Network Optimization

Chapter 11

This chapter is designed to provide the student with an overview of the Ericsson tools that are available and recommended for use in a network optimization process. It addresses the tools, their functions, features, and requirements.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- recognize the benefits of using EET and the capabilities of the software application
- explain the functionality of the TEMS software and telephone
- discuss the use of OSS for the purpose of viewing, changing cell parameters and defining cells
- explain how cellular network measurement in OSS is carried out
- identify the capabilities of Cellular Network Analyzer (CeNA)
- understand how network optimization can be carried out by means of parameter tuning
- discuss different methods of increasing the capacity of a mobile radio network, in particular the cell split

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11 Network Optimization

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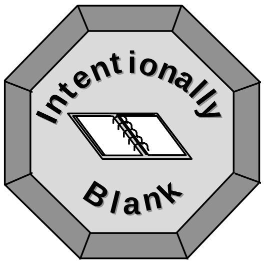
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INTRODUCTION

After an initial cell plan has been compiled and approved, it is time to begin the installation of the network equipment. As a time saving measure, we can begin to optimize the performance of the radio network as it is being built up. This chapter broadly covers some of the tools that Ericsson recommends for diagnosing a network. The major benefit of using these tools comes not only from their initial use but through continued use of them to monitor and improve network performance. At the end of this chapter, radio network tuning by means of parameter adjustment is discussed.

ERICSSON ENGINEERING TOOL (EET)

During the initial phases of the network design process a reliable radio wave propagation tool is necessary. This need continues to exist even for the most mature radio networks. One of the primary responsibilities of an RF engineer is to improve the radio network when required to do so. This could be the result of growth or decreased performance. Ericsson Engineering Tool (EET) is based on experience and continual development that is adapted to a rapidly changing technology (Figure 11-1).

EET is based on Planet by Mobile Systems International (MSI) Ltd. It is a UNIX open windows based software package designed to simplify the process of planning and optimizing a cellular network. Some of the more important features of EET are discussed in the following sections.

NETWORK DIMENSIONING

In the packet it is easy to create new sites or move old ones. All information about the sites is stored in the site data base. It is possible to make changes on one site, a group of sites or on all sites.

A height path profile can be displayed between any two points on the map. This is very useful for microwave link planning.

FREQUENCY PLANNING

EET allows the allocation of channels or frequency groups to a cell. It is possible to do this manually or automatically. The frequency assignments are stored in the carrier data base. The frequencies can be displayed by labeling the cell with the ARFCN, the group name or by color coding the coverage areas according to the frequency groups.

PREDICTING

When the sites are created it is time to initiate a prediction. It is possible to predict one site, a group of sites or all sites. The result of the prediction is the path loss from the sites.

After predicting, arrays for coverage and interferences (C/I and C/A) can be created. The signal strength and interference levels are calculated for each pixel. The advantage of having both prediction and array steps in this procedure is that it speeds up the calculations. If the user would like to change for example the output power at one site, there is no need for a new prediction because the change does not affect the path loss. He only has to create a new array. Creating arrays is just a matter of adding dB, so it is not very time consuming. On the other hand, predictions are more complicated.

The basic propagation model in EET is Ericsson's algorithm 9999. Out of the topographical data base, the profile between the transmitter and receiver is extracted. The path loss is calculated based on terrain variations in height along the profile, including contributions due to knife edge diffraction, the earth's curvature, the land usage plus empirical corrections. The latter are a result of Ericsson's unique experience of wave propagation, and numerous measurements all over the world. In addition to the algorithm 9999, EET includes the Okumura-Hata model, the Cost 231 and the Walfish-Ikegami models.

TOOLS

Using EET, the user can spread traffic on the map to plan for capacity. The traffic can be displayed with different colors for different amounts of Erlangs/km^2 or the user can highlight the cells that do not meet the specified GoS.

It is possible to import data from a test mobile and display the information on the map.

EET can import radio survey files which can be used to tune the prediction model for the area where the network is to be planned.

Data can be imported and exported to OSS.

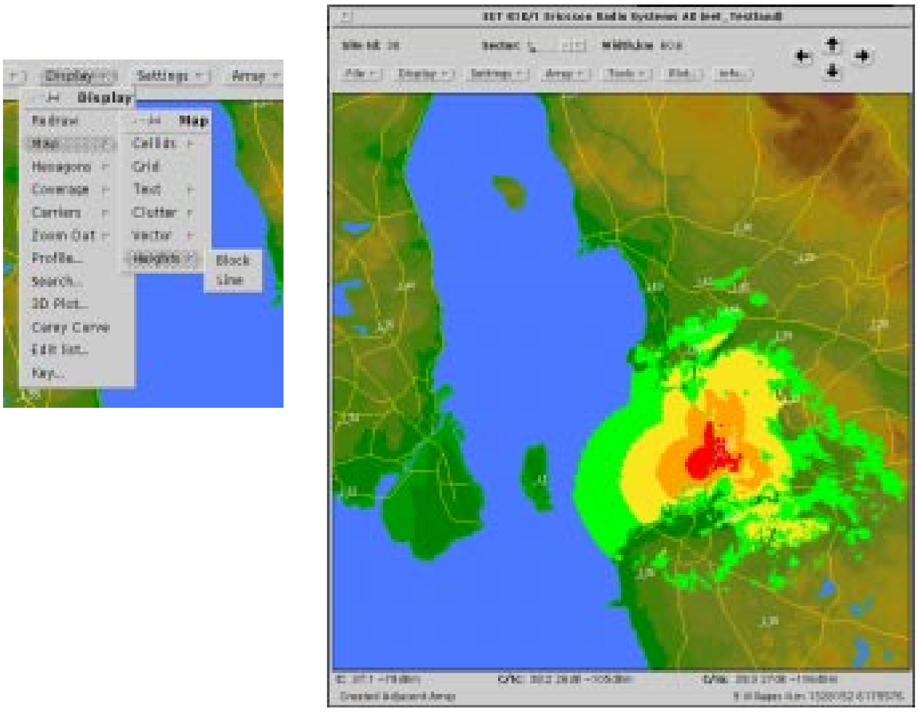


Figure 11-1. Graphical user interface, the EET main window

TEST MOBILE SYSTEM (TEMS)

The TEMS, TEst Mobile System, is a test tool used to read and control the information sent over the air interface between the base station and the mobile station in a GSM system. It can also be used for radio coverage measurements. TEMS can be used both for field measurements and post processing.

It consists of a mobile station with special software, a portable PC and optionally a GPS receiver (Figure 11-2).

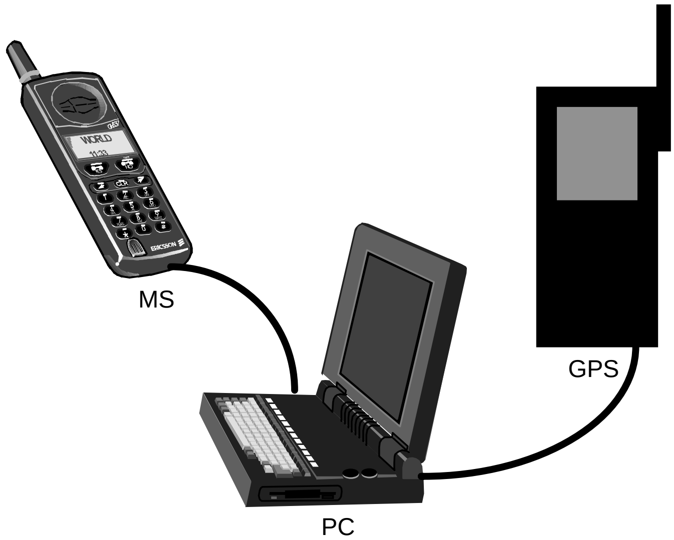


Figure 11-2. TEMS Hardware

The mobile can be used both in active state and idle mode, and in any GSM network, depending on the SIM card. Both layer two and layer three messages can be monitored and recorded. The MS can simulate GSM 900 power class 2 to 4. It is possible to lock on a single frequency. The MS can test each time slot on a selected frequency to verify that all TCHs are available and functioning.

The PC is used for presentation, control and storage of the measurements. For the serving cell it is possible to display for example RxLev, Rxqual, TX power, TA, BSIC, ARFCN. For the six strongest neighboring cells it is possible to display RxLev, BSIC, and ARFCN. The information can be displayed in real time or recorded and replayed.

The GPS receiver gives the position of the measurements. When the satellite signals are shadowed by obstacles, the GPS system switches to dead reckoning. The dead reckoning consists of a speed sensor and a gyro. This provides the position if the satellite signals are lost temporarily.

The TEMS measurements can be imported to EET with the use of File and Information Converting System (FICS). This means that the measurements can be displayed on the map so that, for example, the measured handovers can be compared with the predicted cell boundaries. FICS can also convert to EXCEL and word processing packages.

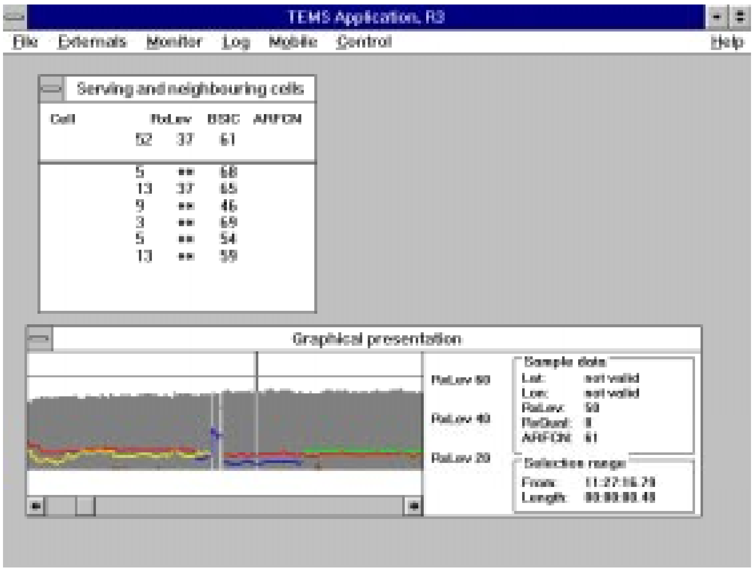


Figure 11-3. TEMS graphical user interface

OPERATIONS SUPPORT SYSTEM (OSS)

INTRODUCTION

The GSM Operations Support System (OSS) is a UNIX based tool that enables the supervision, planning, and engineering of a network from one central location. The capabilities of the OSS that concern RF Engineers are discussed in this chapter (Figure 11-4).

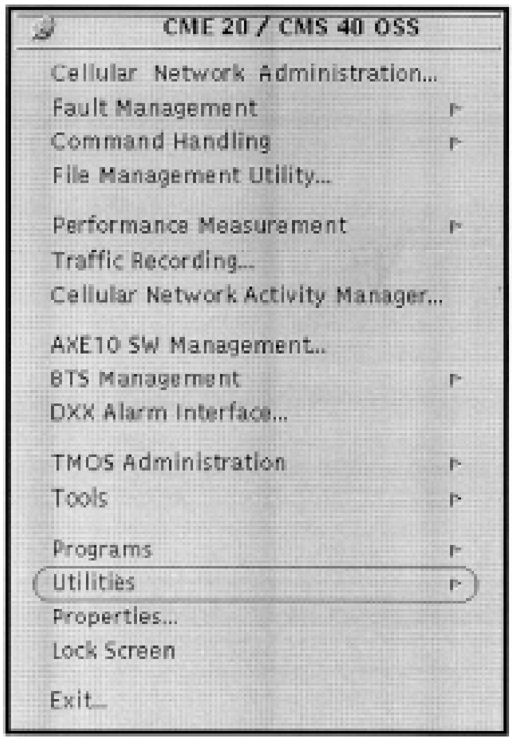


Figure 11-4. OSS Main menu

CELLULAR NETWORK ADMINISTRATION (CNA)

One of the most important aspects of managing a cellular radio network is that of managing the individual cells. The cells represent the infrastructure from which the mobile subscriber accesses the network. Hence, a poorly managed infrastructure will most likely be reflected by dissatisfied customers and a subsequent loss of revenue.

The purpose of the Cellular Network Administration (CNA) feature is to provide a user friendly interface from which a user can manage the cells in an efficient and controlled manner.

Normally, there is a multitude of radio related parameters that need to be set in several different network elements in a consistent manner in order to achieve a well balanced, properly functioning radio network. Default parameters are used when the operator does not enter a parameter value. Parameters can be copied from one cell and pasted into another. It is also possible to create profile areas collecting all cell parameters commonly used for different types of cells. Cell parameters are validated at the time of the entry. This particular feature helps to reduce the possibility of incorrect cell parameters and increases the efficiency of personnel as the number of cells in the network increases (Figure 11-5).

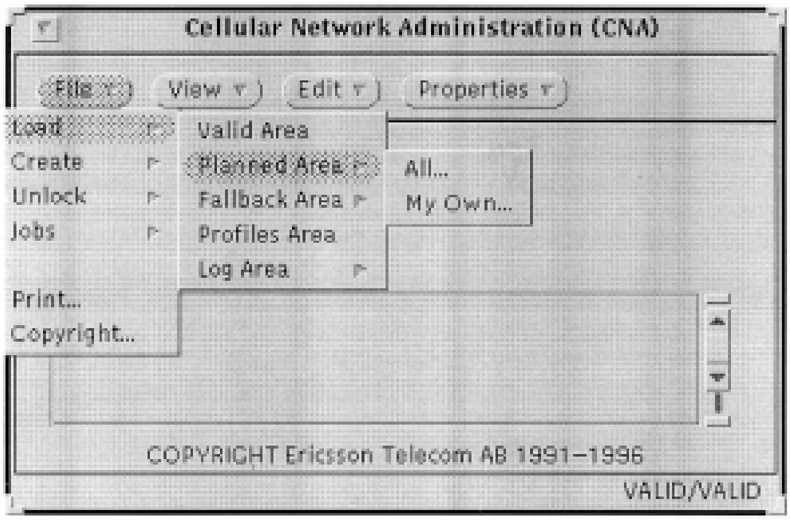


Figure 11-5. Part of OSS CNA menu

CELLULAR NETWORK ADMINISTRATION INTERFACE (CNAI)

The Cellular Network Administration Interface (CNAI) is an external interface to Cellular Network Administration. The CNAI allows for an external cell planning tool (e.g. EET) to exchange information with the CNA database. The data is exchanged between the two via ASCII coded text files. The essence of this interface is to provide simplified data import and export capabilities to CNA for ease of user handling of the data transfer mechanism.

Cell planning data can be used as an example. The OSS interacts with the Ericsson Engineering Tool (EET). Such external systems can retrieve data from the actual radio network, re-engineer the new cell data and transfer back the new cell data in a simple manner. This avoids time consuming manual entry (Figure 11-6).

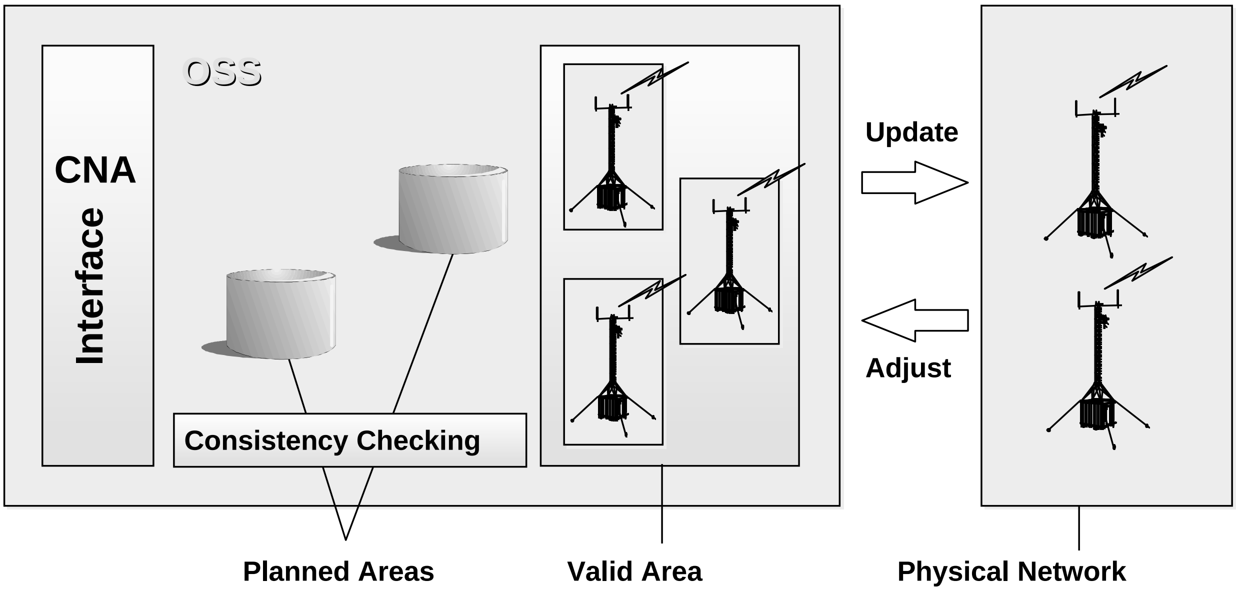


Figure 11-6. CNA Interface (CNAI)

CELLULAR NETWORK MEASUREMENT AND RECORDINGS

Cellular network measurements are a way for the telecom company to supervise the quality of the services provided by the network. The measurements are used for early detection of faults and for planning future extensions. For the measurements to be of any use however, they must be presented in a way that clearly shows the conditions or trends that are of interest.

Long-term Measurements

These performance measurements presents statistics collected in Operation & Maintenance Subsystem (OMS) and Statistics and Traffic measurement Subsystem (STS). They provide a picture of how the network is working. This requires a certain amount of subscribers generating traffic in the network.

- Data from OMS measures traffic on routes, traffic types and traffic dispersion on different routes. All recordings relate to one piece of AXE equipment.
- Data from STS collects data regarding statistics within the radio environment.

Statistical Report Packages (SRP)

The Statistical Reports Package (SRP) is a new set of reports which focus on collecting and presenting data used for managing, planning, and engineering a cellular network. The reports are divided into three categories:

- Management reports
- Planning and Engineering reports
- Operation reports

This provides different target groups reports specially designed for specific needs.

The SRP reports are primarily based on the statistical information from the AXE subsystems Statistics and Traffic Measurement Subsystem (STS) and Operations and Maintenance Subsystem (OMS), i.e. from the performance measurements described earlier and is part of the performance measurement functions in OSS. This data is complemented with configuration data retrieved from the CNA database and printouts obtained from interrogation of the network elements.

Management Report

The Management Report and its subreports are customized to provide comprehensive information about the cellular network in both tabular (alphanumeric) and graphical form. This enables management to increase the control of the network size and behavior. The following subreports are included in the tabular part of the Management Report:

- Subscriber Data
- Call Processing
- Infrastructure Data
- System Performance
- Cell Performance

The following reports are included in the graphical trends part of the Management Report:

- HLR Subscribers Distribution Trend
- Network Subscriber Distribution Trend
- Traffic per Subscriber Trend
- System Calling Minutes and Traffic Trend
- Switch Peak Hour and Peak Processor Load Trend
- Restart Statistics Trend
- Availability Trend
- Radio Network Performance Trend

Planning and Engineering Reports

The Planning Reports are specially designed to identify those areas in the radio network and the switching system where future network expansions are needed. The reports assist in focusing network improvements on critical problem areas and supports the operator in prioritizing the planned network expansions. These are a set of reports intended to be used by planning and engineering personnel and consist of the reports listed below.

- Planning Report Summary

  The Planning Report Summary provides an overview of the network size and performance in both tabular and graphical form. Information presented in tabular form is:

  Call processing per node:

  - System performance (switched network, radio network, and traffic channel availability)
  - Cell performance (total dropouts, top and bottom 10 on traffic, top and bottom 10 on congestion and utilization)
  - Handover performance

  The graphical trend reports in the Planning Report Summary are:

  - Switch Peak Hour and Peak Processor Load
  - System Calling Minutes Trend
  - Restart Statistics Trend
  - Availability Trend
  - Radio Network Performance Trend
  - Sdcch Performance Trend
- Radio System Performance
- Cell Traffic reports
- Neighboring Cell Analysis Performance report
- Route Traffic report
- Traffic Dispersion report
- Traffic Profile
- Subscriber Activity Profile

Operation Reports

Operation Reports include reports for both the radio network and the switching network. The reports are used to quickly detect cells and routes with unacceptable performance enabling the operator to take immediate action to preserve the quality of the network. In particular, the exception reports combined with SRPs scheduling function provide an invaluable tool for identifying and analyzing vital performance situations. The reports listed below are generated only if the thresholds set by the operator are passed.

- Radio Exception report
- Detailed Radio Statistics report
- Handover Matrix report
- Route Exception report
- Call Rejection Exception report

Short-term Measurements

The traffic recording part of Radio Network Recording (RNR) serves as a compliment to regular statistics collection as well as to so called test mobile systems (e.g. TEMS). RNR monitors the behavior of the mobile from the network side and from the mobile telephone side as well as the result of the chosen channel allocation strategy. This is enabled by three recording facilities in the BSC:

- Mobile Traffic Recording (MTR)
- Cell Traffic Recording (CTR)
- Channel Event Recording (CER)

Mobile Traffic Recording (MTR)

The mobile related recordings trace practically everything happening to a mobile, specified by International Mobile Subscriber Identity (IMSI) number by recording events and measurements. Example of events are layer 3 messages, assignment, handover and disconnection and measurements include e.g. signal strength on uplink and downlink, signal quality on uplink and downlink signal strengths for neighboring cells and timing advance. The recorded material is sent from the BSC to OSS where the mobile related recording data can be analyzed and presented in tables or graphs (Figure 11-7). The results can be used for tuning cell parameters for better system performance, forecast, cell planning, and verifying poor mobile stations.

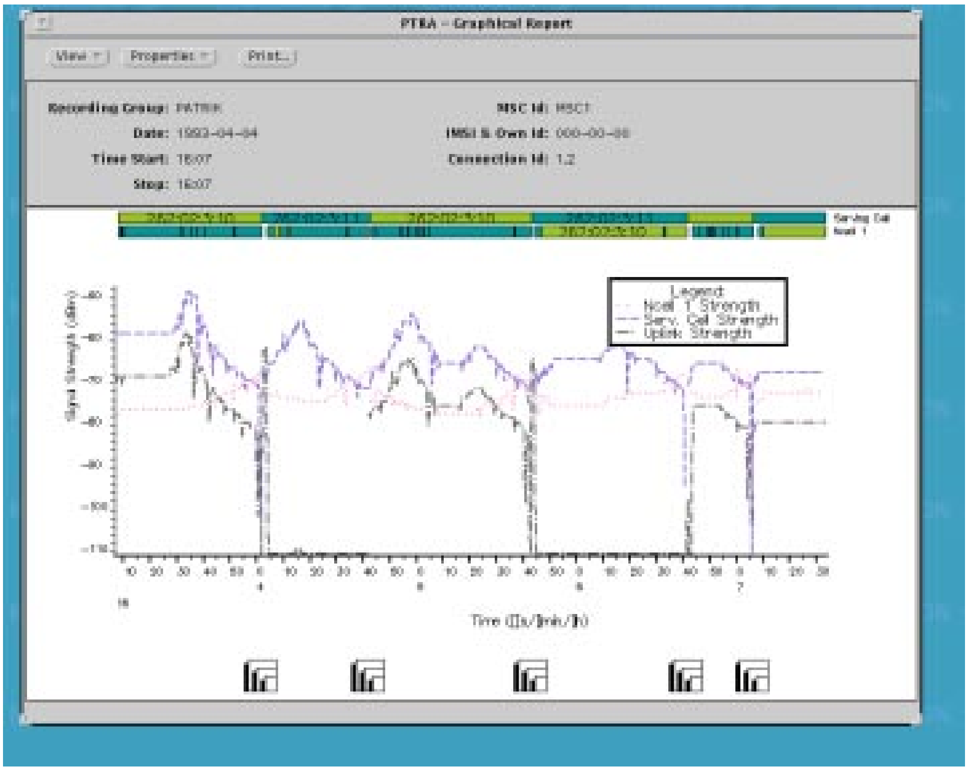


Figure 11-7. MTR

Cell Traffic Recording (CTR)

The cell related recordings record the same type of information as MTR but for a number of connections originating in a specific cell.

Channel Event Recording (CER)

The channel event recording is a new BSC feature that can be initiated from OSS. It assists in monitoring the BSC functions Channel administration, Differential channel allocation and Idle channel measurements and shows the behavior of TCH and SDCCH channels with respect to channel allocations and idle time.

CELLULAR NETWORK ANALYZER (CeNA)

The Cellular Network Analyzer (CeNA) is a cellular quality information system that enables optimization of a digital network's performance. The system is comprised of several features that assist the network operator in achieving maximum performance from his equipment (Figure 11-8).

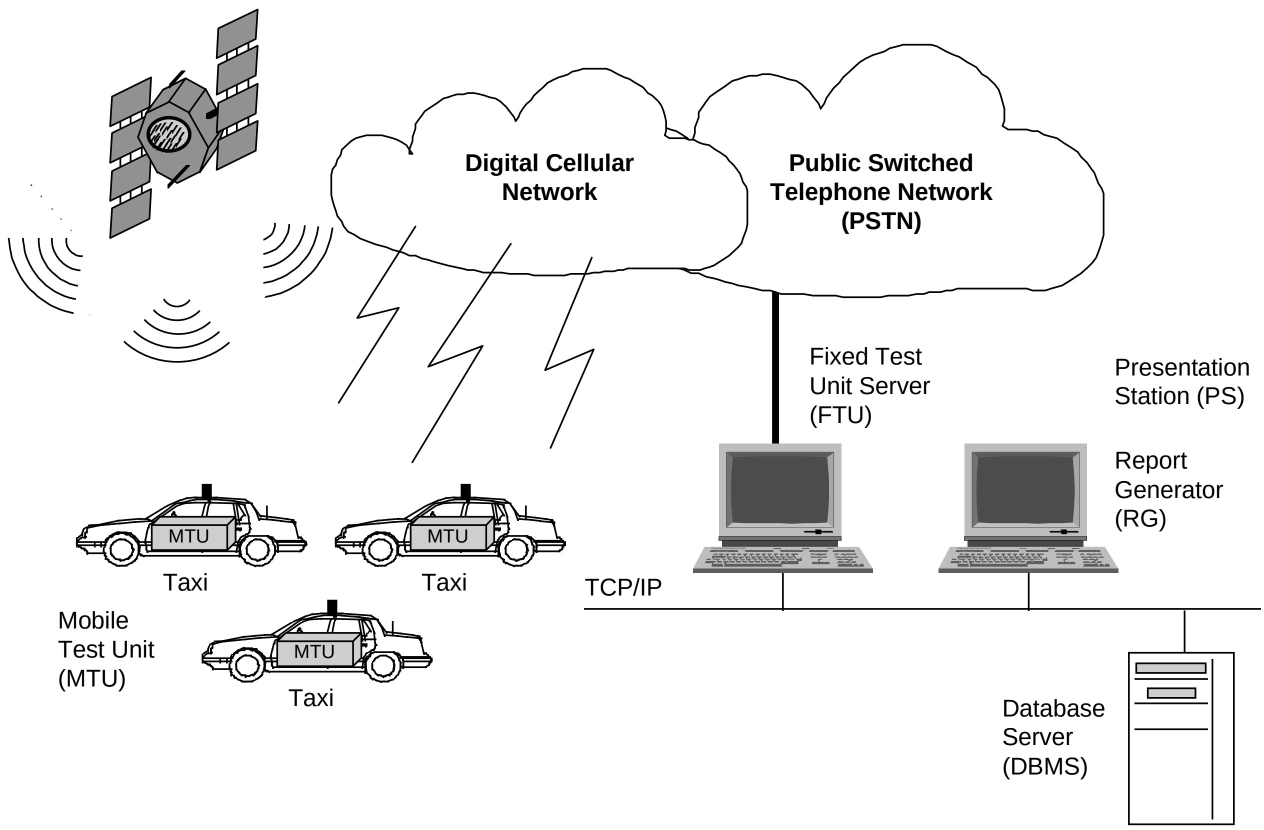


Figure 11-8. Cellular Network Analyzer (CeNA)

The CeNA system is able to carry out a number of measurements. The basic measurements used include:

- Received signal level (Figure 11-9 and Figure 11-10)
- Signal Quality
- Timing advance
- Transmission power
- Call events (drop, block, connection and handover)
- Protocol signaling (layers 1 and 3)

Using CeNA it is easy to generate reports, present measured results from a conversation (Figure 11-9) or present statistics (Figure 11-10).

All measurement activities, result collection, result storing and result transition are based on unattended operation. Mobile units (MTUs) are mounted in vehicles and assigned with subscriber numbers in the cellular network (Figure 11-8). A subscriber number in the public network is assigned to a fixed unit (FTU). In accordance with a measurement order, MTUs regularly calls FTU, executes measurements and transfers the results to a data base for storage and transition (DBMS). All measurement-order setups, result presentations and report generations are executed from an operator terminal (PS, RG).

All measurement results are stored in an open data base system, allowing easy access to, and sharing of information throughout the organization via LAN or WAN. The open data base system architecture also enables the operator to access and use information in his own application and in conjunction with information from the same or other data base systems.

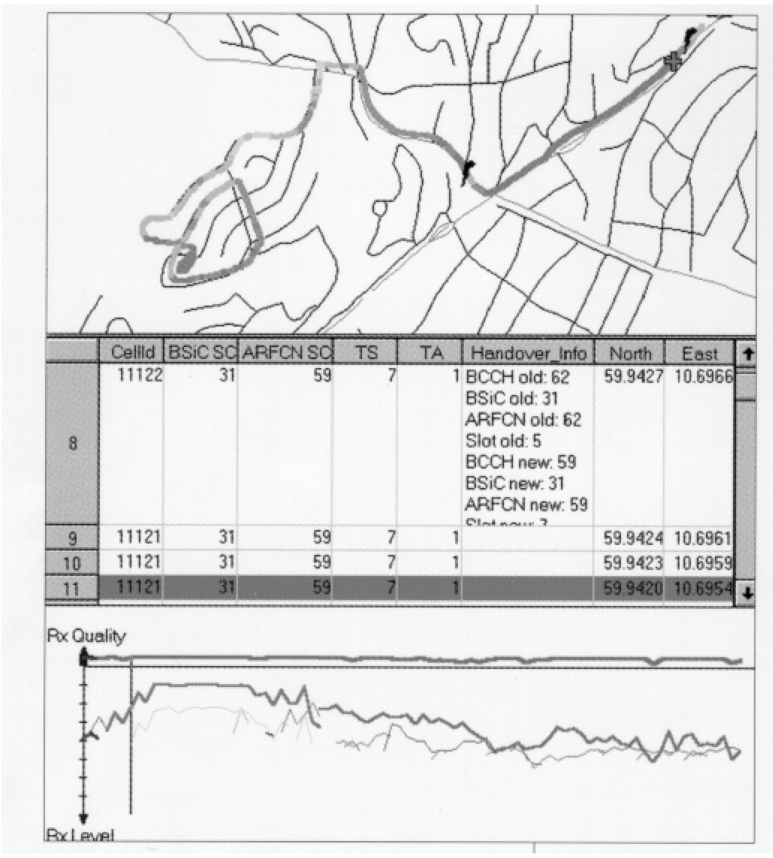


Figure 11-9. Conversation route presented by CeNA in map, table and graph form (symbol key not shown)

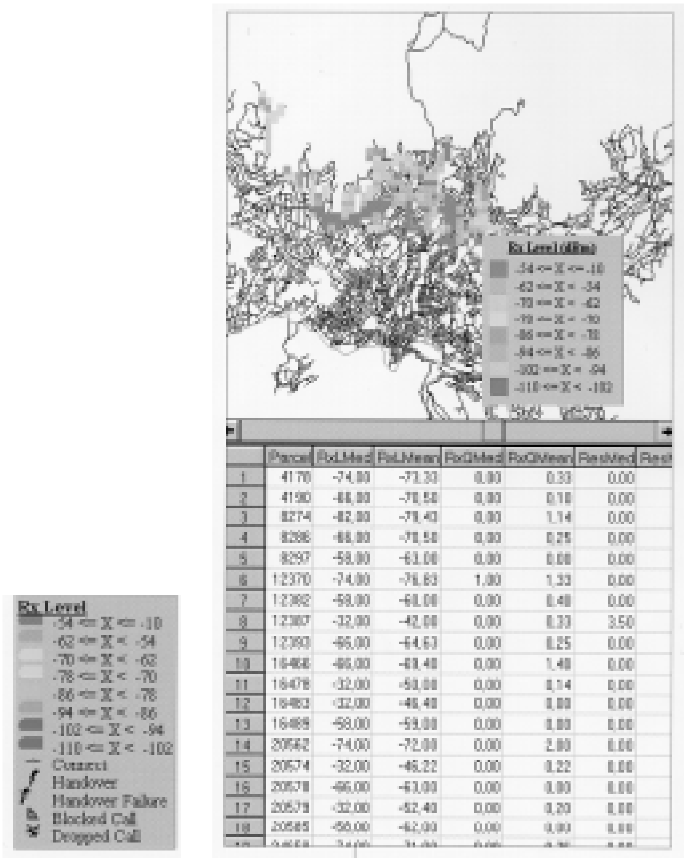


Figure 11-10. Statistics presentation by CeNA in map and table form

Some of the main benefits of CeNA are as follows:

- Increased revenue with less call failure
- Improved call quality
- Accurate network information
- Maximized geographical coverage with existing infrastructure
- Visual network performance
- Acquire network data and performance information without a manpower requirement
- Detect interference and improve frequency planning
- Improved traffic routing

CELL PARAMETER ADJUSTMENT

When all measurements have been analyzed, the user may determine that there is an inconsistency in the parameter setting. He can then tune hysteresis and offset parameters to improve the network quality.

OSS provides a graphical user interface for changing parameters. Using OSS also limits the possibility for human errors by performing validation and consistency checks on the parameter settings. This means that the user can run checks on the parameter settings before updating the network. OSS also provides a storage and fallback area that can be loaded if errors occur during network update.

After the changes are made, the user can continue monitoring the network performance in his STS based reports in order to follow up on the changes in network performance.

CELL PARAMETERS

When a new system is built or when new cells are added or changed in an existing system, the cell planner provides the operator with a document for each cell containing data for insertion of the cell in the radio network. This document is called Cell Design Data (CDD). The data from all such documents is then converted into Data transcript Tape (DT) and loaded into the corresponding BSC. A data transcript tape contains not only CDD information but also other data needed for the complete configuration of the BSC. More details are given in the chapter “Radio Network Parameters and Cell Design Data”.

The reason for having so many parameters is so that the operator can adjust and tune the network to fit his specific requirements. All parameters are permitted to be set within a certain range and usually have a default value.

The default values provide a good basis to start with. Parameters can be changed later if for example measurements indicate that adjustments are necessary. Do not change several parameters at the same time because it is more complicated to know which parameter setting change effected the system.

Some of the parameters are system specific and some are set per site, cell, or subcell.

Offset

An offset is used to make a cell appear better (or worse) than it really is by increasing/decreasing measured signal strength. The offset is a cell-to-cell relation, and is always unsymmetrical.

Hysteresis

A hysteresis is used to prevent the ping-pong effect, meaning several consecutive handovers between two cells. The ping-pong effect can be caused by fading, the MS zigzagging between the cells, or by non-linearities in the receiver. The hysteresis is a cell-to-cell relation, and it is always symmetrical.

Control of Radio Network Features

Other parameters are used to control radio network features like Discontinuous Transmission (DTX), frequency hopping and power control.

Timers and Filters

There are some timers and filters which can be set by parameters. Depending on the timer settings or length of filters, the system responds faster or slower to the change. A fast system is less stable than a slower system. A fast system is necessary if micro cells are used, because handovers are frequent in this case.

Identification

Parameters used to identify for example a cell or a location area in the network.

Penalties

The penalties are used to punish a cell in the locating algorithm. When a cell is punished, it appears worse then it really is. This is to avoid handback in case of an urgent handover, or to avoid several repeated handover attempts in case of signaling failure.

Thresholds

Thresholds for cell ranking, call release and access can be set.

SYSTEM GROWTH

INTRODUCTION

If the number of subscribers in a system continues to increase, at some point it becomes necessary to increase the capacity of the system. There are several ways to do this

- Increase the frequency band (eg. a GSM 900 operator might buy GSM 1800 licenses)
- implement half-rate
- frequency re-use tighter (eg. going from a 4/12 re-use pattern to a 3/9 re-use pattern by implementing frequency hopping)
- make the cells smaller and smaller

After a description of the regular procedure for adding new sites, the cell split, tightening of the re-use pattern by means of Multiple Re-use Patterns (MRP) is briefly discussed.

CELL SPLIT

It is clear that a smaller cell size increases the traffic capacity. However, a smaller cell size means more sites and a higher cost for the infrastructure. Obviously, it is preferable not to work with an unnecessarily small cell size.

What is needed is in fact a method that matches cell sizes to the capacity requirements. The system is started using a large cell size and when the system capacity needs to be expanded, the cell size is decreased in order to meet the new requirements.

This normally also calls for using different cell sizes in different areas. The method is called cell split. This is illustrated in Figure 11-11 to Figure 11-14.

Example:

Initially, the largest possible cell size is used, considering coverage range, see Figure 11-11. Next step is to introduce 3 cells per site, using the original sites and feeding the cells from the corners. This represents a cell split of 1 to 3, see Figure 11-12. Now the number of sites still is the same, but the number of cells are three times as many as before. The following step is to do a cell split of e.g. 1 to 4. See Figure 11-14. As seen from the figure, the old sites are still used in the new cell plan, but additional sites are now required.

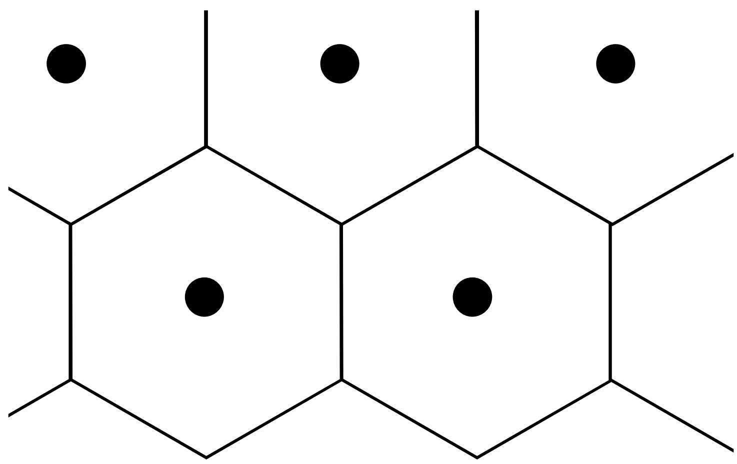


Figure 11-11. Cell split phase 0

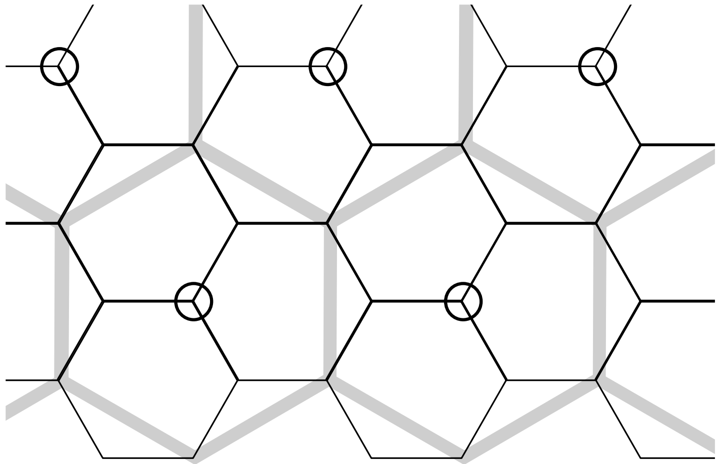


Figure 11-12. Cell split phase 1

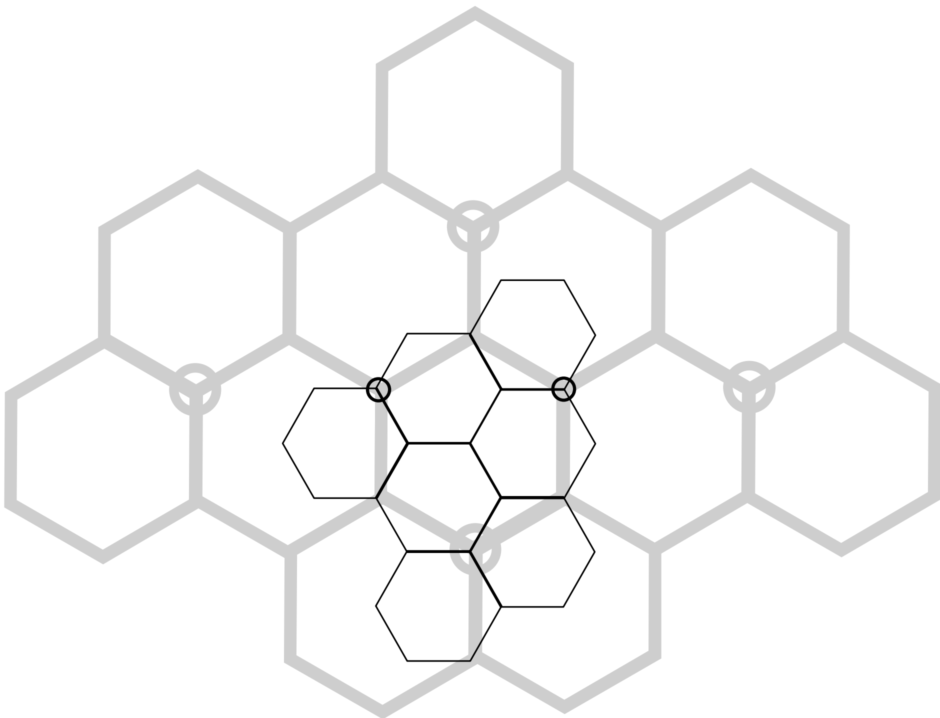


Figure 11-13. Cell split 1:3 (phase 2)

Cell split 1:3, Figure 11-13, requires three times as many sites. After the split, the capacity is three times higher per area unit, and the cell area is three times smaller. The antenna directions on the site that existed before the split must be changed 30 degrees.

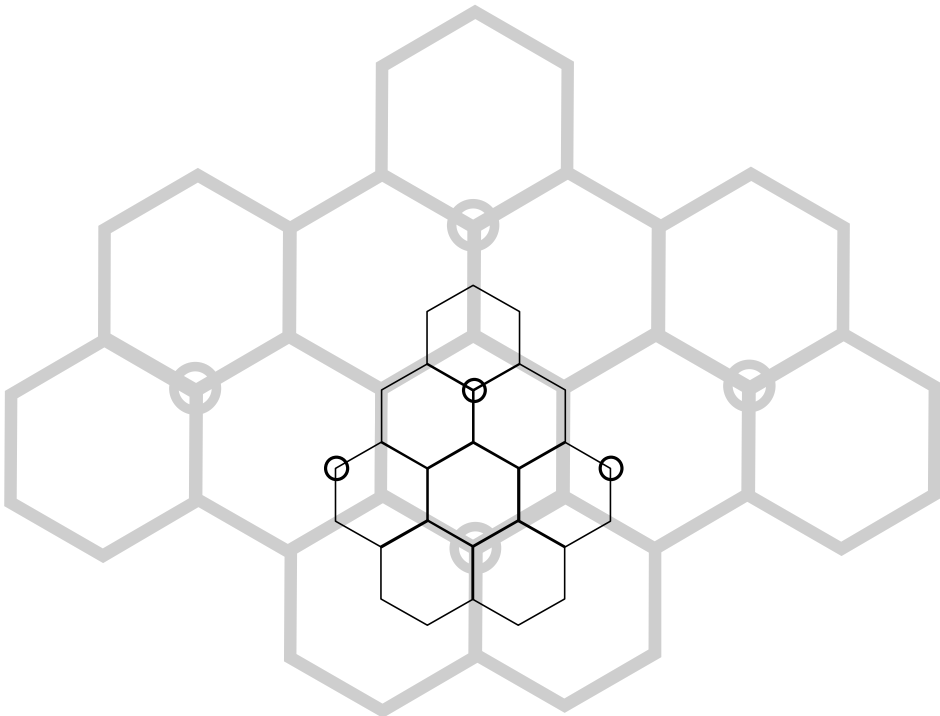


Figure 11-14. Cell split 1:4 (phase)

Cell split 1:4, Figure 11-14, requires four times as many sites. After the split the capacity is four times higher per area unit, and the cell area is four times smaller. There is no need to change the antenna directions in a 1:4 cell split.

MULTIPLE RE-USE PATTERNS

Multiple re-use patterns (MRP) is Ericsson's frequency re-use method and it is a scheme to gradually tightening the frequency re-use in a cellular network. It is also very well suited to handling networks with uneven traffic distribution i.e. different number of tranceivers (TRXs) in each cell.

A tighter frequency re-use means an increased interference level and therefore the scheme demands means to handle this. GSM can offer this by means of some of the radio network features discussed in a later chapter. Particularly those of frequency hopping, DTX and quality based power control.

The idea is that instead of organising the TCH carriers according to a single re-use scheme, the available frequencies could be split into a number of segments each representing a re-use cluster. The BCCH carriers are already planned separately. These re-use clusters are of different sizes providing different re-use situations on each of the carriers in the cell. By then applying frequency hopping over all the carriers averaging the interference situation in each overlaid re-use cluster a very efficient system could be built.

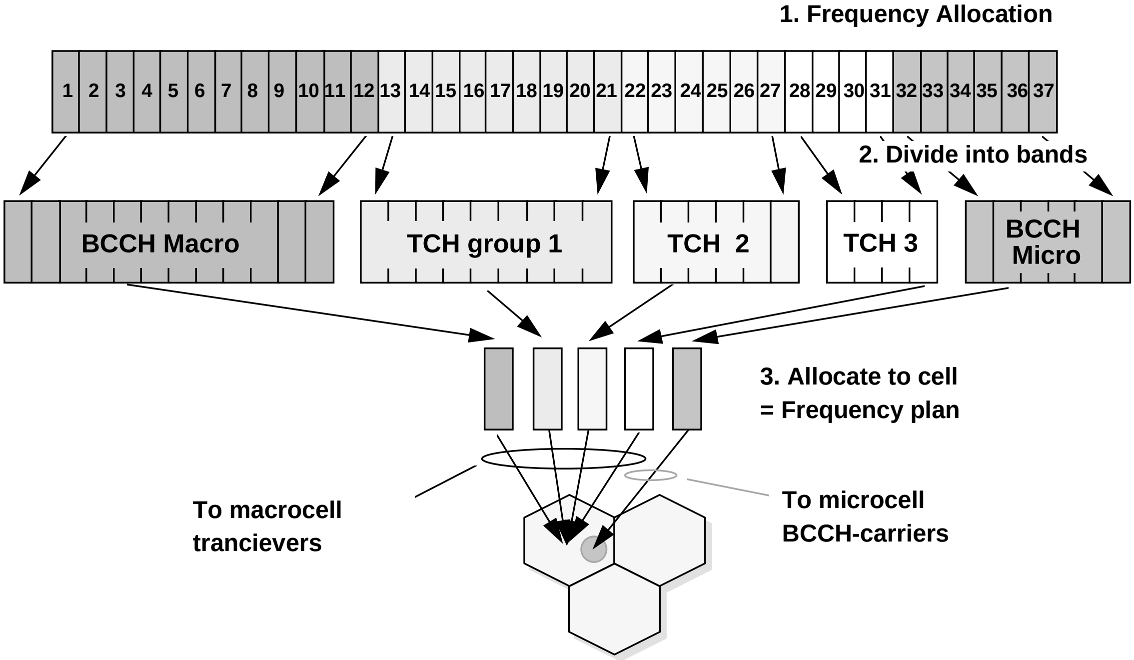


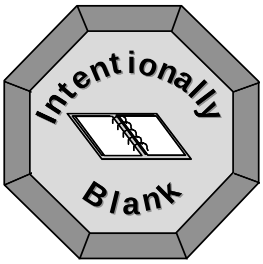
Figure 11-15. Building up a Multiple Reuse Pattern - MRP

In the example in Figure 11-15 the 37 carriers (7.5 MHz) could be split in to 31 carriers for the macrocell layer leaving and six carriers for microcell BCCH frequencies. The macrocell frequencies can be split into e.g. the following bands 12/9/6/4, where the twelve first frequencies is used for the macrocell BCCH carrier frequencies (TRX1). The second group of nine frequencies are then re-used on TRX2, the third group of six frequencies re-used on TRX3 etc. Each cell is only allocated with the necessary number of carriers, starting from the most relaxed re-use, given by the traffic requirements per cell up to a maximum of 4 TRXs per cell. The average re-use for 12/9/6/4 is (12+9+6+14)/4=7.75 for the cell and (9+6+4)/3=6.3 for the TCH frequencies.

The method allows a gradual tightening of the re-use as more transceivers are installed in the cell and it makes the most of the following:

The re-use group on the last transceiver can be tight since it probably not will be used in every cell. This can be traded into tighter re-use.

It will be possible to combine 2 transceiver cells using a 12/9 allocation with 3 transceiver using 12/9/6 and 4 transceiver cells using 12/9/6/4.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