

CASE STUDY



Composites in Aerospace – Case Studies



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

National Oceanography Centre, Southampton, UK 27 June, 2006

Narendhar Rao S.

Technical Lead Composites and Knowledge Based Engineering
Infosys Ltd.

Dr. Ravi Kumar G. V. V.

Group Technical Consultant Product Life Cycle and
Engineering Solutions Infosys Ltd.

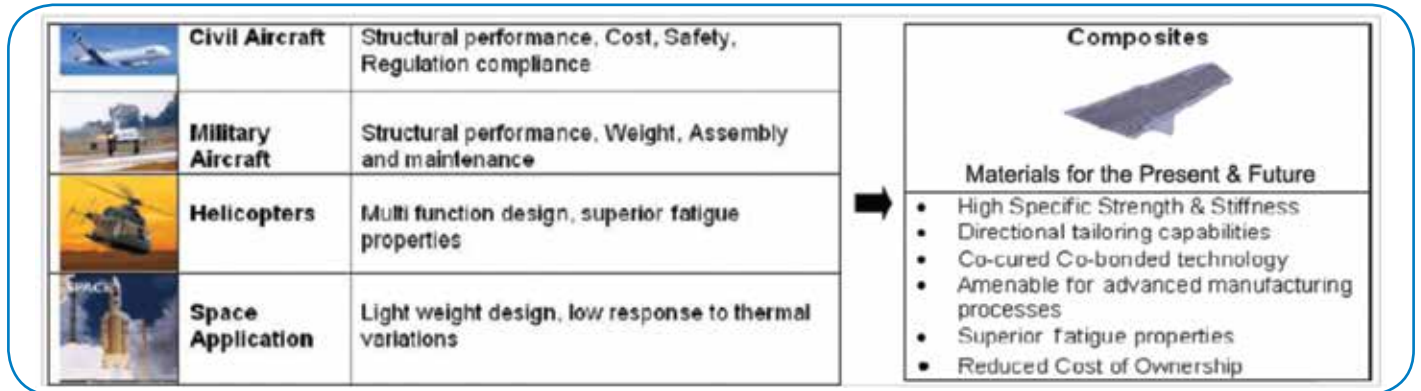
Infosys
be more

Contents

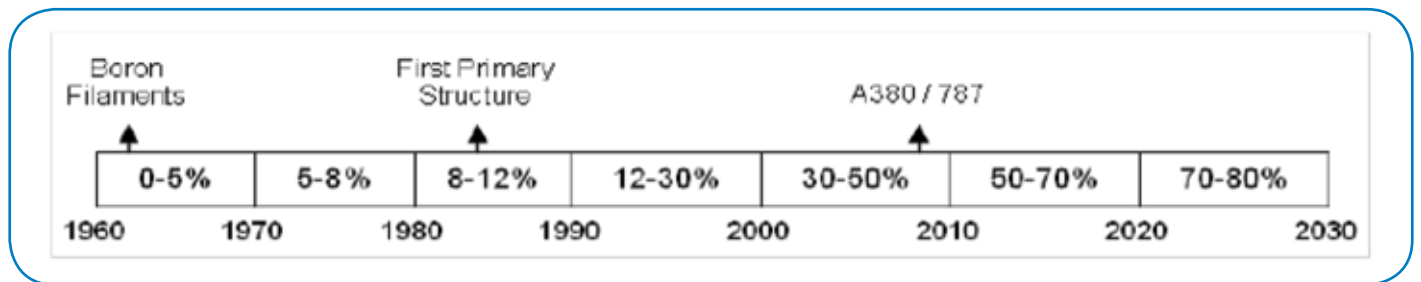
- Composites in Aerospace Industry
- Key Enablers For Composites Growth
- FE analysis to Estimate Damage & its Growth
- FE analysis for Computational Repair Assessment
- Lateral wing Box Stringer Development
- Design of composite rib spar interfaces
- Composites Sandwich Floor Panel Design for A380F
- Design of nose wheel well doors
- 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:

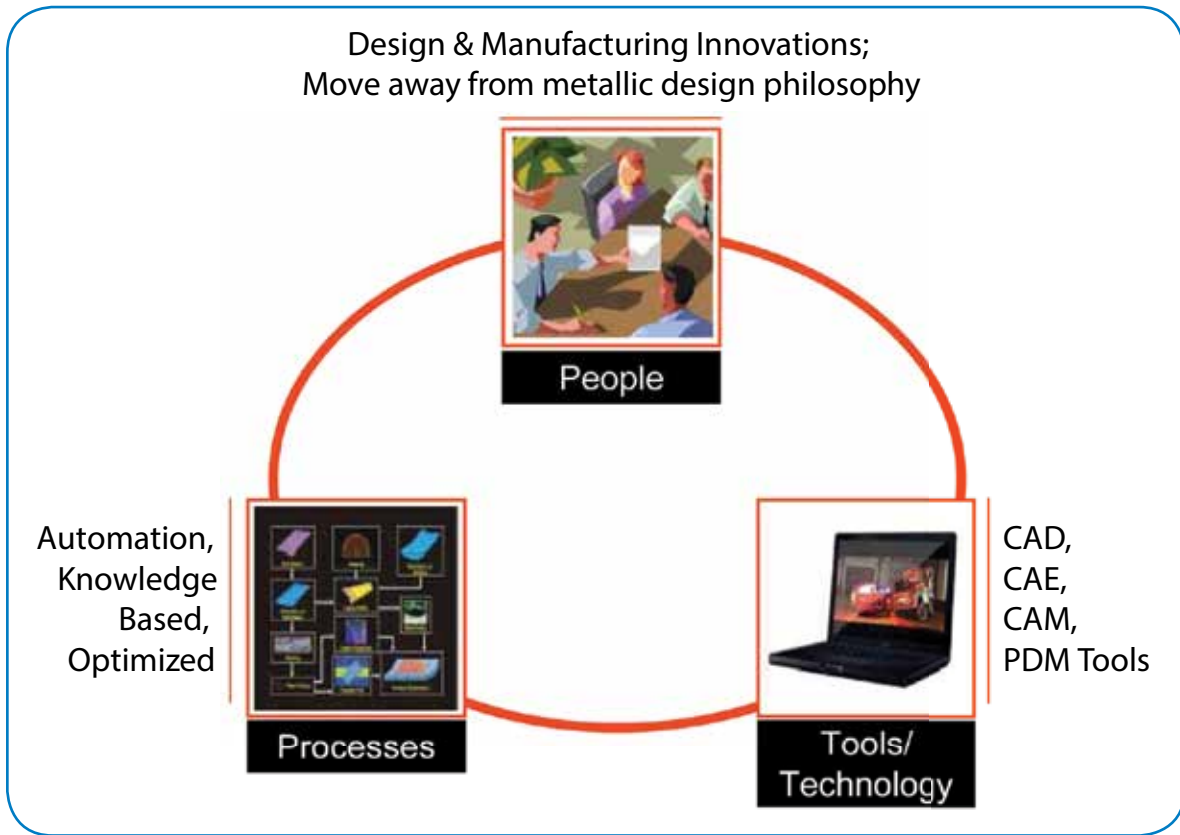


- Composites usage over the years in Commercial Aircraft Industry



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

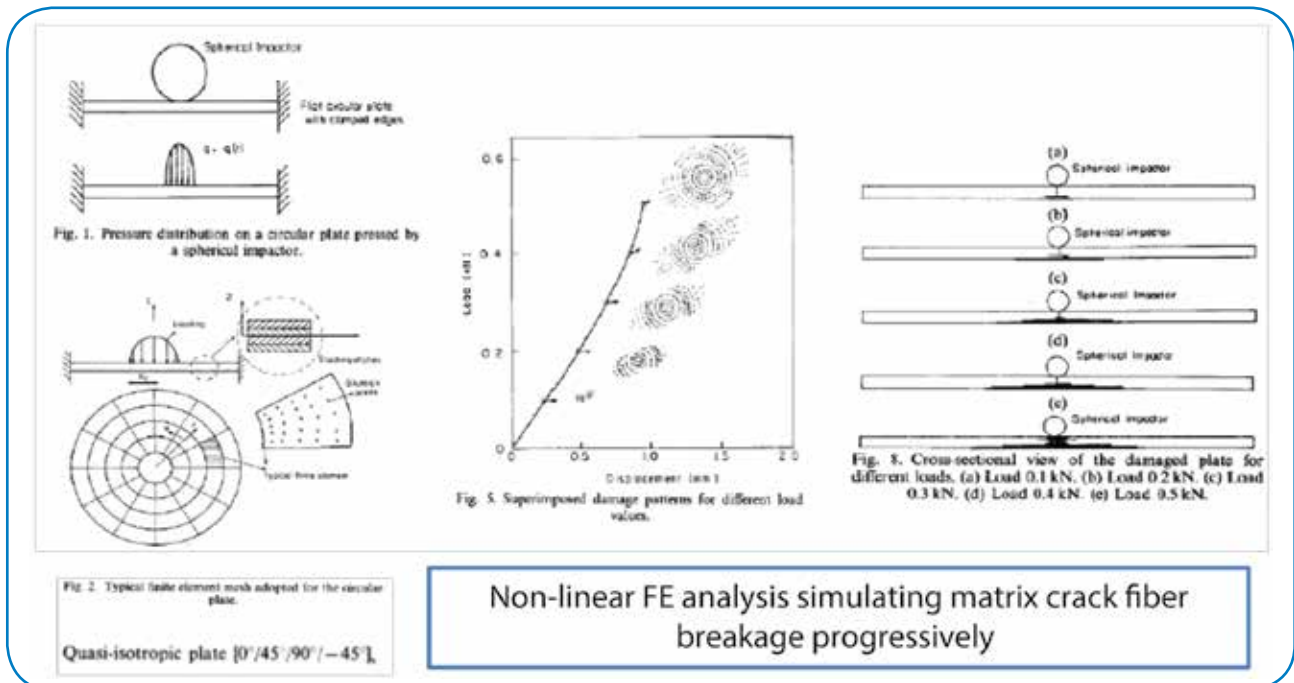
Key Enablers for Composites Growth



FE analysis to Estimate Damage & its Growth

- **Objective**

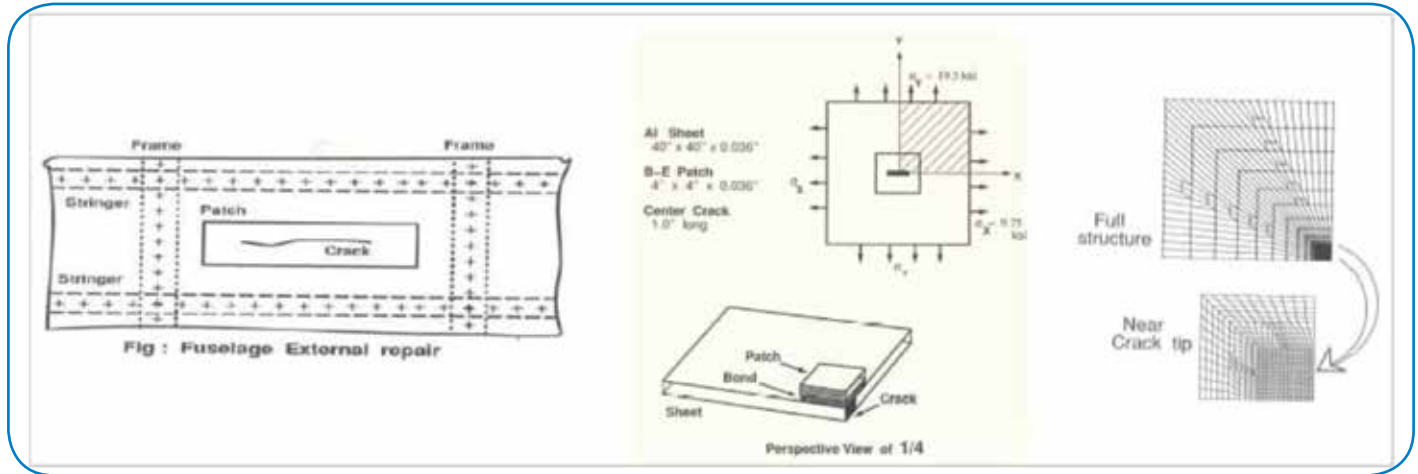
- To estimate damage and its growth under low velocity impact – Debris hit or tool drop



FE analysis to Estimate Damage & its Growth

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..)

The graph plots K_{Ic} (SIF) in $Kcal/\sqrt{in}$ against stations along the sheet thickness (1 to 6). It compares 'Unpatched' (constant high SIF), 'Flat Stopped' (constant low SIF), and 'Unsymmetric Patch' (SIF increasing from Patch End to Far End). The 'Unsymmetric Patch' is further divided into 'Symmetric Patch' and 'Patch End' regions.

The diagram shows a cross-section of a sheet with an un-symmetric patch. The patch is thicker on one side, causing the sheet to bend out of its original plane.

- 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	4.346	3.988	3.628			
Configuration II**	Unsymmetric - Flat	4	4	4	4	4	4
	Unsymmetric - Step	4.652	4.492	4.132	3.772	3.412	3.052

** Maintaining Same patch volume= 0.576 cubic-inch

The diagram compares 'Flat' and 'Stepped' patch configurations. For the 'Flat' patch, the SIF values are 0.036 and 0.004. For the 'Stepped' patch, the SIF values are 0.018 and 0.004. The stepped configuration shows significantly lower SIF values.

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



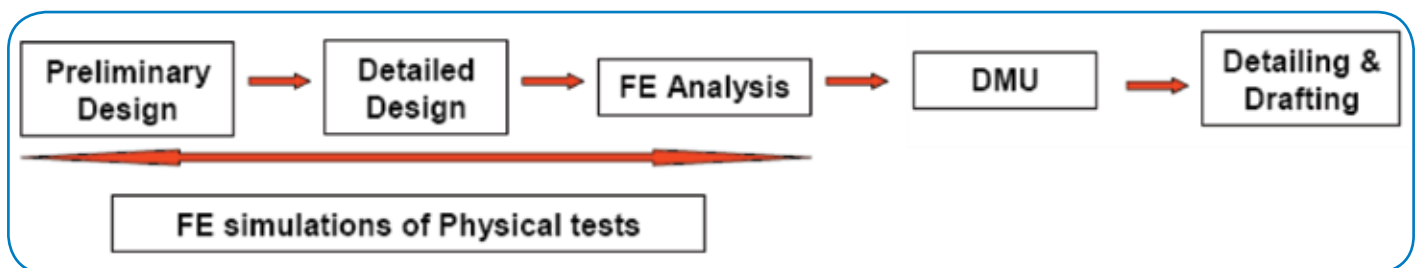
Roll Formed Stringer

Design of composite rib spar interfaces

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • Project Scope: <ul style="list-style-type: none"> — Design support for Airbus lateral wing box composite upper cover stringer development; Stringer & Skin – Non-crimped fabric | <ul style="list-style-type: none"> • Challenges: <ul style="list-style-type: none"> — Co-cured and co-bonded technology — Consideration of maintenance issues during design — Cost of ownership — Mass production | <ul style="list-style-type: none"> • Lessons Learnt: <ul style="list-style-type: none"> — Need for design automation reducing the development time and improved quality — Bridging the technology gaps between Lab to production |
|--|--|---|

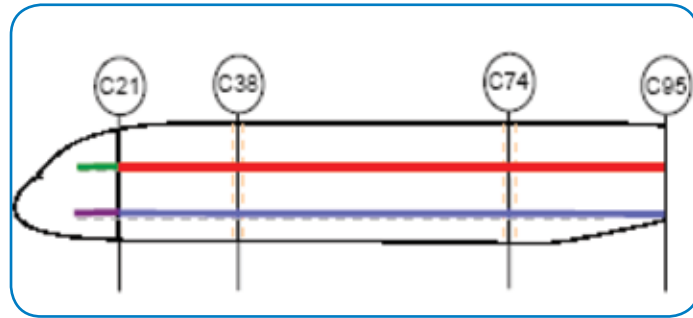
Composites Sandwich Floor Panel Design for A380F

- **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).

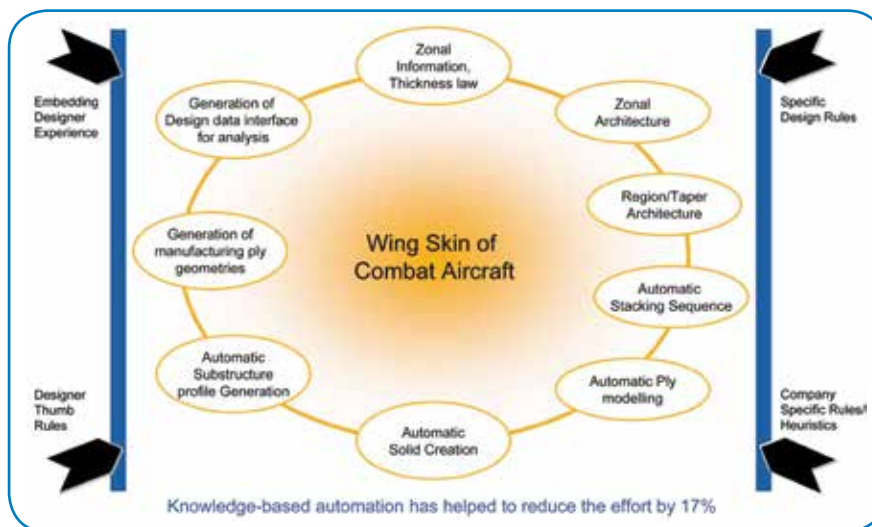
- **Challenges:**

- 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:**

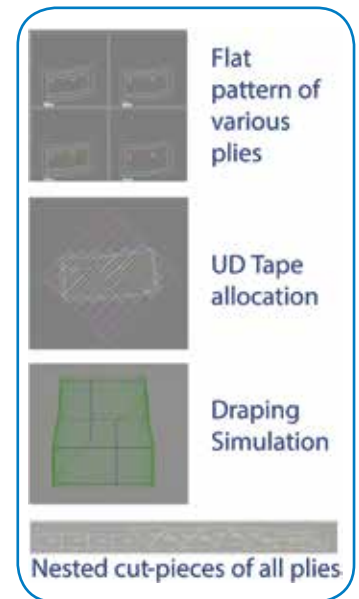
- Company specific design procedures and guidelines
- Need for automation through state of the art tools and utilities
- Limited material test data
- Continuous load and design changes

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:**
 - CADD55, AUTOLAY(CADD5-COMPOSITES)



Infosys Resources/Tools Role in Other Leading Composites programs

<p style="text-align: center;">Indian LCA</p>  <p style="text-align: center;">Design & Development of CFC Wing & Fin skins Fuselage bulkheads Radome, Fuel tanks Cockpit, Sandwich floors</p>	<p style="text-align: center;">HANSA</p>  <p style="text-align: center;">Design & Development of Composite panels of all composite two seat trainer aircraft, complied with JAR/VLA requirements</p>	<p style="text-align: center;">CADD5-COMPOSITES in AIRBUS</p>  <p style="text-align: center;">A380: Central torsion box, ailerons, floor panels TANGO: Central torsion box, aileron A340: Keel beam, fin</p>
--	---	---

For more information, contact askus@infosys.com



© 2017 Infosys Limited, Bengaluru, India. All Rights Reserved. Infosys believes the information in this document is accurate as of its publication date; such information is subject to change without notice. Infosys acknowledges the proprietary rights of other companies to the trademarks, product names and such other intellectual property rights mentioned in this document. Except as expressly permitted, neither this documentation nor any part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, printing, photocopying, recording or otherwise, without the prior permission of Infosys Limited and/ or any named intellectual property rights holders under this document.