FIG 1 The R&S®TSMU automatically detects, analyzes and displays the results of co-channel and adjacent-channel interferences in GSM networks during a drive test.

Radio Network Analyzer R&S®TSMU

Automatic detection of interferences in GSM networks

The R&S®TSMU is a compact test system for coverage measurements in WCDMA and GSM networks. With the R&S®TSMU-K13 option, it automatically detects the sources of co-channel and adjacent-channel interference in GSM networks, evaluates the data and displays the results.

Interferences – a frequent impairment in radio networks

In addition to criteria such as attractive prices, a product portfolio matching customer's needs, a comprehensive range of services and effective marketing, a network operator's image and economic success depend primarily on the technical performance of the radio network. Yet precisely the need to ensure and optimize the quality of radio networks poses a permanent challenge to network operators. This involves, for example, detecting the impairments that most frequently occur in radio networks, i.e. interferences. Solving this problem with conventional measuring equipment is very difficult and time-consuming. The Radio Network Analyzer R&S®TSMU from Rohde&Schwarz (FIG 1) makes this task a great deal easier. In conjunction with the R&S®ROMES measurement software, this specialist for the analysis of receive conditions in mobile radio networks automatically detects and analyzes interferences during drive tests and displays the results in a straightforward manner.

Interferences may have a variety of causes. Radio networks are never complete; they are continuously being expanded, for example by adding new base stations or transmit channels. Changes usually have to be made under great pressure of time, which places considerable demands on frequency planning and network operation. Such measures often affect existing frequency plans that were optimized for the original radio scenarios. Interference may also be caused by incorrectly set frequencies or carriers of other networks, both in one's own country and in neighboring countries. The problem of interference is aggravated in areas close to the border.

System components for GSM interference analysis

The following components are required for interference analysis in GSM networks (FIG 6):

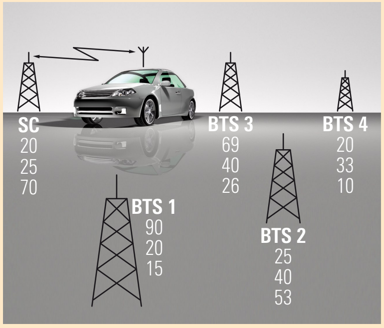
- PC (e.g. notebook) for performing the measurements
- Radio Network Analyzer R&S®TSMU
- Coverage Measurement Software R&S®ROMES including functionality for GSM interference analysis
- GSM Network Scanner R&S®TSMU-K13 (option)
- Test mobile phone (e.g. Sagem OT290 supporting C/I parameter) and associated driver in R&S®ROMES
- GPS system and associated driver in R&S®ROMES
- List of GSM base stations of network operator

What causes interferences in GSM networks?

Interferences are defined in a variety of ways; the explanations below therefore concentrate on typical problems encountered in the radio field. Interferences are most commonly caused by the mutual interaction of GSM useful frequencies. Co-channel or adjacent-channel interferences cause serious problems in signal reception. Interferences may also result from unwanted external frequencies radiating into the network, e.g. emissions from unshielded appliances or frequencies used by the military.

FIG 2 shows a radio scenario with five base stations (BTS), one of these acting as the serving cell (SC) for the terminal. The base station uses carrier C0 (referred to as the BCCH carrier) of the serving cell to transmit to the terminal the information it requires to identify and synchronize to the cell. This transmission takes place via timeslot T0. In the remaining timeslots of the BCCH carrier, traffic data (voice or data) is transmitted. Channels C1 and C2 transport traffic data only. The other four base stations also transmit data on their respective BCCHs and channels C1 and C2, but are at this moment not actively communicating with the terminal.

FIG 3 shows all interferences that may occur in this scenario, stating all co-channels and adjacent channels that may impair the current SC. In accordance with the GSM standard, the BCCH transmits at maximum power in each of its timeslots (possibly only dummy bursts) and will therefore be received by the terminal permanently and with the highest level. The traffic channels Cx (C1 and C2) are differently loaded during their eight timeslots, depending on the traffic volume; plus, their transmit power can be controlled. Their total power is as a rule lower than that of the BCCH carrier, and the interferences they cause can therefore usually be considered lower than that caused by the BCCH carrier. Of the eight timeslots of the BCCH carrier, the R&S®TSMU only measures and analyzes timeslot T0 (FIG 4). The remaining timeslots are not considered in the analysis for the reasons stated above. In the case of a C0Cx interference (traffic channel Cx interferes with channel C0), only the BCCH belonging to the Cx is analyzed as an interference frequency.



	SC	BTS 1	BTS 2	BTS 3	BTS 4
C0 (BCCH)	20	90	25	69	20
C1	25	20	40	40	33
C2	70	15	53	26	10

FIG 2 Radio scenario with five base stations, one of them acting as a serving cell. The channel numbers are listed in the table.

	Potential interference channels	Type of interference
C0 of serving cell (channel 20)	C0 of BTS 4 (channel 20)	C0C0
	C1 of BTS 1 (channel 20)	C0Cx
C1 of serving cell (channel 25)	C0 of BTS 2 (channel 25)	CxC0
	C2 of BTS 3 (channel 26)	CxCx (adjacent channel)
C2 of serving cell (channel 70)	C0 of BTS 3 (channel 69)	CxC0 (adjacent channel)

FIG 3 Complete list of interferences that may occur in the radio scenario shown in FIG 2.

FIG 4
The eight timeslots of the BCCH carrier.

C0	T0	T1	T2	T3	T4	T5	T6	T7

FCCH, SCH, BCCH, CCCH

Five steps to reach your goal

GSM interference analysis basically is performed in five steps:

1. The test mobile phone is operating in the endless call mode (e.g. voice call). The RxLev and RxQual parameters and, if supported by the phone, the C/I parameter are analyzed.
2. If one or more parameters exceed predefined thresholds, the scanner will identify this as being caused by interference (FIG 8).
3. Potential interference frequencies are determined by comparing the current serving cell channel against co-channels or adjacent channels that are included in the BTS list and lie within the user-defined radius (FIG 9).
4. The cell identities (CIs) measured with the GSM network scanner are compared against the CIs of the potential interference frequencies included in the base station list.
5. Results found are displayed in plain text, giving the name of the cell as stated in the BTS list.

With a rate of up to 80 measurements per second, the analysis system covers all preselected GSM channels. It decodes the channel numbers and the levels as well as the CI, MNC, MCC, LAC and BSIC parameters with reference to both time and position. These measurements require no network authorization by means of a SIM card. If the system detects several BCCH carriers in one channel, it can identify the carriers – depending on their spacing – by their CIs as separate co-channel signals and display them separately (FIG 5).

Within a definable time window, the analysis system measures the N strongest BCCH carriers and saves them in a pool. For the analysis, the final, valid level values of the interference signals are filtered from this pool as a function of the predefined interference thresholds and the results obtained from the mobile phone measurements. These values are then output together with the information included in the BTS list.

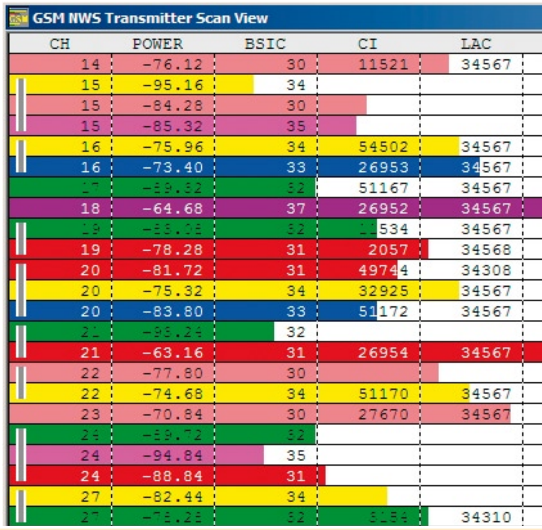
Measured data acquisition and interference analysis take place in realtime. Detected interferences as well as analysis results are displayed and measured values stored already during the measurement. This allows users to subsequently modify interference display criteria by changing threshold values.

Measurement sequence in detail and analysis of results

As with all T&M equipment, preparatory operations are required in order to achieve optimum results (FIG 7). The R&S®ROMES measurement software has to be started and the appropriate map and a base station list have to be loaded. Then the drivers for the test mobile phone and the GSM network scanner have to be loaded and configured. These settings can later be easily loaded by calling a *workspace* in a configuration menu.

Setting options for the analysis algorithm

FIG 10 shows the various options for defining interference criteria, using the BTS list, and optimally configuring the Top-N list. All results are presented in windows in a straightforward manner. Each interference is displayed in detail stating the type (COCO, COCx, etc), power, duration and distance covered as well as the interfering BTS (name derived from BTS list). In the *coupled focus* mode, results are additionally displayed in a map (FIG 11). In addition, all interferences are displayed in the clear-cut *Frequency Reuse Event* list. Results can be exported to planning tools.

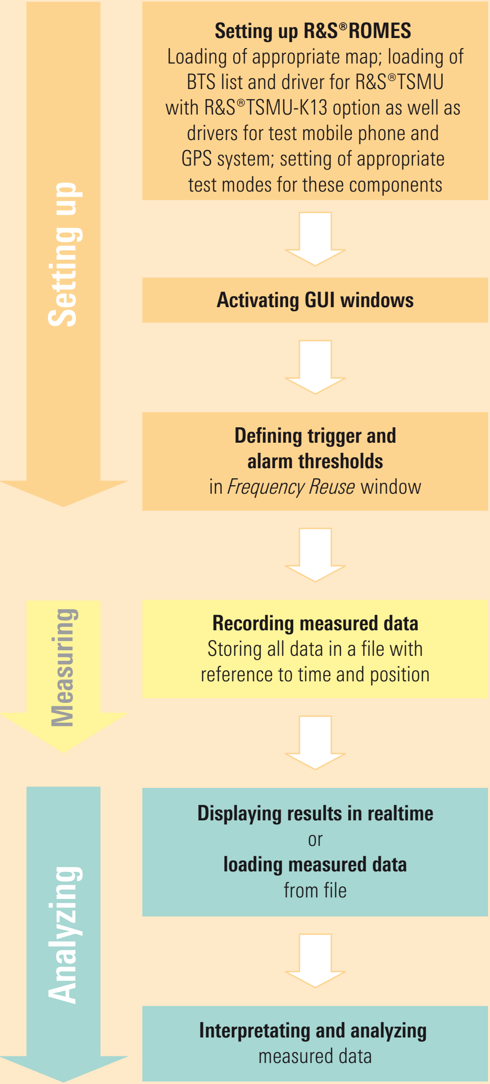


GSM NWS Transmitter Scan View

CH	POWER	BSIC	CI	LAC
14	-76.12	30	11521	34567
15	-95.16	34		
15	-84.28	30		
15	-85.32	35		
16	-75.96	34	54502	34567
16	-73.40	33	26953	34567
17	[illegible]	[illegible]	51167	34567
18	-64.68	37	26952	34567
[illegible]	[illegible]	[illegible]	[illegible]534	34567
19	-78.28	31	2057	34568
20	-81.72	31	49744	34308
20	-75.32	34	32925	34567
20	-83.80	33	51172	34567
[illegible]	[illegible]	32		
21	-63.16	31	26954	34567
22	-77.80	30		
22	-74.68	34	51170	34567
23	-70.84	30	27670	34567
[illegible]	[illegible]	[illegible]		
24	-94.84	35		
24	-88.84	31		
27	-82.44	34		
[illegible]	[illegible]	[illegible]	[illegible]	34310

FIG 5 Co-channel signals are identified and displayed separately.

FIG 7 Sequence of GSM interference measurements in detail.



MNC	MCC	T (MEAS)	T (TDMA)	FN	T3
001	262	0:03:21	3.056	1881799	1
		0:02:39	4.570	781509	36
		0:03:20	6.066	1797239	50
		0:03:21	1.955	162695	5
001	262	0:03:20	6.035	2259582	27
001	262	0:03:21	2.814	1853850	0
001	262	0:03:19	5.409	1034094	18
001	262	0:03:21	2.814	1853850	0
001	262	0:03:15	3.054	1881799	1
001	262	0:03:21	5.825	2340248	11
001	262	0:03:05	1.448	16270	1
001	262	0:03:19	4.139	2238808	10
001	262	0:03:19	5.409	1034094	18
		0:02:34	6.998	959807	38
001	262	0:03:21	2.814	1853850	0
		0:03:21	3.334	2226819	6
001	262	0:03:21	5.410	1034094	18
001	262	0:03:21	2.634	1516143	15
		0:02:30	0.522	492767	5
		0:03:21	3.304	2314136	11
		0:03:21	0.482	2058628	13
		0:03:20	0.427	2420208	3
001	262	0:03:21	2.434	2510416	43

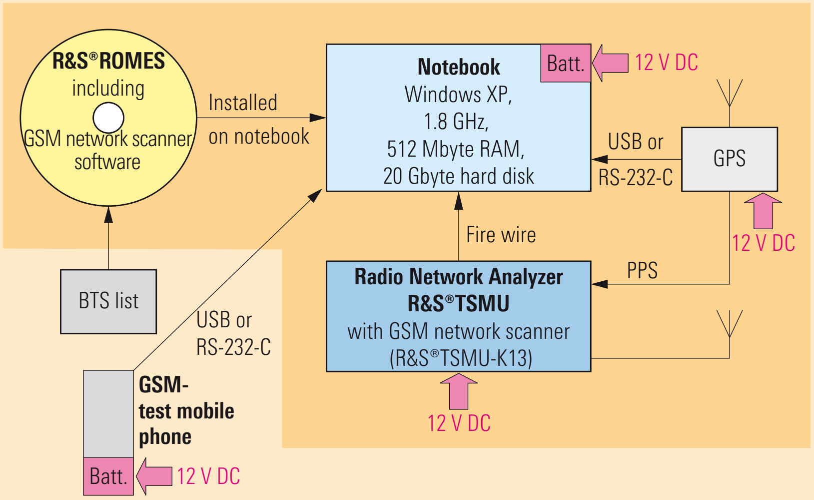


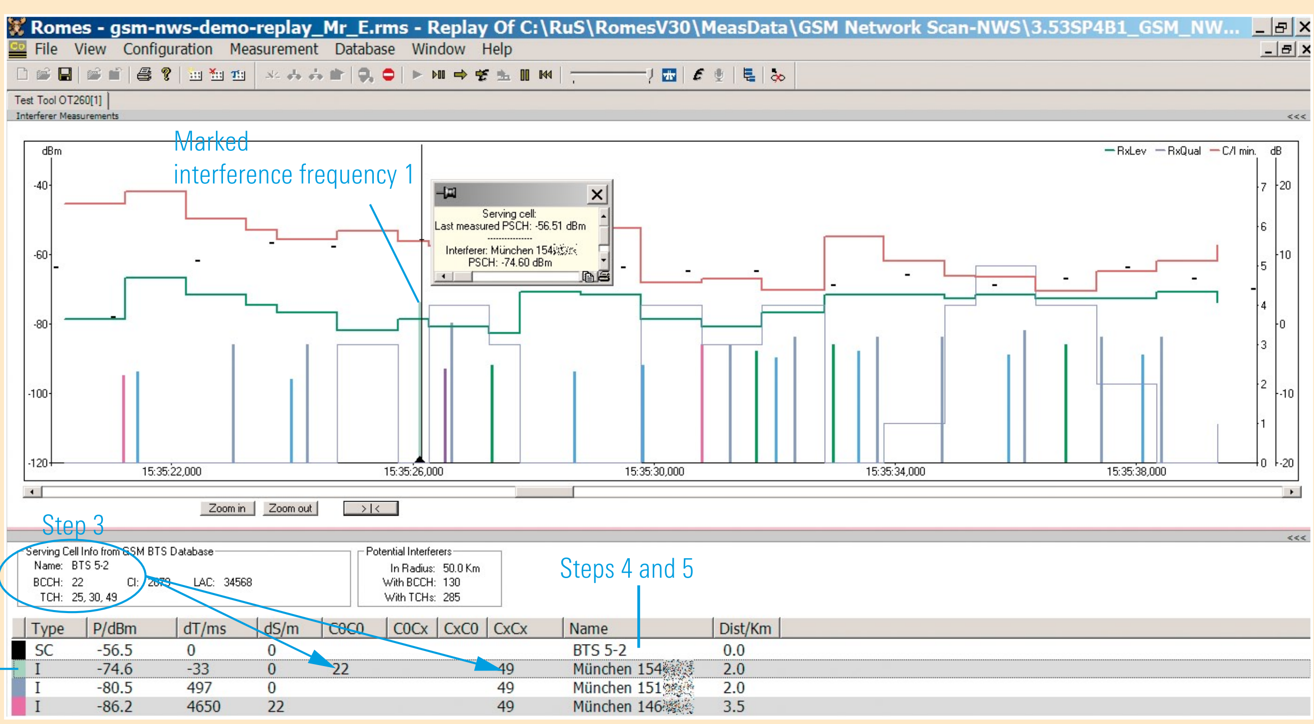
FIG 6 Components required for GSM interference analysis.

Romes - gsm-nws-demo-replay_Mr_E.rms - Replay Of C:\RuS\RomesV30\MeasData\GSM Network Scan-NWS\3.53SP4B1_GSM

	Time	Details	Serving ...	Chan.	C/I dB	Mobile	Length	Duration
1	15:32:40,175	Mobile measured C/I < threshold value	BTS 5-1	44	-6.0	Test Tool OT260[1]	14.8	1.0
2	15:32:54,769	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-1	H	-	Test Tool OT260[1]	9.3	1.0
3	15:33:04,330	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-1	H	-	Test Tool OT260[1]	4.3	1.0
4	15:33:16,924	Mobile measured C/I < threshold value	BTS 5-1	89	9.0	Test Tool OT260[1]	0.0	2.0
5	15:33:24,971	Mobile measured C/I < threshold value	BTS 5-1	44	9.8	Test Tool OT260[1]	0.0	2.0
6	15:33:28,486	Mobile measured C/I < threshold value	BTS 5-1	44	9.9	Test Tool OT260[1]	0.0	1.0
7	15:34:41,970	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 7-1	32	-	Test Tool OT260[1]	6.5	2.0
8	15:34:41,970	Mobile measured C/I < threshold value	BTS 7-1	32	5.8	Test Tool OT260[1]	6.5	2.0
9	15:35:13,673	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	10.8	1.5
10	15:35:12,673	Mobile measured C/I < threshold value	BTS 5-2	49	5.3	Test Tool OT260[1]	8.9	1.5
11	15:35:15,188	Mobile measured C/I < threshold value	BTS 5-2	30	9.0	Test Tool OT260[1]	20.3	1.0
12	15:35:29,783	Mobile measured C/I < threshold value	BTS 5-2	49	5.8	Test Tool OT260[1]	0.9	1.0
13	15:35:30,797	Mobile measured C/I < threshold value	BTS 5-2	22	6.3	Test Tool OT260[1]	0.0	8.5
14	15:35:41,361	Mobile measured C/I < threshold value	BTS 5-2	30	6.3	Test Tool OT260[1]	0.0	1.5
15	15:35:40,359	Mobile measured C/I < threshold value	BTS 5-2	22	9.2	Test Tool OT260[1]	0.0	4.0
16	15:35:53,939	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	21.9	1.0
17	15:36:03,502	Mobile measured C/I < threshold value	BTS 5-2	49	9.6	Test Tool OT260[1]	8.8	1.0
18	15:36:04,516	RxLev/RxQual thresholds in dedicated mode exceeded	BTS 5-2	H	-	Test Tool OT260[1]	8.6	1.0

FIG 8 *Frequency Reuse Event* display listing interferences determined as a function of the set thresholds.

FIG 9 *Frequency Reuse C0* display.



An investment that pays off rapidly

Detecting and identifying interferences used to be an extremely time-consuming procedure. The Radio Network Analyzer R&S®TSMU automatically detects and analyzes interfering base stations in a short time, including plain-text display, without requiring any manual reworking. The R&S®ROMES software ensures highly convenient, flexible and efficient operation of the system.

More information and data sheets on R&S®TSMU and R&S®ROMES at www.rohde-schwarz.com (search term: TSMU/ROMES)

REFERENCES
Radio Network Analyzer R&S®TSMU: Unprecedented quality for mobile measurements in GSM networks. News from Rohde&Schwarz (2005) No. 186, pp 4–7

Summary

The Radio Network Analyzer R&S®TSMU from Rohde&Schwarz is a high-end analysis tool for radio coverage measurements. With the appropriate options installed, this compact solution not only supports network operators in planning and optimizing their GSM networks, but also helps them set up and structure WCDMA and HSDPA networks.

Christian Fischer; Johann Maier

Condensed data of the R&S®TSMU with R&S®TSMU-K13 option

Sensitivity	<–112 dBm
Level error	±1 dB
Minimum C/I for initial decoding of CI, MNC, MCC, LAC, etc	>2.5 dB
Level measurement rate including the decoding of CI, BSIC, LAC, MNC, MCC	up to 80 channels/s
Cycle times (typ. / max.)	
GSM900	1.54 s / 3 s
GSM1800	4.65 s / 9 s
GSM-R	0.25 s / 0.5 s

Abbreviations

ARFCN	Absolute radio frequency channel number
BCC	Base station color code
BCCH	Broadcast control channel
BSIC	Base station identity code
BTS	Base transmitter station
C/I	Carrier-to-interference ratio
CI	Cell identity
CCCH	Common control channel
FCCH	Frequency correction channel
LAC	Location area code
MCC	Mobile country code
MNC	Mobile network code
NCC	Network color code
SC	Serving cell
SCH	Synchronization channel

Highlights of the R&S®TSMU with the R&S®TSMU-K13 GSM option

- Efficient, time-saving optimization of GSM, GPRS and EDGE radio networks independently of the infrastructure
- Covers all GSM frequencies (GSM 450/850/900/1800/1900/GSM-E/GSM-R)
- Multichannel capability within a measurement setup
- Higher measurement speed and measurement accuracy than obtainable with test mobile phones
- Requires no network authorization by means of SIM card
- Can be used with GSM, GPRS and EDGE test mobile phones for triggering and signaling
- Identification and analysis of roaming problems and interferences originating, for example, from networks of neighboring countries
- Automatic off-the-air measurement and demodulation of all GSM channels
- Decoding of type 1 to 4 system information such as NCC, BCC, CI, LAC, MNC and MCC; output of ARFCN, RF level, and name and position of base station
- Supplies coverage measurement data, i.e. one measurement value per time stamp and position

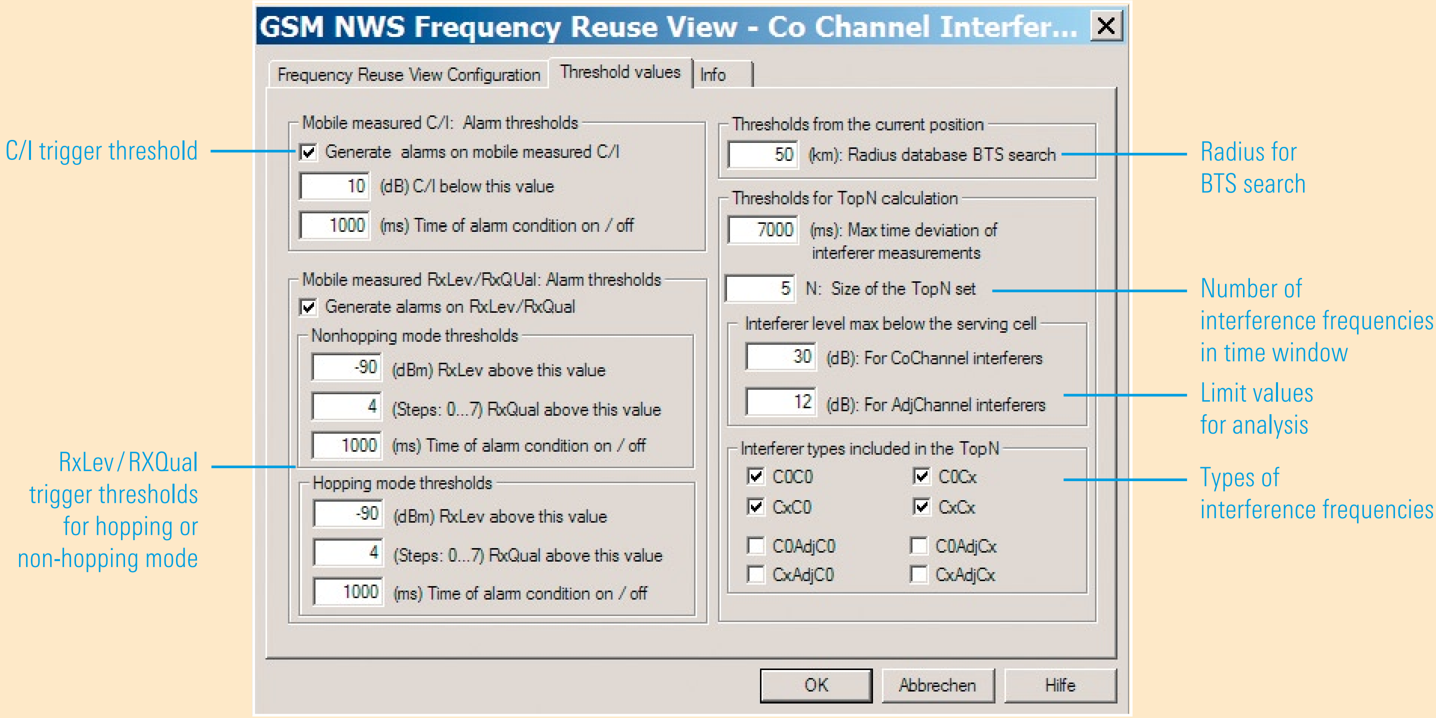


FIG 10 Menu for defining the thresholds and other parameters for interference analysis.

FIG 11 Complete, straightforward and correlated representation of results.