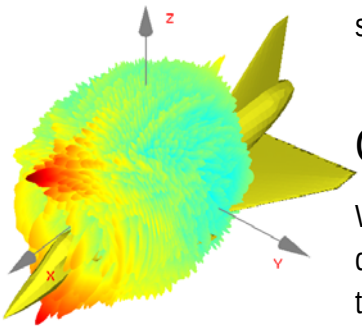
Electromagnetic & Acoustic Simulation Technologies

Wave Computation Technologies, Inc.

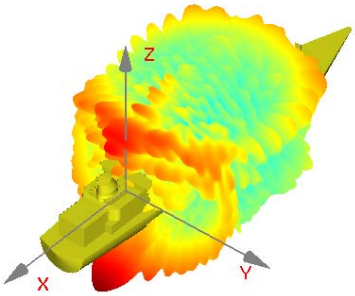
Mission

Wave Computation Technologies, Inc. (WCT) was founded in 2005 at the Research Triangle Area, North Carolina, USA. The mission of WCT is to develop leading-edge wave computation technologies, to deliver robust and user-friendly simulation solutions and personalized technical support, and to accelerate customers' innovations and enable their design optimization.



Core Competencies

Wavenology simulation software packages bring together over 40 years of algorithm development in computational electromagnetics and computational acoustics. The WCT R&D team applies and develops state-of-the-art algorithms to solve electromagnetic and elastic wave equations. The Wavenology series software packages are general-purpose simulation tools for design optimization and for analyzing the physics of wave phenomena. We have developed the following software products as the efficient design optimization tools in the corresponding markets.



* **Wavenology EM**

  A general-purpose 3D electromagnetic wave simulation software package.

* **Wavenology EL**

  A general-purpose, 3D transient acoustic, elastic and seismic wave simulator.

* **Wavenology BHA**

  An advanced elastic wave simulator for borehole acoustics.

* **Wavenology SQUID**

  Co-simulation of electromagnetic fields and Superconducting Quantum Interference Devices.

* **Wavenology EM-IMG**

  Wideband radar (such as ground penetrating radar and through-wall radar) imaging.

* **Wavenology EL-IMG**

  Wideband elastic, acoustic, ultrasound and seismic imaging.

* **Wavenology Litho**

  Optical lithography design simulation for integrated circuits.

* **Wavenology PIC**

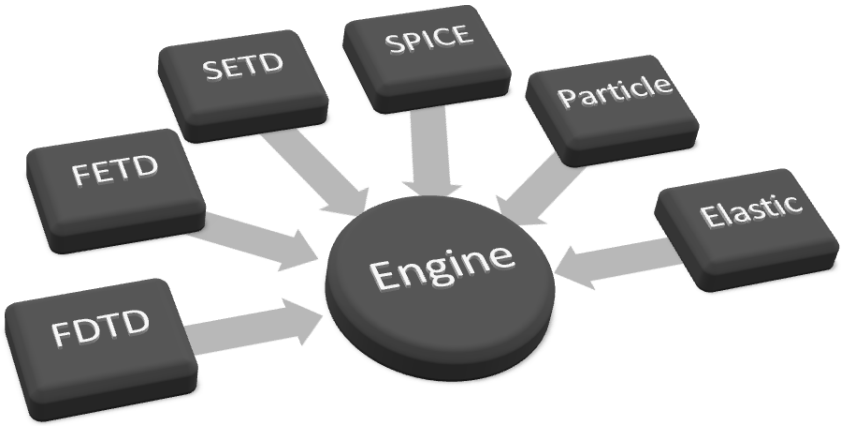
  Electromagnetic particle-in-cell simulation tool.

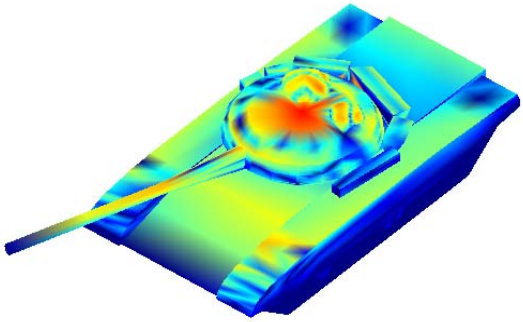
The solution packages utilize a 3D full-wave hybrid technique combining the enlarged cell technique (ECT, an improved version of the conformal finite difference time-domain method), spectral element time-domain (SETD) method, and finite-element time-domain (FETD) method to simulate multi-scale transient electromagnetic and elastic wave propagation and scattering behaviors in complex media.

Wave Computation Technologies

Vision

As the manufacturing capability has rapidly increased during the past few decades, computer-aided design (CAD) and numerical simulation have entered the mainstream of the industry production process. The up-to-date designs and products always require multi-functional (smart), large integration scale and high operation speed. The challenge of computer aided simulation has evolved from simulating the properties of a single component to capturing the real-life system-level behaviors. To achieve this, multiscale, multi-algorithm, multi-physics, and multi-process (parallel) simulations are essential techniques. As a result, much research has been devoted to such techniques during recent years. However, it has been realized that each numerical technique has its own advantages and disadvantages. None of them can handle all problems in all situations. The key factor to achieve a real system-level simulation is to put complementary techniques together and to guarantee accurate, robust and efficient communications, which leads to the technique of hybridization. WCT's R&D team is passionate about providing the best solutions for real-life engineering problems by utilizing the most advanced simulation technologies and by integrating them into a general solution framework so that each numerical technique can run in its most suitable place. Ultimately, a real-life system-level simulation is performed by a series of hybridized, optimally organized simulators.





As a high-tech software company, our business has been steadily expanding. We will continue to expand our business by establishing new partnerships with our industry clients and by providing them the most advanced, efficient and easy-to-use software solution techniques. Our vision is to cultivate an engineering design community that uses rigorous cutting-edge wave simulation software for innovations.

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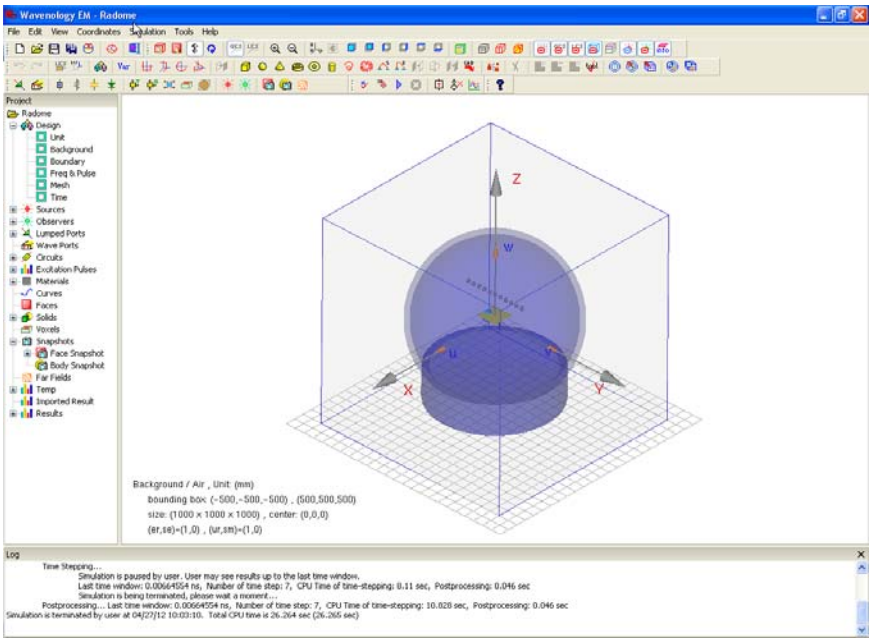
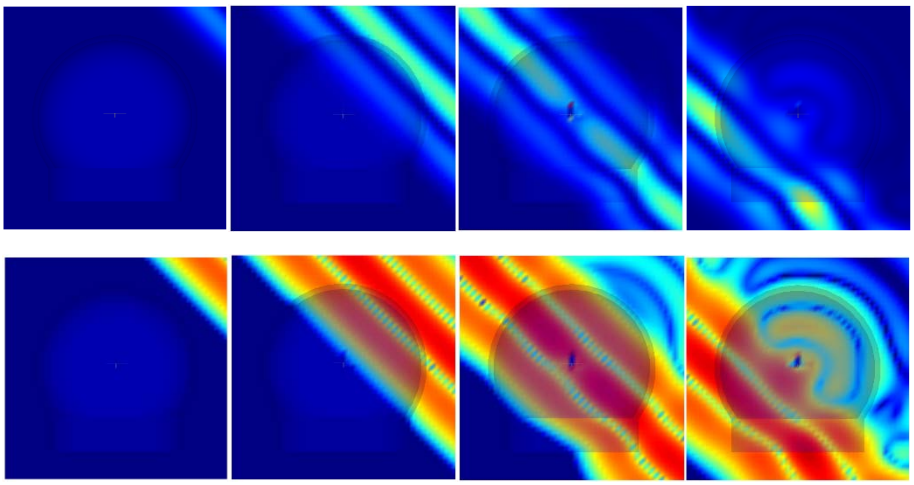
Wavenology EM

Wavenology EM is a general-purpose 3D electromagnetic wave simulation software package for electromagnetic field and circuit co-simulation package, including high-speed electronic circuits, antenna, RF/microwave and optical devices. Wavenology EM utilizes a 3D full-wave hybrid technique combining the enlarged cell technique (ECT, an improved version of the conformal finite difference time-domain method), spectral element time-domain (SETD) method and finite-element time-domain (FETD) method to simulate electromagnetic wave propagation and scattering behaviors in complex media. With Wavenology EM, the user can perform co-design of RF/microwave devices and complex nonlinear circuitries and find electromagnetic fields at any location, extract scattering (S) parameters, calculate the transmission, reflection and radiation losses, and visualize 3D electromagnetic fields in near zone and far zones. Both transient behaviors and their frequency spectra can be obtained efficiently by the simulator.





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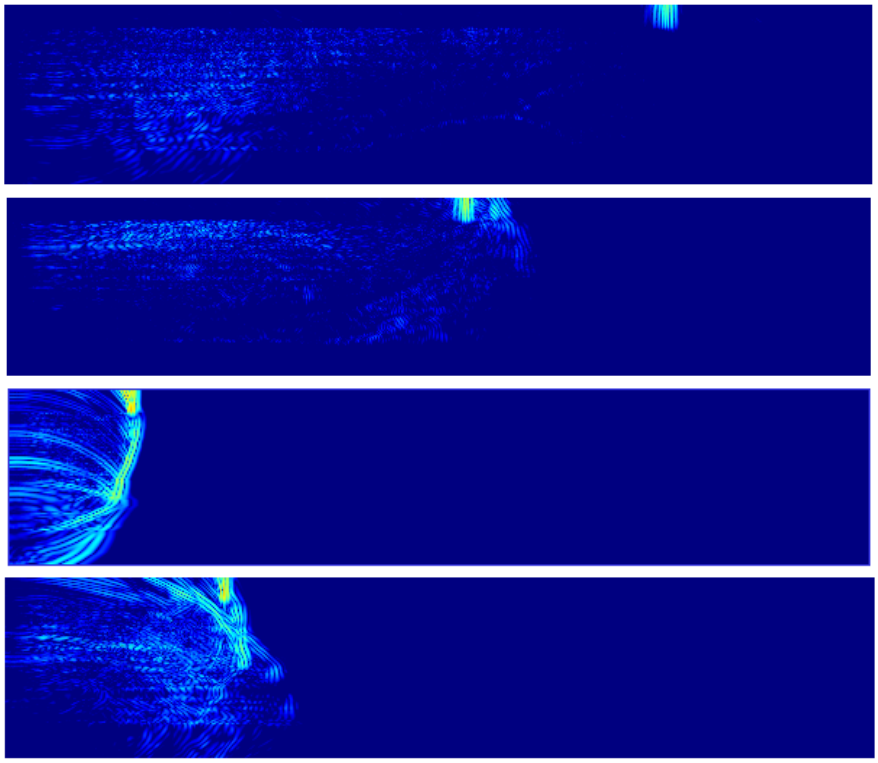
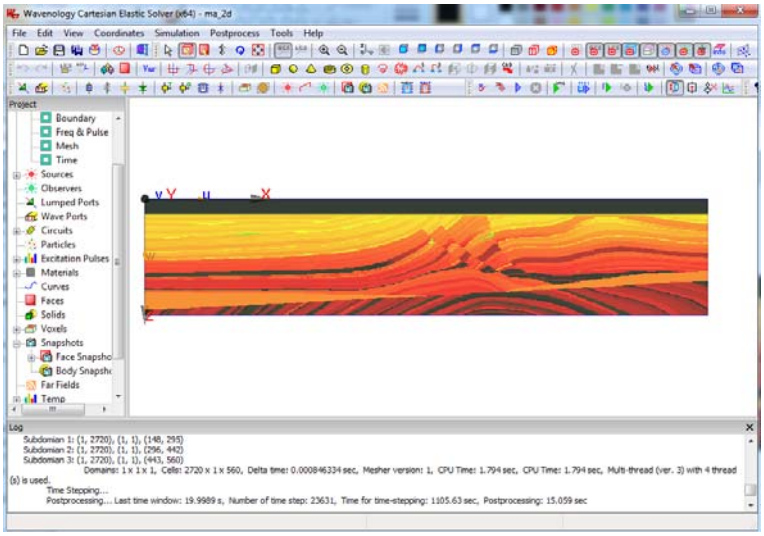
Wavenology EL

Wavenology EL is an advanced, general-purpose, 3D transient elastic wave simulator. It focuses on oil various elastic and acoustic waves, including applications in seismic, sonic, and ultrasonic waves, with major oil services companies and biomedical imaging companies as potential clients. The software contains a fully graphic user interface and integrates a robust transient elastic wave simulator. With Wavenology EL, the designer can analyze and optimize real-life engineering structures for elastic wave scattering and propagation.





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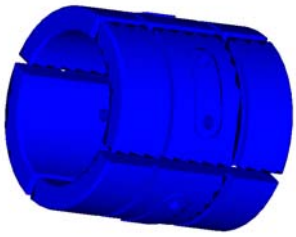
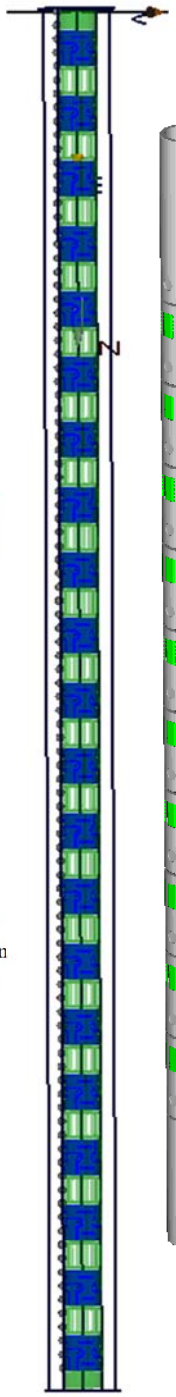
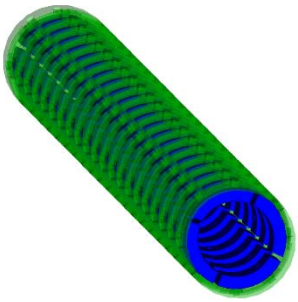
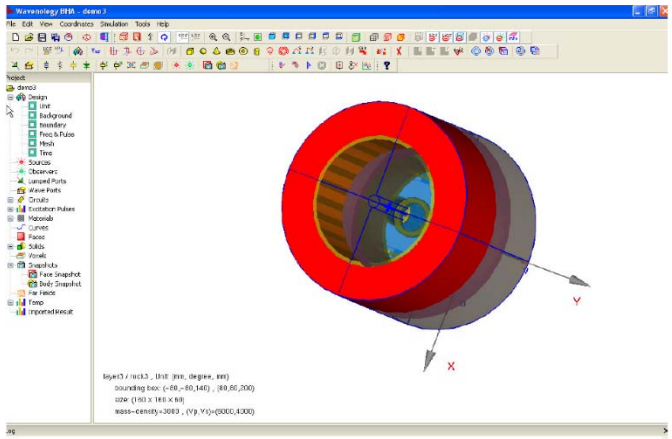
Wavenology BHA

Borehole acoustics is important for sonic (acoustic) well logging in the geophysical subsurface exploration industry; it is also useful for sonic and ultrasound characterization of cement bond and pipeline integrity in the oil industry. In such applications, acoustic waves in a circularly cylindrical borehole environment is of interest, so often it is more desirable to solve the acoustic/elastic wave equations in the cylindrical coordinate system. Effects of a sonic/ultrasound tool body within the borehole have to be well characterized in order to design a high-performance acoustic well logging tool; effects of geological formation heterogeneities and attenuation need to be simulated in order to understanding the received signals. Wavenology BHA is such a full-wave acoustic/elastic wave solver that accounts for material heterogeneities and attenuation in a cylindrical coordinate system. It provides the oil exploration industry with a unique design simulation tool, and can be also a valuable tool for pipeline defect characterization.

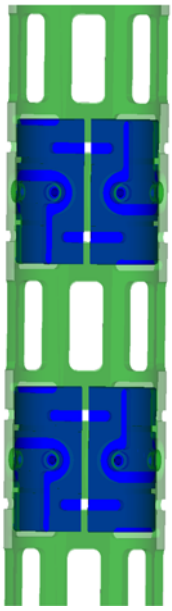


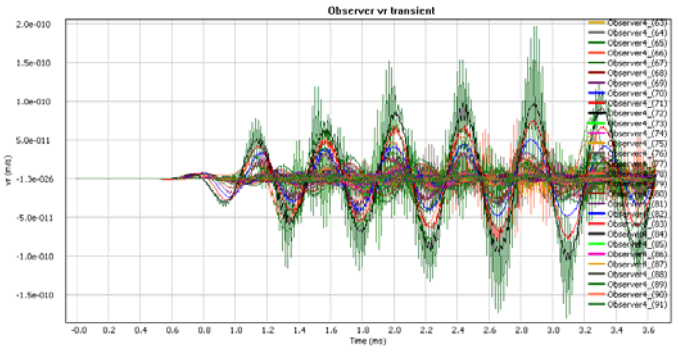






Integrated design environment (IDE) from model creation to result exploration

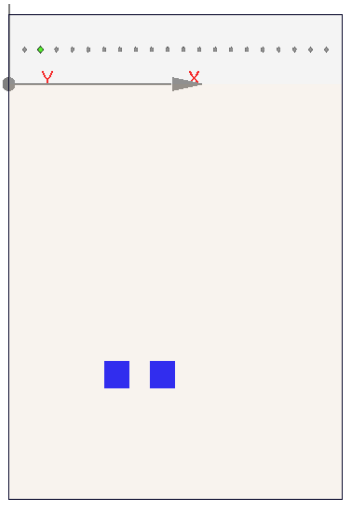


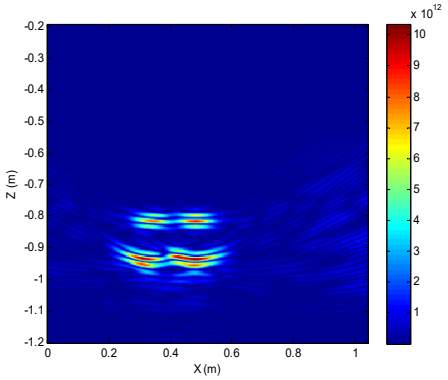


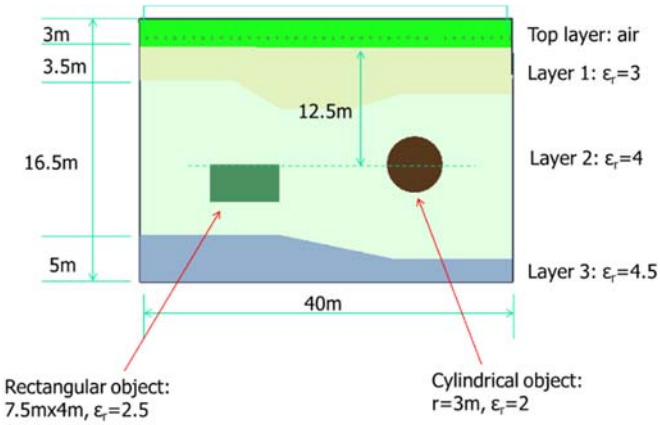
Wave Computation Technologies

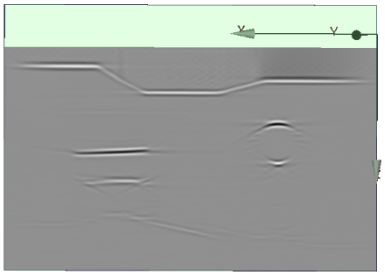
Wavenology EM-IMG

Electromagnetic (EM) waves are widely used for imaging targets in complex environments. Processing collected EM signals to achieve high-resolution images is central to electromagnetic imaging. Wavenology EM-IMG software tool has been developed with a graphic user interface to obtain high-resolution images from wideband EM signals, such as those collected by ground penetrating radar (GPR), through-wave imaging (TWI) radar, and other ultra wideband microwave and millimeter wave radars. One impediment for obtaining high resolution in EM imaging is the multiple scattering from a complex environment. Wavenology EM-IMG has the capability to include the effects of realistically complex environments so that such multiple wave scattering processes can be accurately accounted for, thus achieving high-resolution images. With the Wavenology EM-IMG graphic user interface, the user can design a best measurement configuration to image the targets of interest. Both synthetic and measured wideband radar data can be directly utilized by the Wavenology EM-IMG package.





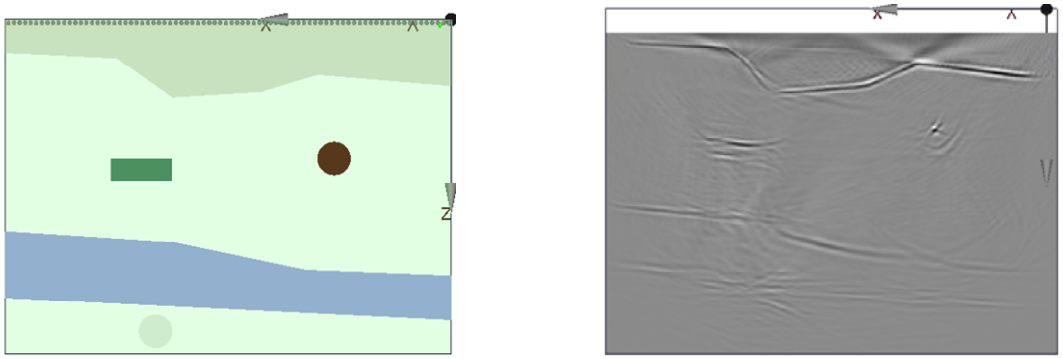




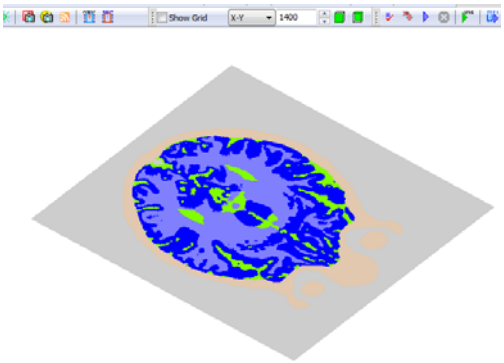
Wave Computation Technologies

Wavenology EL-IMG

Acoustic and elastic waves are widely used in biomedical and geophysical subsurface imaging, as well as ultrasound nondestructive testing and evaluation. In such applications, acoustic or elastic waves interact with targets and their complex environments. The aim of acoustic and elastic wave imaging is to utilize the collected wideband acoustic/elastic wave signals to arrive at high-resolution images of targets. Wavenology EL-IMG is a physics based imaging software tool with a graphic user interface to obtain high-resolution acoustic and elastic wave images from wideband signals, such as those collected by medical and structural ultrasound transducers, seismic sensors, and sonar sensors. By using full-wave acoustic and elastic wave solvers, Wavenology EL-IMG can accurately account for the multiple scattering effects of the environment and targets, thus obtaining high resolution in its images. With the Wavenology EL-IMG graphic user interface, the user can design a best measurement configuration to image the targets of interest. Both synthetic and measured wideband sonar, ultrasound and seismic data can be directly utilized by the Wavenology EL-IMG package.



Seismic Imagining of Subsurface Targets

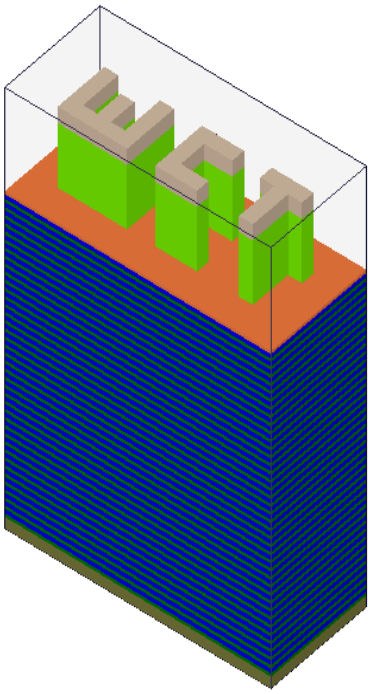


Biomedical Ultrasound Imaging of human head

Wave Computation Technologies

Wavenology Litho

Wavenology Litho is developed as a highly accurate tool to model optical diffraction in lithography. Deep ultraviolet (DUV) and extreme ultraviolet (EUV) lithography technologies are crucial to today's high-density semiconductor patterning. However, optical diffractions caused by subwavelength features and multilayer distortions caused by mask defects are challenging to model in large-scale high-resolution lithography models. To simulate the influence of the defected nanoscale structures with high accuracy and efficiency lithography, we have developed a spectral element method combined with a surface integral equation solver, which can be order of magnitude faster than the traditional finite element method.

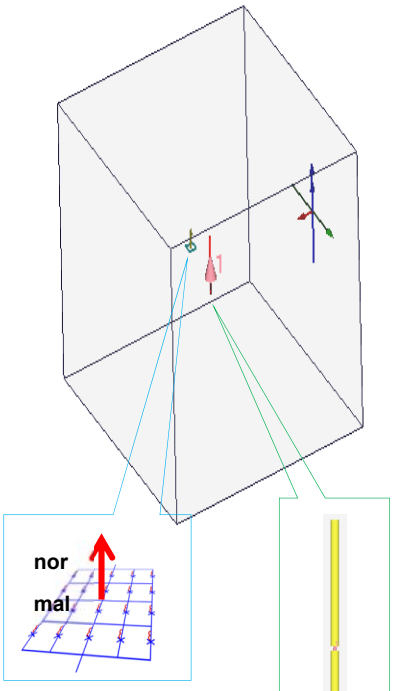


Wave Computation Technologies

Wavenology SQUID

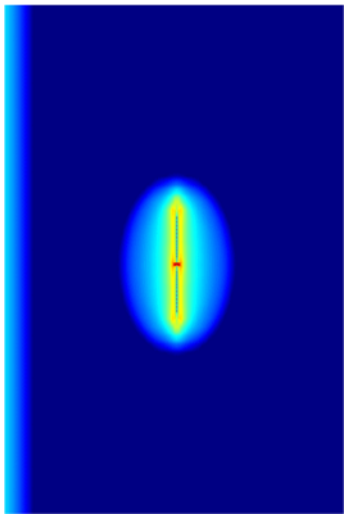
Wavenology SQUID is simulation tool for modeling superconducting quantum interference devices (SQUIDs) and large-scale two-dimensional superconducting quantum interference filters (SQIFs) in a dynamic electromagnetic environment. The fundamental building block of this tool is the Josephson junction and its circuit representation in a SQUID. The simulator has an intuitive graphic user interface (GUI) to enable the layout of 2D SQIFs. It allows one to accelerate the hybrid design of SQUIDs and SQIFs irradiated by electromagnetic fields.

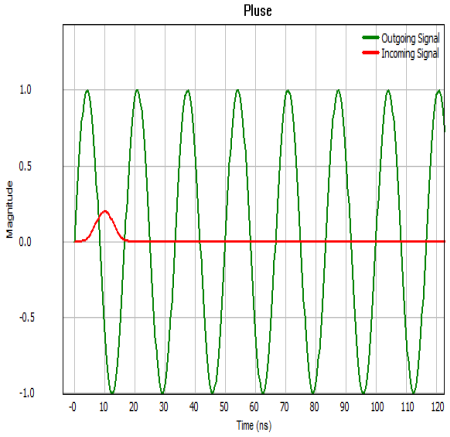
Incident Plane wave



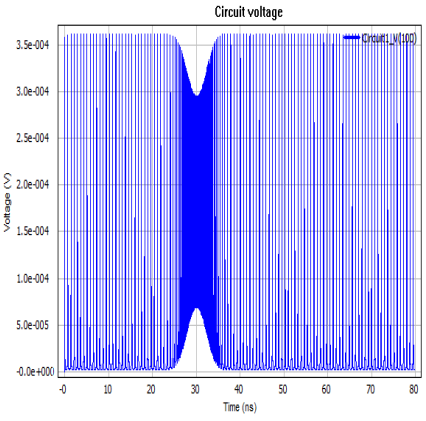
20x20 loops 2D SQIF (B antenna)

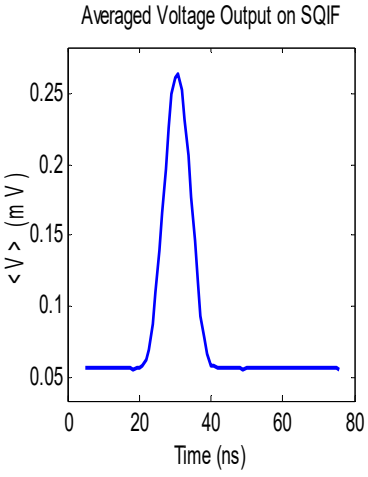
λ/2 dipole E antenna





Transient voltage on B antenna

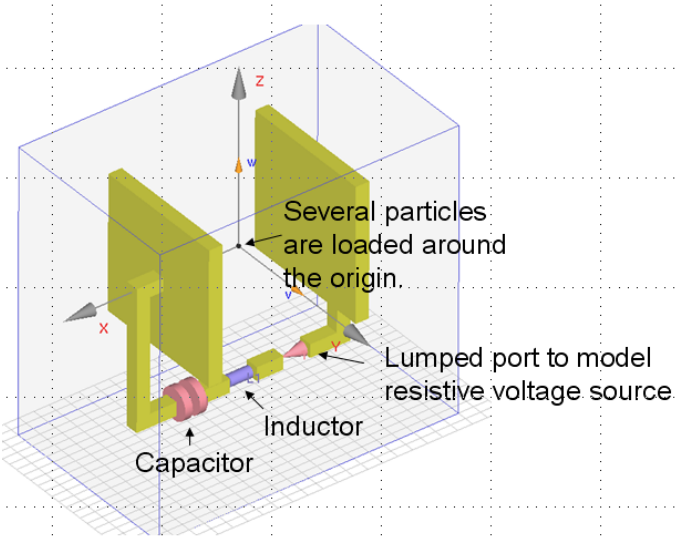


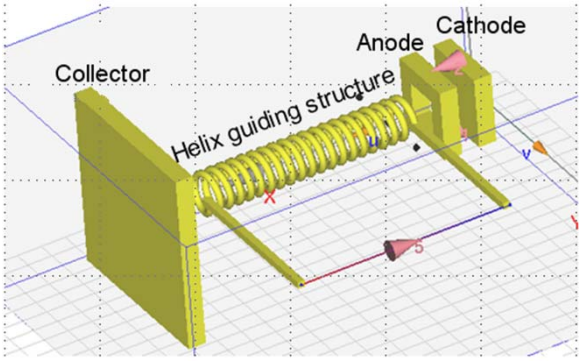


Wave Computation Technologies

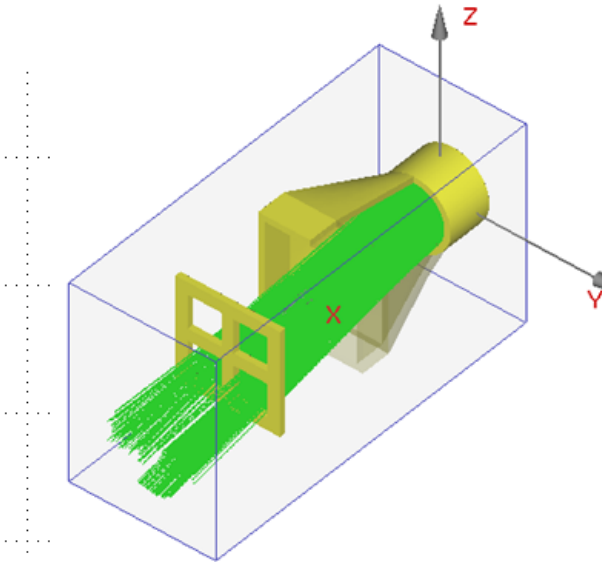
Wavenology PIC

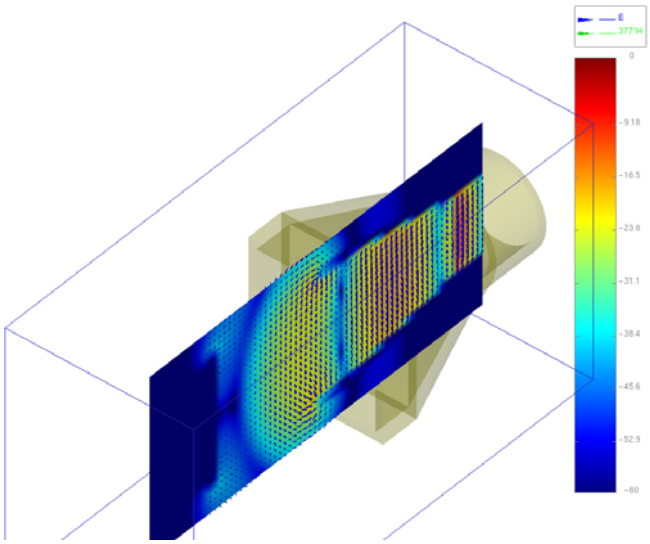
Electromagnetic particle-in-cell (PIC) simulation is an important design prototyping step in research and development of high power microwave sources and other high power microwave applications. Wavenology PIC software tool are developed with a graphic user interface for the PIC simulation. With Wavenology PIC, the user can design a complex geometry for a PIC problem. In addition to hybrid EM-PIC solvers, the EM solver itself contains hybridized solvers as well. To take advantages of each method





in their preferred application domains, ECT is applied to regions with electrically fine structures, while the SETD method is applied to regions with electrically coarse structures. Applications such as: particles between two plates powered by a circuit; Cathode ray tube (CRT) mode; Velocity modulation of traveling wave tube (TWT); and particles in a tube excited by a wave mode can all be efficiently and accurately simulated by Wavenology PIC.

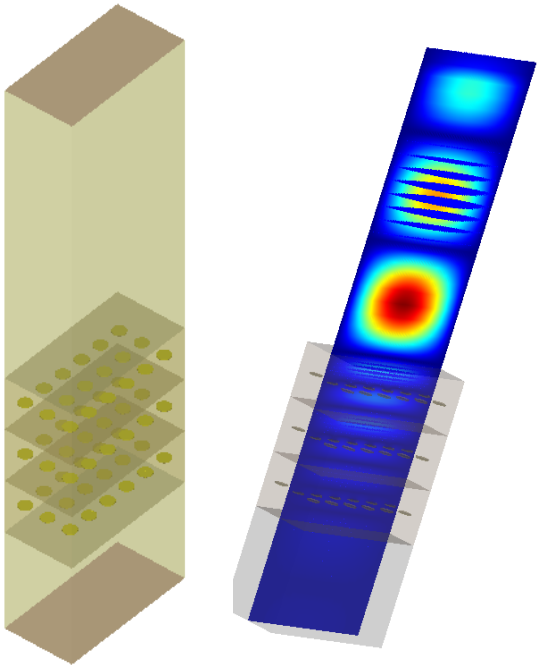




Wave Computation Technologies

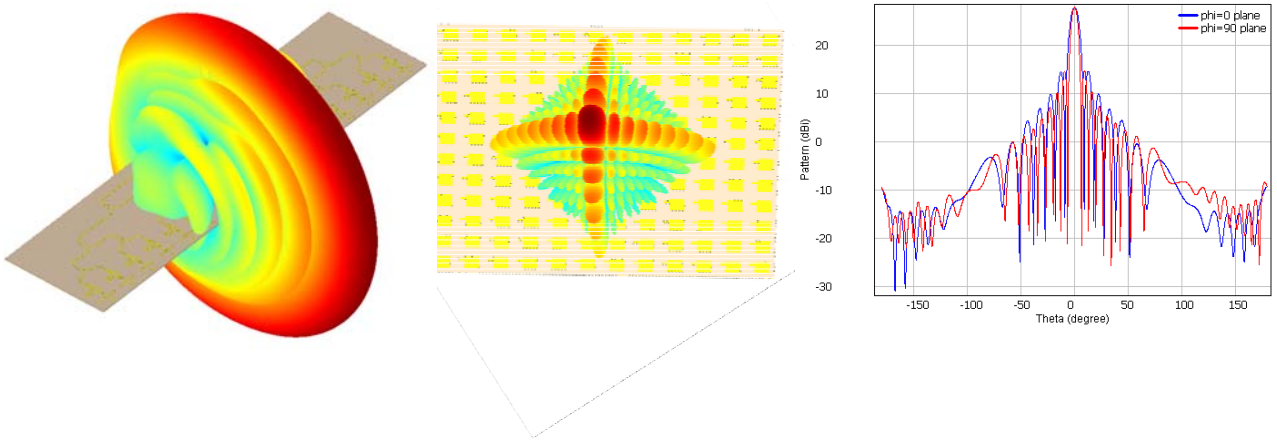
Product Advantages

- Hybrid transient techniques, smartly integrate FETD, SETD, FDTD solvers
- Co-simulation of complex circuit and electromagnetic field systems (Hybrid EM-SPICE)
- Co-simulation of EM and Particle in Cell interactions
- Ability to simulate superconductivity phenomena such as Josephson junction, SQIF and SQUID systems
- Ability to simulate elastic wave behaviors



Selected Awards

- 2011 STTR Phase II Award: Development of Co-Mingled E and B Field Antennas
- 2010 SBIR Phase I Award: Discontinuous Galerkin Modeling of Electromagnetic Propagation through Novel Materials and Configurations
- 2010 STTR Phase I Award: Development of Co-Mingled E and B Field Antennas
- 2009 STTR Phase I and II Award: A Multiscale Software Tool for Field/Circuit Simulation
- 2008 SBIR Phase I and II Award: A New Hybrid Method for High-Order EM-PIC Simulations
- 2006 SBIR Phase I Award: Fast Computation Model for Therapeutic Ultrasound



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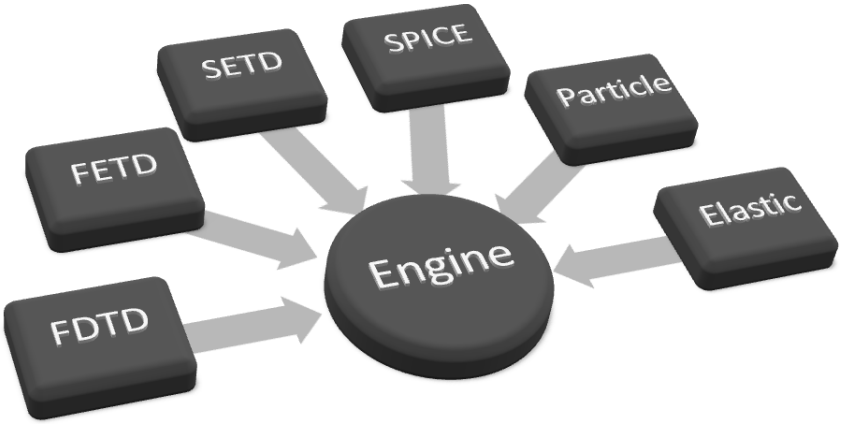

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Wavenology aims to provide customers with the best computation technologies available for waves in electronic, photonic, medical, and geophysical industries. Our research team applies and develops state-of-the-art algorithms to solve wave equations. The software packages are general-purpose tools for design optimization and for understanding the physics of wave phenomena.