

**DS SIMULIA**



**3DEXPERIENCE**

# **OPERA SIMULATION SOFTWARE**

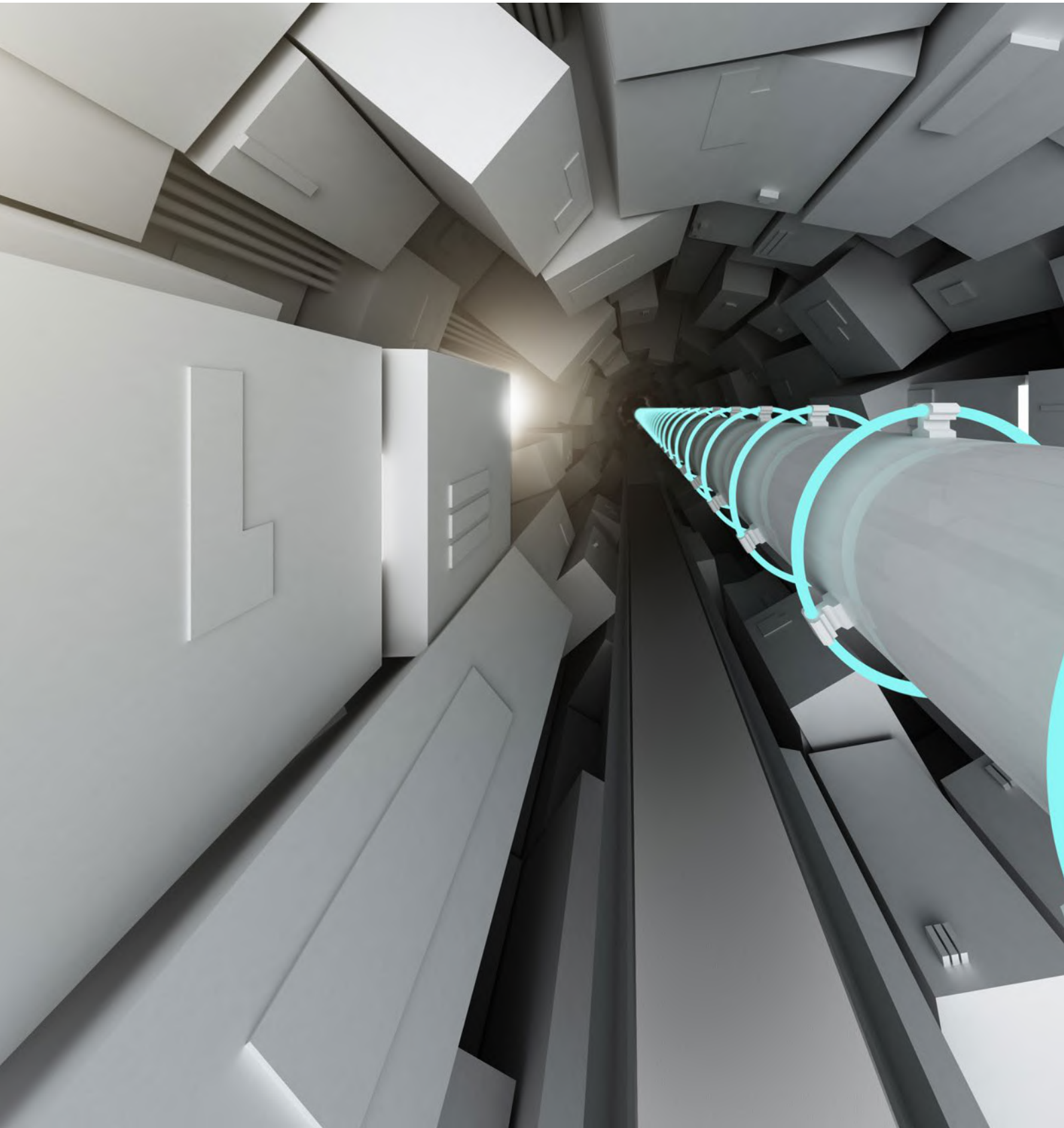
**DS DASSAULT  
SYSTEMES**

**Opera is able to give accurate numerical solutions to real-world problems in:**

- Electrostatics
- Magnetostatics
- Low frequency electromagnetics
- High frequency electromagnetics
- Space charge
- Thermal problems
- Structural problems

**Opera has a wide range of supporting capability to enable high-fidelity models that includes:**

- Moving parts
- Transient fields
- Non-linear materials
- Hysteretic magnet materials
- Lossy dielectrics
- External circuits
- System engineering
- Device optimization



Specialist facilities are offered for examining specific conditions in more detail than might be feasible with standard facilities and solvers, including:

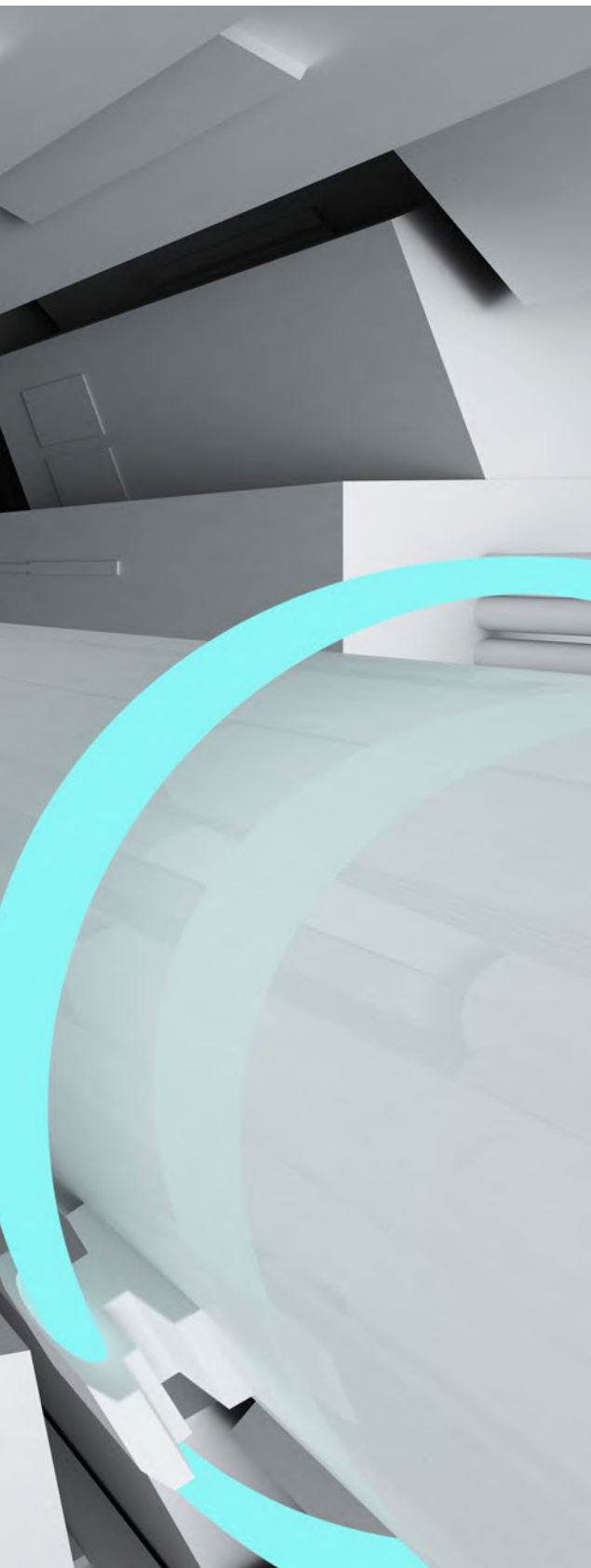
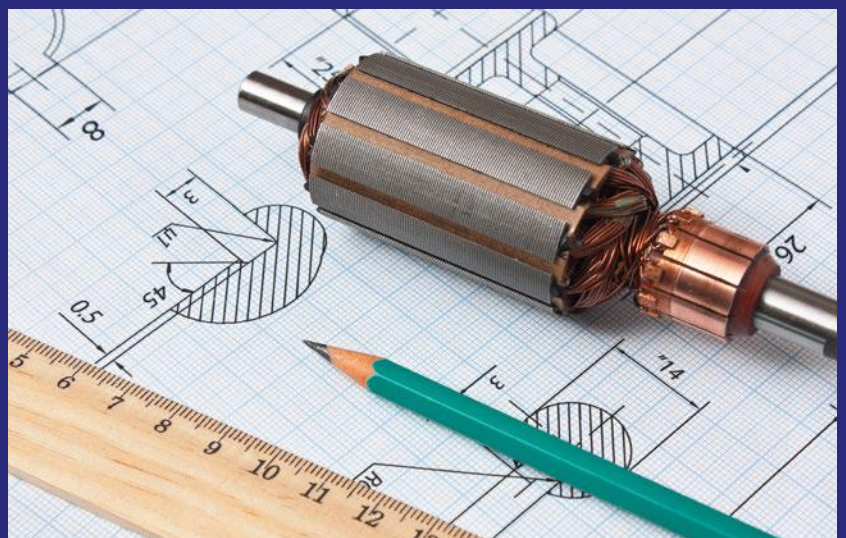
- Quench of superconductors
- Demagnetization of magnets
- Magnetron sputtering

Engineering products are becoming more sophisticated and complex, yet development timescales invariably shorten. In today's global marketplace, competition is becoming more intense. More than ever before, successful products need to be highly optimized for their target markets. This might demand optimization in different forms such as lower raw material costs, better performance, smaller size or greater efficiency.

With engineering skills at a premium, design automation using computer modelling and simulation tools to quickly create virtual prototypes often represents the single most effective investment that companies can make to support an innovative design team. In some engineering product areas, where the scale and cost of engineering is very high, virtual prototyping can sometimes represent the only practical design route.

Exactly how can simulation stimulate innovation? The answer lies in the flexibility of simulation and the ease of change. Once a design model of a new product concept has been created, simulation tools make it simple to take a "What-if?" approach and explore behaviour by changing design parameters. These changes can target every aspect of a design: to get the best performance, the minimum use of expensive materials, the smallest size, the highest power density, the least sensitivity to manufacturing tolerances. Finding the optimal answers to questions like these can even be done automatically, simply by setting targets and using the auto-optimization tool to hunt for the solution using computing resource rather than man-hours.

**MAXIMISE THE PRODUCTIVITY OF YOUR DESIGN TEAM BY ALLOWING THEM TIME TO CONCENTRATE ON WHAT YOU NEED MOST – AN INNOVATIVE, CLASS-LEADING, RELIABLE PRODUCT.**



### PRE-PROCESSING FEATURES INCLUDE:

- Geometry building
- 2d sketching
- Non-linear materials
- BH curve editor
- Library of materials
- Circuit Editor
- Parameterized conductors
- Coupling to systems models
- Geometry interfaces include:
  - Parasolid
  - SAT
  - IGES
  - CATIA
  - Creo
  - NX
  - Solidworks

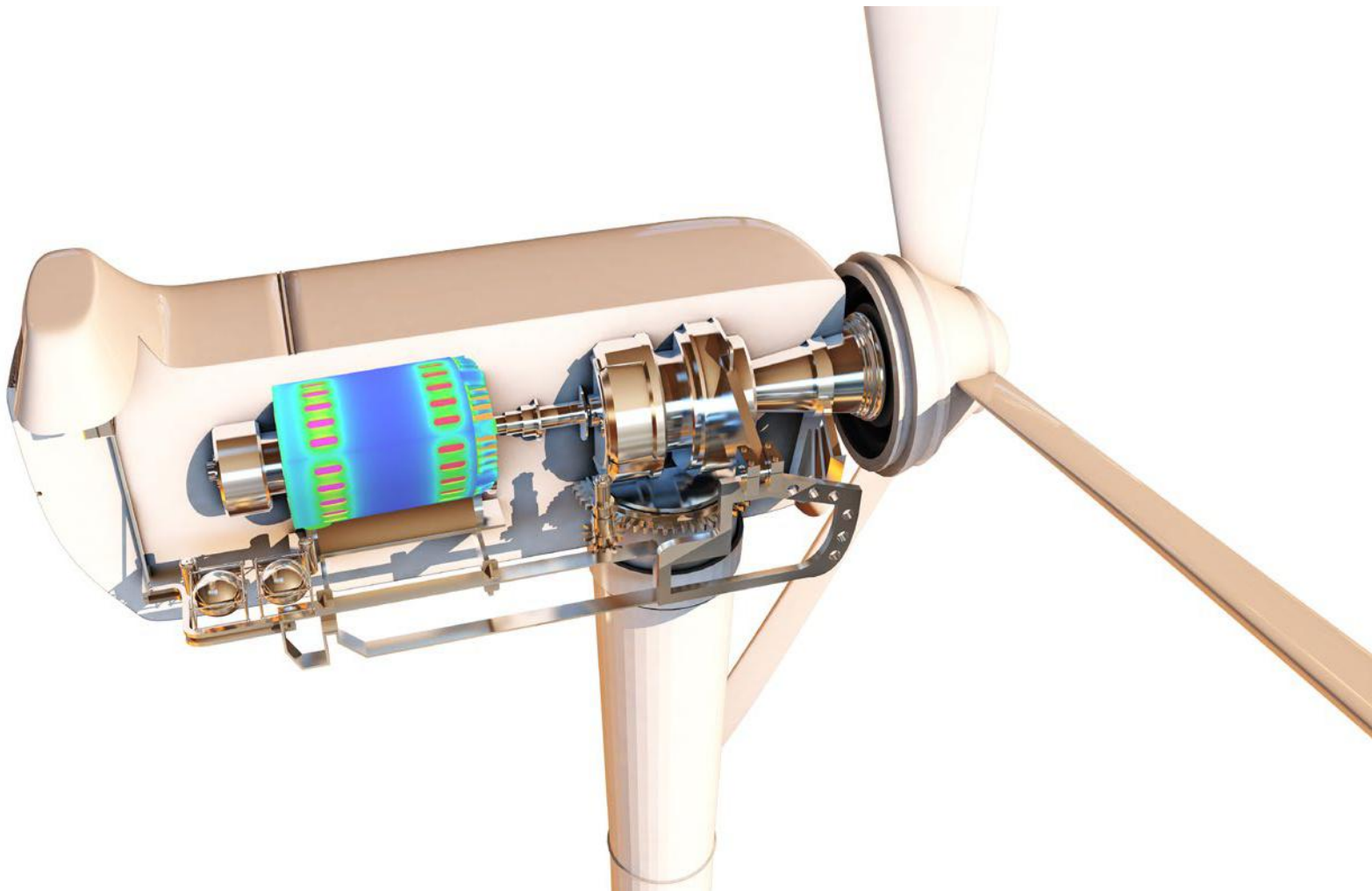
### Build simulation models quickly

Components and assemblies can be imported from an existing CAD system or alternatively be created using Opera's built-in modeller with its powerful ACIS geometry kernel.

A key feature of Opera is its ability to define any dimension of a model as a parameter, allowing the user to perform 'what-if?' investigations and optimize the design model. The Opera model file contains a complete history of the commands that created the database enabling files to be 'replayed' and modified – this then delivers a template that is able to automate the design variations of standard products.

### Solve problems accurately

Opera's solvers have been designed and refined over the decades to be efficient, robust and as accurate as computing resources allow. Modern compute resources, with multiple cores, are ideal for solving either large single-physics or complex multiphysics problems as multi-threaded solutions.



## Interrogate results efficiently

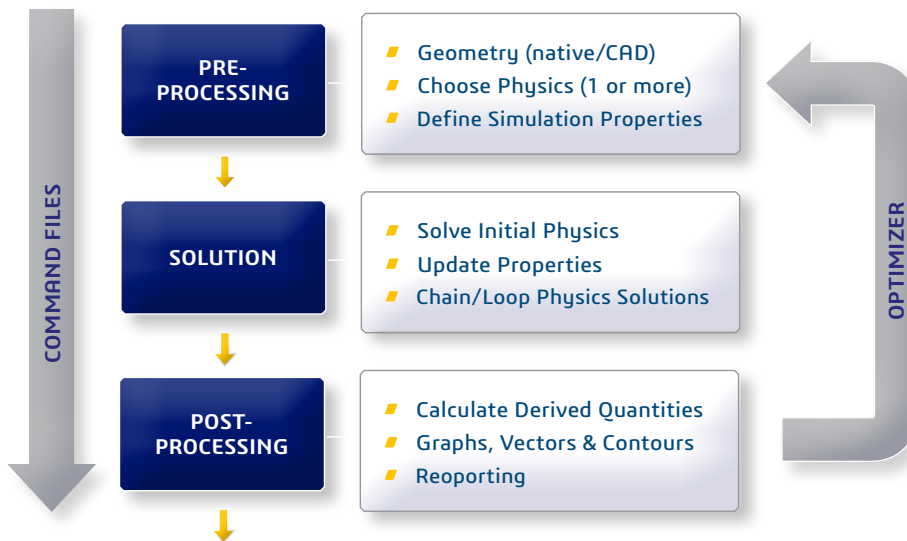
Once the simulation is complete Opera's post-processor simplifies the analysis of the results. As well as displaying the field, temperature or stress, there are numerous functions to prepare and display derived quantities in forms and units familiar to the user (including forces, power loss, stored energy). The post-processor has application-specific capabilities such as being able to compute and display particle trajectories through the computed electric and magnetic fields.

## Optimize designs routinely

Refining designs is easy - you can manually change parameters, rebuild your model and view the effects. This action can be performed automatically using our optional Optimizer module. Optimization problems can be set in minutes, and the computer left to work out the best solution for one, or multiple goals. The Optimizer can save an enormous amount of the normal design effort needed to realise a company's design goals - whether they are lowest cost, highest performance, simplest manufacture, small size (or any other parameters).

## POST-PROCESSING FEATURES INCLUDE:

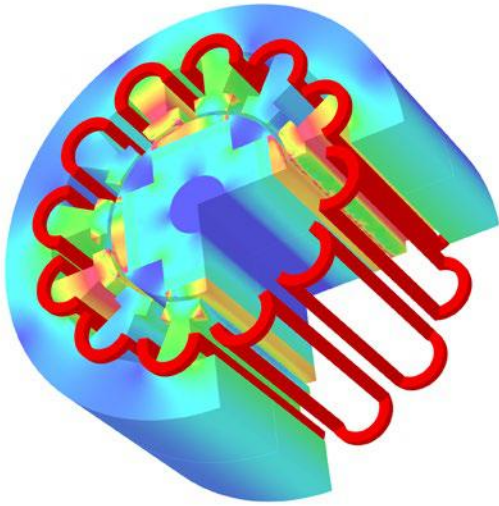
- Contours
- Vector plots
- Graphs
- Results on lines/surfaces
- Integrals
- Reports
- ASCII Export
- Trajectories



## Automate your design process easily

Opera allows you to set up 'macros', to automate your design process. You can create, run and analyse your designs with user-defined dialogs and menus for entering dimensions, material properties and simulation options.

Elements of models can be saved to form a library of component parts. If these parts are saved in parameterized form, key dimensions can easily be set giving you the means to rapidly produce and analyse variants of models.



## **SINGLE PHYSICS OR MULTI-PHYSICS... YOU CHOOSE**

Opera has been developed with a number of physics solvers. Each branch of physics has been developed to offer accurate and efficient solutions. Transfer of results quantities between physics can be automated and chained.

### **Static Electromagnetics**

The Static Electromagnetics module computes magnetostatic and electrostatic fields or DC current flow. The formulation minimises required computational resources whilst offering industry-standard methods for minimising cancellation errors commonly found in other finite element solvers.

### **Low Frequency Electromagnetics**

The Low Frequency Dynamic Electromagnetics Module uses FE analysis to solve Maxwell's equations for the time varying case without displacement currents. The time variation can be harmonic (steady state AC) or transient. Induced eddy currents are calculated.

### **High Frequency Electromagnetics**

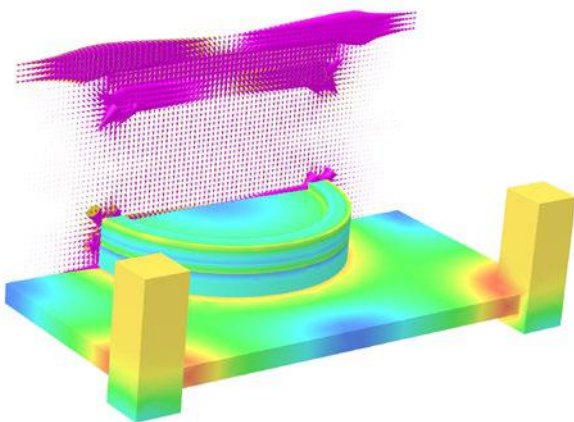
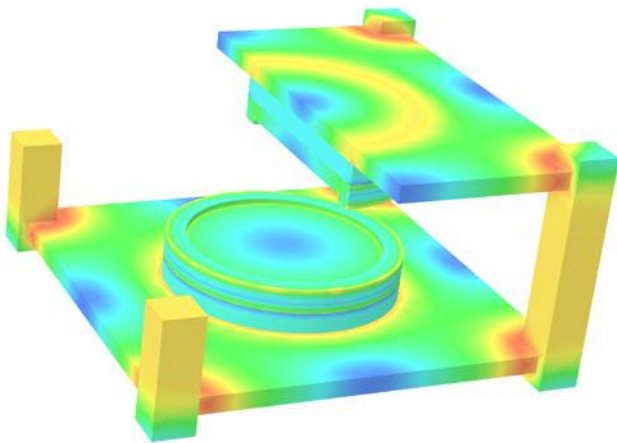
The HF module incorporates displacement current in the field equations so that it can perform full-wave solutions, and allows simulations of devices that may be multiple wavelengths in size. Two are available: Modal HF, which solves for eigenvalues in closed conducting cavities, and Steady-State HF, which performs a harmonic solution for general geometries.

### **Electromechanical**

The Electromagnetic Motion Module computes time varying fields and eddy currents in electric machines and similar devices with either rotating or linear movement. Calculations can include the electrical drive under normal and fault conditions and a dynamic mechanical load. Eddy current losses in all materials, including permanent magnets are calculated.

### **Space Charge**

The Charged Particle Module calculates the interaction of charged particles in electrostatic and magnetostatic fields. It provides a self-consistent solution including the effects of space-charge, self-magnetic fields and relativistic motion. The charging of dielectric materials and the effect this has on the solution can also be modelled with the optional Lossy Dielectric Module.



## Structural

The Stress Analysis Module can be used to perform two different types of solution; Static Linear Stress analysis will calculate displacements, strains and stresses due to external (or internal) forces. Eigenvalue analysis will calculate the eigenmodes and frequencies of a structure in an unloaded state.

## Thermal

The Thermal Analysis Module computes the steady state or transient temperature, heat-flux, and thermal-gradient fields due to electromagnetic heating or external heat sources. Thermal properties, such as the conductivity tensor or specific heat, and heat source density can be specified as a function of position, and can be temperature dependant (leading to a non-linear analysis).

## Circuits

Electrical machines are usually controlled by circuits, sometimes complex ones, and an accurate representation of the dynamic behaviour of the device is not possible without consideration of the drive circuit. The Opera Circuit Editor is a fully-integrated graphical system for defining and solving attached circuits.

## Magnetron Sputtering

Opera combines accurate finite element analysis with detailed models for plasma, sputtering, and film deposition to provide the first practical tools for magnetron design and optimization.

## Superconducting Quench

Multi-physics simulation module coupling thermal, electromagnetic and circuit domains is used to determine the temperature rise, the changing properties of a superconducting coil as it becomes resistive and the magnetic field.

## Magnetic Material Modelling

Directly model the effects of hysteresis in soft magnetic materials, and de/re-magnetization of hard magnetic materials.

**Results from one analysis can be passed automatically to another using Opera's automated techniques, or table files offer a general-purpose route using ASCII data files. Results transferred include:**

- Magnetic Flux density
- Forces
- Displacements
- Heat from coils
- Losses from eddy currents
- Heat from beams
- Temperature



### CAPABILITIES:

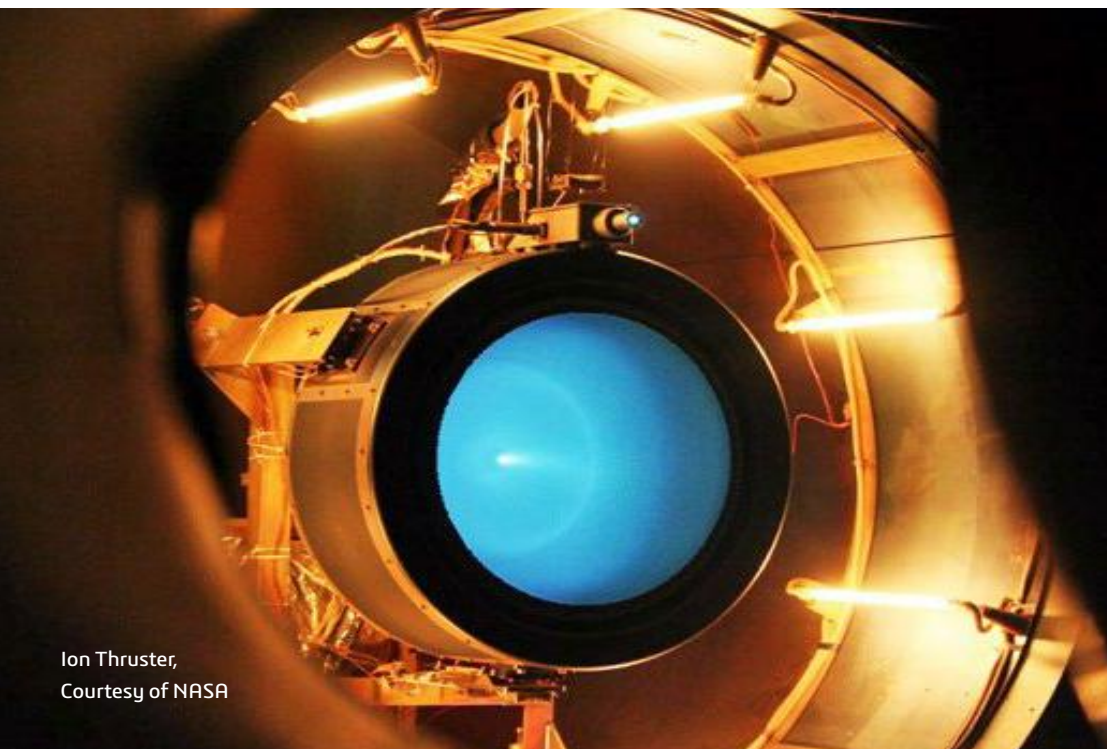
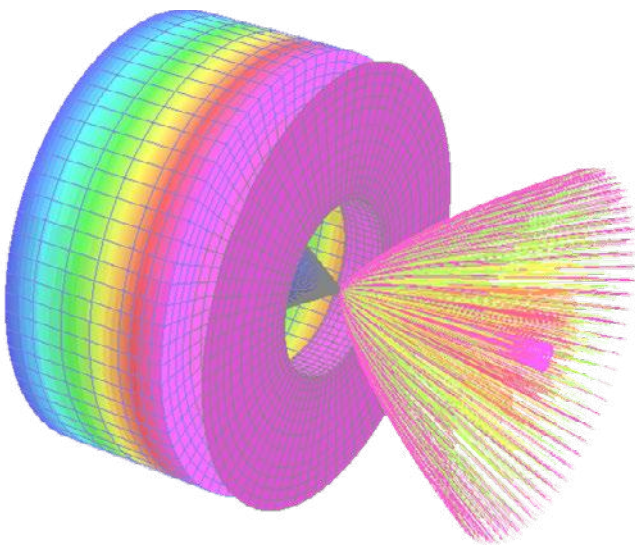
- Self-consistent, relativistic, space charge analysis
- Combined electric and magnetic field tracking
- Includes beam magnetic field, current flow and dielectric charging
- Multiple surface and volume emission models
- Primary and secondary emission
- Plasma modelling
- Fast and accurate

### SPACE CHARGE

Many industrial, medical and scientific products rely on the behaviour of charged particles. Engineers must design systems to precisely control charged particle generation, their manipulation and their interaction with matter and electromagnetic fields. Whatever the application, be it X-ray tubes for NDT or today's most advanced medical scanners, ion sources for high energy physics research, or sputtering systems for thin film deposition, Opera's Space Charge module gives designers a versatile, fast and accurate design and optimization capability.

### Applications

- X-ray tubes
- Electron and ion beam sources and beam transport systems
- Magnetic and electric lenses and deflection systems
- Sputtering and ion beam implantation
- Electron beam microscopy and lithography
- Mass spectrometry
- Field-effect displays



Ion Thruster,  
Courtesy of NASA



## MAGNETS

High performance magnets play an important role in science, medicine and industry. Magnet designs are often made for a relatively low number of installations and re-design of tooling required for manufacture must be minimized. Material costs are also often very high. These characteristics mean that prototyping is both time consuming and expensive. Opera provides the software tools to give confidence that designs are right first time by giving the designer the ability to create virtual prototypes that can be relied on.

In most applications, the quality of the magnetic field is the important criterion for an optimized design.

### Particle accelerators

- Dipole steering magnets
- Quadrupole focussing magnets
- Higher order multipole correction magnets
- Kicker and other pulse magnets
- Wigglers, undulators and other insertion devices
- Detector magnets

### Magnetic resonance imaging (MRI)

- Superconducting, resistive and permanent magnet systems
- Gradient coils

### Nuclear magnetic resonance (NMR)

- Superconducting, resistive and permanent magnet systems

### Spectroscopy

### Ion implant systems

### Proton therapy facilities

### Magnetic separation

### Magnetic particle guidance

- Cancer treatment
- Drug delivery
- Plasma confinement

### Other important design considerations include:

- Losses in AC, ramped and pulsed magnets
- Inductance
- Mechanical forces
- Quench protection circuitry



### CAPABILITIES:

- Parameterized pre-formed coil shapes.
- High precision field calculations.
- Magnetic field can be used to steer and focus a charged particle beam.
- Charged particle tracking can be performed to determine the beam path through individual magnets or multi-magnet systems.
- Losses and forces can be automatically transferred to Opera's multiphysics simulations and their effect on electromagnetic performance can be readily assessed.
- The effect of the inductance and resistance of the magnet on AC and transient performance can be analysed by coupling the winding to its power supply circuit Superconducting quench can also be modelled.

### CAPABILITIES:

- Motional solvers including mechanical coupling and coupled electrical circuit
- Power supply control including soft, switching, PWM, current and position feedback
- Modelling of skewed structures within motional solvers
- Eccentricities and fault operation
- Demagnetization of permanent magnets
- Loss calculation including hysteresis effects

## ELECTRICAL MACHINES

The current demands for high efficiency, reliability and low cost of electrical machines require the use of extremely accurate and integrated simulation tools. Whether designing a motor or a generator, an axial or radial flux topology, rotating or linear motion, Opera provides the right tools for the task. Opera integrated multi-physics capabilities allow for a complete machine characterisation using a multi-disciplinary approach. A powerful scripting language allows for rapid prototyping and optimization, while the integrated Machines Environment gives users the possibility to quickly and easily setup their customised machine designs.

### System level modelling

Opera-2d and Opera-3d can be linked directly to industry-standard software to co-simulate the transient performance of the complete drive or electromechanical system. A dedicated Opera 'block' can be configured by the user to co-simulate any type of electrical machine or linear motion device as an integral part of an overall system.

### Machines Environment

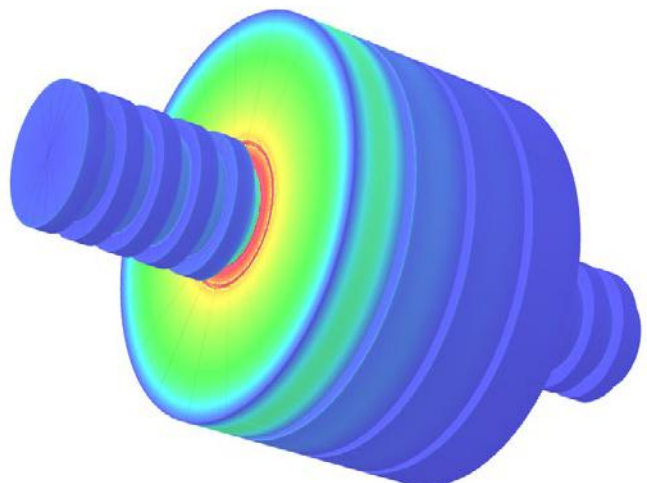
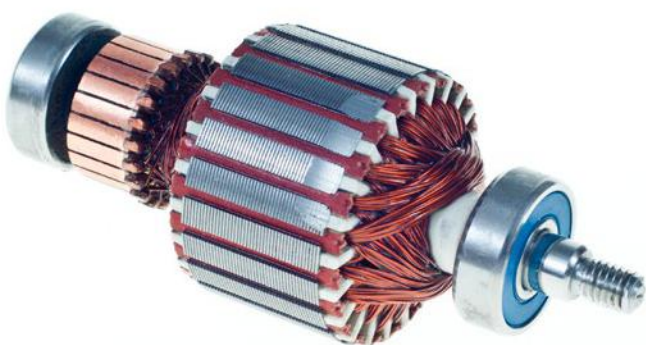
Motor and generator models can be rapidly setup and analysed using parameterized templates. Standard design calculations can be performed to obtain useful results such as back-EMF, cogging torque, load torque, open and short-circuit curves. Coupled multi-physics analyses that include stress calculations are also available in the Machines Environments allowing for quick analysis of complex problems. A direct coupling with the Opera Optimizer allows the refinement and optimization of designs based on user requirements. Extensive model customization can be included in the 2d and 3d Machines Environments in order to meet the user's design requirements.

### Rapid Design

Opera's parameterized modelling provides a truly comprehensive solution for creating standard products and exploring new design concepts. Any machine topology can be modelled and solved, including:

- Induction machines
- Synchronous machines
- Brushless machines
- SRM
- Clawpole generators
- Axial flux machines
- Commutating machines
- External rotor
- Magnetic gearing
- Linear motion machines

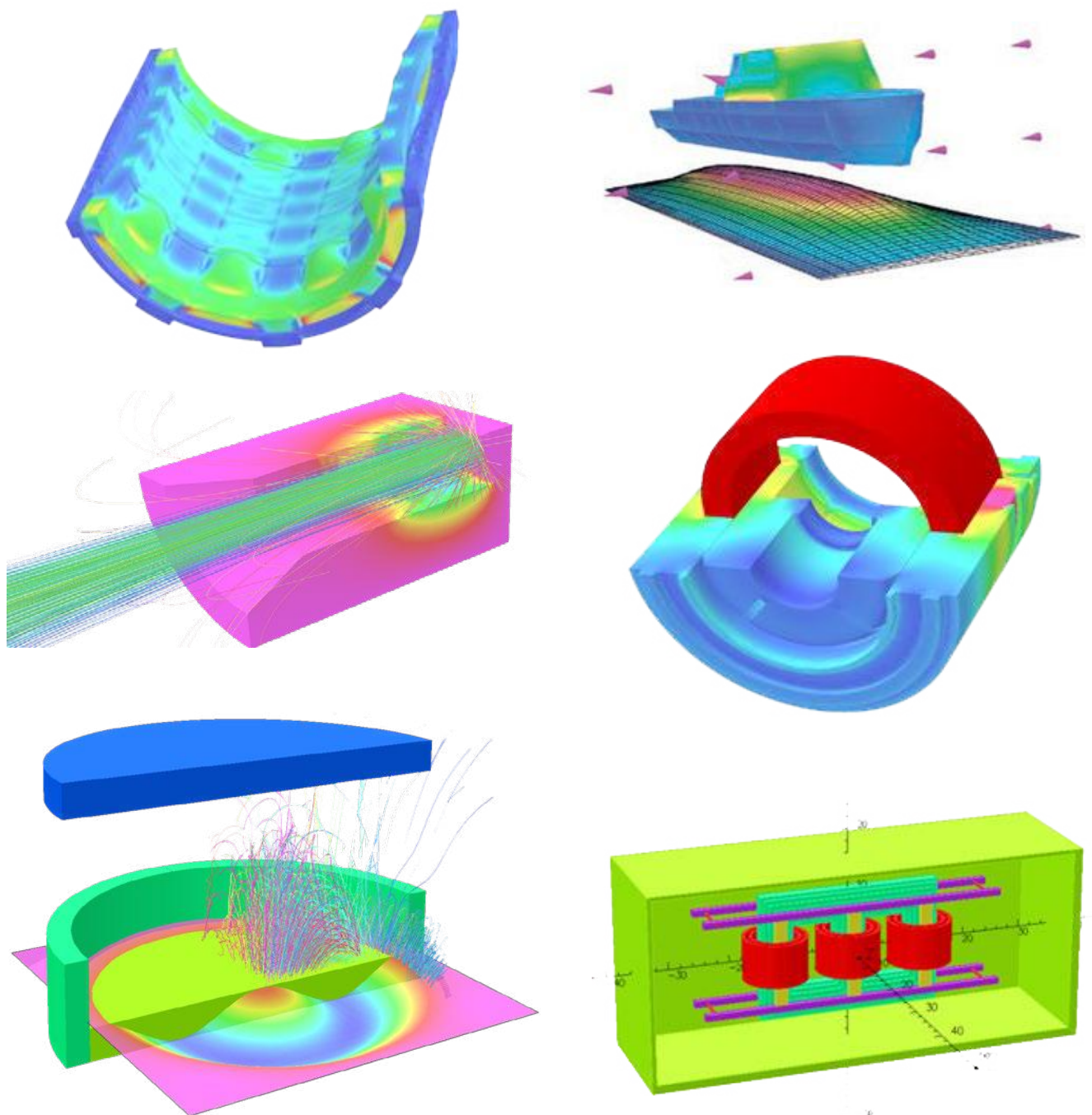
Complex material properties can be included to account for phenomena such as demagnetization and hysteresis. Transient motional solvers offer very powerful, field-proven facilities for simulating the effects of induced eddy currents in both rotating and linear devices.

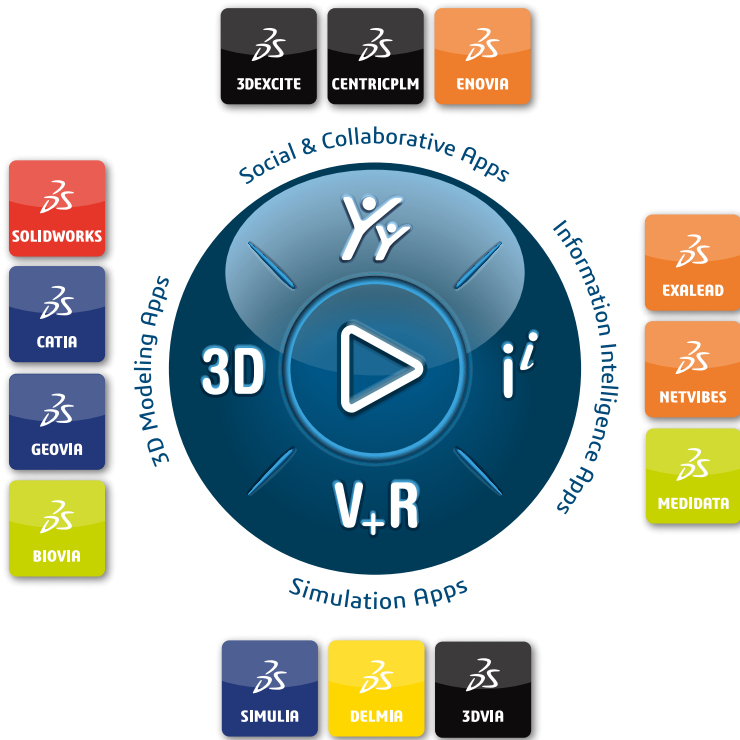


**Opera has been verified and used successfully for many applications in various industries, including:**

- Electrical Machines
  - Actuators
  - Fault Current Limiters
  - Particle Accelerators
  - NMR/MRI Devices
  - Non-Destructive Testing
  - Magnetic Signatures
  - RF Cavity Design
  - Cathodic Protection Systems
  - Induction Heating
  - Lightning Analysis
  - Insulation & Grounding
  - EMC / EMI
  - X-Ray Devices
  - Shielding
  - Magnetic Gearing
  - Transformers
  - Reactors
  - Inductors
  - Permanent Magnet Design
  - Magnetic Stirring
  - Electron Microscopy
  - Proton Beam Therapy Devices
  - Transducers
  - Magnetic Separators
- ...and many more.

Learn more at <https://www.3ds.com/products-services/simulia/products/opera/>





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