



# Composites in Aerospace – Case Studies

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A workshop on Living with Composites - Lessons Learnt in the  
Use of Composites on Aerospace and Marine Structures

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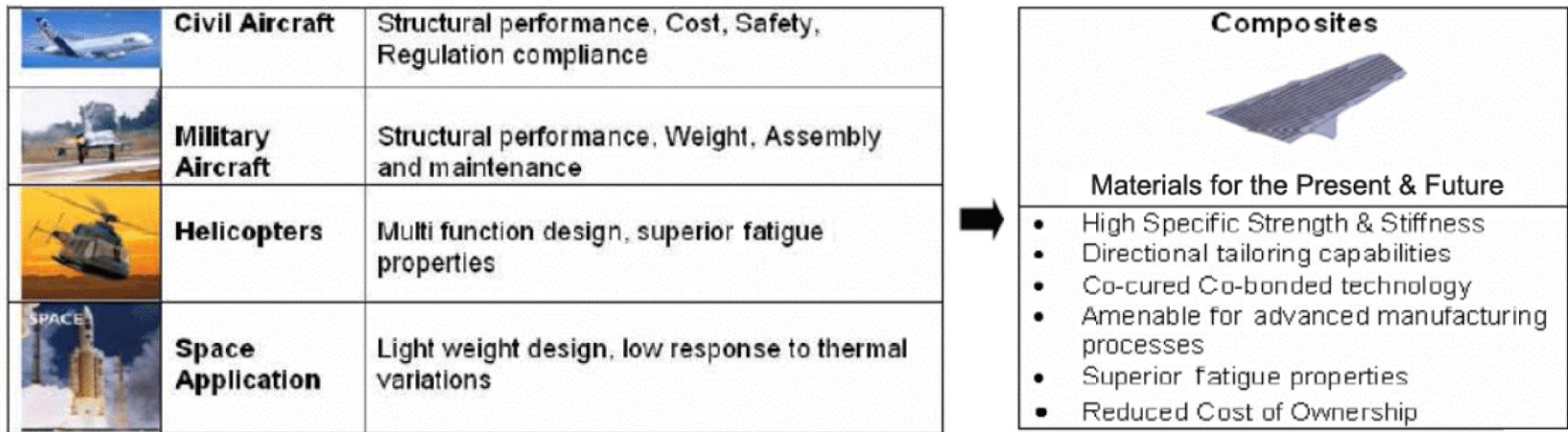
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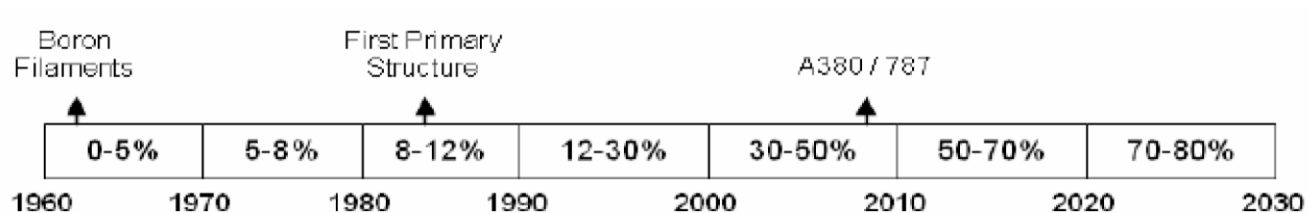
- Composites in Aerospace Industry
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- FE analysis for Computational Repair Assessment
- Lateral wing Box Stringer Development
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- Composites Sandwich Floor Panel Design for A380F
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- Knowledge based process improvements in wing skin
- Automation in flat pattern and manufacturing data generation
- Infosys Resources/Tools Role in Other Leading Composites programs

# Composites in Aerospace Industry

- Key factors influencing the usage of composites:



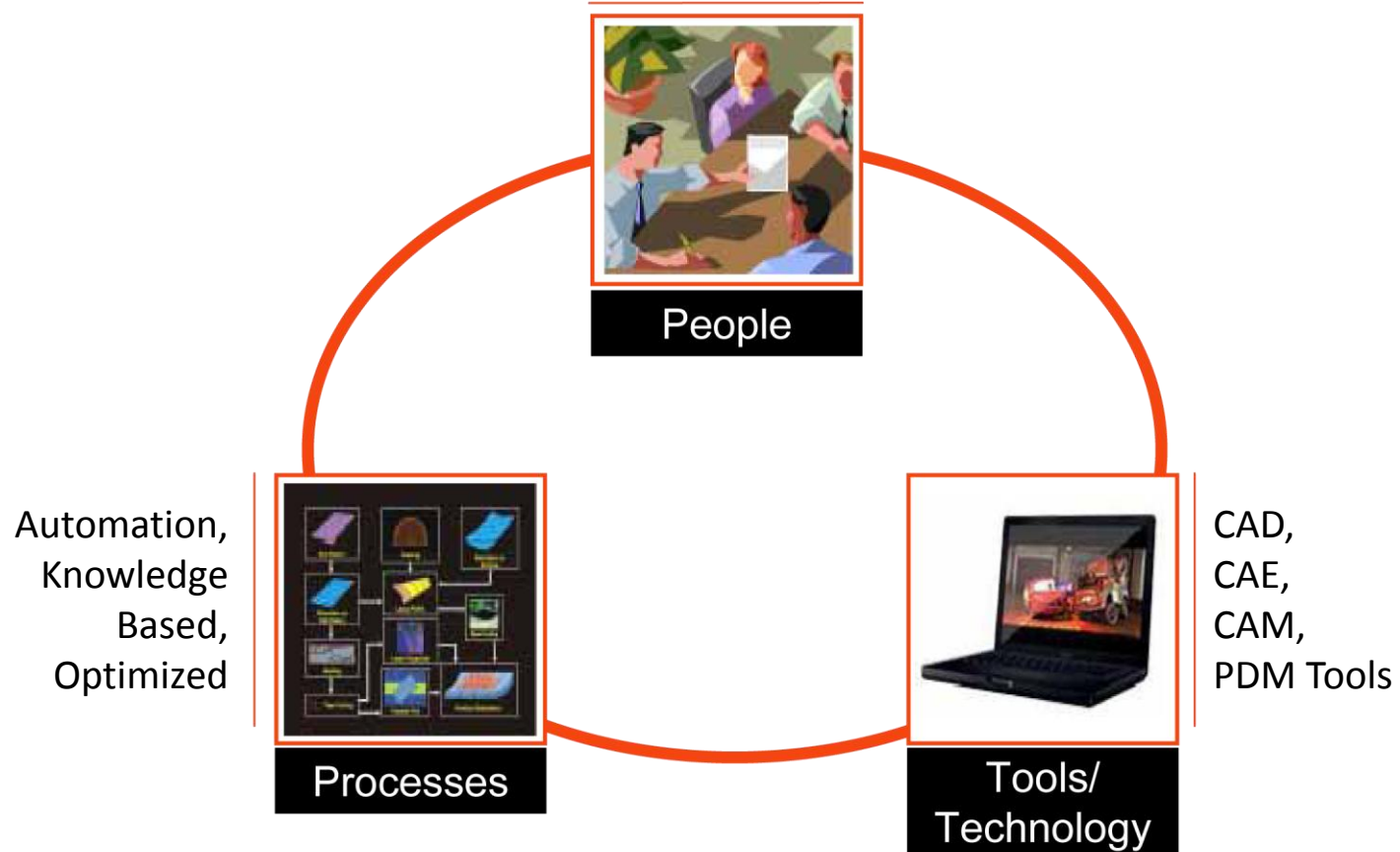
- Composites usage over the years in Commercial Aircraft Industry



Focus is on Affordability, Safety, Ease of Maintenance and Comfort

# Key Enablers for Composites Growth

Design & Manufacturing Innovations;  
Move away from metallic design philosophy



# FE analysis to Estimate Damage & its Growth

- Objective

- To estimate damage and its growth under low velocity impact – Debris hit or tool drop

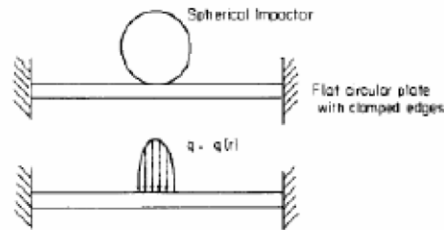


Fig. 1. Pressure distribution on a circular plate pressed by a spherical impactor.

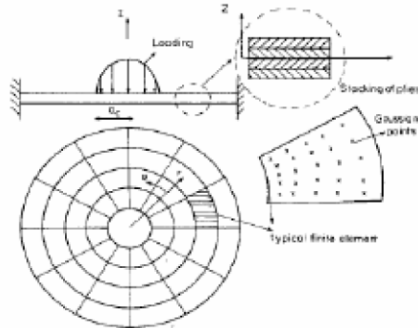


Fig. 2. Typical finite element mesh adopted for the circular plate.

Quasi-isotropic plate  $[0^\circ/45^\circ/90^\circ/-45^\circ]$ ,

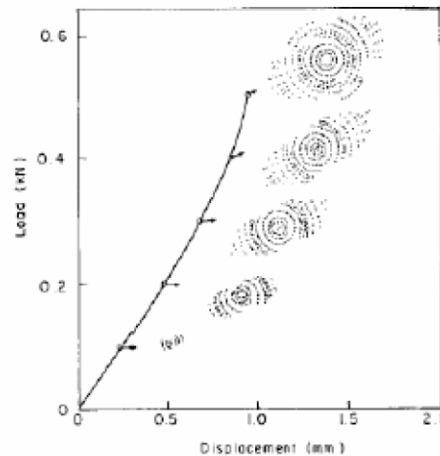


Fig. 5. Superimposed damage patterns for different load values.

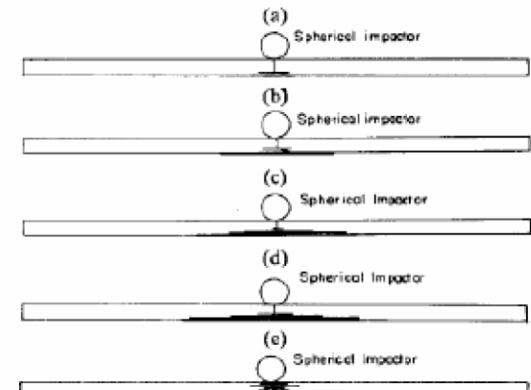
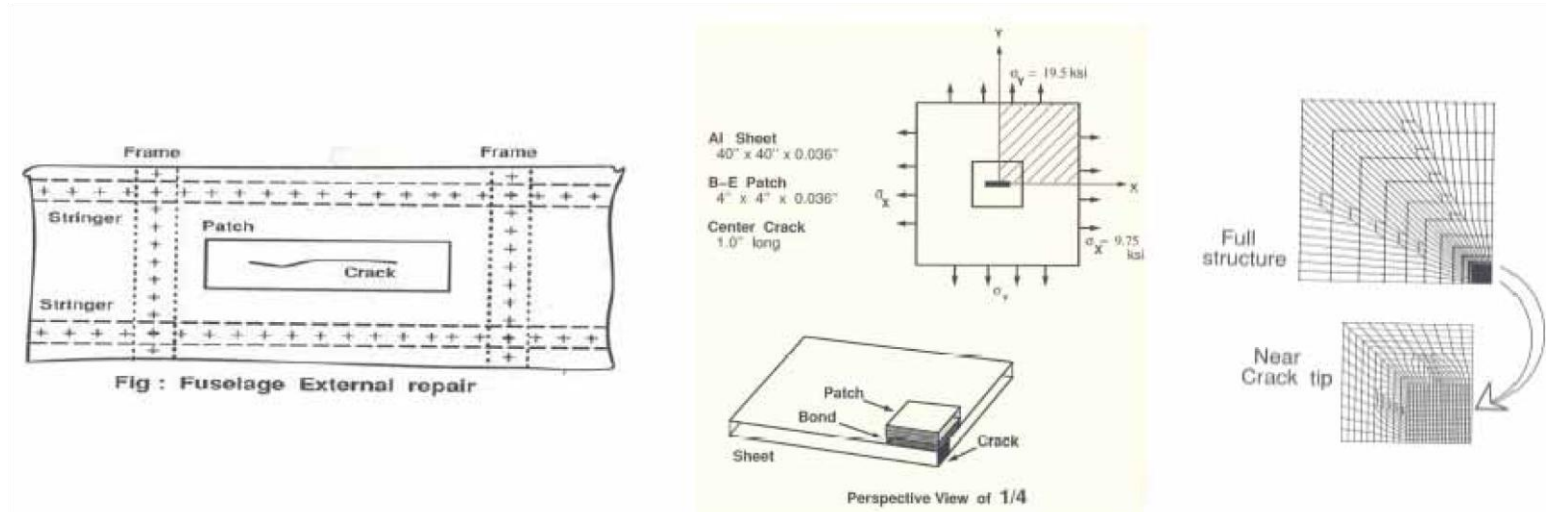


Fig. 8. Cross-sectional view of the damaged plate for different loads. (a) Load 0.1 kN. (b) Load 0.2 kN. (c) Load 0.3 kN. (d) Load 0.4 kN. (e) Load 0.5 kN.

Non-linear FE analysis simulating matrix crack fiber breakage progressively

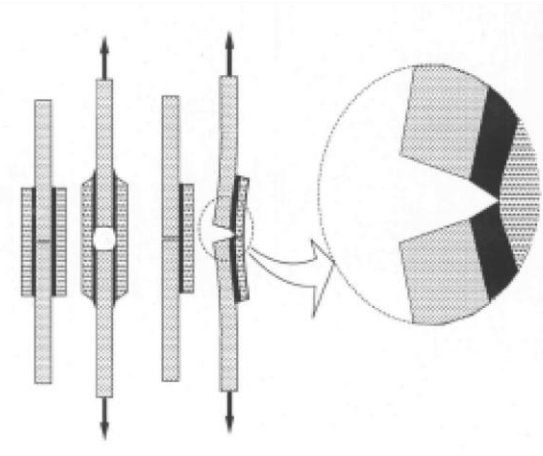
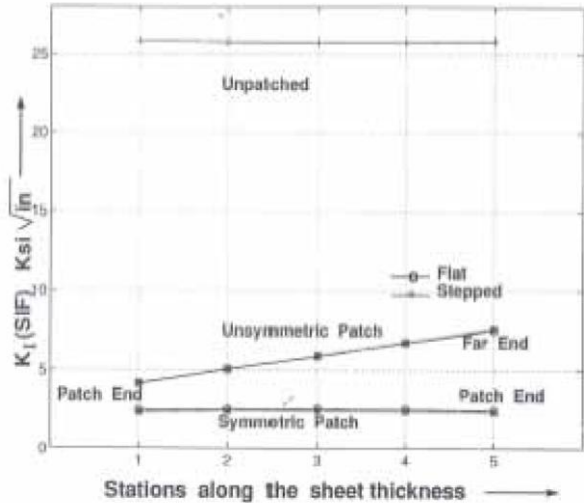
# FE Analysis for Computational Repair Assessment

- Objective
  - To assess the effectiveness of the repair through FE analysis



- FE analysis
  - 8 Noded 3D bricks - Cracked sheet 4 element layers, Adhesive 3 element layers
  - Geometric Non-linearity, Linear material
  - SIF by displacement extrapolation computed using modified crack closure integral (MCCI)
  - Patch effectiveness is ratio of residual life with patch to residual life without patch

# FE Analysis for Computational Repair Assessment (contd..)

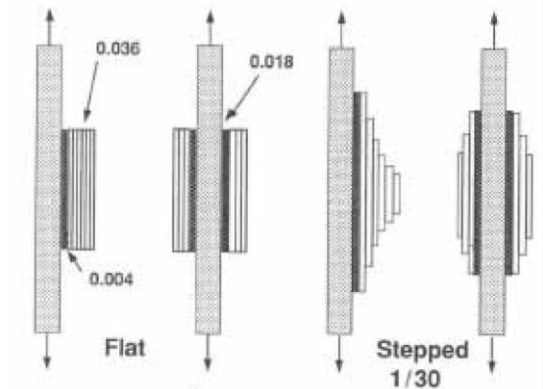


Un-symmetric patch repair causing out of plane bending

- Symmetric stepped configuration gave less SIFs and gave better results

|                    |                    | Stress Intensity Factors (SIF) |       |       |       |       |       |
|--------------------|--------------------|--------------------------------|-------|-------|-------|-------|-------|
|                    |                    | Ply 1                          | Ply 2 | Ply 3 | Ply 4 | Ply 5 | Ply 6 |
| Configuration I**  | Symmetric - Flat   | 4                              | 4     | 4     |       |       |       |
|                    | Symmetric - Step   | 4.348                          | 3.988 | 3.628 |       |       |       |
| Configuration II** | Unsymmetric - Flat | 4                              | 4     | 4     | 4     | 4     | 4     |
|                    | Unsymmetric - Step | 4.852                          | 4.492 | 4.132 | 3.772 | 3.412 | 3.052 |

\*\* Maintaining Same patch volume= 0.576 cubic-inch



Finite Element Analysis can predict damage & assess repair

# Airbus Lateral Wing Box Stringer Development

- **Project Scope:**

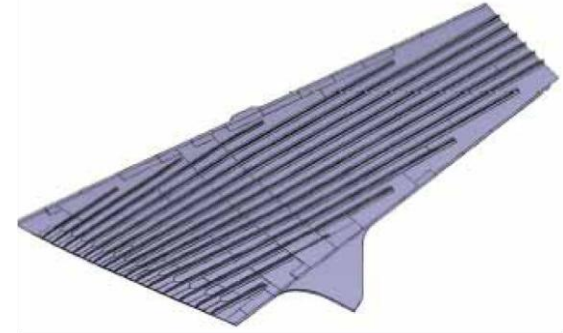
- Design support for Airbus lateral wing box composite upper cover stringer development; Stringer & Skin – Non-crimped fabric

- **Challenges:**

- Co-cured and co-bonded technology
- Consideration of maintenance issues during design
- Cost of ownership
- Mass production

- **Lessons Learnt:**

- Need for design automation reducing the development time and improved quality
- Bridging the technology gaps between Lab to production



Composite wing cover



Roll Formed Stringer

# Design of composite rib spar interfaces

- **Project Scope:**

- Design support for Airbus lateral wing box composite upper cover stringer development; Stringer & Skin – Non-crimped fabric

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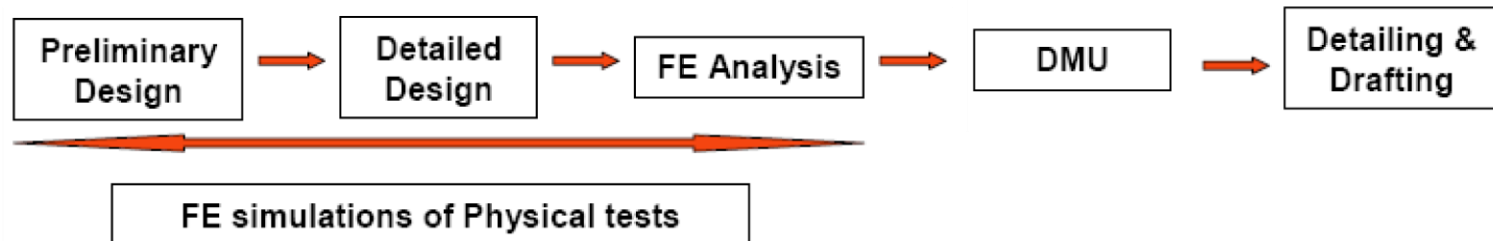
- Need for design automation reducing the development time and improved quality
- Bridging the technology gaps between Lab to production

Project is currently under execution

# Composites Sandwich Floor Panel Design for A380F

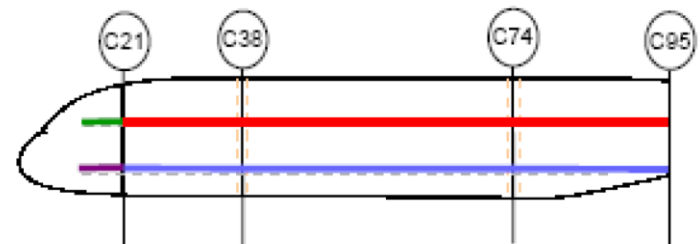
- Project Scope:

- To provide design and analysis support on composites sandwich floor panels of A380 freighter through US aerospace supplier. This includes design of floor panels and their connecting sheets for both upper and main decks involving:



- Lessons Learnt:

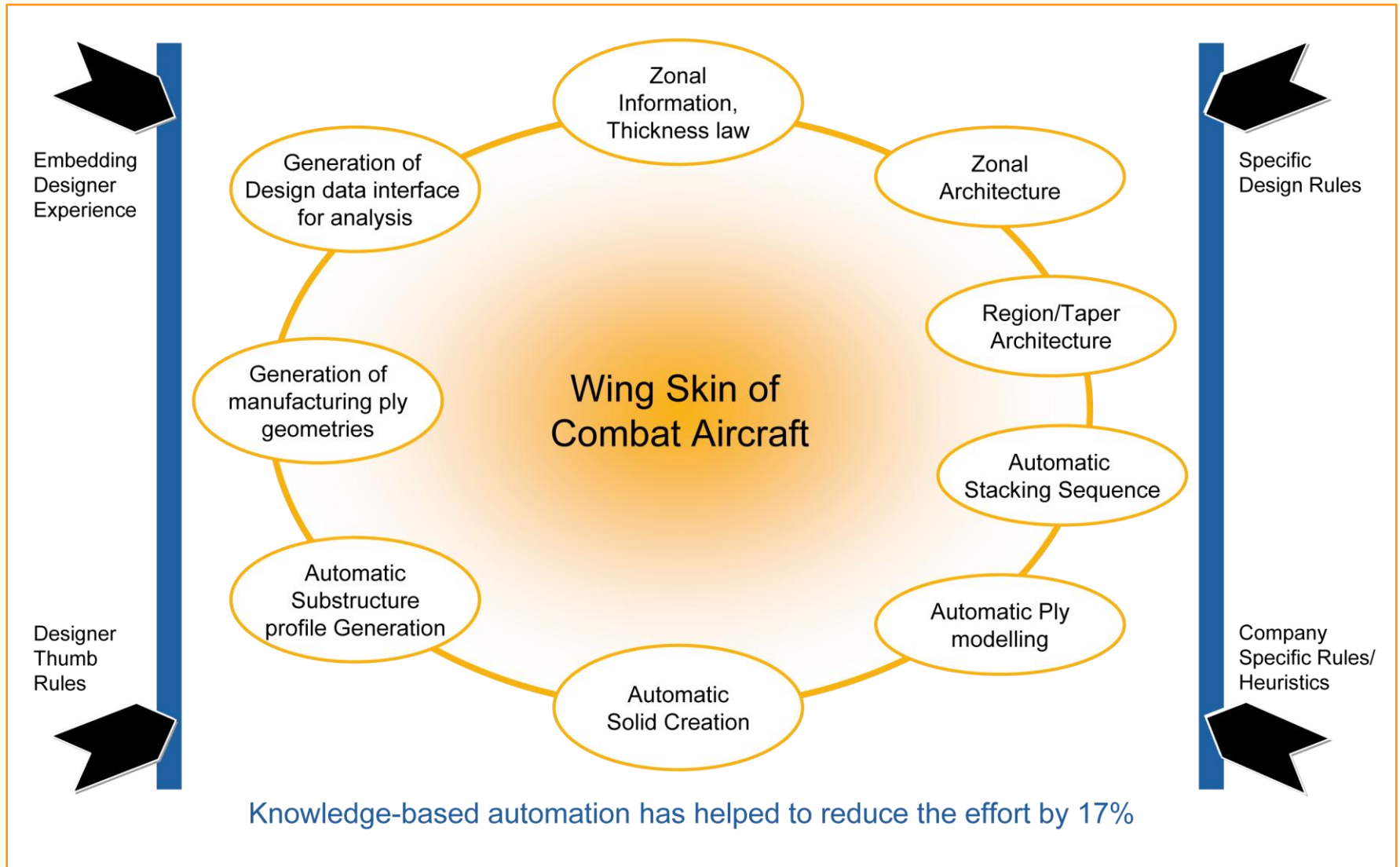
- Conflicting design requirements
- Stringent weight targets
- Optimization based on engineering judgment
- Innovation is the Key
- Reuse of Knowledge
- Automation tools and utilities are necessary
- Mechanisms to handle huge design data
- FE simulations with limited material data



# Design of nose wheel well doors

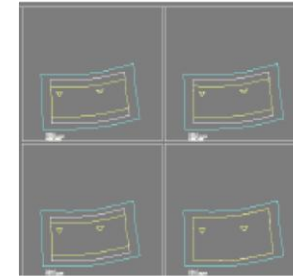
- Project Scope:
  - Design of composite sandwich doors for nose wheel well along with hinges and mechanisms for 787 aircraft through US supplier. The scope includes preliminary design, analysis (FE & Analytical) and detailed design (IDP & FDP).
- Challenges:
  - Complex skin and cores configurations
  - Complex loading conditions
  - Many design, stress and manufacturing constraints
  - Complex design procedures and guidelines
  - Stringent time schedules
  - Stringent weight constraints
- Lessons Learnt:
  - Company specific design procedures and guidelines
  - Need for automation through state of the art tools and utilities
  - Limited material test data
  - Continuous load and design changes

# Knowledge based process improvements in wing skin

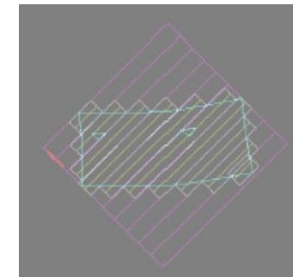


# Automation in flat pattern and manufacturing data generation

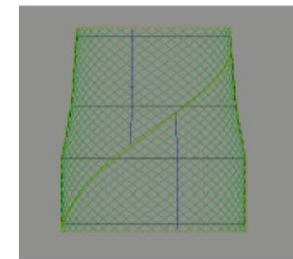
- Project Scope:
  - Flat pattern and manufacturing data generation for spars, fin, test boxes, ribs, wing skin, fin skin, fuselage panels, nozzle flaps, air intake ducts of combat aircraft involving:
    - Modeling the manufacturing plies and the tool surface within CADD5-Composites.
    - Generation Flat pattern of tool surface and the manufacturing plies on tool surface.
    - Automatic generation of flat allocation data on all the flattened plies
    - Automatic nesting of all the tape cut-pieces and printing the nested cut-piece information onto a file for manufacturing interface
- Lessons Learnt:
  - Need to use composites tools
  - Automation is a key
- Tools Used:
  - CADD5, AUTOLAY(CADD5-COMPOSITES)



Flat pattern of various plies



UD Tape allocation



Draping Simulation



Nested cut-pieces of all plies

# Infosys Resources/Tools Role in Other Leading Composites programs

## Indian LCA



Design & Development of  
CFC Wing & Fin skins  
Fuselage bulkheads  
Radome, Fuel tanks  
Cockpit, Sandwich floors

## HANSA



Design & Development of  
Composite panels of all  
composite two seat trainer  
aircraft, complied with  
JAR/VLA requirements

## CADDS-COMPOSITES in AIRBUS



**A380:** Central torsion box,  
ailerons, floor panels  
**TANGO:** Central torsion box,  
aileron  
**A340:** Keel beam, fin

Building  
**Tomorrow's** Enterprise



Thank You

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