1. Introduction

1.1 Background to spectrum engineering

The radio spectrum is a limited resource and can only be used optimally if compatibility is assured between wireless systems located in the same or adjacent frequency bands. For example, an important criterion for radio compatibility is the difference between the wanted and unwanted signal levels in the victim link receiver input. This parameter can be used to derive a separation in physical position or frequency between the victim and interfering systems. Considering only the adjacent bands, the most significant interference mechanisms are unwanted emissions from interfering transmitters as well as blocking and intermodulation in the victim link receiver.

A statistical simulation model based on the Monte-Carlo method has been developed within the CEPT Working Group Spectrum Engineering, named SEAMCAT® (Spectrum Engineering Advanced Monte-Carlo Analysis Tool). This software implementation allows quick yet reliable considerations of spatial distributions of the received signals and the resulting statistical probability of interference in a wide variety of scenarios. By adapting the operational conditions of radio systems with respect to the probability of exceeding the protection criterion, the most efficient use of the radio spectrum can be identified

SEAMCAT is software that simulates radio spectrum systems, allowing the implementation of user customized libraries and the use of those provided by other users to ease the effort to build complete scenarios. These libraries may contain predefined antenna patterns, spectrum emission masks, propagation models, complete radio systems, etc.

SEAMCAT version 5 and upward provides multicore processing allowing for fast computations.

It is possible to join the SEAMCAT community to contribute to the development of the software and libraries, as explained in Section 1.8.


HERE IS THE INTRODUCTION TO THE SOFTWARE... JUST TO START WITH...
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CHAPTER 1
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1.2 Basic Radio Frequency Terminology

The following terminology has been developed to support the SEAMCAT simulation tool. While it is broadly in line with what is in use in ITU-R, ETSI, and CEPT, it may be expected that for other needs or documents, ETSI and CEPT/ECC will use different definitions, for example definitions more focused on specific equipment characteristics or aspects of such products.

1.2.1 Receiver thermal noise

The thermal noise (in Watts) expressed in power level is defined as:

$$N_0(Watts) = k_B T B$$

where:

- k_B is the Boltzmann's constant 1.38 x 10^{-23} in joules per kelvin (J/K),
- T is the receiver absolute temperature in Kelvin (K),
- B is the bandwidth in Hertz (Hz) over which the noise is measured.

It can be seen that the noise power of eq1 is dependent on the temperature and on the bandwidth. This figure is then normally expressed in terms of dBm and is defined as:

$$N_0(dBm) = -173.977 + 10 * log10(SystemBandwidth(Hz))$$

1.2.2 Noise figure and Noise factor

Noise figure (NF) and noise factor (F) are measures of degradation of the signal-to-noise ratio (SNR), caused by components in a radio frequency (RF) signal chain. It is a number by which the performance of an amplifier or a radio receiver can be specified, with lower values indicating better performance.

The noise factor is defined as the ratio of the output noise power of a device to the portion thereof attributable to thermal noise. The noise factor is thus the ratio of actual output noise to that which would remain if the device itself did not introduce noise, or the ratio of input SNR to output SNR.

The noise figure is simply the noise factor expressed in decibels (dB).

$$NF = 10 * \log_{10}(F) \qquad \text{(Eq. 3)}$$

1.2.3 Receiver noise floor

Any practical measurement will be subject to some form of noise or unwanted signal (thermal noise or interfering signals). The noise floor limits the smallest measurement that can be taken with certainty since any measured amplitude cannot on average be less than the noise floor.

The noise floor (*N*) is the level of noise introduced by the receiver system below which the signal that is being captured cannot be isolated from the noise, and is defined in dBm as:

$$N\ (dBm) = N_0\ (dBm) + NF\ (dB) \qquad (Eq.\ 4)$$

or in linear domain:

$$N\ (Watts) = 10\hat{}((-173.977 + 10{*}\log_{10}(systemBandwidth\ (Hz)) + NF)/10) \qquad (Eq.\ 5)$$

As an example, in SEAMCAT, for a receiver with a noise figure of 9 dB and a bandwidth of 5 MHz, the noise floor will be

$$-173.977\ \text{dBm/Hz} + 60\ \text{dB/MHz} + 10{*}\log_{10}(5\ \text{MHz}) + 9\ \text{dB} = -98\ \text{dBm}$$

Another example is that for a noise figure of 4 dB and a bandwidth of 200 kHz with thermal noise = kTB = -121 dBm, the noise floor is -117 dBm.

In SEAMCAT, the input is the distribution of the strength of the noise floor. This parameter is used for the probability calculation when the criteria is C/(N+I), (I/N) or (I+N)/N.

1.2.4 Receiver sensitivity

The sensitivity of a receiver is normally taken as the minimum input signal (S_{min}) required to produce an output signal with a specific signal-to-noise (S/N) ratio. S/N is a required minimum ratio, if N is increased, then S must also be increased to maintain the S/N ratio. The threshold value is chosen high enough above the mean noise level so that the probability of random noise peaks exceeding the threshold, and causing false alarms, is acceptably low. It is defined (in log domain/dB) as

$$Sensitivity = NoiseFloor + Receiverprotectionratio \quad \text{(Eq. 6)}$$

In SEAMCAT, the following equation (in log domain/dB) is applied:

$$Sensitivity = NoiseFloor + C/(N+I) \quad \text{(Eq. 7)}$$

Where C/(N+I) is the carrier (or signal) to interference plus noise ratio as input to SEAMCAT. The S/N is equal to the C/(N+I) in the absence of any interferer.

In SEAMCAT, this is used in the calculation of the receiver attenuation in Sensitivity mode. See Annex A8.5 for further details.

1.2.5 Wanted signal: dRSS

The **victim’s wanted signal strength** also called **desired Received Signal Strength** (dRSS), corresponding to the carrier level (C), is calculated as a simple link budget between the victim link receiver (VLR) and the victim link transmitter (VLT) as described in ANNEX 4:.

1.2.6 Interfering signal: iRSS

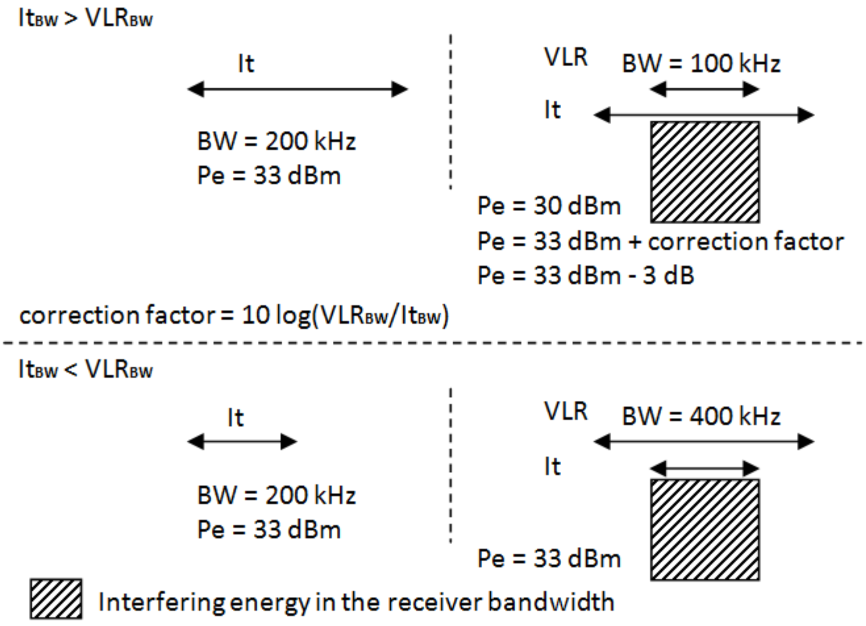
The **interfering Received Signal Strength** (iRSS), corresponding to the interference level (I), is calculated as a link budget between the VLR and the interfering link transmitter (ILT) as described in ANNEX 5:.

The various interference mechanisms resulting in different iRSS (i.e. unwanted, blocking and intermodulation) are described in Section 1.4.5.

1.2.7 Bandwidth correction factor

When the bandwidth of the interferer and the victim are different, SEAMCAT automatically applies a bandwidth correction factor to calculate the unwanted emission power for a specific bandwidth.

The following example introduces an interferer transmitting 2 W. This is equivalent to 33 dBm (see conversion in Table 97). The amount of energy that a VLR receives in its bandwidth can be derived according to these two cases illustrated in Figure 1.



Further examples of correction bandwidth can be found in section 3.3.8.

1.2.8 Desensitisation

Desensitisation (D) of the receiver in the presence of an interfering signal, given in dB, corresponds to the ‘noise rise’ or ‘noise augmentation’ due to the interfering signal and is derived by the following equation in dB:

$$\mathrm{D} = 10.\log10[(\mathrm{i} + \mathrm{n})/\mathrm{n}]$$

(Eq. 8)

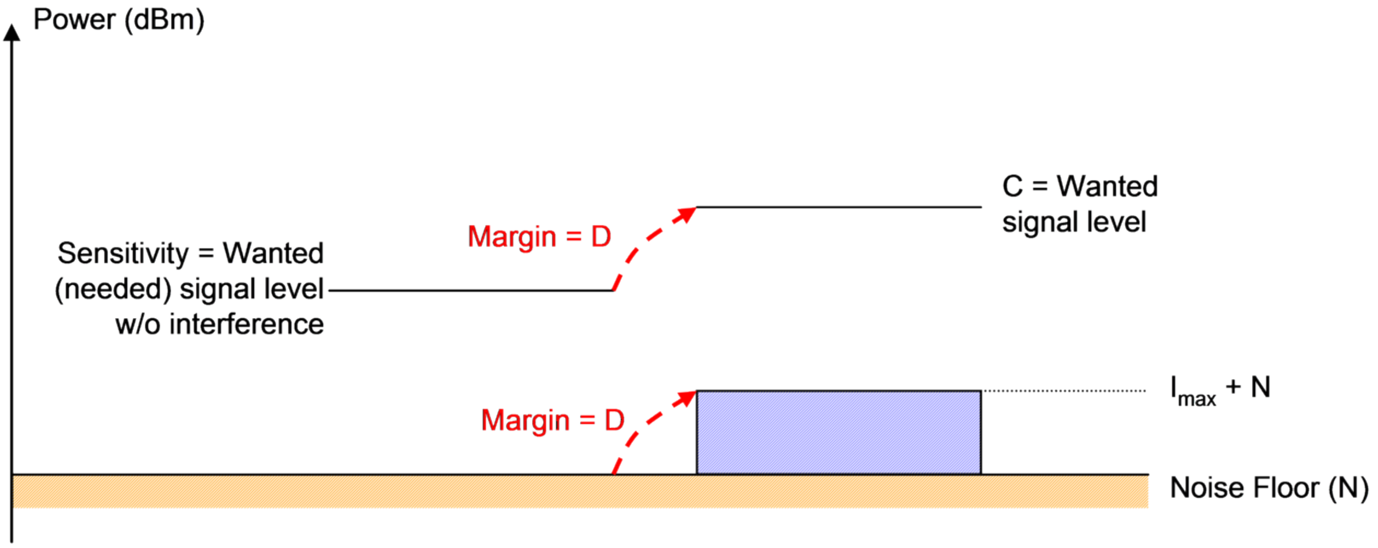
and is equivalent in the linear domain to:

$$\mathrm{D} = 10.\log10[(10(\mathrm{N}/10) + 10(\mathrm{I}/10))] - \mathrm{N}$$

(Eq. 9)

To ensure proper operation, the receiver is designed to include a margin equal or lower than D which allows it to tolerate a certain level of interference (I) in the listened channel. This can be caused by co-channel and/or non-co-channel interference sources.

When running a radio network or a radio link, the objective is to maintain the signal to interference and noise ratio SINR equal to the sensitivity to noise ratio. This is illustrated in the following figure.



An equivalent expression of the desensitisation, (N+I)/N, is expressed as follows in terms of interference to noise ratio I/N in dB.

$$\mathrm{I/N} \ = 10.\log10(10\mathrm{D}/10 - 1)$$

(Eq. 10)

noting that in linear domain it is equivalent to:

$$\mathrm{I/N} \ = 10.\log10(10\mathrm{D}/10 - 1)$$

(Eq. 11)

1.2.9 Blocking

The term “Blocking” is used in SEAMCAT to describe the capability of the victim receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted input signal on a different frequency than the one of the wanted signal.

It has to be noted that most standards and specifications distinguish between the receiver selectivity given as Adjacent Channel Selectivity (ACS) for frequency offsets close to the centre frequency of the VLR, and Blocking (a term often associated with desensitisation) for frequency offsets far away from the centre frequency of the VLR. It is assumed that the receiver blocking performance is flat over the bandwidth of the interfering signal.

1.2.10 Adjacent channel selectivity (ACS)

The receiver selectivity is often given as Adjacent Channel Selectivity (ACS) – i.e. when the concept of "channel" has been defined for the system being considered. As the wording suggests, this parameter defines the requirement in case one single ILT is set at the centre frequency of the (first) adjacent channel. The values for the second and third adjacent channel are occasionally also defined by a standard. However, standards generally implicitly define the interfering signal as of the same system type as the victim, i.e. using the same bandwidth and generally the same or at least a similar modulation scheme.

1.2.11 In-band, out-of-band, spurious, unwanted emission

In-band emission is understood as relating to the necessary bandwidth.

The ITU-R Radio Regulations define the followings in Nos. 1.152, 1.144, 1.145 and 1.146:

1.152 Necessary bandwidth: For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

1.144 Out-of-band emission: Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions.

1.145 Spurious emission: Emission on a frequency or frequencies which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

1.146 Unwanted emissions: Consist of spurious emissions and out-of-band emissions

These definitions are illustrated in the following figure (see also Figure 1 in ECC Recommendation (02)05 [18]):

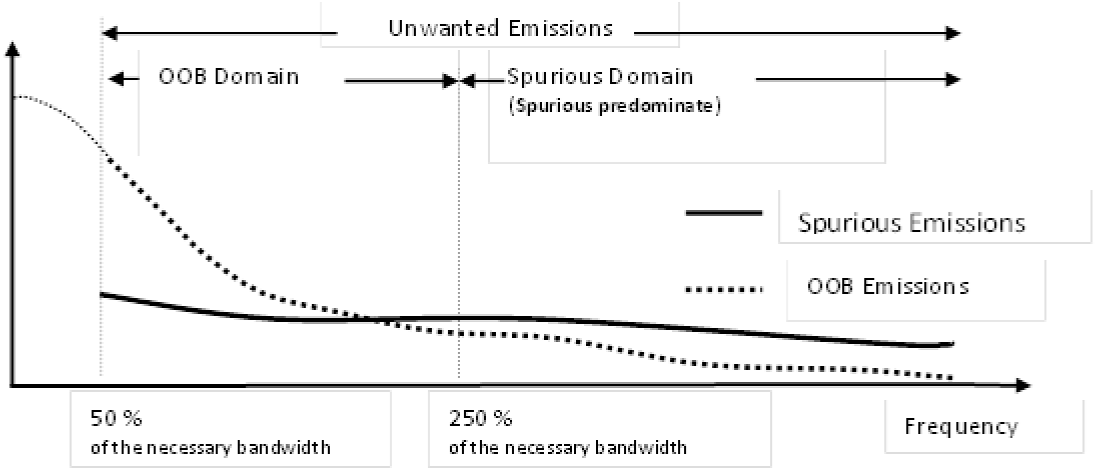


Figure 3:

Illustration of the OOB and Spurious Domains

1.2.12 Co channel

A co-channel interference scenario can be illustrated as shown in figure below. In this case a part or the whole component of the interference is within the receiver bandwidth of the victim receiver.

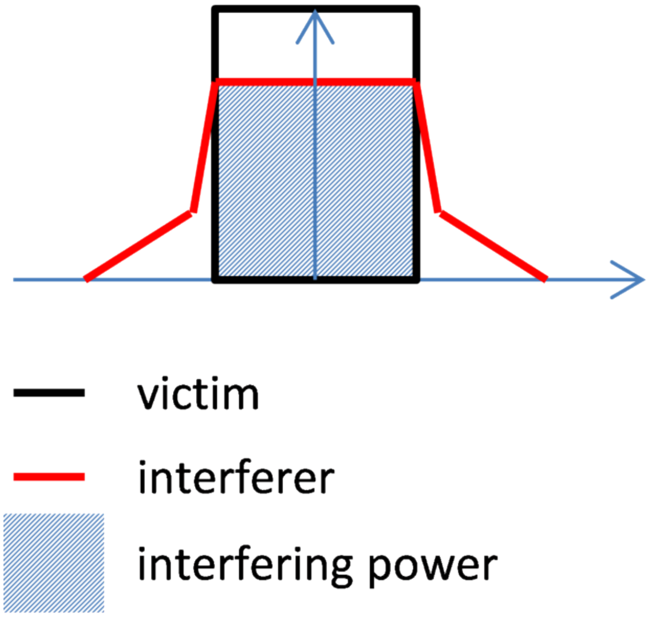


Figure 4: Co-channel interference scenario

1.3 Monte-Carlo Basics

The statistical methodology used as a basis for SEAMCAT is the Monte Carlo method. Statistical simulation methods may be contrasted to conventional analytical methods, which are typically applied to ordinary or partial differential equations that describe some underlying physical or mathematical system. In many applications of the Monte Carlo method, the physical process is simulated directly and there is no need to even write down the differential equations that describe the behaviour of the system.

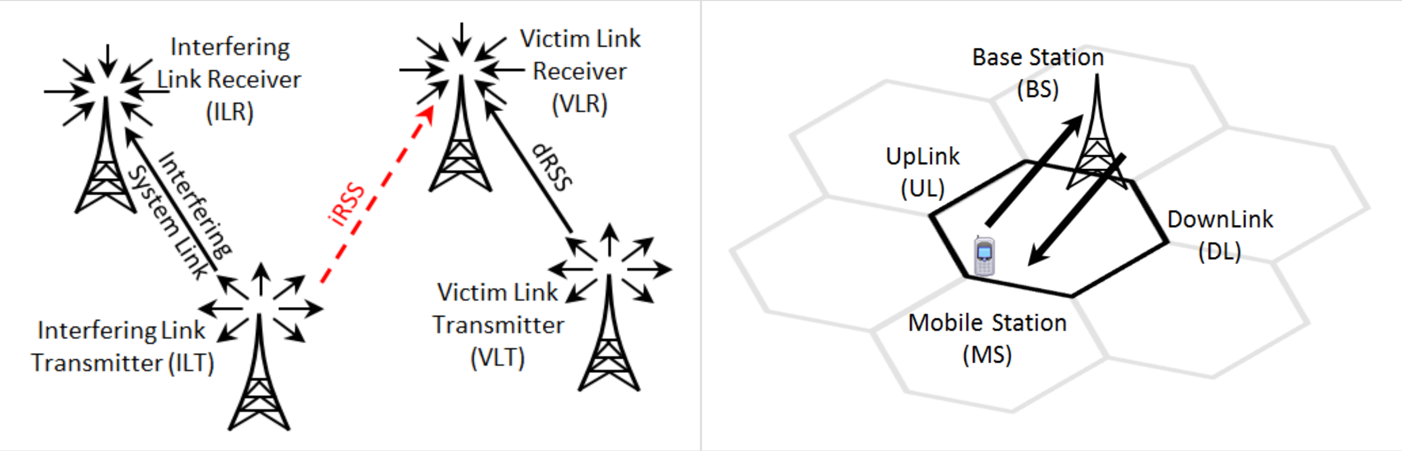
The Monte-Carlo simulation method is based upon the principle of taking samples of random variables from a given distribution. Before the simulation the distributions need to be defined for all relevant parameters of the wireless systems to be modelled (e.g. antenna heights, powers, operating frequencies, positions of the transceivers, etc.). Fixed values can be specified for parmaters which do not vary in the scenario (e.g. systems with specific frequenecies or heights). The technical specifications of the receiver and transmitter are generally extracted from relevant equipment standard (e.g. standards produced by ETSI, 3GPP, IEEE etc.).

SEAMCAT uses these distributions to generate random events (Event, snapshot and simulation trial have the same meaning in this report) using samples of the above mentioned distributions. For each event, SEAMCAT stores the signal strength of the interfering and the desired signals calculated in dedicated data arrays. As a very final step, the probability of interference can be calculated by comparing the wanted and unwanted signals at the victim link receiver in each event to the relevant interference criterion (e.g. C/I).

The only requirement is that the physical or mathematical parameter can be described by a probability density function (PDF). Once the PDFs of the relevant parameters are known, the Monte Carlo simulation can proceed by randomly sampling them. Many simulation trials are performed with different random samples for each trial and the desired result is taken as an average over the number of observations. In many practical applications one can predict the statistical error in this average result and hence an estimate of the number of Monte Carlo trials that are needed to achieve a given error.

SEAMCAT models one single victim link receiver (VLR) connected to a victim link transmitter (VLT) operating amongst a population of one or more interfering link transmitters (ILT) which are linked to an interfering link receiver (ILR). These interferers may belong to the same system as the victim, a different system or a mixture of both. The locations of the interferers are distributed around the victim either completely randomly or with some relation to the location of victim in a manner that can be specified by the user.

Figure 5 illustrates the terminology of the various elements that are simulated for (a) ‘generic’ systems (i.e. non-cellular) and (b) cellular systems.'



(a) (b)

Figure 5: Terminology used in SEAMCAT (a) generic systems and (b) cellular systems

It is common practice to use a uniform random distribution for the locations of the transceivers. The density of interferers is set in line with the environment being modelled, i.e. an urban environment should have a higher density than a rural environment. Only a proportion of the interferers are active at any instance. This proportion may depend for example on the day of the week as well as the time of day. Figure 6 illustrates how the interferers and victim may appear for one simulation trial. Also illustrated is the victim link transmitter providing the victim’s wanted signal (dRSS: desired Received Signal Strength).

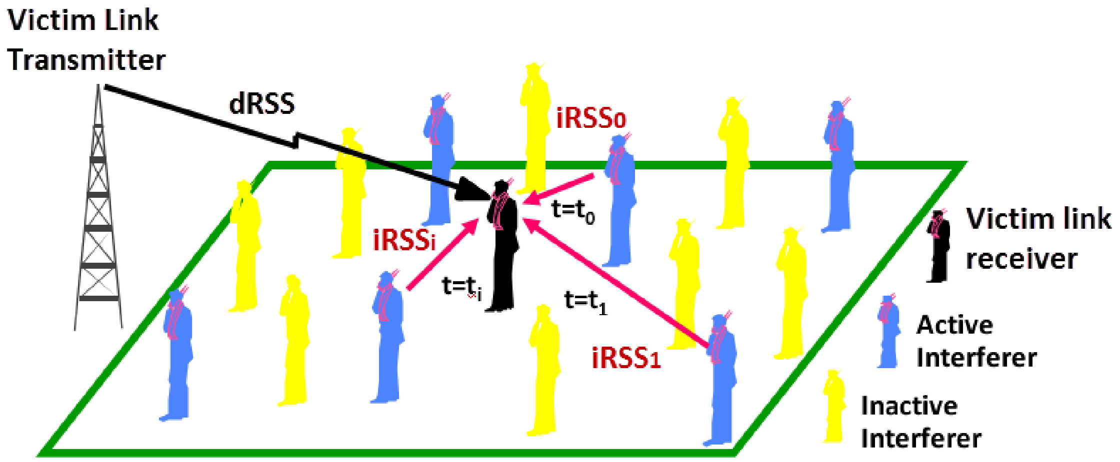


Figure 6: A typical victim and interferer scenario for a Monte Carlo simulation trial

For cellular simulations, the generation of events includes additional complexity - several iterations of a power control loop (CDMA) may be needed within each event, and some initial pre-calculations are required, such as the calculation of non-interfered (nominal) capacity. For victim CDMA systems the interference criterion is the excess outage, i.e. the percentage of previously served users disconnected as a result of the interference impact. For victim OFDMA systems the interference criterion is the bitrate loss, i.e. the percentage of bit-rate lost compared to a non interfered victim network.

1.4 Interference calculations in generic systems

1.4.1 Introduction

In this section the interference calculations for ‘generic’ systems are described. Cellular systems (OFDMA and CDMA) use a different interference calculation method based on throughput

and capacity loss which are described in more detail in ANNEX 15:

1.4.2 An illustration with C/I as interference criterion

The C/I ratio available at the victim receiver’s input is computed using both the iRSS (Interfering Received Signal Strength) and the dRSS (desired Received Signal Strength),. Figure 7 illustrates the various signal levels used to determine whether or not interference is occurring.

Figure 7(a) represents the situation in case of no interference - the VLR is receiving the dRSS with some safe margin above its sensitivity level. The victim’s signal level is the sum of the sensitivity and wanted signal margin l.

Figure 7 (b) illustrates the case of tolerable interference. The interference power iRSS adds to the noise floor power resulting in an increase of the noise floor. The example introduces an increase of 1 dB of the noise floor caused by an iRSS 6 dB below the noise floor. As a result the wanted signal margin is also reduced by 1 dB assuming a constant wanted signal power. However since the original wanted signal margin is much larger the interference is tolerable –i.e. the C/I ratio available at the receiver’s input is larger than the S/N required for the operation of the system.

Figure 7(c) shows the case of interference which can not be tolerated – i.e. the operation of the system is impaired. The power sum of all the interfering signals including the noise floor of the receiver results in an insufficient wanted signal margin -, i.e. the C/I ratio available at the receivers input is less than the S/N ratio required for the intended operation.

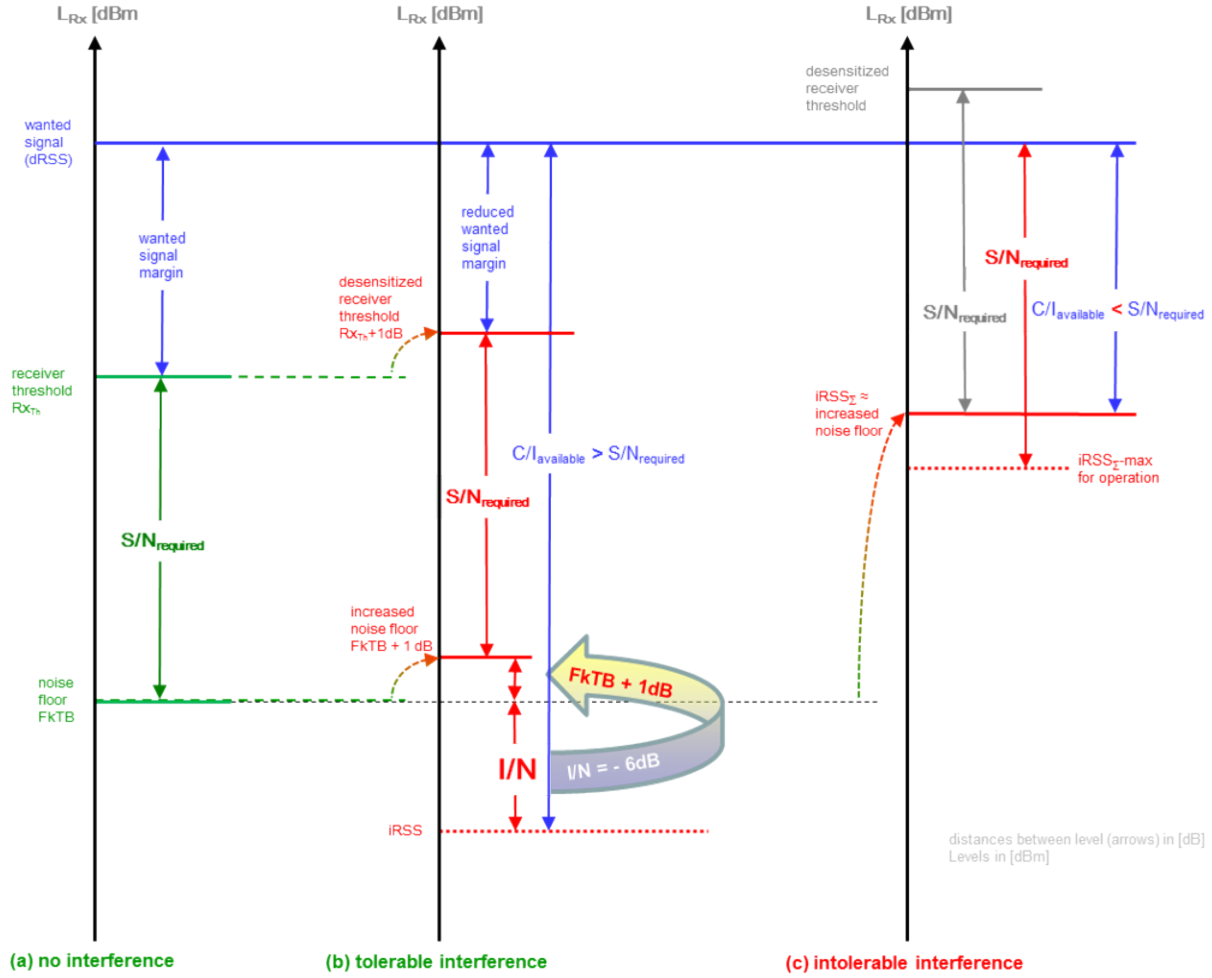


Figure 7: Levels used to determine whether or not interference is occurring

As a receiver cannot distringuish between various sources of interference or noise, the sum of all interefing signals including the receiver noise floor has to be taken into account. The C/I ratio available at the receiver's input must be greater than the S/N required for the operation of the system if the interference is to be avoided. SEAMCAT checks for this condition and records whether or not degradation due to interference is occurring. This is illustrated further in Figure 8

The Monte Carlo technique works by considering many independent events in time (or in space). For each instant a scenario is built up using a number of different random variables, i.e. where the interferer is located with respect to the victim, the signal strength of the wanted signal, which channels the victim and interferer are using etc. If a sufficient number of simulation trials are run then the probability of a certain event occurring can be calculated with a high level of accuracy.

In this way, the tool is able to quantify the ***probability of interference*** between radio systems and is able to help determine appropriate frequency arrangement rules or identify suitable limits for transmitter/receiver performance.

You can select the ***interfering modes*** (unwanted and blocking) as well as the ***interference criteria*** of your choice in SEAMCAT as shown in Figure 97.

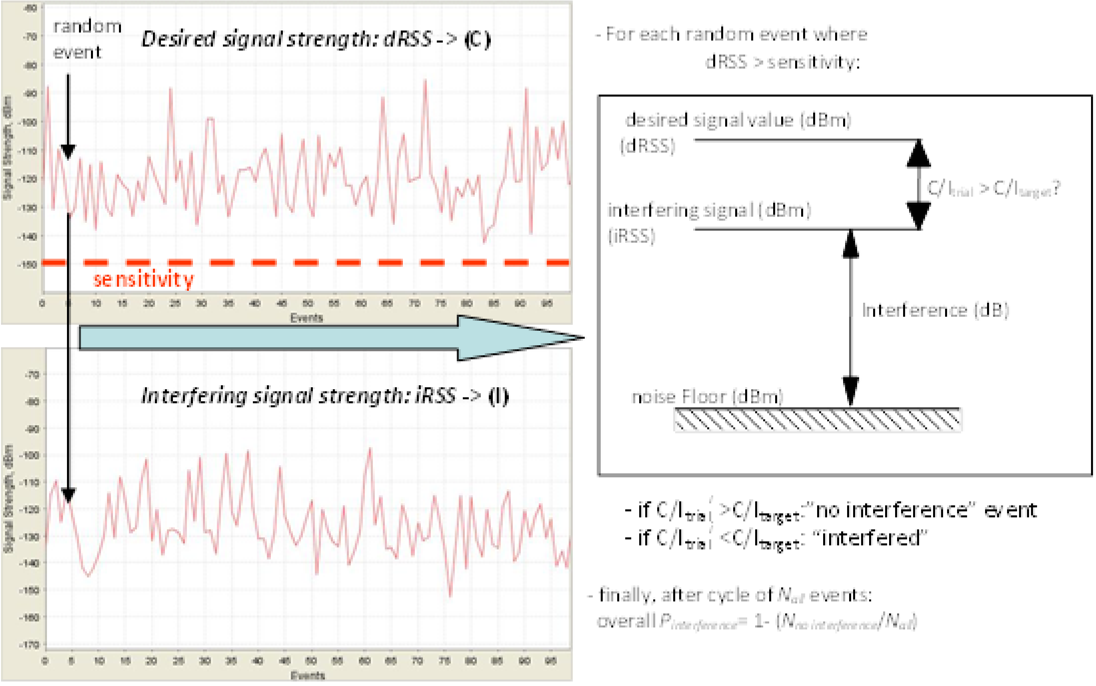


Figure 8: Illustrative summary of the interference criteria computation

1.4.3 Methodology associated to the interference criterion (C/I, C/(I+N), (N+I)/N, I/N)

Four interference criteria are considered within SEAMCAT:

- C/I   : Carrier to interference ratio;
- C/(I+N)   : Carrier to interference plus noise ratio;
- (N+I)/N   : Desensitisation;
- I/N   : Interference to noise ratio.

All of these criteria can be specified as an input to your simulation. (Figure 9), but a single criteria needs to be chosen for the interference calculation (Figure 10). Multiple interference calculations are possible on the same set of results if more than one criterion are used separately. In the example below the criterion for interference to occur for the VLR isa carrier to interference ratio (C/I) less than the minimum allowable value of 19 dB-

These parameters are also used in the evaluation of the two blocking modes (Protection ratio and Sensitivity, see section 1.4.5).

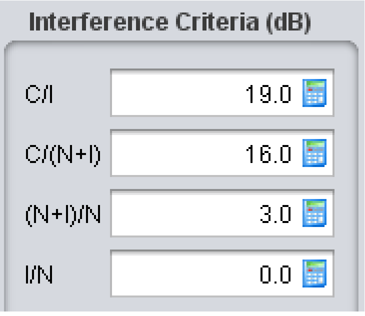
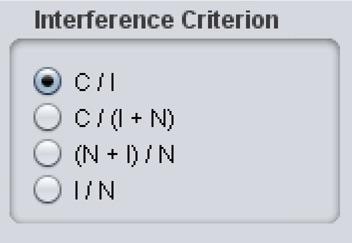
 **Interference Criteria (dB)** C/I 19.0 C/(N+I) 16.0 (N+I)/N 3.0 I/N 0.0	 **Interference Criterion** ● C / I ○ C / (I + N) ○ (N + I) / N ○ I / N

Figure 9: Interference criteria values that you provide as input to your simulation	**Figure 10: Selection of the interference criteria used for the evaluation of interference (from the Interference Calculation Engine control panel)**

1.4.4 Interference criteria relationship

C/I may vary typically from 9 dB (e.g. for QPSK) to 26 dB or higher (e.g. for 64QAM…). By introducing artificial noise iRSS on top of the noise floor (I/N), C/I is then desensitised by (N+I)/N resulting in C/(N+I). Note that the desensitisation is exactly the factor (N+I)/N (also = 1+I/N).

Further details of the relationship are given in ANNEX 3:.

Considering that

$$\left[\frac{C}{N+I}\right]_{dB}=\left[\frac{C}{I}\right]_{dB}-\left[\frac{N+I}{I}\right]_{dB}; \text{ and } \left[\frac{N+I}{I}\right]_{dB}=\left[\frac{N+I}{N}\right]_{dB}-\left[\frac{I}{N}\right]_{dB} \quad \text{(Eq. 12)}$$

and assuming a C/I of 19 dB, the following examples may be considered:

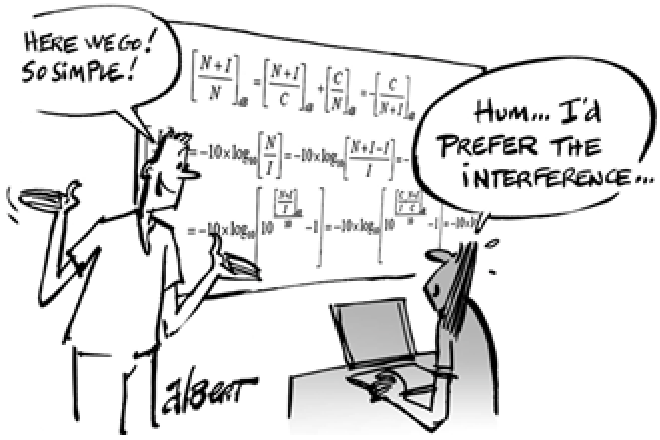
- I/N = 0 dB, results in (N+I)/N = 3 dB and considering C/I = 19 dB, then C/(N+I) = C/I - 3 dB = 16 dB
- I/N = -6 dB, results in (N+I)/N » 1 dB and considering C/I = 19 dB, then C/(N+I) = C/I - 7 dB = 12 dB
- I/N = -10 dB, results in (N+I)/N » 0.4 dB and considering C/I = 19 dB, then C/(N+I) = C/I - 10 dB = 9 dB
- I/N = -20 dB, results in (N+I)/N = 0.04 » 0.1 dB and C/I = 19 dB, then C/(N+I) = C/I - 20 dB = -1 dB

Note:

In case C/(I+N) is chosen as the protection criterion:

if I/N ≤ -20 dB, the impact of the interferer is negligible compared to the noise floor (i.e. C/(I+N) ≈ C/N);

if I/N > 10 dB, then C/(I+N) ≈ C/I (i.e. the interferer is more dominant than the noise).


HERE WE GO! SO SIMPLE!
$\left[\frac{N+I}{N}\right]_{dB} = \left[\frac{N+I}{C}\right]_{dB} + \left[\frac{C}{N}\right]_{dB} = -\left[\frac{C}{N+I}\right]_{dB}$
$= -10 \times \log_{10}\left[\frac{N}{I}\right] = -10 \times \log_{10}\left[\frac{N+I-I}{I}\right]$
HUM... I'd PREFER THE INTERFERENCE...
albert

1.4.5 Unwanted emissions

The level of ***unwanted emissions*** (i.e. consisting of the out-of-band emissions and the spurious emissions [8] of the ILT) falling within the VLR receiver bandwidth (Figure 11) is determined using the interferer's transmit mask, the receiver bandwidth of the VLR, the interferer-to-victim frequency separation, the gains of the antennas and the propagation loss. The receiver experiences the unwanted power directly as additional noise in terms of I+N. There is no possibility in terms of filtering with which the receiver could reduce this impact by itself.

Note that the receiver bandwidth is taken into account in the unwanted calculation.

Further details on the unwanted emission mask are provided in ANNEX 6:. Details on the iRSS$_{\text{unwanted}}$ calculation are given in ANNEX 5:. The unwanted emission is also sometimes quantified using the term Adjacent Channel Leakage Ratio (ACLR) (see Annex A15.7).

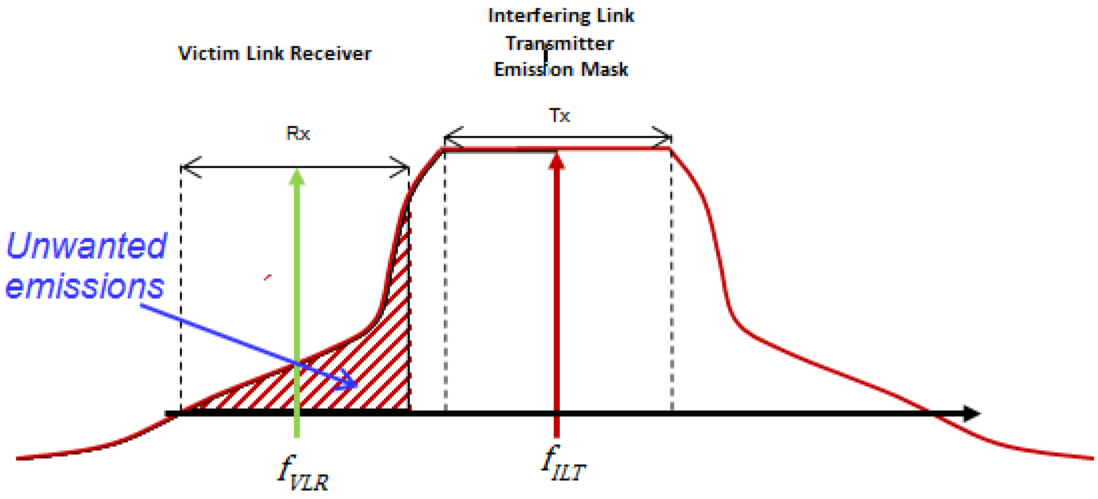


Figure 11: Illustration of the interference due to the unwanted emissions (i.e. the unwanted emissions of ILT falling in the receiver bandwidth of VLR)

1.4.6 Receiver blocking

The level of interference determined by the interferer’s transmit power, the antenna gains and propagation loss, is further decreased due to the receiver blocking performance for a given interferer/victim frequency separation. Details on the $iRSS_{blocking}$ calculation are given in ANNEX 5:.

Note that from SEAMCAT 5.0.1 onwards, the blocking attenuation is computed at the ILT frequency and that the ILT bandwidth is nowconsidered (see ANNEX 8:). There are 3 ways to calculate the blocking response which are described in more detail in ANNEX 8::

User Defined (dB): $Att_{Blocking} = Block_{UD}$ *(dB)* *(Eq. 13)*

Protection Ratio (dB): $Att_{Blocking} = Block_{PR\ (dB)} + C/(N+I)_{(dB)} + (N+I)/N_{(dB)} - I/N_{(dB)}$ *(Eq. 14)*

Sensitivity Mode (dBm): $Att_{Blocking} = Block_{Sens\ (dBm)} - Sensitivity_{VLR\ (dBm)} + C/(N+I)_{(dB)} - I/N_{(dB)}$ *(Eq. 15)*

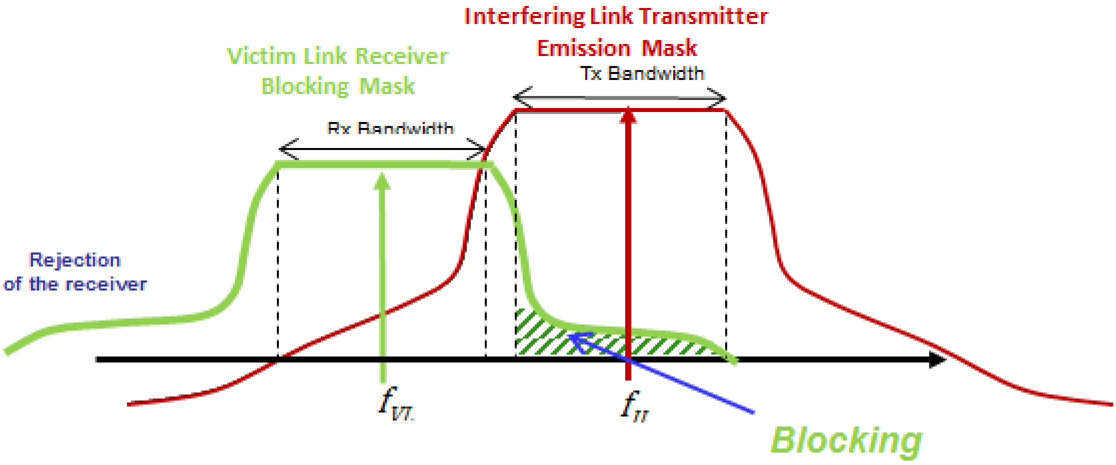


Figure 12:

Illustration of the blocking of the victim link receiver (i.e. total emission power of ILT reduced by the blocking attenuation (selectivity) function of the VLR

1.4.7 Intermodulation

The ***intermodulation interference***, i.e. the power of intermodulation products, reduced by the intermodulation attenuation function of the VLR can be used in interference calculations. See ANNEX 5: for further details.

1.4.8 Overloading

Overloading threshold is the minimum interfering signal levelat which the receiver loses its ability to discriminate against interfering signals at frequencies other than that of the wanted signal. See Annex A2.2 for the use of overloading in interference calculation and Annex A5.4. for the iRSS$_{\text{overloading}}$ calculation.

1.4.9 Combined interference mechanism

The combination of the ***unwanted emissions and receiver blocking*** can also be studied simultaneously in SEAMCAT as depicted in Figure 13. See Annex A2.3 for further details.

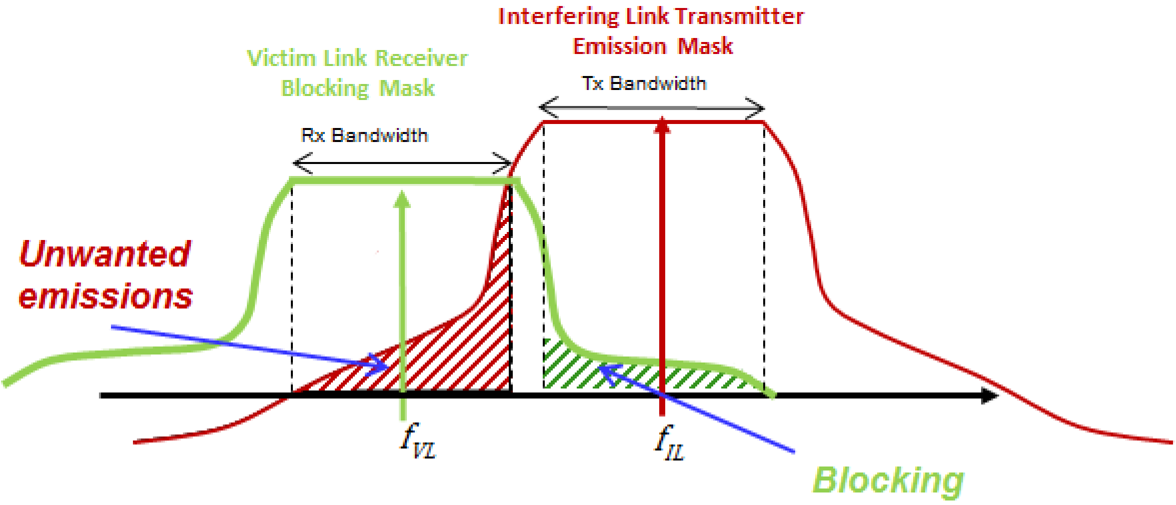


Figure 13: Illustration of the combined unwanted emissions and the receiver blocking mechanism in SEAMCAT

1.4.10 Interference calculation

SEAMCAT calculates the probability of interference for generic (i.e. non-cellular) victim systems. Each sample of dRSS and iRSS generated during a simulation is compared against the relevant signal-to-noise criterion (specified in the scenario, such as C/N, C/N+I etc). The probability of interference is calculated for all events where the dRSS is greater than the sensitivity of the victim link receiver ($dRSS >$ sens). This probability can be calculated for two different modes, as illustrated in Figure 271 of section 12.9.2.

- **Compatibility**: This mode provides a single-figure estimate of the probability of interference in a given interference scenario;
- **Translation**: This mode calculates probability of interference as a function of changing one of the following parameters:

1. Transmitter power of the interefering link transmitter;
2. Blocking response level of the victim link receiver;
3. Intermodulation rejection level for the victim link receiver

1.5 Applicability of SEAMCAT to spectrum engineering problems

SEAMCAT can address virtually all radio interference scenarios on terrestrial[1] paths in both co-channel (sharing) and adjacent frequency (compatibility) interference studies. This flexibility is achieved by the way the system parameters are defined as variable (or constant) through their distribution functions. It is therefore possible to model even very complex situations by relatively simple variations of some elementary functions. A number of various wireless services can be modelled using SEAMCAT, such as:

- Broadcasting: terrestrial systems and Earth stations of satellite systems;
- Fixed Services: Point-to-Point and Point-to-Multipoint fixed systems;
- Mobile Services: Land Mobile Systems, Short Range Devices and Earth based components of satellite systems.

Section 1.9 presents various radio systems that have been simulated in various ECC Reports.

In general, SEAMCAT may be used to address the following spectrum engineering issues:

- Sharing studies between different radio systems operating in the **same** frequency band;
- Compatibility studies between different radio systems operating in **different** frequency bands;
- Evaluation of transmitter and receiver masks;
- Evaluation of limits for certain system parameters, such as transmitter unwanted emissions (spurious and out-of-band), and receiver blocking or intermodulation levels.

SEAMCAT assumes a flat Earth model for calculating path geometries and propagation losses. This limits the range of considered standard interference scenarios to terrestrial configurations and non-path-specific propagation models. Certain aeronautical and space-to-Earth paths can also be modelled if suitable propagation models are used.

1.6 Understanding Radio Jargon

Many common terms in RF engineering are used differently depending on the specific community where they are used. The following gives a non-exhaustive example of the variety of terms that can be found.

C (i.e. the wanted signal level) is referred to in different radio standards and documents as follows. It is specified for a given sensitivity and a given desensitisation.

- Useful signal (ETSI TS 145.005 - Chapters 5.1.2 and 5.1.3);
- Wanted signal mean power (ETSI TS 136.104 - Table 7.5.1-1);
- Pw (ETSI TS 136.101 - Table 7.6.3.1-1);
- Prefsens + desensitisation (ETSI TS 136.104 - Table 7.5.1-1, ETSI TS 136.101 - Table 7.6.3.1-1) ;
- “C”.

I_{OOB} (i.e. the allowed power of an interfering blocking signal as specified by the standard) is referred to in different standards as follows. It is specified for a given frequency offset, a given sensitivity and a given desensitisation.

- *Blocking signal level* (ETSI TS 145.005 - Table 5.1-2a);
- *Puw* (ETSI TS 136.101 - Table 7.6.3.1-1);
- *Interfering signal mean power* (ETSI TS 136.104 - Table 7.5.1-1).

Sensitivity is referred to in different standards as:

- *Reference sensitivity level* (ETSI TS 145.005 - Tables 6.2-1x);
- *Reference sensitivity* (ETSI TS 136.101 - Table 7.3.1-1);
- *Reference sensitivity power level* (ETSI TS 136.104 - Tables 7.2.1-1 and 7.2.1-2);
- *Prefsens* (ETSI TS 136.101 - Table 7.3.1-1, ETSI TS 136.104 - Tables 7.2.1-1 and 7.2.1-2).

1.7 SEAMCAT software

1.7.1 Installation using .jar package

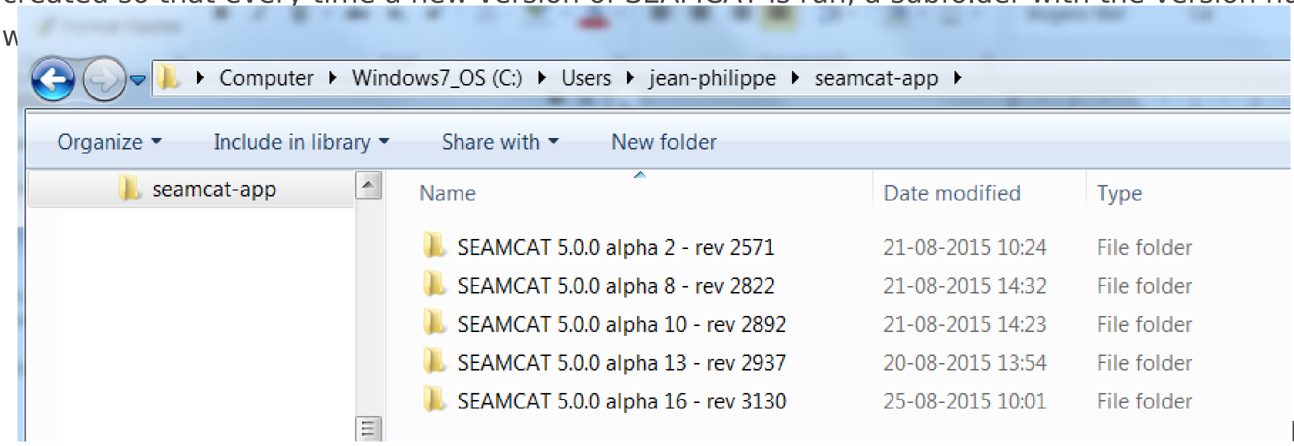
SEAMCAT is an open source project developed using Java which means it can run on any operating system supported by Java. The SEAMCAT installation is started by clicking on the install link from www.seamcat.org and it is free of charge.

The .jar package is platform independent so that you can run SEAMCAT on either Mac OS, Linux or Microsoft Windows operating systems. You need to check on the website that you have the latest version installed.

It is required that you have the Java runtime environment (JRE) installed on your computer, available to download free of charge from www.java.com. The latest version is recommended.

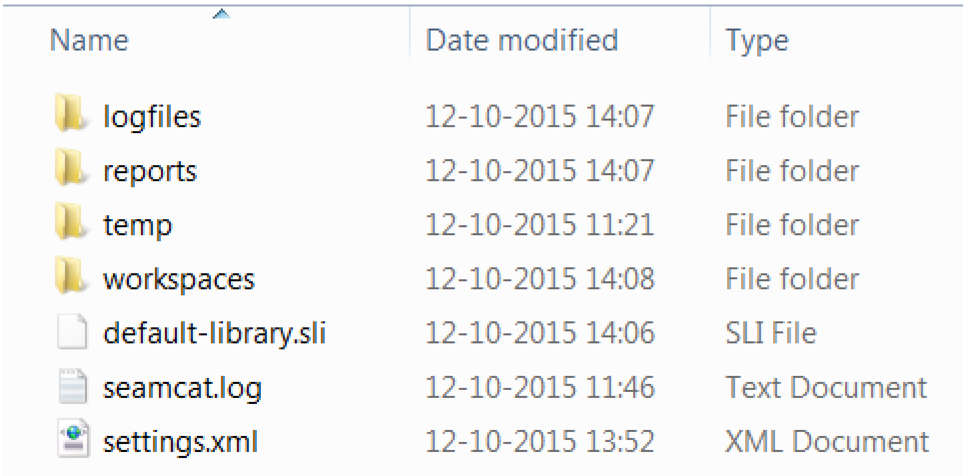
1.7.2 SEAMCAT home directory and configuration panel

When SEAMCAT (5 and upward) is run, a folder (SEAMCAT home directory) will be automatically created so that every time a new version of SEAMCAT is run, a subfolder with the version number w



Name	Date modified	Type
SEAMCAT 5.0.0 alpha 2 - rev 2571	21-08-2015 10:24	File folder
SEAMCAT 5.0.0 alpha 8 - rev 2822	21-08-2015 14:32	File folder
SEAMCAT 5.0.0 alpha 10 - rev 2892	21-08-2015 14:23	File folder
SEAMCAT 5.0.0 alpha 13 - rev 2937	20-08-2015 13:54	File folder
SEAMCAT 5.0.0 alpha 16 - rev 3130	25-08-2015 10:01	File folder

Figure 14: Illustration of the seamcat-app content



Name	Date modified	Type
logfiles	12-10-2015 14:07	File folder
reports	12-10-2015 14:07	File folder
temp	12-10-2015 11:21	File folder
workspaces	12-10-2015 14:08	File folder
default-library.sli	12-10-2015 14:06	SLI File
seamcat.log	12-10-2015 11:46	Text Document
settings.xml	12-10-2015 13:52	XML Document

Figure 15: Content of a work directory

Table 1: Description of the content of the SEAMCAT home directory

Name of file/folder	Type	Description
logfiles	Folder	Contains the log file (.txt) generated when debug mode is used
reports	Folder	Contains the report files (.xml/.html/.xlsx) generated by the Report feature
temp	Folder	Contains temporary files used by SEAMCAT
workspaces	Folder	Default folder for creating new workspaces and saving result workspaces. This can be changed from the File menu
Default-library.sli	File	Contains the default library of SEAMCAT (systems, masks, antennas, etc.)
seamcat.log	File	Text file containing all the log information reported by SEAMCAT (errors, warnings etc.) . Note that the file may be appended with information everytime you launch SEAMCAT is launched. You This folder may wish be to deleted it from time to time if so wished to clear computer space or reset settings. When deleted, it is automatically created next time you launch SEAMCAT is launched.
settings.xml	File	Contains the settings of your SEAMCAT configuration including all settings related to external plugins

The location of the home directory can be modified in the SEAMCAT configuration panel accessible via general menu option <File/Configuration> (⚙) also using <CTRL+G>. Further information is given in Annex A20.1.

1.7.3 Java source code

The source code for SEAMCAT is made available for scrutiny. The only condition for obtaining a copy of the source code is to sign a special **Source Code User Licence Agreement** and deliver it to ECO by email (seamcat@eco.cept.org). The procedure is described at:

http://www.cept.org/eco/groups/eco/seamcat-source-code.

1.7.4 Multi processing power in SEAMCAT

As of version 5, SEAMCAT is able to run in multiprocessor environments to increase the computation speed. The more processors a computer has, the less time a simulation will take. Since the Monte Carlo simulation method considers that each event is independent from each other, events can therefore be distributed across all the processor cores in the machine in order to decrease the computation time. The EPP runs in parallel for each event.

1.8 The SEAMCAT community

1.8.1 SEAMCAT Technical Group (STG)

The SEAMCAT project is an ongoing WG SE (Working Group Spectrum Engineering) activity (Figure 16). The daily maintenance of the project and the SEAMCAT software is entrusted to the ECO. The project is funded by the signatories of the ECO council. The SEAMCAT Technical Group (STG) acts as the supervising committee and source of technical expertise. For further information on STG visit the CEPT web page: http://www.cept.org/ecc/groups/ecc/wg-se/stg.

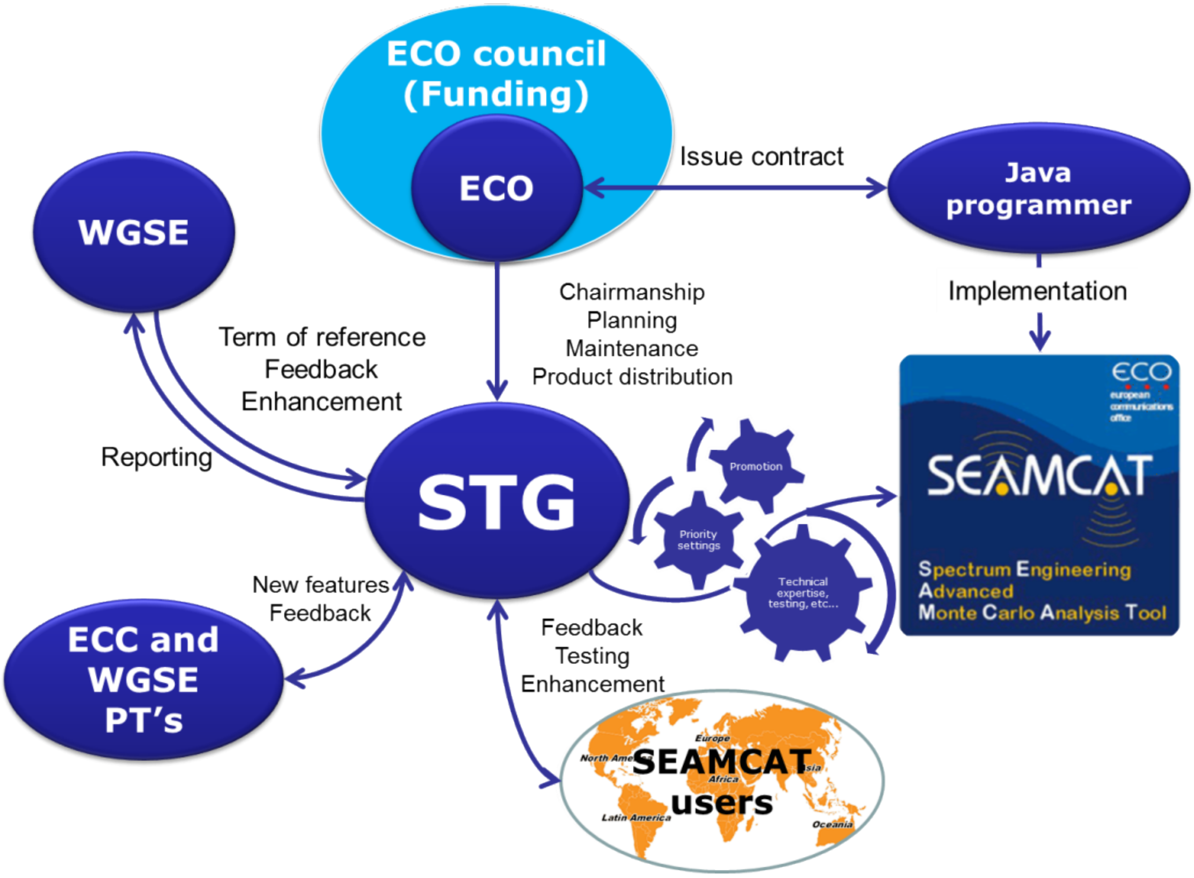


Figure 16: SEAMCAT project organigram and steakholders

1.8.2 SEAMCAT community - more than STG

SEAMCAT allows building customized library of components (systems, antennas etc.) or use those created by someone else. It is possible to use predefined antenna patterns, spectrum emission masks, and propagation models etc. which are available in the SEAMCAT library, so that reuse of scenarios, library items, etc. can be used in new studies. You can join the SEAMCAT community to contribute to this activity.

The SEAMCAT community is a forum where active SEAMCAT users can report feedback on the use and improvement of the tool (see Section 2.22). This includes the members of STG but also users from universities and organisations all around the world. This community has extended itself well beyond the CEPT borders as depicted in Figure 17.

It is possible to contribute to the community by sharing workspaces, populating libraries, creating and sharing plugins (EPPs, propagation plugins, etc...) and contribute to ECC and CEPT reports with SEAMCAT simulations. Any plugins are automatically embedded, so it’s only necessary to share workspaces by email.

The SEAMCAT application is open source and it is available free of charge.

The SEAMCAT community is accessible via different media:

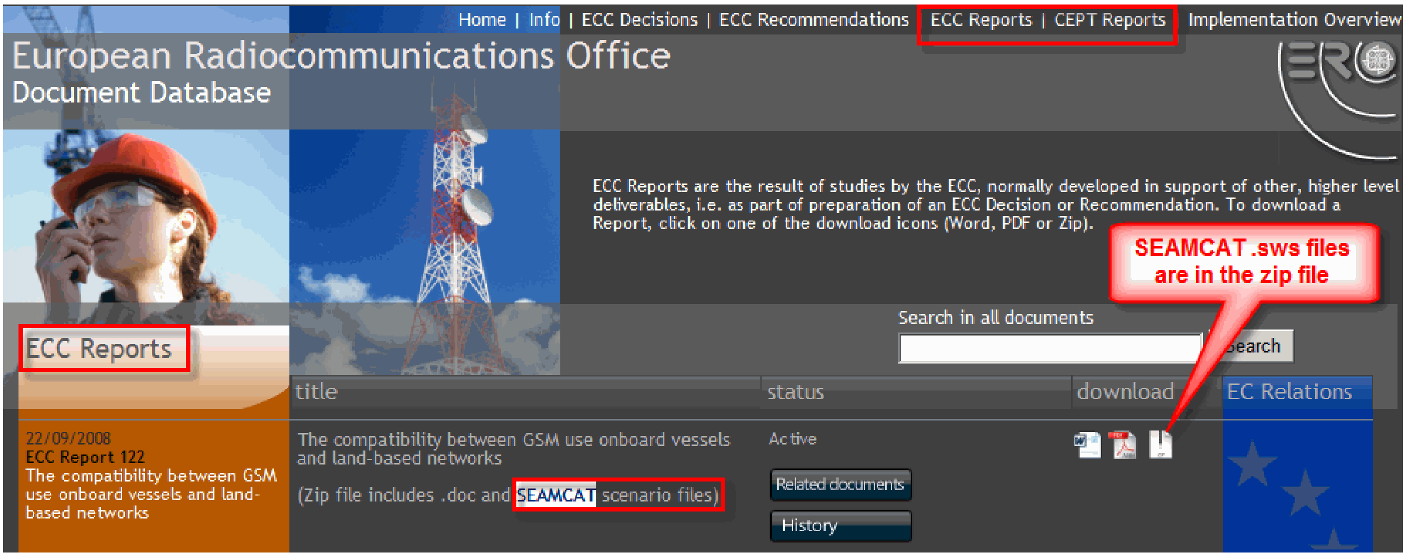
- SEAMCAT email reflector (seamcat@list.cept.org):
- To subscribe: mailto:seamcat-request@list.cept.org?subject=Subscribe;
- To unsubscribe: mailto:seamcat-request@list.cept.org?subject=unsubscribe;
- STG-ECO forum (http://www.cept.org/ecc/groups/ecc/wg-se/stg/client/forum).

1.9 Reference material and ECC / CEPT reports

Existing workspaces (i.e. .sws files) which have been generated as part of some ECC report or CEPT reports activities are available at the following address www.ecodocdb.dk. These files are can be opened with the latest SEAMCAT version, with the following restrictions:

1. Post processing plugins created in previous versions are not compatible in version 5, as they were moved into Event Processing Plugins
2. The local environments, which were placed together with the propagation models in previous versions, are to be found in version 5 in the system link tab (ILT –> ILR path, VLT –> VLR path). These settings are not migrated from previous versions.

See ANNEX 21: for an overview of studies per technology where SEAMCAT was used from various ECC deliverables. An example is shown in Figure 18 for the ECC Report 122.



ECC Reports are the result of studies by the ECC, normally developed in support of other, higher level deliverables, i.e. as part of preparation of an ECC Decision or Recommendation. To download a Report, click on one of the download icons (Word, PDF or Zip).

22/09/2008
ECC Report 122
The compatibility between GSM use onboard vessels and land-based networks

The compatibility between GSM use onboard vessels and land-based networks

(Zip file includes .doc and SEAMCAT scenario files)

Figure 18: ECC database where .sws file used in producing ECC or CEPT report are stored

(see ANNEX 21)