MSC Software: Case Study - ADA

Certified To Fly

Key Highlights:

Industry

Aero

Challenge

Determine unsteady air loads due to the structural vibration modes at various altitudes and speeds

MSC Software Solutions

Patran to create a FE model, check the quality of the data and the import process.

MSC Nastran Aeroelasticity to determine the unsteady air loads due to the structural vibration modes at various altitudes and speeds.

Benefits

• Accurate FE Model Reproduction

• Reliable Analysis

• Improved Design Process

Fighter aircraft typically carry a number of different under-wing external stores such as fuel tanks, bombs and missiles. The geometrical and inertial parameters of these stores have an influence on the flight envelope and the flutter characteristics of the aircraft. An imported aircraft is certified by the OEM for the carriage of certain stores within a specified envelope. However, if the country which has acquired the aircraft decides to integrate a new store, then it has to either approach the OEM to help in the certification process or devise a mechanism to carry out the exercise itself. The former approach has a twofold disadvantage viz. violation of secrecy and also the prohibitive cost. Hence, it is imperative that an independent approach, along with the local certification authorities, be evolved to achieve the required objective.

Assisting with Flight Certification

One of the aircrafts in the inventory of the Indian Air Force had to be integrated with a new store which the aircraft under consideration was not certified to fly with. At this juncture the Aeronvvautical Development Agency (ADA), located at Bangalore, was approached for assisting in obtaining the necessary flight certification. ADA was established in 1984 to oversee the design and development of the Light Combat Aircraft, Tejas During the course of this program, ADA has acquired expertise in various areas of Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), Avionics, Systems, Independent Validation and Verification and Flight Simulation. One of the areas in which ADA is acknowledged as an authority in the country is in the area of Loads,

"The excellent correlation between FE based flutter analysis and flutter analysis based on GVT data validated the use of this method on the second aircraft, the one with a new store requiring flutter clearance."

Structural Dynamics and Aeroelasticity. The group which is responsible for this task is part of the Airframe Directorate of ADA. This group was charged with the responsibility of formulating a strategy for obtaining the clearance for integrating the new store on the aircraft under consideration. The task of formulating the strategy and implementing it to certfy the aircraft with the new store was completely handled by Mr. Dhandabani V, Dr. Hemalatha E and Mr. Kamesh J V of ADA and Shripathi V of CSM Software, Bangalore, India. CSM software is a provider of Engineering Services and also a business partner of MSC Software. Through its partnership with MSC Software Corporation, CSM has helped many companies accelerate innovation and generate a higher return on investment.

This case study primarily deals with the clearance of the Altitude – Mach No. envelope of the aircraft, with the new store, which is essentially based on flutter computations.

The Novel Methodology

The method developed by ADA takes advantage of the fact that flutter computations are carried out in the modal domain and that modal parameters can also be generated by Ground Vibration Tests (GVT). GVT data is normally used to measure Aircraft modal characteristics and to verify and update analytical vibration models. In GVT testing, soft support systems are used to simulate the unconstrained boundary conditions that an aircraft experiences during flight. The aircraft is excited through the

use of electrodynamic shakers. Accelerometers are used to measure the response of the structure. A data acquisition and analysis system is used to acquire the data and extract modal parameters from measured data.

ADA analysts validated the new method on an aircraft (Aircraft-1) for which a complete FE model was available. They created a dummy FE model of this aircraft in Patran with a small number of nodes; one for each accelerometer used in GVT. The nodes were connected with 2D CQUAD and TRIA elements. Mode shapes were visualized in Patran to check the quality of the data and the import process.
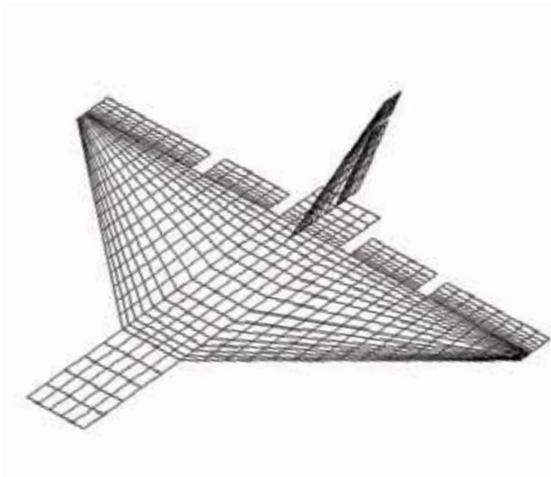
MSC FlightLoads was used to create a 2D aerodynamic model using plan form geometry. The aerodynamic and structural models were then coupled for flutter computations at
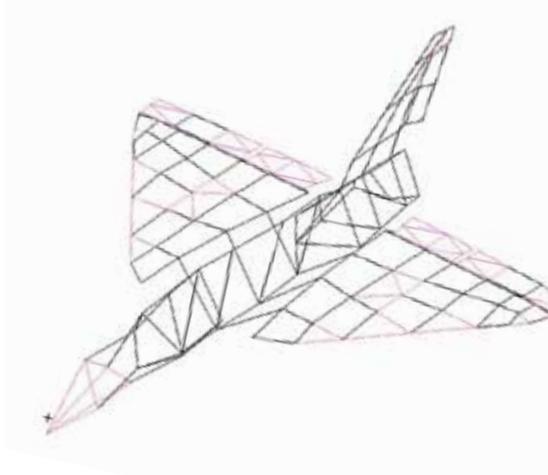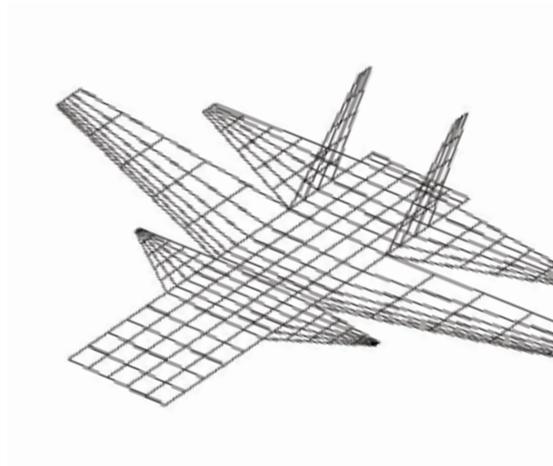

FE model of the aircraft generated from accelerometer locations in GVT
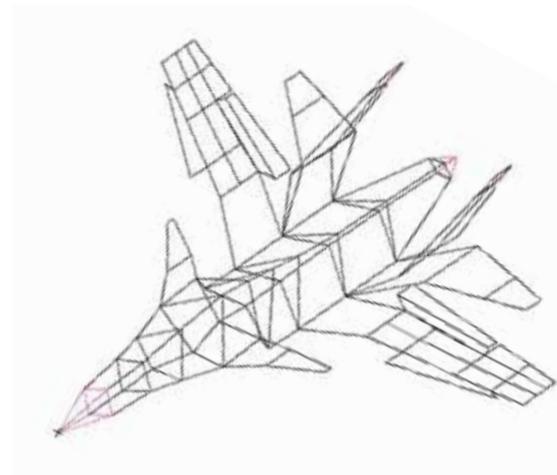
Dummy finite element model of aircraft requiring flutter clearance

Aerodynamic model of aircraft used for validation

Aerodynamic model of second aircraft

the required altitude and speed levels. MSC Nastran Aeroelasticity I and II were used to determine the unsteady airloads due to the structural vibration modes at various altitudes and speeds.

The MSC Nastran Direct Matrix Abstraction Programming (DMAP) module was used to update the structural model by replacing the modal mass, stiffness and mode shape matrices with the data measured in GVT. The DMAP module provides the ability to modify MSC Nastran's prewritten solution sequences or write customized solution sequences to solve specialized problems. DMAP delivers a high-level, flexible, and powerful programming language that allows users to expand MSC Nastran's capabilities by writing their own applications and installing their own custom modules. DMAP has its own grammatical rules and compiler built inside of MSC Nastran that provide matrix operations for the manipulation and creation of data blocks for use by MSC Nastran or other programs.

The methodology described above was used to predict the flutter characteristics of the aircraft for which FE data was available using MSC Nastran Solution 145 for flutter analysis. The flutter results using GVT data also matched up well to those obtained from the FE model as shown in Figure 4. The Mach numbers show the speeds at which the analysis predicted that flutter would occur.

| Altitude | Flutter Characteristics | | | |
| | Detailed FE Flutter Analysis | | Model Based on GVT Data | |
	Mach	Freq (Hz)	Mach	Freq (Hz)
Low	1.39	12.7	1.41	13.04
Medium	1.69	12.7	1.54	12.5
High	2.18	12.7	1.88	13.03

Flutter results based on full FE model vs. results obtained from GVT data for the validation study

Application of the Methodology to Aircraft under Consideration

The excellent correlation between FE based flutter analysis and flutter analysis based on GVT data validated the use of this method on the second aircraft, the one with a new store requiring flutter clearance. The same method described above was used to calculate the flutter characteristics of this second aircraft. Figure 7 shows the primary flutter speeds and frequencies obtained from the analysis at different altitudes for the new store. The results show that the flutter speed of the new store lies between two previous certified stores, Store 1 and Store 2, in the majority of cases. Based on this study the certification authorities cleared the aircraft for carrying the new store.

The method of using GVT data to drive a FE analysis has been used previously but this application is believed to be the first time that flutter clearance has been based on GVT data. This approach made it possible to quickly and efficiently evaluate the flutter performance of the aircraft with the new store.

| Altitude | Flutter Characteristics (Mach) | | |
	Store 1	New Store	Store 2
Low	2.66	1.68	1.52
Medium	3.01	1.89	1.55
High	3.57	2.31	1.69

Flutter speed and frequency for aircraft requiring flutter clearance

MSC Software

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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