MSC Aerospace Solutions:
Optimizing the Design-to-Certification Process

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Abstract

This paper describes MSC's solutions for optimizing our aerospace customers' structural design-to-certification processes. It describes the strategies, software, and services we offer, many provided by working in close partnership with key aerospace companies. These solutions are designed to optimize the processes by improving the time to market and decreasing the costs. In addition, the presentation shows our current and future aerospace solutions plan.

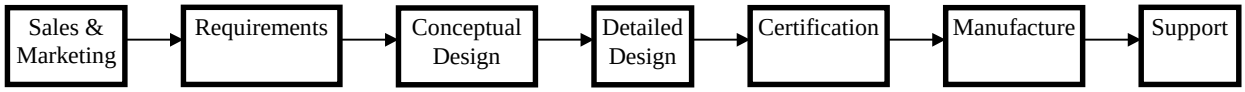
Introduction

The worldwide aerospace industry is rebounding from its low period of a few years ago. This rebound is led by the commercial aviation and space markets. Even though the market is increasing, many companies will not add the same number of engineers they had before. In addition, there are other business factors such as consolidation, globalization, and risk/cost sharing. All of this means that companies are trying to do more, with less (less cost, fewer people, less time). In becoming more efficient, companies are focusing on improving their engineering processes, especially their design-to-certification process.

This is the focus of MSC's aerospace business.

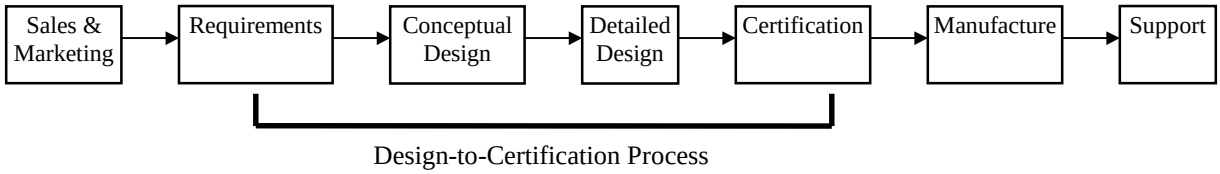
Design-to-Certification Process

The processes and functions that take place during the lifetime of an aerospace project are:

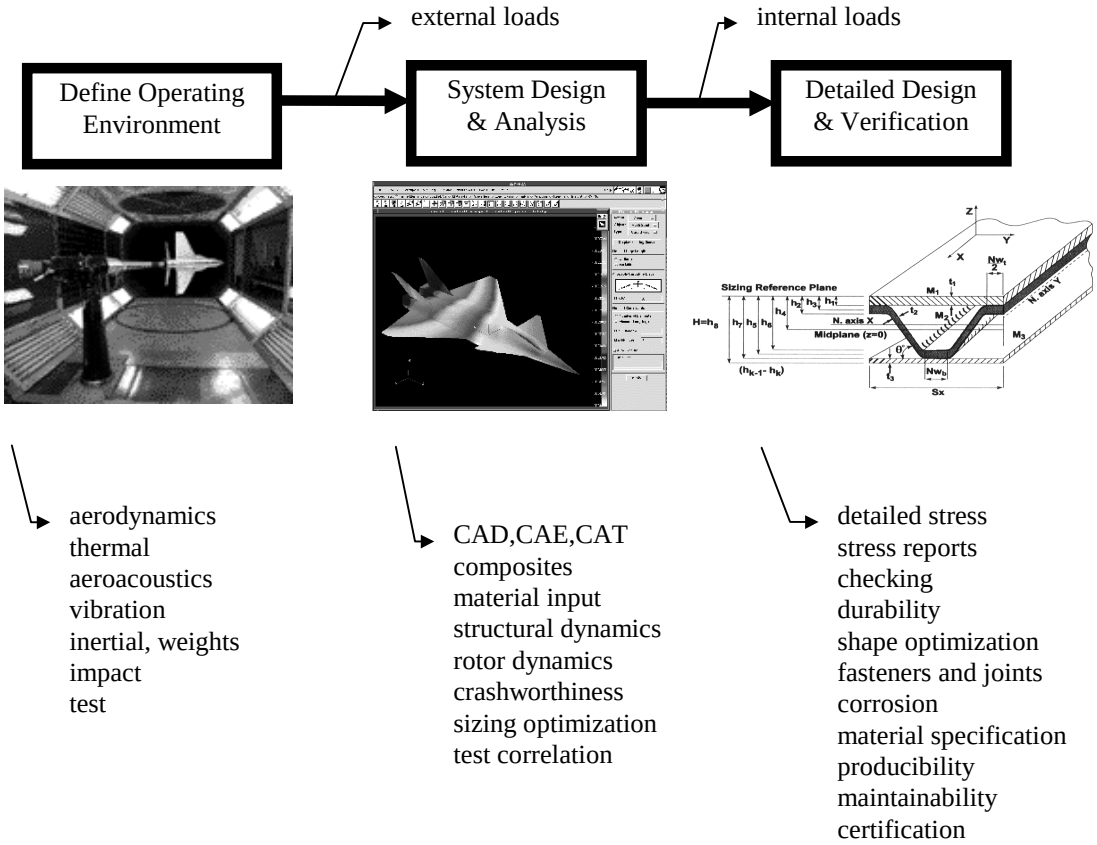


These functions loop back between processes as well as within a given process. Depending on the project, these loops can be significant. Also, because of the long lifetimes of some projects--the 747 was designed in the early 1960s, and the last one will fly until about 2040--the support function (including modifications and upgrades) can take on a whole life of its own. Similarly, in the commercial market each order can be unique, so there can be many variations of the same basic design.

The design-to-certification process takes place in the middle of the aerospace "big picture" process diagram:



The structural design-to-certification process is itself comprised of three major functions:



The exact nature of this process varies by company. Also, some products--satellites and defense hardware (transports, fighters, and missiles)--do not actually get certified, but they are designed and verified and therefore go through most of the above process.

Commercial software is used in the middle--“Systems Analysis”--function. In fact, one way to look at that portion is that it is like a transfer function: it transforms external loads into internal loads. While MSC and other CAE/CAD/CAT vendors have been focused on reducing the time and effort required in that area, the other areas are where aerospace companies have invested crucial resources...and, invested more people there than in the “Systems” area. The “Environment” area is important, because no structure ever failed because its basic structural model was wrong--it failed because the analysis loads were significantly lower than the in-service loads. Likewise, “postprocessing” the stresses to determine detailed design needs in joints and fasteners, or in surface finish, is very important, especially since material and tooling decisions are made based on these results.

Unlike the “Systems” area, in which there is popular commercial software, there are no popular--or standard--commercial programs in the other two areas. In the “Environment” area, there are numerous products for computing loads but each discipline (thermal, aerodynamics, etc.) is completely different...and each requires a different type of model

and mesh. In the “Detailed Design” area, perhaps spreadsheet programs come closest to being the standard. However, it is in these two areas—“Environment” and “Detailed Design”--that companies *today* see as their competitive advantage in the design-to-certification process. *Tomorrow*, however, that may be different, as we are starting to see companies extolling the virtue of using a performance-based, conceptual design model as the driver for the rest of the design. When that happens, the design process will begin with a coarse model and then substitute refined models as the design progresses. This will involve assembly modeling, automatic “stitching together” of dissimilar meshes and different submodels (FEA, CFD, test), tying multiple meshes to a single geometry, and file management of the overall process. *That is precisely where MSC/SuperModel is headed.*

In essence, the design-to-certification process specifies the environment and external loads, computes the internal loads, and uses the loads to make geometry, topology, material, and tooling decisions. The overall goal is for this process to be completed in time to affect the tooling and material specification. *That* is where the value lies, regardless of how each company gets there, and that is why it is important to optimize the design-to-certification process.

Aerospace Mission and Objectives

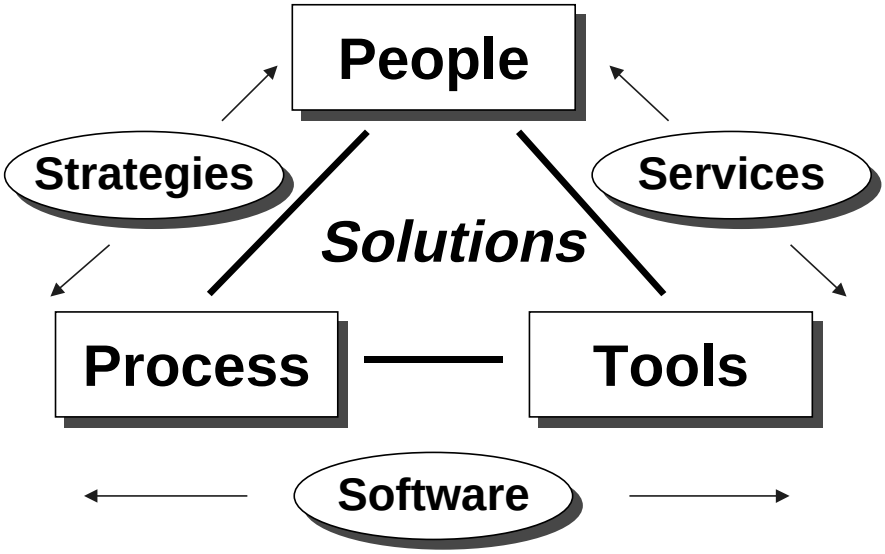
Our mission is to anticipate and fulfill the needs to optimize the design-to-certification process for those who design, analyze, test, build, and maintain flight structures.

Our objectives are to:

- Provide *solutions* to our customers' design-to-certification challenges.
- Help our customers *manage* and *leverage* their CAE processes and data.
- Create strategic *partnerships* with key customers.
- Enhance MSC’s position as the aerospace standard.

Aerospace Solutions

Solutions link a company's infrastructure (its people, processes, and tools) in the following way:



MSC's aerospace solutions are comprised of three components:

- *Strategies*. We work with our customers to enhance their engineering processes, doing so by performing audits of their current processes and then recommending changes. We have done this for several aerospace companies. In addition, we provide joint development, customization, and commercialization of in-house software.
- *Software*. This includes MSC/NASTRAN and MSC/PATRAN, which were developed from the aerospace industry and which are aerospace standards. MSC/MVISION and MSC/SuperModel also have aerospace origins.
- *Services.* These include training, technical support, and users' conferences. In addition, we also provide an aerospace web (www.macsch.com/aerosapce).

All components--strategies, software, and services--are necessary in order to optimize the design-to-certification process. MSC has an excellent record in providing the three components.

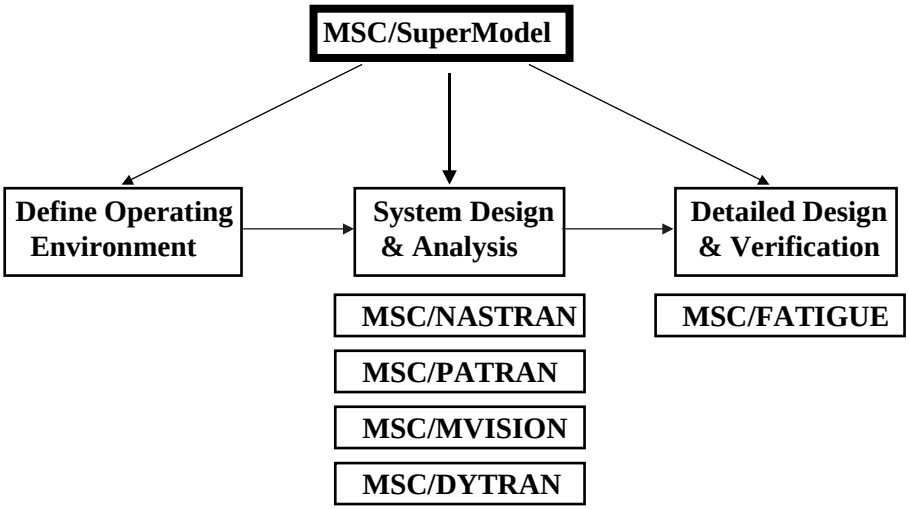
<u>Three-Year Solutions Plan</u>

Our three-year plan is to deliver additional aerospace-specific solutions. New software will be built by using MSC/NASTRAN and MSC/PATRAN as the core. Please note that these are current plans, which means that they can change. Also note that during these

three years, we will continue to enhance our products--MSC/NASTRAN, MSC/PATRAN, MSC/MVISION, MSC/MVISION, MSC/FATIGUE, and others.

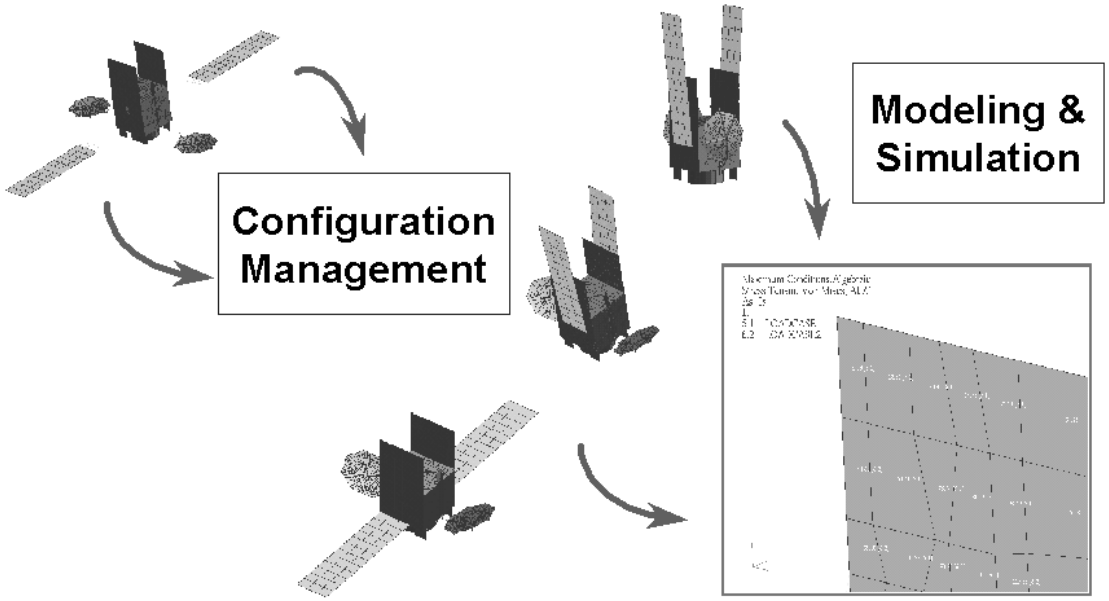
Traditionally our software primarily addresses the "Systems Analysis" area. The introduction of MSC/SuperModel in early 1997 extends the range of MSC's product offerings:

Current Aerospace Products

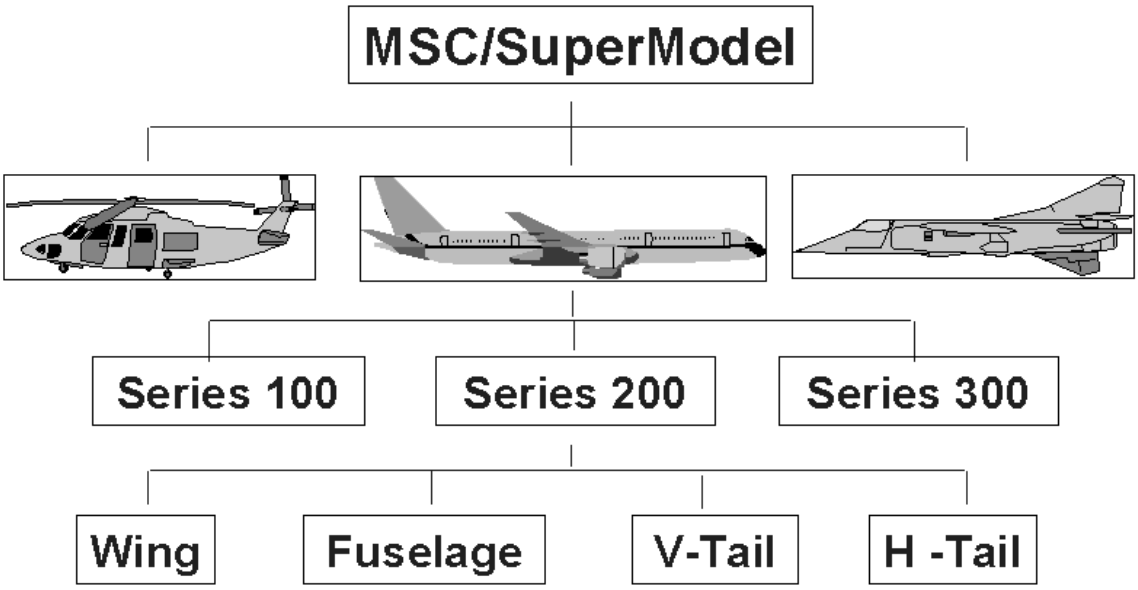


MSC/SuperModel operates inside of MSC/PATRAN, and it works with MSC/NASTRAN. MSC/SuperModel has three components:

- Aerospace modeling and simulation:
  This component offers a suite of modeling and simulation tools that aid in the representation, analysis and results visualization of aerospace structures. Customer-developed applications are easily integrated with the standard set of tools delivered with MSC/SuperModel.
- Assembly and configuration management:
  This component allows engineers to model and analyze aerospace structures as an assembly of components. Its ability to assemble component models in an automated procedure allows project teams to more easily manage structural modeling tasks. It also allows engineers to analyze multiple structural configurations as defined in a single model.

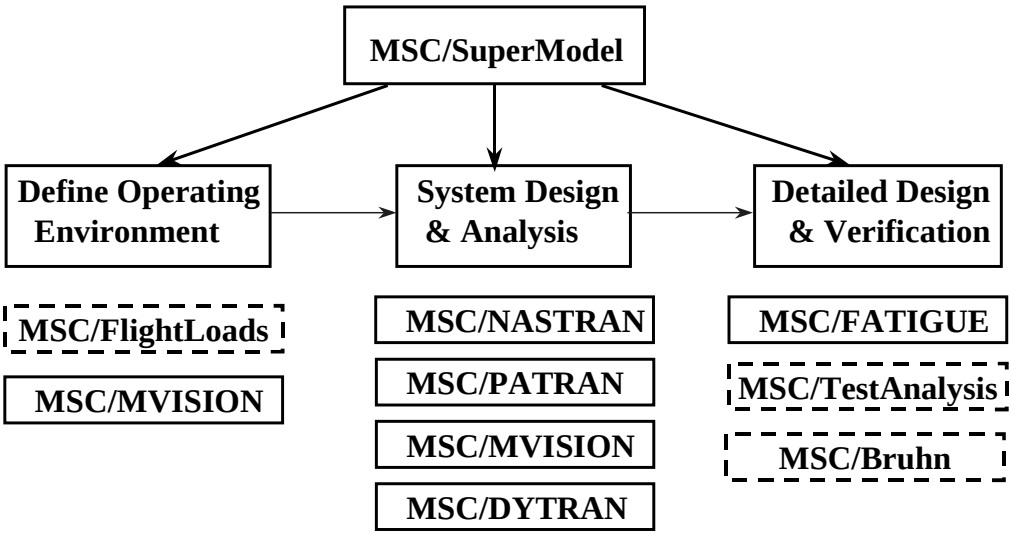


- File management:
  This component helps engineers manage their CAE data. The file manager uses client-server technology and a large suite of tools to support and maintain engineering models and associated data files.



Currently, MSC/SuperModel has been utilized in the production environments at Boeing (St. Louis), St. Louis, Raytheon E-Systems (Waco), GKN Westland Helicopter in the United Kingdom, and other worldwide aerospace and space systems locations.

Future Product Plan

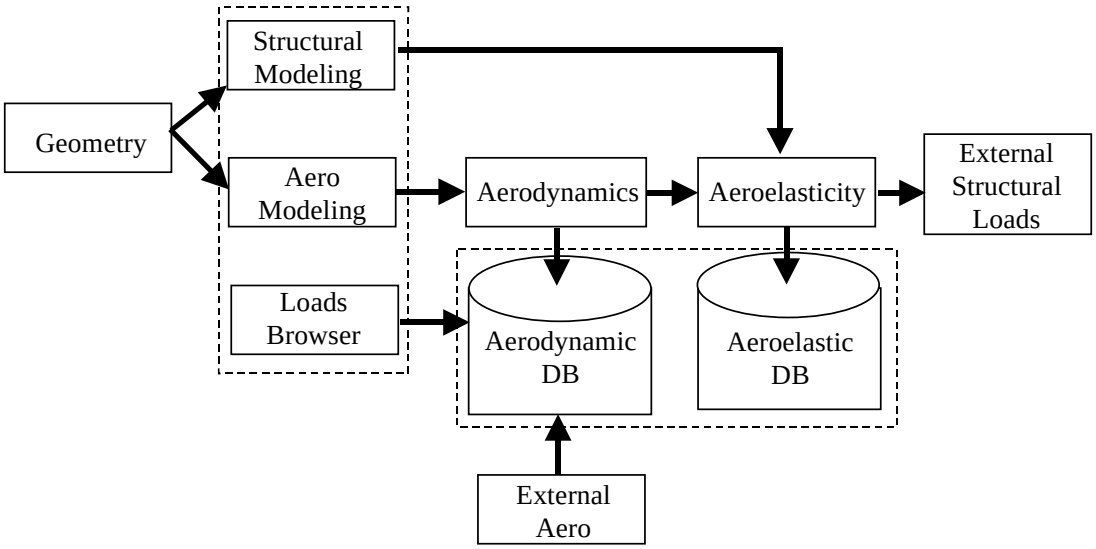


In 1998, our future plan will start with the introduction of a new Flight Loads system, which is a comprehensive, graphically driven system that addresses two crucial design and analysis requirements for flexible air vehicles traveling at both subsonic and supersonic speeds:

(1) Accurate calculation of external loads, and
(2) Structural dynamic response (i.e., flutter, gust, etc.).

A technical paper, “The MSC Flight Loads and Dynamics System” [1], co-authored by Douglas Neill and Greg Sikes of MSC, will be presented in the 1997 MSC Aerospace Users’ Conference, which will be held in Southern California in November. The paper presents the critical requirements of the system that resulted from numerous discussions with aerodynamicists, loads analysts, structural dynamicists, and aeroelasticians in the aerospace community.

This Flight Loads system will use MSC/PATRAN for the graphical user interface and MSC/NASTRAN for the solver.



In addition to Flight Loads, we will deliver additional aerospace solutions. We will look at utilizing MSC/MVISION--our materials management system--for managing loads. We will deliver an MSC/PATRAN utility for test-analysis correlation. We will also address the “Detailed Design” area by creating a program to convert MSC/NASTRAN-computed internal loads into detailed stress calculations (similar to those in Bruhn’s handbook [2]) and stress reports. This program--code named MSC/Bruhn--will utilize Web technology.

Strategic Partnerships

One of our objectives is to partner with our key customers. In a true partnership, both companies are working together to satisfy mutual business goals. This is more than simply a supplier relationship; in a strategic partnership, each company learns a lot about the other, and each provides ways that the other company can improve.

MSC's recent strategic partnership with Lockheed Martin is a good example. In that partnership, MSC will work with Lockheed Martin to enhance its Virtual Development Environment, which is aimed at making “next generation” advances in aircraft design, analysis, and manufacturing. MSC and Lockheed Martin will work together to co-develop software specifically for that objective.

Our customers are creating partnerships because they want to: (1) reduce the number of suppliers (and overhead); and (2) have each partner take on greater responsibility for the customer's success. In the automotive industry, for example, many car manufacturers are reducing their next-tier supplier base by requiring that there be fewer "mega-suppliers" that take responsibility for a larger assembly rather than for only a single component.

Partnering is driven by the need to cut costs, reduce cycle time, and increase quality. In addition, companies are now refocusing on their core business--building airplanes, space systems, engines, and assemblies/components--and are not spending as much time, money, and effort in writing in-house software. The emphasis is, instead, on COTS (commercial off-the-shelf) software and on integrating it into the company's process. From the July 28 issue of Aviation Week [3], "[Lockheed Martin] intends to use only commercially available software...to help develop its 'Virtual Development Environment.' The company recently signed with [The] MacNeal-Schwendler Corp. to codevelop advanced computer-aided engineering systems under this initiative. Ultimately, this environment should enable simulation of every aspect of fighter design, support and manufacturing processes long before the first metal is cut."

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Lockheed Martin Reconstructs TAS Unit as 'Fighter Enterprise'

WILLIAM C. SCOTT/FORT WORTH

Lockheed Martin Tactical Aircraft Systems has capitalized on its "Lean Initiatives" experience through cost reductions on F-16 production—even as rates dropped dramatically—while also revamping internal business practices to improve company competitiveness on future fighter programs.

Although not the only U.S. defense contractor to benefit from Lean Initiatives (LI) experience, Lockheed Martin TAS (LMTAS) has been particularly aggressive about integrating certain LI concepts and simultaneously "remaking" the company over the last few years. Changes are extending well beyond the factory floor, and now affect internal business systems, how modeling and simulation are employed, and the structure of design and engineering staffs.

robot can paint and coat the JSF inlet, Sconyers said.

LMTAS intends to use only commercially available software, and is actively seeking partners to help develop its "Virtual Development Environment." The company recently signed with MacNeal-Schwendler Corp.

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of Los Angeles to codevelop advanced computer-aided engineering systems under this initiative. Ultimately, this environment should enable simulation of every aspect of fighter design, support and manufacturing processes long before the first metal is cut.

Engineering process audits are very important in a partnership. These audits are done to ensure that the best possible processes are being used; once the processes are understood and optimized, specific software is then applied to automate the new processes. The Lockheed Martin strategic partnership means that MSC must fully understand Lockheed Martin's engineering processes.

Constant communication is important to any strategic partnership. This communication must occur on several levels: technical, management, and executive. Periodic meetings are important. With some of our partnerships, companies send several managers and

technical personnel to MSC for updates and to test--hands-on--the new software versions. This type of constant feedback is very important to both companies.

Enhancing MSC's Position as the Aerospace Standard

MSC's products are the standards in aerospace. MSC/NASTRAN is heavily used for loads and dynamic analysis, and the FAA (U.S. Federal Aviation Administration) guidelines state that analysis results need to be verified against known answers. "The NASTRAN program, for example, is a program that industry uses on a regular basis. As such, it is accepted that, if proper input is made to the program, the answers will be acceptable." This quote is from the FAA newsletter, December 1987.

Our software is the standard because of our "open architecture" concept. We publish the data formats for our products, meaning that it is easy for third parties to interface to MSC software. In addition, MSC/PATRAN can import numerous CAD geometries--CATIA, Unigraphics, Pro/ENGINEER, Computervision, Matra, and IGES.

MSC/NASTRAN, MSC/PATRAN, MSC/MVISION, and MSC/SuperModel were all developed from the aerospace industry. Whereas MSC/NASTRAN is the aerospace analysis standard FEA program, MSC/PATRAN is fast becoming the FEM standard. MSC/MVISION is the closest thing to a materials standard. MSC is committed to making MSC/SuperModel a similar aerospace standard.

By using such standard software, you ensure file, database, and results compatibility. This is especially important when a project is worked on by multiple companies, typical of most aerospace projects.

Our software is the standard, and we are also working with standards organizations--such as ISO (International Standards Organization)--to define and implement data exchange standards. We are working with different groups on STEP (STandard for the Exchange of Product data) standards AP203, AP209, and AP214. AP209 is for the exchange of product data for design and analysis, and is the FEA standard. (AP203 and AP214 are for geometry.) We work closely with Keith Hunten (Lockheed Martin), the author of AP209. We are also working with Boeing on a project to integrate structures and aerodynamic analyses using AP209 to perform aeroelastic analyses of the Boeing V-22 tilt-wing aircraft. The analyses were done hundreds of miles apart--in Seattle (Boeing) and in Costa Mesa (MSC)--using a proprietary CFD program, MSC/NASTRAN, and MSC/PATRAN, and using AP209 as the data exchange mechanism.

It is important for MSC and for the industry that MSC's products continue as the aerospace standard, and that MSC continue to take the lead in developing and implementing ISO standards for data exchange.

Summary

MSC is committed to providing our worldwide aerospace customers the necessary strategies, software, and services to give them a competitive advantage. Through this solutions approach, our customers can streamline their internal business practices, achieving lower design, engineering, and production costs, while building higher quality products in shorter time. MSC is well positioned to help our customers optimize their aerospace design-to-certification processes.

References

1. Douglas Neill and Greg Sikes, "The MSC Fight Loads and Dynamics System," to be presented and published in the 1997 MSC Aerospace Users' Conference to be held at Southern California, November 1997.

2. E. S. Bruhn, "Analysis and Design of Flight Vehicle Structures," published by Tri-State Offet company, 1965.

3. "Lockheed Martin Reconstructs TAS Unit as 'Fighter Enterprise'," Aviation Week & Space Technology, July 28, 1997.