TEMS Investigation

GSM 900/1800/1900
Release 3.1

Product Description

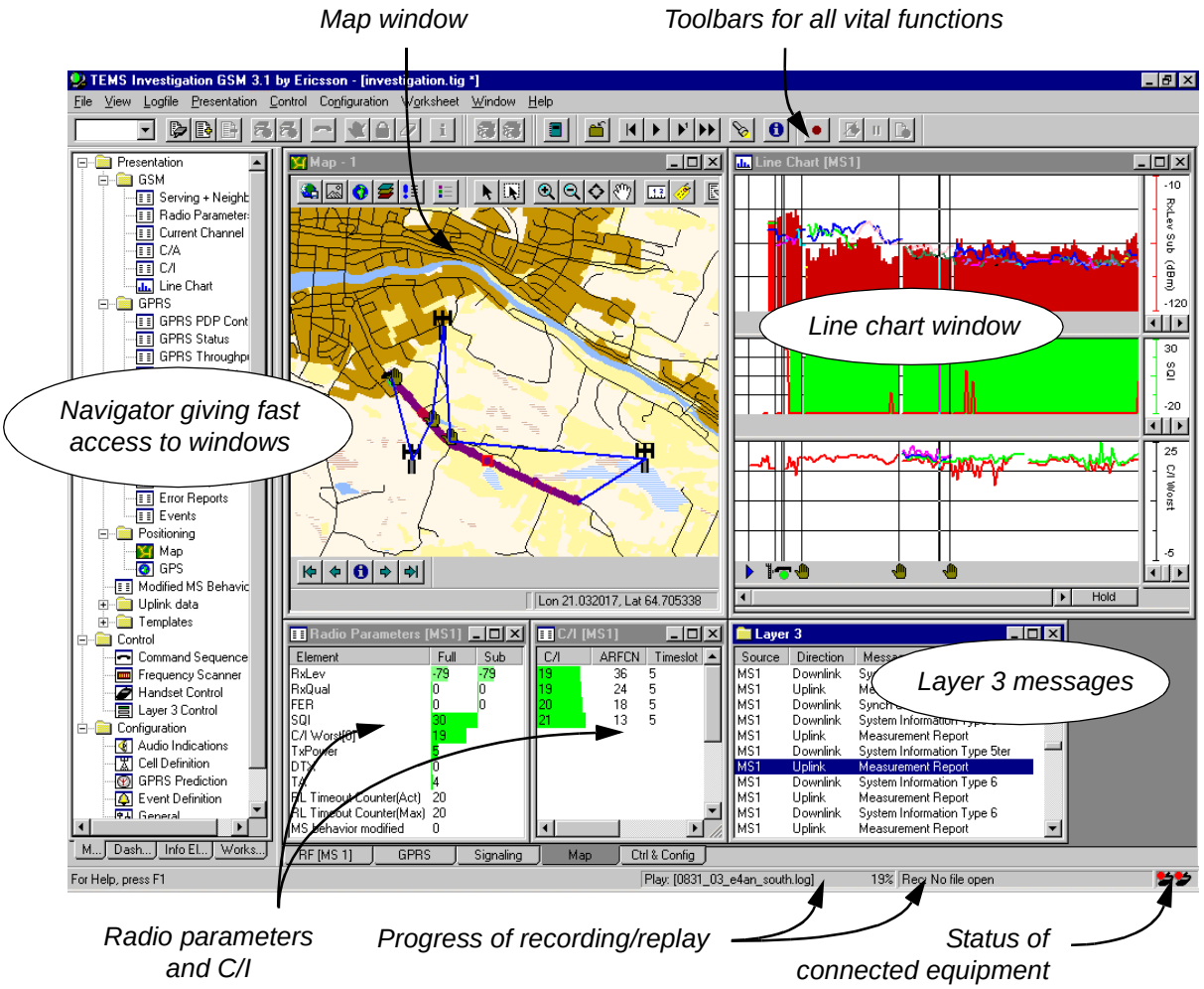
ERICSSON

Contents

Introduction

TEMS Investigation is an air interface test tool for real-time diagnostics. It lets you monitor voice channels as well as data transfer over GPRS, circuit-switched (CSD) or high-speed circuit-switched (HSCSD) connections. TEMS Investigation is equipped with basic testing and inspection functions as well as powerful analysis and post-processing features useful to the experienced RF engineer.

The TEMS Investigation package consists of a PC software application that receives data from up to four TEMS mobile stations in idle as well as dedicated mode. A dedicated scanner mobile (TEMS Scanner) can also be connected as well as a GPS unit for geographical positioning.



The wealth of details on air interface parameters and signaling collected by the TEMS mobile puts the analyst in an excellent position to tackle thorny network problems. Getting at the roots of matters is further facilitated by the frequency scanning and data import functions. There

are also generous facilities for manipulating mobile station settings and signaling behavior in order to simulate various network modifications.

Data is presented in real time throughout. This makes TEMS Investigation ideal for advanced drive testing sessions of trouble-shooting, performance tuning, etc. All data can also be saved in logfiles for purposes of post-processing.

The TEMS Investigation base package is composed of a CD with PC software, a TEMS mobile station, a serial cable for connecting the mobile to the PC, and various other items (complete listing on page 36). The software is a 32-bit application running under Windows NT 4.0, Windows 2000, or Windows 98.

Examples of Applications

Commissioning

Putting new cell sites into operation entails careful checking of the added equipment. The predicted cell coverage must be verified; handover behavior must be checked against specifications; all timeslots must be functional; and most importantly, the speech quality must be satisfactory. All these checks can be performed with TEMS Investigation.

Network Optimization and Tuning

Tuning and optimizing the network typically boils down to tilting site antennas, adjusting cell and location area boundaries, etc. TEMS Investigation makes it easy to try out various tweaks and adjustments and monitor their effect in real time, or log the data for later scrutiny in the office.

Troubleshooting

Resolving tricky network problems calls for a dynamic analysis tool where the user has great freedom to configure presentations and events. The most crucial requirement, however, is that the analyst be able to obtain a detailed, while still lucid and readily interpretable, overview of the course of events.

GPRS Verification

In deploying a GPRS network, the estimated data throughput must be carefully verified, and the impact of air interface interference on the packet data traffic ascertained. TEMS Investigation makes it easy to locate spots with bad throughput where the network configuration must be reconsidered.

What's New in Release 3.1

Data Service Measurements (HSCSD)

Throughput, retransmissions, C/I by timeslot, and a number of other parameters can be monitored for HSCSD as well as ordinary circuit-switched data transfer. New information elements have been added holding this information.

Channel Verification

This new utility allows you to check the availability of a set of traffic channels, making calls in all relevant timeslots to verify each of them separately.

TEMS Pocket R520m 1.1

The TEMS mobiles are release 1.1 of the TEMS Pocket R520m phone. The new release has added GPRS functions.

What Was New in Release 3.0

The most important novelty in the 3.0 release was the introduction of GPRS measurements in live networks.

GPRS Features

- Modified R520m GPRS mobile station used as TEMS mobile
- New information elements – notably throughput, resend/decode error percentages, timeslot use, but also many others
- New events reporting on the GPRS connection – for example, "GPRS Attached" and "GPRS PDP Context Activated"
- New presentation windows

The GPRS performance predictor introduced in an earlier release of TEMS Investigation, taking ordinary GSM network data as input, was kept in this release.

TEMS Pocket Functions in TEMS Mobiles

All TEMS mobiles to be used with TEMS Investigation are equipped with a full set of TEMS Pocket functions (they *are* TEMS Pocket mobiles).

License Handling Reworked

The old license handling system using CrypKey was abandoned. A TEMS Investigation-specific mobile station is now required for real-

time presentation and recording. Such a mobile (an R520m) is included in the product package.

Automation and User-friendliness

The call sequence available in previous TEMS Investigation releases was replaced by the *command* sequence. Like its predecessor, the command sequence makes it possible to automate sequences of calls, but it also enables control of logfile recording and handover behavior.

To the Navigator was added a *Dashboard* tab. Equipped with large buttons for calling, recording, etc., it eases the task of operating the application during drive tests.

Improved Text Format Logfile Export

The text-format export of logfiles was made more selective. Instead of choosing groups of information elements, the user now picks out individual information elements (and individual constituent parts of complex elements) for inclusion in the export file.

Multiple Mobiles Support

TEMS Investigation now supports full logging with up to four TEMS mobiles. A mobile functioning as scanner (or a TEMS Scanner) and a GPS unit can also be connected simultaneously, bringing the total number of connectable external units to six.

New MTR File Format Supported

R8 MTR files are now accepted as uplink data files.

Pausing the Recording

Logfile recording can now be paused. On resumption, the recording continues to the same file.

Supported Cellular System Versions

TEMS Investigation GSM has triple band support: E-GSM 900, GSM 1800, and GSM 1900.

TEMS Investigation for Other Cellular System Standards

TEMS Investigation is also available for the following cellular system technologies:

- CDMA
- TDMA
- WCDMA

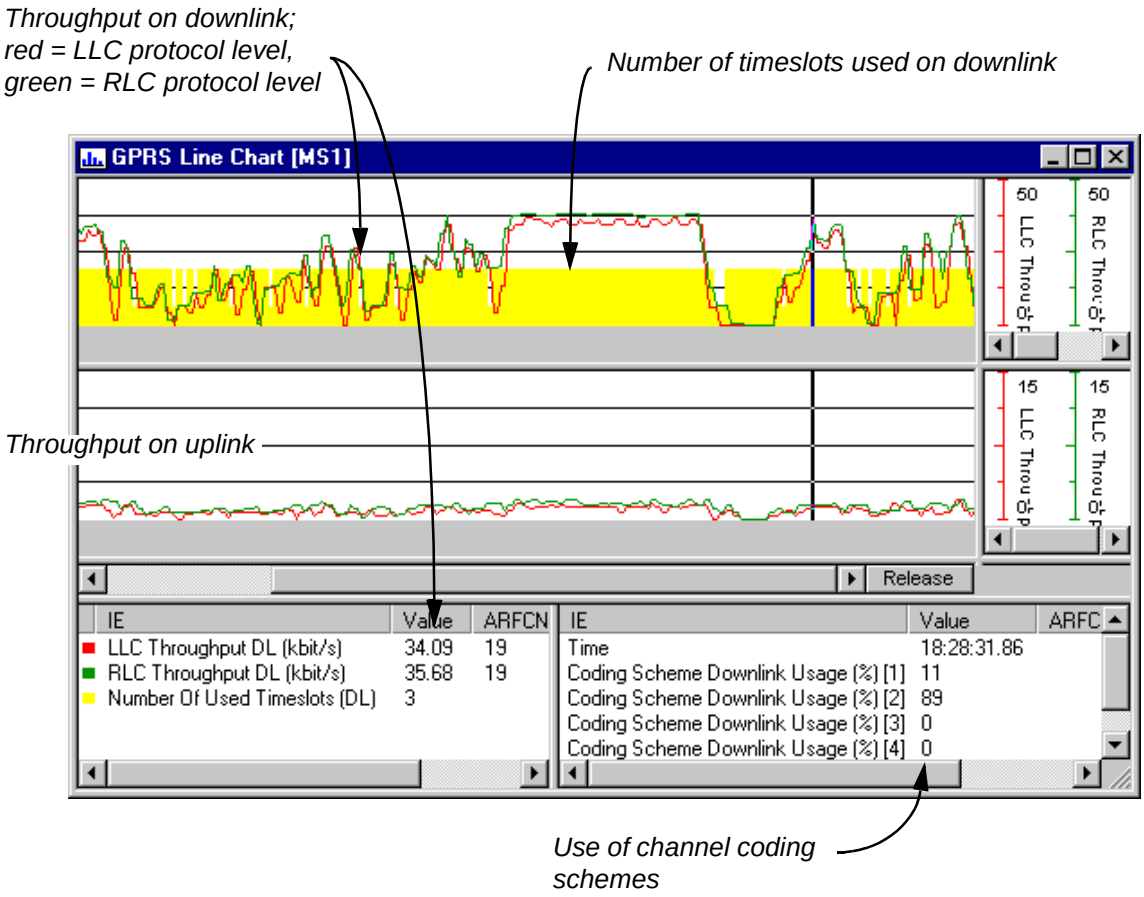
Where to Find Out More

For additional information concerning TEMS Investigation or other TEMS products, please visit Ericsson on the Web at www.ericsson.se/tems.

Highlights of TEMS Investigation

GPRS: Evolution of Data Transfer Session

Measurements from GPRS networks can be presented in a variety of presentation windows. The line chart is the natural choice for studying, for example, throughput fluctuations and changes in timeslot allocation:

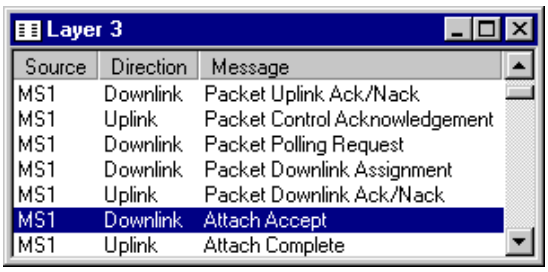


The chart shows typical FTP session behavior with near-constant activity and non-zero throughput on the channel (for web browsing, on the other hand, one would expect long uneventful intervals interspersed with fairly short periods of intense data transfer). Note the long stretch of downloading in the middle of the segment. The maximum throughput is about 38 kbit/s.

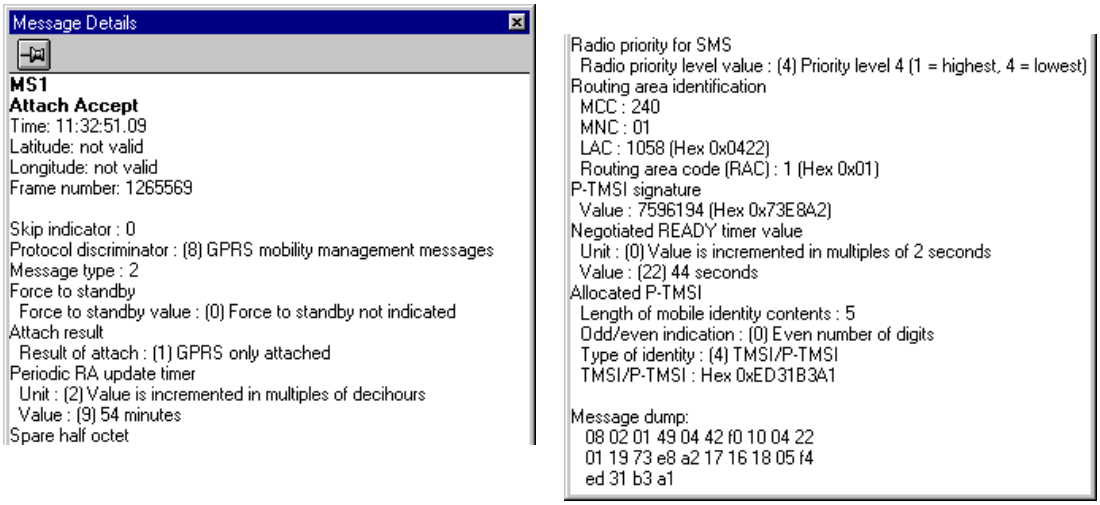
At the instant indicated in the charts by the black vertical line, coding scheme CS-2 is the one predominantly used.

GPRS: Layer 3 Messages

GPRS Layer 3 messages are displayed in the Layer 3 message window along with other Layer 3 messages.

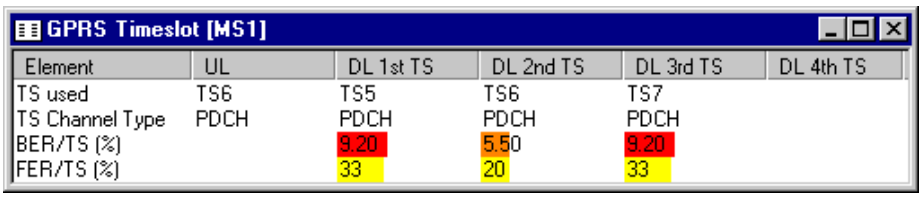


Just like ordinary GSM Layer 3 messages, the GPRS-related messages can be inspected in plain-text format:



GPRS: BER and FER by Timeslot

The bit error rate and frame error rate is given separately for the individual timeslots used, enabling the user to pin down the extent and also the causes of interference problems with greater precision.



The error rates are highest on downlink timeslots TS5 and TS7, while the problems on timeslot TS6 are less serious.

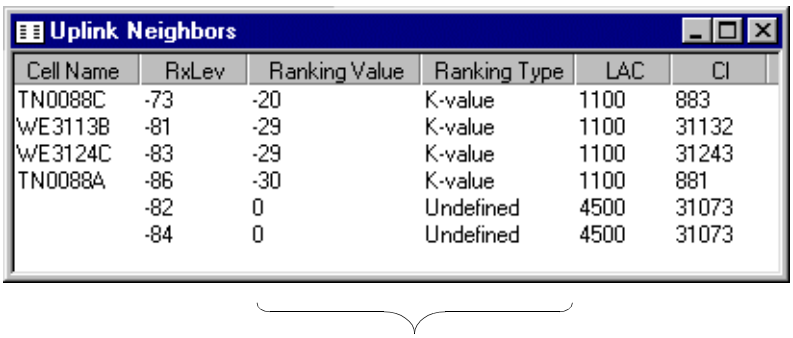
Seeing the Big Picture: Uplink Data

Ordinary TEMS logfiles contain downlink data only. In TEMS Investigation it is now possible to augment logfiles with recordings of uplink data obtained by other means. (This requires that infrastructure from Ericsson be used in the cellular network.)

The benefit of studying uplink data is that it yields a clearer picture of what is going on in the network and thus permits the network analyst to draw more informed conclusions.

Example 1: Handover

Decisions about handovers are made for the mobile station by the network (normally in the BSC), and not by the mobile itself. The mobile contributes in the decision-making process by reporting the signal strength of neighboring cells, but the network bases the neighbor ranking and the resulting handover decisions on other information as well (independent measurements of signal strength, and also estimates of radio quality and timing advance).

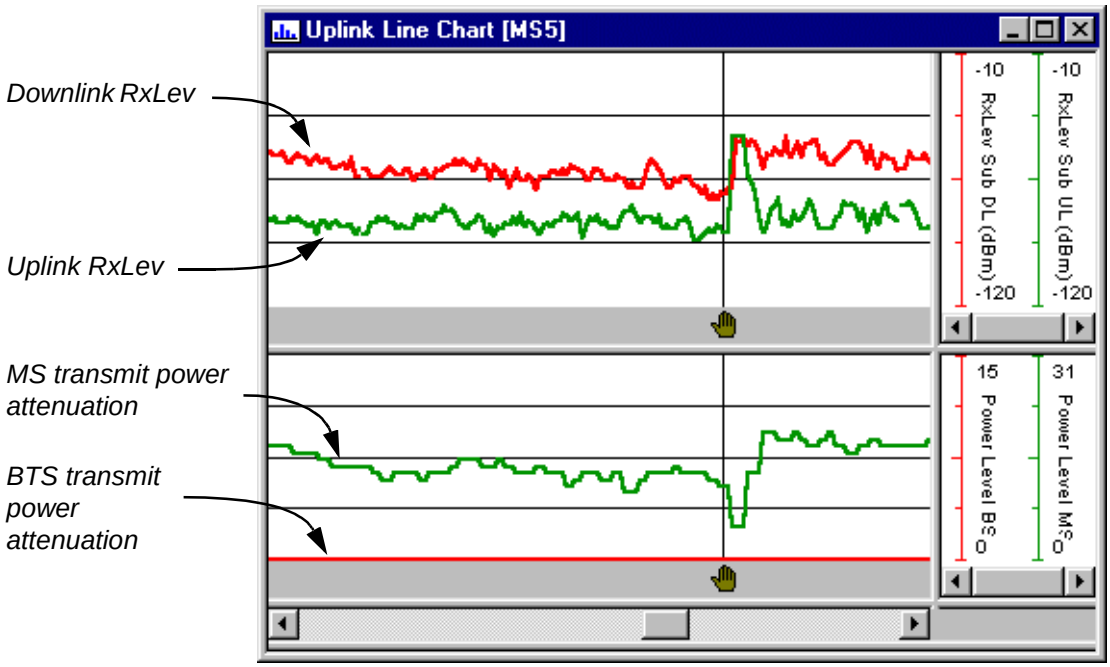


Neighbor ranking

The TEMS logfile contains only the mobile's own "advisory" measurements, whereas the uplink data includes the final decision arrived at by the BSC (expressed as ranking of neighbors). Therefore, the uplink data shows more clearly how the mobile station interacts with the network.

Example 2: Handover and Power Control

The following chart exemplifies the interaction between the mobile station and the cellular system.



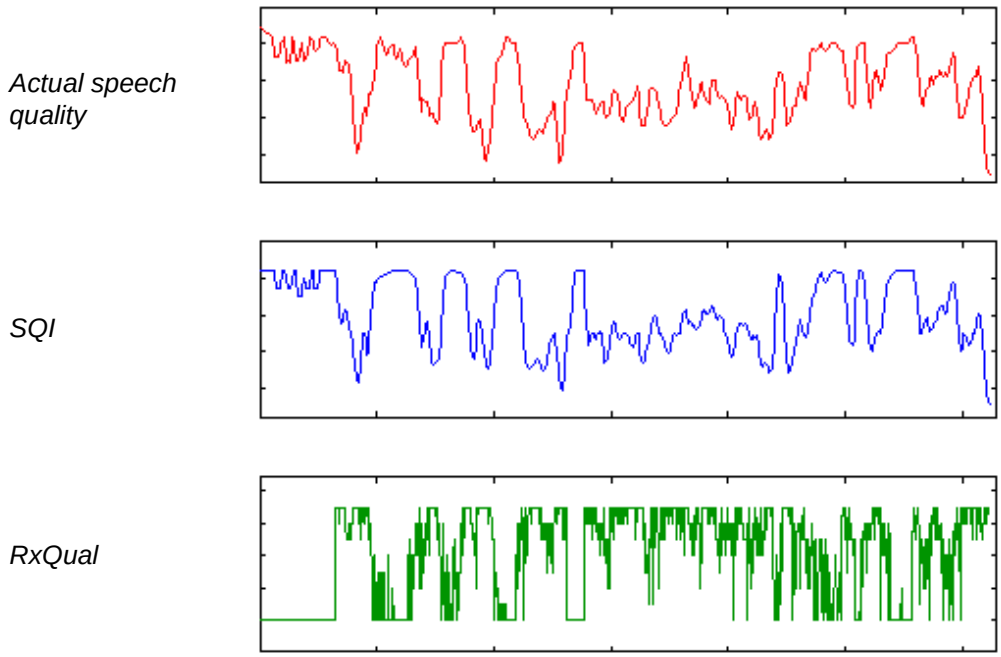
The top chart shows uplink and downlink signal strength (RxLev), and the bottom chart shows the transmit power of the base station and mobile station respectively. A handover takes place at the stage indicated by the hand symbol.

In the new cell, the mobile begins at maximum transmit power as always, causing the uplink RxLev to rise sharply. The dynamic power control algorithm finds that this power level is excessive and promptly lowers it again; in fact, to maintain the signal strength, a somewhat lower power than in the old cell proves sufficient. That the mobile's receiving conditions are also better in the new cell is evidenced by the rise in downlink RxLev.

SQI – A Faithful Measure of Speech Quality

Speech quality in GSM networks is traditionally assessed by means of the RxQual parameter. RxQual, however, suffers from a number of drawbacks which make it an unreliable indicator of speech quality. TEMS Investigation includes a more sophisticated quality measure, the Speech Quality Index (SQI; Pat. No. WO-9853630), which is dedicated to reflecting the quality of the speech as opposed to radio environment conditions.

SQI is computed by an algorithm that imitates results from listening tests, taking into account information on bit error and frame erasure rates and their respective distributions, as well as handover events. The SQI value is updated twice a second.



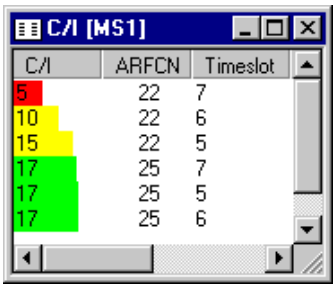
Comparison of SQI and RxQual with actual speech quality as assessed in listening tests. It is obvious that SQI is by far the better approximation of actual speech quality.

C/I – An In-Depth View of Air Interface Conditions

The carrier-to-interference ratio is the ratio between the signal strength of the current serving cell and the signal strength of undesired (interfering) signal components. This parameter is of prime importance when it comes to judging radio network performance.

TEMS Investigation presents the measured average C/I for each of the frequencies used in an ongoing call, data which enables the identification of frequencies exposed to high levels of radio interference. C/I is also measured in idle mode (on the serving cell BCCH carrier). Such information can in turn be taken into account when optimizing the frequency plan, so that the speech and data quality in the network can be improved.

In GPRS mode C/I is calculated and presented separately for each timeslot used (see figure).



C/I for currently used channels and timeslots in a GPRS network with frequency hopping. There is a fairly serious interference problem on channel 22, timeslot 7.

See the document “Measuring C/I in TEMS Investigation”, EPL/T/R-99:150, for more information about this feature.

See also the document “Interpreting the Information Element ‘C/I’ ”, EPL/T/TN-00:022, in which various reasons for bad C/I readings are discussed, among them the following:

- Co-channel interference
- Adjacent channel interference
- Blocking
- Noise
- Intermodulation products
- Time dispersion

Survey of Functions

Presentation

TEMS Investigation has a number of different types of presentation windows, the most important of which are the line chart, the map, and the status windows containing tabular listings.

The predefined window types can be freely modified by the user. There are also blank line chart and status window templates which the user customizes from scratch.

Status windows are constantly refreshed to show the situation at the current time instant, whereas maps and line charts accumulate information and display the whole history of the testing session. All windows are synchronized: When the user selects an earlier time instant in a map or line chart, the status windows are automatically updated to show this older data.

Line Chart

The line chart visualizes how numerical information elements evolve over time, while also displaying at what points events have occurred.

The Line Chart window is subdivided into a number of synchronized panes. See page 13.

Map

Drive test routes can be presented graphically on a map of the investigated area. Measurement data and events are plotted in symbolic form. The positions of cell sites can also be drawn with the added possibility of indicating the serving cell throughout the test drive by means of successive connecting lines.

See the examples on pages 14 and 15.

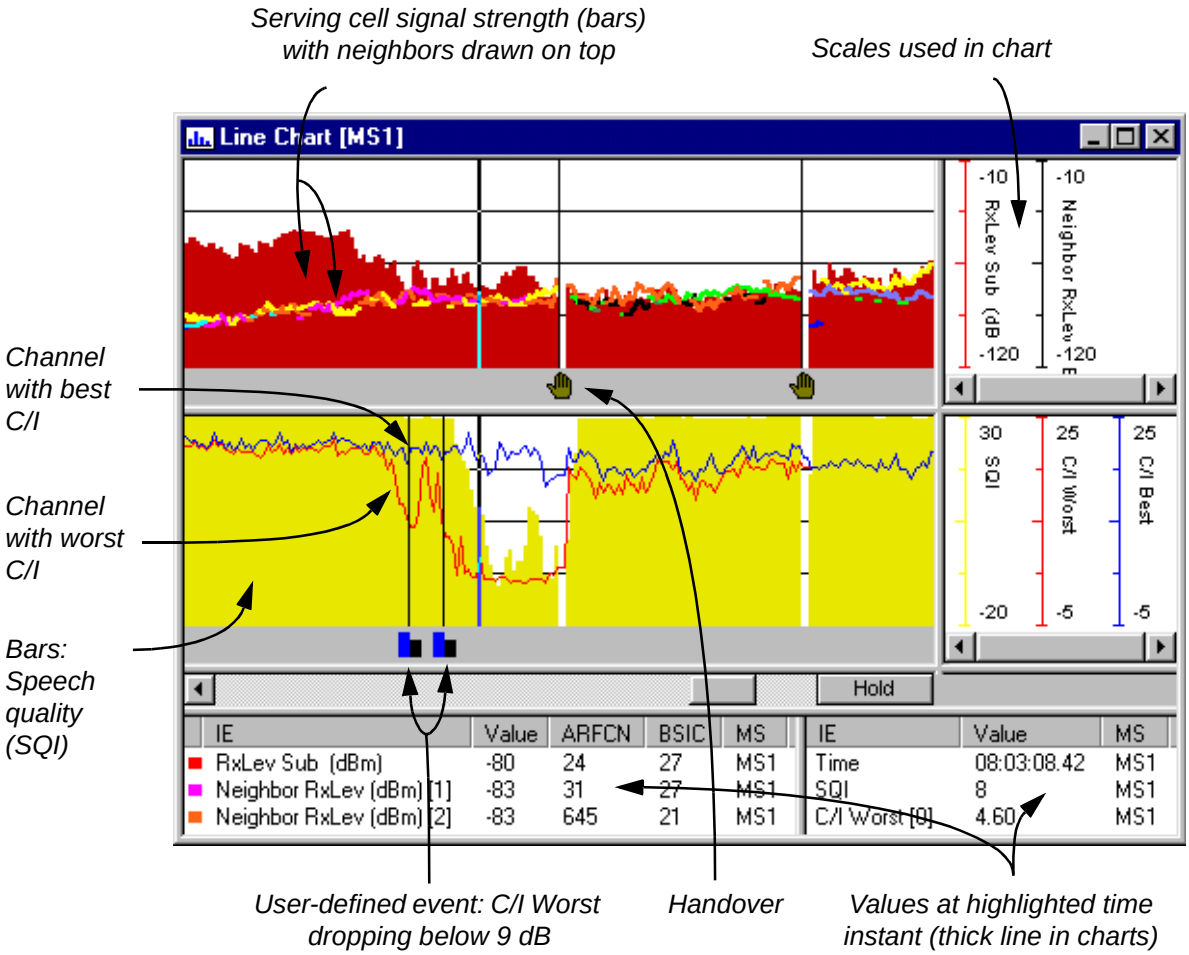
Status Windows

The status windows present information elements in tabular form. There are a number of ready-made windows designed for presenting particular categories of information (such as signal strength or SQI). In addition, There is also a blank template which can be used to compose status windows of the user’s choice.

See page 16.

Line Chart Example

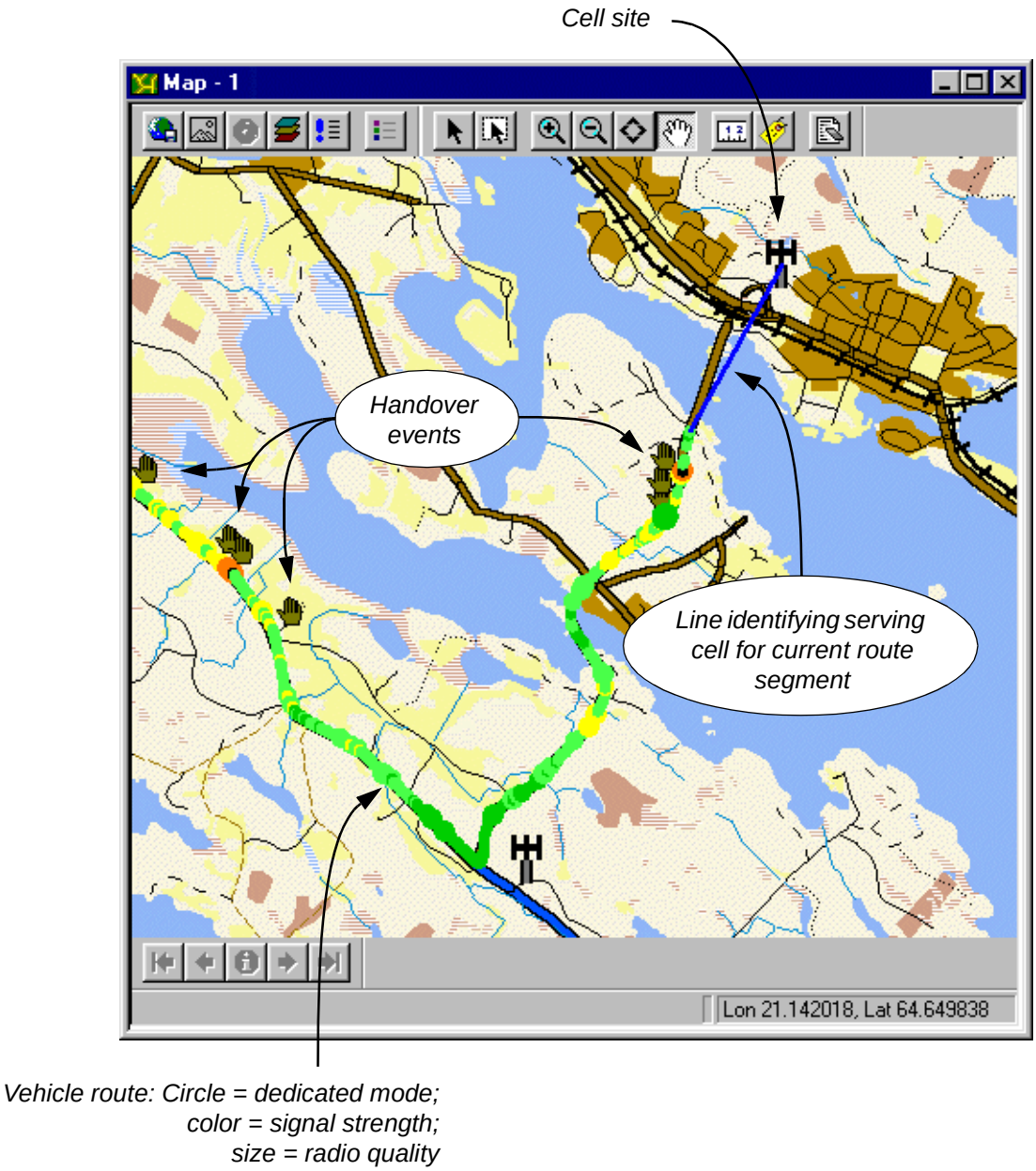
An example of line chart presentation.



It is interesting to study what happens in the middle part of this segment. One (at least) of the hopping frequencies (lower chart, red) is suddenly subjected to intense interference. This triggers a (user-defined) event, but at first does not affect speech quality (SQI stays high). However, a little later the disturbance becomes so severe as to cause a handover. That the handover is not due to some neighbor becoming markedly stronger is obvious from the upper chart, which shows no dramatic RxLev changes prior to the handover.

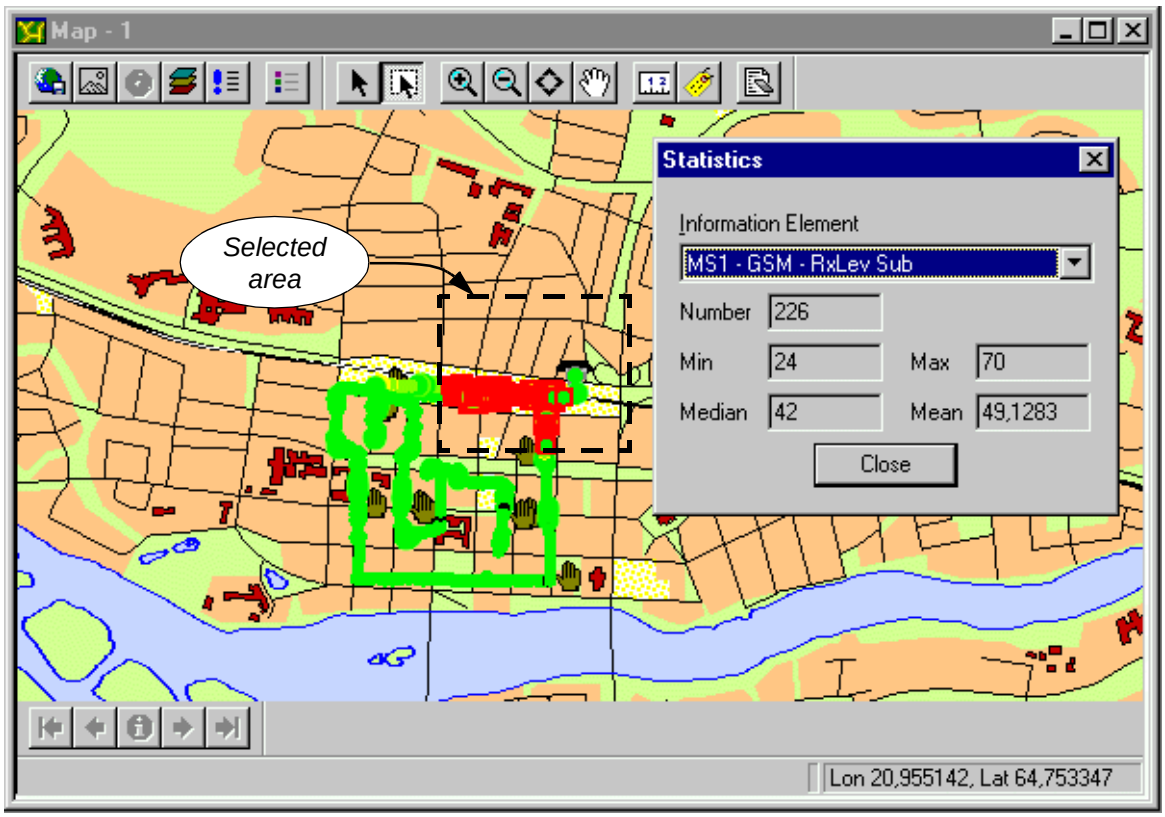
Map Examples

Two examples of map use.



The default settings for route markers (showing among other things RxLev and RxQual) can of course be freely modified by the user. Each route marker can code up to three information element values (size, color and shape). Several markers can be drawn in parallel in order to show more data.

The exact data represented by a map symbol is easily retrieved by clicking it. Selecting an area enables presentation of some statistics for this area:



A multi-layer structure is used for the presentation data (as well as, indeed, for the elements of the map image itself). The visibility of each layer can be controlled separately.

Other map features include:

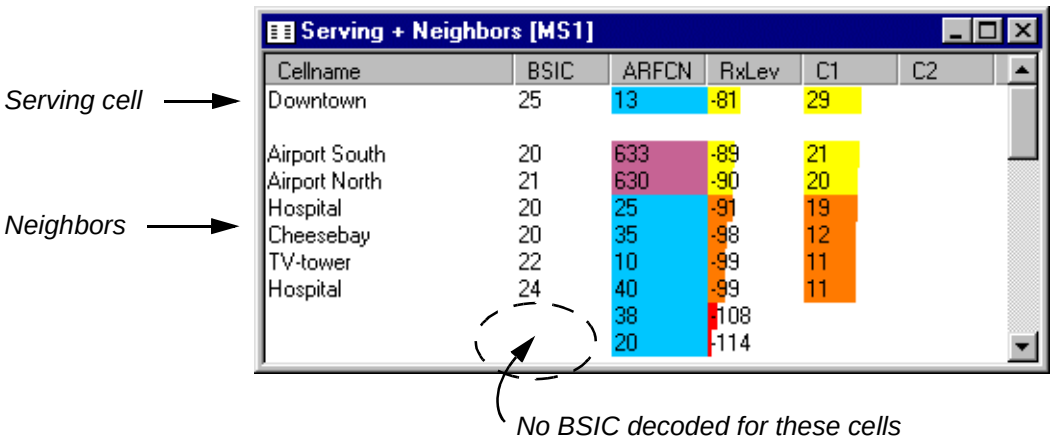
- Panning
- Zooming
- Labeling of map elements
- Choice between different projections (using GeoSet file)

Maps can be in MapInfo, TIF or bitmap format. Note that map plotting requires access to GPS data.

Status Windows

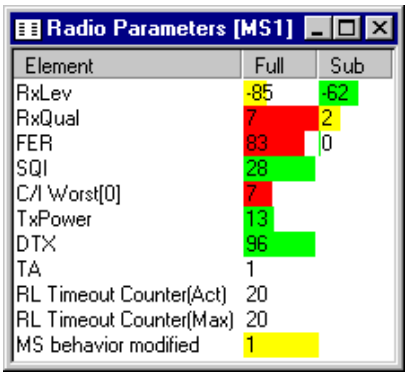
Serving + Neighbors

The Serving + Neighbors window presents, in tabular form, the BSIC and ARFCN of the serving cell and of up to 32 of the strongest neighboring base stations. The window also presents the path loss and cell reselection criteria, C1 and C2.



Radio Parameters

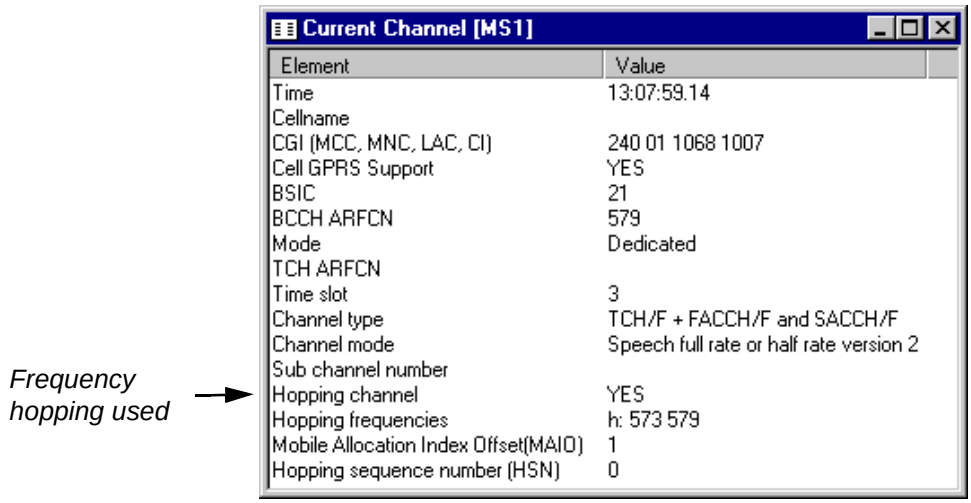
This window displays radio parameters for the serving cell.



Note that in this example, downlink DTX is activated, so the base station does not transmit continuously. Therefore, for RxLev, RxQual and FER, the seemingly alarming "Full" values are irrelevant; the "Sub" values give the true picture.

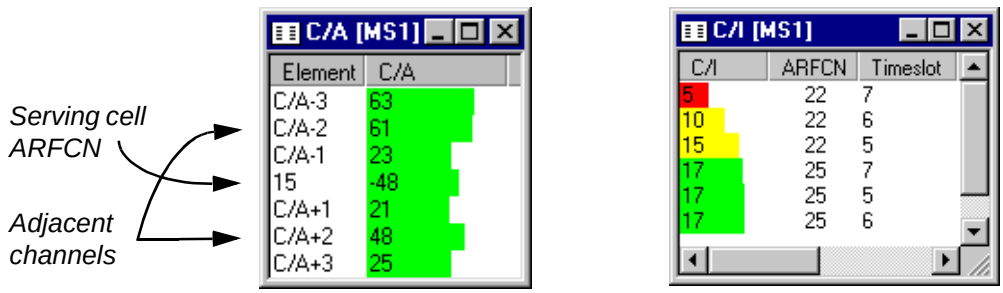
Current Channel

Here, information about the channel currently used by the mobile station is listed.



C/A, C/I

These windows show the results of adjacent channel scanning and carrier-to-interference ratio measurements.

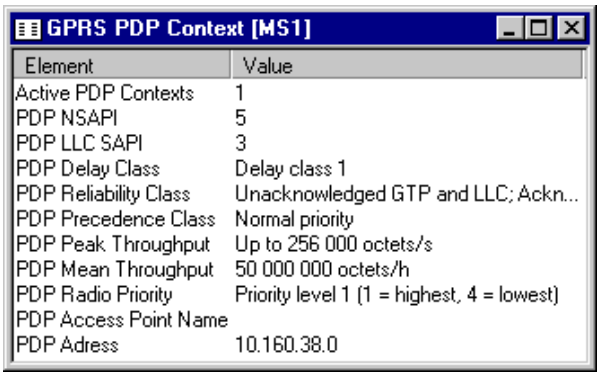


(compare page 11)

GPRS Status Windows

GPRS PDP Context

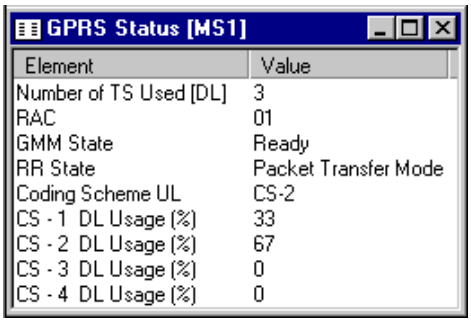
This window summarizes the results of the PDP Context negotiation between the user and the network. In other words, these parameters describe the quality-of-service offered by the network to the user for the duration of the current PDP Context.

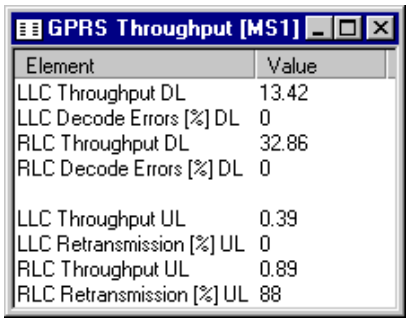


GPRS Status, GPRS Throughput

The GPRS Status window shows the state of the GPRS connection: number of timeslots used, coding schemes on uplink and downlink, Routing Area Code, etc.

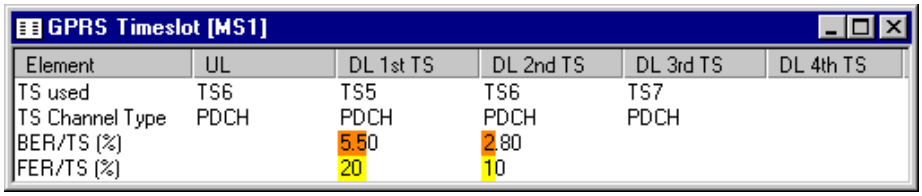
The GPRS throughput window shows throughput and retransmission figures.





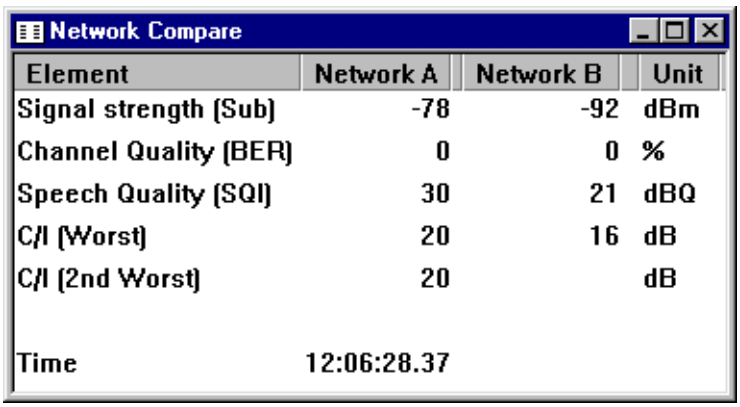
GPRS Timeslot

This window shows the timeslots used on uplink and downlink, and the performance (in terms of bit error rate and frame error rate) of each timeslot.



Status Window Template

The blank status window template allows the user to design his own status window. In this way any set of information elements may be viewed together:



In this window two networks, A and B, are compared with respect to a number of parameters. A uses the EFR speech codec, whereas B uses the FR codec. The speech quality, as might be expected, is superior for A at the time instant shown. It can also be seen that A uses frequency hopping while B does not (B has no "2nd Worst" C/I, as only a single channel is used).

Two mobiles are used for the measurements, one for each network.

Some Information Elements

These are some of the most important data items presentable in TEMS Investigation.

GSM

Downlink information elements (from TEMS mobile).
[n]: *Also available for neighboring channels.*
[s]: *Frequency scanning data collected in special information elements.*

- ARFCN of BCCH [n s]
- ARFCN of TCH [s]
- BSIC [n s]
- C/A for channels +/– 1, 2, 3
- C/I
- C1 [n], C2 [n]
- Cell names [n]
- Cell Global Identity
- DTX percentage on downlink
- FER, full and sub values
- Hopping frequency list
- Mobile station transmit power
- Radio link actual timeout
- Radio link max timeout
- RxLev, full and sub values [n s] (also for adjacent channels)
- RxQual, full and sub values
- SQI, Speech Quality Index
- Time
- Timing advance
- Timeslots used

Uplink information elements (from MTR files)

- Base station transmit power
- DTX percentage on uplink
- Neighbor ranking values
- Neighbor RxLev
- Uplink RxLev, full and sub
- Uplink RxQual, full and sub

GPRS

(from TEMS mobile)

- Throughput (LLC protocol level, RLC protocol level; uplink and downlink)
- Timeslots used
- BER by timeslot
- C/I by timeslot
- FER by timeslot
- Coding scheme usage

- Details on active PDP context(s): precedence class, delay class, peak throughput, etc.
- Percentage of blocks resent on uplink
- Percentage of blocks erroneously decoded on downlink
- C31, C32
- Neighbor C31, Neighbor C32

GPRS Prediction

(calculated from data reported by TEMS mobile)

- Predicted throughput
- Predicted block error rate (BLER)
- Predicted best coding scheme

HSCSD

(from TEMS mobile)

- Throughput (RLP protocol level; uplink and downlink)
- Timeslots used
- BER by timeslot
- C/I by timeslot
- FER by timeslot
- Percentage of blocks resent on uplink
- Percentage of blocks erroneously decoded on downlink

Data from Positioning Equipment

- Altitude (meters and feet)
- Heading (degrees from north)
- Latitude
- Longitude
- Vehicle speed (km/h and mph)

Mobile Station Control

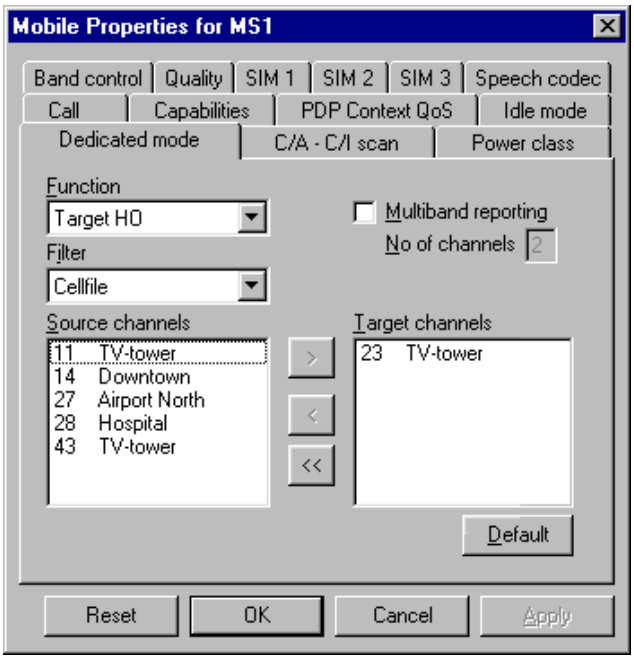
TEMS Investigation has rich facilities for controlling and modifying the behavior of the mobile station:

- Customization of mobile station behavior
- Recording of call sequences
- Monitoring and control of Layer 3 signaling

These functions are very important when it comes to simulating problems or trying out changes in the network configuration.

Customization of Mobile Station Behavior

Among other things, TEMS Investigation provides functions for manipulating cell selections and handovers. All the functions can be accessed from a multi-tab property page; the most important ones also have their own toolbar buttons as shortcuts.



Idle Mode Functions

When the mobile station is in idle mode, that is, no call is currently in progress, it can be locked to a specific control channel. This inhibits all control channel reselections. The selected control channel will then be used independently of the signal strength and quality of current neighboring cells.

Dedicated Mode Functions

When the mobile station is in dedicated mode, that is, a call has been established, its handover behavior can be manipulated in various ways:

- Force handover to a particular frequency
- Prevent handover to specified frequencies
- Disable handover altogether

GPRS Functions

The set of GPRS capabilities that the mobile will report to the network can be edited. By changing these settings you can simulate a mobile with more restricted capabilities than the R520m.

The level of quality-of-service (specified in the subscription) that the mobile station asks for in its PDP Context Requests can be changed. That is, the reliability class, peak throughput, etc., can be set to a value different from the default.

HSCSD Functions

Like the GPRS capabilities, the HSCSD capabilities reported by the mobile to the network can be modified.

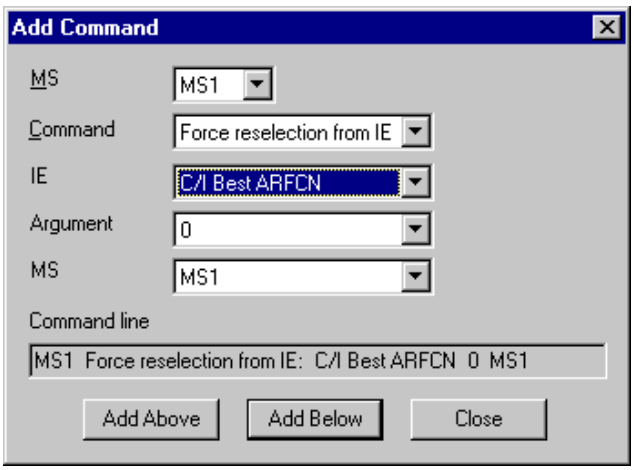
Other Functions

- Redialing of last call/termination of ongoing call
- Redialing on dropped or blocked call
- Automatic answering of incoming calls
- Switching C/A and C/I measurements on and off
- Simulation of higher power class (e.g. Class 4 or 5 for a 900 mobile)
- Force use of frequency band (900, 1800)
- Additional quality measurements giving more accurate RxQual
- Viewing and editing of SIM card information
- Selection of speech coders to be enabled in the mobile station (EFR, FR, HR)

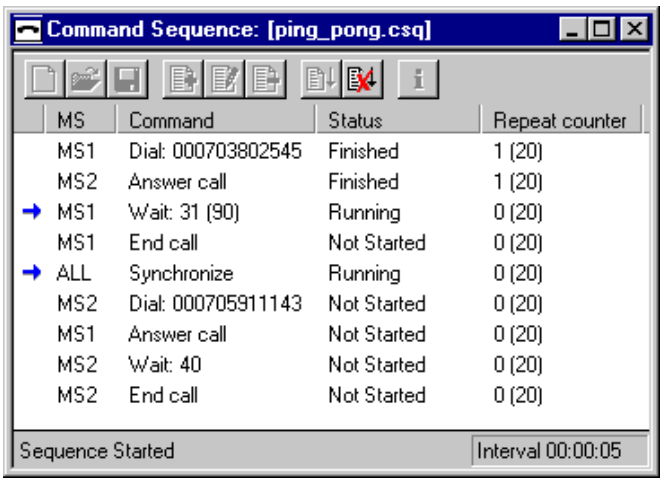
Command Sequences

Command sequences are used to automate testing. They allow the user to record in advance all the commands that are to be given to the mobile stations during a drive test. The command sequence can govern not only calls but also cell reselection and handover behavior, as well as C/A and C/I scanning. If several mobiles are used, they can be made to call each other automatically.

This is the dialog used to compose commands. Here, the mobile station MS1 is instructed to perform cell reselection to the control channel with the best C/I (according to the measurements of MS1 itself).



Example of Command Sequence

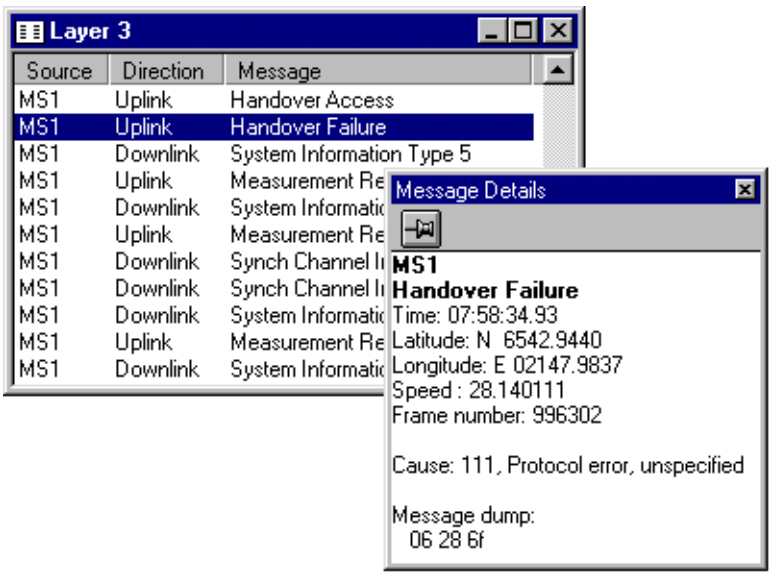


- *MS1 makes a call to MS2. MS1 ends the call after 90 sec.*
- *The two mobiles are synchronized before the next call.*
- *MS2 makes a call to MS1 and ends it after 40 sec.*

The execution of a command sequence can be conditioned by the occurrence of events (predefined or user-defined). A number of ready-made command sequences for common tasks are delivered with the application.

Monitoring of Layer 3 Signaling

Layer 3 messages sent and received by the mobile station are listed in a message window. Individual messages can be inspected in unabridged, plain-text format:



Control of Layer 3 Signaling

The GSM version of TEMS Investigation provides a number of ways to control and manipulate Layer 3 messages exchanged between the mobile station and the network. Operations such as “Send”, “Discard”, “Delay” and “Modify” are applied to individual Layer 3 messages, and these operations are arranged in sequences. The execution flow of such sequences may be modified by introducing loops, unconditional jumps, and a number of other constructs (see below). The operation sequence is downloaded to the mobile and is run there.

Layer 3 operation sequences can be saved to file and reloaded or distributed among other TEMS Investigation users.

Available Operations

Uplink and Downlink

- *Observe:* The application waits for the message to appear before proceeding.
- *Discard:* The message is waited for and then discarded.
- *Modify:* The message is waited for and then modified according to user instructions.

Uplink only

- *Delay:* The message is delayed for a specific length of time.
- *Send:* The message is sent.

Auxiliary operations

- *Repeat:* A part of the operation sequence is repeated a specified number of times.
- *Wait:* The execution of the operation sequence is halted for a period of time and is then resumed.
- *Signal:* On reaching this operation the user is notified, for instance by an audio signal.

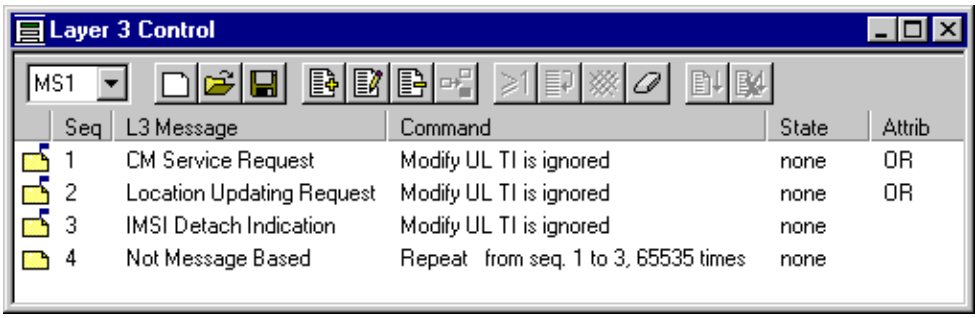
Attributes of Operations

Attributes can be added to operations in order to alter the execution flow.

- *Go to Line:* Unconditional jump.
- *Or:* Combines the operation with the following one (several Or's may be used in succession). Operations joined by Or's are treated as a unit, and the one whose message appears first is executed, the other ones being skipped.
- *Filter:* An operation (or a series of operations) tagged with Filter is executed repeatedly until a message arrives which triggers the next operation in the sequence.

Example of Layer 3 Operation Sequence

The effect of the following example sequence is to change the Classmark of the mobile station. The mobile will register as a Class 1 mobile, although it is actually Class 2.



Changing the Classmark is done by applying a Modify operation to one of the messages in lines 1 through 3. These messages are the ones that involve registration: CM Service Request (initiation of a connection), Location Updating Request (network registration), and IMSI Detach Indication (network deregistration).

The Or expression waits for any of the three messages to appear, and when this happens, the Modify operation alters the encountered message (by setting the "Revision level" to "Phase 1"; see GSM 04.08, section 10.5.1.5).

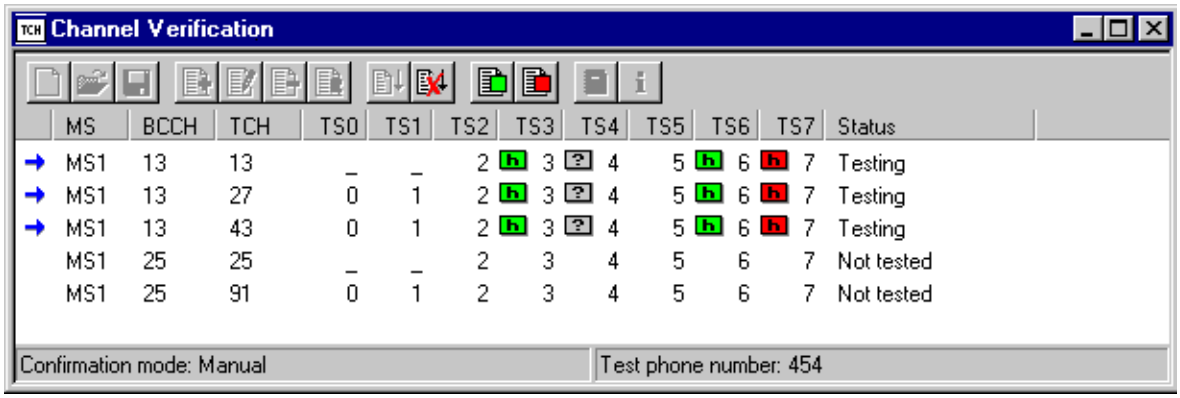
The Repeat on line 4 causes lines 1 through 3 to be repeated indefinitely (that is, until the operation sequence is stopped).

Channel Verification

The Channel Verification tool allows you to check the availability of a set of FR or EFR traffic channels, typically those used in a cell or site. Each timeslot can be verified separately. TEMS Investigation lets one or several TEMS mobiles make calls repeatedly on the chosen channels until all timeslots of interest have been tested.

Verification is either manual or automatic. If you choose manual verification you monitor each call in your preferred manner, for instance by listening to the downlink quality, and indicate yourself whether a timeslot is acceptable or not. If you choose automatic verification, TEMS Investigation decides whether to accept the timeslot, basing its decision on a check of the call setup signaling.

Verification sessions are prepared and run in this window:



The cell described by the first three rows (tagged with blue arrows) is under test. Manual verification has been chosen. Frequency hopping is used in this cell (as shown by the h symbols), so any timeslot tested will be verified for all three TCHs at once.

At this point, the user has accepted the performance of timeslots 3 and 6 (green markers), while rejecting timeslot 7 (red markers). Timeslot 4 is currently being tested, which is indicated by question marks.

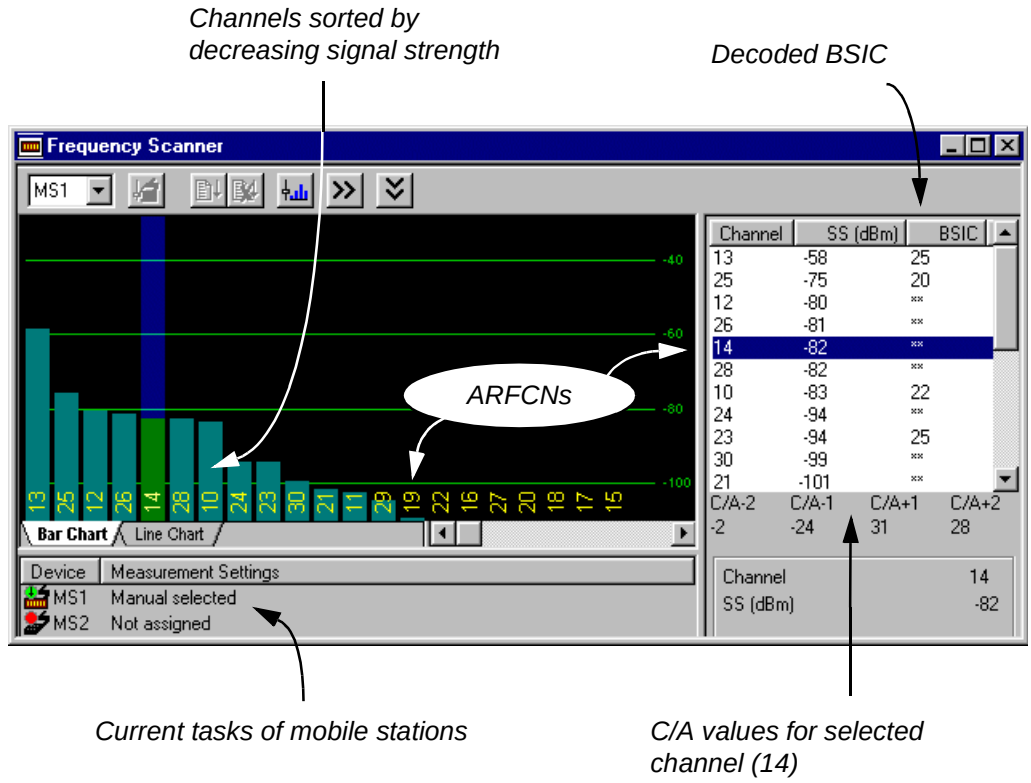
On completing the cell with BCCH ARFCN 13 the test will proceed to the next cell, which has BCCH ARFCN 25 (last two rows).

At any stage of test execution, an HTML report can be generated summarizing the results obtained so far. The test can also be saved to file, complete with results and current execution status.

It is possible to speed up the verification process by letting multiple mobile stations make calls in parallel.

Frequency Scanning

Using either a TEMS mobile or an external frequency scanner (the TEMS Scanner), the user can measure and monitor the signal strength of a given set of radio frequency carriers (channels). The channels are identified by their ARFCNs; the BSICs of the base stations transmitting on the channels can also be decoded.



The set of carriers to scan can be defined in a number of different ways:

- All channels (i.e. as many as the mobile or scanner is capable of scanning simultaneously)
- An arbitrary static set of channels
- All channels in use within a specified radius of the vehicle's current position (requires cell definition file and GPS unit reporting speed)
- The adjacent channels of another mobile

In the last two cases the channel set is dynamically redefined according to the movements of the vehicle and the behavior of the master mobile, respectively.

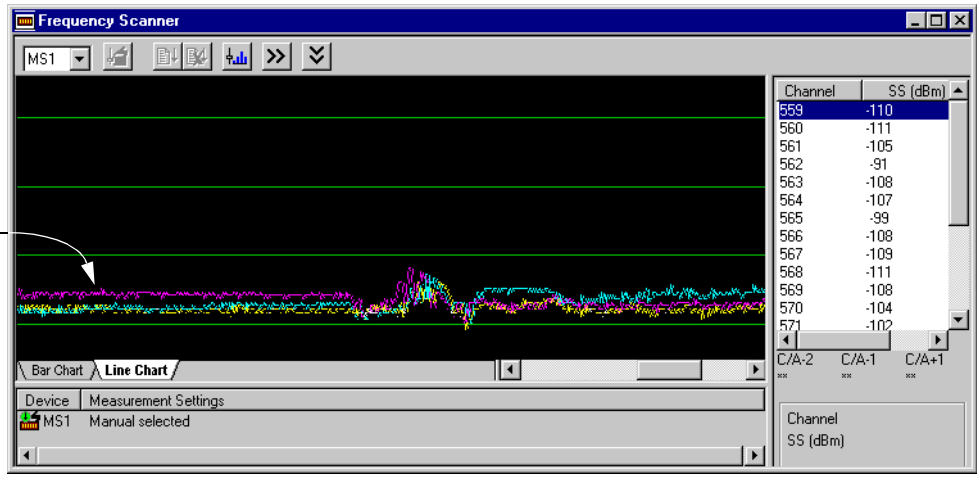
Advanced Scanning Options

- BSIC decoding
- Adaptation of sample rate to vehicle speed (requires GPS data) or to an assumed fixed speed
- Sample averaging in mobile station

Presentation Options

Bar chart (default) or line chart (see below).

Three strongest scanned channels



Channel display options:

- All scanned
- All stronger than a dBm threshold
- All weaker than a dBm threshold
- *N* strongest
- *N* weakest
- Serving cell BCCH and, in dedicated mode, TCH (the whole list of TCHs if frequency hopping is used) + adjacent channels of the BCCH and each TCH
- Handpicked set of channels

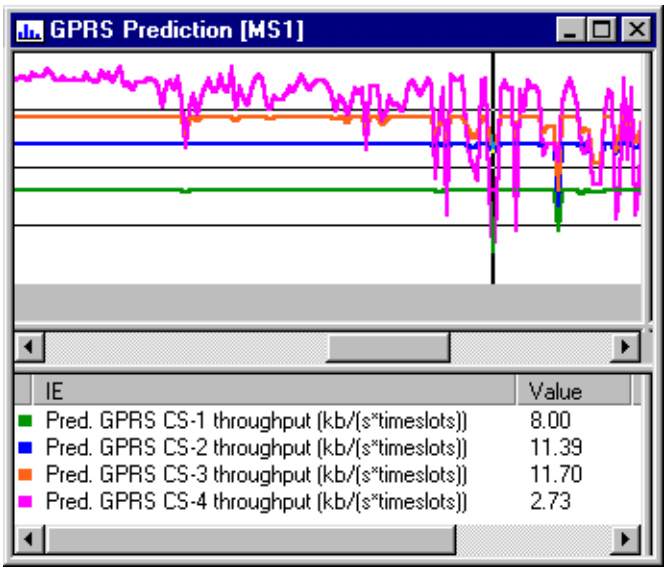
Channel sorting options:

- By channel number
- By decreasing/increasing signal strength
- By frequency
- By the neighbor list of a mobile: First serving cell BCCH, then neighbors by decreasing signal strength, and finally remaining channels by decreasing signal strength

Predicting the Performance of a GPRS Network

In GSM networks not yet offering a GPRS service, TEMS Investigation can estimate the performance achievable on a future GPRS packet data traffic channel. This is done by analyzing measurements taken on the GSM speech channel, which is sufficient since GPRS shares the infrastructure with the ordinary GSM network and, crucially, uses exactly the same radio interface.

TEMS Investigation presents estimates of throughput and block error probability for each of the four GPRS channel coding schemes.



This line chart compares the performance of the GPRS channel coding schemes (CS-1 through CS-4). In the first half of the shown time interval, the radio quality is good, but towards the end it deteriorates considerably. This is reflected in the curve for CS-4, which offers the highest peak throughput but also gives the weakest error protection. CS-1 and CS-2, on the other hand, are very robust, maintaining a near-constant throughput. CS-3 lies in between these two extremes.

The bottom pane shows the throughput values at the time instant highlighted by the thick vertical line.

For further information on GPRS performance prediction, see the document “Estimating GPRS link bit rates in TEMS Investigation”, EPL/T/R-00:051.

Logfiles

Recording of Logfiles

Recording toolbar

All collected data can be recorded in logfiles for later analysis. Data is written to file in a manner that minimizes the risk of losing data in case of, for instance, power failure in the PC. The following options exist:

- *User comments* can be entered after concluding a recording
- *Filemarks* for tagging interesting segments (free text or, if preferred, simply integers)
- *Pause/Resume:* The recording can be paused and on resumption continued to the same logfile
- *Quick logging:* The logfile name is created automatically, and the logging starts at once
- *Logfile swapping:* The logfile is closed after reaching a specified number of messages, and the logging continues to a new file

Replay of Logfiles

Logfile replay is handled from a toolbar which provides the customary "tape recorder" functions, as well as some others:

Replay toolbar

- *Play* at ordinary speed (customizable)
- *Step* one TEMS mobile report at a time
- *Fast-forward* the logfile
- *Rewind* to beginning of file
- *Find:* Search for a time instant, event type, Layer 3 message, Layer 2 message, or mode report

File replay is stopped automatically on reaching the end of the logfile. Once the whole file is loaded, browsing the file is carried out in the presentation windows and not from the toolbar.

Export of Logfiles

Logfiles can be converted to the following formats:

- Plain-text (ASCII) file
- Plain-text scan data (`.scn`) file

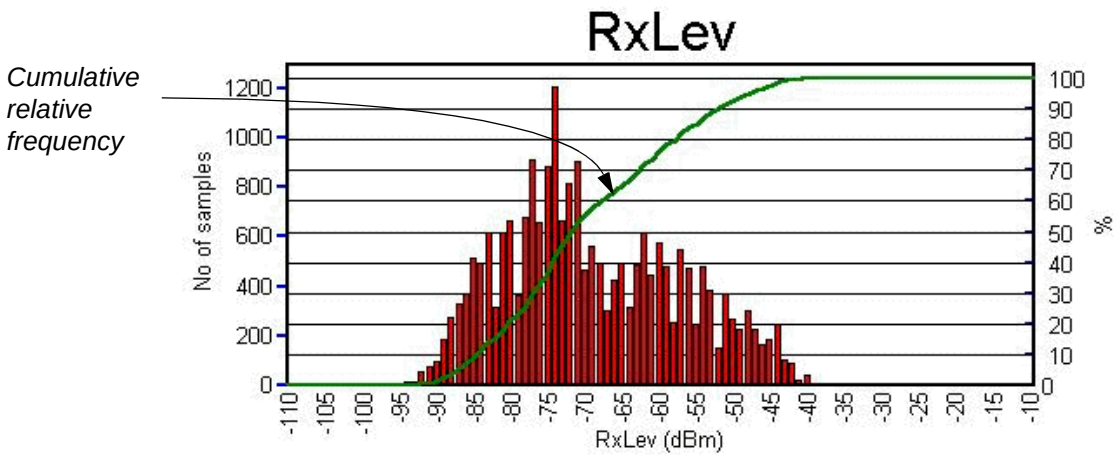
The text files have tab-separated columns and are thus conveniently viewed with a spreadsheet program.

Logfile Reports

From one or several logfiles the user can generate a report in HTML format which summarizes the data in the logfiles. When the report is ready it is opened in the default web browser.

Report Contents

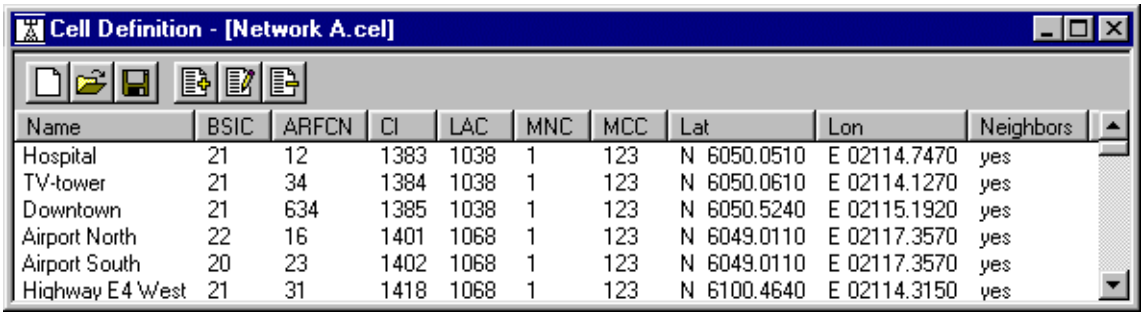
- Date and time of report generation
- Names and total duration of logfiles
- Bar charts for SQI, RxQual, RxLev, TxPow, and TA (see example below)
- The number of times SQI, RxQual, RxLev, TxPow, and TA have satisfied user-specified threshold conditions (up to two for each parameter)
- Event statistics: number of call setups, dropped calls, blocked calls, handover attempts, handover failures



RxLev chart in logfile report.

Import of Cell Site Data

TEMS Investigation can present data on the cell sites of the measurement area. This requires loading of a cell definition file:



Name	BSIC	ARFCN	CI	LAC	MNC	MCC	Lat	Lon	Neighbors
Hospital	21	12	1383	1038	1	123	N 6050.0510	E 02114.7470	yes
TV-tower	21	34	1384	1038	1	123	N 6050.0610	E 02114.1270	yes
Downtown	21	634	1385	1038	1	123	N 6050.5240	E 02115.1920	yes
Airport North	22	16	1401	1068	1	123	N 6049.0110	E 02117.3570	yes
Airport South	20	23	1402	1068	1	123	N 6049.0110	E 02117.3570	yes
Highway E4 West	21	31	1418	1068	1	123	N 6100.4640	E 02114.3150	yes

In the presentation, the cell site data shows up in the following places:

- Map window: Site positions along with indication of current serving cell (see page 14)
- Serving + Neighbors status window (see page 16)

The cell definition file, which is stored in text format, can be built up by entering the cell site information directly in the Cell Definition window. However, for large sets of cells this is cumbersome, and it is then more convenient to assemble the cell definition file with some program suitable for editing text files (for instance a spreadsheet program).

Events

Events signify various interesting occurrences, mostly relating to the operation of the mobile station. Events are presented

- as symbols on the map (see page 14)
- as symbols and vertical lines in line charts (see page 13)
- (optionally) by means of audio signals

A number of common events are predefined: see below. The user can also define his own events by composing logical expressions, which may contain the following types of trigger conditions:

- Occurrence of other event
- Appearance of Layer 3 message
- Change in value of information element
- Value of information element meeting threshold condition (>, =, or <)

Allowed logical operators:

- AND
- OR
- XOR
- NOT

Example of User-Defined Event: Noise Indication

```
C/I Worst < 10
AND
RxLev Sub (dBm) < –99
```

Two common causes of poor C/I values are co-channel and adjacent channel interference. In certain circumstances, however, the main problem is not interference from other callers, but the fact that the signal is overwhelmed by assorted random disturbances – i.e. what is usually called "noise". This means thermal noise generated within the circuits of the mobile station, as well as external background noise from a plethora of sources, including other man-made signals so faint that they merely add up to a quasi-random disturbance.

The event above gives a rough indication that the poor C/I is probably due to a noise problem: the poor C/I coincides with a very low signal strength.

Some Predefined Events

- Blocked Call
- Call Answered
- Call Setup
- Call Hangup
- Cell Reselection
- Dedicated Mode (i.e. dedicated mode entered)
- Dropped Call
- Handover
- Handover (Intracell)
- Handover Failure
- Idle Mode (i.e. idle mode entered)
- MS Connected
- MS Disconnected
- GPRS Attached
- GPRS Detached
- GPRS PDP Context Activated
- GPRS PDP Deactivated
- GPRS Routing Area Updated

Product Package

The TEMS Investigation base package holds the following components:

- CD with TEMS Investigation GSM PC software
- TEMS Investigation-specific TEMS mobile station (R520m), including battery and wall charger
- Dual port serial cable
- Cigarette lighter adapter
- Car holder, HCH-22
- Triple band magnetic mount external antenna
- External antenna connector, HCE-12
- TEMS Investigation user manual
- TEMS Pocket R520m user manual

A troubleshooting package and a drive test package are also available. Please contact Ericsson for further information on these.

Accessories

In addition to the standard packages the following optional items can be delivered:

- Additional TEMS mobiles (R520m)
- TEMS Scanners
- Equipment cases (Slim Case, Drive Test Case)
- Serial cables
- Cigarette lighter adapters
- Vehicle phone holders
- External antennas
- Internal antenna adapters
- GPS units
- PC cards with serial ports
- USB hub with serial ports
- Pen tablet computers

Please contact Ericsson for further information on the available accessories.

Hardware and Software Requirements

- IBM compatible PC
- For a single mobile station and a GPS unit:
  Pentium II 266 MHz, 128 MB RAM

  For a full configuration (four mobiles, one scanner, and a GPS unit):
  Pentium III 500 MHz, 256 MB RAM
- Ports: One serial port for each connected external device, except GPRS mobiles, which require one serial port for TEMS Investigation and one for connecting to GPRS
- Sound card and loudspeakers
- Graphics: 800 × 600 (SVGA) with at least 16 bit colors (High Color)
- Windows 2000, Windows NT 4.0, or Windows 98
- Internet Explorer 5.0 required for Report Generator and online help

GPS Protocol

The following GPS protocols are supported:

- NMEA-0183
- TAIP
- TSIP

However, some other GPS units not using any of these are also compatible with TEMS Investigation. See below.

Recommended GPS Receivers

- Trimble Placer 455/DR
- Garmin GPS 12 XL
- Garmin GPS 35
- Garmin GPS 45
- Magnetti Marelli RoutePlanner NAV200
- Bosch/Blaupunkt TravelPilot RGS 08 Professional
- Bosch/Blaupunkt TravelPilot DX-N Professional

Training

For information about training, please visit Ericsson on the Web at www.ericsson.se/tems/contacts.shtml.

Ericsson is the leading communications supplier, combining innovation in mobility and Internet in creating the new era of Mobile Internet. Ericsson provides total solutions covering everything from systems and applications to mobile phones and other communications tools. With more than 100,000 employees in 140 countries, Ericsson simplifies communications for customers all over the world.

1301-AOM 901 16/5-2 Uen Rev B

www.ericsson.se/tems