CASE STUDY

MSC Software: Case Study - Aeros

Aeros Develops Revolutionary Vehicle Buoyancy Air Vehicle with MSC Nastran

The Aeroscraft is a unique variable buoyancy air vehicle developed by Worldwide Aeros Corp. that combines elements of lighter-than-air crafts such as airships with conventional heavier-than-air aircrafts. The unique design of the Aeroscraft requires high weight efficiency (low ratio of weight over hull surface area) and provides advantages compared to conventional airships but also creates significant challenges in the design and optimization of the structure.

Aeroscraft engineers overcame these challenges by using MSC Nastran to build a finite element (FE) model that was used to optimize the structure. One of many MSC capabilities that simplified the analysis was its automatic inertia relief method that automatically creates inertia forces and moments to counterbalance external loads.

“MSC Nastran provided a very convenient platform to perform complex analyses of the Aeroscraft structure,” said Lin Liao, Aeronautical Engineer for Worldwide Aeros Corp.. “Using this tool, we were able to significantly reduce the weight, optimize configuration, and complete the design in less time than would have been required using traditional design methods.”

Unique Design of the Aeroscraft

The Aeroscraft can be described as an adjustable buoyancy assisted lift air vehicle and is capable of substantially and smoothly varying the volume ratio of lifting gas and air and the lifting gas pressure in the hull, which enables the structure to ascend, descend, and hover steadily. The Aeroscraft generates static/dynamic lift through a combination of aerodynamics, thrust vectoring, gas buoyancy generation and management, canards (forward fins), and empennages (rear fins). In distinct contrast to a blimp, it is a heavier-than-air vehicle. The Aeroscraft mode ML866 is 210 feet long, 56 feet high, 118 feet wide.

Key Highlights:

Industry

Aero

Challenge

Building a variable buoyancy air vehicle

MSC Software Solutions

Patran and MSC Nastran to build an FE model and optimize the structure

Benefits

- Reduced Weight
- Design Optimization
- Time Savings

> **“We were able to significantly reduce the weight of the structure from our initial design while ensuring that the structure delivers the required safety factors. We also saved substantial amounts of time compared to less efficient analysis methods.”**
>
> Lin Liao, Aeronautical Engineer, Worldwide Aeros Corp.

The maximum operating altitude is 12,000 ft and maximum speed is 138 mph.

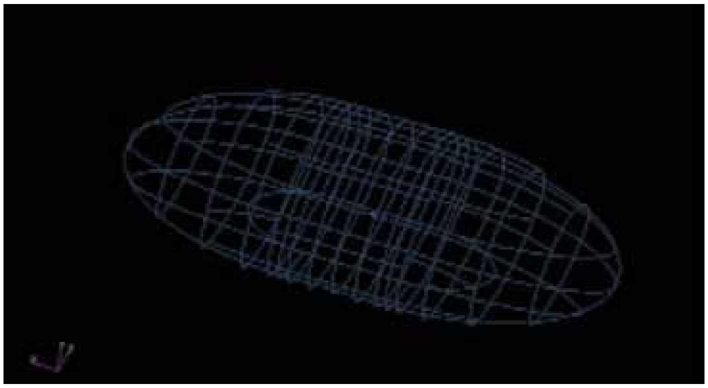
The Aeroscraft will take off and land vertically using engines with vector thrust. The Aeroscraft is equipped with—dynamic buoyancy management system —COSH (Control of Static Heaviness) system, which works by compressing, storing then decompressing helium within the envelope to adjust the vehicle’s buoyancy. Pilot control and avionics systems will use fly-by-light technology with fiber optic cables instead of wires to avoid the cost and weight of shielding against electromagnetic interference.

The Aeroscraft is designed to offer new capabilities to the warfighter by deploying composite payloads of personnel and equipment “from fort to fight”. The vehicle’s design supports a multitude of missions including search and rescue, emergency relief, hurricane evacuation, airborne medical aid and many others. It also offers significant benefits to commercial companies that operate in remote and ecologically sensitive areas such as oil and gas and wind energy industries, by allowing constant access to operating sites with minimum environmental impact.

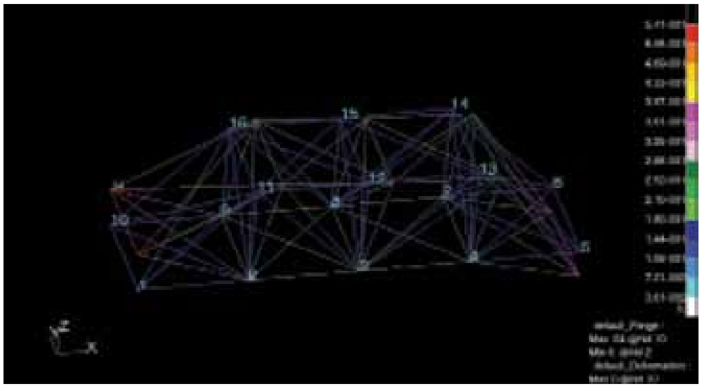
The Aeroscraft external frame or aeroshell consists of a rigid girder system that comprises the hull of the vehicle. An internal frame made of composite trusses serves as the primary load supporting structure and is connected to the external frame. The structure is reinforced by cables running diagonally from joints in the longitudinal and traverse girders of the internal and external frames. Two canards are installed in the fore section of the aerostructure while the empennages are installed in the aft. This unique structural design provides a lower ratio of weight to hull surface area than conventional airships.

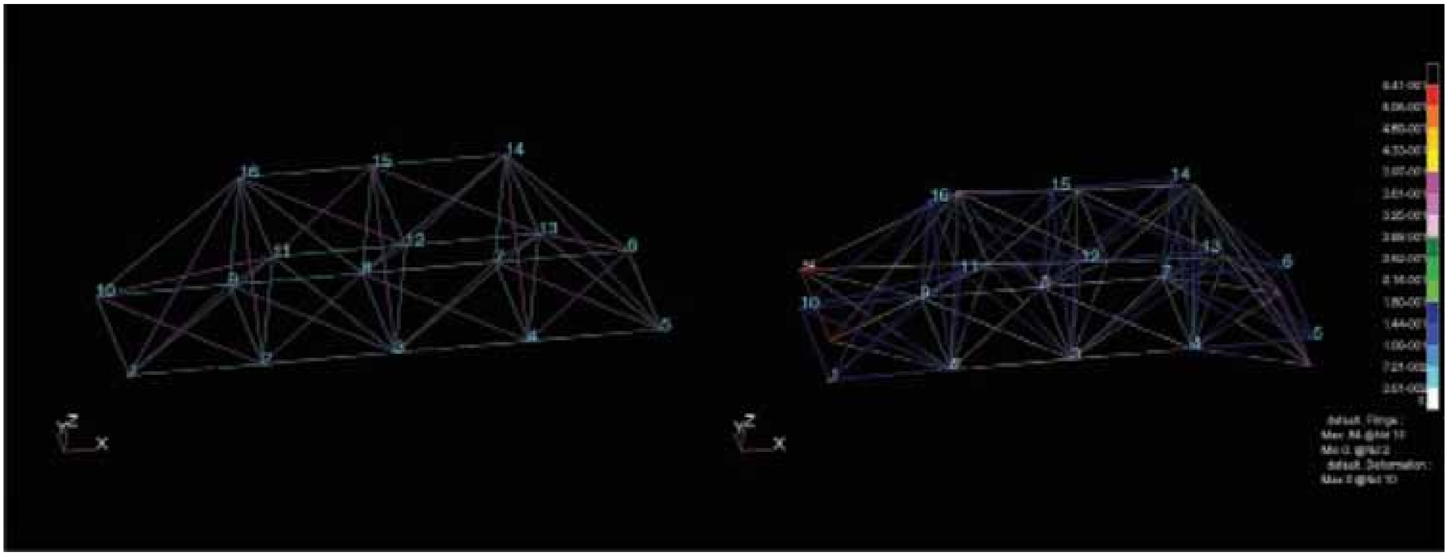
Analyzing the Aerostructure

“We selected MSC Nastran as our primary analysis tool for this important project because it offers unique features for aerospace structures that other software does not possess,” Liao said. “Nastran’s automatic inertia relief function saves considerable time in analyzing structural systems in motion by automatically distributing inertia forces and moments to all of the locations that have mass. MSC Patran offers more meshing capability than other alternatives we considered.”



A Simplified FE Model of External Frame





A Simplified FE Model of Aerostructure

The first step in creating the FE model was model construction with MSC Patran. Liao created the FE model based on the physical properties of the structural components. She modeled the slender girders of the internal/ external frame as beam elements. The main structures of canards and empennages are long and slender, so they were also simulated as beams as well. The internal and external frames were assumed to be perfectly connected.

Liao used tension-only elements to represent reinforced cables in the FE model. Components with concentrated masses such as the vehicle subsystems, power plant, fuel systems, passengers, crew and other commercial payload were represented by concentrated force at specific locations. Testing was used to determine the mechanical properties of complex composite structures which would have been difficult to determine theoretically.

Rigid body motion analysis was used to calculate the load input of FE models for a variety of design maneuver conditions. Buoyant lift and aerodynamic loads were applied as distributed loads at the grid points of the FE mesh. The inertial forces calculated from virtual mass coefficients were applied to the associated structural components.

Inertia Relief Analysis

Inertia effects are accounted and applied in inertia relief calculation. For example, a 2 g dive appears to make the structure twice as heavy as it is when it is in a static equilibrium condition. In MSC Nastran, inertial effects are modeled by generating a stiffness-like matrix representing air forces that react to the g forces. “MSC Nastran’s automatic inertia relief method eliminated the need to apply constraint conditions,” Liao said. “I applied the loads and the software automatically created the inertia forces and moments, achieving a state of static equilibrium so conventional static analysis could be performed.”

The FE model generated detailed structural performance information for the preliminary design including displacements, strains and stresses. This information not only characterized the performance of the preliminary design but also provided insights into how the performance could be improved.

Liao also used MSC Nastran to perform design optimization of the internal frame and external frame. Parametric analysis of many different design alternatives was conducted to optimize individual load supporting members. Girders were added near where stress concentrations occur. The spacing of longitudinal and transverse girders was optimized in order to reinforce locations with high stress while saving weight where stresses are low.

“We were able to significantly reduce the weight of the structure from our initial design while ensuring that the structure delivers the required safety factors,” Liao concluded. “We also saved substantial amounts of time compared to less efficient analysis methods. I have used a number of different FE software packages but I prefer MSC Nastran because it offers a more powerful feature set for analysis of advanced aerospace structures.”

On the Web: www.aerosml.com

About MSC Software

MSC Software is one of the ten original software companies and the worldwide leader in multidiscipline simulation. As a trusted partner, MSC Software helps companies improve quality, save time and reduce costs associated with design and test of manufactured products. Academic institutions, researchers, and students employ MSC technology to expand individual knowledge as well as expand the horizon of simulation. MSC Software employs 1,000 professionals in 20 countries. For additional information about MSC Software's products and services, please visit www.mscsoftware.com.

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About MSC Nastran

Accurate, Efficient & Affordable Finite Element Analysis

MSC Nastran is the world's most widely used Finite Element Analysis (FEA) solver. When it comes to simulating stress, dynamics, or vibration of real-world, complex systems, MSC Nastran is still the best and most trusted software in the world – period. Today, manufacturers of everything from parts to complex assemblies are choosing the FEA solver that is reliable and accurate enough to be certified by the FAA and other regulatory agencies.

Engineers and analysts tasked with virtual prototyping are challenged to produce results fast enough to impact design decisions, and accurate enough to give their companies and management the confidence to replace physical prototypes. In today's world, nobody has time or budget to spend evaluating the accuracy of their FEA software – you need to know it's right.

About Patran

CAE Modeling and Pre/Post Processing

Patran is the world's most widely used pre/post-processing software for Finite Element Analysis (FEA), providing solid modeling, meshing, and analysis setup for MSC Nastran, Marc, Abaqus, LS-DYNA, ANSYS, and Pam-Crash.

Designers, engineers, and CAE analysts tasked with creating and analyzing virtual prototypes are faced with a number of tedious, time-wasting tasks. These include CAD geometry translation, geometry cleanup, manual meshing processes, assembly connection definition, and editing of input decks to setup jobs for analysis by various solvers. Pre-processing is still widely considered the most time consuming aspect of CAE, consuming up to 60% of users' time. Assembling results into reports that can be shared with colleagues and managers is also still a very labor intensive, tedious activity.

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