The Voice of the Customer

Product Simulation Integration
A Strategic Initiative at Boeing Commercial Airplane Group

Rodney L. Dreisbach, Ph.D.
Senior Technical Fellow
The Boeing Company
Computational Structures Technology

Background
Executive management and strategists of engineering and manufacturing companies are continually bombarded with an ever-growing array of tools, technologies, and solutions that promise to bring immediate gains in productivity and efficiency. They are frequently left challenged with trying to assess the true benefits of the tools relative to overall business operations. After investing heavily in the necessary software, training, and services, these executives and strategists often discover that their operating costs have increased, and that their global business expectations were never met. This occurs because implementation is often performed at a local departmental or functional level without consideration of the global impact to the company-level culture, processes, and business operations.

Generally, the core competency of any software developer is to focus its resources on developing and servicing its products exclusively – isolated from the dynamic, heterogeneous environment of COTS (Commercial Off The Shelf) and proprietary tools in which the customer will inevitably deploy them. But, because of the manner in which business must be conducted today, industrial users are now looking for a global perspective on the deployment of new technologies within their proprietary processes to maximize their competitive advantage.

As the functionality and number of CAx computing tools increases within an engineering organization, isolation of the different functional groups and the end-user teams responsible for product development grows. The incompatibility of the data structures and formats of the different tools often results in task-level optimization while operating within a particular tool, at the expense of the overall process when the global flow of product information is considered.

Hence, productivity, at the macro-process level, remains very low. Communications can become strained between the various contributors of any development team, often in different geographic regions of an extended enterprise. Even organizing the program into multidisciplinary integrated product teams (IPTs) often does not resolve the underlying issues of data access, data quality control, data security, product data and process management, and data-relationship management across the multiple systems used by a team or across a program. Data quality, poor configuration control and management between data objects, loss of design intent, and poor visibility of product data often compromise attempts to perform concurrent engineering, distributed collaboration, or rapid design iterations and controlled change propagation. What is required is an effective process-centric strategy for exploiting the new technology.

Ironically, most of the claims made by suppliers of business-critical tools overlook the order-of-magnitude benefits in overall cycle-time and cost reductions that can be achieved when their best-in-class solutions are implemented within an integrated, process-centric environment. The CAx/IT infrastructure required to achieve these

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improvements at an industrial program level must provide a foundational architecture that enables the various tools to interoperate seamlessly and processes to be managed efficiently. The architecture must also enable the data to be accessed in real-time across the enterprise and made directly usable for subsequent tasks. For full benefits to be realized, a far more holistic approach to planning and implementing new technologies is required. It requires one with a balanced emphasis on the CAx/IT infrastructure and the business process transformation necessary to integrate the technology. It must enable effective collaboration, as well as accommodate various cultural and organizational changes needed within the enterprise.

The PSI (Product Simulation Integration) Project
A strategic initiative at Boeing Commercial Airplane Group (BCAG), known as the PSI Project for Structures, is underway to reduce costs and cycle time in the design, analysis, and support of commercial transport airplanes. The “Products” are the airplanes designed and built, and the services provided to customers for their airplane operations. “Simulation” includes the analytical and test processes performed to predict in-service behavior of the airplane structure in support of design requirements and objectives. “Integration” is the close binding of design, analysis, manufacturing, and support processes with the associated product information as 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 information and manufacturing to reduce cycle time and costs.

Fundamental to the success of the PSI project in meeting its goals is establishing standard processes; associating life-cycle information to the product definition data for easy, reliable, and consistent retrieval; and adopting industry standards for sharing these data to facilitate long-term data access.

Standard Processes and Computing Systems
Standard processes reduce variability in the way airplane products are designed, analyzed, and supported, thus lowering training, computing, process support, and sustaining costs. Standard computing systems reduce training due to a common look and feel of the system, and by providing easy access to multiple computing operating systems and environments where required.

Tie to Digital Product Definition
By linking analyses to the product definition data, the records substantiating the design decisions, strength, durability, damage tolerance analyses, and service history of the airplane parts and assemblies are made available for derivative airplane design and analysis while sustaining current configurations. 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 over time. The best opportunity to preserve the data generated today and to minimize regeneration tomorrow is through the adoption of standards for information exchange. Then, in principal, it is possible to unplug the old analysis or information management tool and plug in a new one without extensive conversion and disruption to the engineers and customers.

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The aeroelastic structural design process is iterative because of complex aerodynamics interacting with complex aerospace vehicle structural arrangements. To obviate exhaustive static and dynamic physical laboratory and flights tests for optimally sizing the various structural components for all flight regimes, extensive use of analytical and computational methods are currently used during the design, development, and certification of flight vehicles.

In support of these requirements, the Boeing PSI Project has been developing a new computing architecture based on ENOVIAvpm that allows multiple engineering disciplines to interact and collaborate. This architecture is based on the philosophy of a Process Managed Digital Enterprise (PMDE), developed by Saeed Paydarfar, Ph.D., et al. The requirements are to create an integrated architecture where various design tools and data – 3D models, design simulations, drawings, and auxiliary documents – all can co-exist with the associated engineering analysis tools and data for the entire product structure. A necessary requirement of this environment is that it provide real-time and batch access, as well as data and configuration management, for a wide spectrum of the engineering data that is needed during product definition.

The new computing environment and engineering processes to perform preliminary structural sizing and estimating vehicle weight for conventional commercial airplane configurations are expected to provide greater speed and accuracy during preliminary design and configuration development. The process requires the FEM-based (Finite Element) analysis and simulations to keep in step with vehicle configuration changes to ensure “analyses-in-the-loop.” The challenge of the new process is to consolidate many diverse sub-processes and applications into a single process-managed digital architecture, thereby dramatically reducing the cycle and convergence time following the definition for a new vehicle configuration from many months to a turn-around time of a week.

When complete, this new architecture will assist Boeing in the preliminary design and analysis of its future conventional commercial aircraft, including the new 747X program.
Publish and Subscribe automated messaging mechanisms are also implemented, allowing the Boeing subject matter experts using the VPM environment to be kept informed at key states along the process execution flow and at the end of execution of an invoked process. The VPM Publish and Subscribe mechanism is linked to the Boeing e-mail server for the convenience of the end-users.

A new VPM database was created within the Boeing development environment. Furthermore, a custom VPM data schema was defined and implemented, comprising objects, tables, attributes, model representation types, and a tailored VPM People and Organization security, roles, and permissions. The most intensive and specialized task was developing the VPM User Exits to embed engineering analysis processes captured through the scripts. Finally, the VPM-A and PSN interface was customized to include these new classes and class methods directly within the VPM GUI. Now the processes are mapped to a degree that enables the components to be implemented in VPM. Configuration management is implemented to provide traceability of design and analysis CATIA models and datasets, and to manage the data associated with different vehicle baselines, trade studies, and variants. Versioning, revisioning, and change management processes are also implemented within VPM.

**Conclusion**

Planning is underway at Boeing to map additional engineering analysis processes and to determine the development strategy for integrating these processes into either VPM or ENOVIA v5. These tools provide a strategy, methodology, and architecture for ensuring a global perspective on deploying new technologies. Thus, disciplines, functions, and end-user teams that once were excluded from concurrent participation now are beginning to enjoy the full benefits of integration.