CEPEL

Enhancement of Transmission Capability

by

Luiz A.S. Pilotto

Research & Development Director

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NSF/EPRI Workshop

Urgent Opportunities for Transmission System Enhancement

High Surge Impedance Loading Line - HSIL

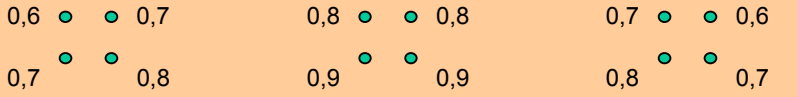
High Surge Impedance Loading Line - HSIL

BASIC CONCEPTS

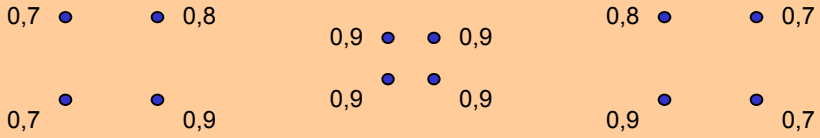
- *Expanded Bundle Geometry Optimizes the Electric Field at the Surface of All Sub-Conductors*
- *Result: an Expressive Reduction of the Positive Sequence Impedance of the Transmission Line*

Electric Field Profile

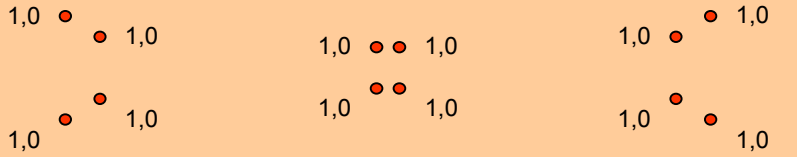
- *Conventional Bundle*



- *Expanded Bundle (EXB)*



- *HSIL - EXB*

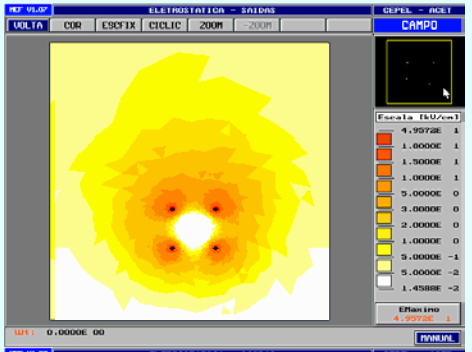


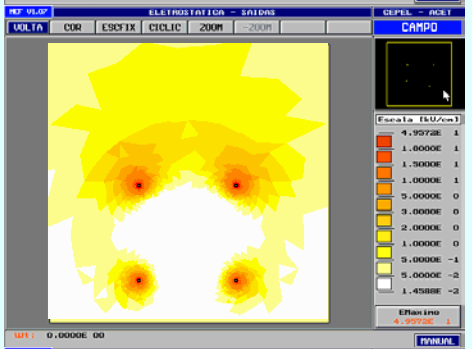
High Surge Impedance Loading Line - HSIL

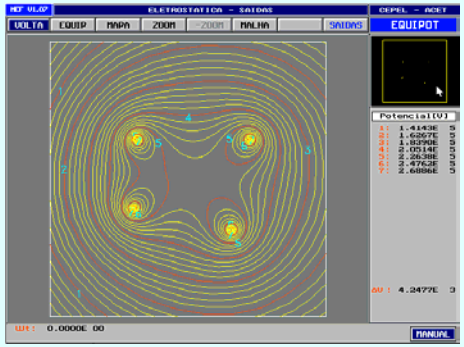
BASIC CONCEPTS

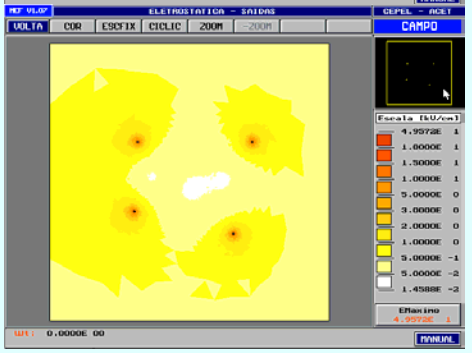
Electric Field Calculation

- Conventional Bundle
- Expanded Bundle (EXB)
- HSIL - EXB









High Surge Impedance Loading Line - HSIL

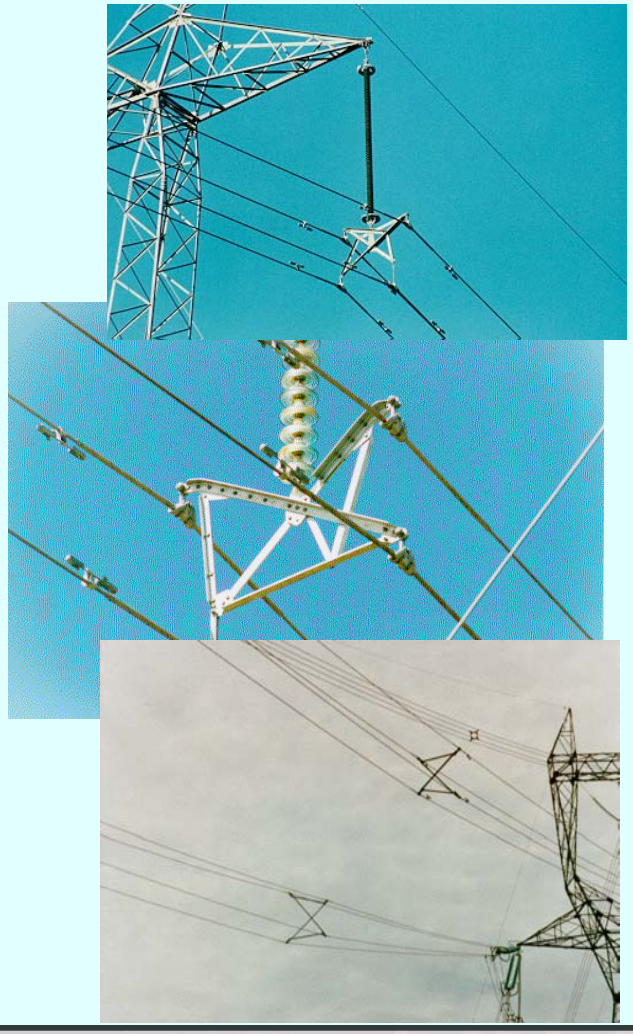
BASIC CONCEPTS

Surge Impedance Loading

$$SIL = \frac{V^2}{Z_1}$$

Voltage Level (kV)	Conventional Line (MW)	HSIL Line (MW)
69	9 - 12	10 - 40
138	40 - 50	50 - 120
230	120 - 130	130 - 440
500	900 - 1020	950 - 2000

Source: CHESF



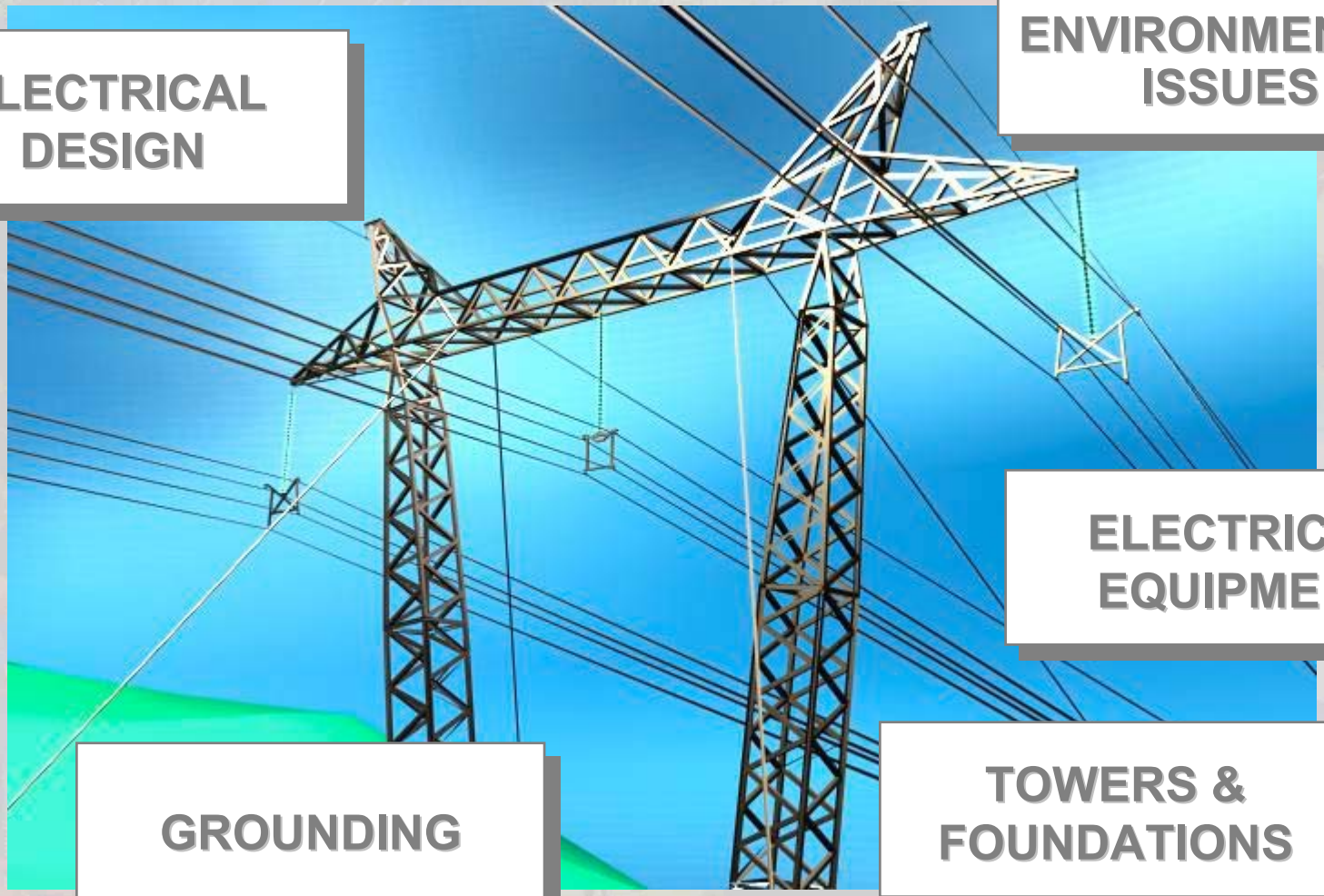
High Surge Impedance Loading Line - HSIL

CHARACTERISTICS OF AN HSIL LINE

- Enhanced Power Transfer Capacity
- Improved Voltage Regulation of Highly Stressed Transmission Lines
- Improved Power Systems Transient Stability Limits
- Maximum Utilization of Existing Right-of-Ways
- Reduced Environmental Impact, for the Same Power Transmission Level

High Surge Impedance Loading Line - HSIL

TECHNOLOGY OVERVIEW



ELECTRICAL DESIGN

ENVIRONMENTAL ISSUES

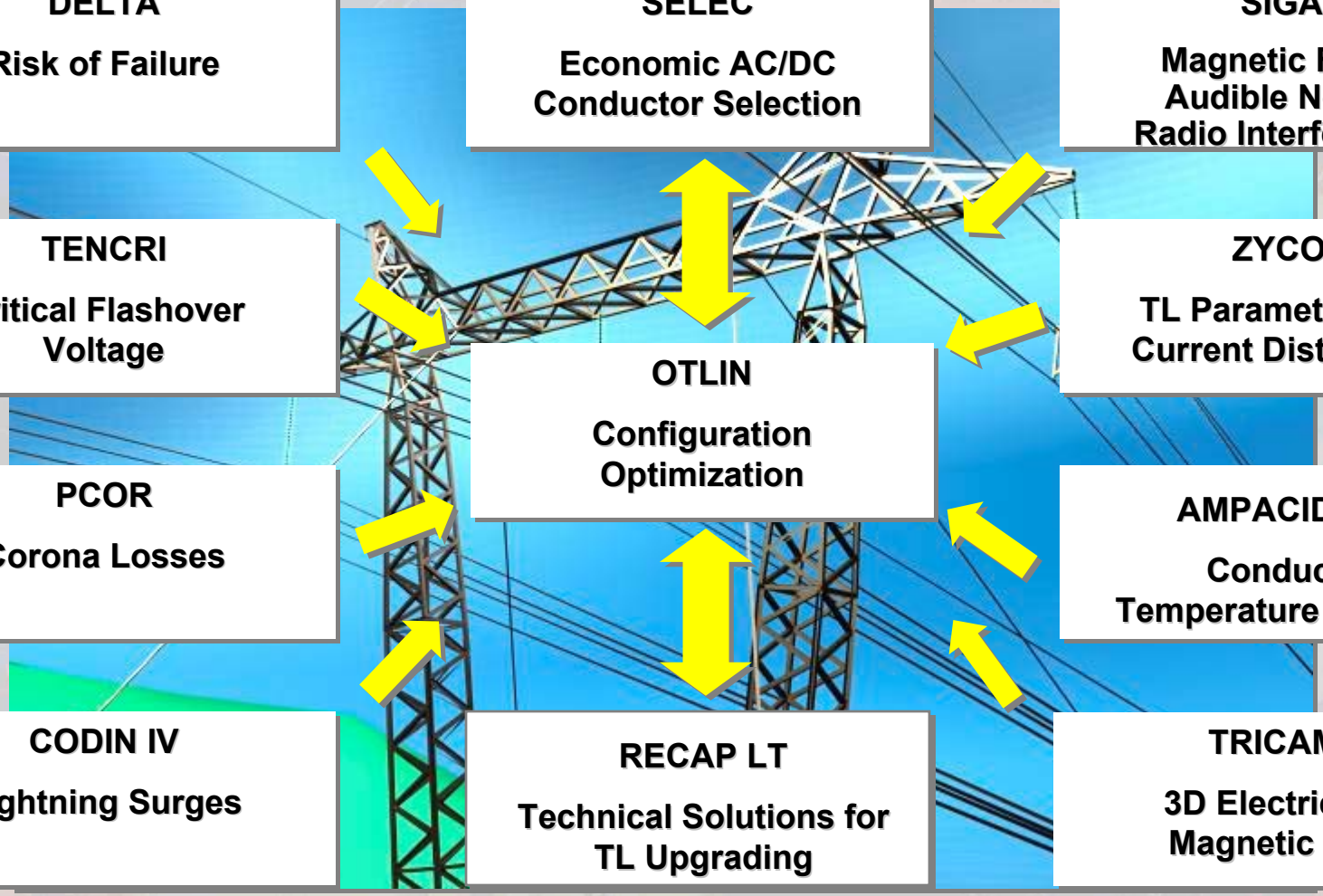
ELECTRICAL EQUIPMENT

GROUNDING

TOWERS & FOUNDATIONS

High Surge Impedance Loading Line - HSIL

ELECTRICAL DESIGN



DELTA

Risk of Failure

SELEC

Economic AC/DC Conductor Selection

SIGA

Magnetic Field, Audible Noise, Radio Interference

TENCRI

Critical Flashover Voltage

OTLIN

Configuration Optimization

ZYCOR

TL Parameters and Current Distribution

PCOR

Corona Losses

AMPACIDADE

Conductor Temperature Analysis

CODIN IV

Lightning Surges

RECAP LT

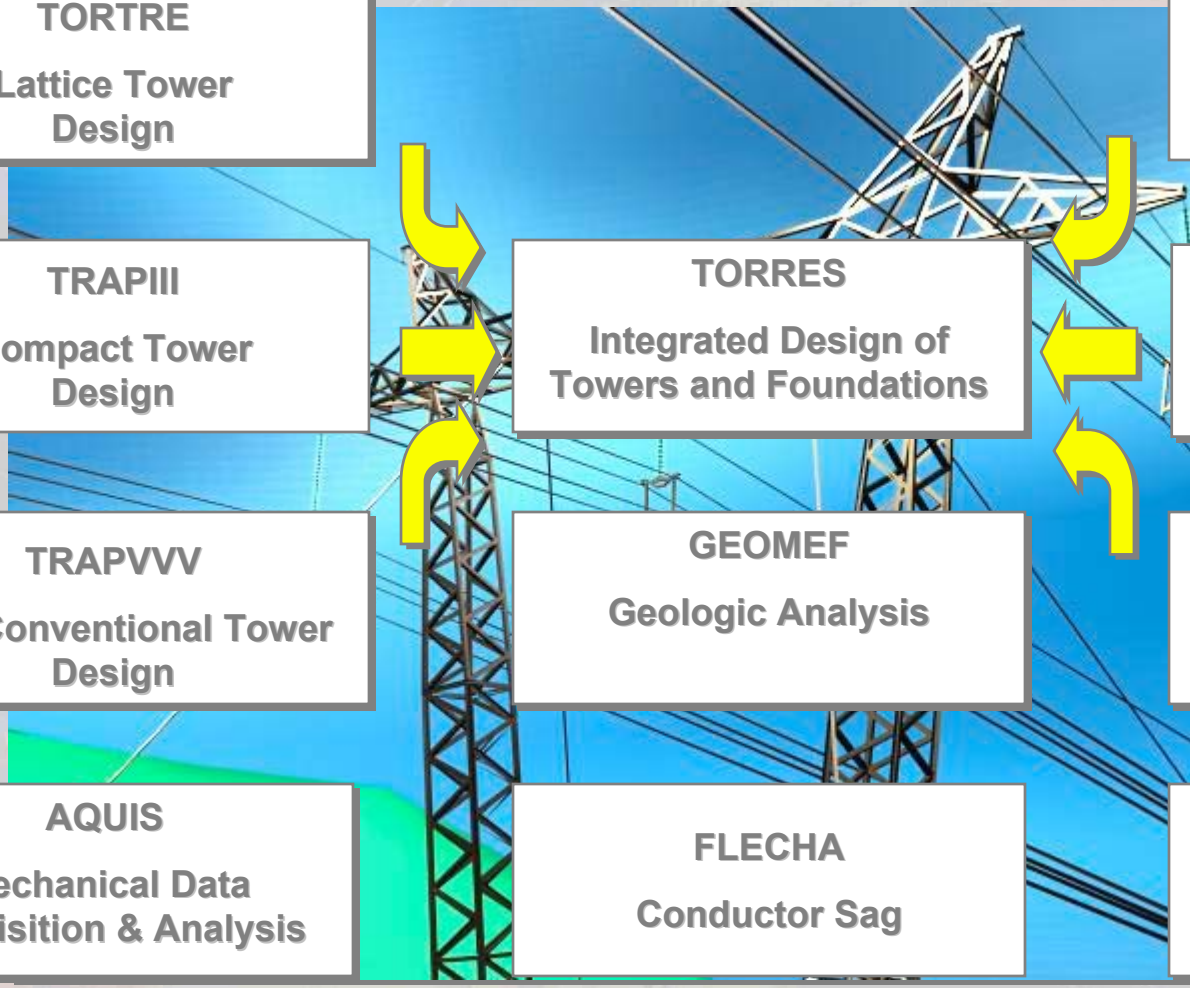
Technical Solutions for TL Upgrading

TRICAMP

3D Electric and Magnetic Field

High Surge Impedance Loading Line - HSIL

TOWERS AND FOUNDATIONS



TORTRE
Lattice Tower Design

TRAPIII
Compact Tower Design

TRAPVVV
Non-Conventional Tower Design

AQUIS
Mechanical Data Acquisition & Analysis

TORRES
Integrated Design of Towers and Foundations

GEOMEF
Geologic Analysis

FLECHA
Conductor Sag

OTIMAS
Optimization Mast

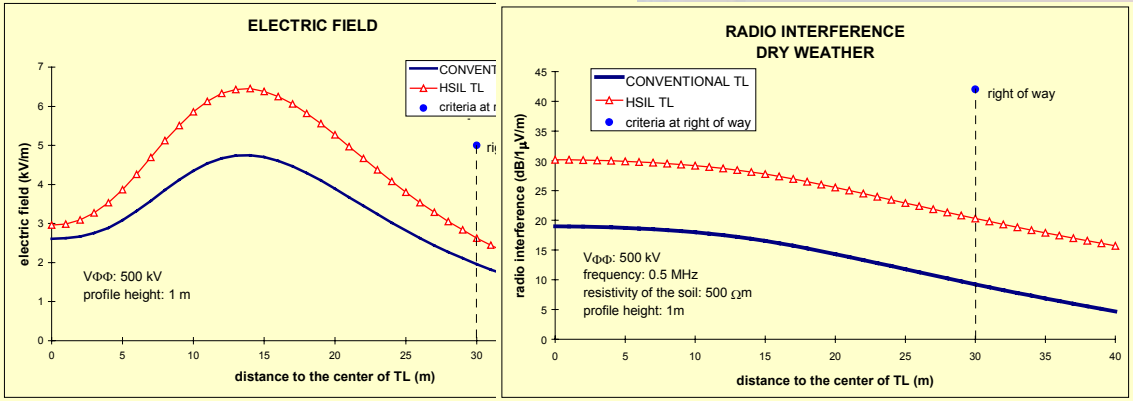
GRELHAS
Metallic Grillage Foundation

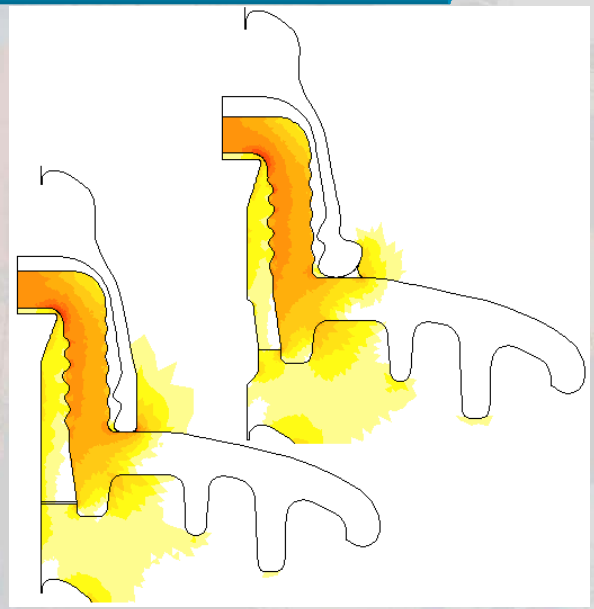
PLOTTOR
Towers and Foundations Sketch Design

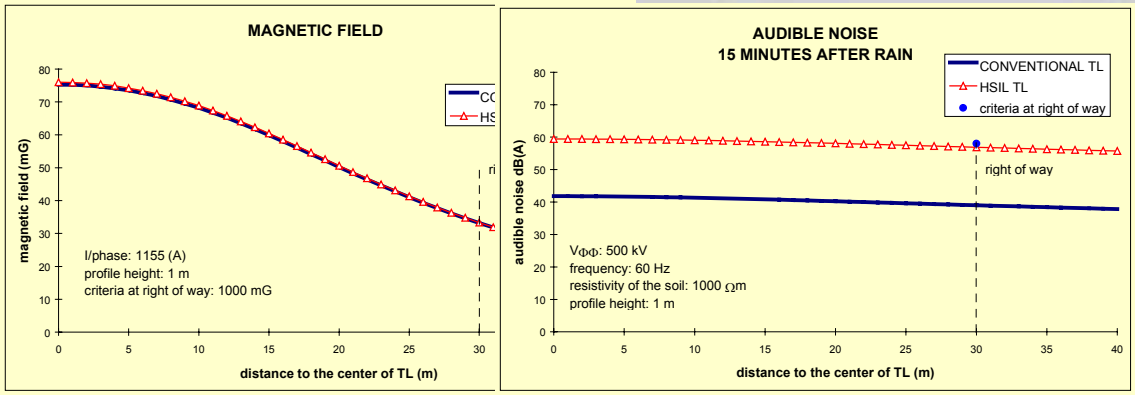
AQUIEEE
Vibration Data Acquisition & Analysis

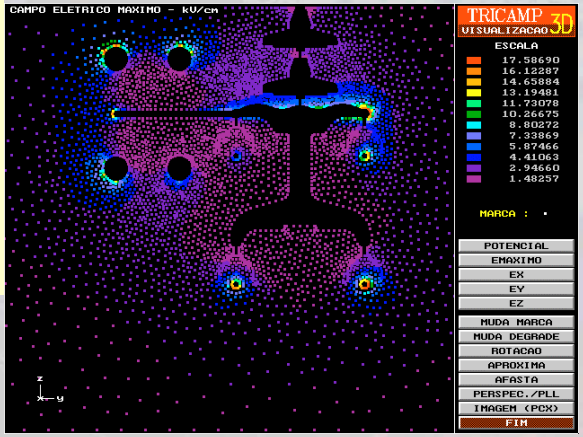
High Surge Impedance Loading Line - HSIL

DEVELOPED TOOLS FOR ANALYSIS AND DESIGN









High Surge Impedance Loading Line - HSIL

LABORATORY STRUCTURE

230 kV HSIL CHESF Line Prototype at CEPEL's High Voltage Laboratory

High Surge Impedance Loading Line - HSIL

LABORATORY STRUCTURE

HSIL (EXB) Banabuiú-Fortaleza - CHESF - Line: 2 x 230 kV

High Surge Impedance Loading Line - HSIL

LABORATORY STRUCTURE

CHESF 500 kV expanded bundle

testing at CEPEL's High Voltage Laboratory

High Surge Impedance Loading Line - HSIL

500 kV P.Dutra – Fortaleza HSIL-EXB Line- 740 km: 2000

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CONCLUSIONS

HSIL Technology is Mature—

Already Adopted by the Coordinating Committee for the Brazilian System Expansion Planning (CCPE)

Currently in Operation:

740 km @ 500 kV

640 km @ 230 kV - double circuit

Experimental 230 kV and 500 kV Lines Report
NO Electrical or Mechanical Incidents for More than 4 Years

Avoided Investment Costs may Reach US$ 1.1 Billion in the Next 10 Years

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