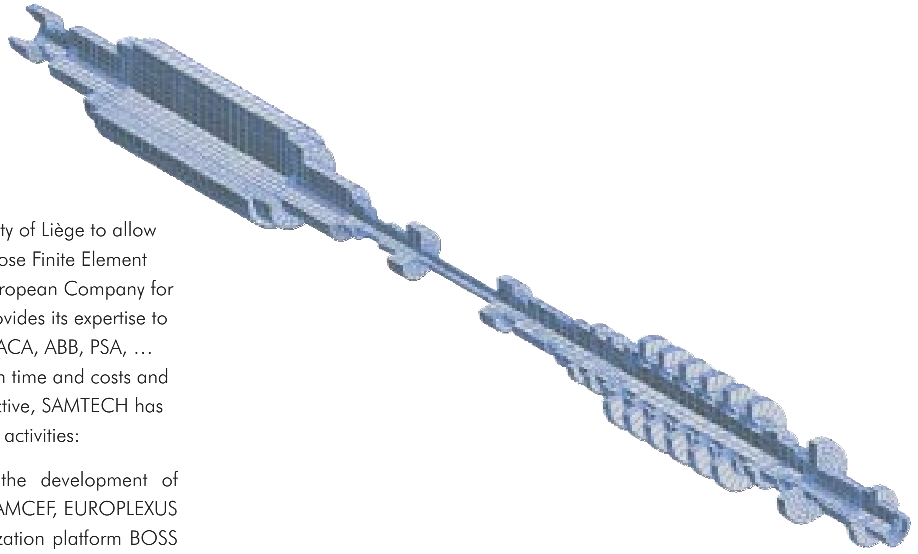
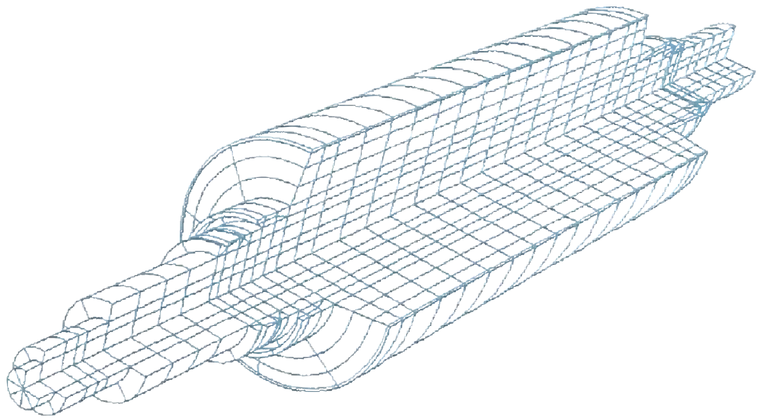


ABOUT SAMTECH

Founded in 1986 from the Aerospace Laboratory of University of Liège to allow the development and commercialisation of the general purpose Finite Element Analysis package SAMCEF, SAMTECH is now the leading European Company for the development of Integrated CAE Solutions. SAMTECH provides its expertise to industries like SNECMA, AIRBUS, EADS, ALENIA, ESA, SONACA, ABB, PSA, … willing to increase their competitiveness by decreasing design time and costs and optimizing their methodologies. In order to answer this objective, SAMTECH has structured its competences around two main complementary activities:

- The "**Software edition"** activity which includes the development of scientific software tools like the general FEA package SAMCEF, EUROPLEXUS for explicit analysis or the open object oriented optimization platform BOSS quattro.
- The **"Engineering services"** activity which provides customized solutions such as consultancy, intellectual services and on-the-road projects. It includes also assistance to prime contractors and high-tech subcontracts to engineering offices, which belongs to industries, as well.



SOME REFERENCES

Spatial aeronautics

EADS-LV, EADS AIRBUS, EADS-CCR, EUROCOPTER, SNECMA, SNECMA-DMF, MESSIER DOWTY, MTU, HUREL DUBOIS, HISPANO, LATECOÈRE, CRYOSPACE, ALTAL, SABCA, SONACA, TECHSPACE AERO, ESTEC, ASC, BOEING HELICOPTER, DASA, IBERESPACIO, BOMBARDIER AEROSPACE, FIAT AVIO, ALENIA AERO…

Transport

PSA, RENAULT, FORD, VALEO, DAIMLER-CHRYSLER, AUDI, LOHR, VW, DELPHI AUTOMOTIVE SYSTEMS, FIAT AUTO, RENAULT SPORT, TUC RAIL, ALSTOM, ADTRANZ…

Energy

EDF, ABB, ENEL, SCHNEIDER, GE ENERGY PRODUCT, ALSTOM, SEHV…

Mechanics

PICANOL, MAK, SOLAC, PONT-à-MOUSSON, GLAVERBEL, COMAU/RENAULT AUTOMATION…

Defence

AÉROSPATIALE MATRA MISSILE, FNNH, GIAT INDUSTRIES, CAP, DCN, DGA…

Research Centers

CNRS/IN2P3, CEA DAPNIA…

SAMTECH Headquarters
Parc Scientifique du Sart-Tilman
Rue des Chasseurs-Ardennais, 8
B-4031 Angleur-Liège, Belgium
Tel. : +32 4 361 69 69
Fax : +32 4 361 69 80
http://www.samcef.com

SAMTECH France
Paris
14, avenue du Québec
Bât. K 2.1, SILIC 618
Villebon-sur-Yvette
F-91945 Courtabœuf Cedex, France
Tel. : +33 1 69 59 22 80
Fax : +33 1 64 46 29 65

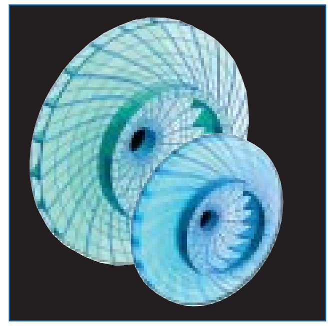
Toulouse
11, rue Marius Terce
F-31300 Toulouse, France
Tel. : +33 5 34 55 20 99
Fax : +33 5 34 55 15 00

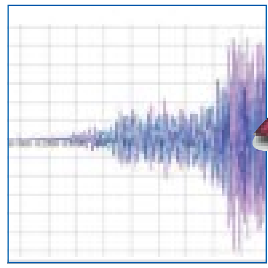
SAMTECH Germany GmbH
Oskar-Kalbfell-Platz 8
D-72764 Reutlingen, Germany
Tel. : +49 7121 92 20 0
Fax : +49 7121 92 20 90

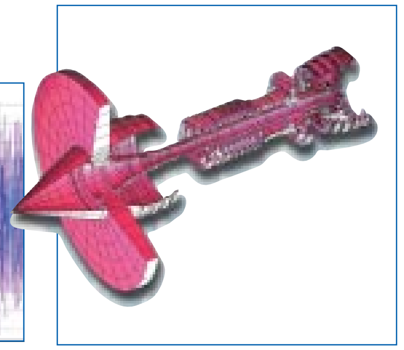
SAMTECH Italia
Via Guido d'Arezzo, 4
I-20145 Milano, Italy
Tel. : +39 02 48 559 407
Fax : +39 02 46 94 998

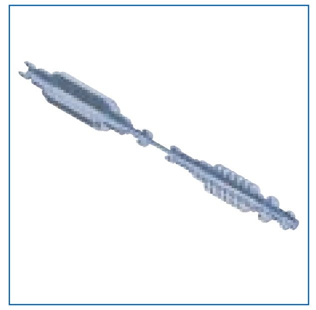
SAMCEF Rotor

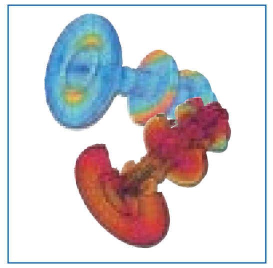
Rotor Dynamics Analysis





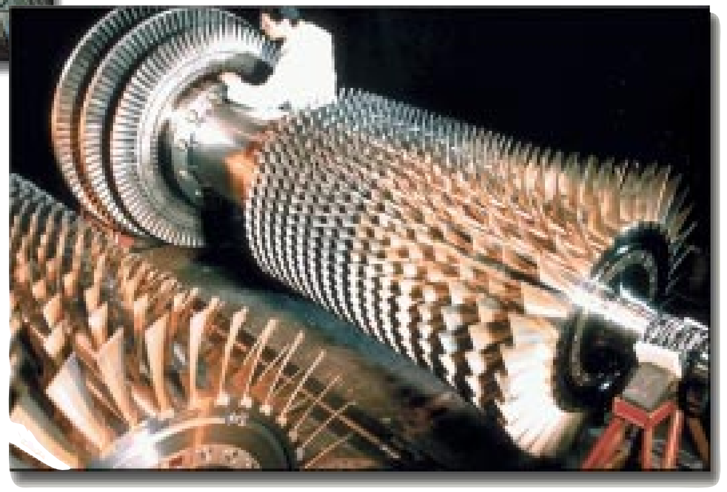






SAMCEF Rotor is a general Finite Element solution specifically adapted to rotating machine analysis.

SAMTECH, Integrating CAE towards Professional Solutions



SAMCEF Rotor is a solution specifically adapted to the dynamic analysis of structure containing rotating components. It is finite element based and allows to compute critical speeds, stability, harmonic and time-transient response of mechanical systems made of rotating parts, fixed parts and linking devices.

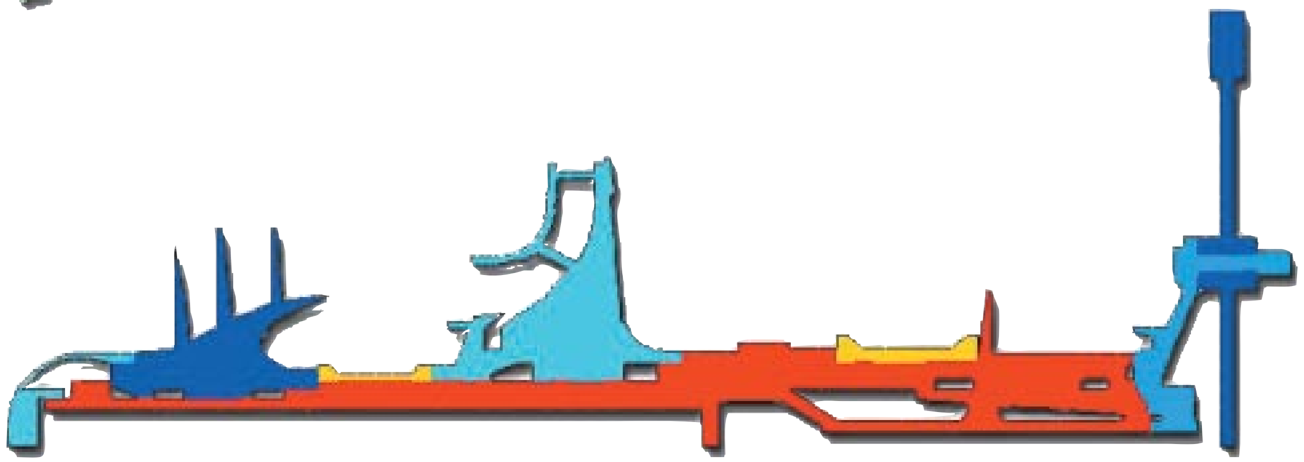
ANALYSIS TYPES

Critical Speeds Computation

Several methods are available and they can be used to solve bending, axial, torsional or coupled problems.

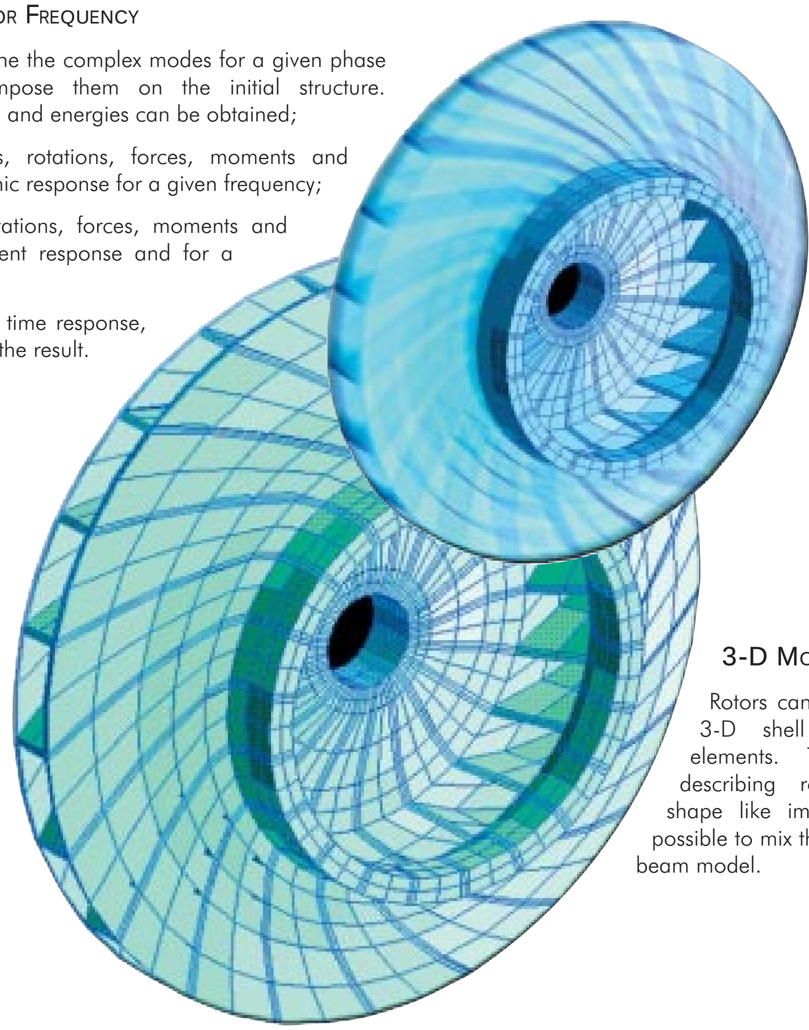
With the sweeping method, the user defines ranges of rotational frequencies whithin which complex eigenvalues have to be computed.

The direct method allows directly obtaining the critical speeds as eigensolutions. It is used for undamped systems with constant stiffness.



Picture at a Given Time or Frequency

- It is possible to recombine the complex modes for a given phase angle and to superimpose them on the initial structure. Displacements, rotations and energies can be obtained;
- Complex displacements, rotations, forces, moments and stresses after the harmonic response for a given frequency;
- Real displacements, rotations, forces, moments and stresses after the transient response and for a given time;
- For both frequency and time response, it is possible to animate the result.



3-D Model

Rotors can also be modeled by 3-D shell or volume finite elements. This model allows describing rotors with complex shape like impellers or fan. It is possible to mix the 3-D model with the beam model.

DOCUMENTATION

For direct access to information, the Users Guide and Help manual are available via your favorite navigator (HTML).

COUPLING SAMCEF ROTOR WITH OTHER SAMCEF PRODUCTS FAMILY

Compatibility between SAMCEF Rotor and other SAMCEF modules allows a linear/non-linear mechanical analysis on the same model. The file compatibility between SAMCEF modules makes it possible to perform a structural calculation while taking into account the dynamic analysis of rotating parts provided by SAMCEF Rotor.

SAMCEF Rotor can also be coupled with BOSS quattro, the application manager and optimization platform developed by SAMTECH.

The following SAMCEF modules are compatible with SAMCEF Rotor:

- SAMCEF Asef, Dynam, Stabi: linear static, modal and buckling analyses,
- SAMCEF Mecano: unique integrated software that solves non-linear structures and mechanisms problems. The software is declined to provide a more specific answer to following analyses:
  - MECANO Structure: dedicated to the non-linear analysis of structures,
  - MECANO Motion: dedicated to the static, kinematical and dynamic analyses of flexible mechanisms,
  - MECANO Cable: dedicated for the analysis of cable systems subjected to electro-dynamic and aerodynamic efforts,
- SAMCEF Thermal: Stationary and transient non-linear themes analysis,
- BOSS quattro : parametric studies, sensitivity analysis, statistical analysis, model updating, design of experiments and response surfaces.

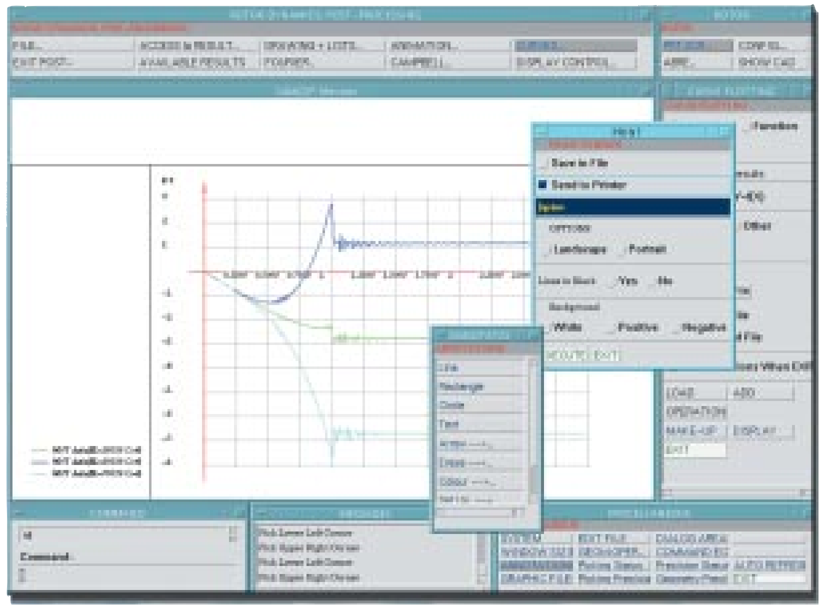
PLATFORMS

SAMCEF Rotor is available on most UNIX platform and on Window NT, 2000 and XP Pro.

MODELING ENVIRONMENT

USER INTERFACE

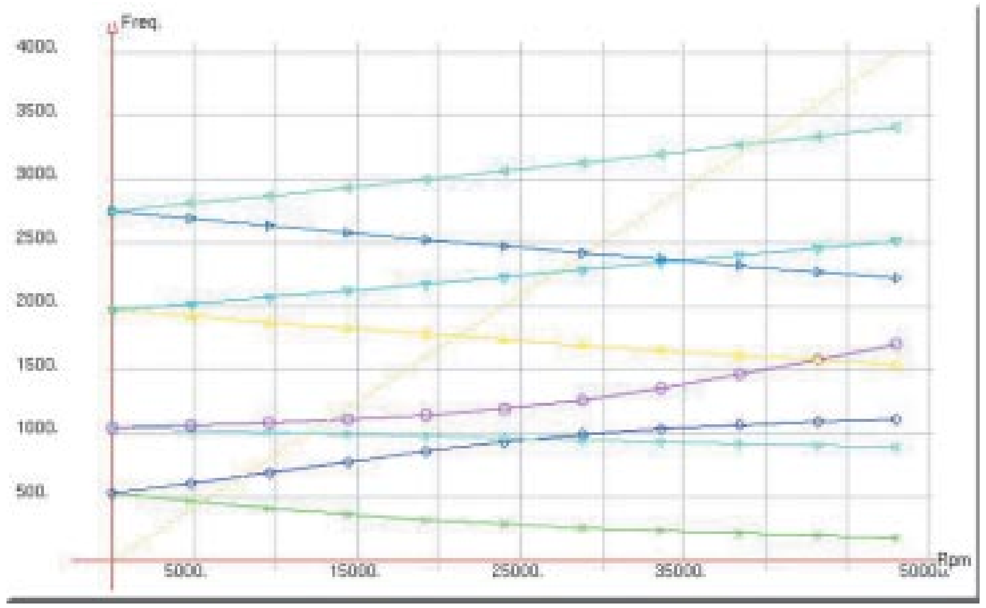
- All features can be accessed through scrolling menus and data acquisition boxes;
- Easy-to-use integrated CAD modeler helps modeling and data preparation;
- Grouped management allowing to work independently of node and mesh numbering;
- Functions Manager facilitating the definition of variable loads, rotation speed or properties;
- The command language can be parameterized;
- The User's Manual is available using HTML Browser.

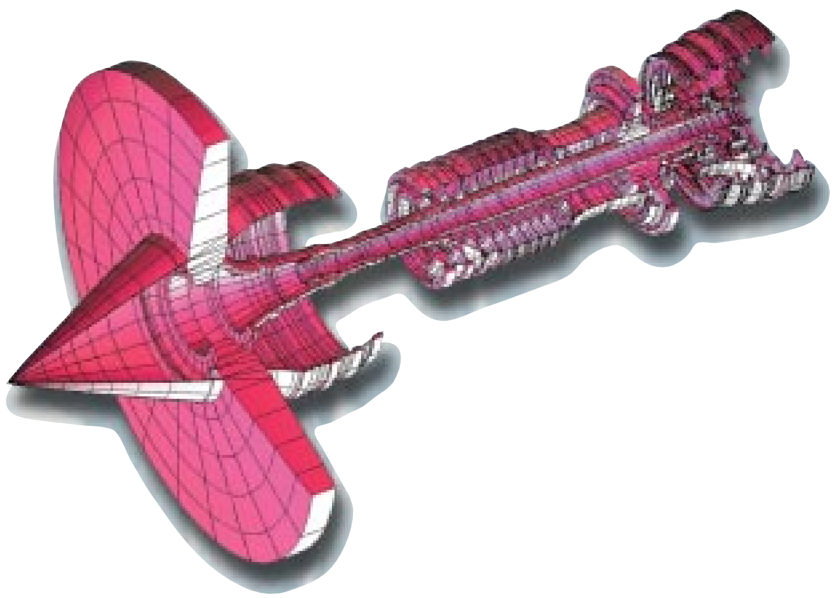


GRAPHICAL POST-PROCESSING

Eigenvalues

- The damping coefficients and frequencies as a function of the rotational speed (Campbell diagram);
- The damping coefficients and frequencies following a variation in certain design parameters;
- Confidence range of the Campbell diagram after a statistical analysis.





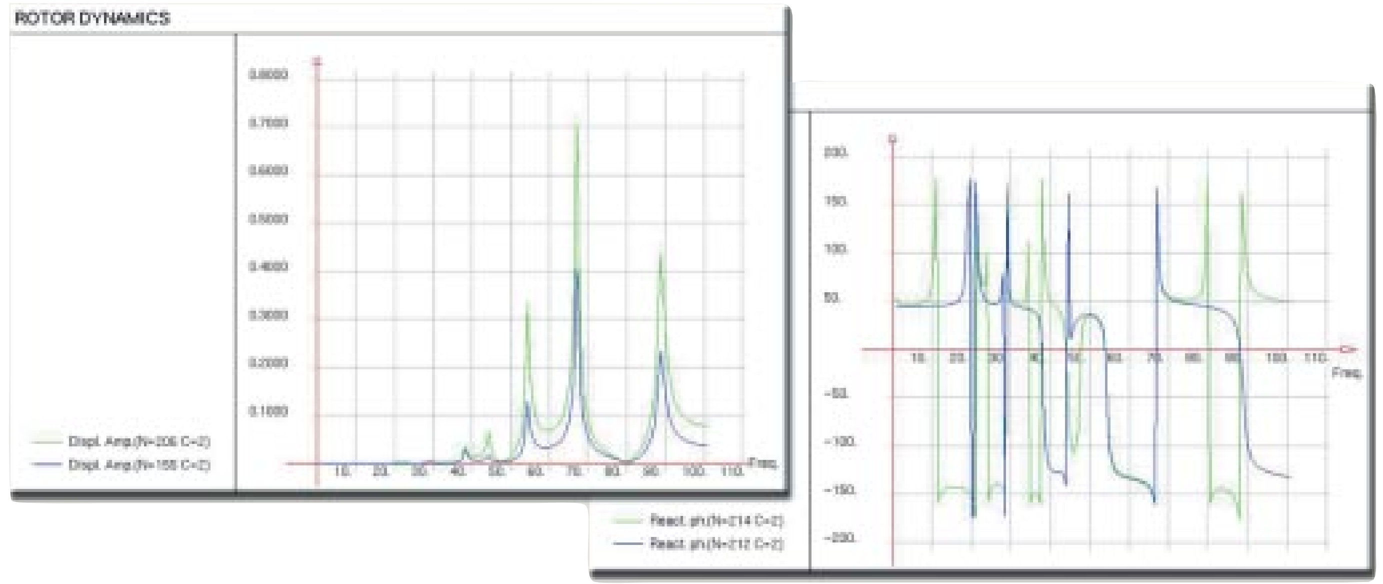
Curves

- The displacements, forces, reactions or stresses obtained by the forced response and as a function of time or frequency;
- Orbits after the transient analysis;
- Confidence range of the harmonic response after a statistical analysis.

FREQUENCY RESPONSE ANALYSIS

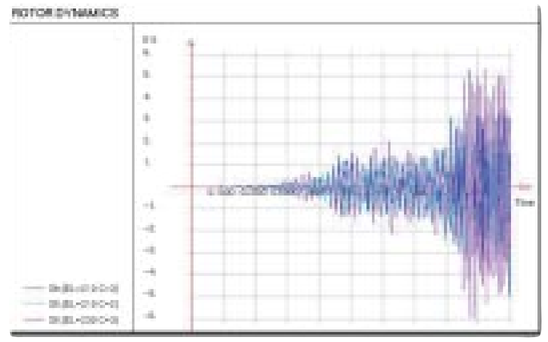
Several methods are available to compute the harmonic response to unbalances or asynchronous loads.

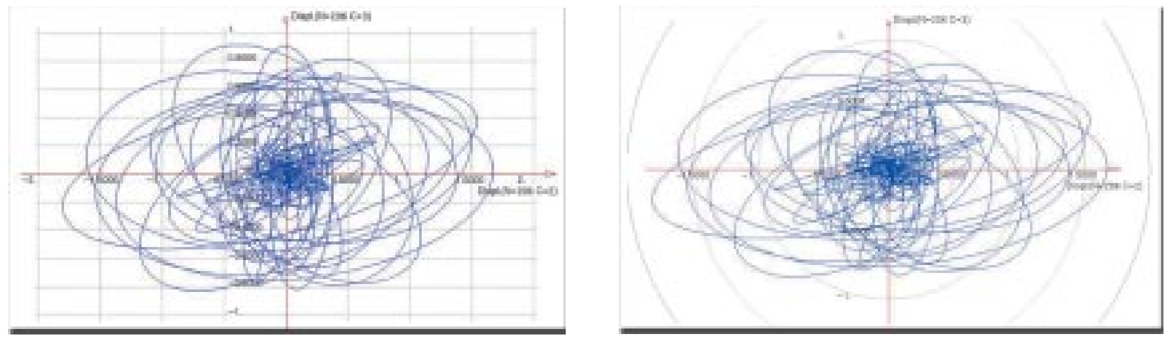
The Modal Method where the forces and matrices are reduced by projection in a modal basis and the Direct Method that allows taking into account local non-linearities (clearances, non-linear stiffness, etc).



TRANSIENT RESPONSE ANALYSIS

Transient response simulates run-up (or run-down) and blade losses. It is using a Newmark integration method. Non-linear effects such as clearances, squeeze-films, hydrodynamic bearings or rubbing are solved using an iterative Newton scheme. An automatic time stepping strategy is available. If necessary, an initial static computation can be performed.

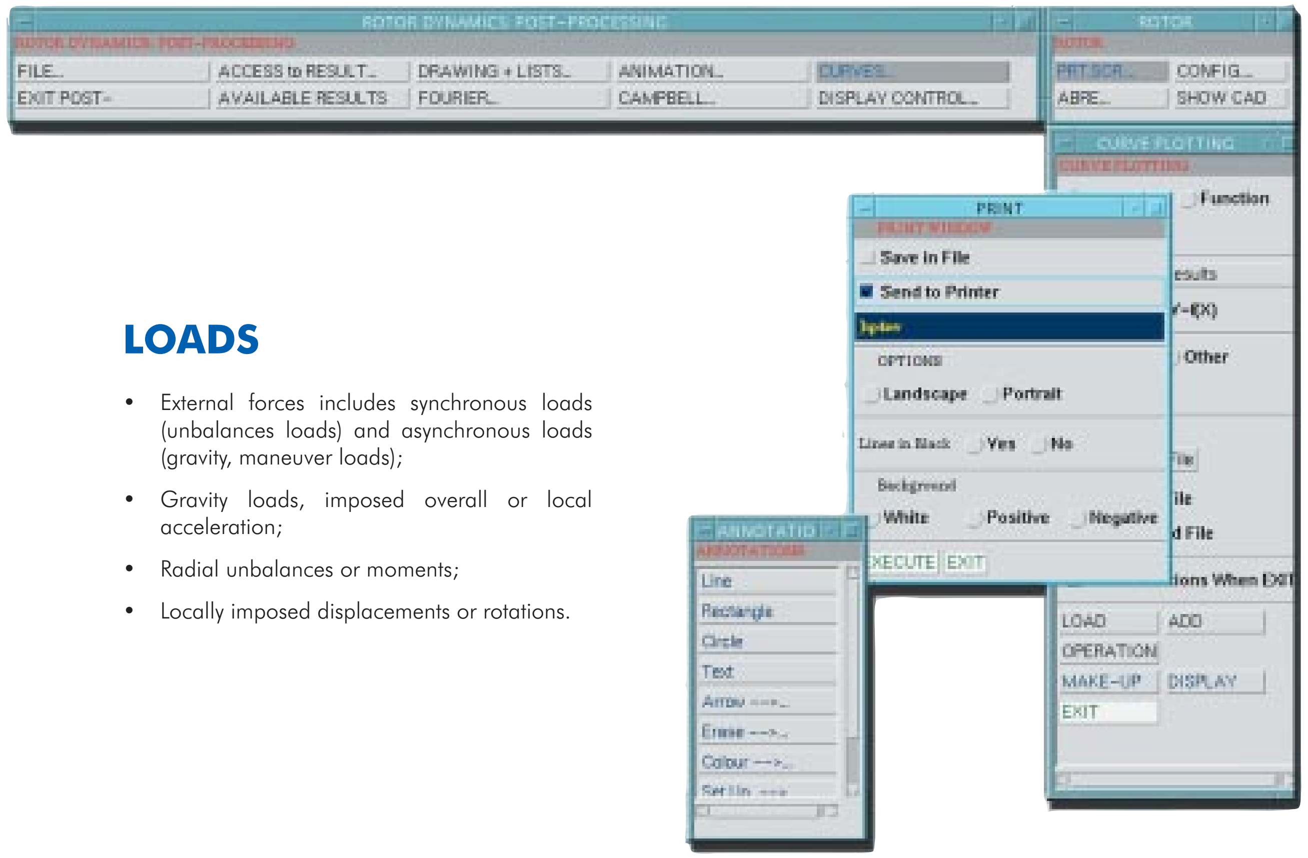




SENSITIVITY AND STATISTICAL ANALYSIS

In the frequency domain, it is possible to carry out a sensitivity analysis of the solution with respect to a variation of a set of design parameters. These parameters can be the dynamic characteristics (stiffness, damping) of the bearing elements.

The sensitivities can then be used to estimate the standard deviation of the solution when the standard deviation of the parameters is given.



LOADS

- External forces includes synchronous loads (unbalances loads) and asynchronous loads (gravity, maneuver loads);
- Gravity loads, imposed overall or local acceleration;
- Radial unbalances or moments;
- Locally imposed displacements or rotations.

LINKING DEVICES AND SPECIALIZED ELEMENTS

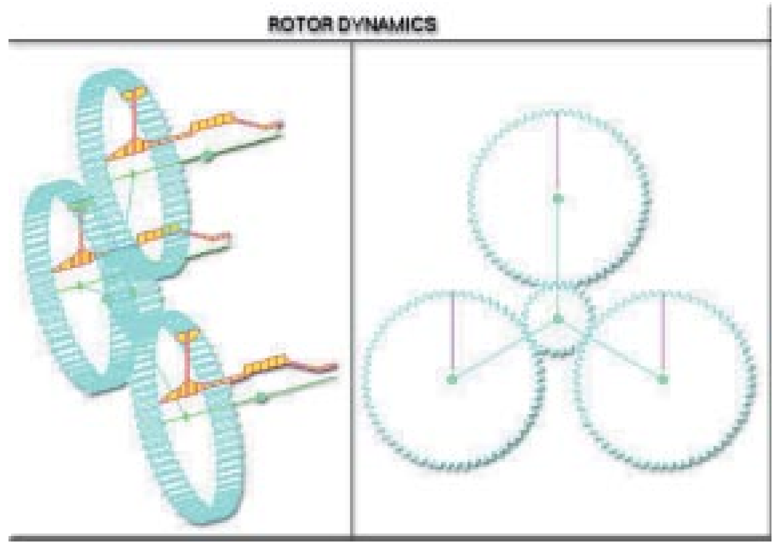
- Many linking devices such as linear and non-linear bearings, squeeze-films dampers (several models), bushing, gear and control elements (sensors and actuators) are available;
- Linear constraints and rigid bodies can be defined between degrees of freedom;
- The inertia and energy properties of a group of elements can be obtained using macro elements;
- A model-linking element is used to connect an axisymmetrical model of the rotor with a 3-D description of the fixed parts;
- Finally, routines are available in order to generate user elements.

MODELING

SAMCEF Rotor can handle rotors with different rotation speeds and the user is free to choose the orientation of the spin axis. We can model the fixed parts using the standard finite element library.

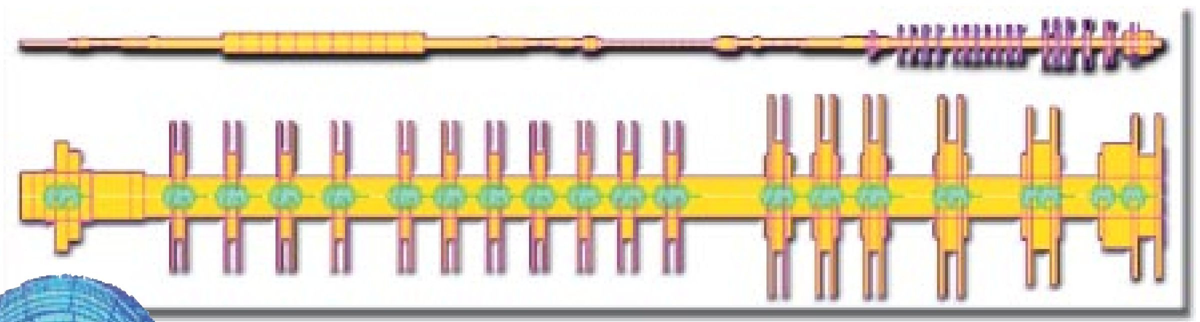
Superelements (Craig and Bampton) can be used to model either rotating or fixed parts.

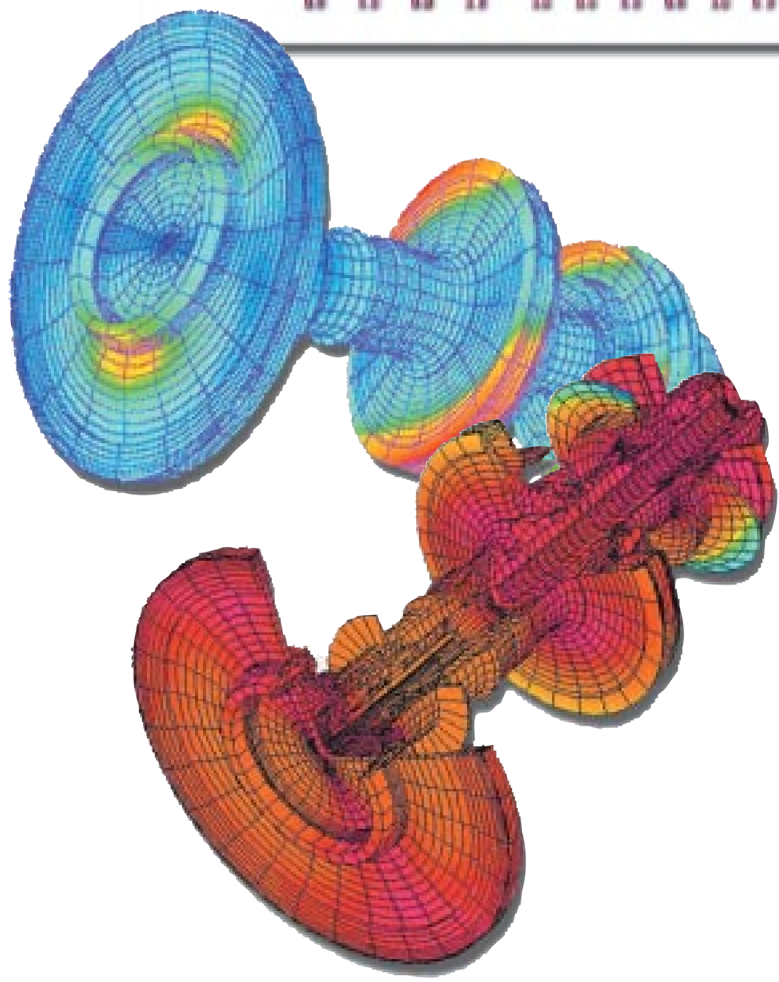
Several models are available to describe rotating parts:



Beam Model

Beams elements are used to model shafts with rigid disks. A bushing element allows defining a stiffness matrix between two nodes and can be used to model shaft coupling. The cross-section can vary along the beam axis (hollow frustum).





Axisymmetrical Model

Flexible rotors are modeled by 2-D axisymmetrical shell or volume finite elements whose displacement field is developed in Fourier series. With this approach, it is no longer necessary to make a distinction between shaft and disks.