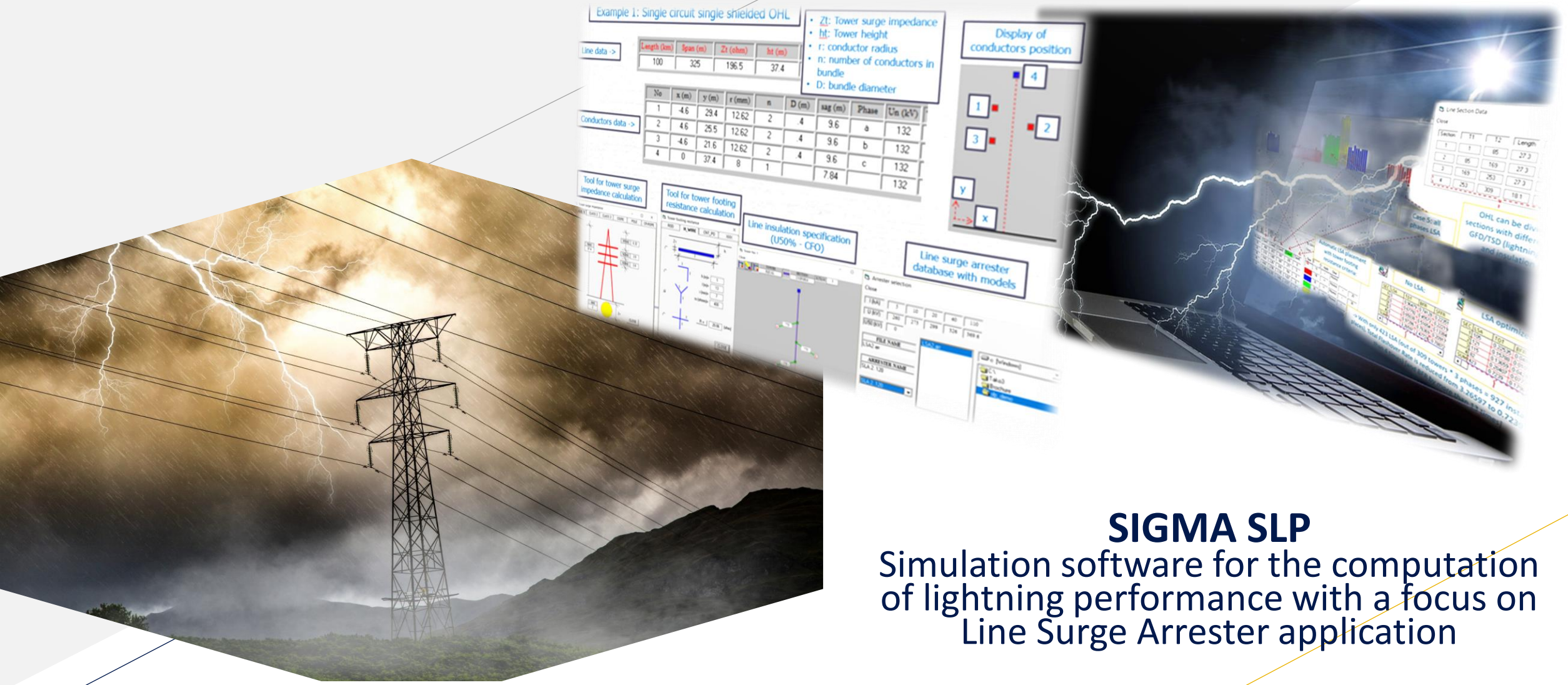


SIGMA SLP

Simulation software for the computation of lightning performance with a focus on Line Surge Arrester application

METARRESTERS

BEYOND THE STANDARDS

Official partner of Sadovic Consultant

M.S. Florent Giraudet - Independent Consultant

Lightning Performance & Line Surge Arresters

www.metarresters.com

SIGMA SLP

Simulation software for the computation of lightning performance with a focus on Line Surge Arrester application

Features :

- Soil Ionization
- Monte Carlo statistical method
- Option for including arresters
- Batch simulations
- Electro geometric Modeling
- Customizable lightning distributions
- Capable of modeling multiple circuits, including underbuilt performance.
- Capable of multiple complex structures geometries
- Internal calculation of surge impedance
- Traveling wave analysis to calculate voltages

Some facts :

- Sigma SLP has been first commercialized in the early 2000's.
- Results of different research works by Prof. Dr. Salih Sadovic in collaboration with international experts.
- Based on "CIGRE WG 33.01, "Guide to Procedures for Estimating the Lightning Performance of Transmission Lines", CIGRE Technical brochure no 63, October 1991"
- Latest update Sigma SLP version 3.1 (2022)
- The software continues to be supported by Sadovic Consultant

Sigma SLP – Example of Input data for a shielded single circuit single line

Conductors data ->

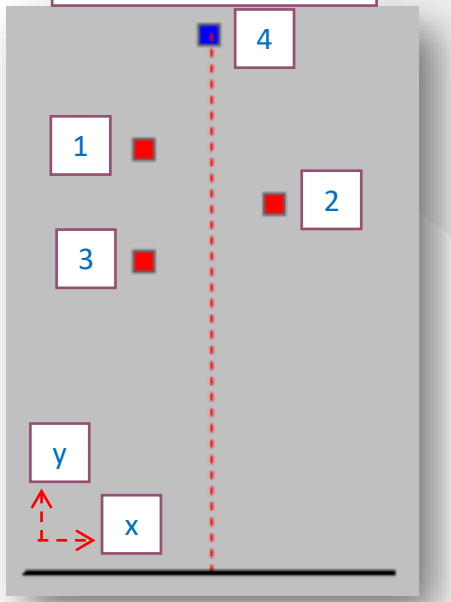
No	x (m)	y (m)	r (mm)	n	D (m)	sag (m)	Phase	Un (kV)
1	-4.6	29.4	12.62	2	.4	9.6	a	132
2	4.6	25.5	12.62	2	.4	9.6	b	132
3	-4.6	21.6	12.62	2	.4	9.6	c	132
4	0	37.4	8	1		7.84		132

Line data ->

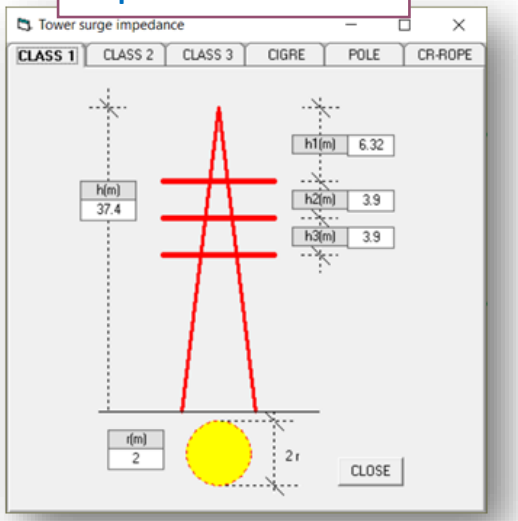
Length (km)	Span (m)	Zt (ohm)	ht (m)
100	325	196.5	37.4

- Zt: Tower surge impedance
- ht: Tower height
- r: conductor radius
- n: number of conductors in bundle
- D: bundle diameter

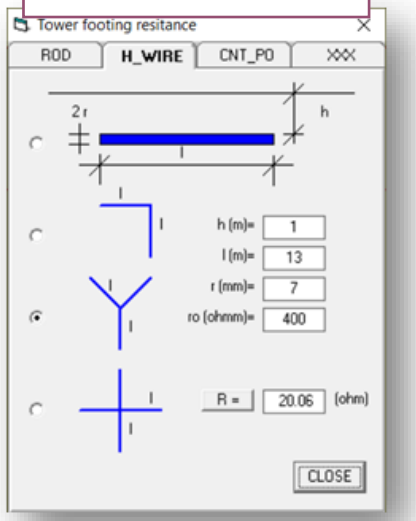
Display of conductors position



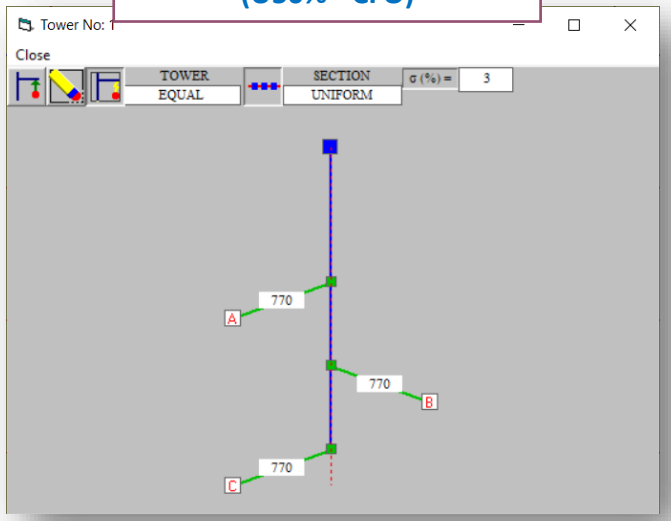
Tool for tower surge impedance calculation



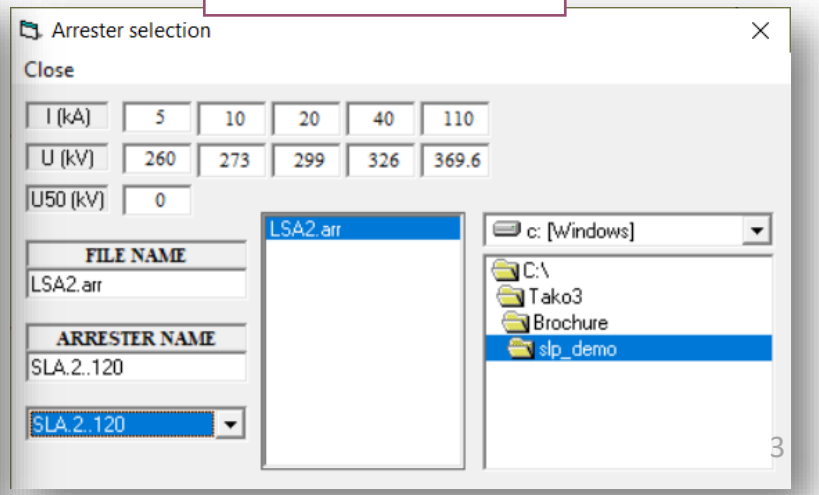
Tool for tower footing resistance calculation



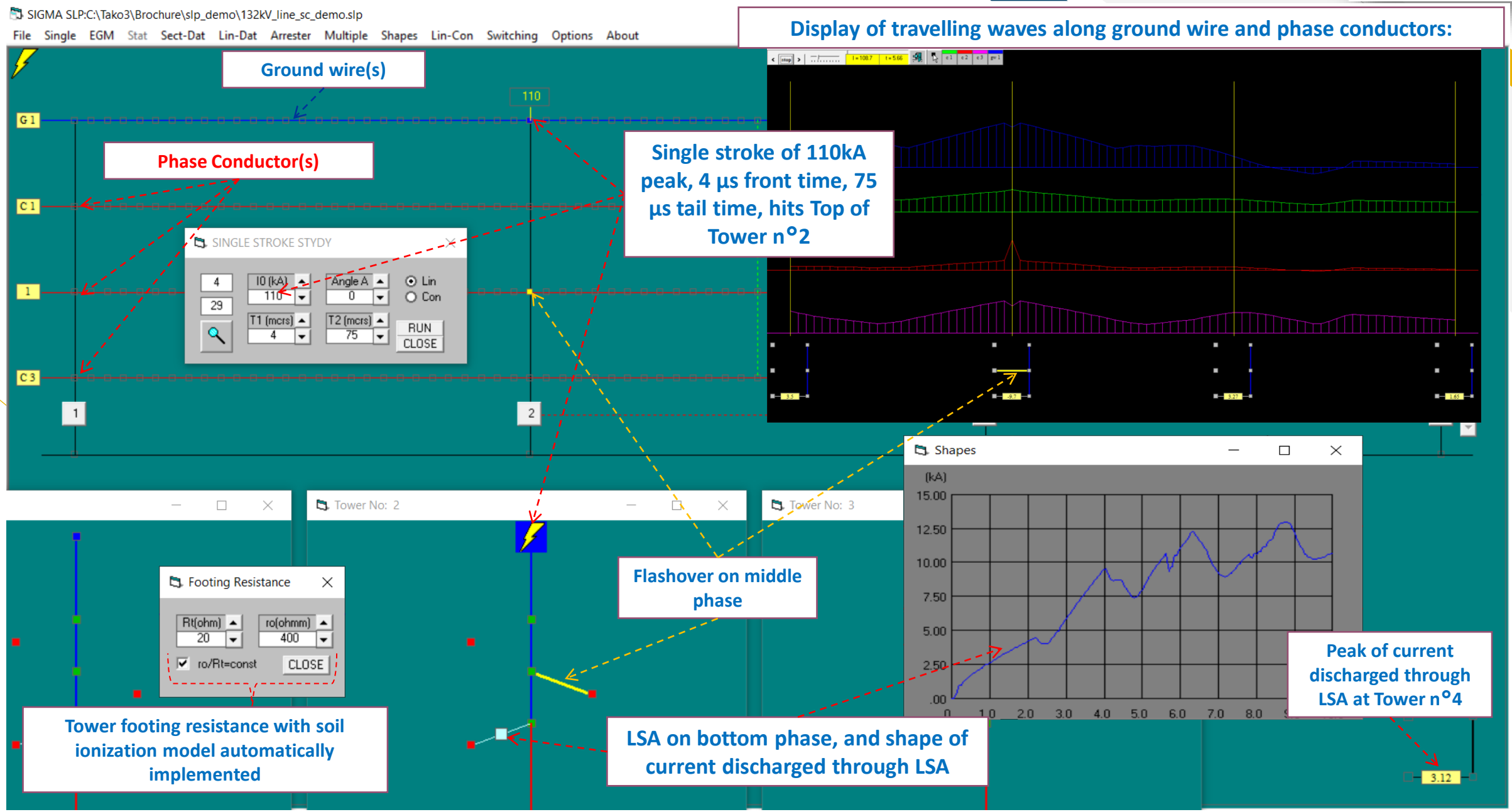
Line insulation specification (U50% - CFO)



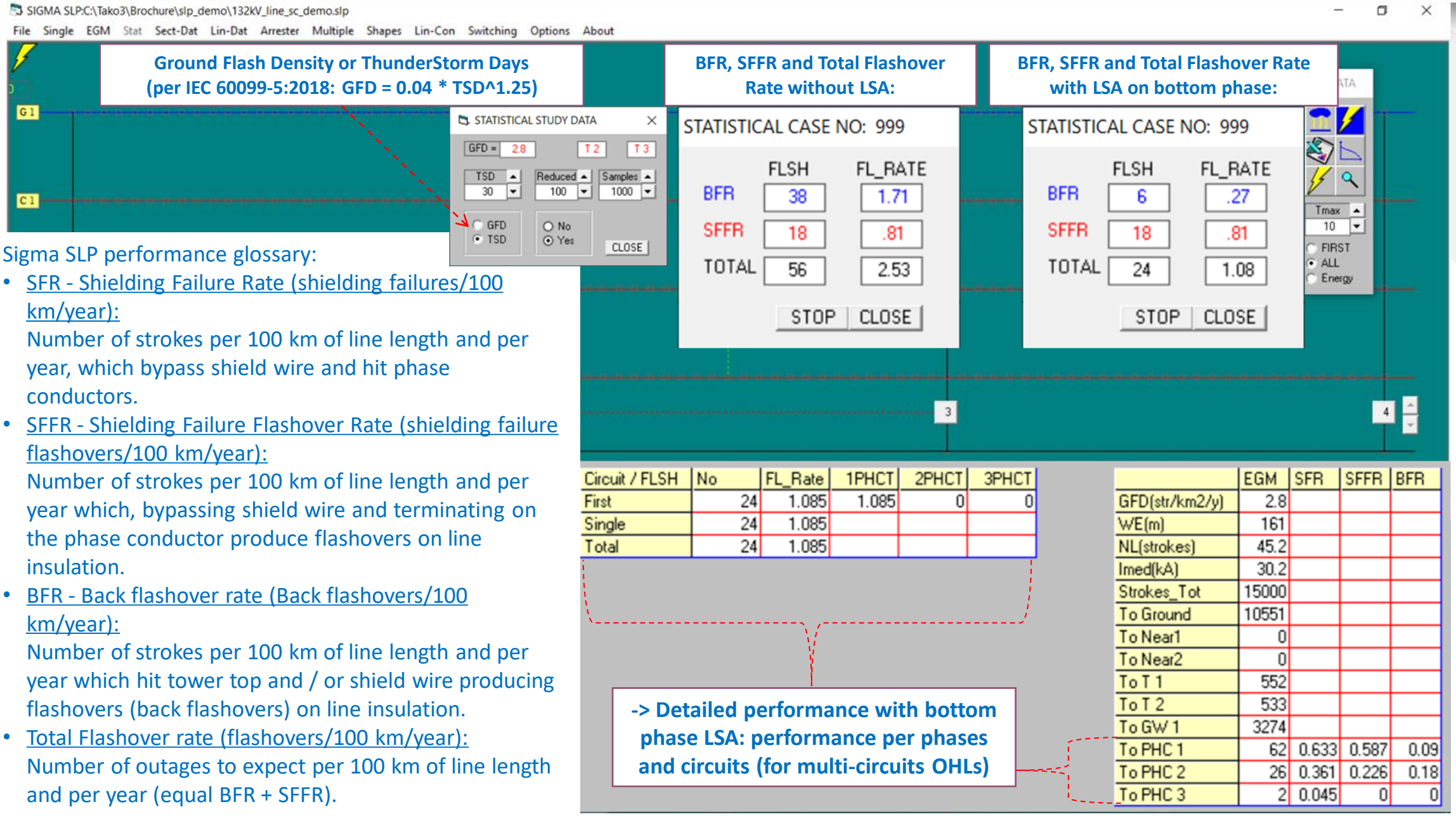
Line surge arrester database with models



Sigma SLP – Example of Single Stroke Study



Sigma SLP – Example of Statistical Study



Circuit / FLSH	No	FL_Rate	1PHCT	2PHCT	3PHCT
First	24	1.085	1.085	0	0
Single	24	1.085			
Total	24	1.085			

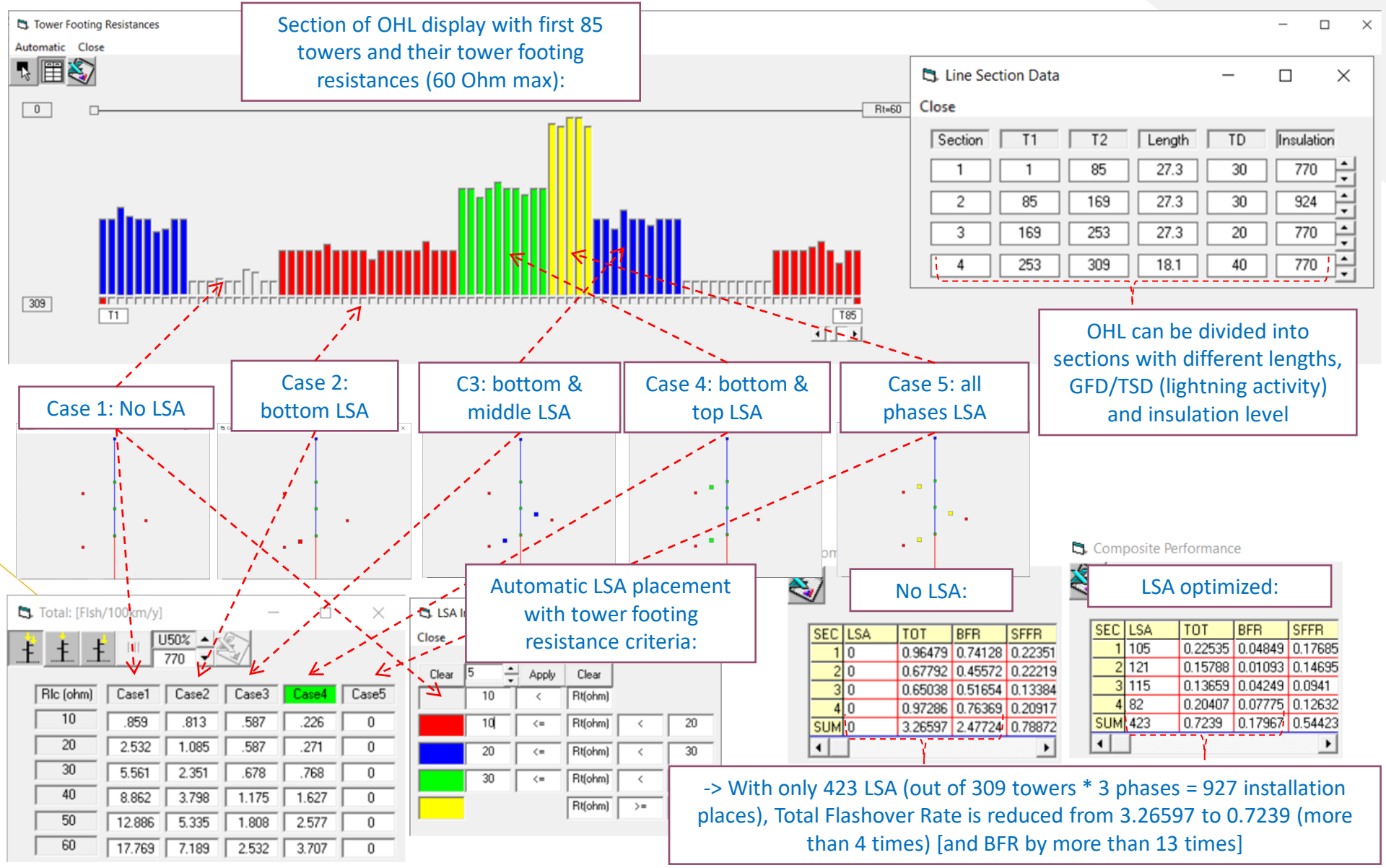
	EGM	SFR	SFFR	BFR
GFD(str/km2/y)	2.8			
WE(m)	161			
NL(strokes)	45.2			
Imed(kA)	30.2			
Strokes_Tot	15000			
To Ground	10551			
To Near1	0			
To Near2	0			
To T 1	552			
To T 2	533			
To GW 1	3274			
To PHC 1	62	0.633	0.587	0.09
To PHC 2	26	0.361	0.226	0.18
To PHC 3	2	0.045	0	0

-> Detailed performance with bottom phase LSA: performance per phases and circuits (for multi-circuits OHLs)

Sigma SLP performance glossary:

- SFR - Shielding Failure Rate (shielding failures/100 km/year):
  Number of strokes per 100 km of line length and per year, which bypass shield wire and hit phase conductors.
- SFFR - Shielding Failure Flashover Rate (shielding failure flashovers/100 km/year):
  Number of strokes per 100 km of line length and per year which, bypassing shield wire and terminating on the phase conductor produce flashovers on line insulation.
- BFR - Back flashover rate (Back flashovers/100 km/year):
  Number of strokes per 100 km of line length and per year which hit tower top and / or shield wire producing flashovers (back flashovers) on line insulation.
- Total Flashover rate (flashovers/100 km/year):
  Number of outages to expect per 100 km of line length and per year (equal BFR + SFFR).

Sigma SLP – Composite performance and Automatic LSA placement



SIGMA SLP – Simple and Specialized

What is used for?

SIGMA SLP is an object-oriented software package for computation of transmission and distribution line lightning performance.

In short, it calculates the number of outages to expect based on configurable system parameters and lightning activities.

It allows simple application of Line Surge Arresters (LSA's) to define optimum quantities and placement of LSA's.

SIGMA SLP helps utilities, grip operators, engineering companies and LSA manufacturers to address lightning performance.

Simplicity above complexity

The software is based on simplicity and does not require advanced knowledge in circuit modeling like other EMTP-based software.

The software does its own complete modeling for electromagnetic transients simulations.

The user specifies only readily available data as line geometry, system parameters LSA's main ratings (catalogue values), grounding conditions, number of towers for the simulated line section, insulation critical flashover voltage, etc.

Method & Models

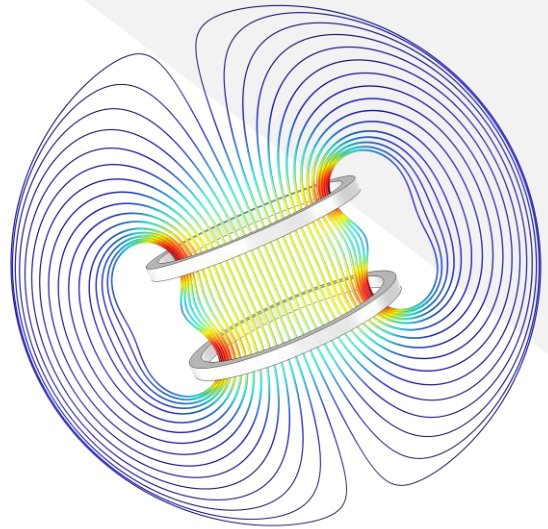
A Monte Carlo statistical method is used for the simulation of lightning activity, while a three-dimensional electro-geometric model is adopted for the determination of stroke terminations.

Electromagnetic transients on the line are computed by the multiphase travelling wave method.

Transients on the line are computed separately from the transients on the towers while corresponding connections are being performed by Thevenin equivalents.

SIGMA SLP – Simple and Specialized

Advanced modeling and simulation



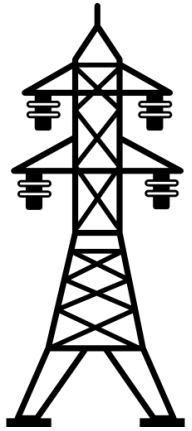
Phase-to-ground(tower) and phase-to-phase flashovers using a leader propagation flashover model can be simulated. Each tower in the simulated line section can include different flashover ratings.

Line insulation flashover voltage are randomly selected in the Monte Carlo simulations.

Soil ionization tower footing resistance model are automatically implemented.

Counterpoise or constant resistance tower footing model can be also implemented.

Linear and non-linear tower footing resistance representation, counterpoise, leader propagation flashover model, linear or upward concave stroke front, initial voltages etc. are standard features used into simulations.



Each line span is divided into short segments to accept strokes between towers and to consider corona influence.

Transients on the conductors separately computed from that on the towers. Corresponding interconnections done in each time step using Thevenin equivalents. This enables extremely fast electromagnetic transients simulations.

SIGMA SLP – Simple and Specialized

Possibility of complex structures

Simulations can be performed either on shielded or unshielded lines since the user can build quickly its own structure.

Standard configuration and compact lines can be analyzed. For multi-circuit lines, each three-phase system can have different voltage levels.

Multi-circuit outages are directly obtained. Unbalanced (differential) insulation can be simulated.

Ground wires or neutral conductor can have different connections along the simulated line section (insulated or grounded at different towers).

Transients on the tower top can be represented. Influence of the underbuilt ground wires or guy wires with separate grounding can also be simulated. Each tower can have different phase-to-ground and phase-to-phase insulation characteristics.

Nearby objects in the electro-geometric simulations are considered.

Line Surge Arresters application

The software is specifically designed to enable quick and easy determination of optimum LSA's installation scheme.

A specific and limited quantity of LSA can be applied methodically on towers and phases to determine the optimal configuration for a specific budget.

Ideally it is often required to define the minimum amount of LSA to achieve the best lightning performance improvement by reducing the number of outages to a negligible value.

Placement can be arbitrarily but an automatic tool for LSA's placement is integrated in the Sigma SLP software.

Line Surge Arresters, connected in parallel with the line insulation can be gapless (NGLA) or with external series gap (EGLA).

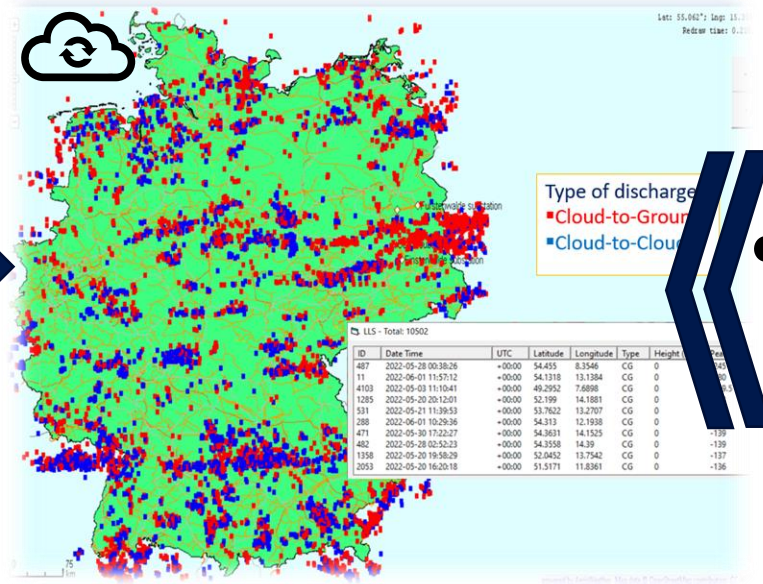
I3CM LLS Solution… To go further …

Advanced system & specialized application software for real-time online monitoring

Dedicated purpose for Lightning Performance determination, improvement and prioritization

I3CM LLS Transient Recorder + Lightning Location System (LLS) + Weather condition monitoring

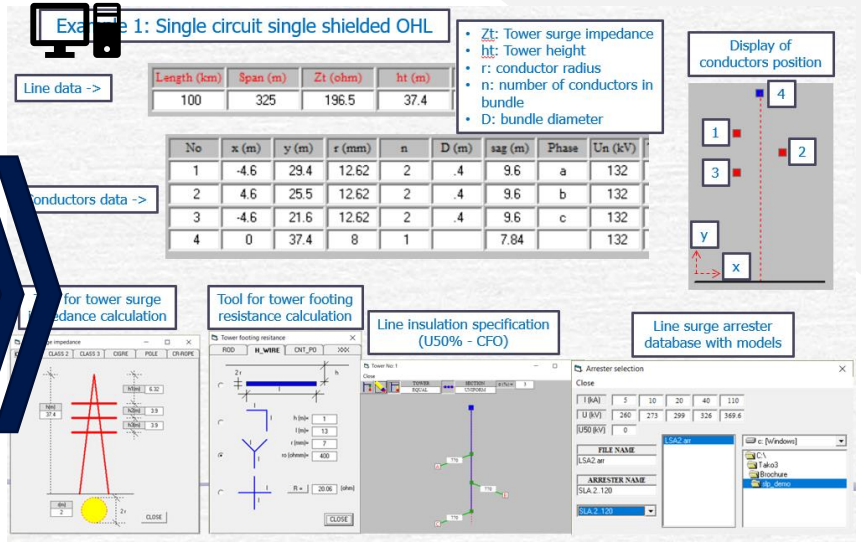
Collect reliable data and identify lightning outages with precision



I3CM LLS Software

Immediate correspondance between faults and lightning strokes

Automatic analysis and notifications



Sigma SLP Software

Populate specialized simulations with real world data

A dedicated tool for Line Surge Arresters and Lightning performance improvment

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Thank You.

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