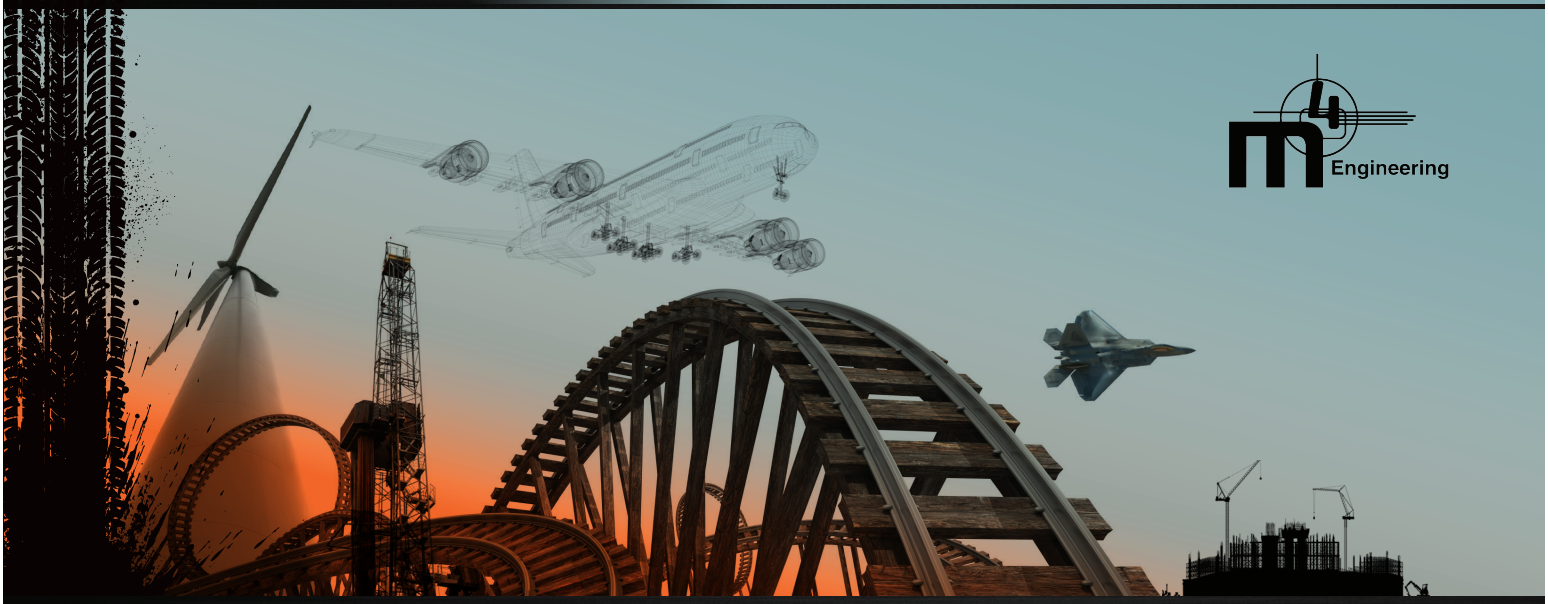

ENGINEERING SERVICES

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Engineering

For private business, government, and global industry, we're the ones to call before it breaks.

SOFTWARE SIMPLIFYING COMPLEX ENGINEERING PROCESSES

We combine state-of-the-art software development with expertise in multidisciplinary design analysis and optimization (MDAO). Together, we are able to save time and reduce the costs associated with the analysis of high performance structures typically found in aerospace, automotive, construction, theme park attractions, and energy production, including wind, oil, and coal.

Through grants provided by the SBIR, we are able to offer our commercial customers world-class software applications to aid in our analysis, research and development services. Additionally, our team can create new strategic software applications for commercial clients seeking to simplify engineering processes.

Our focus is on the entire spectrum of disciplines, including structural mechanics, biomechanics, heat transfer, aerodynamics, trajectory, cost, aeroheating, fluid mechanics, and controls.

Software Applications

- RapidFEM
- Rapid Unsteady Analysis Tool
- Integrated Hypersonic Aeromechanics Tool
- Geometry Manipulation by Automatic Parameterization
- Generalized Reduced Order Modeling
- High Fidelity Multidisciplinary Optimization
- Geometry Modeler
- Integrated Multidisciplinary Optimization Objects
- Uncertainty Quantification

M4 has conducted structural and safety analysis on Southern California's most popular theme parks and attractions.

RapidFEM

The RapidFEM software provides rapid concept evaluation and structural optimization of aircraft type primary structures (e.g., fuselage, wings, and tail). Simple wizards or geometry input files allow users of all skill levels to create models of complex, built-up structures. Leveraging OpenCascade on the backend, RapidFEM delivers accurate and reliable geometry and finite element models for use in the conceptual design phase.

Generalized Reduced Order Modeling

Generalized Reduced Order Modeling (GROM) software application provides reduced order aeroservoelastic state-space models that can be interpolated across a range of flight conditions. This application significantly advances the process of control law development, especially in the design of control systems required to provide flutter suppression, gust load alleviation, and ride quality enhancement. The software application is an excellent compliment to modern linear and nonlinear aeroservoelastic analysis methods.

Geometry Manipulation by Automatic Parameterization

An especially novel feature of our Geometry Manipulation by Automatic Parameterization (GMAP) application is the concept of morphing tools. Morphing tools encapsulate a morphing task into a simple, reusable interface. They ask the user to specify a desired parameter (such as wing span or sweep angle), then automatically morph the underlying mesh to achieve the specified configuration. The GMAP user interface shows how the model morphs as design variables are changed, making it easy to experiment with different values.

Geometry Modeler

M4 Engineering has created geometry modeling and morphing software to enhance the accuracy of modifications to finite element and CFD models. GMAP, RapidFEM, and ATAC Geometry Modeler all function for efficient, swift, and user-friendly application. More specifically, our Aeroheating and Thermal Analysis Code (ATAC) simplifies the process of generating ATAC models through automation. This program reduces the time required to generate an ATAC model of a complex configuration from days to minutes. The software application is an advanced thermal program appreciated for its engineering reliability and accuracy. A wide variety of geometric shapes are provided to aid in complex constructions.

High Fidelity Multidisciplinary Optimization

High Fidelity Multidisciplinary Optimization (HFMDO) delivers physics-based multidisciplinary analysis and design optimization (MDAO) capabilities that are required to develop next generation supersonic fixed wing aircrafts. M4 Engineering and Phoenix Integration combined their specialties to deliver a modular design environment through an enhanced ModelCenter framework that is suitable to high fidelity analysis and design of coupled systems. The integrated modules include geometry, aerodynamics, propulsion, structural, stability and control, noise, and mission as well as our geometry morphing (GMAP) and automatic FEM generation (RapidFEM) software. The software tools and approaches upgrade MDAO capability to the next level.

Integrated Hypersonic Aeromechanics Tool

Our Integrated Hypersonic Aeromechanics Tool (IHAT) is an integrated multidisciplinary analysis system for the design, analysis, and system-level optimization of high speed aerospace vehicles. The software implements as an array of analysis modules suitable for the design, analysis, and system-level optimization. This allows rapid assessment of vehicle performance, including relatively high fidelity analyses, implementation of numerical optimization techniques, and interdisciplinary interactions.

Integrated Multidisciplinary Optimization Objects

The Integrated Multidisciplinary Optimization Objects (IMOO) software application integrates objects and design tools that perform discipline-specific analysis across multiple flight regimes at varying levels of fidelity. IMOO showcases a refined system architecture that allows the system to be less customized to a specific configuration and is capable of analyzing subsonic, supersonic, and hypersonic vehicles.

Rapid Unsteady Store Analysis Tool

Rapid Unsteady Store Analysis Tool (RUSAT) enables trajectory analysis in the presence of unsteady aerodynamic loads with unprecedented speed and ease of use. This software is ideal for organizations looking to increase the accuracy and safety of store trajectory analyses by including uncertain and stochastic effects including unknown release time in dynamic unsteady aerodynamic flowfields, uncertainty in ejector forces, and variability in mass properties of manufactured stores. Deployment of RUSAT within a separation analysis process provides increased assurance against unsafe separation conditions.

Uncertainty Quantification

We developed a comprehensive Uncertainty Quantification (UQ) framework capable of modeling both aleatory and epistemic uncertainties. Additionally, the application propagates mixed uncertainties through the implementation of Non-Intrusive Polynomial Chaos (NIPC) methods. NIPC has been shown to be both an efficient and accurate technique for quantifying uncertainties.

Bonded Joint Analysis Tool

M4 Engineering, in partnership with Sandia National Laboratories, has developed a new Abaqus-Based software tool that guides practicing engineers through all steps to create/extend efficient bond models for component and system design & analysis. Phase II development of this tool was sponsored by the Navy's SBIR/STTR program to meet its demanding customer needs. The software acts as a "plug-in" for the popular Abaqus Unified FEA product suite from SIMULIA and implements the methodology for predicting adhesively bonded joint behavior including both the modeling techniques and the associated testing approaches to populate these models with the necessary material properties.

M4 has consulted on major wind energy projects throughout the Unites States, including Modular Wind Energy, Clipper, and Sauer Energy.

ANALYSIS SAVING TIME AND COSTS

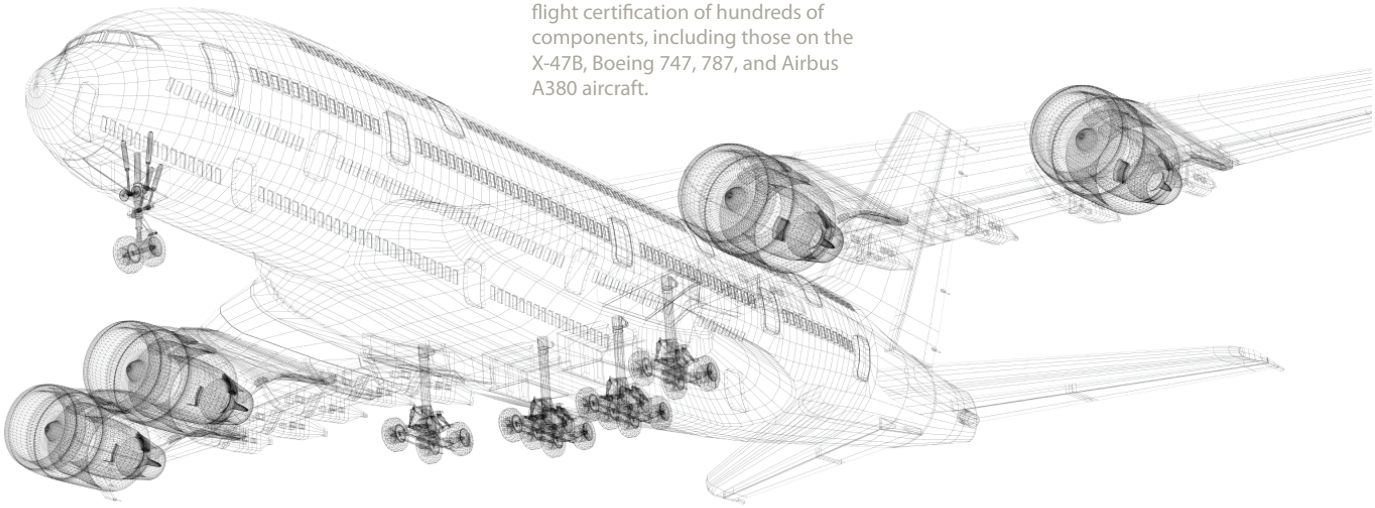
M4 Engineering offers Multidisciplinary Analysis and Design Optimization (MDADO) expertise in structural mechanics, biomechanics, heat transfer, aerodynamics, trajectory, cost, aeroheating, fluid mechanics, and controls.

We combine state-of-the-art software development with expertise in multidisciplinary design analysis and optimization (MDAO). Together, we are able to save time and reduce the costs associated with the analysis of high performance structures typically found in aerospace, automotive, construction, theme park attractions, and energy production, including wind, oil, and coal.

We provide crisis and safety consultation, structural analysis, problem-solving research studies, and time-saving software development to private business, government, and global industry.

Analysis and Research & Development

- Multidisciplinary Analysis and Optimization
- Structural Analysis
- Integrated Hypersonic Aeromechanics Tool
- Aeroelastic Analysis
- Composites
- Structural Optimization
- Testing



M4 analysis has resulted in successful flight certification of hundreds of components, including those on the X-47B, Boeing 747, 787, and Airbus A380 aircraft.

Multidisciplinary Analysis and Optimization

M4 Engineering has outstanding capabilities in multidisciplinary analysis and optimization (MDAO) for a wide variety of complex engineering systems in different industries. We excel at modeling the simultaneous influences among various disciplines in a coupled and integrated computational environment. We provide consultation and analysis across these disciplines: structural mechanics, biomechanics, heat transfer, aerodynamics, trajectory, cost, aeroheating, fluid mechanics, and controls.

Aeroelastic Analysis

M4 Engineering has an excellent background in aeroelasticity. Projects involving aeroelasticity at M4 Engineering encompass a wide range of cutting-edge system development. This range spans from multidisciplinary analysis and optimization tools to analyzing new vehicle configurations to active aeroelastic control to developing new tools for matching existing test data while efficiently tuning analytical models.

Structural Analysis

M4 Engineering has outstanding capabilities in structural analysis for the entire product lifecycle, including preliminary trade studies and detailed certification analysis based on CAD geometry or 3-dimensional drawings. We provide analysis ranging from closed form calculations to complete finite element simulations using industry-standard methods and software. These capabilities are especially useful when combined with our structural optimization capabilities that allow the best possible structures to be designed subject to strength, stiffness, vibration, buckling, weight, and aeroelastic constraints.

Composites

M4 Engineering has outstanding capabilities in design and analysis of composite structure. We have extensive experience, ranging from part design to tooling design to strength analysis. We have a comprehensive tool suite, including both industry standard and in-house software. The complex nature of composite design and analysis makes M4 unique among engineering service providers, allowing us to support efforts of composite components from cradle to grave.

Testing

M4 Engineering offers a range of testing options for customer needs, ranging from tests performed at our facility to mobile testing solutions offered in the field. Testing services are performed by trained engineers/technicians to standard (ASTM, ISO, etc.) or proprietary test specifications where available. Where a standard does not exist for a particular testing goal, our team will develop a test plan from scratch which will ensure accurate and reliable results.

Structural Optimization

Our engineers have optimized all-composite advanced-design aircraft (High Speed Civil Transport, Blended Wing Body, Advanced Subsonic Transport) for strength, durability, structural/aeroelastic stability, and weight. Our expertise includes development of finite element models for structural optimization applications, topology optimization, shape optimization, and sizing optimization. In addition, through close partnerships with manufacturing companies, we ensure that the resulting designs are straightforward and cost efficient to produce.

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