

OOFELIE::Multiphysics 2012

Strongly coupled multiphysics propels your design into the future

Successful technical innovation can only be based on robust accurate design. Today's PLM (Product Lifecycle Management) benefits from using advanced multi-core, multi-grid computer technology. It is now possible to simulate complex multiphysics problems in a single simulation run and thus obtain results that were previously only achievable after lengthy (and time consuming) measurements. As a consequence, accurate multiphysics CAE cuts the number of design cycles and accelerates your innovation capacity.



Intuitive Left-to-Right Design Flow showing a circuit breaker model

Industry Standard Design Flow

OOFELIE::Multiphysics is integrated in SAMCEF Field, an industrial CAD/CAE user interface (UI) used extensively in the Aeronautics and Automotive industry. While featuring all elements for a professional CAE design, it takes an intuitive 5 step approach, presenting only the functionality you need at every step.



Modeler - Use the full CAD interface for parameterized multiphysics modeling of your design. Link into the design flow by importing and manipulating files from various vendors (CATIA®, Solidworks®, STEP, IGES...).



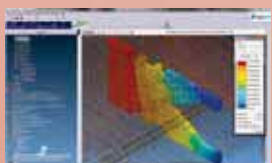
Analysis Data - Use the hierarchical UI to assign the different multi physical (multi-dependant, equation based) material properties to each component. Make use of a pre-defined material data base to increase your efficiency. Set loads and constraints.



Mesh - Define the mesh of your geometry. Take the most accurate and efficient approach by using the full spectrum of mesh shapes (tetrahedron, pentahedron, hexahedron...), mesh orders (linear, quadratic) and mesh generation (Delaunay-Voronoi, Frontal...) methods. Use gluing and mesh contact algorithms to efficiently join separate meshed parts.



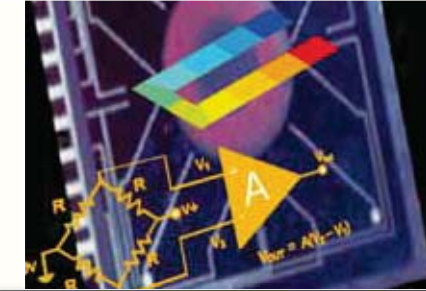
Solver - In the electro-thermal domain (example), you solve for the transient or static response of your parameterized system. OOFELIE will strongly couple thermal and electrical effects to better model Joule heating. Move from verification to design by linking to optimization scripts or to BOSS quattro for parametric analyses, design of experiments, multidisciplinary optimization, sensitivity & statistic analysis.



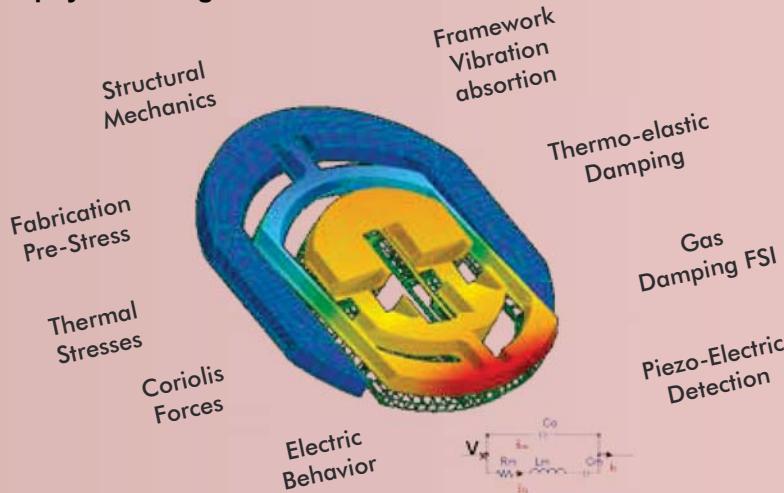
Result - After simulation, examine your results in the solution tree of the hierarchical UI. The results can be 3D plots as well as animations and sound files of the multiple physical fields that are calculated! Finally results are easily exported to other tools for further post-processing.

PRODUCT FEATURES:

- **Mechanical Analysis**
 - Static and transient linear and non-linear
 - Modal and harmonic
 - SEM::Super Element Modeling
 - Iso- and orthotropic materials: viscous, visco-elastic and structural damping perfectly matched layers (PML)
 - 3D, 2D planar & axisymmetric modeling
 - (Oriented) volume, membrane, shell, rod, beam, lumped mass elements
 - Large displacements
 - Identical nodes, contact, perfect/non-perfect mechanical gluing, rigid body assemblies
 - Pre-stress
 - Special effects: Coriolis, centrifugal
 - 2 way coupling with thermal, electric, magnetic, fluid, optic, acoustic fields
- **Thermal Analysis**
 - Static and transient linear and non-linear
 - Super Element modeling
 - 3D, 2D planar & axisymmetric modeling
 - Identical nodes, thermal gluing, thermal contact admittance
 - 3D mutual radiation (ray tracing)
 - 2 way coupling with mechanical, electrical, fluid fields
- **Electrical Analysis**
 - Static and transient linear and non-linear
 - Super Element modeling
 - FEM/BEM coupling
 - Dielectric materials
 - Identical nodes, perfect/non-perfect electrical gluing
 - RLC, electric dipole elements
 - 2 way coupling with mechanical and thermal fields
- **Acoustic Analysis**
 - Modal and harmonic
 - FEM/BEM coupling: acoustic surface, acoustic Rayleigh surface
 - Acoustic material
 - Viscous, structural damping, perfectly matched layers (PML)
 - Absorbent panel with frequency dependent admittance and impedance
 - Plane wave excitation, point acoustic source,
 - Prescribed normal displacement, velocity, acceleration
 - 2 way coupling with mechanical field



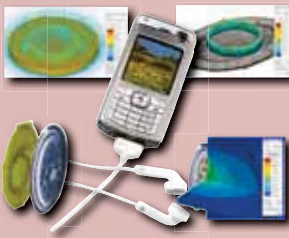
Why Today's Sensors and Actuators need Strongly Coupled Multiphysics Design



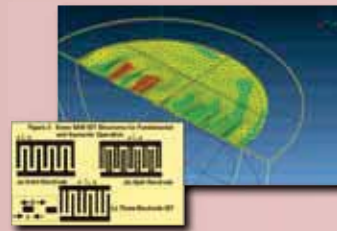
VIA - Vibrating Inertial Accelerometer: Based on piezo-electric detection of a Vibrating beam. - Courtesy ONERA.

Today's sensors and actuators often involve multiple physical phenomena such as Capacitive – Electrostatics, Piezoresistivity, Piezoelectricity, Acoustics, Thermics, Peltier effects and ElectroMagnetics.

As components are increasingly scaled down (nanotechnology, MEMS), specific microscopic physical phenomena assume greater importance (Electrostatic effects, Peltier). Furthermore the time-constants of these physical phenomena have similar orders of magnitude (electrical, mechanical and thermal effects). Classical design techniques performing sequentially coupled simulations of the different physical phenomena will yield poor accuracy. Not so with OOFELIE::Multiphysics, which can solve more than 4 of such phenomena in a single, strongly coupled simulation setup for optimal accuracy and convergence.



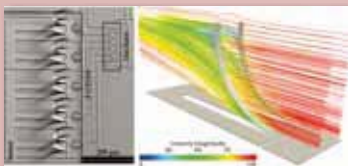
Electro-magnetic actuation of mini-speaker used for mobile communication. Top-left: Electromagnetic field - top-right resulting EM forces on membrane. Bottom-right Sound-pressure field.



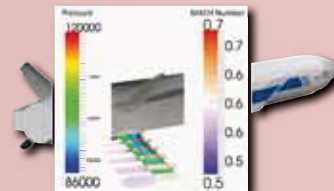
SAW (Surface Acoustic Wave) Filter, based on piezo-actuation and detection. Take into account the large scale differences and infinite domains necessary for modeling a typical electronic multilayered structure.

OOFELIE Opens The world of CFD to The Entire Multiphysics Domain

You can solve microsystem FSI problems such as flow sensors or micro-pumps using OOFELIE::Multiphysics.

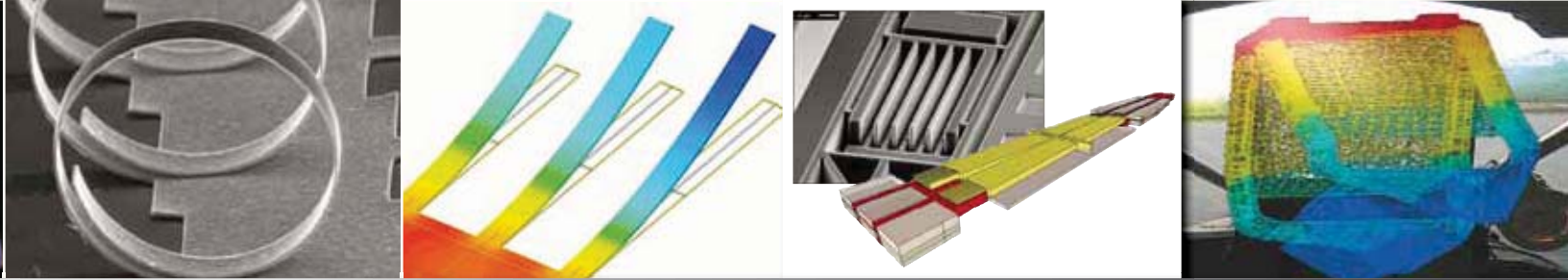


Integrated design of a MEMS-based Flow-sensor system: Streamlines circulating around two out-of-plane fingers - using OOFELIE::Multiphysics



Fluid Structure Interaction: missile wing deformation under influence of airflow, using FINE™/FSI-OOFELIE.

- **Fluid Analysis**
 - Static and transient linear and non-linear
 - 3D, 2D planar modeling
 - Symmetry planes
 - Incompressible, compressible subsonic, compressible supersonic (FINE™/FSI-OOFELIE) inviscid, laminar viscous, turbulent viscous (FINE™/FSI-OOFELIE)
 - Boundary conditions: velocity and temperature at inlet, pressure at outlet
 - Boundary conditions: non-slip flow, surface heat flux or temperature at walls
 - 2 way coupling with mechanical and thermal fields
- **Electro-Magnetic**
 - Electro-technical hypotheses
 - Static and transient linear and non-linear
 - Harmonic
 - 3D, 2D planar & axisymmetric modeling
 - Magnetic non-conductor and conductor, isolator, active and passive conductor
 - Permanent magnet
 - Inductor: given current direction, axi-symmetric
 - Electromotive source: current driven, potential driven
 - Infinite extension medium, electromagnetic wire
 - Coupling with mechanical (Laplace force) and thermal (Joule effect) fields
- **Thermo-Mechanic**
 - Static and transient linear and non-linear
 - Modal and harmonic
 - SEM::Super Element Modeling
 - 3D, 2D planar & axisymmetric modeling
 - Thermo-elastic iso- and orthotropic materials
 - Thermo-elastic damping effect
 - Thermal dependency of material properties
 - Phase change
 - 2 way coupling with electric, electromagnetic, fluids, optics, acoustics fields
- **Piezo-electric**
 - Static and transient linear and non-linear
 - Modal and harmonic
 - SEM::Super Element Modeling
 - Piezoelectric materials: hexagonal C6, trigonal D3, triclinic C1
 - Perfectly matched layers (PML)
 - Volume, membrane
 - 2 way coupling with thermal, fluid, optics (1 way) acoustics fields



For large scale problems with complex flow regimes, FINE™/FSI-OOFELIE is an integrated solution for strongly coupled fluid-structure interaction simulations. It combines the latest technology in Multiphysics and Computational Fluid Dynamics (CFD) design.

FINE™/FSI-OOFELIE applications are of crucial importance in critical fields, often those with high security and reliability risks: potentially dangerous fluid-structure interactions (FSI) can occur in aircrafts, such as nozzle vibration, wing flutter or buffeting – and in wind turbine applications. Other Fluid-Structure Interaction applications include fuel tank sloshing or the design of piezoelectric based MEMS for flow characterization.

With FINE™/FSI-OOFELIE you do not need to learn, validate and match three different types of simulation software: structure simulation, CFD simulation and MPCCI for data transfer. Instead you can just setup and launch the complete simulation using the integrated FINE™/FSI-OOFELIE solution so making significant savings in setup time as well as improving reliability.

Advanced Optics Design

Ever more high precision applications are required to perform in demanding conditions. This must inevitably raise the design standards of optical devices with regard to high dimensional stability, increased accuracy and predictable performance.

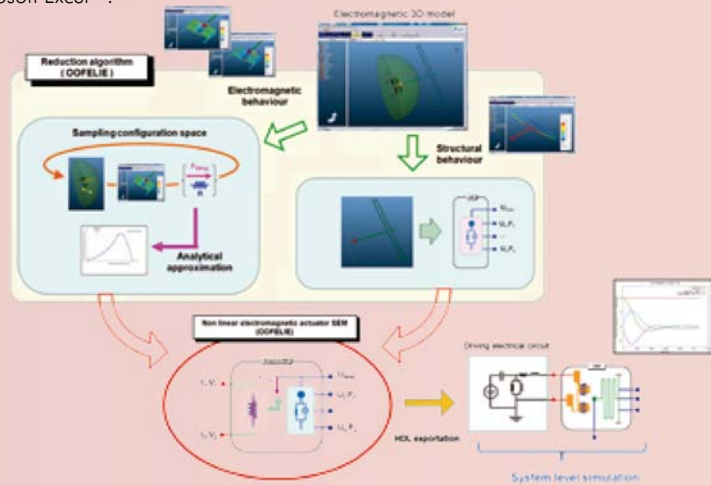
OOFELIE::Multiphysics performs a coupled analysis of Opto-thermo-electro-mechanic interactions linked to Zemax®, including novel optics steering mechanisms such as those based on piezo-electrics and thermo mechanics.



Electrostatic actuated micro-lens for biomedical application (With courtesy of University of British of Columbia and British Columbia Cancer Research Centre, CANADA)

Reduced models (SEM) Solutions for System and MEMS Design

Reduced Order - or Super Element- Models are used when you need to combine the accuracy of Strongly Coupled 3D multiphysics problems with the simplicity of System and Circuit simulation or even Microsoft Excel™.



Reduced order model for an electromagnetic actuator. A parameterized electromagnetic and structure model of the actuator is processed to characterize the structural, electro-magnetic and coupling behaviors of the device. The result is a reduced order model that returns the force and displacement exercised by the actuator as a function of the electric current applied to the pins.

Pyro-Piezo-Electric

- Pyro-piezoelectric materials: hexagonal C6, trigonal D3, triclinic C1
- (Oriented) volume
- 2 way coupling with fluid, optics (1 way) acoustics fields

Vibro-Acoustic

- Modal analysis
- Harmonic analysis coupled: complex direct, projection in coupled modal basis, projection in uncoupled modal bases
- Harmonic analysis uncoupled: uncoupled acoustic radiation, modes radiation efficiency computation
- FMM: Fast Multipole Method
- Vibroacoustic interaction using incompatible meshes: node-based interpolation, projection interpolation
- Vibroacoustic interaction panel using compatible meshes
- Coupling with electromagnetic (1 way), pyropiezoelectric (2 way)
- Chaining with SAMCEF Mecano & Repdyn

Electro-Static actuation

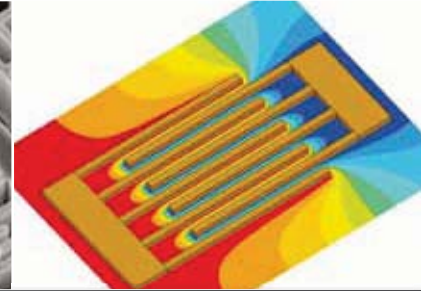
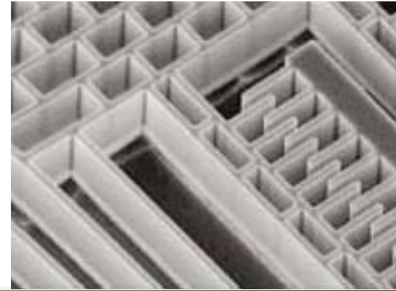
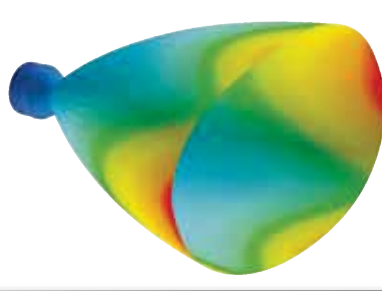
- FEM/BEM coupling
- Mesh morphing
- Fast multipole methods for BEM
- Pre-stress

Electro-thermo-mechanic

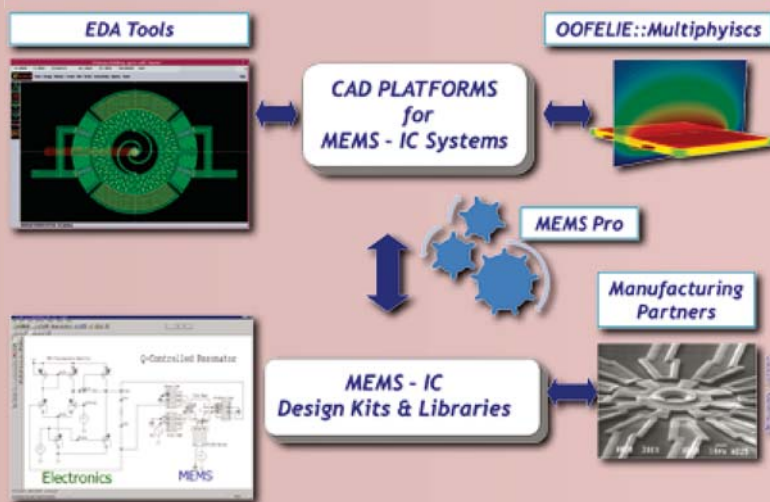
- Static and transient linear and non-linear
- Thermoelectric conductor isotropic
- Thermo-elastic electric conductor isotropic
- Peltier, Seebeck, Thomson, piezo-resistive effects
- Joule heating
- Thermal dependency of electrical and thermal conductivity

Opto-Thermo-mechanics

- Coupling with ZEMAX®: automated data exchange between OOFELIE and ZEMAX-EE via in-memory dialog
- Description of surface deformations: Zernike standard or Zernike fringe polynomials, grid of points, circular, elliptic and rectangular apertures
- Rigid body motion recognition and ability of exporting it separately to ZEMAX®
- Thermo-optic effect: accounting for refractive index change as a function of temperature: computation and visualization of refractive index gradients inside lenses, automated exportation to ZEMAX®



Super Element Models are used intensively in the microsystems (MEMS) design flow. Simulations at circuit level require accurate compact models of the MEMS components, that are generated from computationally expensive 3D numerical models. The models are generated using HDL (Hardware Definition Language) and inserted, in a circuit simulator for MEMS - Circuit co-simulation such as T-Spice.



The MEMS™ Pro design flow links EDA tools layout to OOFELIE::Multiphysics using design kit information from the MEMS manufacturer. The result is a full 3D Multiphysics simulation of the device, that can be exported as a reduced order model for circuit or system simulation.

Speed Up Your Innovation Cycle Using The OOFELIE Software Development Kit

OOFELIE::SDK lets you implement your new ideas inside an industrial class solution. You will speed up your innovation cycle by building your solution upon an established multiphysics simulation tool.

You can create innovative solutions:

- **Customize OOFELIE.** Extend the OOFELIE capabilities using the C++ like scripting functionality or use the SDK to better meet your needs by taking advantage of the toolkit's APIs.
- **Embed OOFELIE inside your own application.** Integrate OOFELIE components inside an existing application.
- **(Re)engineering.** Create a completely different application or reconstruct an existing in-house numerical simulation solution with modern components.
- **Compiled models.** Create compiled models, directly in C++ using OOFELIE components.

Products and Services

Open Engineering, part of the LMS - SAMTECH Group, is a breakthrough supplier of Multiphysics software for the CAE market. Our solutions are based on the OOFELIE::Multiphysics platform, optimized for large complex industrial 3D design work.

OOFELIE::Multiphysics provides you with unique capabilities to analyze industrial applications such as: sensors & actuators, MEMS & MOEMS and Fluid-Structure Interaction problems.

Fluid-Structure Interaction

- Static and transient linear and non-linear
- Thermo-elastic iso- and orthotropic materials for structure materials
- Thermal dependency of material properties
- Fluid materials for fluid domain
- 3D, 2D planar modeling
- Symmetry planes
- Fluid structure interfaces, fluid structure incompatible mesh gluing
- Fluid damping permits to take into account fluid surrounding vibrating structure: incompressible BEM/stokes formulation

Command Line Interpreter

- C++ like object oriented syntax
- Access to complete model
- Full access to elementary and global matrices and vectors
- Define new - or adapt - existing algorithms
- Advanced results post-processing
- Parametric design

Optimization

- Using BOSS quattro
- Parametric design
- Multidisciplinary design optimization
- Statistic studies (Monte-Carlo)
- Model updating
- Design of experiments and response surfaces



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