NOKIA

Nokia UltraSite System Overview for GSM Evolution

Contents

1 About this document

This document introduces Nokia UltraSite Solution for GSM networks and gives an overview of the issues to be considered when introducing Nokia UltraSite into the network.

The document introduces

- Nokia UltraSite Solution and its building blocks
- network planning
- network implementation
- operation and maintenance
- Nokia Services.

The document describes the GSM network evolution to new services via EDGE (Enhanced Data Rates for Global Evolution) and WCDMA (Wideband Code Division Multiple Access) technologies. The focus is on the GSM sites, therefore the deployment of stand-alone Nokia UltraSite WCDMA Base Station sites is not covered in this document.

Detailed information about the Nokia UltraSite elements and management tools can be found in the appropriate network element documentation.

2 Nokia UltraSite Solution

This chapter deals with the Nokia UltraSite Solution and its building blocks.

2.1 Network applications

Nokia UltraSite is a complete macrocellular solution for digital mobile (GSM, EDGE and WCDMA) networks. It provides the operators with the needed high traffic and transmission capacity along with wide cell ranges.

The solution will also play an essential role in future multimedia networks. Nokia UltraSite utilizes the latest development in the data communications along with the traditional voice services. Refer to *Nokia UltraSite Solution Description*.

2.1.1 Macrocellular network

Requirements for high traffic capacity in cities and wide coverage in rural areas set challenges for macrocellular networks. Nokia UltraSite provides a solution for these challenges.

Nokia UltraSite offers an extremely wide cell range due to its high output power and receiver sensitivity. This helps to create coverage fast when building the network, which enables quick revenue flow for the operator. In rural areas where the traffic is light the number of sites can be kept lower.

When a wide frequency band is available, the capacity of the existing macro sites can be increased by installing Nokia UltraSite elements. Nokia UltraSite Base Station (BTS) accommodates a great number of Transceivers (TRXs) per cabinet, and per site. Due to its compact size it is easy to install in the existing sites.

Sometimes, dense urban areas may already be covered fully by the existing macrolayer, and the spetrum allocated may be fully exploited (i.e. all the frequencies are used to the best). Then, further capacity increase can be achieved with Nokia UltraSite by:

- dual band roll-out
- Nokia Soft Capacity features.

Dual band configurations can be built either in single or multiple Nokia UltraSite GSM BTS cabinets. Integrated dual band duplex units allow the usage of common antenna feeders and antennas.

2.1.2 Multilayer GSM network

The capacity of a GSM network can be increased by dividing it into overlapping macro-, micro- and even picolayers. Nokia UltraSite is the solution for the macrolayer operation, whereas Nokia MetroSite Solution and Nokia InSite BTS are designed for the reduced-cell-size layers.

Nokia's solutions for these different network layers are fully compatible so that they form one functional network. This network can use a common Network Management System (NMS) and Base Station Controllers (BSCs). The versatile and high-capacity transmission of Nokia UltraSite offers an access solution to the microlayer. No separate access transmission network needs to be built for different network layers.

2.1.3 Multimedia network

Nokia UltraSite provides a platform for the voice and data services of the future multimedia networks. Nokia UltraSite supports the existing voice services, and the new High Speed Circuit Switched Data (HSCSD) and General Packet Radio Service (GPRS) data services.

The HSCSD offers higher data rates particularly for applications requiring constant data speeds such as video conferencing, remote LAN access and wireless imaging. With the GPRS, GSM networks will work seamlessly within Internet networks. In addition, data transmission capability will receive a massive boost with speeds in excess of 100 kbit/s.

The EDGE standard will increase the data rates even higher with EGPRS and ECSD services. As the modulation scheme will change, SW and HW updates are required anyway in the existing networks. Nokia UltraSite supports EDGE services and even upgrading the network services further on.

Nokia UltraSite will allow site upgrades by supporting integration of WCDMA carriers into Nokia UltraSite cabinets. Furthermore, for even higher capacity the site can be furnished with dedicated Nokia UltraSite WCDMA BTS.

The transmission capacity requirements will be much higher with the new services. Nokia UltraSite has integrated transmission capacity for all the foreseen needs.

2.2 Solution architecture

Many operators have invested a lot in their macrocellular GSM networks and continuously expand them for capacity reasons. Also, changes at sites are needed as the existing older equipment does not always support the latest features available and thus they need to be upgraded.

Nokia UltraSite is designed to make the macrocellular network expansion and upgrade feasible. Not only has Nokia UltraSite GSM BTS a high TRX count per cabinet but the cabinets on site can also be chained together. Further, flexible antenna combining stages allow to build various configurations.

The expansion of the Nokia Talk-family sites using Nokia UltraSite has been made easy. The upgradability to the future services in the whole network has been taken into consideration in the solution architecture. Upgrades are supported with minimum changes in the equipment.

Transmission has been of special importance in product design. Transmission solution for various network layers is seamless. With Nokia UltraSite's scalable high-capacity access transmission, the needs of large capacity networks and data services can be fulfilled.

Particular emphasis has been put to ease the implementability and operability of the network and to speed up network roll-out.

2.2.1 Nokia UltraSite building blocks

Nokia UltraSite consists of the following elements:

- Nokia UltraSite Base Station
- Nokia UltraSite Support
- Nokia UltraSite Antenna Systems
- Nokia FlexiHopper Microwave Radio
- Nokia UltraHopper Microwave Radio.

A short overview of each element in the GSM network is given in the following sections. Detailed technical information can be found in the appropriate network element documentation.

2.2.1.1 Nokia UltraSite GSM Base Station

Figure 1. Nokia UltraSite GSM BTS Outdoor, Indoor and Midi Indoor cabinets

Nokia UltraSite GSM BTS is used in GSM 900, GSM 1800 and GSM 1900 systems, or as a GSM 900/GSM 1800 Dual Band Base Station. It is optimised for macrocellular applications.

Nokia UltraSite GSM BTS Indoor and Outdoor are offered as 1 - 12 TRX cabinets, or they can be configured to hold up to 6 TRXs and an optional integrated battery backup system. Up to 40 Ah capacity can be provided, which means 45 minutes backup time for those 6 TRXs. Additionally, Nokia UltraSite GSM BTS Midi Indoor, a 1 - 6 TRX BTS for indoor installations, is available.

The Nokia UltraSite GSM BTS cabinet accommodates up to 12 TRXs. This makes Nokia UltraSite GSM BTS an efficient solution for building capacity in mobile networks in the areas of heavy telecommunication traffic. With the BTS's high output power and receiver sensitivity, large coverage can be achieved in rural areas and when building the network. The output power can be further increased with an optional booster.

Site's TRX capacity can be increased by chaining multiple Nokia UltraSite GSM BTSs. In most configurations, only the synchronization cabling is needed between the cabinets. Up to 9 Nokia UltraSite GSM BTSs can be chained together. With RF hopping, cells split between different cabinets can use common hopping frequencies. Base-band frequency hopping is not possible between the chained cabinets, i.e. they must have separate hopping groups. However, base band hopping with TRXs in a single-cabinet sector is supported.

Nokia UltraSite GSM BTS can be used as an omni or sectored base station. As to the sectoring, there are virtually no constraints. In BSC SW release S10, the cells can be split between the cabinets with the Multi-BCF feature. In dual band case, any sector can be configured to operate either on 900 MHz or 1800 MHz band.

Nokia UltraSite GSM BTS can be installed in the same site as Nokia Talk-family BTSs. These cabinets have a similar physical appearance and compatible interfaces. They have the same footprints and mounting options. The existing Nokia Talk-family cells can be expanded horizontally with Nokia UltraSite GSM BTS using the Multi-BCF feature.

Nokia UltraSite GSM BTS offers a platform for GSM multimedia services. HSCSD and GPRS CS 1 and 2 services are supported with the initial hardware.

EDGE support can easily be accomplished with minimum HW changes. Only the EDGE TRX RF and Base Band units need to be installed; all the other units remain as they are. BTS SW release in use must support EDGE functionality. Basic GSM and EDGE TRXs can co-exist in the same cabinet and cell.

WCDMA carriers can as well be added into Nokia UltraSite GSM BTSs. They can operate simultaneously with the basic GSM and EDGE TRXs. The use of WCDMA equipment reduces the maximum number of basic GSM and EDGE TRXs to 6 in one cabinet.

Nokia UltraSite GSM BTS has 4 slots reserved for the integrated transmission units. The BTS can even be used as a transmission hub in the BSS (Base Station System) network. The inbuilt transmission capacity is adequate for any foreseen application.

This integrated transmission supports various transmission media, such as copper wire, optical fibre and microwaves. The signals can be multiplexed using either PDH (Plesiochronous Digital Hierarchy) or SDH (Synchronous Digital Hierarchy). Signals can be cross-connected down to 8 kbit/s level in the GSM BTS. Alternatives for integrated transmission interfaces are:

- T1 balanced
- E1 balanced or unbalanced

- Flexbus interface. Flexbus is a Nokia proprietary coaxial interface that offers up to 16 x 2 Mbit/s capacity. It is compatible with Nokia FlexiHopper Microwave Radio and Nokia MetroHopper Radio and it can also be used for connecting the BTSs together on the site.
- Optical STM-1, either connected to Nokia UltraHopper Microwave Radio or optical fibre.

Various antenna combining options are provided:

- 2-way wideband combining
- 4-way wideband combining
- remote tune combining (6:1)
- combining by-pass.

Nokia UltraSite GSM BTS has the same core mechanics in both indoor and outdoor BTSs. Outdoor and indoor cabinets differ only by the kits attached to the core mechanics. Cabinets can be mounted side by side and there is no need for back access. With the indoor cabinets, 50 mm of free space is required for the air intake at the back of the cabinet.

The ambient operating temperature range for Nokia UltraSite GSM BTS Outdoor is -33°C (-27.4°F) to 50°C (122°F) and the BTS is IP55 protected. Forced open air cooling is used in the outdoor cabinet. Therefore, no heat exchangers or air conditioning units are needed.

BTS SW release PU1.0 offers the basic support for Nokia UltraSite GSM BTS, while the later releases will introduce many more features, such as:

- 4-way diversity
- RSSI antenna monitoring
- EDGE
- E-cell
- Multi-BCF cell
- Intelligent shutdown
- Adaptive Multi Rate (AMR) coding.

For more detailed information, refer to *Nokia UltraSite GSM Base Station Product Overview*.

2.2.1.2 Nokia UltraSite Support

Figure 2. Nokia UltraSite Support Outdoor and Indoor cabinets

The Nokia UltraSite Support supplies essential battery backup and space for customer equipment for all configurations within Nokia UltraSite.

Applications for Nokia UltraSite Support vary from integrated battery backup in Nokia UltraSite GSM BTS Indoor and Outdoor to a high-capacity Nokia UltraSite Support. The integrated battery backup supports up to 18 TRXs and provides up to 40 Ah backup resources. Nokia UltraSite Support supports up to 36 TRXs (in GSM BTS) and provides up to 368 Ah backup. The maximum backup time can be reached by using an additional battery cabinet.

The high power consumption of EDGE and WCDMA are taken into account by arranging enough expansion capability for handling electricity shortages.

Nokia UltraSite Support cabinet is designed for compliance with Nokia UltraSite BTS.

The Nokia Power System Management (PSM) feature enables the remote control and supervision of Nokia UltraSite Support via the Nokia Network Management System (NMS), by using a Q1 interface. Locally, this control can be done with a dedicated element manager.

The primary aim of the Nokia PSM is to provide network operators with more accurate information about the power system status, and the possibility to control the system remotely, and maximize the electrical efficiency of the batteries and charging system. Implementation of the Nokia PSM will therefore reduce the number of service visits to the site.

The constant power (1300W) rectifier units generate the float charging voltage to batteries and the DC power supply to the BTS and customer equipment. The nominal output voltage (54 VDC at 25°C/77°F) of the rectifier is programmable and temperature compensated. It is possible to replace a rectifier unit to the Nokia UltraSite Support without disrupting the DC power to the BTS.

In Nokia UltraSite Support there is space reserved for customer equipment (e.g. Line Terminal Equipment) ranging from 6U to 18U. The space reserved for customer's equipment is protected against environmental detriment. Also, the temperature of this space can be actively controlled.

Installation of customer equipment in Nokia UltraSite Support is easy. There is no need for additional racks or external cabling for customer equipment. The integrated construction of Nokia UltraSite Support fulfils all the requirements of customer equipment - from power supply to monitoring and controlling via the Q1 bus.

Nokia UltraSite Support has the same core mechanics in both indoor and outdoor cabinets. The cabinets differ only by the kits attached to the core mechanics. The high volume-to-power ratio combined with the small footprint allows more possibilities for the site utilization.

For more information, refer to *Nokia UltraSite Support Product Overview*.

2.2.1.3 Antenna systems

Nokia Antenna Systems for GSM network have been designed to meet the demands for compact size, robust construction, strictly defined radiation patterns and aestethic appearance. The number of components in the whole solution has been minimized.

The usage of cross-polarized and dual band antennas as well as diplexers minimize the visual impact which has become an issue in many countries. There are also additional benefits of keeping into a selected portfolio: faster planning and roll out.

An important element in Nokia UltraSite Antenna System is the new Nokia Masthead Amplifier (MHA) which is specially designed for Nokia UltraSite. The MHA improves the sensitivity of the whole system by improving the BTS's receiver sensitivity as well as by filtering out interference. Thus, it improves the overall network operation and reduces annoying call drop-outs. All this leads to an increased transmission quality and subscriber satisfaction, ultimately leading to increased revenues for the operators.

In addition to the antennas and the MHAs, the following components are part of Nokia UltraSite Antenna System:

- feeder cables
- clamps
- feeder connectors
- jumper cables
- grounding kits
- EMP protectors
- diplexers (optional).

The RF feeder can be of different sizes (1/2", 7/8", and 1 5/8"), depending on the length of the mast and the desired attenuation.

The cable clamps are made of stainless steel and they are easy and fast to install. All connectors are IP68 classified.

The jumper cable is a flexible low-loss cable (1/2") which is used at the ends of the feeder. It protects the connectors from the forces caused by the feeder cable.

The grounding kit ensures that the antenna line is DC grounded against lightning.

The EMP protection protects the BTS against lightning and overvoltage coming down the antenna line.

For more information, refer to *Nokia UltraSite Antenna System Product Overview*.

2.2.1.4 Nokia FlexiHopper Microwave Radio

Figure 3. Nokia FlexiHopper Microwave Radio

Nokia FlexiHopper Microwave Radio is available for 13, 15, 18, 23, 26 and 38 GHz frequency bands. The radio and its indoor unit are connected together with a Flexbus. The Flexbus is a single coaxial cable which carries all the signals between the indoor unit and the radio. It also carries the power to the radio. The distance between the indoor unit and the radio can be up to 300 meters.

Nokia FlexiHopper Microwave Radio supports Plesiochronous Digital Hierarchy (PDH) capacities of 2 x 2, 4 x 2, 8 x 2 and 16 x 2 Mbit/s. The used capacity can be defined locally at the site using an element manager, or remotely from the NMS. Capacity changes do not require any hardware changes.

Nokia FlexiHopper Microwave Radio has several indoor unit options:

- FXC RRI indoor unit is fully integrated with Nokia UltraSite GSM BTS. It provides Flexbus connections for two radios and full cross-connection, loop protection and grooming capability.
- FIU 19 is a compact 19” indoor unit providing connections for up to four radios depending on the configuration, flexible capacity expansion possibilities, and various site configuration possibilities.

Nokia FlexiHopper Microwave Radio can be managed locally with

- Nokia Hopper Manager (with FIU 19)
- Nokia UltraSite BTS Manager (with FXC RRI)

or remotely from the Nokia NMS.

For more detailed information please refer to *Nokia FlexiHopper Microwave Radio Product Overview*.

2.2.1.5 Nokia UltraHopper Microwave Radio

Figure 4. Nokia UltraHopper Microwave Radio

Nokia UltraHopper Microwave Radio is a high-capacity, medium-haul radio. It is available for the 18, 23, and 26 GHz frequency bands. The radio transmission capacity of Nokia UltraHopper is STM-1 (155.52 Mbit/s). 63 x 2 Mbit/s signals can be carried within the STM-1.

Nokia UltraHopper is a stand-alone radio with a standard optical STM-1 interface. The radio can be installed on roof, wall, or mast. Nokia UltraHopper is connected to other units by an optical cable (with two fibres) and a power cable. The power cable can be up to 300 m long.

At Nokia UltraSite, Nokia UltraHopper is connected to the FXC STM-1 transmission unit. FXC STM-1 and FXC Bridge are always used together, and they take one trasmission unit slot each. They contain the following functions:

- FXC STM-1: two standard optical STM-1 interfaces and power connections, SDH level cross-connection functionality, support for two Nokia UltraHopper radios
- FXC Bridge: SDH layer termination, cross-connection on 8 kbit/s level

Nokia UltraHopper can be managed locally with

- Nokia UltraHopper Manager
- Nokia UltraSite BTS Manager (when used with FXC STM-1 and FXC Bridge in Nokia UltraSite)

or remotely with the Nokia NMS.

For more information, please refer to *Nokia UltraHopper Microwave Radio Product Overview*.

2.2.1.6 Local management and Nokia SiteWizard

Figure 5. Commissioning wizard pages

Nokia UltraSite BTS Manager is used for managing locally Nokia UltraSite equipment including the GSM BTS with its integrated transmission equipment and Nokia FlexiHopper and UltraHopper microwave radios as well as the site support system.

Nokia SiteWizard is a tool that supports all phases of installation and commissioning. Site information and parameters are loaded from the NMS/2000 to the PC containing Nokia SiteWizard. This site information can be used during installation to determine equipment needed and procedures to be followed. The commissioning wizard (see figure above) eases the process of the BTS and transmission commissioning. During commissioning, the site parameters are automatically read by Nokia SiteWizard.

Usually, the equipment on the site is managed using a network management system like NMS/2000. However, Nokia UltraSite BTS Manager acts as a master if it is activated.

Nokia UltraSite local management applications have a graphical user interface and run in Windows NT4.0 or Windows95 environment.

2.2.2 Network Management System

Nokia UltraSite Solution can be fully managed with the NMS/2000 network management system. The NMS/2000 offers centralized management for the whole cellular network. NMS SW release T12 is required for Nokia UltraSite GSM support.

The NMS/2000 offers integrated management for Nokia UltraSite Solution as well as the whole GSM network including both cellular and transmission sections. The Nokia UltraSite cellular transmission solutions built with both SDH and PDH equipment using wire line, optical fibre or microwaves as the transmission media can be managed with the NMS/2000. It has full management functionality including configuration, fault and performance management. The NMS/2000 uses the NMS/10 as the node manager server for transmission nodes.

The NMS/2000 supports many features and related products that will bring the best out of the network. Nokia Network Data Warehouse (NDW) collects, stores, manages and presents long-term performance, alarm and configuration data from the NMS database. Nokia Configuration Data Warehouse (CDW) supports network planning, deployment and operations. It controls the network parameters and manages the data and work process for introducing parameter changes and network expansions. CDW performs automatic and periodical network audits to find inappropriate parameter values in the network which enables effective supervision of the configuration changes in the network. Optimal parameter settings ensure good service quality and effective system performance. The ability to manage individual parameter settings enables detailed cell tuning and optimum exploitation of network features.

The autoconfiguration capability helps operators to minimize both time and costs spent on commissioning and network integration. The NMS/2000 supports autoconfiguration by documenting the elements and their configurations, topology, and the transmission connections into the NMS/2000 database.

NMS/2000 SW release T12 will offer the basic support for Nokia UltraSite GSM solution. With NMS/2000 SW release T13, many new features (such as RSSI antenna monitoring and Multi-BCF) become available.

2.2.3 Base Station Controller

The basic support for Nokia UltraSite GSM solution will become available with BSC SW release S9. With S9 the operator can start to introduce the Nokia UltraSite into the network.

With S10 a more complete support will become available in the form of EDGE support and multiple new features such as horizontal expansion by splitting cells between several cabinets. Also features like Adaptive Multi Rate (AMR) speech coding and Single BCCH for Dual Band Cells will become available for enhancing the capacity of the GSM networks.

The Nokia BSC supports co-siting of Nokia Talk-family and Nokia UltraSite GSM BTSs so that the equipment is seen by the rest of the network as consisting of separate entities. Also, alarms are managed separately.

The Nokia UltraSite BSC transmission solution includes both the SDH and PDH transmission. Dynamic Abis (in BSS10) will be a very important feature in future EDGE networks for optimising the usage of Abis capacity. The dynamics of the Abis interface will reduce the capacity requirement greatly from that of permanent time-slot allocations for each EDGE TRX.

The new Nokia Large Capacity BSC’s enhanced capacity is targeted for future networks in which increasingly more capacity is needed in the form of larger macrocellular sites and dense microcellular layers. There it will be a natural companion for Nokia UltraSite Solution.

3 Nokia UltraSite GSM applications

This chapter provides information on Nokia UltraSite transmission at both network and site levels. Also, examples are given on various site configuration packages called Nokia UltraSite Pack. Nokia UltraSite Pack includes all the elements required to integrate the site into a network with minimum effort and maximum ensurance.

Finally, issues concerning the site and network evolution paths will be discussed.

3.1 Transmission

Cellular communications are evolving towards higher capacity demands. The operator's future capacity needs have been taken into account in the development of the Nokia UltraSite elements. Nokia UltraSite Solution includes highly integrated high-capacity (SDH) and low-capacity (PDH) transmission. Every Nokia UltraSite GSM BTS can act as a powerful transmission hub.

Transmission is an integral part of the Nokia network planning and network management tools and services. Implementation of the transmission network has been made easy by the automatic configuration (end-to-end) feature.

3.1.1 Transmission technologies

Cellular Access networks have so far mainly been implemented using the PDH technology. This is now changing as the capacity demands are growing due to increased traffic and new services. The high-capacity solution will be SDH in many cellular access networks and also in the core network (e.g. BSC-MSC).

SDH transmission supports the following bit rates in general:

- STM-1
- STM-4
- STM-16.

Even higher bit rates can be achieved by Wavelength Division Multiplexing (WDM) which is used to carry multiple SDH signals inside a single optical fibre. STM-1 capacity is very suitable for BTS access networks. The Ater traffic from the BSC to the MSC (Mobile Switching Center) or the traffic from co-located BSCs to the BTSs require often more than one STM-1 connection. There, STM-4 or STM-16 is the most feasible solution.

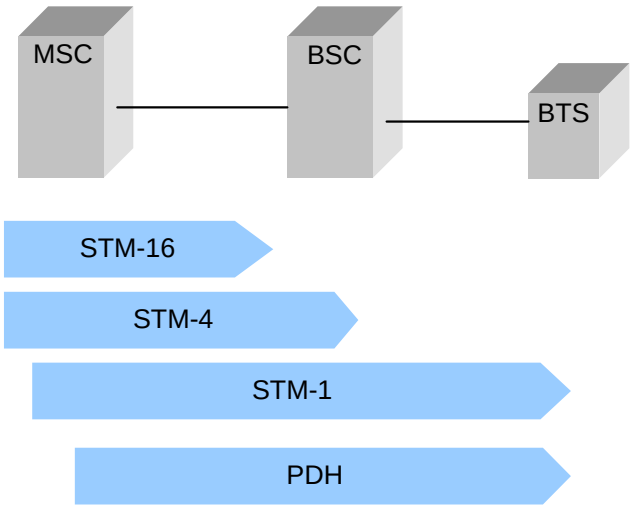


Figure 6. Transmission hierarchies

The lower-rate PDH transmission is based on the E1 (ETSI) and T1 (ANSI) standards. The capacity of E1 is 2 Mbit/s and the capacity of T1 is 1.5 Mbit/s. STM-1 can carry 63 x 2 Mbit/s which is approximately half of the Nokia BSC's capacity.

In addition to the standard solutions, Nokia has implemented an optimal transmission solution for transmission between the microwave indoor unit and the PDH radio. This solution is called Flexbus. The Flexbus is a Nokia proprietary bus. It carries 16 x 2 Mbit/s in both directions, and power for the radio in one coaxial cable. The Flexbus is also ideal to connect together BTS cabinets and transmission nodes on a site. The cable length can be up to 300 meters.

3.1.2 Network topologies

Nokia UltraSite GSM BTS supports all topologies directly without a need for separate transmission nodes. High and low transmission capacity, microwave links, leased wire lines and fibres may be used simultaneously in the BTS.

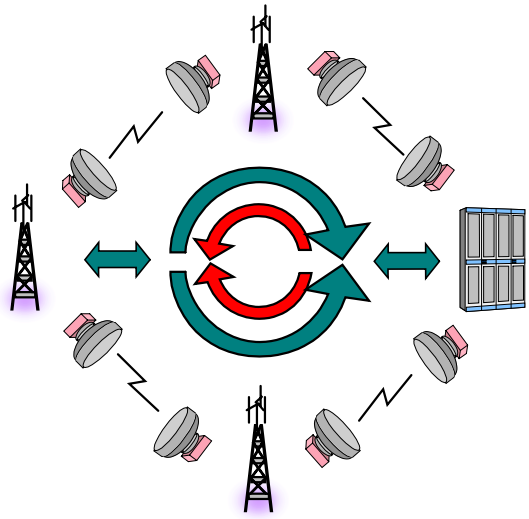


Figure 7. Nokia UltraSite loop topology example

The network topology is chosen mainly based on transmission media and availability requirements. The preferred solution for reliable transmission is the loop topology. When compared to a chain topology, the loop provides excellent protection against microwave link fading and equipment failures. Loop protection improves availability normally by 10 - 1000 times compared to a single connection.

Nokia UltraSite GSM BTS is a powerful transmission hub node. For instance, there can be 8 microwave connections in a single-cabinet Nokia UltraSite GSM BTS and 20 in a 3-cabinet site. The transmission can be directly connected to Nokia MetroSite GSM BTS via Nokia MetroHopper Radio or Nokia FlexiHopper Microwave Radio. Grooming at the BTS further optimizes transmission capacity.

To optimize costs, tail sites can be implemented using FC E1/T1 transmission units. However, it is recommended to use FXC units to enable flexible expansion of sites and direction of transmission to further sites. The FC E1/T1 should not be used in the BSC direction as it will not support enough capacity for a 12 TRX BTS when EDGE is introduced.

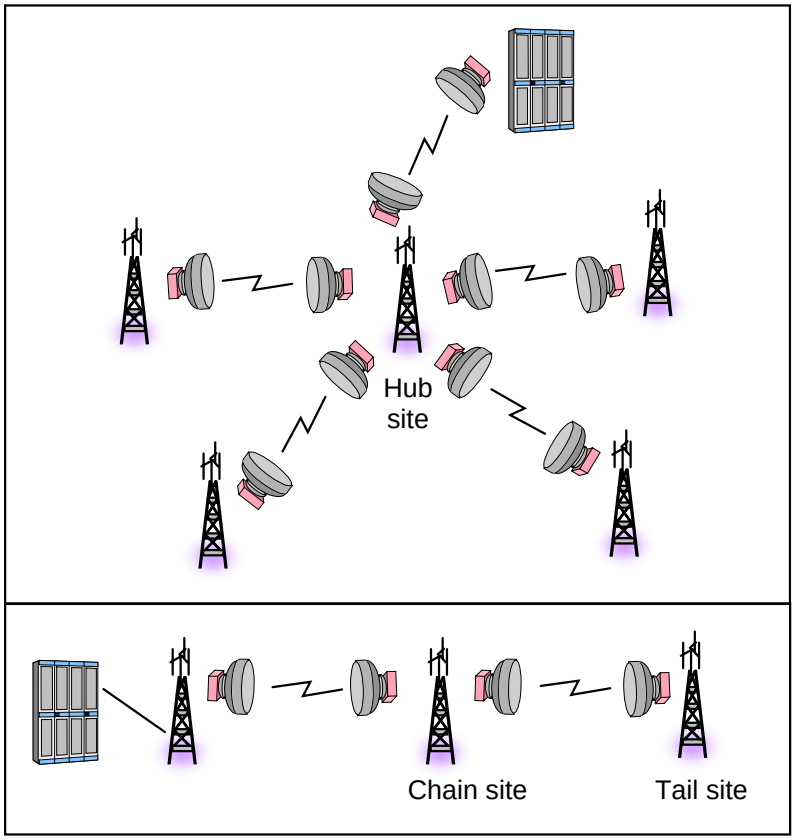


Figure 8. Nokia UltraSite transmission site examples

3.1.3 Transmission site solutions

At BSS level, there can be three types of transmission sites: BTS site, BSC site and stand-alone hub site. Nokia UltraSite offers solutions for all these sites.

At the BSC and stand-alone hub sites, Nokia UltraHub can be used. This hub is a scalable high-capacity transmission node specially designed for cellular transmission.

3.1.3.1 UltraSite GSM BTS transmission

Every Nokia UltraSite GSM BTS cabinet contains 4 slots that are reserved for integrated transmission units. Each cabinet can provide add-drop capacity for other sites. The integrated transmission is capable of grooming traffic and acting as a PDH loop master. Cross-connections are done down to 8k granularity which provides the means of efficent usage of transmission capacity.

Using Nokia MetroHopper Radio or Nokia FlexiHopper Microwave Radio you get up to 8 Flexbus connections from one BTS cabinet without any external equipment. The corresponding number of E1/T1 interfaces is 16.

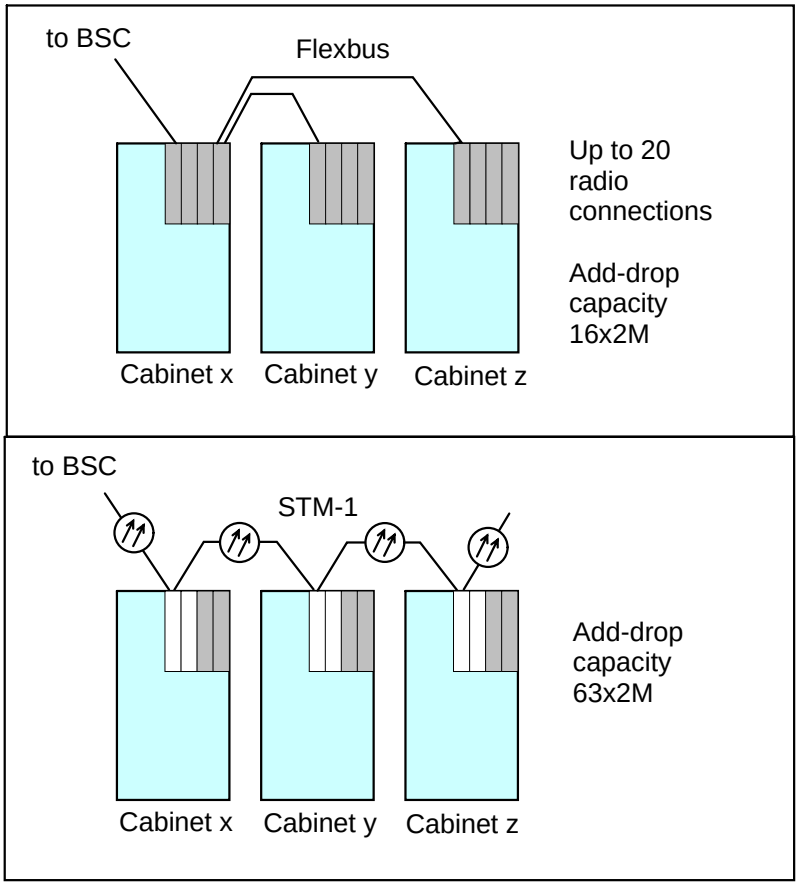


Figure 9. BTS transmission interconnections with Flexbus and STM-1

The STM-1 interface unit includes two STM-1 interfaces and it consumes two slots (FXC STM-1 + FXC Bridge units). The unit can be used as an interface to a fiber optic network or as an indoor unit for Nokia UltraHopper Microwave Radio.

The number of connections can be increased when new cabinets are installed. However, the cabinets must be interconnected. The preferred solution when interconnecting cabinets is Flexbus. Connecting two cabinets requires one Flexbus interface in each cabinet. Multiple cabinets are connected as star to the first cabinet (see figure above).

The Flexbus is used to interconnect the cabinets when a total add-drop capacity of 16 x 2 Mbit/s is sufficent. When more capacity is needed, the STM-1 transmission can be chained through multiple cabinets giving 21 x 2 Mbit/s add-drop capacity per cabinet. The STM-1 interface leaves space for 2 transmission units per cabinet. A 3-cabinet BTS with an STM-1 interface in each cabinet provides a total add-drop capacity of 63 x 2 Mbit/s.

When E1 or T1 (leased wire line) interfaces are used, it is recommended that the connections towards the BSC are all connected to the same cabinet. This enables the grooming benefit for interconnected cabinets.

A co-located Nokia Talk-family BTS can be connected to Nokia UltraSite GSM BTS using the integrated E1/T1 interface or Flexbus.

During the upgrade phase, Nokia Talk-family transmission interface towards the BSC can be used to provide Abis for Nokia UltraSite GSM BTS. This, however, limits the capacity and expandability of the BTS. Therefore, it is recommended that the external transmission interface is connected via Nokia UltraSite GSM BTS.

3.1.3.2 BSC transmission

The Nokia UltraHub solution for BSC includes both SDH and PDH transmission. The main functions of the BSC transmission are to adapt the BSC ET interfaces to the transmission used in the BTS access network and to groom traffic if needed. The BSC transmission also includes the BSC-MSC connection (Ater).

The BSC concentrates the traffic from the BTS towards the MSC. The concentration ratio is around 4:1 depending on the planning parameters. Still, when connecting several BSCs towards the MSC, the capacity demand may exceed STM-1 for which reason higher rates like STM-4 and STM-16 are feasible.

The transmission at the BSC site can be divided into three main categories:

- SDH
- E1/T1 (leased wire lines)
- microwave radios.

In Nokia UltraSite SDH solution, a large number of BTSs are normally connected to the BSC via an STM-1 interface which means that the SDH node must be very reliable. It is advisable to divide the BTSs under one BSC into 2 or 3 STM-1 loops. This ensures a secure growth path towards EDGE and WCDMA.

Leased wire lines can either be connected to the BSC directly or via a cross-connection node. A cross-connection is needed if the time-slot utilization in the E1/T1 interfaces is low and the BSC is running out of E1/T1 interfaces. Nokia MetroHub or the DN2 can be used for the grooming function. Nokia MetroHopper Radio, Nokia FlexiHopper Microwave Radio and Nokia UltraHopper Microwave Radio can be connected to the BSC using the FIU19 unit or Nokia MetroHub. These solutions provide max. 16 x 2 Mbit/s per unit. The distance (cable length) from the indoor unit to the radio can be up to 300 meters.

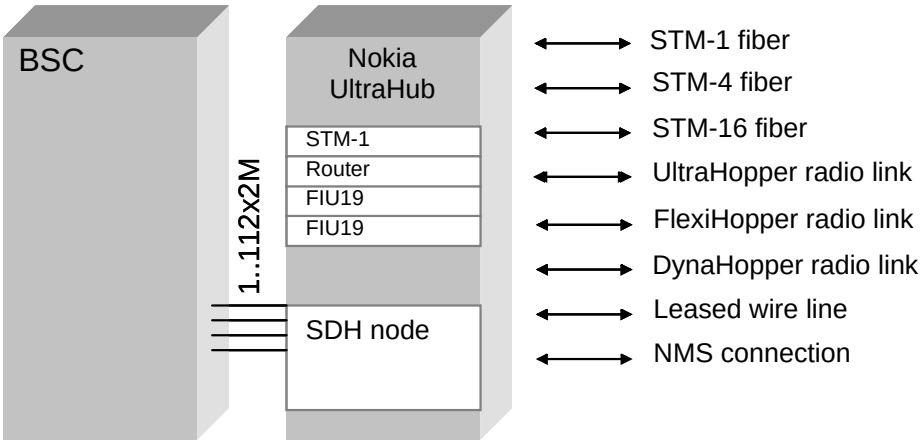


Figure 10. BSC transmission solution

3.1.3.3 Stand-alone transmission sites

Sometimes, it is feasible to build a separate hub site. This would be the case where the optimal hub position would not fit a BTS or the transmission functionality would require special equipment. The BSC is one case of a transmission hub.

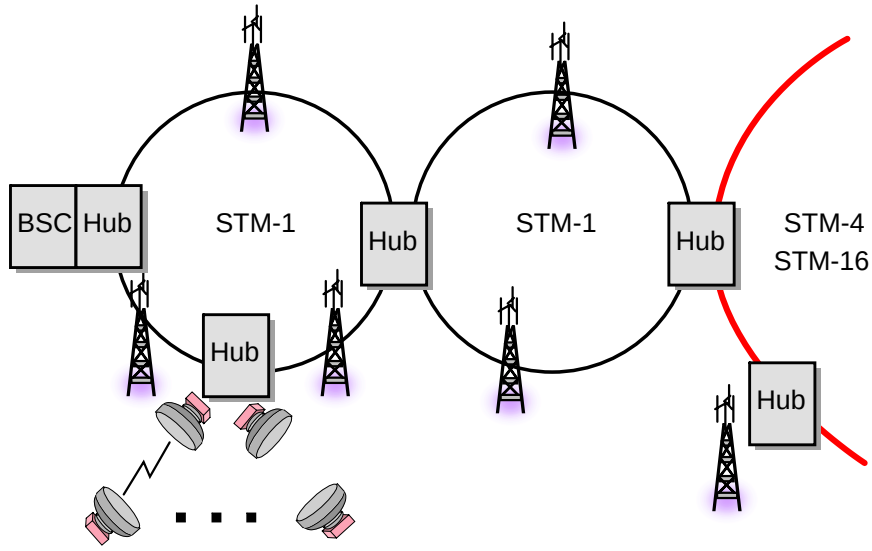


Figure 11. Usage of separate Hub nodes

Nokia UltraSite Solution includes two main alternatives: the indoor high-capacity Nokia UltraHub and the outdoor/wall mounted Nokia MetroHub. Refer to *Nokia MetroHub Transmission Node Product Overview*.

Nokia UltraHub is a high-capacity transmission node based on a standard ETSI type of rack. The functionality is the same as in the BSC case (see figure 9).

Nokia MetroHub is a small powerful stand-alone element which can be equipped with up to 5 transmission units which are the same as those in Nokia UltraSite GSM BTS.

3.1.4 Cross-connections

Different transmission nodes support different cross-connection granularities and connection types in GSM transmission networks. The cross-connections are non-blocking which means that a constant bit rate is ensured. The BTS access networks normally use 16 kbit/s for signalling and traffic. To be able to fill higher-level transmission pipes, the nodes must be able to make cross-connections on the 16 kbit/s level.

The Nokia UltraSite transmission range varies from STM-16 down to 8 kbit/s. Also, the Nokia UltraSite is capable of handling the most important cross-connection granularities of:

- 8 kbit/s, needed when grooming Abis traffic
- 64 kbit/s or "time slot" level. 1 GSM TRX requires 2 TS for the payload and 1/4 - 1 TS for signalling
- 2 Mbit/s, corresponding to the E1 interface
- 1.5 Mbit/s, corresponding to the T1 interface
- VC-12, virtual container inside VC-4. Capacity is 2 Mbit/s
- VC-4, virtual container inside STM-1. Capacity is 63 x VC-12.

The figure below shows the cross-connection capabilities of each node.

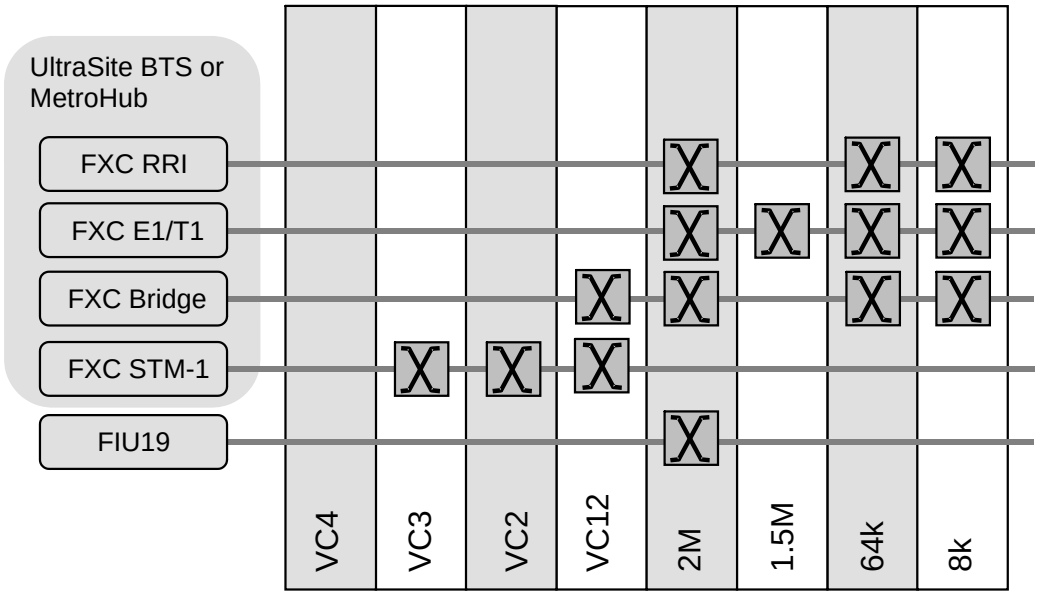


Figure 12. Cross-connection capabilities

3.1.5 Protection

To achieve high availability of critical BTSs and transmission hubs, transmission must be protected. There are several complementary ways of protecting transmission against, e.g. cable cuts, fading in radio link or faults in the equipment.

Equipment protection

Equipment protection is used to ensure transmission regardless of faults in the equipment. This means that redundancy is built at the equipment level.

The Hot Standby (HSB) equipment protection for Nokia FlexiHopper Microwave Radio can be implemented with either one (FIU19, FXC RRI) or two (FIU19 only) indoor units. Also, Nokia UltraHopper Microwave Radio supports HSB.

Protection of an FXC STM-1 unit can be implemented by installing a redundant FXC STM-1 unit. In the case of a fault in the operating unit or a forced switch by the management function, the redundant, protecting unit becomes the primary unit. This changeover is non-reverting.

Path protection

In path protection, diverse paths for the traffic are configured to protect traffic against faults:

- 1+1 path protection: the traffic is sent in two paths simultaneously, and the protection switching is done entirely at the receiving end.
- 1:1 path protection: the redundant path does not normally carry traffic. Only in the case of a fault, the diverse path is used.
- 1:N path protection: the same as the 1:1 path protection but the redundant path is shared by a number of operating paths.

The SDH multiplexing structure enables efficient path protection schemes. Single multiplexer sections as well as VC paths over several multiplexer sections can be protected independently. The multiplexer sections may contain several regenerator sections.

The FXC STM-1 units configured as Add/Drop Multiplexer (ADM) are capable of VC-12 level SNC/I (inherently monitored sub-network connection) 1+1 protection. In multiplexer section protection the FXC STM-1 uses the single-ended switching mode where both directions of transmission operate independently.

Loop protection

For connection protection to be efficient, diverse routes for the paths are needed. Loop or ring network structures are the most appropriate for this purpose. Loops are a very efficient way to protect against failures in transmission path and equipment. Two FXC STM-1 units can be used to interconnect two loops (in later release).

SDH equipment provides efficient add/drop multiplexers without separate up and down multiplexing. The ADMs can be used efficiently to provide automatically protected transmission loops. The FXC STM-1 unit has two STM-1 interfaces which enables easy loop implementation.

PDH loops with Nokia elements are implemented by a Nokia proprietary master-slave principle. The transmission direction in the loop is selected by using special pilot bits. The pilot bits can be configured to be used as any bit in the 2 Mbit/s signal. The loop master sends the pilot bits and thus controls the transmission direction of the loop.

Very reliable SDH-PDH loop protection can be built by connecting the PDH loop to two separate SDH nodes. This way the SDH-PDH connection point is protected and no separate unit protection is needed. This solution requires no additional hardware at the BTS site, but it requires capability for 64 kbit/s cross-connection at the BSC site.

3.1.6 Network management interface

The integrated transmission equipment is managed using the Q1 protocol. The management is based on polling, which is done by the BSC, BTS or a dedicated mediator. Each BSC can have 14 service channels (Q1 buses), whereas the BTS has one local Q1 bus. Each Q1 bus can serve multiple transmission elements. The management connection to the BSC can be either an management channel in the Abis in the case of BTS polling, or an overhead channel of microwave radio, STM-1 header or a dedicated time slot in the case of BSC or mediator polling.

For more information, refer to NMS document *Q1 Implementation in Cellular Transmission Networks*.

3.1.7 Synchronization

The transmission networks work properly only when synchronization is planned and implemented properly. Usually, the master-slave synchronization method is used. This synchronization method uses a Primary Reference Clock (PRC) to which the equipment clocks are synchronized. In figure 13, the PRC is connected to the MSC.

The synchronization functions can be configured using the Nokia NMS or the Nokia UltraSite BTS Manager. The user sets the available synchronization references in priority order according to the synchronization plan. The highest-quality source is used to synchronize the equipment.

The following sources can be set as synchronization references for the equipment clock:

- incoming STM-1 signal
- incoming 1.5 or 2 Mbit/s signal of E1/T1 unit interface
- incoming 2 Mbit/s signal of FXC RRI unit’s Flexbus interface.

The transmission unit’s internal frequency is used for synchronization if there is no other reference source available.

Synchronization status messaging can be used to ensure that the best available timing source will be used. The messaging can also be used to prevent timing loops in ring and mesh networks. The status messaging is transferred in the S1 byte in the STM-N Section Overhead, or in TS0 of the 2 Mbit/s frame. Older SDH or PDH equipment may not have the synchronization status messaging implemented. In such cases, Nokia UltraSite BTS Manager can be used to set the desired quality status for these signals.

The primary method used for synchronization of the BSC is to use the external 2 MHz synchronization output of the SDH node and the external 2 MHz synchronization input of the BSC. An alternative method is to use the 2 Mbit/s signal. The re-timing function can be used if the quality of the 2 Mbit/s signal is too poor for the BSC, however, this function adds delay in the signal.

When building the cellular network, or replacing PDH based networks by SDH networks case by case, it may happen that parts of SDH transmission network become isolated from each other. These SDH islands should be synchronized to one of the 2 Mbits/s signals synchronized to the BSC clock.

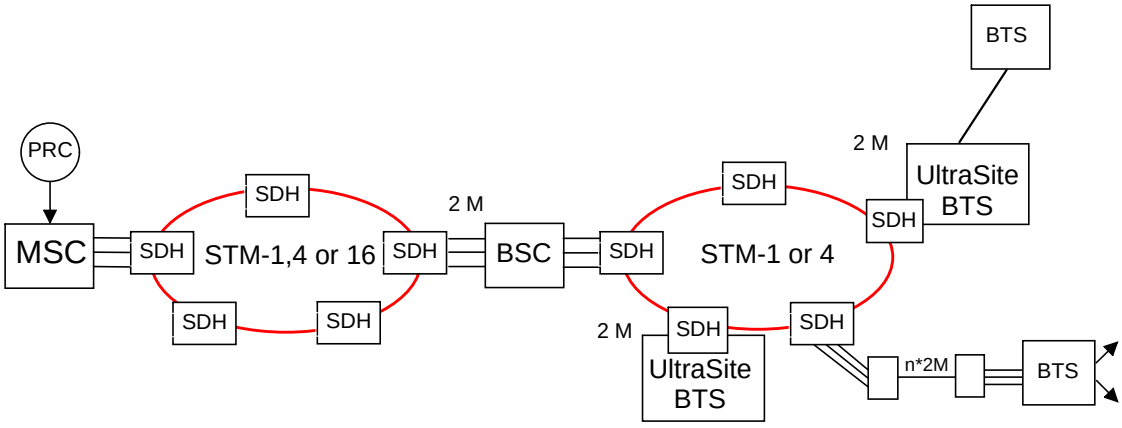


Figure 13. BSS synchronization

3.2 Sites

Nokia UltraSite Pack can be defined for all applications, taking into account the high-capacity demands in dense urban environment, and also rural applications with low-capacity, large-coverage-area requirements keeping in mind both indoor and outdoor installations. The modular design of Nokia UltraSite supports efficient capacity growth.

In this document, a few typical GSM applications have been picked up and configurations have been defined for them. They are completely equipped sites with transmission and auxiliary equipment. The Nokia UltraSite elements can be integrated into other mobile network applications as well.

The sites described in the following sections are given as examples of possible site configurations.

3.2.1 Road site

Figure 14. Road site

The road site has typically wide coverage and small capacity. The road area is covered by a 1+1 TRX configuration. Wide coverage is achieved with standard combiner by-pass configurations. However, coverage can be enhanced with boosters and 4-way diversity. Both sectors have two X-polarized antennas to enable the 4-way diversity. Masthead Amplifiers (MHAs) are used for both sectors. The MHA extends the uplink coverage in a large cell and compensates for the losses caused by long feeder cables.

Integrated battery backup allows the operator to build a cost-efficient one-cabinet outdoor solution. Typically, the site uses Nokia FlexiHopper Microwave Radios for both transmission directions. As the road sites are built along the road, transmission is chained.

3.2.2 Rural site

Figure 15. Rural site

The rural site has very similar requirements as the road site. High output power means large coverage area and fewer sites in the network. The capacity need is relatively modest due to sparse rural population and lack of extensive business usage. The site has a 2+2+2 TRX configuration with by-pass combining. The number of antennas is reduced by using X-polarized antennas. Masthead Amplifiers for each sector are used to compensate for the feeder cable losses. This outdoor site has also an integrated battery backup system allowing for the one cabinet solution. With the Nokia Intelligent Coverage Enhancement (ICE) feature the capacity can be expanded while retaining the initial coverage.

The rural site may be in the margins of the network and therefore it does not have transit transmission. Being a tail site, it needs only one Nokia FlexiHopper Microwave Radio for transmission.

3.2.3 Suburban site

The outdoor solution for the suburban site provides large coverage area and high capacity. A 6+6+6 TRX configuration with RTC (Remote Tune Combiner) combining (6:1) can be used. Thus, only one X-polarized antenna is needed for each sector. Masthead Amplifiers are used to compensate for the feeder cable losses. With integrated battery backup this solution can be implemented with only two cabinets.

Transmission in the high-capacity environment uses loop topology. The site can include three Nokia FlexiHopper Microwave Radios; two for the loop and one for a separate branch coming from other sites.

3.2.4 Urban site

Outdoor rooftop is a common choice for urban site installations. The urban site offers a flexible evolution path from small configurations to large capacity configurations. For instance, a 4+4+4 TRX configuration with wide band combining (2:1) can be implemented with only one cabinet. This solution has one X-polarized antenna per sector.

Battery backup is located in the Nokia UltraSite Support cabinet which also has space for customer equipment. This battery backup supports site extension up to 12+12+12 TRX configurations. The transmission of this loop site uses two Nokia FlexiHopper Microwave Radios.

3.2.5 Dual band urban site

The urban site may be built indoors and outdoors. High traffic capacity for voice and data services is achieved by using two bands (GSM 900/GSM 1800). The 8+8+8 / 4+4+4 TRX dual band configurations with wide band combining (4:1, 2:1) ensure maximum hopping flexibility. Three cabinets are used for this configuration.

Integrated dual band duplex units in the BTS allow for the usage of common antenna feeder cables for both frequency bands. One dual band XX-polarized antenna with integrated diplexers is used per sector. The battery backup is located in Nokia UltraSite Support.

As the BTS's transmission capacity is high, it can be used as a hub site as well. In this case, it is connected to an optical SDH loop with FXC STM-1. Two Nokia FlexiHopper Microwave Radios are used for other BTSs' transmission. The usage of SDH provides high transmission capacity for future needs of data transmission.

3.2.6 Talk-family/UltraSite urban site

Figure 16. Talk-family/UltraSite urban site

Nokia UltraSite can be used to provide capacity expansion or EDGE upgrade for existing indoor Nokia Talk-family sites.

In this case, a Nokia Intratalk 4+4+4 TRX configuration with RTC combiners is expanded by a Nokia Ultrasite 2+2+2 TRX configuration with wide band combining (2:1). The site is connected to a transmission loop with two Nokia FlexiHopper Microwave Radios.

Battery backup is supplied by the existing site support cabinet, to which more rectifiers and batteries are added. Existing antennas can also be used for the new TRXs. The already installed facilities make the network expansion feasible and cost effective.

3.3 Site evolution

Network capacity often needs to be increased and new services introduced in the network. Nokia UltraSite provides solutions for these cases. In the sections below, GSM evolution is discussed at BTS site level.

3.3.1 Expanding existing macrocellular site

Often, macrocellular networks need to be continuously expanded due to capacity reasons. Nokia UltraSite is designed to make this macrocellular network expansion feasible.

Easy cabinet installation

The Nokia UltraSite cabinets fit into corresponding Talk-family BTSs' footprints. So the floor space reserved for Talk-family BTS expansion cabinets can be utilized by Nokia UltraSite as such. The Nokia UltraSite cabinets can be installed side by side. There is no need for back access.

Flexible site support

Nokia UltraSite GSM BTS can use Nokia Talk-family site support system. The existing Talk-family site support cabinet may need to be upgraded if the battery backup time is not sufficient for the new site or if the rectifiers cannot feed the required current for the larger configuration. Also the power feeders and fuses have to be checked.

Also, Nokia UltraSite Support is compatible with Nokia Talk-family BTSs. Nokia UltraSite Support provides higher capacity and longer backup times.

Synchronization

Nokia UltraSite GSM BTSs can be synchronized to the existing Nokia Talk-family BTSs by a cable connection (see figure below). Synchronization allows to fully benefit of large configurations. It makes horizontal extension of the sectors possible. The Nokia Talk-family and UltraSite TRXs can be configured to a common cell. Only one BCCH transmission channel is needed per sector. RF hopping between the sectors with the same frequency lists can be used in synchronized BTSs, and synchronized handovers will become possible.

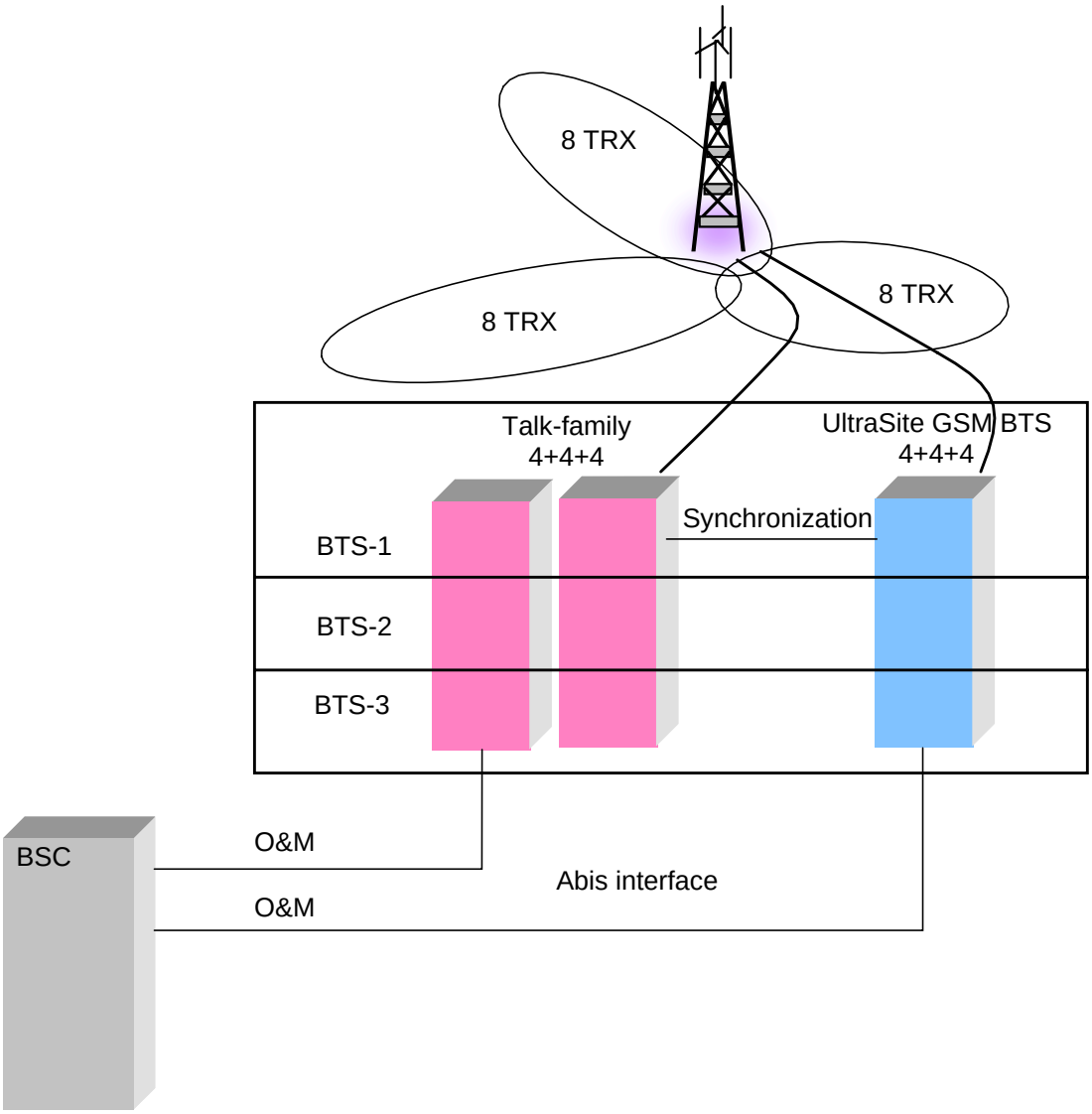


Figure 17. Nokia Talk-family/UltraSite GSM BTS synchronization

The maximum distance between all synchronized BTSs is 100 meters. The Nokia Talk-family BTS acts as the master, when it and Nokia UltraSite GSM BTS(s) are synchronized together. Synchronization requires a BCFx (Base Control Function) unit update in the Nokia Talk-family BTS.

Common alarm management

Both UltraSite and Talk-family equipment are seen as separate entities by the NMS. The alarms are managed independently.

External alarms and controls are compatible. The mains alarm from Nokia Talk-family site support equipment can be connected to Nokia UltraSite BTS and vice versa. The mains alarm information between UltraSite cabinets is transferred via the synchronization cable.

High-capacity transmission

The most economical solution for site expansion is to use the spare capacity of the existing transmission connection. If there is no spare capacity available, the existing transmission can be kept as such and new transmission connections can be built for the expansion. Nokia UltraSite Solution uses highly integrated high-capacity (SDH) and low-capacity (PDH) transmission and the BTSs can act as powerful transmission hubs. Therefore the Abis interface of the existing equipment can be connected to Nokia UltraSite where it can be groomed and cross-connected with the new transmission. Then all Nokia UltraSite transmission solutions are available.

Optimized use of existing antenna system

The antenna system can be shared either fully or partially based on the intended configuration and existing antenna scheme. Sharing the existing antennas and feeders depends on how they are utilised by the BTS. Utilizing existing facilities makes the network expansion feasible and cost effective.

One of the easiest way to share the antennas is to re-organise Talk-family TRXs so that the Talk-family BTS provides capacity for 1 - 2 sectors and Nokia UltraSite GSM BTS takes care of the rest of the sectors. In this case, if combining is done separately in each BTS cabinet, no antenna changes are required and no RF cabling is needed between the BTSs.

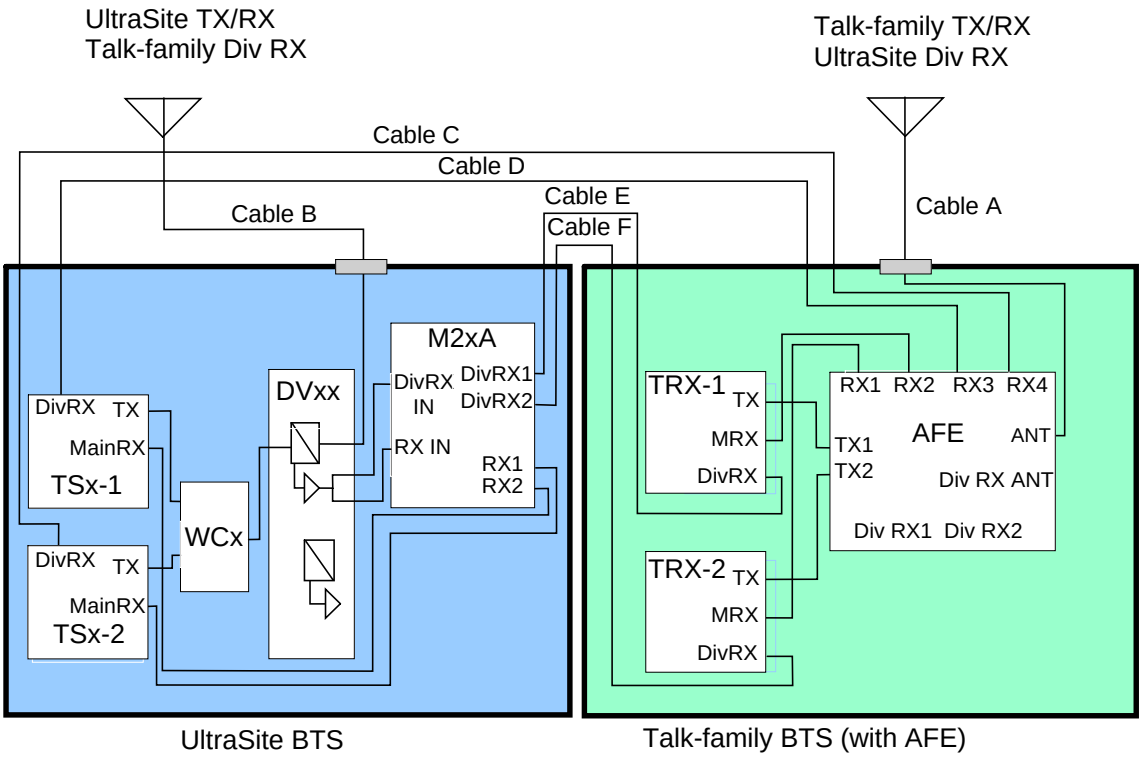
When the site expansion is done horizontally by using the Multi-BCF cell feature, cells are split between Nokia Talk-family and UltraSite BTSs. The existing Talk-family TRXs do not need to be re-organized but the UltraSite BTS brings more capacity to the existing cells.

New antennas can be introduced for the UltraSite BTS. The advantage of this is that the expansion can be built separately without touching the existing equipment. This means that the expansion can be brought into use with practically no down time at all.

Sharing the existing antennas and feeders depends on the way the Talk-family BTS uses them. If they are all used for transmitting by Talk-family BTS and if no new antennas can be introduced, then the only way to share the antennas and feeders is to do external hybrid combining before running the signals to the feeders. The disadvantage of this is the reduced output power caused by the extra combining.

In cases where the Talk-family BTS uses only some of the antennas for transmitting, its receiver diversity branch can be used for transmitting by Nokia UltraSite GSM BTS and the receiver diversity information can be exchanged between the BTSs using a separate cable set.

An example of a configuration of a wide-band combined 2+2+2 TRX Nokia Talk-family BTS with 2+2+2 TRX Nokia UltraSite GSM BTS is presented below. In this configuration there are 2 antenna elements per sector, i.e. duplexing and diversity are in use. In this case, a set of 12 receiver diversity cables is needed between the cabinets. The same applies to Nokia Talk-family BTS with a 1+1+1 TRX diversity configuration.



TSxx	TRX RF part
WCxx	Wide band combiner
DVxx	Dual duplexing unit
M2xA	Multicoupler

Figure 18. Nokia Talk-family/UltraSite macro site RF cabling

As Nokia Talk-family RTC configurations have only one RX output, an additional splitter is required to exchange the diversity information between the Talk-family and UltraSite BTSs.

The diversity branch cabling as well as the different gains of the diversity paths coming from the other cabinet degrade the diversity receiver sensitivity.

If Nokia UltraSite GSM BTS is used to provide dual band capability for an existing single-band Talk-family site, the difference compared to a pure single-band case is that only antennas may need to be changed to dual band antennas with integrated diplexers.

Using one dual band cross-polarized antenna per sector saves antenna installation space. Existing 900 MHz antennas can be utilized if new 1800 MHz antennas can be installed. If a dual band sector is built within the UltraSite BTS, employment of integrated dual band duplex units in Nokia UltraSite BTS allows to share the feeders. If a Nokia UltraSite GSM 1800 BTS is co-sited with a Nokia Talk-family GSM 900 BTS, external diplexers have to be used in the BTS end of the antenna line in order to minimize the number of antenna feeders.

3.4 Network evolution

Nokia UltraSite provides coverage for the existing voice and data services and introduces new features for these services. It provides a solid platform towards future multimedia networks.

3.4.1 Voice and data services

Currently, the voice services dominate the use of GSM networks. Nokia UltraSite supports all voice services. Moreover, the Adaptive Multi Rate (AMR) feature will bring with it optimized speech quality, capacity and coverage. This is achieved by adapting the coding rate and the codec.

Much of the traffic in the fixed network is data. Also the need for the wireless data services is growing. New data applications are introduced continuosly. Direct Internet connections will further increase the data usage. Currently GSM can provide data rate of 9.6 kbit/s. Higher wireless data rates would benefit many applications and allow new applications to emerge. With Nokia UltraSite new data solutions become available. The first Nokia UltraSite release supports High Speed Circuit Switched Data (HSCSD) and General Packet Radio Service (GPRS) services.

The HSCSD increases the data rate of a channel to 14.4 kbit/s. Data rates up to 57.6 kbit/s can be achieved by utilizing several channels simultaneously.

The GSM network has been circuit switched while more and more of the data traffic is packet switched. Especially the Internet applications are becoming dominating. The GPRS enables packet data connection to the mobile station and provides a direct connection for the packet switched public data networks. New network elements introduced in the GSM network with the IP core and packet switched backbone of GPRS are complementary with the circuit switched GSM network elements.

The transmission capacity requirements will be much higher with the new services. Nokia UltraSite has transmission capacity for all the foreseen needs.

3.4.2 EDGE

The Enhanced Data Rates for Global Evolution (EDGE) standard will further increase the data rates of both existing circuit switched (CSD) and packet switched (GPRS) data services. Implementation of these new EGPRS and ECSD services will not require new network elements as EDGE is built on the existing backbone.

Due to the new EDGE modulation scheme in the air interface, higher data capacity can be achieved with the existing frequency band. Nokia UltraSite provides a perfect solution for EDGE upgrades required in the existing networks because of the new modulation. Nokia UltraSite is the coverage solution for the EDGE.

Nokia UltraSite can be used to introduce EDGE in a Nokia Talk-family site without any limits to EDGE capacity. The implementation of the EDGE upgrade follows the same principles as described in the section above, i.e. the existing equipment can be shared, and in some cases it needs to be upgraded for new services. Antenna considerations are also similar.

If Nokia UltraSite is installed in the site using standard TRXs, the BTS can later be upgraded by adding EDGE TRXs. As Nokia UltraSite is designed for high data usage, it will provide full EDGE capability, meaning that all the TRXs within Nokia UltraSite GSM BTS can be EDGE capable and used simultaneously in EDGE mode, without restrictions. The EDGE TRXs can be simultaneously used in both GSM and EDGE modes. In addition to the benefit of full EDGE capability, the 2 dB link budget improvement in Nokia UltraSite BTS (compared to Nokia Talk-family BTS) can be used for better data coverage.

3.4.3 WCDMA

The third generation of wireless communication has been developed for multimedia purposes right from the beginning, whereas GSM was initially developed mainly for voice services. In WCDMA, the network resources can be optimized flexibly for the services provided including their quality.

The air interface of the WCDMA is completely different compared to the GSM air interface. Also, a new frequency band is allocated for WCDMA. Deployment of WCDMA requires new elements like the new Radio Network Controller (RNC) which is equivalent to the GSM BSC. However, in current GSM mobile networks, most elements are compatible with WCDMA. Nokia UltraSite Solution offers an smooth upgrade path towards WCDMA.

Nokia UltraSite Solution supports the integration of WCDMA carriers with minimum effort into the Nokia UltraSite GSM cabinets equipped with GSM and EDGE TRXs. This WCDMA upgrade is supported with both indoor and outdoor installations. Three WCDMA carriers with 5W output power can be installed. The installation of these carriers limits the number of GSM or EDGE TRXs to 6 in that cabinet. 1 - 3 WCDMA sectors can be configured to a single GSM cabinet.

When the capacity requirements in the network increase, Nokia UltraSite WCDMA Base Station can be installed into the network. Configurations up to 12 carriers per cabinet are possible. Maximised WCDMA capacity and coverage can be gained using six sector configurations and Nokia Smart Radio Concept (SRC).

Also, installation of dedicated Nokia UltraSite WCDMA cabinets into the same site with Nokia UltraSite GSM cabinets is as easy as what is the case with Nokia UltraSite and Talk-family co-siting. The Nokia UltraSite WCDMA and GSM BTSs can share a common site support system.

External diplexers can be used for sharing the feeders whether WCDMA carriers and GSM or EDGE TRXs are installed in the same cabinet or separate cabinets. If the diplexers are used, MHAs can be used only in one of the systems. The external alarms and controls (EACs) are compatible.

The Nokia UltraSite GSM transmission solutions support the WCDMA transmission. These solutions offer a physical path for the ATM based transmission of the WCDMA which is seen only as a capacity increase in the transmission network. This can be taken into account when building Nokia UltraSite transmission for GSM network.

3.4.4 Transmission network

As the number of end users and their mobile usage increase, higher capacity for the transmission network is required. Also the new services and the third generation network set new requirements for the transmission network. Upgrading a typical Nokia cellular transmission network from current second-generation speech-service based (narrowband) network to a wideband multimedia third generation network, where the air interface can be either GSM-EDGE or WCDMA, is presented in this chapter.

EDGE can be seen as a direct continuation to the current GSM requiring only capacity increase in the network, whereas upgrading to WCDMA means adding two totally new network layers (ATM and IP). Together with capacity growth, traffic shifts from circuit switched speech to packet data, both real time and non-real time data.

The cellular transmission networks like other transmission networks consist of three different logical networks running on a single physical network:

- payload
- operation and management network (DCN)
- synchronization network.

Upgrading may have an effect on all these logical networks. Especially the topological changes in physical layer create a lot of new investments. In the best case, the spare capacity of the existing network can just be brought into use. Also, in some cases, only the physical links (fiber, radio, copper) between the sites have to be upgraded, but the topology can be preserved.

Any new transmission layer like ATM in WCDMA brings new requirements for the DCN solutions. Combining WCDMA to an existing GSM network means that a totally new DCN has to be created beside the running one. WCDMA uses an IP layer for DCN.

Synchronization is carried over the lowest layer i.e. the physical layer. Generally, synchronization is not affected by the network upgrades. However, if new media like IP or a LAN section is added to the network, the synchronization network may also change.

All the above mentioned logical networks have to be considered when the overall transmission capacity is calculated. Also, there are various protocols on different network layers, each of which add to the overhead and thus to the final capacity need.

Upgrading the base station sites to higher capacity means that the whole network will be affected, both access and core. The upgrading may bring significant changes in three areas:

- topology
- site configuration
- media.

In the case of WCDMA, the new ATM based transmission can be interfaced to the GSM network which may require new interfaces and equipment at sites.

The two transmission networks and different kinds of traffic can be run in parallel. If the ATM and circuit switched SDH and/or PDH networks are all deployed, the existing PDH and SDH capacity is going to be increased and ATM will be conveyed on top of those transmission technologies. Fractional E1 links can be used to maximize the usage of transmission capacity within cellular networks. The WCDMA and GSM traffic is combined to the same physical link by allocating the 64 kbit/s time slots dynamically. Traffic can be easily aggregated/segregated by using existing 64 kbit/s cross-connects.

A unique and homogeneous ATM network can achieved by utilizing Circuit Emulation Service (CES). All GSM traffic, which is TDM based, is converted to ATM traffic by encapsulating 64 kbit/s time slots into ATM cells.

Inverse Multiplexing for ATM (IMA) allows transmission of ATM cell streams over multiple physical links, forming a higher capacity virtual link whose capacity is approximately the sum of the link rates. The traditional multiplex levels are used for physical links, e.g. T1 or E1. This approach provides for modular capacity, while using existing PDH/SDH transmission equipment. That is useful in particular when links of the higher multiplex levels are not readily available or not economical.

The IMA group is terminated at each end of the IMA virtual link. The receiving end reconstructs the ATM cell stream after accounting for link differential delays. Links can be added or removed to/from operational IMA groups to dynamically adapt capacity to changing needs. In case of link failures the group stays operational with reduced capacity, using the remaining links.

4 Deployment of Nokia UltraSite

This chapter describes the implementation of Nokia UltraSite into the network and gives an overview of the operation of the product. The main emphasis is put on the deviations from the methods used with other Nokia products.

The commissioning and integration of Nokia UltraSite can be done by one team and during one site visit without online assistance from the NMS site. The commissioning of Nokia UltraSite is made simple as the Nokia SiteWizard and Nokia Autoconfiguration help the personnel through the procedure. The commissioning wizard can read a Site Configuration File (SCF) which includes most of the required commissioning parameters.

Autoconfiguration helps to automate the commissioning and integration of the site. It creates transmission circuits between the BTS and the BSC that can be used for passing the information needed in commisioning and integration of a new BTS. It provides an end-to-end transmission management in the GSM access network.

Nokia provides services for all these activities. For more information on services, see chapter 5.

4.1 Network planning

In cases where Nokia UltraSite is implemented into an existing network, the configuration of that particular network is used as a basis for changes or the new configuration.

4.1.1 Radio network planning

Nokia UltraSite as such does not change the radio network planning requirements and procedures. New or improved features that affect radio network planning are described in this chapter.

Nokia UltraSite GSM BTS can be equipped with GSM 900, GSM 1800 or GSM 1900 TRXs without any limits in the sectorization. In the Nokia UltraSite GSM BTS cabinet there can be 1 - 6 sectors. The maximum number of TRXs per site is 108 and per sector 36.

Wide coverage can be achieved with Nokia UltraSite Solution. The output power of Nokia UltraSite GSM BTS is up to +44.5 dBm (28.2 W) when no combining is used. The receiver sensitivity is up to -112 dBm. So the link budget has improved by about 2 dB compared to that of Nokia Talk-family BTSs.

The coverage can be further increased by using a booster unit. With the booster the output power can be increased up to +48 dBm (62.9 W). To have the radio link budget in balance, the receiver sensitivity can be increased by using 2-way or 4-way diversity which increases the sensitivity theoretically by 3 dB or 6 dB accordingly.

Table 1. Nokia UltraSite GSM BTS's output power

TX antenna combining method	Output power, dBm	Output power, W	Max. no. of TRXs/ antenna
By-passing (dual duplexing)	44.5	28.2	1
Wide band combiner 2:1	41.0	12.6	2
Wide band combiner 4:1	37.5	5.6	4
Remote tune combiner	41.5	14.1	6
Booster	48.0	62.9	1

Table 2. Nokia UltraSite GSM BTS's receiver sensitivity

Reciever diversity scheme	Sensitivity (dBm) in GSM 900	Sensitivity (dBm) in GSM 1800/1900
Single branch without MHA	-110.5	-111.0
Single branch with MHA	-111.0	-112.0

Nokia UltraSite supports several other GSM features that further increases the coverage. Those features are:

- base-band and RF hopping
- Masthead Amplifiers
- Intelligent Coverage Enhancement (ICE)
- Enhanced Coverage by Frequency Hopping
- Extended Cell Range.

With Nokia UltraSite GSM BTS, the sectors can be expanded horizontally using the multi-BCF feature. This means that the TRXs of a sector can be located in several cabinets and they may even be of different bands (in dual band networks) or EDGE TRXs.

With the Single BCCH feature, only one BCCH channel is needed in a sector which is split between several cabinets. This means fewer BCCH channels in the network and more capacity. This applies also to dual band BTSs.

With Nokia UltraSite it is possible to build sites of very high capacity by just adding more TRXs to the existing sites assuming a wide frequency band is available.

If only a narrow frequency band is available, the needed capacity increase can be achieved with dual band operation, multilayer network or with Nokia Soft Capacity features such as Intelligent Underlay Overlay or Intelligent Frequency Hopping.

Radio network planning can be easily done with the Nokia Totem Suite which is an integrated planning solution. Nokia Totem Planning System for GSM networks is part of that solution. It runs in PC environment. Totem has a direct interface to Nokia Transmission planning system NPS/10. Radio network planning information concerning the network and the sites can be transferred from Totem to the NPS/10, which saves a lot of time and energy. Totem includes also a direct interface to the CDW and the NMS/2000.

For Nokia UltraSite GSM Base Station's RF performance, refer to *Nokia UltraSite GSM Base Station Product Overview*.

4.1.2 Transmission network planning

Nokia UltraSite offers numerous alternatives for transmission. The future capacity needs have been taken into account when developing it. Nokia UltraSite brings new integrated media, optical fibre, and a new multiplexing hierarcy, SDH, to the BSS.

The integrated transmission capacity in Nokia UltraSite GSM BTS is very high. The BTS cabinet can accommodate 4 integrated transmission units. In a site with several cabinets, the same capacity is available in each BTS cabinet thus making the transmission capacity very high. The BTS can even be used as a transmission hub for other elements in the network. It can connect the transmission between various macrocellular layer elements, or groom the transmission coming from the microcellular layer. This reduces the need for separate transmission nodes in the cellular access network and thus also reduces the investment, and implementation and operation costs of the network.

When using Nokia UltraSite PDH transmission with the new autoconfiguration feature, no routing information is needed in the transmission plan for that part of network. It is only to be secured that there is enough transmission capacity. However, whether or not autoconfiguration is in use, transmission plans are needed for the topology and capacity planning, availability calculations, radio link routing and interference planning.

Capacity has to be reserved to connect the Nokia Autoconfiguration pools through a transmission network that does not support autoconfiguration to the transmission network that supports it. Also the capacity and connections for the telecom traffic must be planned for those parts of transmission network that do not support autoconfiguration (this is the case with networks using SDH and older generation PDH equipment).

Transmission plans can be done with the Nokia NPS/10 transmission planning tool. The NPS/10 (version C5.0) supports all the transmission media and multiplexing hierarchies that can be used with Nokia UltraSite. The radio network planning information concerning the network and the sites can be transferred from Totem radio network planning tool to the NPS/10. The NPS/10 calculates the required transmission capacity and the required autoconfiguration pools. The data can be transferred electrically from the NPS/10 to the NMS.

4.1.3 Site acquisition

Nokia UltraSite does not change the site requirements much when compared to those of the existing macrocellular Talk-family BTSs. Nokia Talk-family sites can be utilized directly by Nokia UltraSite.

All the outdoor UltraSite GSM elements work in the ambient temperature of -33°C (-27.4°F) to 50°C (122°F) and the outdoor cabinet is IP55 protected; thus, normally, no additional protective shelters are needed. The temperature range for Nokia UltraSite GSM BTS Indoor is -5°C (23°F) to 50°C (122°F). Forced open air cooling is used in the outdoor cabinet; therefore additional heating or cooling is not needed during the operation.

For small-capacity sites with space for only one cabinet, Nokia UltraSite offers a solution with all the needed elements in one cabinet. This one cabinet contains an integrated battery backup system and up to 6 TRX Nokia UltraSite GSM BTS with integrated transmission and all the features. Up to 45 minutes of backup time can be provided for that configuration.

Midi cabinets can be installed in indoor sites that have limited height. The cabinet has all the Nokia UltraSite GSM features and can accommodate up to 6 TRXs. Midi cabinets can be placed side by side as well.

When Nokia UltraSite WCDMA BTS is brought to the same site, it must be taken into account that the heat transfer and the power consumption of the WCDMA BTS are higher compared to those of Nokia UltraSite GSM BTS.

Table 3. Nokia UltraSite GSM cabinet dimensions

Cabinet	Height	Width	Depth
Midi	1100 mm (43.31 In)	600 mm (23.62 In)	570 mm (22.44 In)
Indoor	1800 mm (70.87 In)	600 mm (23.62 In)	570 mm (22.44 In)
Outdoor	1940 mm (76.38 In)	770 mm (30.31 In)	750 mm (29.53 In)

4.2 Network implementation

The sections below provide information on the network implementation phases (preparation, installation, commissioning and integration) which can be started after the network planning is completed and sites and necessary equipment are available.

4.2.1 Preparation

Some preparational work is required before a new site can be integrated into the network.

The radio and transmission network plans are first loaded into the NMS. The NMS creates the radio network objects and the transmission network objects automatically of the plans. The autoconfiguration pools and the signalling links for every BTS are defined in the transmission network plan. The NMS creates the Site Configuration File (SCF) which is loaded to a PC containing the Nokia SiteWizard. Nokia SiteWizard reads the parameters in the file during the actual commissioning.

The NMS/2000 configures the BSC automatically. It loads the BSC configurations to the BSC database when the BSC is operational. The NMS/2000 automatically preconfigures transmission capacity, that can be freely allocated to autoconfiguration usage, to the Abis interfaces of the BSCs. That transmission capacity is called AC pool. After that, the BSC is ready to serve the accessing Nokia UltraSite network elements.

SDH and older generation PDH equipment do not support autoconfiguration. The AC pools have to be configured through these parts of transmission network according to the transmission plan. The same applies to the capacity and connections of the telecom traffic.

The AC pool provides transmission circuits between the site and the BSC that can be used for passing the information needed in commisioning and integration of the new site. The existing Nokia UltraSite PDH transmission elements can detect whether there are new AC pools by checking the unused telecom time slots.

When a new BTS is installed and connected to the transmission network, its transmission finds the routes to the nodes having an AC-pool connection and further to the BSC. After that a channel is created between the newly installed BTS and the BSC. This channel is then used for commissioning and integration of the new BTS.

4.2.2 Site installation

The highly integrated Nokia UltraSite Solution obviates the need for various separate elements and cabinets at the site. The transmission and the combining equipment as well as the site support system are all integrated in the Nokia UltraSite. Also, Nokia UltraSite Support offers additional space for customer equipment.

Nokia UltraSite GSM cabinet fits in to the corresponding Talk-family cabinet's footprint both indoors and outdoors. The Nokia UltraSite GSM cabinets can be placed side by side. All installation work can be done without any need for back access to the Nokia UltraSite GSM cabinet. The cabinet mechanics are designed so that the cabinets can be installed against the wall.

In the case of indoor installation, no special plinth is required. The indoor cabinet can simply be bolted directly to a treated or covered concrete base. The outdoor installation is likewise easy; the fixing points are the same as in Nokia Talk-family BTSs.

The power feeding may have to be enhanced if the existing cabinets are replaced with fully equipped Nokia UltraSite GSM BTSs because of the high number of Nokia UltraSite transceivers and increased power consumption.

Battery backup can be either integrated to Nokia UltraSite GSM BTS or it can be provided by Nokia UltraSite Support. The already existing battery backup can be used as well if there is such. In that case, it has to be remembered that the backup time will be shortened by the additional new equipment unless the battery capacity is increased.

Nokia UltraSite GSM BTS has external alarm inputs that can be used for site and support alarms. These alarms can be sent to the NMS and reported as any other alarms.

The cabinet internal cabling is delivered with the plug-in units. As the cabling is not attached to the cabinet itself, no money is wasted in excess cabling in small configurations.

All the external cabling is routed through the cabinet roof. Also, the antenna and the feeder cables can be routed to whichever direction from the cabinet roof. Jumper cables can be routed through the tops of the cabinets in large configurations where several cabinets are located side by side in a row.

During the initial installations, future expansions should be reckoned with. Usually small configurations are the starting point. The combining method and the reservations for additional TRXs in the cabinet can be taken into account if the expansion path can be predicted. The lower part of the indoor cabinet can be used for WCDMA expansion.

4.2.3 Site commissioning and integration

The Nokia SiteWizard and autoconfiguration can be used to automate the commissioning and integration of the site. The work can be done by one team and during one site visit without online assistance from the NMS site.

First, the Nokia SiteWizard PC is connected to the GSM BTS and Nokia Site Wizard is started. Nokia UltraSite then automatically detects the installed active hardware and their configuration. The number of parameters to be added manually is minimized. The passive units (like cables) need to be defined in a configuration file during the commissioning. No separate HW database or HW info file are needed with Nokia UltraSite.

The commissioning wizard is started and the Site Configuration File is opened. The site is selected by the address after which the wizard reads the required parameters. Some of the parameters are given manually.

The BTS is now in pre-commissioned state. It can be left in this state at the site. Once the Abis links are activated, the autoconfiguration takes place, i.e. the connection between the BTS and the BSC is created. After that, the management channel and the BTS are tested automatically and the radio network parameters are downloaded. The BTS is integrated to the BSC.

A circuit manager is used for optimizing the transmission connections created by autoconfiguration.The information about the transmission connections is automatically uploaded to the NMS.

4.3 System operation and maintenance

This section deals with the NMS/10 and node managers. Local and remote management are discussed.

4.3.1 Network management

All the Nokia UltraSite equipment can be managed from one point with the NMS/2000. It offers integrated management for Nokia UltraSite Solution as well as the whole GSM network including both cellular and transmission sections. The NMS/2000 uses the NMS/10 as the node manager server for transmission nodes.

Power System Management (PSM) enables management of Nokia UltraSite Support. The PSM is connected to the Q1 bus of the Nokia UltraSite BTS and can be managed with Nokia NMS like any network element. With PSM the alarms in the power system as well as the condition of the batteries can be monitored remotely. The PSM is available in BSS10.

If non-Nokia transmission equipment is supervised via the External Alarm and Control (EAC) lines, alarms can be sent to the NMS/2000 (via BSC). In this case, supervision is performed by Nokia UltraSite GSM BTS and alarms are reported as normal external alarms.

4.3.1.1 Local management

Nokia UltraSite GSM BTS can be managed locally using the Nokia UltraSite BTS Manager. Nokia UltraSite has just one V.28 (RS-232) local management port (LMP) for the BTS and integrated transmission.

The Power System Management has a dedicated local management port in Nokia UltraSite Support.

The Nokia UltraSite equipment can be managed by the NMS/2000 and Nokia UltraSite BTS Manager - Nokia UltraSite BTS Manager acts as a master when it is activated. Management operations performed by Nokia UltraSite BTS Manager are documented to the NMS.

In BSS10, it is also possible to connect Nokia UltraSite BTS Manager remotely to Nokia UltraSite GSM BTS and manage it as if Nokia UltraSite BTS Manager were connected locally to the equipment. Nokia UltraSite BTS Manager can also be connected to the Nokia NMS or BSC and the management connection to Nokia UltraSite is created through the Abis.

Nokia UltraSite GSM BTS provides a dedicated Q1 port for Nokia UltraSite Support and additional Q1 ports for other Nokia Q1 managed elements on the same site.

4.3.2 Maintenance

Generally, there is no need for periodic maintenance in Nokia UltraSite. This has been one of the objectives when designing Nokia UltraSite Solution.

The backup batteries have a limited life time. This life time depends on the batteries used, their usage and the environmental temperature, so general guidelines cannot be given of the battery replacement frequency. Batteries specified for Nokia UltraSite have a 10-year life time when they are used in their nominal temperatures.

Regular extraction of dirt may be needed in extreme conditions with high contamination of the air.

Nokia UltraSite SW can be updated easily. SW background downloading can be initiated either locally with Nokia UltraSite BTS Manager or remotely from the BSC and the NMS. The new software can be activated at any time.

5 Nokia Services - the full service house for evolving networks

Nokia is there for its customers throughout the lifecycle of their networks. Nokia can help to plan, deploy, manage, and develop mobile and data networks all the way to third generation network systems with a full house of service solutions. This comprises everything from consulting to turnkey deliveries, network operations and management, system integration as well as upgrading live networks with the latest technology. Nokia can offer all this in customised and localised packages, which fit exactly to the operators' requirements.

Planning networks and services to meet long-term business goals

With Nokia's planning expertise and advanced planning and information management tools, a network can be designed to meet demands now and in the future as new services are launched. Good planning is vital to bring new telecom or data services online quickly and give operators a competitive advantage. Once the plan is ready, Nokia can help design and implement end-user services, the real revenue driver in the telecom market.

Deploying and integrating systems for early entry into the market

Nokia has a proven record in network installation, commissioning and integration. This expertise covers live network upgrades and the implementation of complete end-to-end solutions with a single supplier interface. Nokia offers flexible Roll-out Services Packages to accommodate the varying deployment needs of different types of operators.

Operating and continuously developing network and service management systems

Nokia helps operators raise their service quality, network availability and operational efficiency, thus achieving peak performance. This way, operators can concentrate on serving their customers, knowing that Nokia will support their network evolution every step of the way.

For the sake of brevity, this document gives only selected highlights of those Nokia Services that are of particular interest in Nokia UltraSite Solution. Specifically, this document introduces:

- Capacity Evolution Path & Strategy Service. Rapid evolution towards mobile multimedia, enabled by Nokia UltraSite Solution, requires a clear strategy for the Network Evolution. This Service helps in evaluating the spectral efficiency of your network and recommends a cost-effective capacity growth path based on the selected business strategy.
- Nokia Roll-Out packages for optimised deployment of the voice and multimedia service coverage. These Service Packages enable the planning and implementation of the network in a manner which optimally suits your regulatory and business environment.
- BSS Removal Service Family. Upgrading the existing network may reveal a demand for a safe and easy-to-handle process for replacing, relocating and recycling obsolete equipment (such as non-Nokia BSS, for example).
- Nokia Online Services, which complements the traditional services by providing fast and flexible access to the full service house via the Internet.

Obviously, this is only a fraction of available Nokia Services; for an up-to-date account of full Service portfolio, please refer to Nokia Services in the Internet [http://www.nokia.com/networks/services/index.html]. The selected highlights are discussed in more detail in the following sections.

5.1 Planning the network evolution path for multimedia

Nokia can help plan a solution that provides room to grow as the network evolves towards mobile multimedia. Nokia provides advanced planning services for defining the right development strategy for the network and planning the right solutions for capacity development for voice, data and multimedia. Together with the advanced Nokia Totem Suite network planning system, Nokia's experience and persistent commitment in telecom and IP networks assist operators in:

- finding a solution for long-term business needs
- optimising the use of operator's resources and planning work
- obtaining a faster network implementation
- ensuring a quality network enabling distinctive end-user services.

5.1.1 Capacity evolution path and strategy

The purpose of Capacity Evolution Path & Strategy (CEPS) Service is to evaluate the efficiency of the utilisation of spectrum and recommend a cost-effective capacity growth path that is in line with the Operator's business strategy. The evaluation will take into consideration the environment, the effectiveness of network planning and the existing capacity enhancements. Growth path alternatives will be created to support the Operator's business strategy in time frames of two to five years.

The target of CEPS Service is to provide the following benefits:

- A powerful decision-making aid. Operator receives the possible growth paths that comes complete with:
  - simulations of the existing and the forthcoming Nokia implementation of capacity enhancements
  - the advantages and disadvantages of each solution
  - ranking
- Business budgeting inputs. Customer receives estimates of investment and operational cost of each alternative over the target time frame, which in turn would assist the budgeting.
- Managed and timed growth to maximise returns. Infrastructure investments can be timed appropriately to avoid capacity bottlenecks and to maximise the net present value.

The contents of CEPS Service are explained in more detail in the following sections.

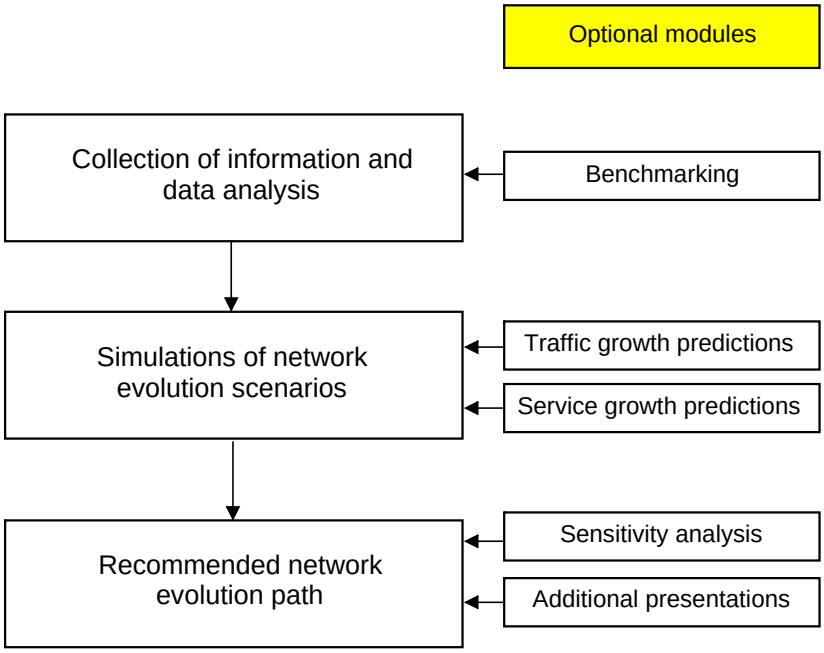


Figure 19. Contents of the Capacity Evolution Path and Strategy Service

5.1.1.1 Collection of information and analysis

The necessary information on business scope and strategies, existing network infrastructure and performance, capacity bottlenecks and predictions is collected. The information can either be provided by the Operator, acquired interactively or produced by Nokia. The collected information is analysed in detail together with the impact of new services, tariffs, competition etc. to the network infrastructure.

As a result of the analysis, the guidelines (system preferences) for the network development are defined. The input data, results and the reasoning are documented.

5.1.1.2 Simulation of network evolution scenarios

The evolution of the system solution is planned through simulation of scenarios. The simulations are based on the use of network dimensioning and planning tools. It is important that there are clear investment phases and an ensured growth path. The phases are defined so that the network building will be done in optimum steps with minimum investments in advance, but without jeopardising growth.

5.1.1.3 Recommended network evolution and plan

An optimal network evolution is recommended and the plans for it worked out in this module. The "final" solution using the coverage, capacity and quality targets given for the end of the planning period is planned first. This plan is then divided into reasonable phases ensuring a smooth growth path and an optimised investment programme.

Outputs of this module contain the optimum roll-out, investment and operational cost estimates and business measures.

5.1.1.4 Optional modules

- Benchmarking. Nokia compares the Operator's frequency spectrum usage to the selected competitors in the market. With this option the customer can determine his growth potential as well as that of his competitors'.
- Traffic Growth Prediction. Nokia makes the traffic growth predictions for the Operator based on its knowledge and experience it has gained globally. Nokia's estimates can also help the Operator in verifying its own predictions.
- Service Growth Prediction. Nokia makes the predictions on the volume of new services and the impact on network infrastructure. These predictions can help in estimating the potential volumes for the existing and the oncoming services.
- Sensitivity Analysis. In the basic service, the low, average and high scenarios are simulated. Sensitivity analysis is an optional module that provides the sensitivity of selected inputs for the selected outputs. In this module uncertainty (distribution) is introduced to selected inputs and outputs are given as distributions.

  With this module, the Operator gets the results in the form of probabilities. For example, the pay back time of the investment can be three years according to the investment calculations but the Sensitivity Analysis option could show that with 90% probability the pay back time is less than four years.
- Additional Presentations. The basic modules include documentation of the alternatives and two presentations. Additional presentations are available. The content of the additional presentations can be general or they can concentrate on specific topics related to capacity.

5.2 Nokia roll-out services packages for optimised deployment

For planning and deploying a telecom network, Nokia offers four Roll-out Services Packages designed to take into account the varying needs of operators in today's regulatory environment and market place:

- the Telecom Deployment Package.
- the Roll-out Management Package
- the Time-to-Market Package
- the Turnkey Responsibility Package.

The following table characterises the contents of the packages:

Table 4. Contents of service packages

	Telecom deployment package	**Roll-out management package**	**Time-to-market package**	**Turnkey responsibility package**
Project management	(X)	X	X	X
NW pre-planning	-	-	-	X
NW planning	O	O	O	X
Site acquisition	-	O	X	X
Construction works	-	O	X	X
Telecom implementation	X	X	X	X

In the table above:

- X = included in the package
- (X) = for Telecom implementation only
- O = non-mandatory item
- - = excluded from the package.

5.2.1 Telecom deployment package

The Telecom Deployment Package is designed for operators who buy network roll-out services from several service suppliers.

Telecom Implementation includes all activities and project management related to the physical installation of the equipment at the installation site, commencing from the unpacking of the delivered equipment and ending at the commissioning of such equipment (i.e. when bringing such equipment into traffic).

* Network Planning can also be included in the Telecom Deployment Package on a consultancy basis.

5.2.2 Roll-out management package

The Roll-out Management Package is designed for operators who buy telecom implementation and roll-out project management from one service supplier.

By letting Nokia take the responsibility for managing the project, network implementation becomes more efficient, the roll-out smoother and the operator's investment safer. Proven management and working methods as well as clear lines of reporting at different levels help operators achieve their goals on schedule with agreed costs and quality criteria.

The scope of Project Management may vary from traditional telecom implementation to cover network pre-planning and planning, site acquisition and construction works. Nokia project teams are equipped with experience from managing multinational teams and global logistics.

* Network Planning can also be included in the Roll-out Management Package on a consultancy basis.

5.2.3 Time-to-market package

The Time-to-Market Package is designed for operators for whom a quick entry to the market place is the first priority. They are willing to trust one partner for all the network roll-out services but prefer to have network pre-planning and planning done by themselves. This pre-defined network plan is then the basis for the project implementation plan.

Site Acquisition Service comprises site proposals based on site hunting, site assessment, technical site survey and reporting, models for purchasing/lease agreements and technical documents for acquiring permissions from the authorities. The extent of the work is agreed upon between Nokia and the operator. The service is flexible, from simply assisting with the legal and financial planning aspects of obtaining a site to a turnkey delivery.

Construction Works Services include all activities related to the construction and erection of the Site infrastructure. These do not include Nokia telecommunications equipment supplies and work other than that included in Telecom Implementation services.

* Network Planning can be included in the Time-to-Market Package on a consultancy basis.

5.2.4 Turnkey responsibility package

The Turnkey Responsibility Package is the most extensive of Nokia's Roll-out Services Packages. It is designed for operators who are willing to purchase defined network performance starting from a defined date on a defined geographical area without being involved in building the network.

The Turnkey Responsibility Package corresponds to what is contemporarily referred to as "a turnkey telecom network with a performance statement".

One interface is safer, less complicated and more efficient for the operator: there are less co-ordination problems, fewer misunderstandings and fewer meetings. One interface reduces the time span of the roll-out - hence revenue generation begins sooner.

Network Pre-Planning and Planning are included in the scope of the Turnkey Responsibility Package. Radio Network Planning provides a good structure for a network based on coverage, capacity and quality requirements. Transmission Network Planning aims to design an optimal transmission network taking into account the operator's economic and technical constraints and targets.

5.3 BSS removal services for site evolution

The fast developing telecommunications market results in generations of obsolete or out-dated products that need to be replaced, relocated and/or recycled from customer networks. Although Nokia UltraSite Solution architecture is designed to maximize the cositing with previous Nokia equipment, such a need may arise from site space considerations, or obsolete non-Nokia BSS, for example.

The continuous need to increase network capacity requires new / more capacity bearing products in densely populated areas. New equipment may replace the dismantled old ones on the same sites. This also gives opportunities to reinstall older equipment in non-urban areas that still lack coverage.

Obsolete equipment, due to out-dated product or changes in the operator's network creates the necessity to implement a safe and easy-to-handle process for replacing, relocating and recycling such equipment.

The BSS Removal Service Family consists of three services, which include different options of removing telecommunication equipment. Different combinations of these services can be provided and should be agreed upon on a case by case basis.

- Replacement Service - the equipment is removed and a newer generation product is installed at the same site.
- Relocation Service - the equipment is removed, refurbished and re-installed to another location in the network. For example, older equipment may be relocated to non-urban areas with less capacity requirements.
- Recycling Service - An environmentally sustainable way to finalise the Replacement Service. In this service the equipment is dismantled and recycled by Nokia.

Nokia has global experience in replacement projects having performed replacements, for example, in Austria, Belgium, France, Italy, Norway, Spain, Sweden, UK, China, Indonesia, Taiwan and Thailand. Over 5600 BTSs and 25000 TRXs have been replaced in total. Nokia's proven experience in replacing other suppliers' BSS equipment shows that Nokia can execute a replacement on a live network with minimal risk to the existing network quality.

The replacement of infrastructure is a major undertaking, especially on a live network. The cost and effort involved must be justified by the improvements in performance, cost of ownership and up-to-date technology evolution.

As customer satisfaction is essential for any operator, this should be considered when the replacement is executed. Thus the two most important criteria for a replacement project are:

1. Minimal network downtime during the replacement
2. Achieving targeted network quality after the replacement.

The BSS replacement process can be divided to three principal phases:

1. Preparation of the replacement, site visits, implementation of the TCSMs , BSCs and the NMS
2. Replacement of the BTSs (installation and changeover)
3. Acceptance of the replacement.

Phase 1, the preparation of the replacement, involves the participation of the project teams from both the operator and Nokia. The objective of this phase is:

- Test drive of the target network. Agreement of acceptance criteria
- If necessary, training of the operator's technical teams
- Site survey to all sites

- Creation of Radio Frequency, BCF and transmission plans
- Definition of each site's replacement folder (parameters, inputs, process)
- Adaptation and testing of the procedures used in the actual project
- Definition of the target network
- Definition of the site typologies, the work to be done and the replacement method.

The installations of transcoder (TCSM) equipment and BSCs as well as the preparation of the designated NMS should be carried out during this phase, so that efforts can be concentrated on the changeover of the BTSs. The objective is to limit the duration of the interruption as much as possible.

Phase 2 consists of installing the new Nokia BTSs on the sites and integrating them into the network, replacing the original BTSs. The accepted principle is replacement by BSC cluster. The success of this phase depends on the accuracy of its organisation, both for the changeover work as well as for the interruption options accepted in advance.

Phase 3 is a review of each site and cluster changeover.

The site acceptance is granted on the basis of integration tests including test calls and by observing the performance indicators in the NMS . Concerning the cluster acceptance, the fulfilment of predefined performance criteria agreed on during the preparation phase is tested during the agreed observation period.

The BSS Replacement Service can be completed by additional services agreed in the contract such as Network Operating Service or Network Optimisation. Using the BSS Relocation Service, the removed Nokia equipment can be installed to another part of the operator's network An alternative way to handle the removed equipment is to use the Recycling Service for secure end-of-life treatment.

5.4 Nokia online services for fast and flexible access to Nokia resources

Nokia Online Services complement Nokia's service offering to network customers via the Internet. These services are available 24 hours a day, 7 days a week. Nokia now makes it possible to have online access to Nokia databases, work independently, and proactively seek solutions to different queries.

Nokia Online Services are connected to Nokia's global backbone data systems thus allowing customers to utilise the best expertise anytime world-wide. In addition to the standard PC connection with a Web browser, the services can remotely be reached via wireless terminals, such as Nokia Communicator, when working in the field.

Nokia Online Services offer valuable resources to different professionals in the customer's organisation. For example, technical engineers will find services for preventive maintenance and troubleshooting, network planners and performance optimisation personnel for network benchmarking, quality analysis and so on. Training applications and product documentation section will help technical personnel to effectively operate with Nokia equipment in all circumstances.

In addition to technical resources, the cooperation between the customer and Nokia is supported by a team room application, which helps to share relevant information e.g. about project schedules and progress or Nokia's overall performance.

The current content of Nokia Online Services consists of the following modules

- Preventive Maintenance for preventing problems before they occur
- Trouble Management to help to resolve occasional problems
- Service Parts, to manage your spares
- Training, for competence development
- Customer Specific Team Room, for effective and continuous communication between the customer and Nokia
- Documentation, providing quick access to Nokia's system documentation.

Please note that the services to be provided online are agreed separately with each customer. Nokia continuously develops and adds new services to its online services portfolio. The latest information about NOLS is available via the local Nokia office.

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