CIMdata eBook

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Siemens Digital Industries Empowers Aerospace Design with NX and Fibersim

Contributing to Aerospace Innovation

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What You Need to Know

Introduction

The air transport industry is growing at an unprecedented rate. The International Air Transport Association (IATA) [www.iata.org] has published that current trends indicate passenger numbers could double to 8.2 billion by 2037. The Asia-Pacific region shows the biggest expansion contributing more than half the total number of new passengers over the next 20 years.

Also, in a recent report, the US Pentagon has stated that "Climate change poses 'immediate risks' to national security and will have broad and costly impacts on the way the US military carries out its missions." They note that damage inflicted upon defense facilities and the interdependent assets they host (such as aircraft, hangars, and radar equipment) can cripple the military's ability to respond to a crisis, in addition to costing taxpayers millions of dollars to repair and replace these resources.

Given this predicted growth and pressure on operating costs in the aerospace and defense industry, intense competition is driving the pace of technological innovation. To increase production rates to meet the high demand from commercial and military defense clients, airframe manufacturers need to improve their operational and manufacturing performance.

Reducing Operational Costs

A range of worldwide trends are encouraging an increase in the use of composite materials in both commercial and military aircraft manufacturing.

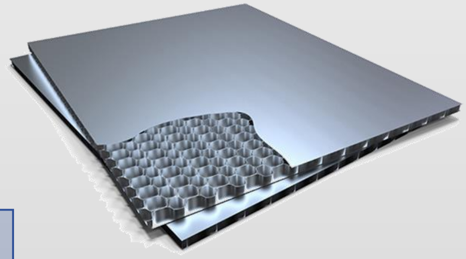
Fuel cost has been a well known, volatile portion of operational cost for commercial airlines and military aircraft alike. To be competitive, airframe manufacturers look to produce more fuel-efficient aircraft and composite materials are a clear choice to reduce weight. Reduced weight directly translates into fuel efficiency and lower operational costs.

Commercial airlines and the military spend an inordinate amount of their annual operational budget on aircraft maintenance. Corrosion and metal fatigue are taxing and force aircraft operators to conduct costly inspections to find and repair. Composites provide an alternative with better corrosion resistance than metal. Improved maintenance cycles offer lower support costs and keep the aircraft flying.

Takeaway #1
The drive to reduce aircraft operational costs is spurring the increased use of composite materials.

Takeaway #2
Siemens Digital Industries' Fibersim provides flexible design methodologies that capture 3D composite definitions and extend their use through the manufacturing lifecycle.

Takeaway #3
Siemens Digital Industries' NX 's modeling efficiencies and assembly management capabilities provide fundamental advantages in handling model changes, a common occurrence in composite design.



Courtesy of Siemens Digital Industries

Composites

Advantageous Properties

Composite Material

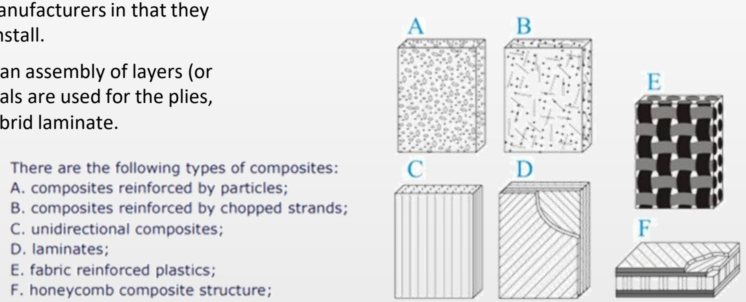
A composite material is a material composed of two or more substances, each of which has different physical or chemical properties. While each retains their separate and distinct characteristics, when combined, each contributes desirable properties to the whole. In general, composite materials offer benefits in strength, reduced weight, resistance to corrosion, durability, and part integration that helps reduce assembly costs. In addition, composite material can often be molded into complicated shapes offering added design possibilities.

Fiber-Reinforced Polymer Composites

Fiber-reinforced polymer (FRP) composites are produced from a polymer matrix that is reinforced with either an engineered, man-made, or natural fiber such as glass or carbon. The composite matrix guards against environmental damage. The matrix also binds the fiber reinforcement, giving the composite component its shape and determining its surface quality. The fibers offer strength and stiffness that reinforce the matrix.

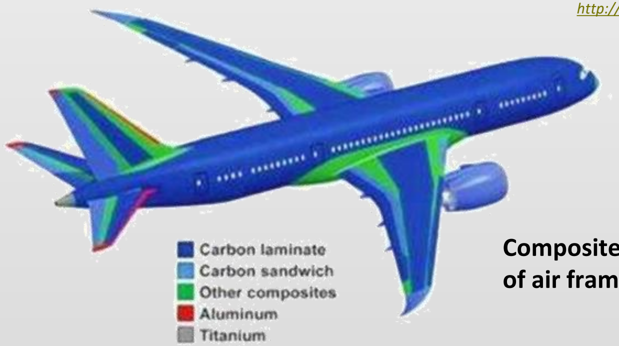
Fiber-reinforced composites present excellent strength-to-weight ratios surpassing those of other materials. FRP composites have been shown to be 70% lighter than steel and 40% lighter than aluminum. Their light weight provides further benefits to aerospace manufacturers in that they are easy to handle and install.

A composite laminate is an assembly of layers (or plies). If different materials are used for the plies, the result is termed a hybrid laminate.



Composite types

http://www.kokch.kts.ru/me/t9/SIA_9_Composites.pdf



Composite makeup of air frame

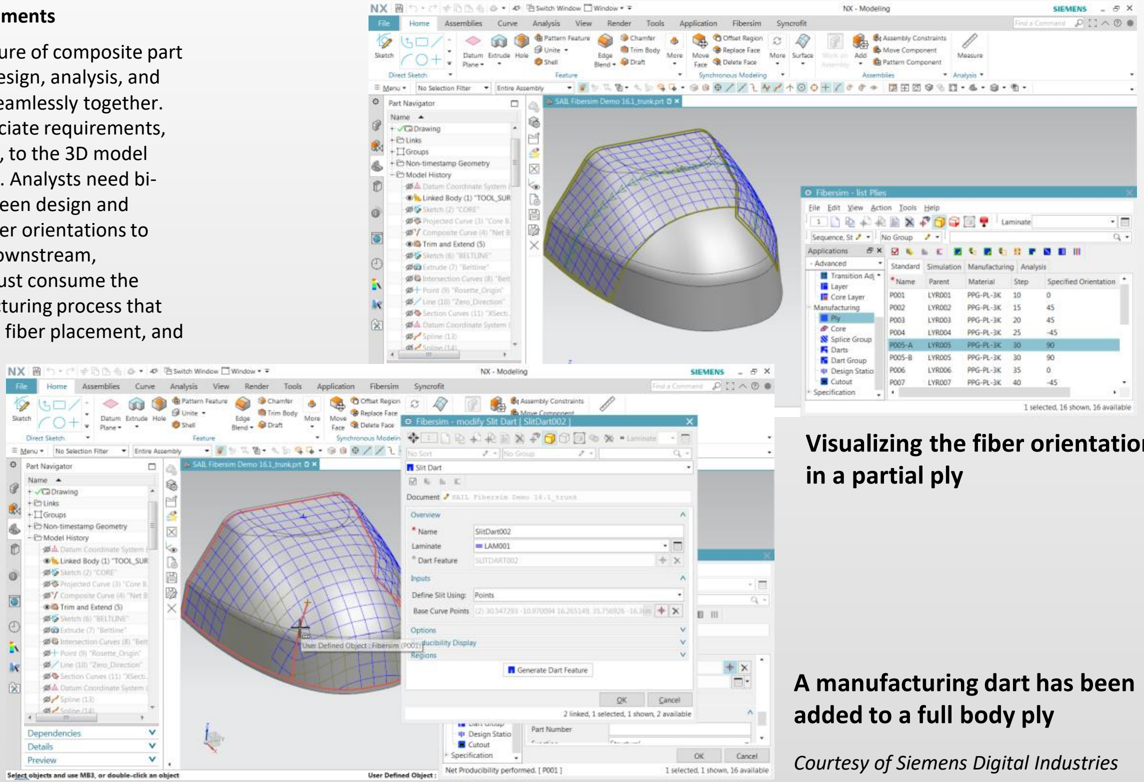
https://www.slideshare.net/GranchBerheTseghai/2-textile-reinforced-composites-52380588

Design of Composites

Design, Analysis, and Manufacturing Working Together

Accurately Capture Requirements

Because of the complex nature of composite part authoring, contributors in design, analysis, and manufacturing must work seamlessly together. Design engineers must associate requirements, such as material constraints, to the 3D model while creating ply geometry. Analysts need bi-directional interaction between design and analysis to help optimize fiber orientations to meet performance goals. Downstream, manufacturing engineers must consume the design data for the manufacturing process that can include nesting, cutting, fiber placement, and inspection.



Visualizing the fiber orientation in a partial ply

A manufacturing dart has been added to a full body ply

Courtesy of Siemens Digital Industries

Fibersim

Composite Engineering and Manufacturing

The Design-to-Analysis Loop

Siemens Digital Industries' answer to the complexity of designing and manufacturing composites is the Fibersim portfolio of solutions. Fibersim's open architecture delivers an engineering environment for the creation of a composite digital twin in NX, CATIA, or Creo. The Fibersim solution supports design methodologies that capture the specifications from design and analysis and guide designers through the manufacturing process.

Fibersim facilitates the tight connection between design and analysis needed in composite design. It offers a bi-directional Analysis Interface module that automatically provides an exchange of stress requirements into a CAD model to help guide the designer. The Analysis Interface exports design model data to the CAE software for analysis. This two way communication proves to be invaluable in the tight loop of analyze—change design—re-analyze that is needed to author an optimum composite part. Composite design information is important to CAE analysts because fiber orientations can help reduce material knockdown factors and increase optimal material use.

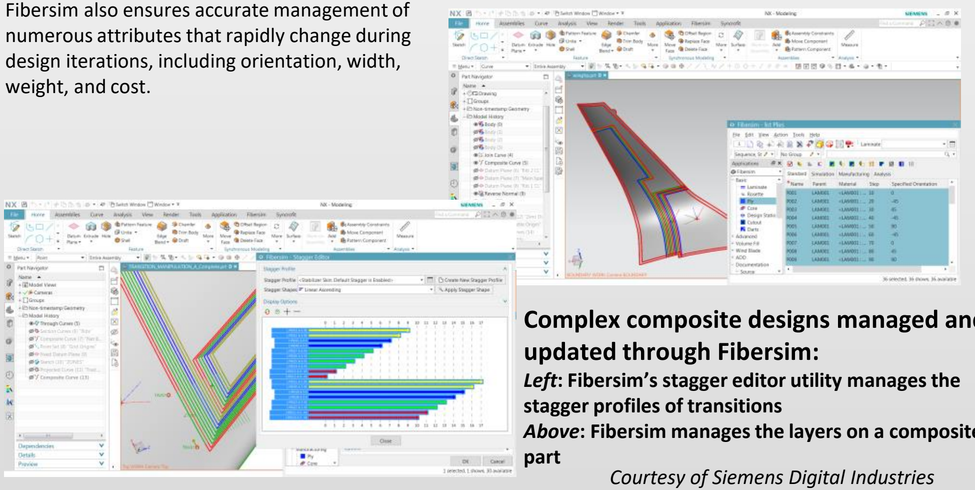
Ply Design

Fibersim can reduce ply development time. Multi-ply design is a special Fibersim automated composite design method that uses the same specifications to drive geometry creation. Unlike traditional zone- and grid-based design methods, independent base ply shapes or reinforcement regions can be placed on top of each other. When used in combination with zone- and grid-based design, multi-ply can eliminate zone and grid redefinition due to added reinforcement. Customers using these design approaches have reported up to an 80 percent increase in design efficiency.

Fibersim also ensures accurate management of numerous attributes that rapidly change during design iterations, including orientation, width, weight, and cost.

Production

The Fibersim close coupling of design and analysis is further enriched by its integration with the manufacturing process. In support of a collaborative product development process, Fibersim sustains associativity between the engineering and manufacturing composite definitions after the design data has been consumed. During fabrication, Fibersim delivers extended support for part inspection as a final manufacturing process step.



Complex composite designs managed and updated through Fibersim:

***Left*: Fibersim's stagger editor utility manages the stagger profiles of transitions**

***Above*: Fibersim manages the layers on a composite part**

Courtesy of Siemens Digital Industries

Advantages of NX

Modeling Efficiency and Assembly Management

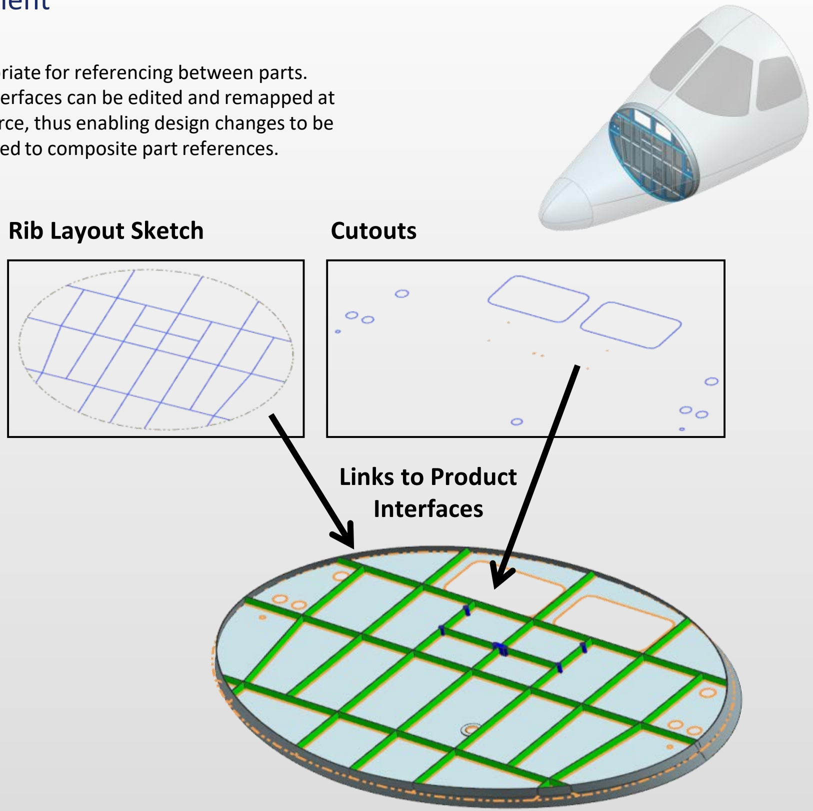
Optimized Composite Structures

Given the geometrically complex composite structures in aerospace, design engineers face major challenges in 3D modeling. A single composite part may be constructed of hundreds to thousands of unique elements such as plies, cores, and attaching inserts. Further, because of the highly optimized nature of composite parts, change is a common occurrence as the design engineer and analyst work closely together to find the most favorable ply definitions. NX requires the designer to construct fewer geometric features to author the requisite composite geometry than comparable modeling solutions. That efficiency makes handling change more straightforward.

Assembly Context

In aerospace, composite parts are often designed in context of a larger aero structure assembly. Within the assembly, part dimensions and inter-part interface contact points change due again to the frequent changes that occur during design iterations. All such modifications put a heavy strain on the CAD model assembly relationships. NX provides designers with tools to simplify the creation and editing of inter-part references.

As shown in the figure, in NX, the designer uses a tool called Product Interfaces to identify what data is appropriate for referencing between parts. Those interfaces can be edited and remapped at their source, thus enabling design changes to be propagated to composite part references.



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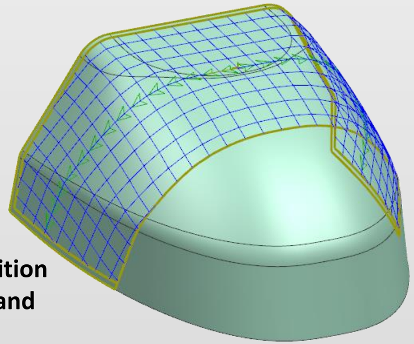
Analysis and Design Verification

Design and Analysis Interplay

Optimized Composite Structures

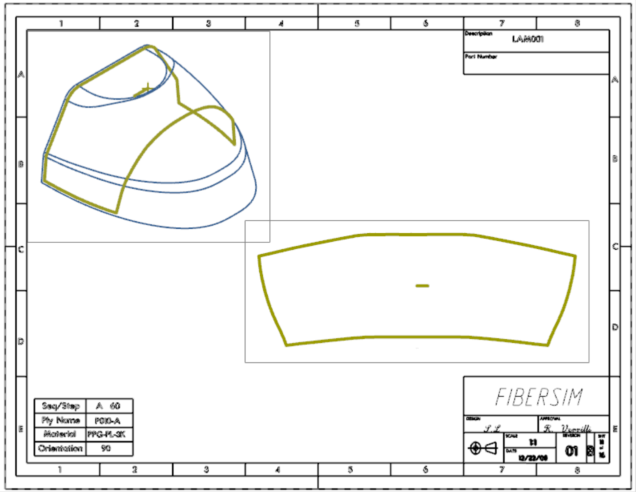
Design verification is a critical aspect in the composite design workflow. Any change to design standards, requirements, or attributes can risk failing to meet the composite part's requirements. It is important to have engineering documentation that highlights composite details such as ply materials and ply order. Cross sections and annotations must also change as the design evolves and changes. Engineering documentation makes composite details visible to all stakeholders during the design process. Fibersim automates the creation of composite engineering documentation and ensures accurate, fully up-to-date information.

Assembly structures and inter-part relationships are also important to support clash detection and packaging needs. Fibersim automatically generates surface and solid model representations to facilitate both needs.



Visualization of ply definition includes layup direction and methodology to enable manufacturing verification

Courtesy of Siemens Digital Industries



Plybook page generated from Fibersim includes: 3D ply boundary, corresponding flat pattern, and any relevant manufacturing notes necessary for communication

Composite Manufacturing and Inspection

Production Realities

Design Factors

With composite parts, it is critical to address all production issues prior to release to manufacturing so as to meet all requirement specifications and cost targets. Issues such as material deformation and fiber buckling are important to resolve. Fibersim provides automated splicing and darting capabilities that mitigate such problems.

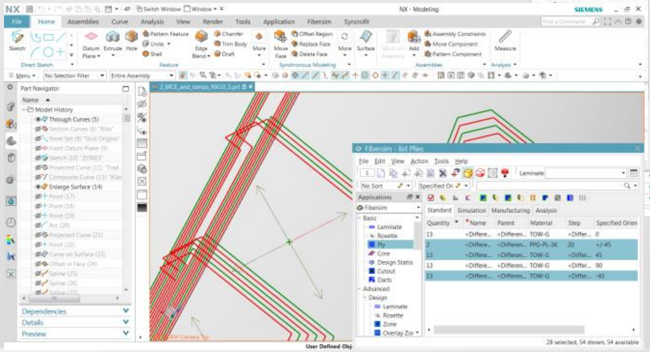
The fabrication of composite materials is also dependent upon the machine characteristics used to produce it. Design engineers need to work with manufacturing engineers to consider questions such as minimum cut length and roller height. Fibersim automatically identifies such design-for-manufacturing requirements and automatically applies ply boundary adjustments to maintain an accurate engineering and manufacturing definition for the composite part.

Manufacturing Documentation

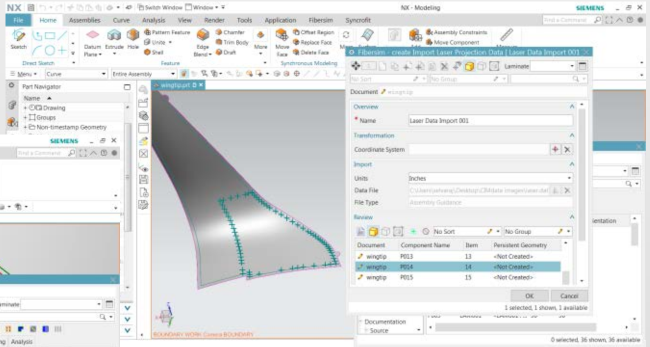
Accurate, up-to-date information is necessary to avoid errors in manufacturing. Repeatability of the manufacturing process maintains the best quality and lowest cost composites. Fibersim offers a wide range of capabilities to generate manufacturing documentation. For example, part manufacturing information (PMI) notes can be added to the 3D views of composite parts.

Composite Part Inspection

Final inspection is an obligatory step in composite production. Siemens Digital Industries offers quality planning solutions to reduce the complexities of planning, control, and monitoring of processes and corporate quality. To produce high quality composite products, Fibersim ensures that the material, orientation, location, and order are correct during the fabrication process. Inspection of the results can be a time-consuming and costly manual effort that can be shortened by proper documentation.



Automated manufacturing features such as “bird beaks” and “bat ears” are automatically added to plies.



Laser projection data generated automatically from the composite definition

Courtesy of Siemens Digital Industries

Summary

Fibersim for Composite Design and Manufacturing

A winning approach to composite design and manufacturing is the close collaborative interaction of design, analysis, and manufacturing. All three must work hand-in-hand to collectively produce high quality and low cost composite parts. CIMdata reflects favorably upon Fibersim's implementation of the close coupling of design and analysis with influence of production manufacturing processes. By covering the full composite product development process from design and analysis through fabrication and inspection, Fibersim delivers an exceptional solution that can sustain its users at the forefront of composite design engineering.

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