Agenda

• Challenges
• Design Process Overview
  • Analysis Design Interchange
  • Design Methods
  • Specification Driven Design
  • Analysis Design Iteration
  • Simulation and DFM
  • Design Release
  • Enterprise Consumption
Challenges | Solutions

**Challenges:**
1. Achieving optimal composite products
2. Reducing time for development
3. Increasing production rate and quality

**Solutions:**
1. Concurrent engineering approach
2. Tools that support communication
3. Design for manufacturing
Overdesign

Industry Observations …

"Overdesigned composites cannot compete with lower-cost, established material systems – but composites are the future."

"Overdesign to address uncertainty negates the advantages of composites. This leads to excess weight, schedule, and cost"
Achieving Optimal Composite Products

Concurrent approach to product engineering early in the development process
Achieving Optimal Composite Products

Concurrent approach to product engineering early in the development process
Achieving Optimal Composite Products

Concurrent approach to product engineering early in the development process
Reducing Development Time

Verification via simulation and test
- Specialized composite simulation and test

Analysis and Performance Simulation

Powerful Design Methodologies

Manufacturing Simulation and Integration

"Window to the Manufacturing Floor"
- Verification
  - Understands the impact of design choices on cost and schedule

Structured, integrated definition processes
- Integrated, novel design methods
Increasing Production Rate and Quality

Methods to increase production rate and quality

- Reduce the material used to make the part
- Consolidate parts to minimize assembly procedures
- More quickly bring the part into optimized, volume production

All require iterative, cross-disciplinary optimization to achieve real savings
Lifecycle Flow of Composite Data

1. Preliminary Loft
2. Design Consumption of CAE Material Requirements
3. Selection of Design Method
4. Simulation and Design for Manufacturing
5. Generation of Layers\Plies
6. Definition of Specifications
7. Design\CAE Iteration
8. Design Release Deliverables and Reporting
9. Enterprise Consumption of Composite Data

Software Tools:
- Fibersim Pre-CAD
- Fibersim CAE Exchange
- Fibersim in CAD
- Teamcenter MPP\PDIPS
Fibersim

- **Authoring complex composite designs** while meeting specification, schedule, and budget.

- **Managing, finding and reusing data** across multiple sites, domains, tools and processes

- Intelligently **assessing the impact of changes** across domains and product configurations

- **Timely validation of performance** and readiness for manufacturing
Lifecycle Flow of Composite Data

- Preliminary Loft
- Consumption of CAE Material Requirements
- Selection of Design Method
  - Definition of Specifications
  - Generation of Layers/Plies
  - Simulation and Design for Manufacturing
  - Design/CAE Iteration
  - Design Release Deliverables and Reporting
  - Enterprise Consumption of Composite Data

- Fibersim
- Pre-CAD
- Fibersim CAE Exchange
- Fibersim in CAD
- Teamcenter MPP/PDIPS
Consumption of Material Requirements

NX CAE to/from Fibersim exchange of composite definition

- Ply(layer) based
  - Element boundary to design boundary

- Zone based
  - Application to regions of the part
Consumption of Material Requirements

**NX CAE to\from Fibersim** exchange of composite definition

- **Ply(layer) based**
  - Element boundary to design boundary

- **Zone based**
  - Application to regions of the part
Preliminary Simulation Model

- Split the mold surface following zones, with boundaries that:
  - Are physically meaningful
  - Are arbitrarily defined for downstream optimization
- Mesh the resulting faces
- Define laminates
  - Import from Excel
  - NX Open
Design Variable Creation
Nastran Design Optimization
Share with Fibersim
Lifecycle Flow of Composite Data

1. Preliminary Loft
2. Design Consumption of CAE Material Requirements
3. Selection of Design Method
4. Simulation and Design for Manufacturing
5. Generation of Layers\Plies
6. Definition of Specifications
7. Design\CAE Iteration
8. Design Release Deliverables and Reporting
9. Enterprise Consumption of Composite Data

Tools:
- Fibersim Pre-CAD
- Fibersim CAE Exchange
- Fibersim in CAD
- Teamcenter MPP\PD\IPS
Fibersim Powerful Design

- Flexible design method for hand layup
- Captures all data and assures manufacturability

Ply Based

- Driven from mating specs
- Automates design for wings/fuselages
- Enables automated material deposition

Zone Based

- Allows effective optimization of complex designs
- Supports robust analysis workflows

Structure Based

- Automates ply based design
- Best of ply and zone
- Allows late design modifications without adding tedious work

Multi Ply Based

- Best of ply and zone
- Allows late design modifications without adding tedious work
Fibersim Powerful Design

- Flexible design method for hand layup
- Captures all data and assures manufacturability

**Ply Based**
- Driven from mating specs
- Automates design for wings/fuselages
- Enables automated material deposition

**Zone Based**
- Allows effective optimization of complex designs
- Supports robust analysis workflows

**Structure Based**
- Automates ply based design
- Best of ply and zone
- Allows late design modifications without adding tedious work

**Multi Ply Based**
- New
Lifecycle Flow of Composite Data

- Preliminary Loft
- Design Consumption of CAE Material Requirements
- Selection of Design Method
- Definition of Specifications
- Generation of Layers\Plies
- Design Release Deliverables and Reporting
- Enterprise Consumption of Composite Data
- Design\CAE Iteration
- Simulation and Design for Manufacturing
- Selection of Design Method

Software Tools:
- Fibersim Pre-CAD
- Fibersim CAE Exchange
- Fibersim in CAD
- Teamcenter MPP\PD\IPS
Define Specification

Design is **specification driven** not geometry driven

- **Drop Off** (Offset) Specifications
  - Flexible control of EOP spacing
  - Linear, Double Linear, Triple Linear
  - Structure Centered
  - Structure Offset
  - Fill To
  - Custom
Define Specification

Design is **specification driven** not geometry driven

- **Drop Off** (Offset) Specifications
  - Flexible control of EOP spacing
  - Linear, Double Linear, Triple Linear
  - Structure Centered
  - Structure Offset
  - Fill To
  - Custom
Define Specification

Design is **specification driven** not geometry driven

- **Drop Off** (Offset) Specifications
  - Flexible control of EOP spacing
  - Linear, Double Linear, Triple Linear
  - Structure Centered
  - Structure Offset
  - Fill To
  - Custom
Define Specification

Design is **specification driven** not geometry driven

- **Stagger Profile** Specifications
  - Global and local control
  - Linear Ascending, Descending
  - Symmetric, Asymmetric
  - Custom

Applied Globally
Define Specification

Design is **specification driven** not geometry driven

- **Stagger Profile** Specifications
  - Global and local control
  - Linear Ascending, Descending
  - Symmetric, Asymmetric
  - Custom

Applied Locally
Define Specification

Design is **specification driven** not geometry driven

- **Stagger Profile** Specifications
  - Global and local control
  - Linear Ascending, Descending
  - Symmetric, Asymmetric
  - Custom

Applied Locally
Define Specification

Design is **specification driven** not geometry driven

- **Corner Behavior**
  - Variable, Constant, Min Length, Fixed Chamfer
  - Minimum Course
Lifecycle Flow of Composite Data

- Preliminary Loft
- Design Consumption of CAE Material Requirements
- Selection of Design Method
- Definition of Specifications
- Generation of Layers/Plies
- Simulation and Design for Manufacturing
- Design/CAE Iteration
- Design Release Deliverables and Reporting
- Enterprise Consumption of Composite Data
Define Specification

Plies/Layers are created from the specification

Change requires only a specification change
- Laminate Specification (Layup)
- Drop Off (Offset)
- Stagger Profile
- Corner Behavior
Define Specification

Plies/Layers are **created from the specification**

**Change** requires only a **specification change**
- Laminate Specification (Layup)
- Drop Off (Offset)
- Stagger Profile
- Corner Behavior
Define Specification

Plies/Layers are created from the specification

Change requires only a specification change
- Laminate Specification (Layup)
- Drop Off (Offset)
- Stagger Profile
- Corner Behavior
Lifecycle Flow of Composite Data

1. Preliminary Loft
2. Design Consumption of CAE Material Requirements
3. Selection of Design Method
4. Definition of Specifications
5. Generation of Layers\Plies
6. Design Release Deliverables and Reporting
7. Enterprise Consumption of Composite Data

Simulation and Design for Manufacturing

- Design\CAE Iteration
- Simulation and Design for Manufacturing

Tools:
- Fibersim Pre-CAD
- Fibersim CAE Exchange
- Fibersim in CAD
- Teamcenter MPP\PD\IPS
Part Performance | Fiber Alignment

Fiber misalignment impact on modulus and strength

Ref1
Simulation and Design for Manufacturing

Hand Layup Simulation
• Woven Material
Simulation and Design for Manufacturing

Hand Layup Simulation

Process Effects

Material Effects

start layup here

start layup here

start layup here

start layup here

start layup here
Simulation and Design for Manufacturing

- Fiber steering
- Localized deformation
- Fiber buckling
Simulation and Design for Manufacturing

AFP/ATL

- Uni Tape Tow
- Machine Limitations
  - Min Course
  - Across Cut Angle
  - Min Cut Width

Understanding Machine Characteristics
Effects on Design
Simulation and Design for Manufacturing

ATL/AFP
- Import of path planning
- Design changes
- Achieving fiber orientations

Path Planning in the Context of Design
Simulation and Design for Manufacturing

ATL/AFP

- Import of path planning
- Design changes
- Achieving fiber orientations
Simulation and Design for Manufacturing

ATL/AFP
- Import of path planning
- Design changes
- Achieving fiber orientations

Variation from Desired (Yellow-5Deg, Red-10Deg)
Lifecycle Flow of Composite Data

1. Preliminary Loft
2. Design Consumption of CAE Material Requirements
3. Selection of Design Method
4. Definition of Specifications
5. Generation of Layers/Plies
6. Design Release Deliverables and Reporting
7. Enterprise Consumption of Composite Data
8. Simulation and Design for Manufacturing
9. Design\CAE Iteration

Fibersim
Fibersim Pre-CAD
Fibersim in CAD
Fibersim CAE Exchange
Teamcenter MPP\PD\PS

Siemens PLM Software
Validation of as-manufactured design

Ply exchange with Fibersim

- Sheared fiber orientations from Fibersim producibility simulation
- Stacking sequence
- Start point and orientation
- Materials & properties

Zones computed from Fibersim-oriented plies and sent to solver as physical properties, real constants or section data

- NX Nastran, Samcef, MSC.Nastran, Ansys, Abaqus, LS-DYNA

Hotspots can be modeled using refined 2D or 3D meshes

- 2D or 3D composite elements
Validation of as-manufactured design

Structural evaluation can include the following analyses
• Static linear
• Nonlinear
• Dynamic
  • Transient, harmonic, random
• Progressive damage
• Nonlinear buckling and post-buckling
• Delamination
Validation of as-manufactured design
Validation of as-manufactured design

Ply exchange with Fibersim
• Modified ply data can be exchanged with Fibersim for final incorporation in the composites design
Lifecycle Flow of Composite Data

1. Preliminary Loft
2. Design Consumption of CAE Material Requirements
3. Selection of Design Method
4. Simulation and Design Manufacturing
5. Generation of Layers\Plies
6. Definition of Specifications
7. Design\CAE Iteration
8. Design Release Deliverables and Reporting
9. Enterprise Consumption of Composite Data
Design Release Deliverables

Automated 3D Documentation – Data Reuse
- Annotations
- Cross Sections
Design Release Deliverables

Automated 3D Documentation – Data Reuse

- Annotations
- Cross Sections
Design Release Deliverables

Automated Inner Mold Line (IML) Generation
• Final Part Solid
• Tooling
Design Release Deliverables

Automated Inner Mold Line (IML) Generation

- Final Part Solid
- Tooling
Design Release Deliverables

Automated Plybook Generation

- Flat pattern view generated
- One or multiple views generated
- Layup process displayed
- Tables auto completed

![Diagram showing automated plybook generation with annotations]

ALL DIMENSIONS IN INCHES
Design Release Deliverables

Cutting and Nesting

Laser Projection

Automated Deposition
Lifecycle Flow of Composite Data

Preliminary Loft → Design Consumption of CAE Material Requirements → Selection of Design Method

Simulation and Design for Manufacturing → Generation of Layers\Plies → Definition of Specifications

Design\CAE Iteration → Design Release Deliverables and Reporting

Enterprise Consumption of Composite Data
Enterprise Consumption

Teamcenter

Revision Controlled
Composite model (engineering)
Composite Model (manufacturing)
Documentation
Flat patterns
Laser Projection and inspection
ATL
AFP
Enterprise Consumption

Teamcenter
References

Ref1: Aircraft Structural Design, Practical Design Information and Data on Aircraft Structures, Michael Chun-Yung Niu, Lockheed Aeronautical Systems Company, Burbank, California
Contact Information

David Leigh Hudson
Fibersim Product Manager
Siemens PLM Software
Specialized Engineering Software
Waltham, MA
hudson@siemens.com