Motorola's Experience in Multiband Operation.

5.1 OVERVIEW

Multiband allows a customer with licences in both GSM1800 and E-GSM900 frequency bands to support the use of Multiband mobiles over both bands. By supporting transparent handovers between E-GSM900 and GSM1800, Multiband enables major capacity benefits.



Using experience gained from developing our already successful microcellular algorithms, Motorola have developed unique Traffic Management features (such as Band Preference Mode), which makes full effective use of the extra capacity offered by a Multiband network.

Costs can be reduced, and operability improved by sharing the same OMC-R, BSC, RXCDR and MSC between the two frequency bands. Both Motorola and non-Motorola equipment can be integrated to provide a Multiband Network.

5.2 MULTIBAND SOLUTIONS

A Mobile Subscriber (MS) may operate in one of the following ways in a Multiband network:

⇒ The MS supports only one band.

⇒ The MS supports more than one band, but can only function in one band at a time. Frequently referred to as "Knife Switch" mobiles

⇒ The MS supports more than one band, and can function in more than one of these bands at a time. Usually referred to as "Band Aware" mobiles

ETSI has defined the standards so that a single band MS can still operate correctly in a Multiband network.

A new classmark has been defined by ETSI, which can be sent to the BSS very early in the "camp-on" process to advise the network that it the dual band mobile is able to utilise more than one band. A Band Aware MS is able to listen on both bands and to report back to the BSS the strength of signals heard on either or both bands. The BSS can then use this information together with the classmark information to select an appropriate handover candidate cell for the subscriber.

5.3 LICENSING SCENARIOS

There are three possible scenarios for the granting of Multiband license.

- **Existing GSM900 Network Operator is granted a GSM1800 license**

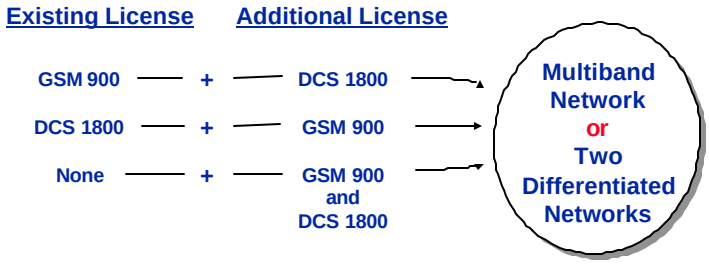
  This is a typical scenario in Europe, where capacity on GSM 900 networks is reaching its limit and Network Operators are requesting the extra frequencies in the GSM 1800 band in order to increase the network capacity.

- **Existing GSM 1800 Network Operator is granted a GSM 900 license**

  This scenario seems less likely, and has not been seen as yet. In Sweden, it has been announced that some GSM 1800 Network Operator will be granted mandatory roaming rights to GSM 900 networks, but this would still be considered as two separate networks rather than a Multiband network, and would not allow for handover between bands.

- **A new Network Operator is granted both GSM 900 and GSM 1800 licenses**

  This scenario may occur in countries with only a single Network Operator, or in new networks, which are planning to be Multiband from initial implementation. It is possible



  that some new licences may be for GSM1800 and EGSM900.

There are several ways that extra channels may be used, often depending both on the regulatory and competitive environment within the country. For each scenario, a different type of traffic management model must be implemented by the network operator to ensure the maximum benefit from the Multiband implementation.

5.4 CAPACITY EXPANSION

The additional spectrum available in either the GSM900 or GSM1800 band offers an existing operator the potential to significantly increase the capacity of their existing network. In many countries mature GSM900 networks are foreseeing huge growth in the level of their macrocellular capacity and operators are considering further investments now in order to provide the required additional capacity.

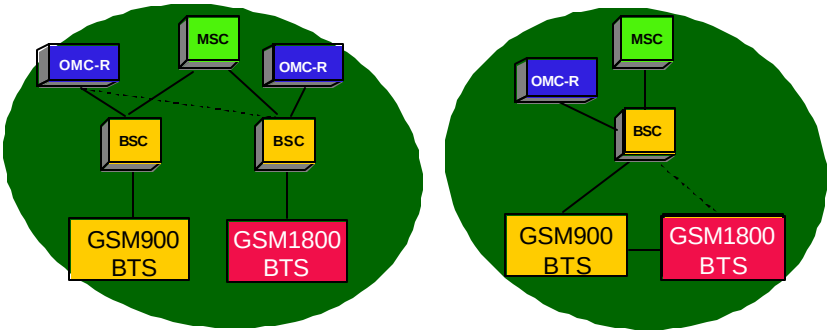
A Multiband network (together with the availability of Multiband MSs) offers the potential of providing a "Capacity overlay" to an existing network using the same PLMN. This would allow traffic on the existing GSM900 or GSM1800 network to be transferred to the other operating band.

The operator has to determine how the alternate band is to be deployed. The operator may choose to provide coverage for hot spots, or ubiquitous coverage in a limited area.

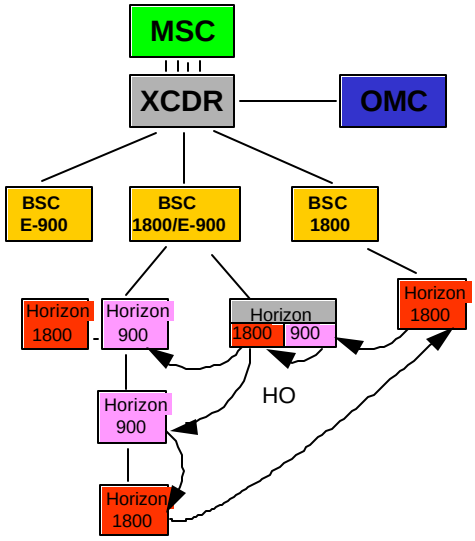
5.5 IMPLEMENTATION OF DUAL BAND SYSTEMS

5.5.1 Network Implementation

A Network Operator would need to determine what network topology works best in any given area. Either of the network architectures shown in the diagram below is possible.



The following alternative is of course the most comfortable for a Multiband site, since we can propose heterogeneous BTS, providing distinct cabinets for different bands.



The MSC can support different BSS networks for each frequency band. This provides the Network Operator with the ability to distribute the changes required for Multiband operation, although the BSS may be a better choice for handover and interband control.

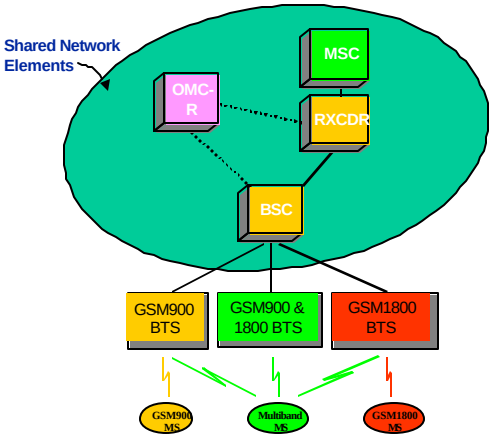
Motorola has sucessfully carried out interface testing between the BSS and Ericsson and Siemens Switching systems, including inter BSS handovers. Motorola have live dual band BSS networks operating with both switch suppliers.

Whichever architecture is chosen, the addition of the "Multiband Inter-Cell Handover (GSM 900 / GSM1800) feature to the BSS is required to support Multiband operation.

5.5.2 BSS Implementation

5.5.2.1 Infrastructure sharing

The Motorola OMC, BSC, and Transcoder Infrastructure can be shared between both E-GSM 900 and GSM1800 networks. This greatly simplifies the implementation of a second network, allowing the E-GSM 900 network infrastructure to be implemented by the addition of E-GSM 900 BTS's only.



5.5.2.2 Co-located Sites

With the need to support a dualband (E-GSM 900 / GSM1800) network, it is likely that at least some of the existing GSM 900 sites will be utilised to locate the new GSM1800 BTS's. A new BTS site can be placed at the current BTS site (co-located). Although co-located BTS sites do require a separate control link for each site, the sites have no impact on each other and can share the leased line to the site via drop and insert feature.

In the downtown urban areas, the placement of GSM1800 cells at the same site as GSM 900 cells, will provide extra capacity.

5.5.2.3 Multiband BTS

In addition to co-siting E-GSM900 and GSM1800 BTSs, it will also be possible to have Multiband BTSs. The Horizonmacro BTS products will be able to support dual-band in the same cabinet (heterogeneous), and Horizonmacro BTS products are be able to support as a standard configuration dual-band capability.

Motorola dual-band BTS Sites use the same 2 Mbit/s link to the BSC and even the same RSL, as the table below shows:

	Number of timeslot for signalling GSM 900	Number of timeslot for GSM 900 speech	Number of timeslot for signalling GSM1800	Number of timeslot for GSM1800 speech	Total number of timeslot required on the Abis link
S222 GSM + S111 GSM1800	3 x 16kbps or 1 x 64 kbps	12 x 64 kbps	0 (signalling GSM1800 is using same timeslot that carries GSM signalling)	6 x 64 kbps	3 x 16kbps + 18 x 64kbps or 19 x 64 kbps
S444 GSM + S222 GSM1800	5 x 16kbps or 2 x 64 kbps	24 x 64 kbps	0 (signalling GSM1800 is using same timeslot that carries GSM signalling)	12 x 64 kbps	5 x 16kbps + 36 x 64kbps or 38 x 64 kbps

Motorola's unique architecture of a Motorola GSM network moves significantly more intelligence into the Base Station Transceiver (BTS) than found in competitive products. A major advantage of this approach is a corresponding decrease in the amount of control and signalling traffic required from Base Station Controller (BSC) to BTS. It is clearly desirable to bear as much revenue generating call traffic as possible with the minimum amount of control overhead. The overhead, known as the Radio Signalling Link (RSL), is carried from the BSC to the BTS using an industry protocol referred to as LAPD. With this architecture, not only Motorola concentrates the signalling of several TRX of a same cell on one LAPD, but also all the signalling of all the TRX disregarding of on which cell they are attached to on one LAPD.

The Motorola solution uses:

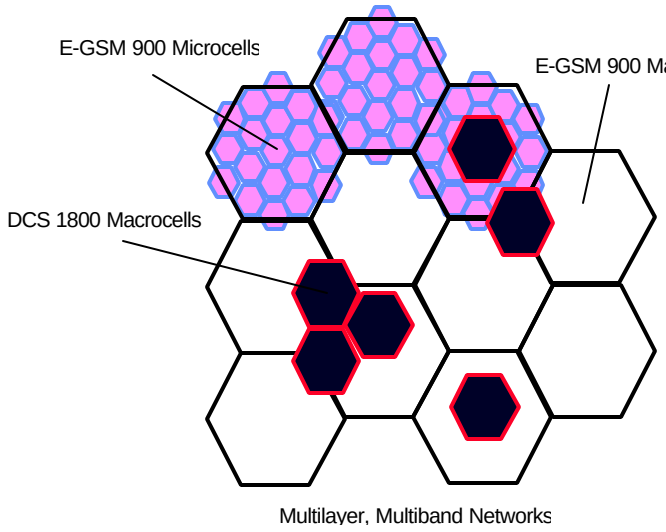
- Only one 64 kbps RSL link regardless of configuration (omni or sector, GSM900, GSM1800 or bi-band) for BTS site with as much as 120 TCH of air capacity, (120 TCH is more than he capacity of a S3 4/4/4 BTS or a S3 2/2/2/2/2/2 (3 sectors being GSM and 3 sectors being GSM1800),
- Two 64 kbps RSL links for BTS sites with higher air capacity.

5.5.2.4 Traffic Management - Multiband Handovers

GSM specifications have defined the way in which Multiband handovers occur based upon signal strength. These "power budget handovers" are engineered to support handovers at the border between cells based upon equal signal strength from serving and candidate handover cell, and will be described in this section.

To give maximum capacity benefit, a Multiband network requires additional Traffic Management. The handover algorithms must allow the mobile network operator to control the selection of layer for each and every call made on the network, based on MS capability and signal quality. Motorola's answer to this need is Band Preference mode. Band Preference Mode allows an operator to direct a mobile to handover to a Preferred Band, even if this is not reporting the strongest signal.

Handover to other layers



A Multiband network can include a Microcellular layer and/or a concentric cells layer in any or all of the frequency bands in use.

The Motorola enhanced algorithms are capable of managing the handovers between any of the layers of the network.

5.5.3 Operations & Maintenance

5.5.3.1 Sharing an OMC between networks

Multiband operation requires that both networks utilise the same PLMN number. Motorola's System Release GSR4 provides for the sharing of the OMC between E-GSM 900 and GSM 1800 network elements, which are part of the same PLMN.

Neighbourhood Propagation

Motorola provides the capability to automatically update the neighbour lists of affected cells when the frequency of a specific cell is changed. This automates the process of updating the neighbour lists and ensures their accuracy.

Network Views

Currently, the OMC views all cells in the network as individual elements. The addition of new cells that operate in the GSM 1800 band do not affect the operation of the OMC in any way. Motorola Geographic Information Display (GIS) system for the OMC manages the display of information on the operator's screen as layers of information.

5.6 PREPARATION FOR MULTIBAND OPERATION

Motorola confirms that the BSC/XCDR/BTS and OMC-R do not require hardware modification to allow dual band operation. However, to prepare a customers BTS sites ready for the introduction of Multiband operation, Motorola experience shows that the antenna and feeder installation, forms the majority of any work required.

5.6.1 Antenna types and antenna systems

There are some GSM900 networks with sites having separate antennas for transmitting and receiving (1 for transmitting and 2 antennas for receive space diversity). In 3 sector sites and using diversity those networks have a total of 9 antennas per site.

Later on we understood that common antennas are more likely being used for transmitting and receiving via duplexers and therefore a typical 3 sector site in a customers network should have currently a total of 6 antennas.

Equipping all the existing GSM900 sites with additional feeders and an additional set of antennas for GSM1800 may be very expensive and very difficult to implement.

An operator going through a network upgrade from GSM900 to a Multiband network can take some advantage from proven techniques and also from recent antenna development and optimise the investment on the Multiband sites. These techniques can be summarised as follows:

- Duplexing
- Polarisation diversity
- Dual Band Antennas
- Dual-Band Diplexers
- Mast Head Amplifiers

5.6.2 Proposal for upgrading EGSM900 sites to Multiband sites

There are several different approaches to providing existing GSM900 BTS sites with compatible antenna systems. Assuming many of the existing installations consist of two antennas per sector, with one duplexed to provide TX/RX and the other as single RX, then additional antennas or dual band antennas will require installing.

Motorola propose the following antenna solutions:

1) Replace per sector the existing two antennas with single dual band GSM900 cross-polar antenna. Install additional new GSM1800 cross-polar antenna to be connected to the 1800 TX/RX paths. Optional Mast Head Amplifiers along with their associated Bias Tees may be fitted into the 1800 TX/RX feeder.

   This provides cross-polar receiver diversity.

2) Replace per sector the existing two antennas with single dual band GSM900 cross-polar antenna with two new GSM dual bands (900/1800) antenna to be connected to the 900/1800 TX/RX paths. Optional Mast Head Amplifiers along with their associated Bias Tees may be fitted into the 1800 TX/RX feeder.

This provides spatial receiver diversity.

5.6.3 Proposal for upgrading EGSM1800 sites to Multiband sites

There are several different approaches to providing GSM1800 existing BTS sites with compatible antenna systems. Assuming many of the existing installations consist of two vertical polarised antenna's per sector, with one or both both duplexed to provide TX/RX, then additional antenna's or dual band antennas will require installing.

Motorola proposes the following antenna solutions:

1) Replace per sector the existing two antenna's with single dual band GSM1800 cross-polar antenna. Install additional new GSM900 cross-polar antenna to be connected to the 900 TX/RX paths.

   This provides cross-polar receiver diversity.

2) Replace per sector the existing two antennas with single dual band GSM1800 cross-polar antenna with two new GSM dual band (900/1800) antenna to be connected to the 900/1800 TX/RX paths. Optional Mast Head Amplifiers along with their associated Bias Tees may be fitted into the 1800 TX/RX feeder.

   This provides spatial receiver diversity.

5.7 MOBILE SUBSCRIBER TERMINALS

Motorola was the first company to have publicly available GSM900/1800 subscriber handset products (International 8000 Series).

Motorola have now a second generation of GSM900/1800 products available to subscribers. These handsets offer the subscriber, full automatic selection of operating band. Motorola are able to offer both the 900 Series and V Series subscriber handsets in the market place today.

These new cellular phones constantly monitor both sets of frequencies, and report signal strength back to the network. The Advanced Load Management feature, built into the network, will search for the dual band phones and automatically switch the subscriber to the best GSM900 or 1800 frequency in relation to available cell capacity.

5.8 MOTOROLA'S EXPERIENCE IN MULTIBAND OPERATION

Motorola was the first company in the world to demonstrate dual band advanced traffic management network feature working with dual band mobiles, for automatic seamless handover between GSM900 and GSM1800 dual band cellular networks.

As part of the multiband systems, Motorola have successfully completed the integration testing between its multiband BSS system and the followings switches: Siemens, Alcatel, Ericsson and Nortel.

Motorola have a dedicated Multiband team of experts based in Madrid, Spain which are able to provide our customers with, network advice, planning, optimisation services and support other multiband issues.