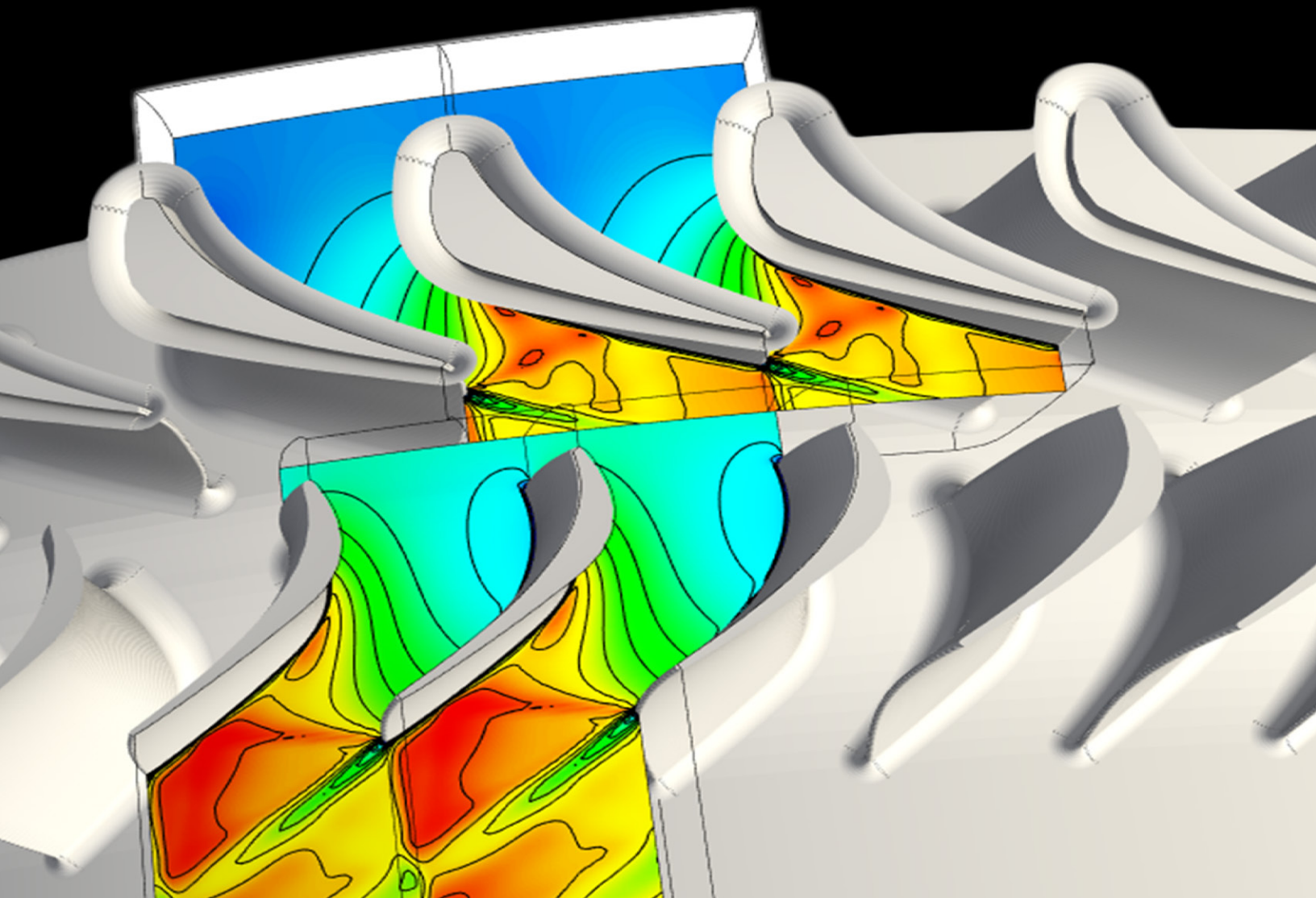# Concepts NREC

The Experts in Turbomachinery

CAE Software

Agile Engineering Design System®
Computer-Aided Engineering Software

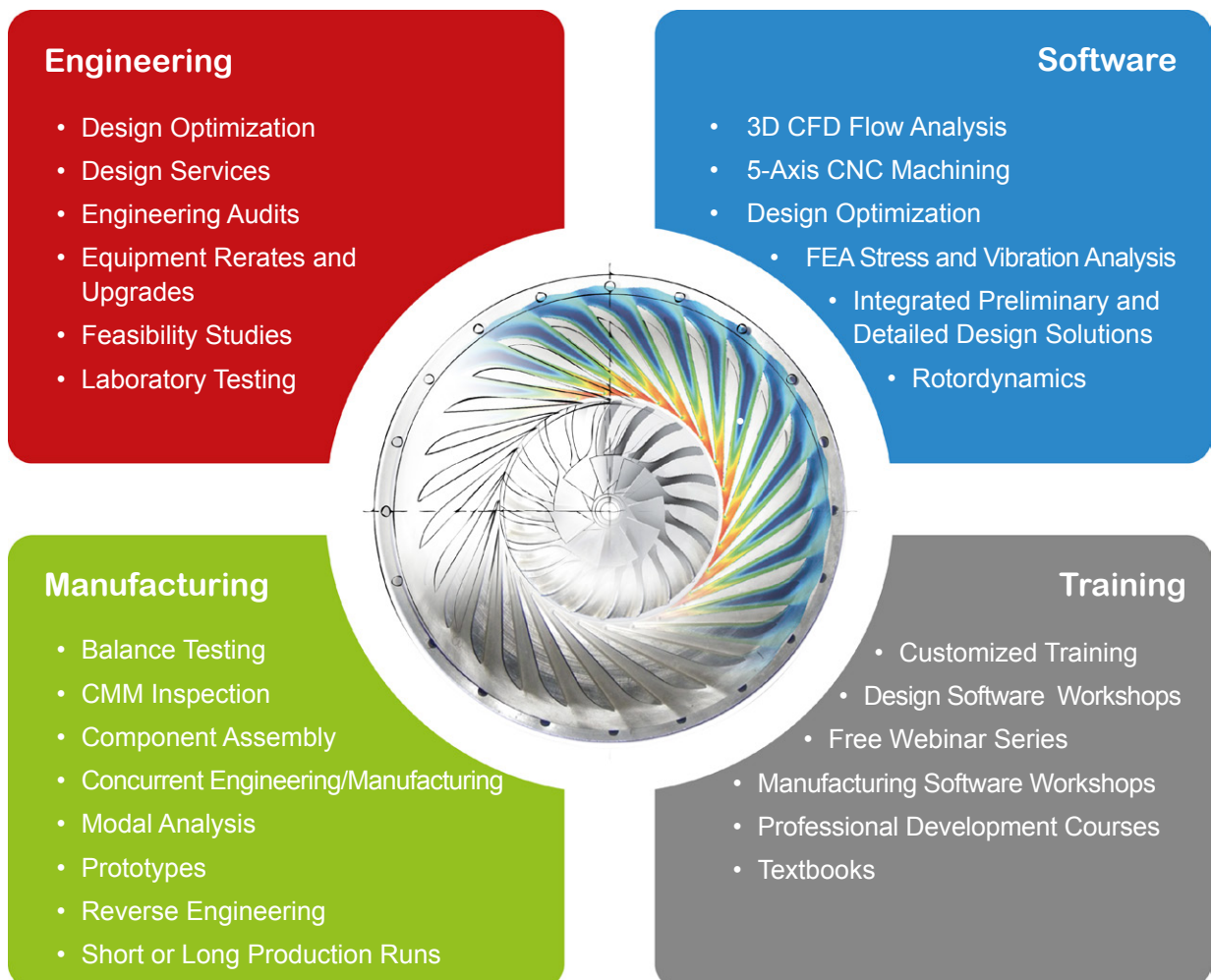• **Engineering**   • **Software**   • **Manufacturing**   • **Training**

Concepts NREC

For over 60 years, Concepts NREC has been partnering with the world's leading OEMs to improve the performance and manufacturability of turbomachines. We are the only company in the world whose in-house capabilities span the entire process — from conceptual design through manufacturing, testing, and installation. This creates powerful synergies that drive innovation across our entire offering. Our clients benefit from having a trusted partner who can see the big picture and provide valuable insights that save them time and money.

We are ISO 9001:2008 certified, and committed to providing our customers with products and services that meet international quality standards.

Advancing the State of the Art in Turbomachinery

Concepts NREC maintains a robust in-house research and development program. We hold over 70 patents worldwide, with numerous patents pending. Concepts NREC is also the leader of the global *Advanced Centrifugal Pump and Compressor Consortium for Diffuser and Volute Design*, an internationally-sponsored research venture dedicated to advancing diffuser and volute design.

At Concepts NREC, we push past what *has* been done to explore what *can* be done. We have the vision to create great designs and a hard-earned reputation for delivering them.

Engineering

- Design Optimization
- Design Services
- Engineering Audits
- Equipment Rerates and Upgrades
- Feasibility Studies
- Laboratory Testing

Software

- 3D CFD Flow Analysis
- 5-Axis CNC Machining
- Design Optimization
- FEA Stress and Vibration Analysis
- Integrated Preliminary and Detailed Design Solutions
- Rotordynamics

Manufacturing

- Balance Testing
- CMM Inspection
- Component Assembly
- Concurrent Engineering/Manufacturing
- Modal Analysis
- Prototypes
- Reverse Engineering
- Short or Long Production Runs

Training

- Customized Training
- Design Software Workshops
- Free Webinar Series
- Manufacturing Software Workshops
- Professional Development Courses
- Textbooks

The Complete Software Solution - From Art to Part

Concepts NREC's Agile Engineering Design System® is a complementary suite of programs for Computer-Aided Engineering (CAE) and Computer-Aided Manufacturing (CAM). This includes a strategic partnership with NUMECA International that enables us to cover the entire design process from preliminary sizing through final design, with full fluid dynamics, mechanical stress, and vibration analysis.

The full power and benefit of our software suite is realized when the various modules are used together. The suite seamlessly transfers information between modules with the click of a button, saving time and eliminating the possibility of transfer errors. It also facilitates easy transfer at any step of the process to all major CAD formats and other third-party CFD and FEA packages.

Final designs can then be easily imported into our industry-leading CAM software, MAX-PAC, to create efficient 5-axis machining solutions.

Concepts NREC's Agile Engineering Design System®

		Radial				Axial			
		Compressors	Fans	Pumps	Turbines	Compressors	Fans	Pumps	Turbines
CAE Preliminary Design									
Meanline Approach	AXIAL™				✓				✓
Meanline Approach	COMPAL®	✓							
Meanline Approach	FANPAL™		✓				✓		
Meanline Approach	PUMPAL®			✓				✓	
Meanline Approach	RITAL™				✓				
CAE Detailed Design									
3D Geometric Design	AxCent®	✓	✓	✓	✓	✓	✓	✓	✓
Basic CFD Option for AxCent	FINE™/pbCFD*	✓	✓	✓	✓	✓	✓	✓	✓
CFD Option for AxCent	FINE™/Turbo™*	✓	✓	✓	✓	✓	✓	✓	✓
FEA Option for AxCent	Pushbutton FEA™	✓	✓	✓	✓	✓	✓	✓	✓
CAE Specialized Design Software									
Gas Turbine Blade Cooling	CTAADS™								✓
Optimization	TurboOPT II™	✓	✓	✓	✓	✓	✓	✓	✓
Rotordynamics	Dyrobes®	✓	✓	✓	✓	✓	✓	✓	✓
Gas Turbine Cycle Analysis	Gas Turb®	✓				✓			
CAM Toolpaths									
Base Platform	MAX-PAC™	✓	✓	✓	✓	✓	✓	✓	✓
Flank Milling Option	MAX-5™	✓	✓	✓	✓	✓	✓	✓	✓
Point Milling Option	MAX-AB™	✓	✓	✓	✓	✓	✓	✓	✓
Closed Impeller Option	MAX-SI™	✓	✓	✓	✓	✓	✓	✓	✓
Single Blade Option	MAX-SB™	✓	✓	✓	✓	✓	✓	✓	✓

*Offered in partnership with NUMECA International as part of the FINE/Agile™ integrated suite.

Agile Products Support (APS)

APS is a robust software maintenance and support program that takes Concepts NREC from a software provider to a valued partner in the technical development of your products. All APS members receive:


- Free software updates
- One business day response times
- Expert technical assistance
- Major discounts on software workshops
- Annual balloting system for development planning

Subscribers of APS for our CAE software also enjoy the added benefits of one free design review and one free professional development course.

APS is included with all annual licenses and is a highly-recommended option for perpetual software licenses.

Real Fluid Analytics

Concepts NREC offers several optional fluid databases that enable calculations using real fluid properties, rather than having to rely on ideal gas approximations. These databases include D.B. Robinson Real Fluid Properties, National Institute of Standards and Technology (NIST) tables, and ASME steam tables. All operate seamlessly with the design suite modules, and include built-in support for both ideal and non-ideal fluid properties. The databases also support condensed gases, user-modifiable fluid properties, and barotropic fluid modeling as well.
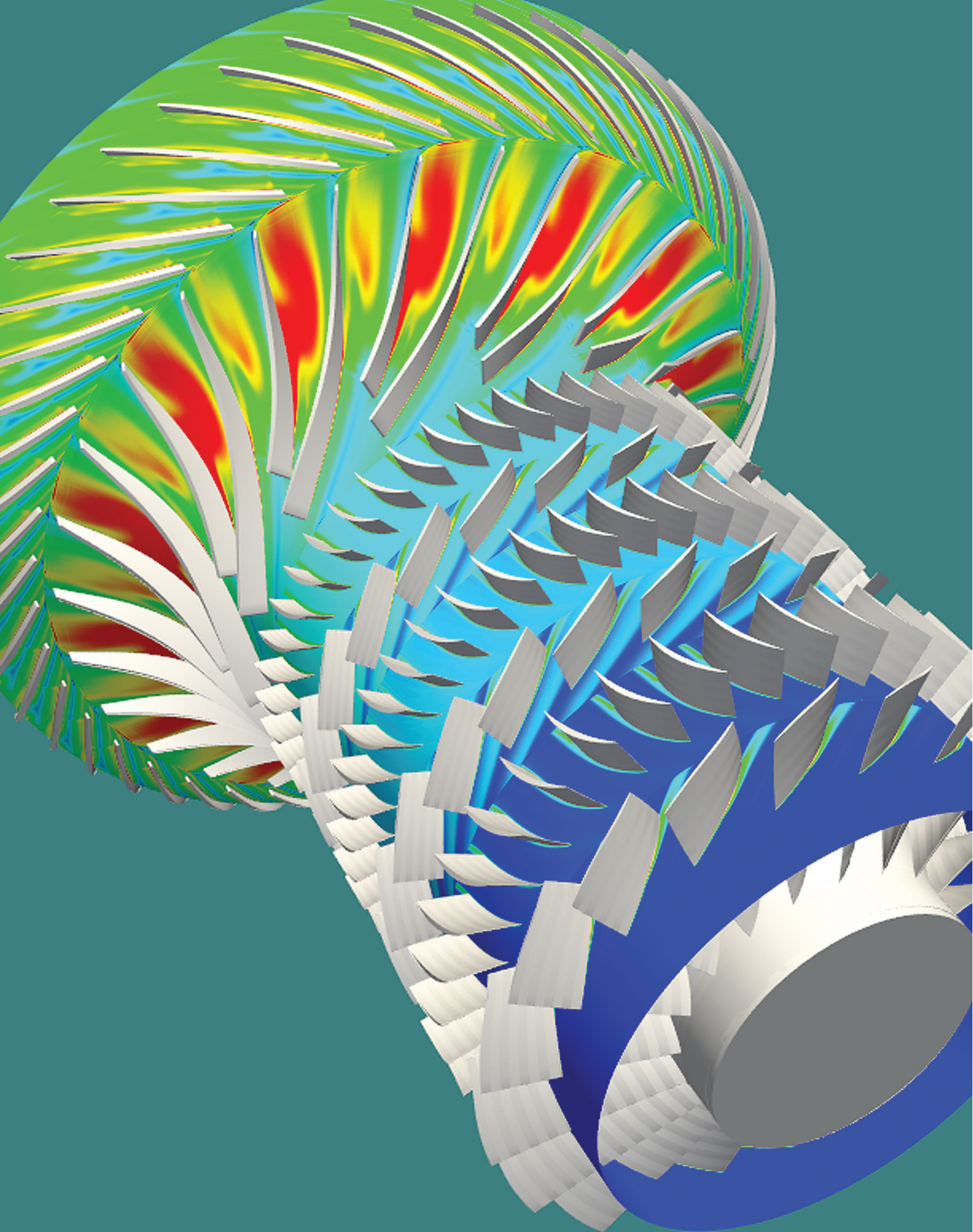
System Overview

While the various modules in our Agile Engineering Design System can be used individually, the full power of the system is realized when the modules are used together. For example, when a preliminary design is completed, an initial detailed design can be instantly created using Concepts NREC or customer-supplied design templates with just one click. Detailed designs can be analyzed for fluid dynamics and stress/vibration with another click. The built-in links save valuable design time and eliminate costly errors that can occur when manually transferring information between codes. In addition, the system allows easy transfer of detailed designs to all major CAD formats as well as third-party CFD and FEA packages.
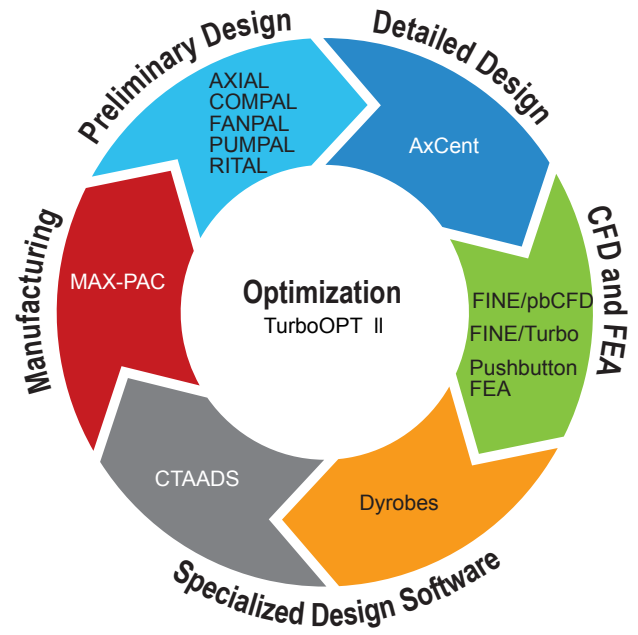
Preliminary Design

Concepts NREC's meanline codes design and analyze any type of turbomachine using a flexible, user-friendly interface with built-in performance mapping. All relevant parameters from the meanline design are seamlessly transferred to our detailed design module, AxCent.

Detailed Design

AxCent provides the aerodynamic design of flowpath and blading. Three-dimensional blading and flowpath design can be quickly developed using available 2D flow solvers (throughflow and blade-to-blade). These solvers run in seconds, allowing rapid convergence from initial design to good loadings and performance.

CFD and FEA

FINE/pbCFD, FINE/Turbo, and Pushbutton FEA all run within the AxCent environment without wasting time on exporting, meshing, and post-processing. Once the initial 3D design has been developed, stress and vibration can be analyzed with one click using Pushbutton FEA. Flow analysis can also be performed with another click using FINE/pbCFD or FINE/Turbo.

Specialized Design

Some situations require specialized software to complement the standard turbomachinery design workflow. To address one such need, Concepts NREC developed CTAADS, a tool for the preliminary design of actively cooled, axial turbine blades. We also distribute the industry-leading Dyrobes rotordynamic analysis software, which includes bearing and seals.

Manufacturing

The seamless link between the design system and the MAX-PAC family of 5-axis machining software allows manufacturability to be considered, along with performance and life expectancy. It also eliminates the tedious and error-prone task of transferring data from the design system to the manufacturing system.

Optimization

Automated optimization saves engineering time and explores new areas of the design space that conventional approaches do not have time to investigate. Concepts NREC developed TurboOPT II software to support optimization at all levels and stages of the design process.

Preliminary Design

Our preliminary design suite uses a meanline approach to rapidly size and analyze virtually every type of turbomachine. Each specialized module features a design wizard, to guide the user through the process with a flexible, easy-to-use interface that includes built-in performance mapping.

Objective	Input	Output
Design	Desired Performance	Preliminary Geometry
Analysis	Preliminary Geometry	Design and Off-design Performance, Map Generation
Data Reduction	Preliminary Geometry & Measured Performance	Model Refinement to Match Models and Measured Data
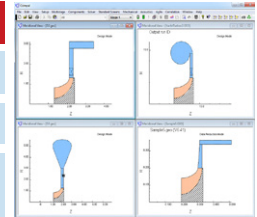
AXIAL™— For Single and Multistage Axial Compressors and Turbines

AXIAL supports axial compressors and turbines, providing design-point and off-design analysis for subsonic and supersonic designs through advanced pressure-based formulation. It covers full analysis of mass flow, pressure ratio, and power parameter. AXIAL also includes estimation of hub and tip flow parameters, evaluation of stall and choke conditions, and analysis of multiple choked and stalled components.

AXIAL includes a state-of-the-art loss modeling system that incorporates all of the industry standards, along with the ability for users to modify the standards or define their own models. Setup of an arbitrary sequence of stage elements, such as rotors, stators, ducts, IGVs, and EGVs, is also supported.
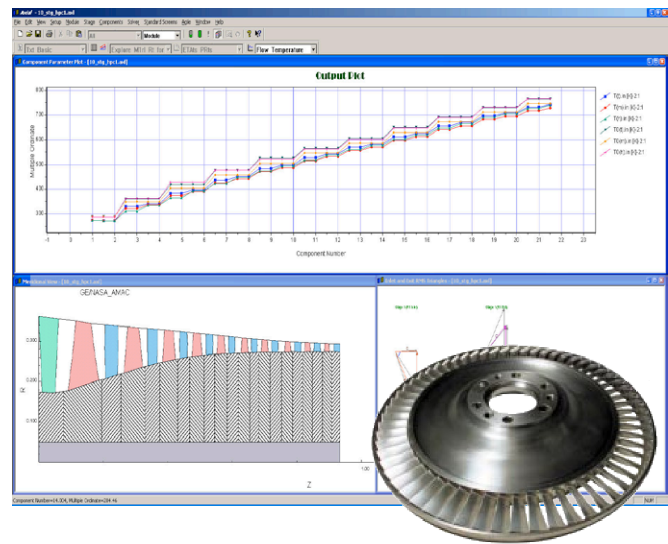
COMPAL® — For Single and Multistage Radial and Mixed-flow Compressors

COMPAL is used to design the compressor stage, analyze performance, refine parameters with data reduction, and model the machine according to a number of performance models. Components supported include upstream and downstream elements, radial or axial inlet guide vanes, open or closed impellers, 2D or 3D impellers, and front and rear seals.
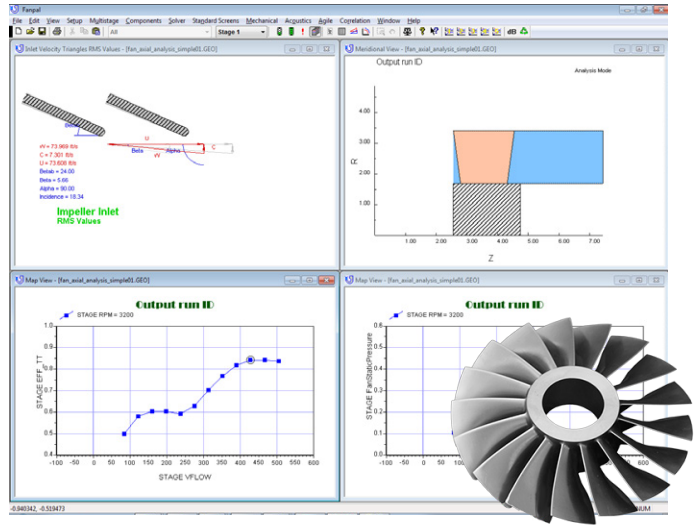
COMPAL can also be used to design diffusers, including arbitrary vaned, vaneless, wedge/channel, cascade, conical, pipe, and 90/180 degree bends. It can also design exit elements, such as collectors, volutes, return channels, and de-swirl and continuous crossovers.
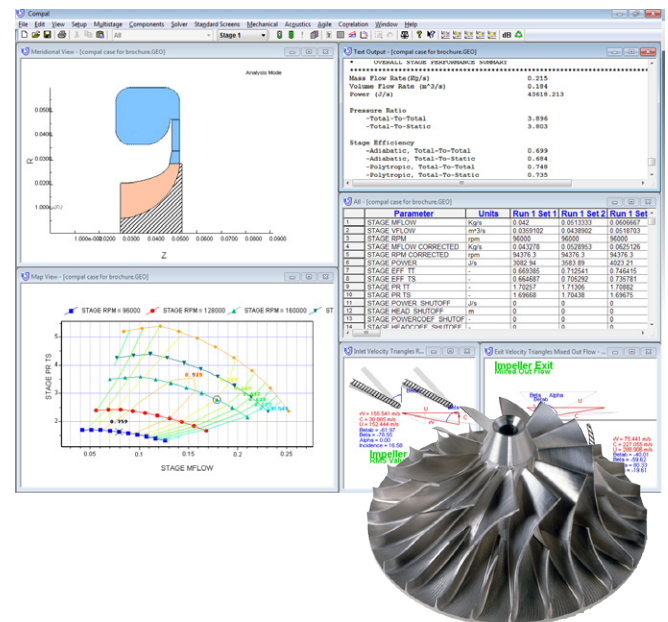
FANPAL™ — For Single and Multistage Axial, Radial, and Mixed-flow Fans

FANPAL is used to design the fan stage, analyze performance, and reduce test data to refine input parameters. It uses a variety of qualified performance modeling approaches, and it supports the design of radial and axial inlet guide vanes, open or closed impellers, and 2D or 3D impellers.

In addition to predicting design and off-design performance, FANPAL predicts fan noise using the industry-standard Mugridge acoustics model. FANPAL can also design diffusers, such as vaned, vaneless, wedge/channel, cascade, conical, 90/180-degree bends, and foil. Exit elements, such as collectors, volutes, and return channels, can also be designed and analyzed with FANPAL.

## PUMPAL® — For Single and Multistage Centrifugal, Mixed-flow, and Axial Pumps
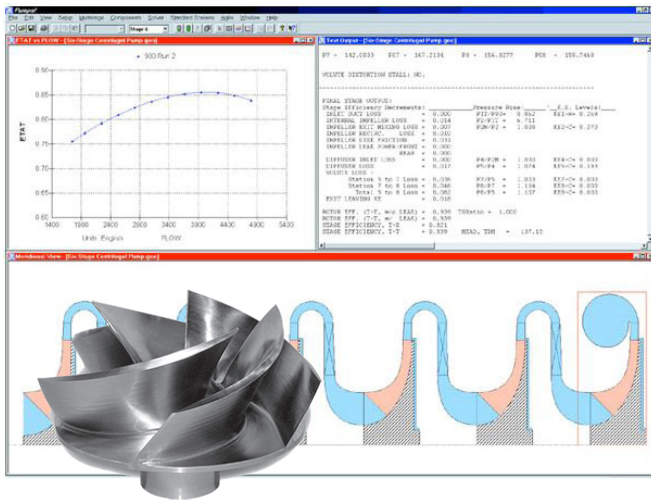
PUMPAL is used to design, analyze performance, refine the parameters with data reduction, and model the pump according to several industry-standard performance models.

Components supported include inlet guide vanes, open or enclosed impellers, 2D or 3D impellers, front and rear seals, and various leakage paths. Diffusers, including arbitrary vaned, vaneless, wedge/channel, cascade, conical, and 90/180-degree bends are supported as well. Exit elements, such as collectors, volutes, and return channels, are also supported.

RITAL™ — For Radial and Mixed-flow Turbines

RITAL performs one-dimensional analysis of radial and mixed inflow turbine stage performance. It uses a built-in model for design, analysis, and data reduction modes that supports inlet volutes, rotor and nozzle diffusion/losses, disk friction, and other phenomena associated with subsonic and supersonic turbine performance.
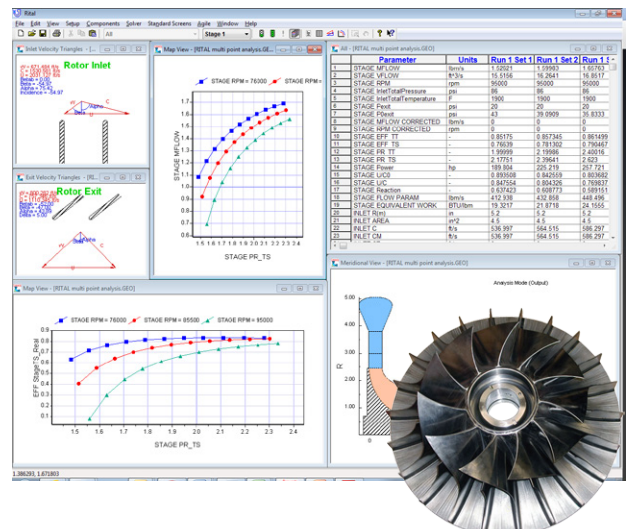
Detailed Design

AxCent® — For Detailed 3D Geometric Design and Rapid 2D Flow Analysis

AxCent is a powerful, full-featured design, analysis, and geometry generation tool for single and multistage axial, radial, and mixed-flow turbomachinery. AxCent easily handles the most complex rotating and stationary blade geometry. Features include parameterized volute geometry generation, split-duct geometry, and fillets with constant or variable radius and aspect ratio.

Users can see design edits in real-time with cutaway and 3D-transparent overlay views. AxCent also includes several 2D fluid dynamic solvers for aero/hydrodynamic performance that update as the geometry is changed.


CFD Options

FINE/pbCFD™ is a baseline tool for CFD users who are interested in a cost-effective alternative to prototype manufacturing and testing. It is designed to quickly and accurately optimize product efficiency and functionality from within AxCent.

FINE™/Turbo is a full-featured Flow Integrated Environment for rotating and non-rotating flow analysis in external and internal turbomachinery applications. It is the fastest CFD suite available for rotating machinery with incompressible and compressible fluids, operating from subsonic to hypersonic flow regimes. All types of multi-stage axial, radial or mixed-flow configurations are supported: compressors, turbines, pumps, fans, propellers or contra-rotating propellers. FINE/Turbo seamlessly launches with one click from AxCent.
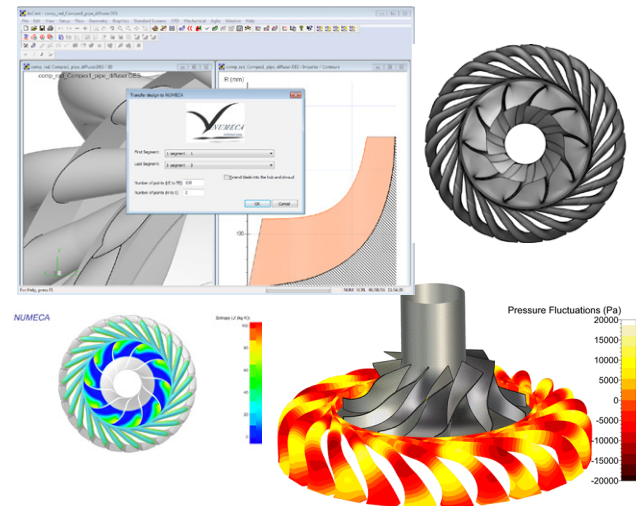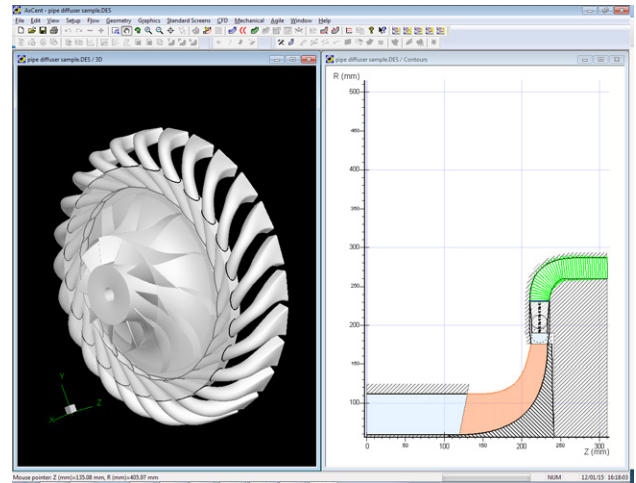

Pushbutton FEA™

This module enables aerodynamic and structural design to be performed concurrently within AxCent utilizing the integrated FEA tools. Since this can be done as soon as initial blade definition is available, structural analysis and life assessment can be performed early in the design process. Pushbutton FEA includes a geometry generator for elements of impellers and blisks that are not in the aero flow path, such as backface, bore, and shroud shapes. Above all, Pushbutton FEA is simple and intuitive for the non-FEA professional, while still providing the necessary power and flexibility for the structural design professional.
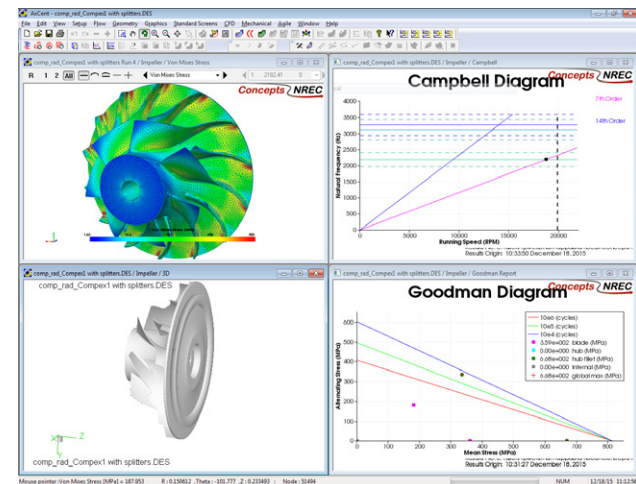
Specialized Design Software

## CTAADS™ — Cooled Turbine Airfoil Agile Design System

Our Cooled Turbine Airfoil Agile Design System (CTAADS) provides a systematic and rapid 3D modeling approach to cooling system design for axial turbine vanes and blades. The system includes many features that significantly reduce the time and cost to generate airfoil cooling-passage geometry and/or perform a complete 3D thermal analysis. CTAADS is also capable of working either with AxCent (highly recommended) or as a stand-alone module.
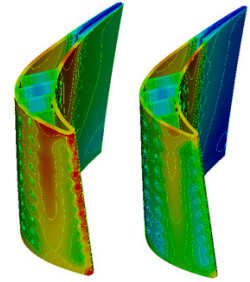
TurboOPT II™ — Holistic Optimizer and Stress Analysis

TurboOPT II enables the designer to achieve an optimal design quickly, based on lowest cost, lightest weight, highest performance, longest life, or any combination of these. TurboOPT II provides optimization across every module in the Agile Engineering Design System, with a flexible user interface and performance maps for each parameter.

Optimization workflows can be set up in minutes using turbomachinery-specific parameters, whereas achieving this same type of optimization using generic (non-turbomachinery specific) software would be tedious and prone to errors. Designers also have the option of using either the built-in optimization algorithms or choosing from any of the well-known, third-party optimization systems.
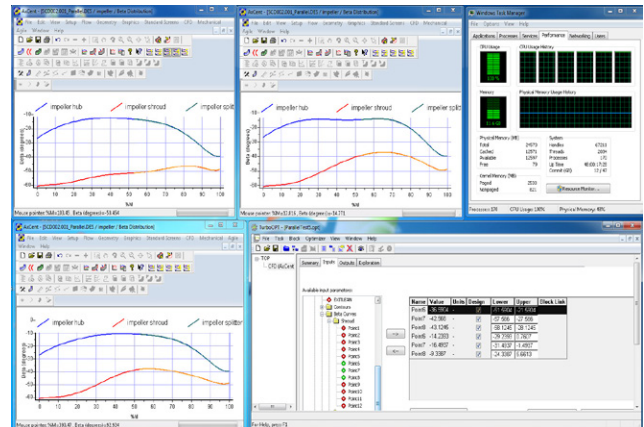
Dyrobes™ — Modeling Dynamics of Rotor Bearing Systems

Dyrobes is a complete rotordynamics software tool that is powerful and versatile, yet easy to learn. Developed for the working engineer, Dyrobes offers complete rotordynamic analysis, vibration analysis, bearing performance, and balancing calculations based in Finite Element Analysis. The software combines an intuitive, Windows-based interface, with sophisticated modeling and analysis capabilities that can satisfy the most demanding industry requirements.

GasTurb™ — Simulated Gas Turbine Performance

GasTurb is a powerful and flexible gas turbine cycle program that simulates the most important gas turbine configurations used for propulsion or power generation. A user-friendly interface presents information in both easy to understand lists as well as graphically. GasTurb simplifies the tasks that performance engineers encounter most frequently.

Other

In addition our proprietary software, Concepts NREC partners with other technology developers to offer state-of-the-art tools for cycle performance analysis, stress analysis, MDO (multidisciplinary optimization) procedures, and smooth interaction with most CAD packages.

FINE/Agile™ Software Solution

## Offered in Partnership with NUMECA International

FINE/Agile is an integrated solution that spans preliminary design through detailed 3D steady or unsteady CFD analysis. It is the combination of a preliminary design tool, AxCent, and either FINE/pbCFD or FINE/Turbo. By combining the best capabilities of both companies, customers have access to the most advanced turbomachinery software suite available in the market.

Turbomachinery Type	Meanline	Geometry	CFD
Centrifugal Compressors	COMPAL	AxCent	FINE/pbCFD or FINE/Turbo
Axial Turbines and Compressors	AXIAL	AxCent	FINE/pbCFD or FINE/Turbo
Radial Turbines	RITAL	AxCent	FINE/pbCFD or FINE/Turbo
Pumps	PUMPAL	AxCent	FINE/pbCFD or FINE/Turbo
Fans/Blowers	FANPAL	AxCent	FINE/pbCFD or FINE/Turbo

Additional Modules and Capabilities

FINE/Agile can be customized for specific needs with powerful add-ons, including:

- CPU-Booster™ for 10 -1000 times faster results overall

- HEXPRESS™ unstructured meshes and FINE™/Open solvers to solve complex geometry including secondary/upstream/downstream flow that is not possible with structured solvers

- FINE™/Acoustics is a complete simulation suite for the analysis of a broad range of applications involving acoustics, vibro-acoustics and aero-acoustics

- Uncertainty Qualification module to enable users to set input parameters' uncertainty prescribed by arbitrary PDFs, combine them, and then analyze the effects on the solution

- High Performance Computing (HPC) solutions to allow running multiple-million node mesh structures and CFD-based optimization in an accelerated time frame

- Non-Linear Harmonics (NLH) capability to eliminate the risk of missing important phenomena that cannot be otherwise captured if only using a steady state solution

- Modal and Flutter analysis tool for an efficient method for fluid structure interaction prediction
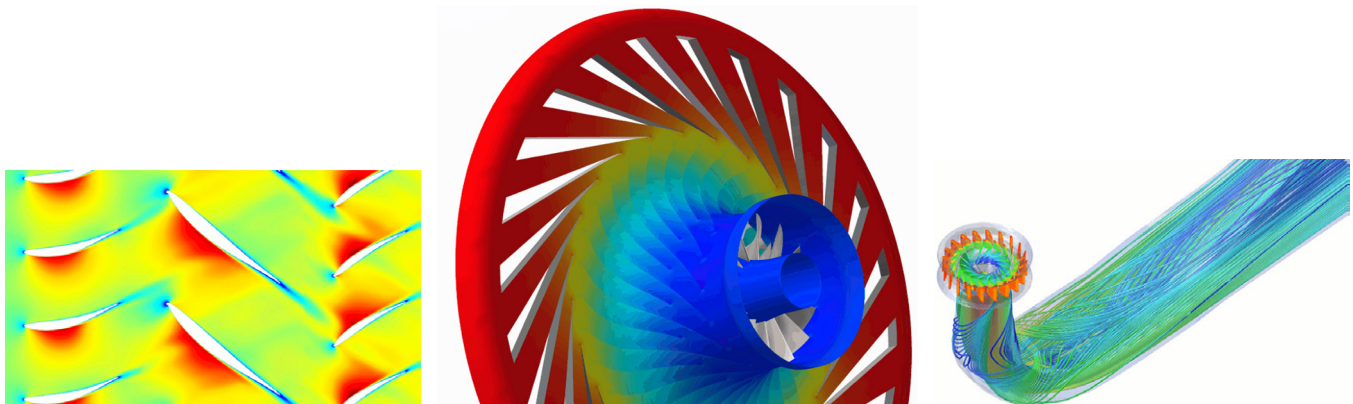
Manufacturing

MAX-PAC™ — CAM Software

The seamless transition between our design suite and the MAX-PAC family of 5-axis machining software allows manufacturability to be considered early in the design process. This avoids the time-consuming task of separately transferring data and files back and forth between the design system and manufacturing system. Compared to other similar CAM tools, MAX-PAC is faster to learn, easier to use, and requires less programming and machining time to create state-of-the art turbomachinery parts and components.
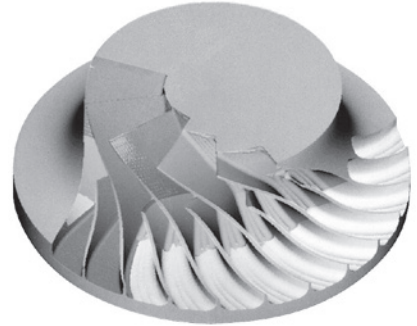
Based on decades of experience and incorporating several patented methodologies, MAX-PAC has long been recognized as the leading software for 5-axis milling of turbomachinery impellers, blisks, and rotors. MAX-PAC is used worldwide by turbomachinery manufacturers, job shops, and 5-axis machine-tool manufacturers who are passionate about producing the highest-quality parts.

MAX-5™ — Flank Milling

MAX-5 creates 5-axis CNC machining instructions for flank milling of ruled-surface turbomachinery components. Typical applications include parts for centrifugal compressors, pumps, inducers, fans, turbochargers, stators, radial-inflow turbines, expanders, and torque converters.
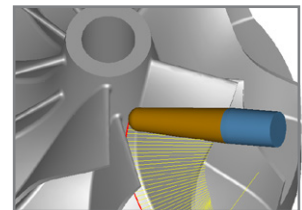
MAX-AB™ — Point Milling

MAX-AB creates 5-axis CNC machining instructions for point milling of turbomachinery components with arbitrary (free-form) blade surfaces. Typical applications include axial compressors and turbines, pumps, compressors, turbochargers, radial-inflow turbines, and inducers.
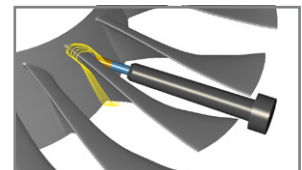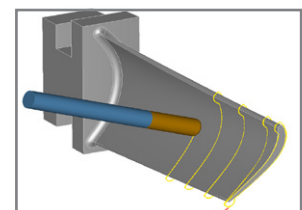
MAX-SI™ — Integrally Shrouded Impellers

MAX-SI creates 5-axis CNC instructions for milling integrally shrouded (enclosed) turbomachinery components for expanders, pumps, compressors, and turbines. It can also generate machining instructions for large axial compressors and blisks, using a side-entry machining approach.
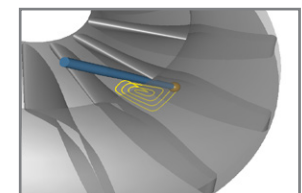
MAX-SB™ — Single Blades

The MAX-SB module generates tool paths for quickly machining single blade parts with smooth 5-axis motion. It is specifically designed for flat/torus cutters that are more efficient than a ball tool. MAX-SB also provides optimized angles for the smallest cusps, to avoid gouging in concave areas.

Concepts NREC

The Experts in Turbomachinery

London, UK

White River Junction, USA

Shanghai, China

Bangalore, India

★ Worldwide and regional headquarters. We also have sales offices and representatives strategically located throughout the world to support our global clients.

We Offer

- CAE Software
- CAM Software
- Design Audits
- In-house Laboratory Testing
- Manufacturing Services
- Precision Prototypes
- Research and Development
- Scoping Studies
- Specialized Products

Our Focus

- Air Dynamometers
- Compressors
- Fans and Blowers
- Gas Turbines
- ORC Turbine Generators
- Pumps
- Steam Turbines
- Superchargers
- Turbochargers

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