

Technical University of Riga
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Spectrum Engineering towards 5G: Helping to ensure efficient and interference-free wireless communications

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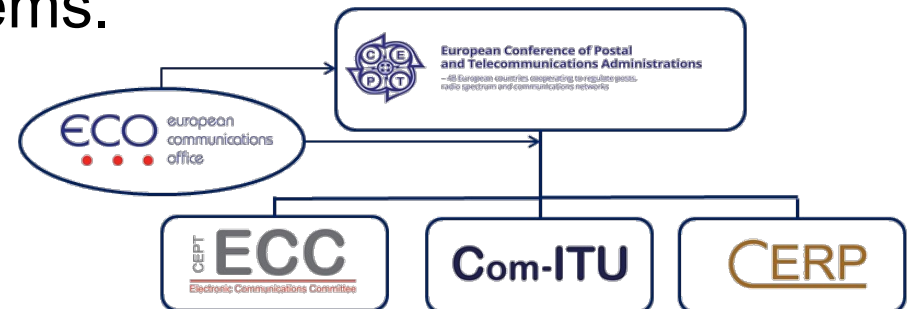
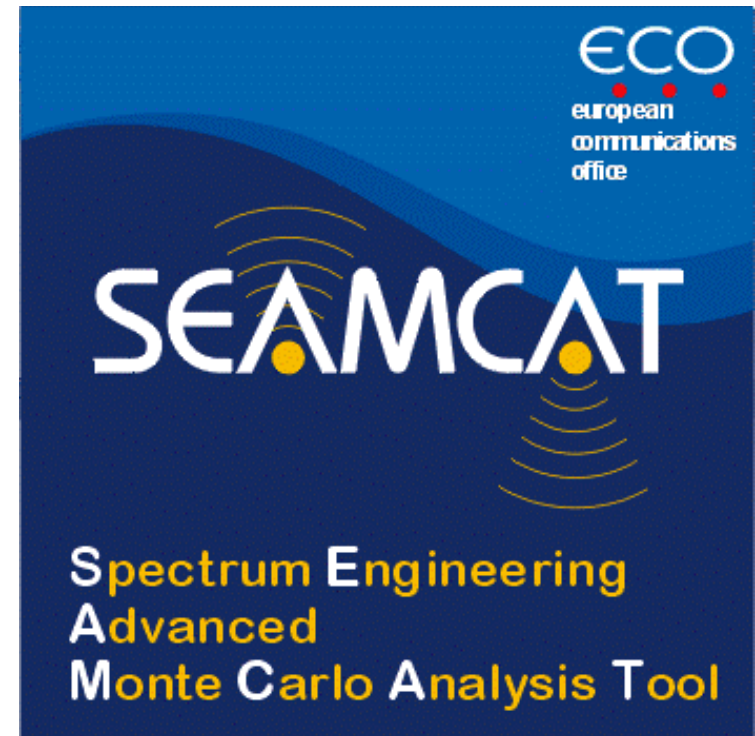
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Summary

- What is SEAMCAT?
- Why SEAMCAT?
- SEAMCAT at a glance
- Hand's on Exercises

What is SEAMCAT?

- **Open Source** software tool
- **Free of cost**
- Based on the **Monte Carlo simulation method** for statistical modelling of interference scenarios between radio communication systems.



SEAMCAT is intended for:

- **Co-existence studies** between radio communication systems operating in the same or adjacent frequency bands.
- Simulation of systems operating mainly under **terrestrial services** (some scenarios involving satellite systems are also possible).
- Quantification of the **probability of interference** (probability that one system is interfered by one or more other systems).

It is not designed for network planning purposes.

Why SEAMCAT?

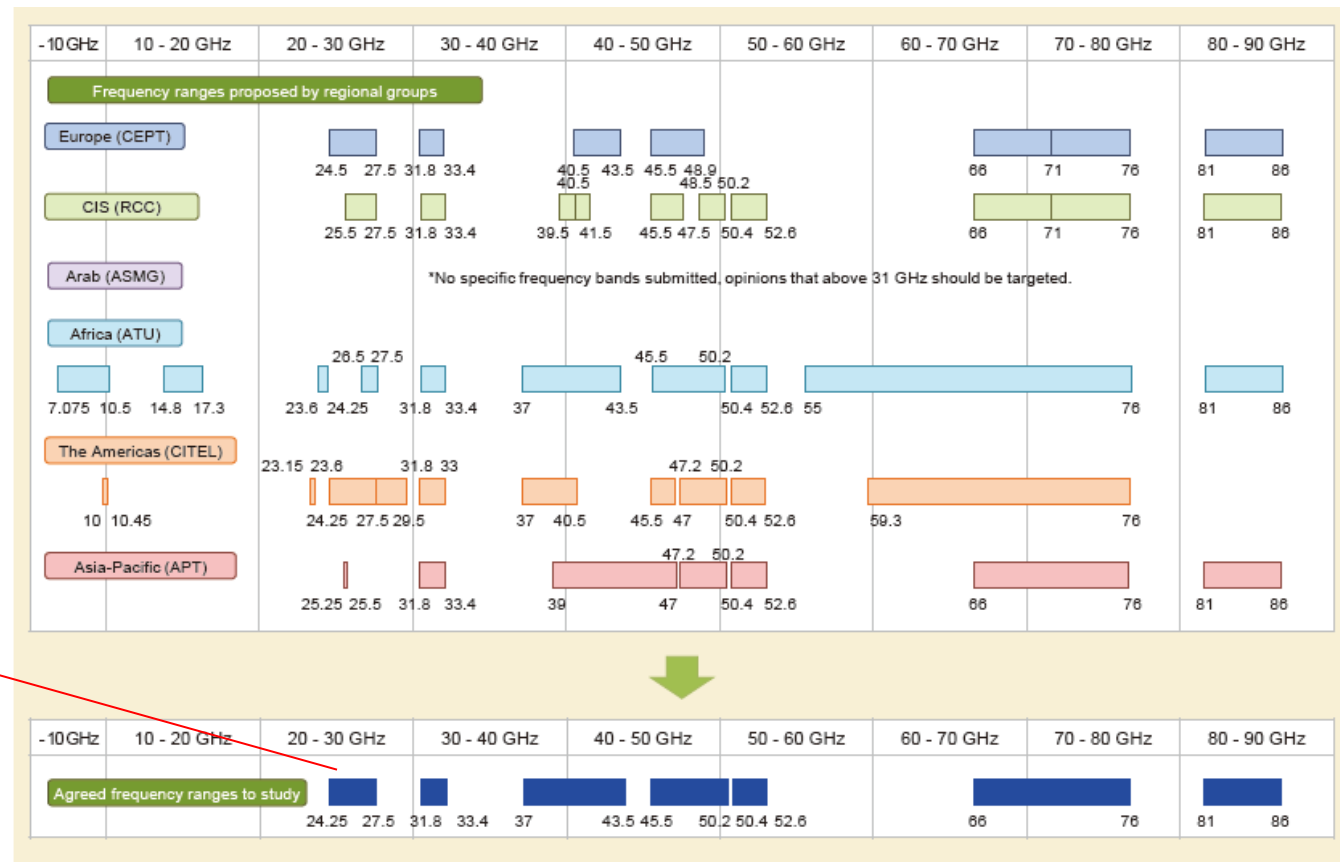
- **Congestion** in the radio spectrum resource.
- Radiocommunication systems need to **share the resources** efficiently.

440 MHz	450 MHz	455 MHz	456 MHz	459 MHz	460 MHz	470 MHz	790 MHz	862 MHz	890 MHz	942 MHz
Wind profil	Paging	Mobile	Mobile	Mobile	Mobile	Radiomics/	Radiomics/	Wireless A	Mobile	Mobile
Paging			Maritime	Paging	Maritime	PMSE	PMSE	Radiomics/	Defence	
PMR446	PMR/PAMR	Paging	Paging	PMR/PAMR	PMR/PAMR	Broadcastin	Broadcastin	SRD	PMR/PAMR	
PMR/PAMR		PMR/PAMR				Wind profil	none	RFID	GSM-R	MCV
			PMR/PAMR	Maritime	SRS	RAS	MFCN	Mobile	none	MCV
				Defence	Defence	MFCN	Defence	PMR/PAMR	Mobile	Mobile
								Track & Tra	SRD	
								TTI	Radiomics/	
								Mobile	RFID	
								Defence		

- **Sharing and compatibility studies** are required to assess the possibilities for radio systems to coexist in the same or in adjacent frequency bands.

Why SEAMCAT?

- Frequency ranges for 5G systems (from ITU-WRC15)
- Compatibility studies are still needed...

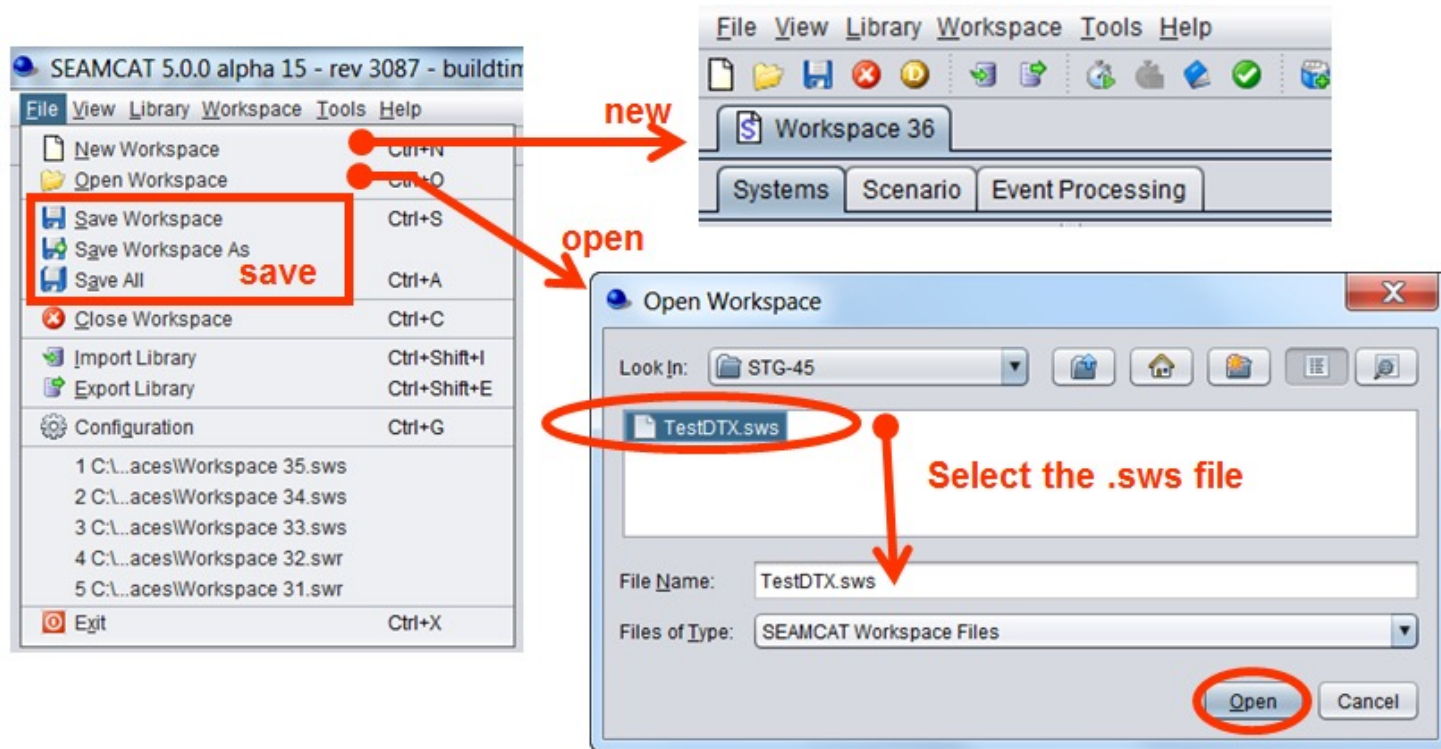


Earth Exploration Satellite Services (EESS)

SEAMCAT at a glance

Creating – Opening and Saving a Workspace

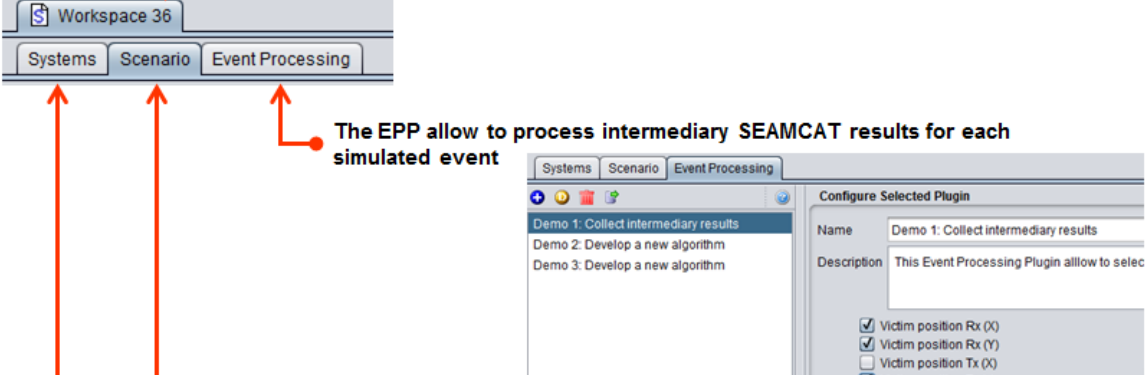
Creating - Opening - Saving a workspace scenario (.sws)



Workspace

Workspace Scenario (.sws)

**Workspace storing the scenario only.
Fields are editable.
File saved as .sws (SEAMCAT Workspace Scenario)**



The EPP allow to process intermediary SEAMCAT results for each simulated event

Set the scenario, i.e. select the systems to use for the victim and interferer(s) as well as the path between the victim and the interferer(s), number of events, debugging logging

Set the characteristic of the systems to investigate (generic Tx, Rx and path between Tx/Rx or cellular general settings, positioning)

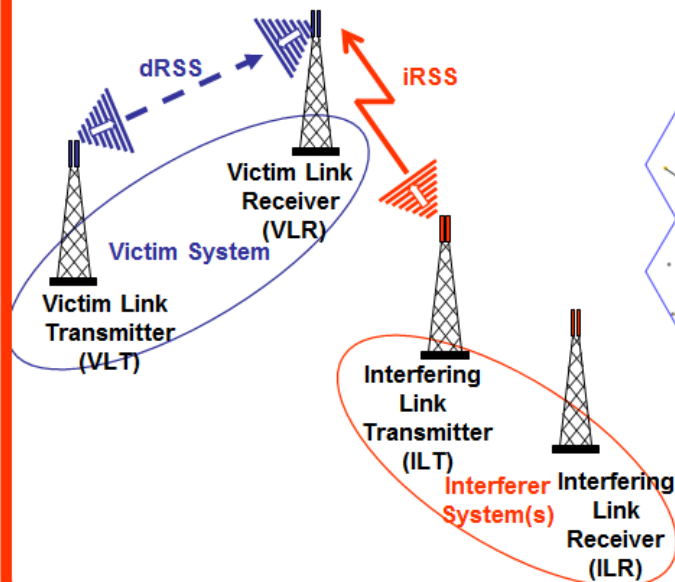
Systems that can be simulated in SEAMCAT

Systems that can be simulated in SEAMCAT

Generic Systems

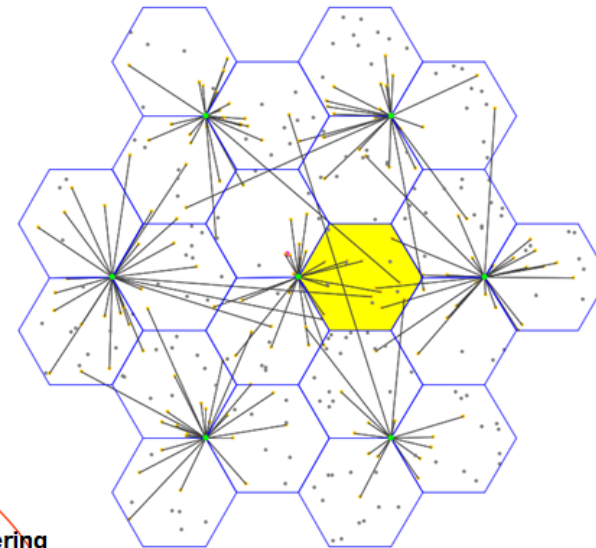
Land Mobile, Short Range terrestrial broadcasting and Devices, Point-to-Point and Point-to-Multipoint fixed systems

Earth based stations (e.g. DTH receivers) of satellite systems



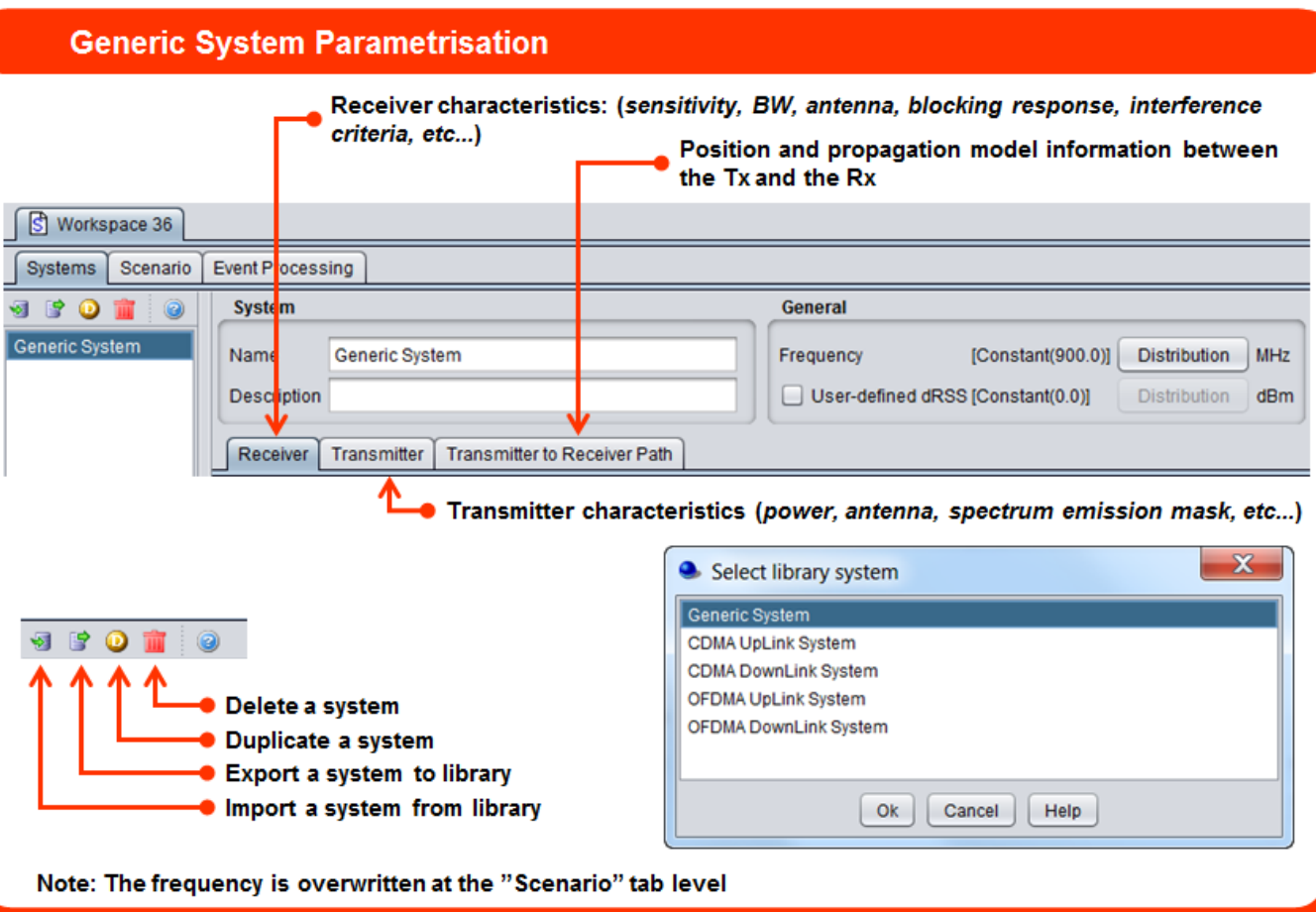
Cellular Systems

CDMA (UMTS, CDMA 2000x ...), OFDMA LTE



Generic System Parametrization

Generic System Parametrisation



Receiver characteristics: (sensitivity, BW, antenna, blocking response, interference criteria, etc...)

Position and propagation model information between the Tx and the Rx

Transmitter characteristics (power, antenna, spectrum emission mask, etc...)

- Delete a system
- Duplicate a system
- Export a system to library
- Import a system from library

Select library system

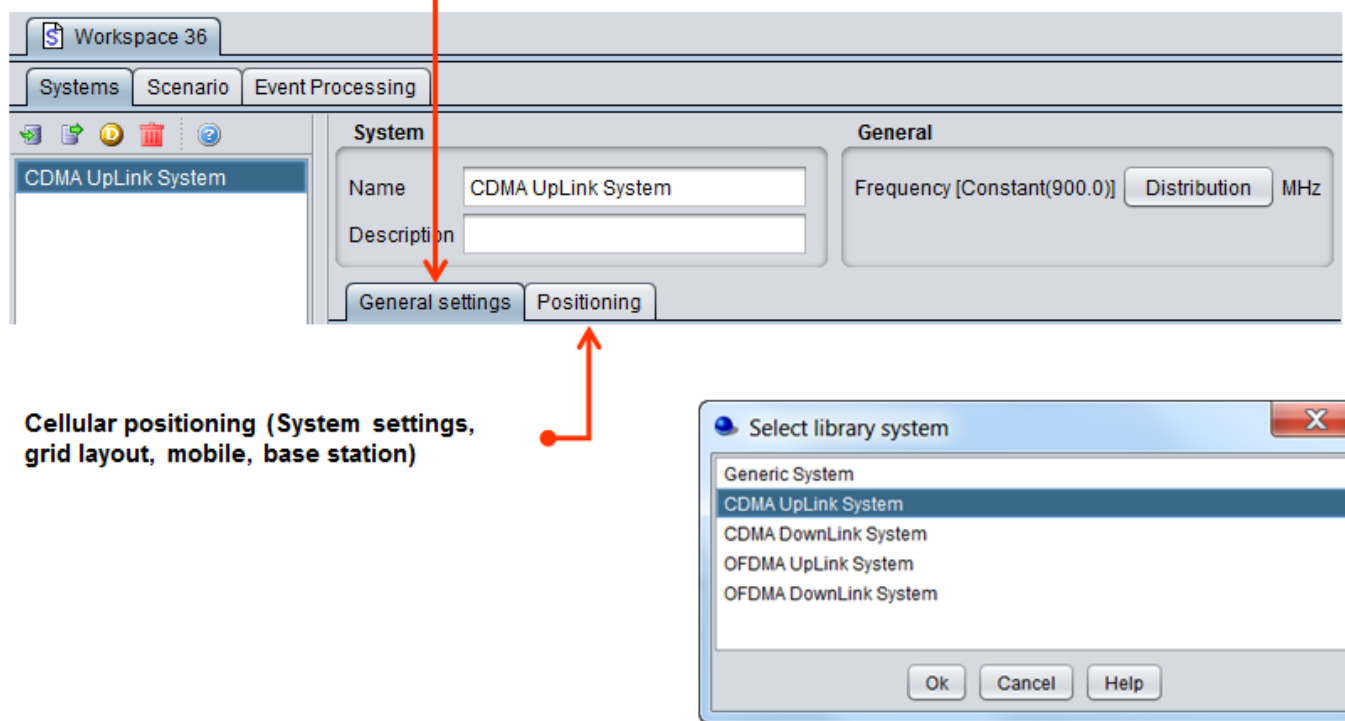
- Generic System
- CDMA UpLink System
- CDMA DownLink System
- OFDMA UpLink System
- OFDMA DownLink System

Note: The frequency is overwritten at the "Scenario" tab level

CDMA / OFDMA system parametrization

CDMA/OFDMA System Parametrisation

CDMA/OFDMA settings (Rx/Tx settings, links, capacity, local environments, propagation model, pathloss correlation, etc...)



Cellular positioning (System settings, grid layout, mobile, base station)

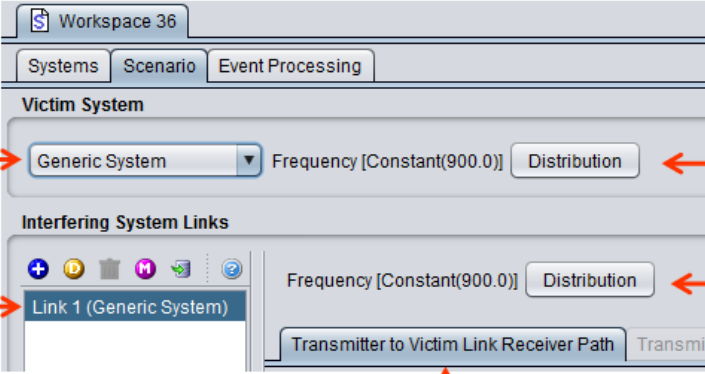
Note: The frequency is overwritten at the "Scenario" tab level

Scenario parametrisation

Scenario Parametrisation


Select one victim from a list defined under the "system" tab

Select interferer system(s) from a list defined under the "system" tab

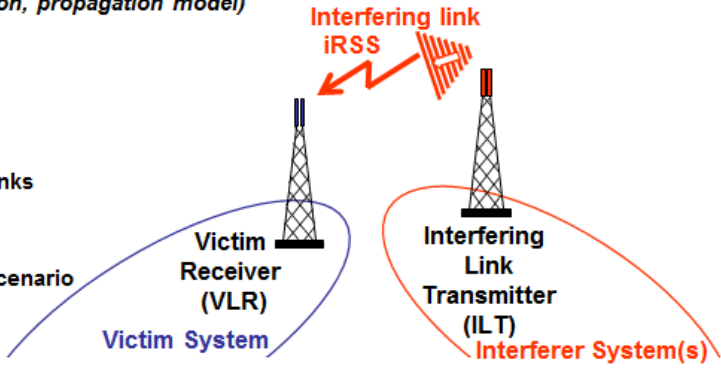


Frequency in "Scenario" overwrites settings in "Systems"

Set the path characteristic between the victim and interfering system (*Relative positioning, interferers density, pathloss correlation, propagation model*)



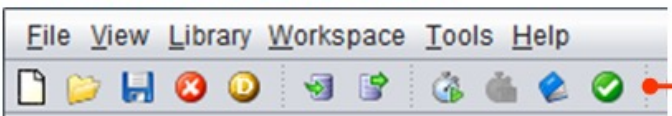
- Change the system's type
- Generate multiple interfering links
- Delete a link
- Duplicate an interfering link
- Add an interfering link to the scenario



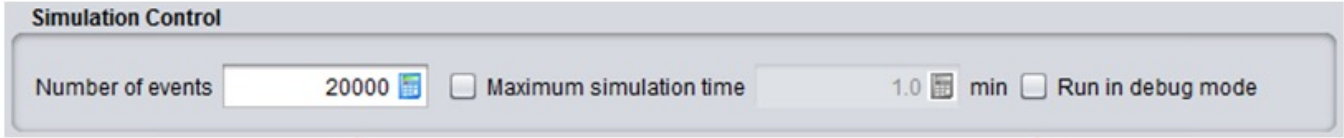
Start a simulation

Start a simulation

A. Check consistency



B. Select the number of events



Setting the number of events for normal simulation

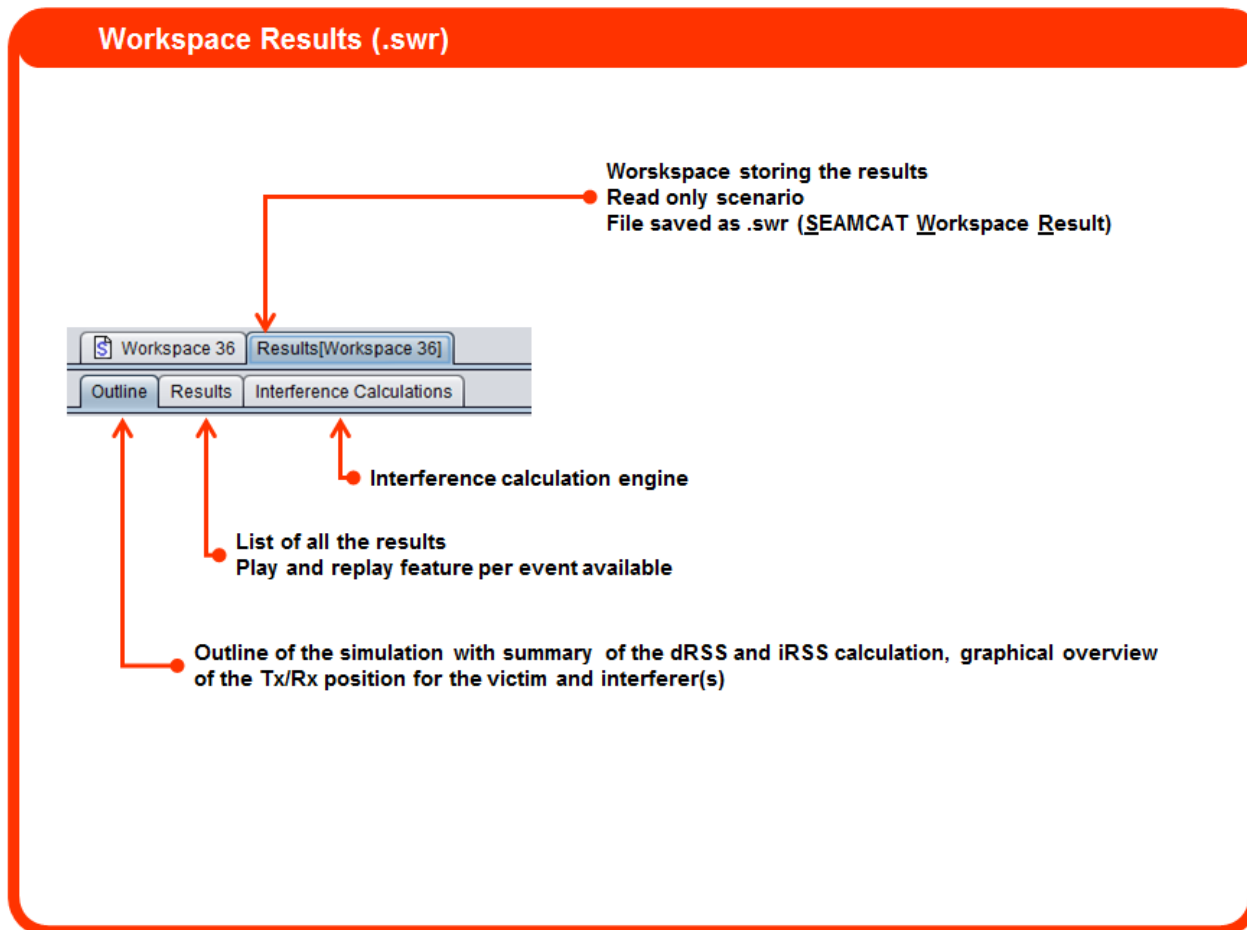
Setting the debug mode (small event number)

C. Run a simulation



Run a simulation

Workspace results

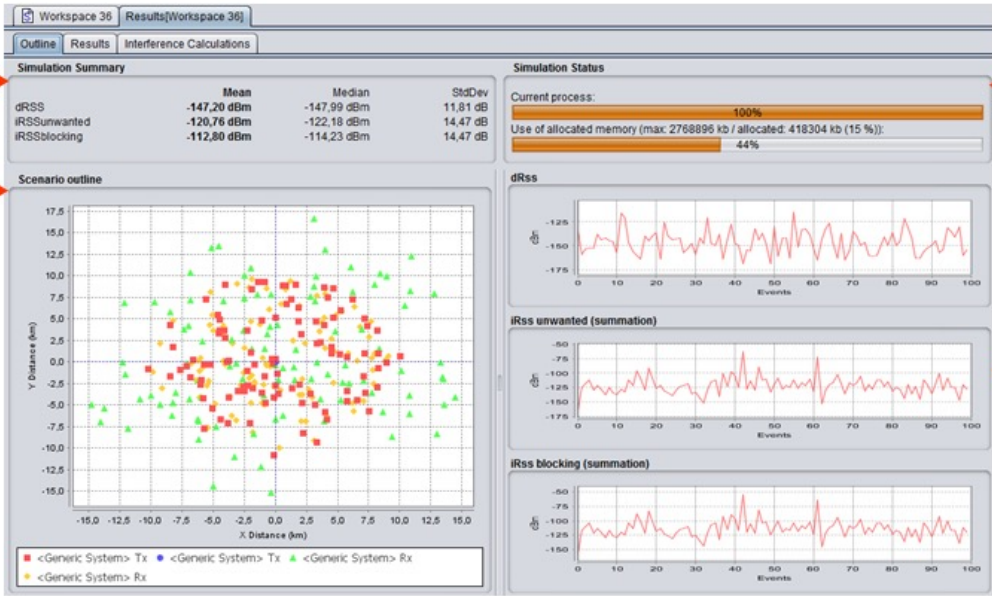


Workspace results - Outline

Workspace Results - Outline

Summary of the dRSS and iRSS results

Progress bar to track the current task status and the system memory



The screenshot displays the 'Results' tab of a simulation workspace. It includes a 'Simulation Summary' table, a 'Simulation Status' section with progress bars, a 'Scenario outline' scatter plot, and three time-series plots for dRSS, iRSS unwanted, and iRSS blocking. Red arrows point from the text annotations to these specific elements.

	Mean	Median	StdDev
dRSS	-147,20 dBm	-147,99 dBm	11,81 dB
iRSSunwanted	-120,76 dBm	-122,18 dBm	14,47 dB
iRSSblocking	-112,80 dBm	-114,23 dBm	14,47 dB

Simulation Status

Current process: 100%

Use of allocated memory (max: 2768896 kb / allocated: 418304 kb (15 %)): 44%

Scenario outline

Y Distance (6m)

X Distance (6m)

Legend:
■ <Generic System> Tx
● <Generic System> Tx
▲ <Generic System> Rx
● <Generic System> Rx

dRSS

iRSS unwanted (summation)

iRSS blocking (summation)

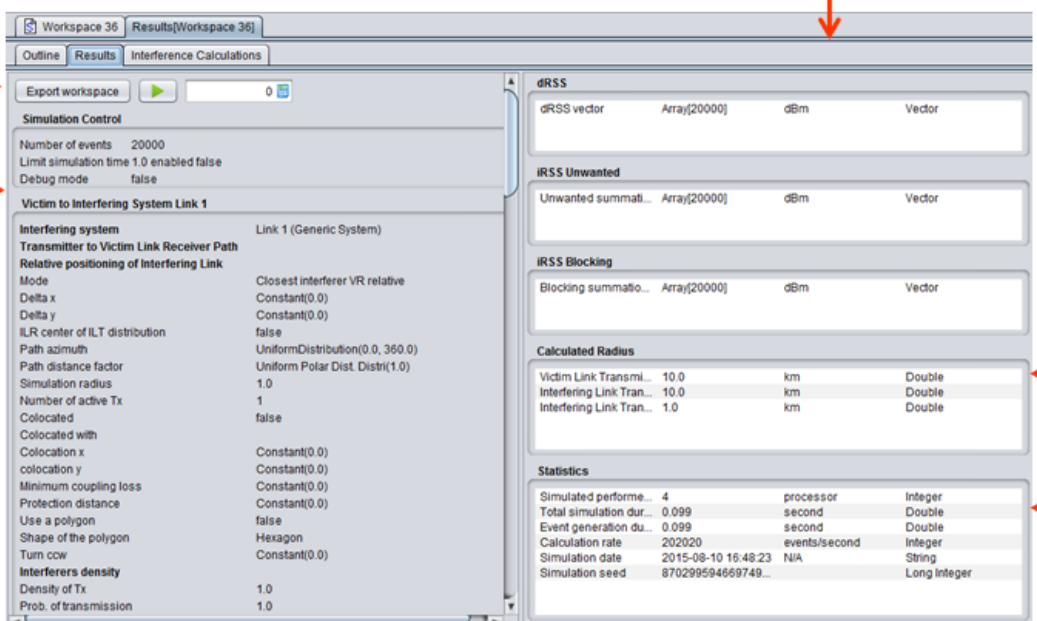
Display the victim and interfering link element for each snapshot

Quick overview of the dRSS and iRSS during run time

Workspace results - Results

Workspace Results - Results

Output vector from the SEAMCAT simulation



Play/Replay feature for one event

Input parameters used for these specific simulation results (read only)

Display any output results of an EPP

Statistics on the simulation process, time consumptions, number of processor used

dRSS			
dRSS vector	Array[20000]	dBm	Vector

IRSS Unwanted			
Unwanted summati...	Array[20000]	dBm	Vector

IRSS Blocking			
Blocking summatio...	Array[20000]	dBm	Vector

Calculated Radius			
Victim Link Transmi...	10.0	km	Double
Interfering Link Tran...	10.0	km	Double
Interfering Link Tran...	1.0	km	Double

Statistics			
Simulated performe...	4	processor	Integer
Total simulation dur...	0.099	second	Double
Event generation du...	0.099	second	Double
Calculation rate	202020	events/second	Integer
Simulation date	2015-08-10 16:48:23	N/A	String
Simulation seed	870299594669749...		Long Integer

Workspace results – Interference calculations

Workspace Results – Interference Calculations

Compatibility: Probability of interference as a single result
Translation: Probability of interference as a function of parameters

Interference Calculation Inputs

Mode & Criteria	Signal type	Interference Criterion	Translation parameters
Compatibility C/I <input checked="" type="checkbox"/> Compute only events w...	<input checked="" type="checkbox"/> Unwanted <input type="checkbox"/> Blocking <input type="checkbox"/> Overloading <input type="checkbox"/> Intermodulation	C/I 19.0 dB C/(N+I) 16.0 dB (N+I)/N 3.02 dB I/N 0.02 dB	Translation Parameters Min (dBm or dB) Max (dBm or dB) # points

Calculate

Control of the Interference Calculation Engine

Compatibility: Probability of interference

Compatibility (single result)

Probability 0.175129533678756

17.5 % of probability of interference

Translation: Probability of interference as a function of parameters

Translation Parameters

Blocking response level / Victim link

Intermodulation response level / Victim link


Power supplied / Interfering link 1

Results

Compatibility (single result)

Probability 0.0

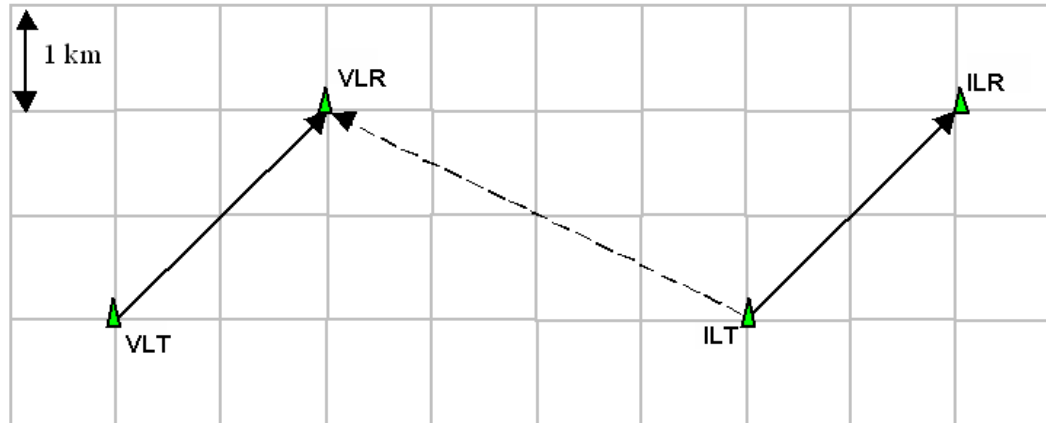
Translation (probability function of translation parameter)



Hand's on SEAMCAT

Example 1

Modelling interference between fixed links



System parameters

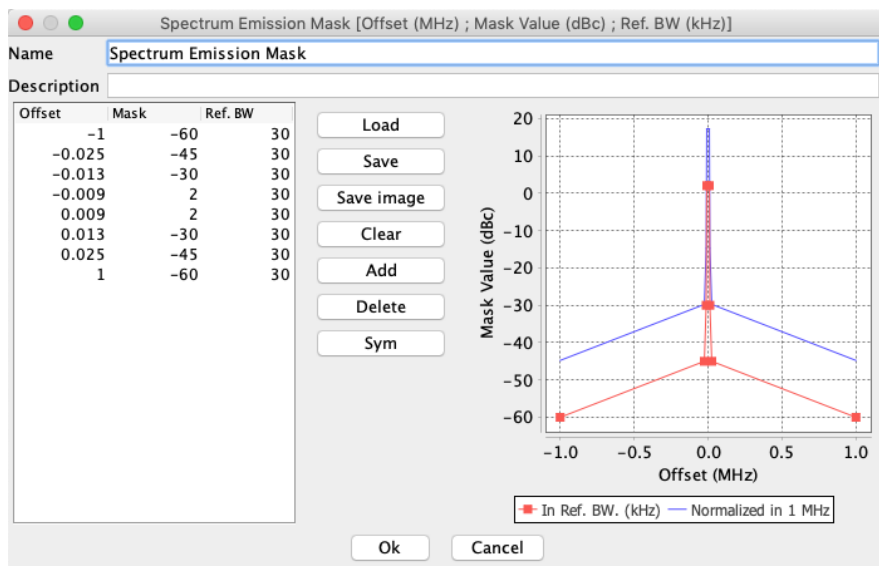
Transmitter

Parameter	Value
Frequency	1 GHz
e.i.r.p.	30 dBm
antenna peak gain	9 dBi
Antenna	omnidirectional
Antenna height above ground	1.5 m
Spectral Mask	See Figure below

Receiver

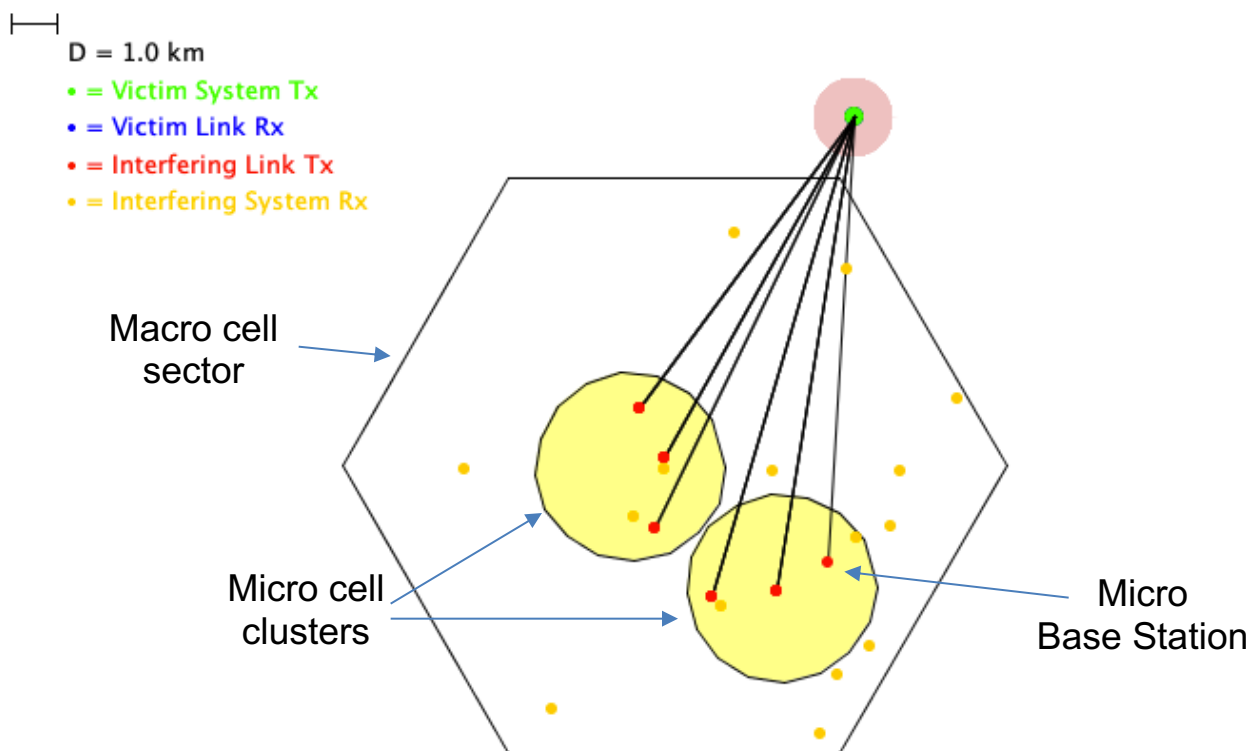
Parameter	Value
Frequency	1 GHz
Receiver bandwidth	25 kHz
antenna peak gain	9 dBi
Antenna	omnidirectional
Antenna height above ground	1.5 m
Noise Floor	-114 dBm
Sensitivity	-103 dBm
Interference criteria	C/I = 19 dB

Spectrum Emission Mask



Example 2

Modelling interference between IMT-2020 microcell and Earth Exploration Satellite Service (EESS)



IMT-2020 parameters

Micro Base station (Downlink)

Parameter	Value
Frequency	26 GHz
Channel bandwidth	200 MHz
Antenna array	8x8 elements
Element gain	5 dBi
Main beam antenna gain	23 dBi
Total output power (after ohmic loss)	25 dBm
e.i.r.p.	48 dBm
Antenna height above ground	6 m
Antenna panel mechanical down tilt	10 degrees
Antenna panel boresight azimuth	Uniform distribution 0° - 360°
Antenna electrical steering (elevation)	Directed towards the UE
Antenna pattern	Recommendation ITU-R M.2101
Relative antenna gain from peak towards horizon	-0.2 dB -
e.i.r.p. density towards horizon	17.8 dBW/200 MHz (-5.2 dBW/MHz) -

Mobile equipment

Parameter	Value
Frequency	26 GHz
Channel bandwidth	200 MHz
Antenna array	4x4 elements
Element gain	5 dBi
Main beam antenna gain	17 dBi
Antenna height above ground	1.5 m
Antenna panel boresight azimuth	Uniform distribution between 0° and 180° (one beam)
Antenna panel tilt	Uniform distribution 0° to -90°
Antenna electrical steering	Directed towards BS
Antenna pattern	Recommendation ITU-R M.2101
Antenna relative gain towards horizon	0 dB
Body loss	4 dB

EESS (s-E) data relay earth station parameters

Earth Exploration Satellite Service

Parameter	Value	Reference
Frequency	26 GHz	
Antenna diameter	6.8 m	
Antenna centre height above ground	6 m	
Antenna Gain	61.8 dBi	
Antenna pattern	RR Appendix 8, Annex III	
Earth station location	51.57775 N, -1.30478 E	
Satellite GSO location	9° East	
I_0/N_0 (0.1% of time)	-6 dB	Recommendation ITU-R SA.1155-2
System noise temperature	300 K	Recommendation ITU-R SA.1414-2
Receiver system noise	-143.8 dBW/MHz	
Interference criteria (0.1% of time)	-149.8 dBW/MHz	

More information...

Handbook:

<https://www.ecodocdb.dk/download/5b8f9726-04a6/ECCRep252.pdf>

WiKi:

<http://confluence.seamcat.org/display/SH/SEAMCAT+Handbook>

Thank you for your attention!

Questions?

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