WHITE PAPER

Modeling, Simulation and Analysis for Effective New Product Development and Design Improvements

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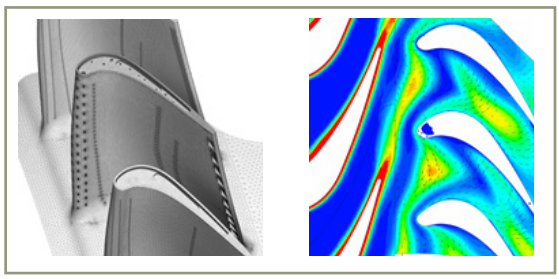
QUEST
BORN TO ENGINEER

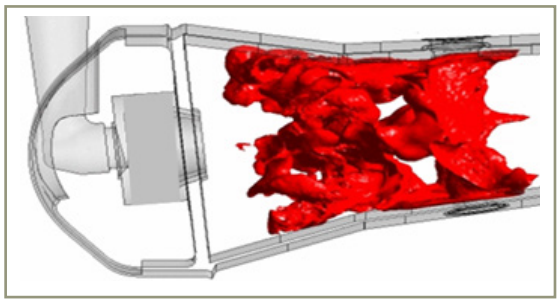
Several global organizations in aerospace, aircraft engines, automotive, medical systems, power generation, and oil and gas industries constantly face challenges to improve reliability, performance, bring newer products to the market quickly, at lower cost and at best value. Modeling and Simulation using advanced computational methods, numerical algorithms, design optimization techniques and visualization tools can significantly contribute to the understanding of complex design and performance issues faced by many of these high-tech and industrial technology industries.

Modeling and Simulation Plays a Key Role for Technology Advancements in Aero Engines

Aircraft engine manufacturers constantly face challenges to design and develop advanced propulsion systems capable of carrying passengers over long distances while meeting strict safety and environmental guidelines related to emission and noise. Newer commercial engines are expected to have lower specific thrusts for reduced noise, improved combustor technology and have lower specific fuel consumption for reduced emissions. For achieving these challenging goals, radical design changes that deviate from conventional designs are needed. Advanced technologies on ways to improve engine bypass efficiency and core thermal efficiency are two focal areas for overall engine performance and reliability gains. Important aspects of the aforementioned technologies include incorporating advanced aerodynamics, inter-turbine combustion, turbine cooling and thermal-mechanical modeling to name a few.

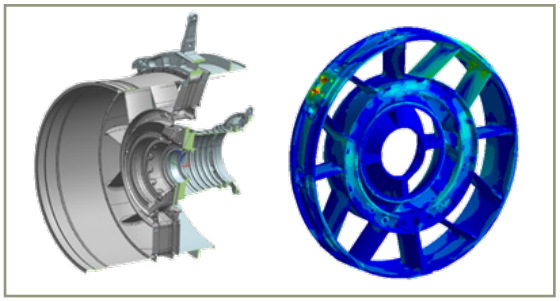


Simulation of Unsteady Cooling Flow and Film Effectiveness in an advanced High Pressure Turbine Stage



Unsteady LES Combustor Flame-Front

QuEST is well experienced in supporting major aircraft engines OEMs and power generation companies for many years. We have been recognized and valued by our customers for providing critical and timely support for several of their challenging engineering needs. Project support has included system as well as component level modeling, simulation and customized software developments to solve major technical issues.

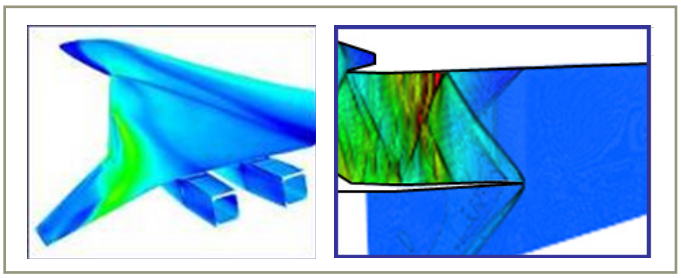


Fan Frame Structural Analysis to determine high stress locations for flight integrity

Modeling and Simulation for Aerospace Applications

Next generation passenger airplanes are envisioned to incorporate airframe designs that considerably deviate from the predominant tube and wing design of the present time. Some revolutionary concepts that are being pursued by major aircraft OEMs include, blended wing body (BWB) concept, with engines mounted on top of the aft section. This design is to reduce the heavy drag that results from having the engines mounted below the wings of the conventional designs. While reducing overall vehicle drag, this configuration presents other challenges like understanding the effect of boundary layer ingestion (BLI) or the slower moving air from the surface of the body entering the engine face on overall performance. Since the demise of the Concorde passenger operation and supersonic passenger flights in 2003, various government agencies and airplane OEMs have been spending considerable effort in developing next generation supersonic aircraft that could boast of considerable fuel saving, noise reduction and safety.

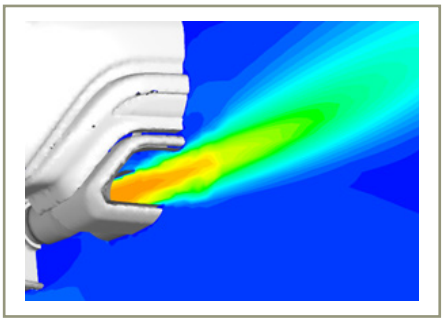
Modeling and simulation using advanced CFD methods would have a huge impact on understanding such complex flow features, while saving developmental cost in expensive wind tunnel testing.



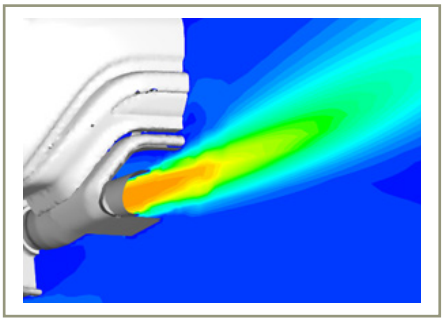
Aircraft and supersonic inlet flow features

Modeling and Simulation to Meet Automotive and Rail Industry Challenges

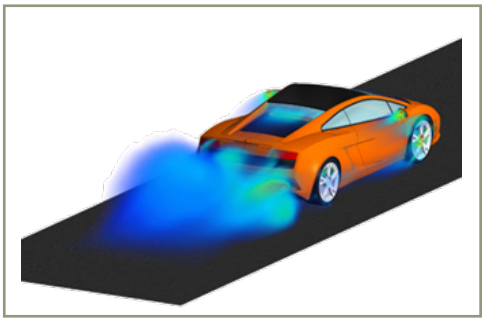
Opportunities are aplenty in the automotive and rail industries, focused on providing many engineering improvements driven by modeling and simulation techniques. In the highly competitive personal vehicle market, manufacturers must constantly look for an edge by improving fuel efficiency, reducing noise, improving passenger comfort and safety, and incorporating sound engineering into attractive aesthetic and safe design. QuEST has significant experience in both automotive and rail industries. Project support has included climate control simulation for passenger comfort, aerodynamic modeling for vehicle performance prediction and overall drag reduction for fuel savings, and re-designs for noise reduction.



Baseline Design

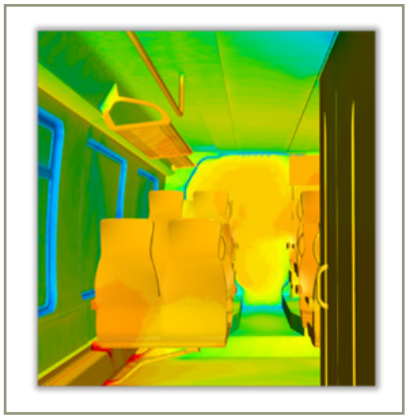


Improved Design reducing noise level



Simulation of automotive Turbulence Intensity

As in the case for automobiles, passenger rail cars have their own challenges with ever-increasing needs for a comfortable passenger experience through long hours of travel. Environmental comfort, handled by onboard HVAC systems, can be optimized through the use of detailed CFD, heat transfer modeling, and resulting thermal environment simulation.

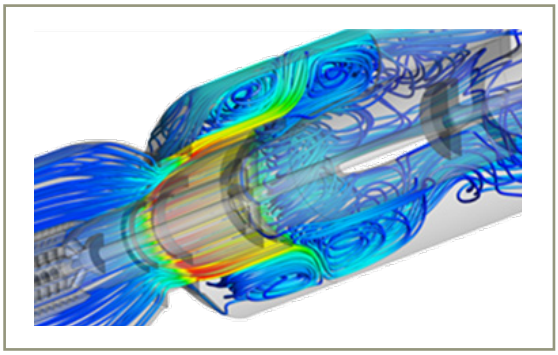


Temperature distribution inside a rail car

Modeling and Simulation for Oil & Gas Industry Application

The oil and gas industry has been facing an ever-increasing level of challenges related to deep sea oil and gas extraction, distribution, and refinement. Subsea, deep water drilling, hydraulic fracturing, and other modern extraction techniques have created technical challenges that are relatively new to many of the companies involved, and offer great opportunities to apply advanced modeling and simulation techniques that can solve emerging problems. As such, accurate, physics based modeling and simulation methods can play a crucial role in addressing challenging issues.

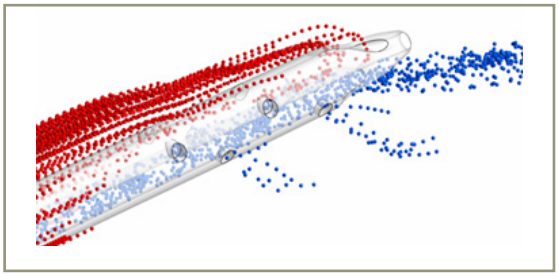
Our service involvement in the Oil & Gas industry include modeling drill-bit erosion, pressure data mapping onto FEA surface mesh to aid structural designs and design changes, develop flow models for mud pulse telemetry valves, transient operations of rotary wobblers, and down hole drill head flow visualization.



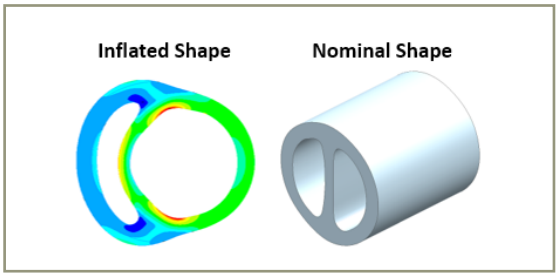
Flow simulation and visualization of mud pulse telemetry and valve assembly

Medical Devices: Modeling and Simulation Benefits

The multi-phase, multi-disciplinary technology challenges presented by the ever advancing medical device industry are well-served by advanced physics based modeling and simulation techniques. Catheters designed to deliver medication directly to the blood stream can be designed and analyzed in a very robust way using fluid structure interaction methods that combine highly detailed 3D CFD analysis with equally high-fidelity elastomeric structural analysis.



Catheter FSI Analysis and Particle Visualization

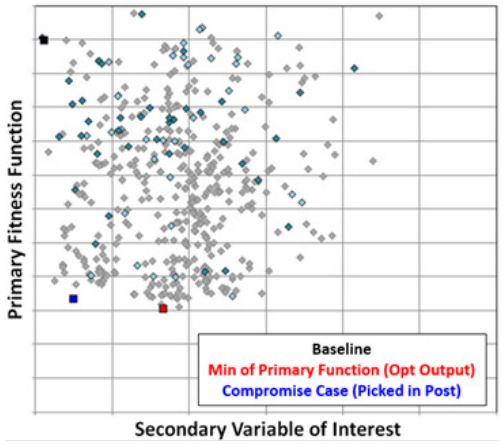


Biomedical Elastomeric FSI Analysis

We have remarkable experience in supporting the requirements of manufacturers of medical devices. As illustrated above, modeling and simulation based project support has included analyzing catheter fluid structure interaction, and highly viscous fluid flow analysis in small discrete and invasive medical instruments.

Advanced Design Optimization Expertise

QuEST has developed in-depth capabilities in the application of advanced optimization techniques. Our genetic algorithm based process allows the customer to explore the design space comprehensively by examining thousands of potential design cases in a very short time, with efficient use of computational resources.



Example of Genetic Algorithm Design Selection

QuEST Global, a Valued Engineering Solutions Provider

QuEST Global is a valued partner and a leading solutions provider to many major engineering companies in several parts of the world. We have a successful history and proven track record of providing valuable solutions to our customers using advanced modeling and simulation techniques. Some key benefits of using such methods in the earlier product development cycle include:

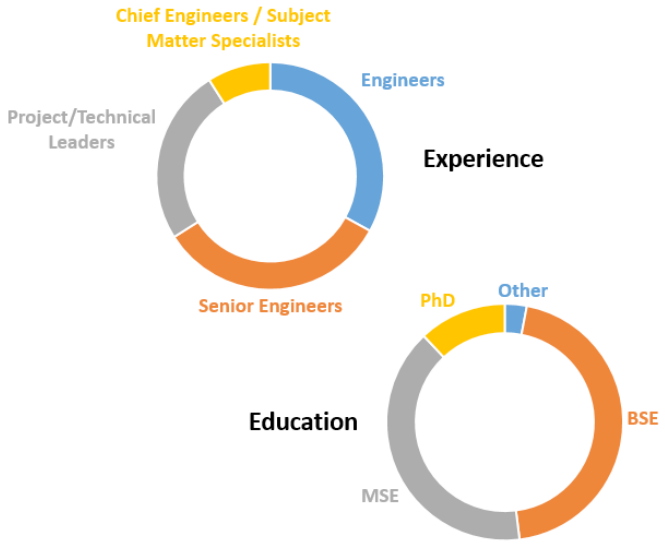
- Relevant and key performance parameters can be obtained earlier in the design process
- Design objectives and performance goals can be estimated in a relatively shorter time frame
- Complex aero and mechanical features that adversely affects performance can more quickly be identified and easily addressed
- System level challenges can be analyzed at the component levels to understand individual and overall performance
- Reduce laborious and expensive experimental testing; focus testing on promising and final designs

For over 20 years, QuEST has effectively developed and utilized appropriate modeling and simulation methods in the primary disciplines of Aerodynamics, Computational Fluid Dynamics (CFD), Combustion Modeling, Structural Analysis and Custom Software Development applicable to wide variety of engineering products and processes. We have grown significantly in this area with continuous focus on research, product design, tools development, validation, and process improvements applicable to high tech industries that include aero engines, automotive, rail, oil and gas, and medical devices.

A Dependable and Experienced Team in the Application of Modeling and Simulation for Product Design and Development

QuEST today has a team of over 10000 engineers globally, including a strong pool of domain experts in the fields of advanced aerodynamics, aero thermal design analysis, heat transfer methods, structures and custom engineering software development. Our engineers are familiar with the application of advanced methods using 1D, 2D and 3D design tools such as 1D flow and thermal network solvers, coupled fluid-thermal behaviors, proper application of advanced Computational Fluid Dynamics (CFD) codes, Finite Element Methods (FEM) for coupled fluid-thermal-structure interaction studies, pre- and post-processing software for meshing and interpretation of results. Our engineers are also familiar with customers' proprietary methods, tools and best practices.

QuEST has developed and effectively implemented a local-global delivery model that provides best value at best cost to our customers.



Typical QuEST Analysis Team Demographics

Summary

QuEST Global has been providing advanced engineering services to our customers using advanced modeling and simulation based techniques to solve challenging problems. Using such advanced analysis tools, complex issues are often addressed and solved in a relatively short period of time. Our customers get the best value for the cost involved, leveraging our highly experienced local-global execution team. We have established long-standing relationships with major customers, and have earned their trust as a value-added service provider. Over the last two decades, we have demonstrated expertise in a wide variety of physics based modeling and simulation methods and their effective applications to solve problems, explore newer design spaces quickly and address unforeseen issues in a time critical manner.

We have highly experienced and reputable modeling and analysis teams spread over multiple geographies to effectively serve diverse industrial customers. Constant learning and innovation on state-of-the-art methodologies, and the capability to offer relevant training to stakeholders enabling them to perform complex analysis, along with dedication and a committed mindset are the values QuEST brings to the table.

Our diverse culture, strength, commitment to quality and excellence along with our robust experience built over twenty years of engineering engagements have been instrumental for our customers as they look to meet their product development needs and performance improvement goals in a timely manner.

ABOUT AUTHORS

Dr. Sunderesa (Mani) Subramanian

Mani joined QuEST in December of 2008. As a Global Technology Solutions Lead for Aero and Fluid Systems (AFS) discipline, Mani plays a key role across the organization in advising and guiding proper application of advanced aero, CFD and heat transfer methods for our diverse customer base. Mani has over 35 years of aerospace and mechanical engineering experience with specialization in developing as well as applying advanced analytical and CFD methods for the design and performance improvements in aircraft engines, power generation and high-speed propulsion systems for space applications. Mani has done Ph.D. and M.S. from Old Dominion University, Norfolk, VA in the US and a B.S. in Mechanical Engineering from the University of Madras, India.

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Jonathan King

Jon joined us in December 2008, and currently holds the position of Senior Manager for North America in QuEST's Technology Excellence Group (TEG). He has over 17 years of experience in heat transfer and flow analysis for a variety of industry applications, as well as in leading high-capability engineering teams. Jon holds a Bachelor's degree in Science in Aerospace Engineering from Trine University in Angola, IN. He is based in Cincinnati, OH.

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Chad Iverson

Chad Iverson joined QuEST in 2008, and is currently the Manager of the Engineering Analysis Center of Excellence in Cincinnati, OH. Chad has over 12 years of experience in advanced aero-thermal analysis (CFD and heat transfer), multi-disciplinary analysis, design optimization, and methods/tools development. He has worked across QuEST's practice verticals, including Aero Engines, Aerospace and Defense, Oil and Gas, and Power.

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Dr. T.C. Ramesh

Ramesh joined QuEST in January of 2001. As Global Head of Technology, Ramesh plays a key role in identifying emerging and new technologies that are changing the market, and in developing them within the organization. Ramesh has over 24 years of experience in the FEA/CFD discipline and is currently working on digital technologies such as Deep learning, Augmented Reality and Digital Manufacturing that are expected to impact next-generation product development. Ramesh holds a Ph.D in Applied Mechanics from IIT Madras.

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David Griffiths

David joined QuEST in 2011 and is the technical lead in QuEST North America for structural analysis discipline. He has over 10 years of experience working with Finite Element Analysis (FEA) software to solve structural analysis problems. He has led projects including full system engine modeling for bird strike and fan blade out (FBO) events, detailed models of blade retention hardware, and detailed analysis of nozzle components. Prior to joining QuEST, David worked in Arup's Advanced Technology and Research group for projects in infrastructure, transportation and nuclear industries. David holds an M-Eng. in Engineering Science from Oxford University.

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G. Chella Rao

Chella Rao joined QuEST in 2013, and is currently Principal Engineer of the CFD methods and analysis team at our Bangalore Center. Chella has over 18 years of experience in design, analytical, experimental, Computational Fluid dynamics (CFD), heat transfer and Finite Element methods. His innovations include application of advanced analytical methods to Aero Engines, HVAC, Consumer Electronics, Home appliances, Healthcare, Semiconductor, Automotive and Oil and Gas industries. Chella holds an MTech. degree from Jawaharlal Nehru Technological University, Hyderabad, India.

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QuEST Global is a trusted engineering services and solutions partner to many of the world's most recognized Fortune 500 brands in aero engines, aerospace & defense, automotive, medical devices, oil & gas, power, hi-tech, industrial and rail with more than 10,300 associates. For more than 20 years, QuEST has been a trusted partner providing comprehensive support across the complete engineering lifecycle to help our customers improve efficiency, increase quality, create new products and open new markets. Through a collaborative and customized approach, QuEST enables its customers to manage traditional engineering requirements as well as the convergence of digital and mechanical technology to help them create safe, dependable and high quality products and services.

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