PRODUCT SIMULATION INTEGRATION FOR STRUCTURES

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ABSTRACT

The Product Simulation Integration (PSI) Structures project is under way in BCAG to reduce costs and cycle time in the design, analysis, and support of commercial airplanes. The objective of the PSI project is to define and enhance the processes, methods, and tools to integrate structural product simulation with structural product definition. This includes automated engineering analysis as an integral component of the product definition. Subprojects have been defined and we are working selected topics toward accomplishing the objectives of the PSI for BCAG Structures. Formalized integration activities have also been identified to support the PSI subprojects through their technology life cycle.

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INTRODUCTION

A strategic initiative at BCAG, the Product Simulation Integration (PSI) for Structures project, has been undertaken to reduce costs and cycle time in the design, analysis, and support of commercial airplanes.

The "Product"*: the airplanes we design and build, and the services we provide to satisfy our customers' needs*.

The "Simulation": *the analytical and test processes performed to simulate and predict in-service behavior of the airplane structure in support of design requirements and objectives*.

The "Integration": *a close binding of our design and structural analysis processes and data where it supports reduced costs and cycle time.*

The primary objectives of PSI are:

1. Establish and enhance preferred engineering and business processes.
2. Improve the suite of engineering methods and tools, and migrate legacy applications and data.
3. Integrate structural analysis and test with product definition to reduce cycle time and costs.

PROBLEM DEFINITION

In much of the aerospace industry since the dawn of the jet age there has been a formal division between the analysis and design processes and data. The custodians of these data each perform their jobs to meet drawing release schedules and to satisfy requests from The Boeing Company's outside customers. Later, during the sustaining cycle, the engineers and management need to retrieve data frequently and rapidly to satisfy customer's queries. Much of the time the necessary data is either unavailable or difficult to interpret and have to be regenerated. This can lead to results that are too conservative and/or not timely. Also, reassigning personnel to new jobs becomes difficult when common preferred processes and data are not well defined nor documented.

The 747 comes to mind as an example of our need to have data available and accessible for long periods of time. Originally proposed in the early 1960's as an entry into the C5 competition, the 747 was conceived and born. Current predictions are that the last model of the last derivative will go down the production line in the year 2030 with a 30 year design life. Hence, the original design data will need to be accessible for 100 years!!

ANALYSIS

We can meet the challenges of our competition by producing our products cheaper and with shorter cycle times. Fundamental to the success of PSI for Structures in meeting these goals are establishing standard processes where practical, tying life-cycle data to the product definition for easy, reliable, and consistent retrieval, and adopting industry standards for exchange of these data to facilitate long term data access.

Standard Processes and Computing Systems

Standard processes will reduce variability in the way we design, analyze, and support our airplane products, thus lowering training, computing, process support, and sustaining costs. Standard computing systems will reduce training due to a common look and feel of the system, as well as providing easy access to multiple computing operating systems and environments, where required. The current "Single Glass" computing architecture concept within BCAG includes a RISC-based UNIX workstation in combination with Windows NT.

Tie to Digital Product Definition

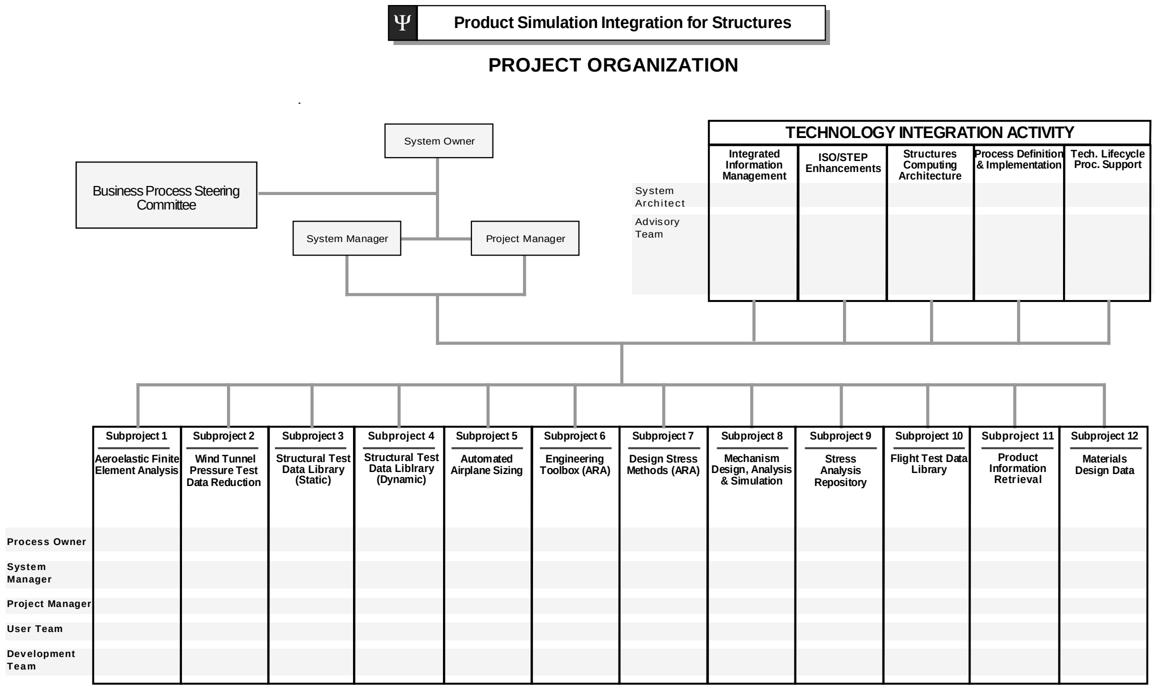
By linking analyses to the product definition, the records substantiating the design decisions, strength, durability, damage tolerance analyses, and service history of the airplane parts and assemblies are then available for derivative airplane design and analysis, as well as sustaining. To be successful, these data must be available for the life of the airplane products. The PSI project is working to extend the definition of SSPD (Single Source Product Definition) to include analysis and test data that may not necessarily be physically linked, but at a minimum will be logically linked.

Data Exchange Standards

Evolving computing software and hardware systems have made the task of information retrieval increasingly difficult with time. Our best opportunity to preserve the data we generate today and minimize regeneration tomorrow is through the adoption of standards for information exchange. Then in principal we can unplug the old analysis or information management tool and plug in the new one without extensive conversion and disruption to the engineer and customers.

DISCUSSION

The PSI project is divided into subprojects which share many common elements. To ensure consistency, the following Technology Integration Activities (TIA) have been defined and work in concert with the subprojects. The figure that follows shows the overall project organization.



- PSI Project Organization -

Technology Integration Activities

- **Integrated Information Management** - Support the efficient management of product information through interfacing and integrating with the new standard processes, as well as incorporating state-of-the-art information management technologies.

- **ISO/STEP Enhancements** - Use evolving standards such as the STEP application protocols AP203 for geometry and AP209 for composite and metallic structure. Lead, proactively, the identification of additional ISO/STEP requirements for new engineering analysis and simulation requirements.

- **Structures Computing Architecture** - Minimize training, support costs, and facilities requirements through adopting a *Single Glass* computing environment which reduces variation and provides access to the necessary tools for both design and analysis.

- **Process Definition and Implementation** - Document the preferred processes to provide visibility to Structures engineers and management supporting current and future airplane programs. This activity will also ensure that implementation of the Structures preferred engineering processes, tools, repositories, and standards, developed through the Product Simulation Integration project and other approved projects and subprojects, is performed in a consistent, integrated, and timely manner.
- **Technology Lifecycle Process Support** - Manage computing systems using a structured approach which extends from the identification of new engineering

analysis and simulation requirements, followed by demonstration, evaluation, implementation, and support of the preferred computing systems in support of BCAG's processes, and finally phase out systems as they become unneeded.

PSI Subprojects

The focus of the principals in reducing cost and cycle time in the PSI for Structures project is the product simulation technologies, summarized below, each of which is supported by one or more subproject teams. Each subproject has a *Process Owner* who champions the subproject and removes roadblocks to implementation within the discipline; a *System Manager* who leads the definition of engineering requirements; a *Project Manager* who manages computing resources required to accomplish the identified development; a *User Team* that represents airplane program areas and defines their specific requirements; and a *Development Team* who creates the computing solutions, in collaboration with the User Team.

- **Aeroelastic Finite Element Analysis** - Create structural finite element models automatically from airplane lofts using rule-based systems. Capture and control associativity between structural model and airplane lofts in a formal data repository.
  Subprojects
  1. Aeroelastic Finite Element Analysis
  8. Mechanism Design, Analysis and Simulation

- **Wind Tunnel Test Data Reduction** - Standardize, collect, reduce for use in design, and manage wind tunnel pressure test data in a formal repository.
  Subproject 2.

- **Structural Test Data Reduction** - Standardize, collect, reduce, and manage structural test data in a formal repository.
  Subprojects:
  3. Static Structural Test Data Library
  4. Dynamic Structural Test Data Library

- **Automated Airplane Sizing** - Size and analyze standard structural components using knowledge based engineering (KBE) rules and finite element sizing capability, and capture in a formal data repository.
  Subproject 5.

- **Detailed Analysis - Resizing - Analysis** - Automatically generate structural component sizes using bi-directional association of the geometric product definition with structural model idealizations.
  Subprojects:
  6. Engineering Toolbox
  7. Design Stress Methods
  12. Materials Design Data

- **Stress Analysis Repository** - Capture and control detailed stress analysis of all parts in a formal data repository.

Subproject 9.

- **Flight Test Data Reduction** - Standardize, collect, reduce, and manage flight test data in a formal repository.
  Subproject
  10. Flight Test Data Library

- **Product Information Retrieval** - Extract and format selected product information as required by engineering, manufacturing liaison, customer support, and regulatory agencies as views from a formal electronic data repository.
  Subproject 11.

Because of their expertise in solving real-world engineering problems, The MacNeal-Schwendler Corporation has supported PSI by performing an extensive requirements definition audit of BCAG Structures Engineering processes. This audit has identified key areas of change to the existing processes where the objectives of PSI can be met.

CONCLUSIONS

The Product Simulation Integration for BCAG Structures project is a multiple year project underway to reduce airplane development and support costs, and cycle time. Fundamental to the success of PSI is establishing standard processes and computing systems, defining and managing life-cycle data tied to the product definition for easy, reliable, and consistent retrieval, and the adoption of industry standards for exchange of these data. Application of these principals will allow BCAG to be competitive well into the next century. The project is well underway toward implementing both short term solutions, through 1998, and long term solutions in the years beyond.

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