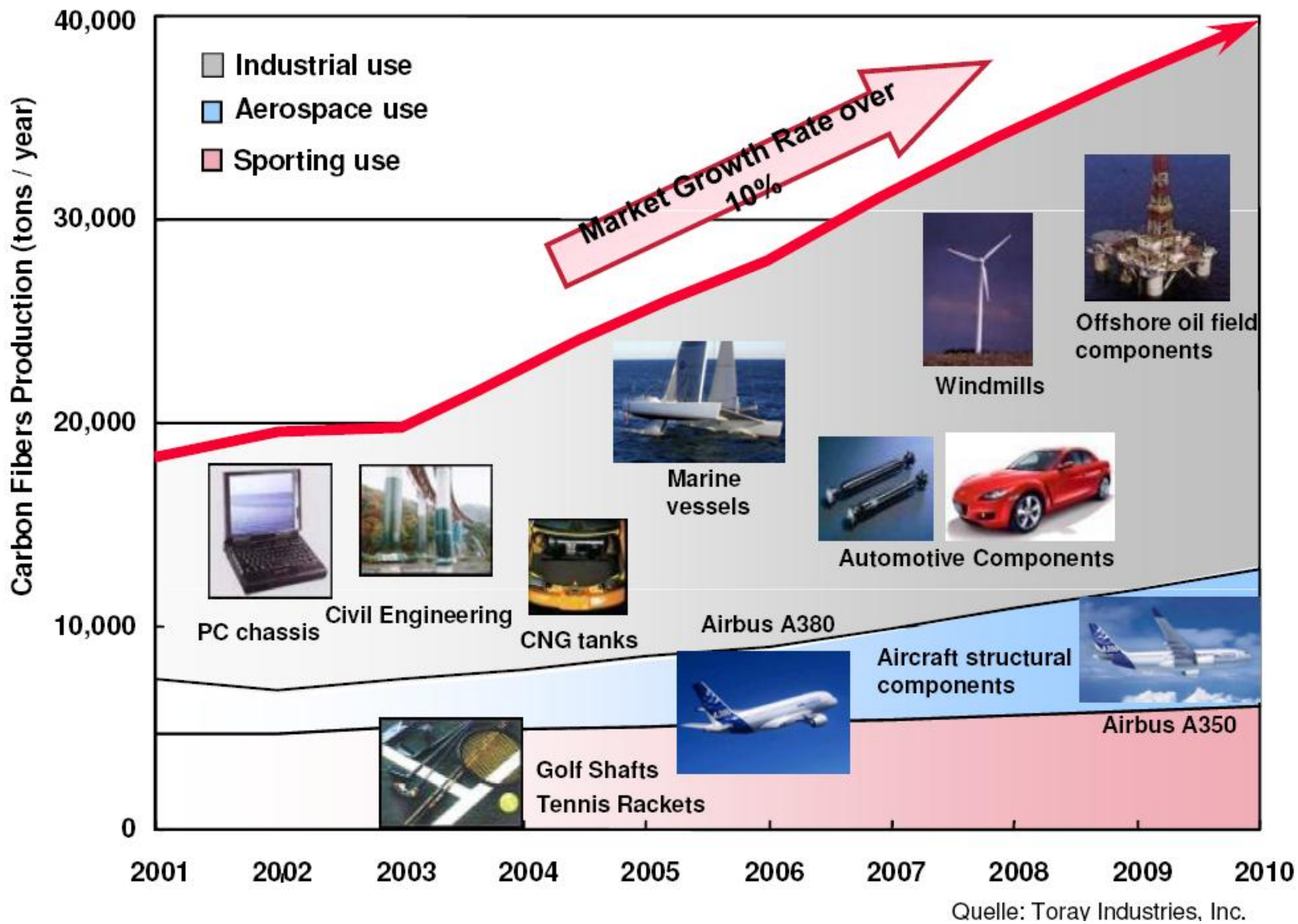
2. Augsburger Produktionstechnik-Kolloquium

Automatisierungsbedarfe in der CFK-Produktion

Presented by
Jörg Petermann

Table of Contents

Applications of composites



~5% Air traffic growth

Growing market for composite materials
Rising importance of other industries

Composite structural weight evolution in Airbus fleet

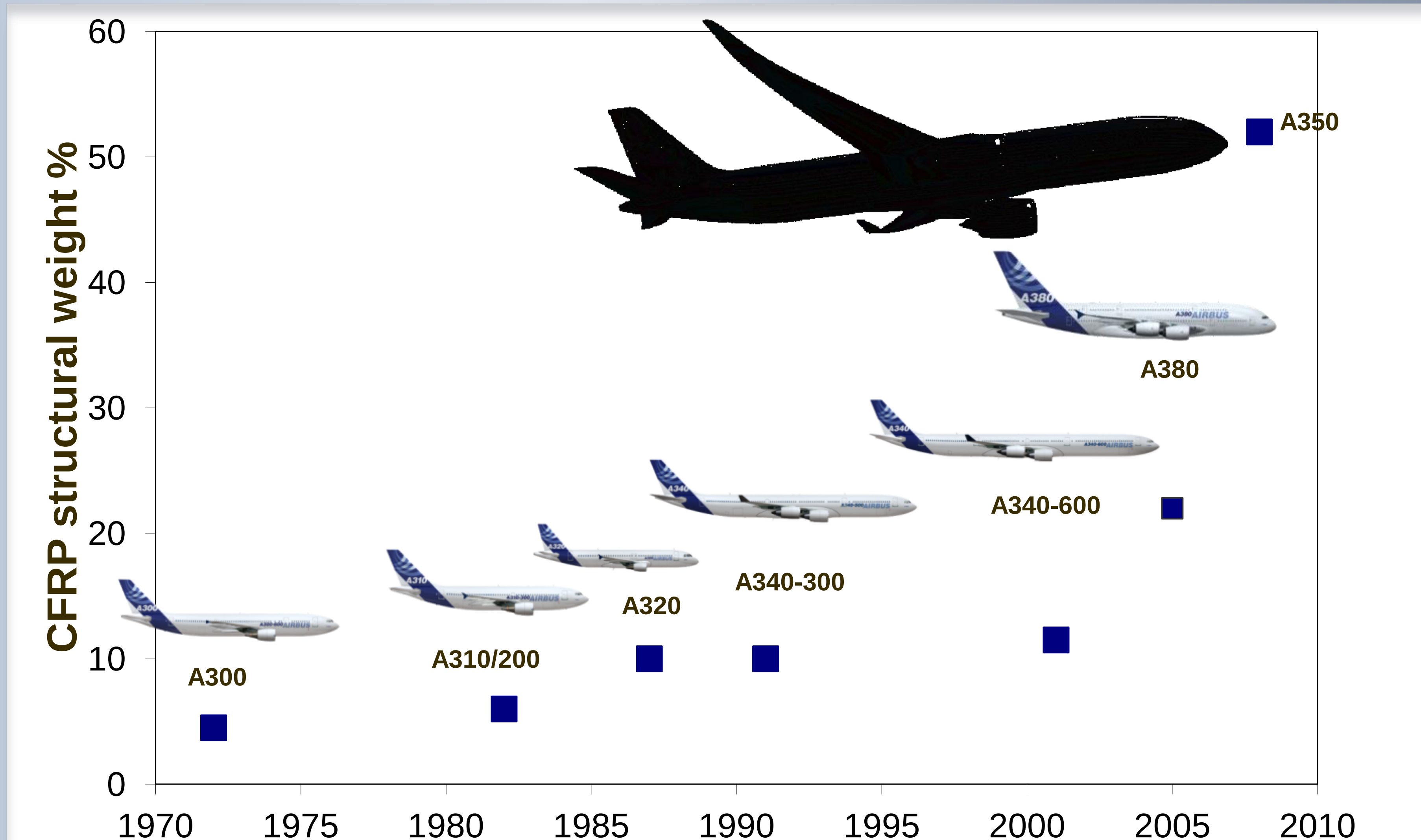
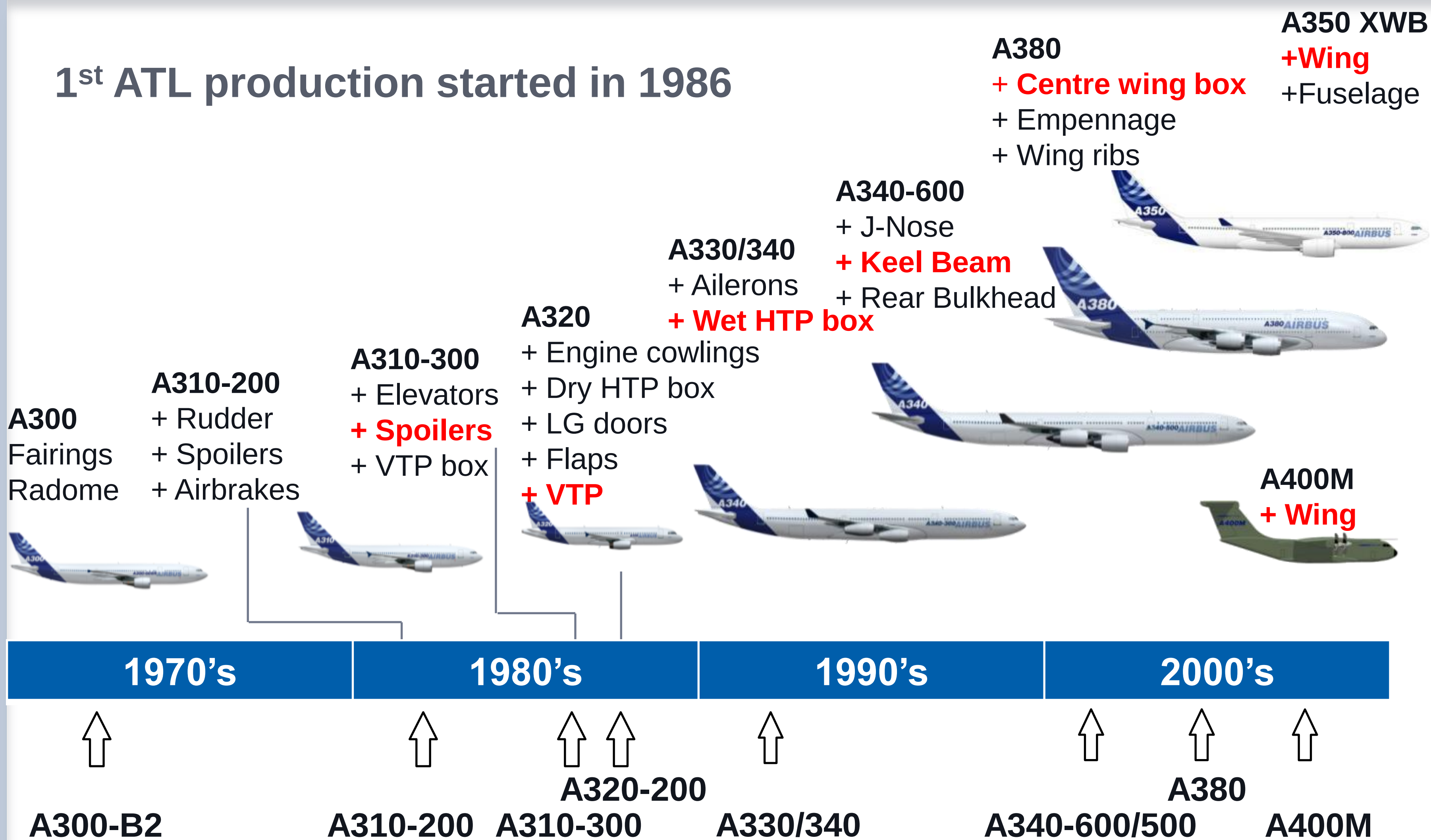


Table of Contents

Automation in Composites Manufacturing

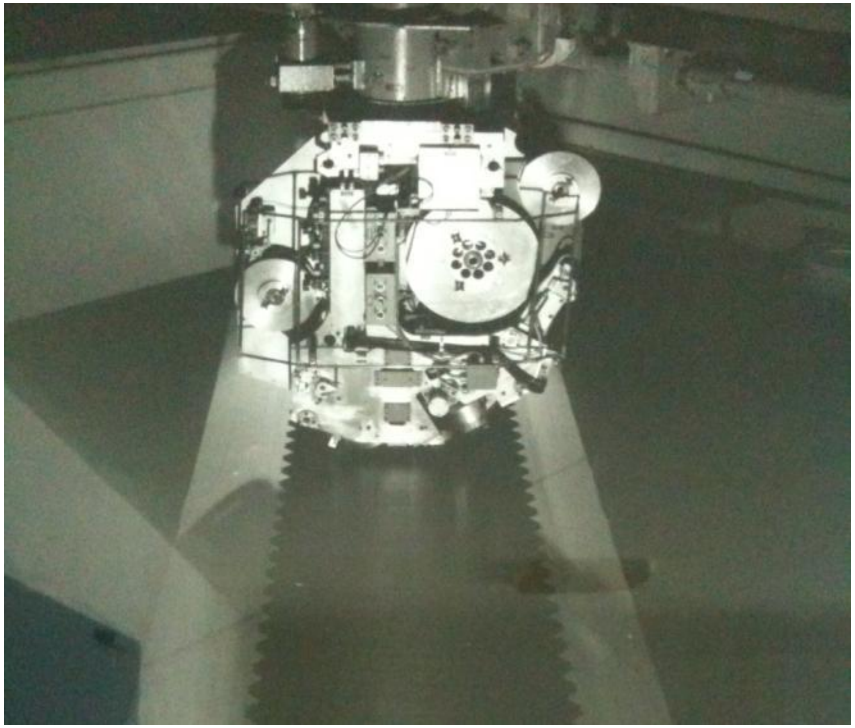
1st ATL production started in 1986

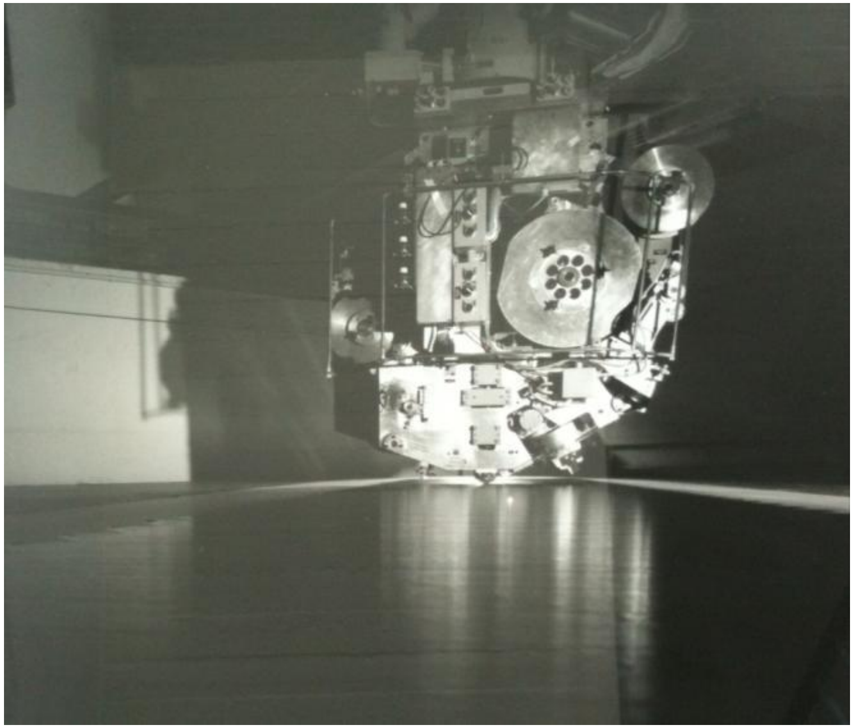


Automated Tape Laying (ATL)

Early ATL Production at Airbus Stade, 1986

A310/A300-600 Spoiler





Automatic Tape Laying (ATL)

A350 XWB Lower Wing Cover ATL, 2011

- 33m long, 7 m wide
- Span and chord wise curvature, 3D geometry with steering
- Complex Ply ramping, parallel to spar and stringers
- Some functional materials laid up automatically (ECF, glass, peel ply)

Automated Tape Laying (ATL)

Era	1970's	1980's	1990's	2010's
Aircraft	**A300**	**A310/A320**	**A330**	**A350 XWB**
Process	manual layup, with aids	9-axis ATL	11-axis ATL	11-axis ATL
Complexity	–	2D - limited 3D	moderate 3D	3D with steering
Size	–	7m	12m	33m
Material type	woven prepreg	UD prepreg	UD prepreg	UD pregreg
Material width	–	75mm	150mm	300mm
Functional materials	manual layup	manual layup	manual layup	ATL

Today's material requirements:
- Carbon prepreg: Improved material performance, different fibre areal weight grades
- Glass prepreg
- Expanded copper foil (prepreg)
- Peel ply (prepreg)

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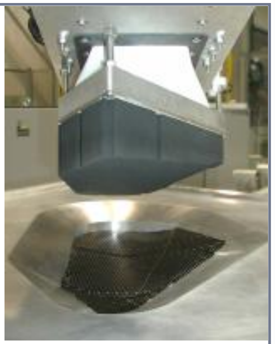
Automated RTM



Handling devices

Main Innovations

- Automated cutting of preforms
- Automated handling of textile blanks by robots
- Introduction of Microwave technology for consolidation of preforms
- Automated resin- and vacuum-supply with a reduction of waste material
- Demoulding of cured part by robot
- Automated cleaning of tool

**Highly automated process chain for RTM part manufacturing available.
Stepwise implementation to shop floor.**

Automation in Structure Assembly

- Past: 3 manual steps (drilling, countersinking, reaming) of thick multi-material stacks

Presence: Flexible Drilling Head System

- One-shot drilling process with very good quality results regarding diameter and countersink
- Hand over to production in November 2010
- Reduction of lead time
- Huge improvement of ergonomic situation for workers

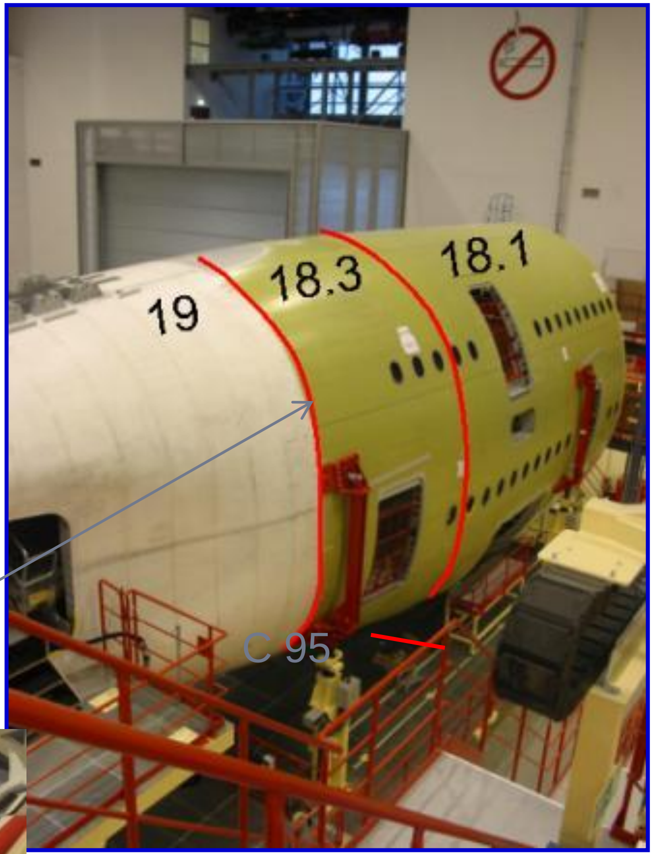
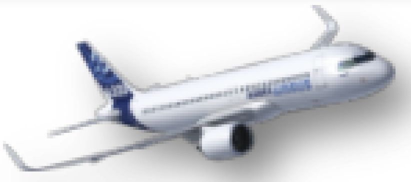


Table of Contents

Product Policy



Short term

- 2015 A320 NEO
- 2017 A350-1000

Mid term: Derivatives Improvements

- 2020+ A320 NEO, A380 and A350 Improvements

Short/mid term

- Improvement potential in processes enhancements in constrained architecture and supply chain
- **Industrial driver: Low cost, high flexibility**

Long term

- Special machinery (1 machine for 1 application) limited to automation for large components/assemblies at start of a/c program

Requirements for Next Aircraft Generation

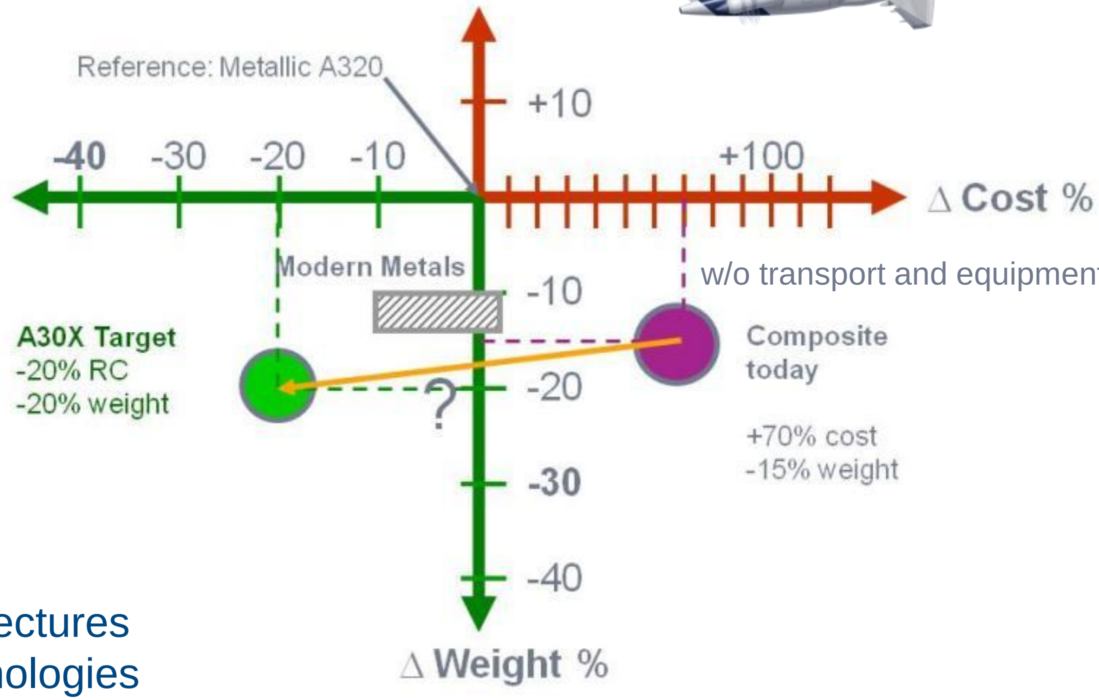
Proof of future applications of composites in weight vs cost trades

Weight
-20% airframe weight

Cost:
-20% recurring cost

Industrial system
Fast Ramp-up
Robust and scalable production

➔ **Higher Efficiency by**
- All new materials and architectures
- All new manufacturing technologies
- More Automation



Automation as a key facilitator for process cost reduction.

Finding the Optimum Level of Automation

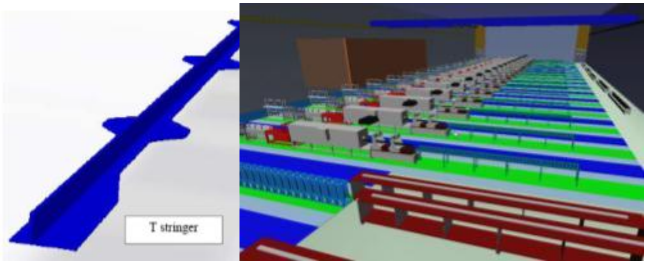
with respect to:

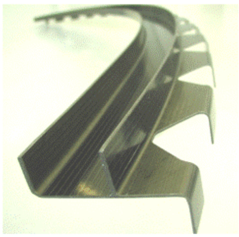
- **Boundary conditions**
  - Number of parts
  - Complexity of parts
- **Economics of the industrial system**
  - Cost of non quality
  - Process steps vs process chain
  - Continuous vs discontinuous processes
  - Estimated total production time
  - Critical path
- **Human centred production**
  - Repetitive work load
  - Critical ergonomic operations

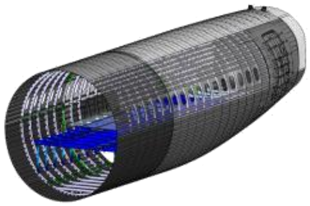
Automation strategy as a multi-variant optimisation problem.

Automatisierungsstrategie 1/3

- **Welcher Automatisierungsgrad für welche Produktionsrate?**





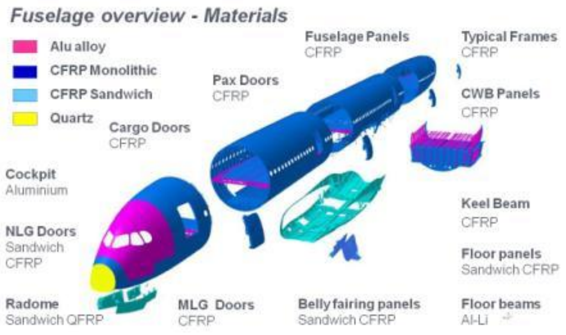


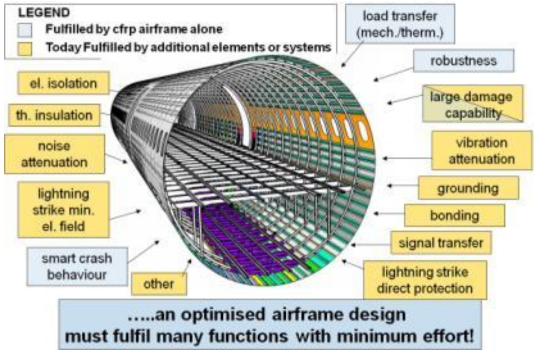
ca. 920 km Stringer p.a.

ca. 180.000 Spante p.a

ca. 40 a/c p.m.

- **Welcher Automatisierungsgrad für welche Bauteilkomplexität (Bauweise vs. Werkstoffe)**



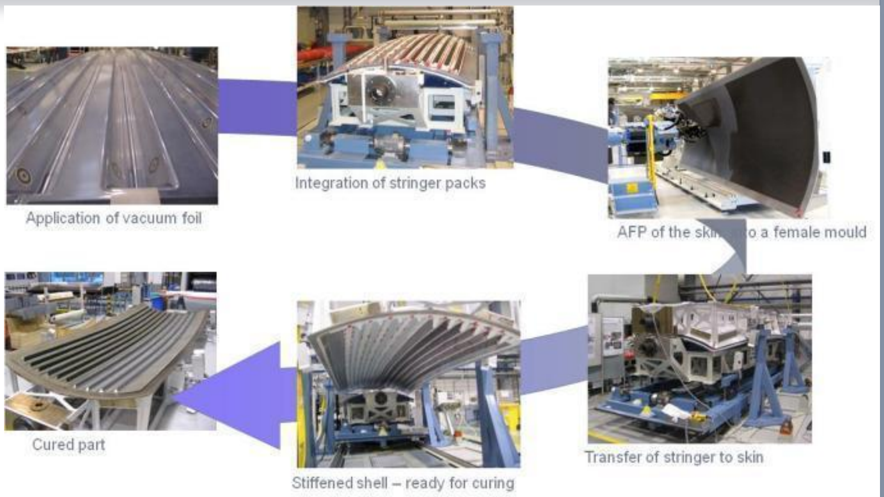


Materialmix

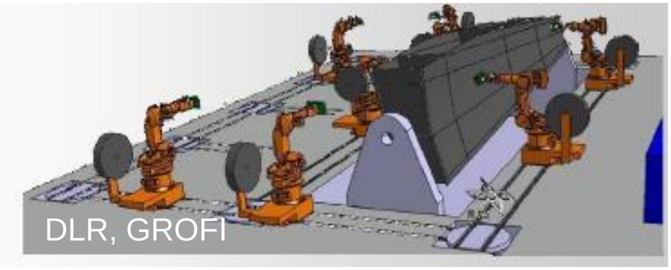
Funktionsintegration

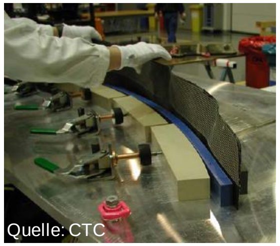
Automatisierungsstrategie 2/3

- **Welcher Automatisierungsgrad für einzelne Prozessschritte/ die ganze Prozesskette?**
  - Teilefertigung und/oder Montage
  - Wo liegt der kritische Pfad?
  - Welche Produktionsschritte an welchen Stationen?
  - Wieviele Stationen für denselben Prozessschritt?
  - Kombination kontinuierlicher/nicht kontinuierlichen Verfahren



Automated Integration of stringers





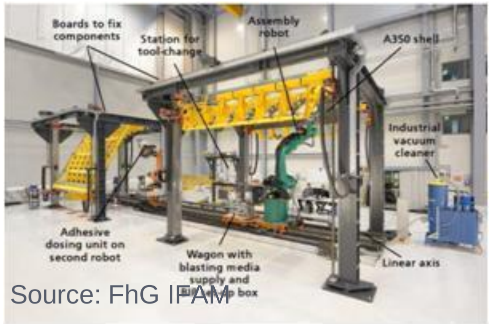
Automatisierungsstrategie 3/3

- **Automatisierung als Innovationstreiber für neue Bauweisen und korrespondierende Produktionssysteme**
    - Einfache Formen (2D vs 3D)
    - Nutzung der Bauteilsteifigkeit
    - Ortsreferenzierung/Geolokalisierung
    - Zugänglichkeit (Blindniete, Mensch-Maschine Interaktion)

- **Antizipation zukünftiger Produktionsprozesse**
    - ATL→AFP/textile Halbzeuge
    - Bohren → Kleben/Schweißen

- **Erfüllung allg. und spezieller Anforderungen**
    - Genauigkeiten (Positionierung, Wiederholung)
    - Kein CFK Staub in der Systeminstallation (kein Bohrstaub vs. kein Bohren)

Source: EADS IW



Source: FhG IFAM

Source: Dust Control

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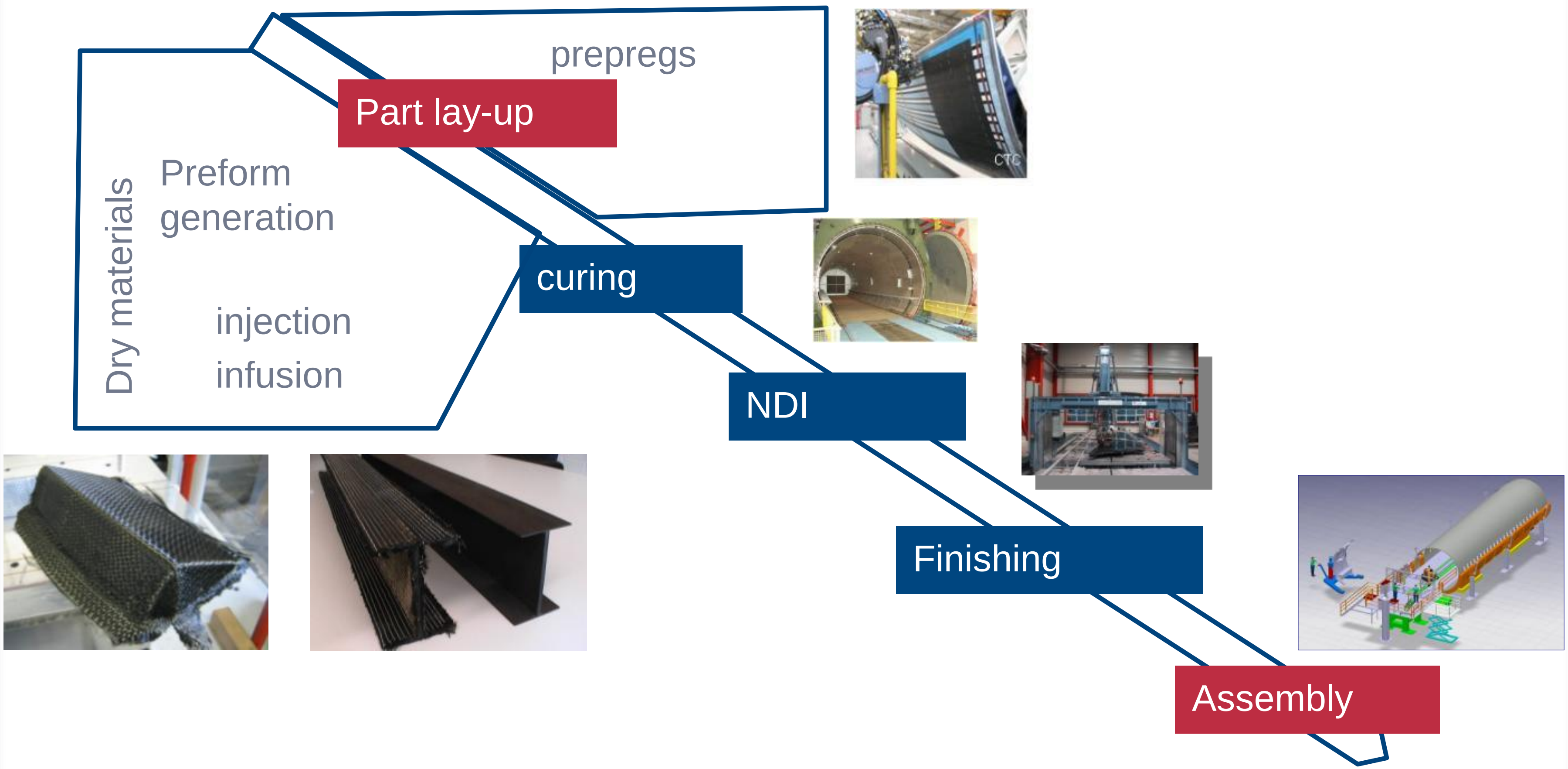
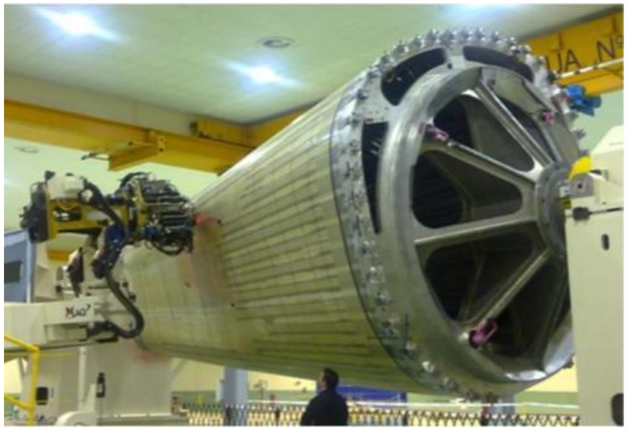
Table of Contents

Composite Process Chain



Lay-up by ATL/AFP



State of the Art

- ✓ Well adapted for large and thin /thick structures
- ✓ Reduction of scrap
- ✓ Customized stacking sequences
- ✓ High accuracy and repeatability

- ! High maintenance effort
- ! Lower averaged deposition rate
- ! Higher NRCs
- ! Too specific devices (tools, heads, etc.)

Needs

- Automated cleaning of tools
- Automated lay-up of auxillary materials (vacuum bag, breather…)
- Calculation and prediction of productivity
- Systematic online monitoring of production parameters/disturbances
- Feed production parameter to design loop

Ablegen textiler Halbzeuge

Technologie

- Prozesskette bestehend aus den Schritten Vorkonfektionieren, Aufnehmen des Zuschnittes und Ablegen auf dem Werkzeug
- Beliebige Wiederholung der Prozessschritte
- Ablage von bis zu vier unterschiedlichen Faserausrichtungen je Ablegeschritt

Automatisierte Ablage von Trockenfaser-halbzeugen mittels Rollen-Effektor in 2D

Bedarfe

- Entwicklung automatisierter Effektoren zum Ablegen von Trockenfaserzuschnitten
- Erstellen von Preforms für großflächige einfach und doppelt gekrümmte Bauteile
- Handhabung komplexer Zuschnitte
- Erhöhung der Ablegerate
- Erhöhung der Positioniergenauigkeit
- Verbesserung der Drapierfähigkeit von Multiaxialgelegen
- Prozessmonitoring

Ablage eines biaxialen Geleges in 3D

Automated Systems for Major Components Assembly

Needs:

- Low NRC for system → short return of invest time
- Multi Operations → max. reduction of manual workload
- Flexible → mobile, multi use cases, multi programme
- Cooperative & safe → can operate in same environment with worker
- Standards → standard components/solution for hard- & software
- OEE* → 100% (system is running 24/7 without any stops)
- Easy → can be positioned/operated by any worker
- Communication → worker/machine and machine/machine communication

Objective: Minimized machine hourly rate!

*OEE = Overall Equipment Effectiveness

Out of Automation Strategy - examples

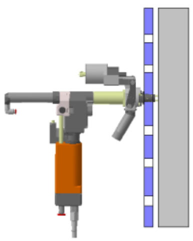
High NRC, stationary, specific solution for one Use Case, low OEE, complex, high qualified staff

The pictures shown are only examples for visualization and have no link to the statements on this slide

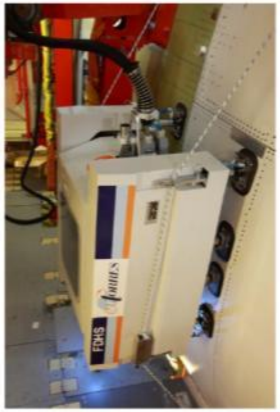
Drilling possibilities for external junctions
(with countersinking)

CURRENT / BEST PRACTICE

Concentric collet
+
Thick template



Crawler robot
(double curved)



FUTURE NEED

System requirements:

- light
- collaborative
- fully modular
- low capital expenditure
- different operations with one system
- parallelisation of work

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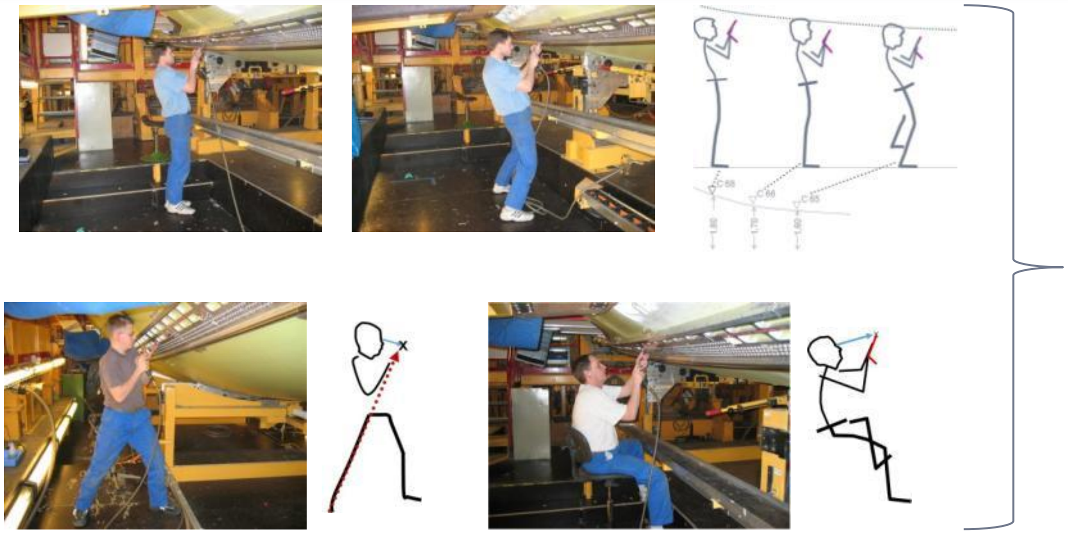
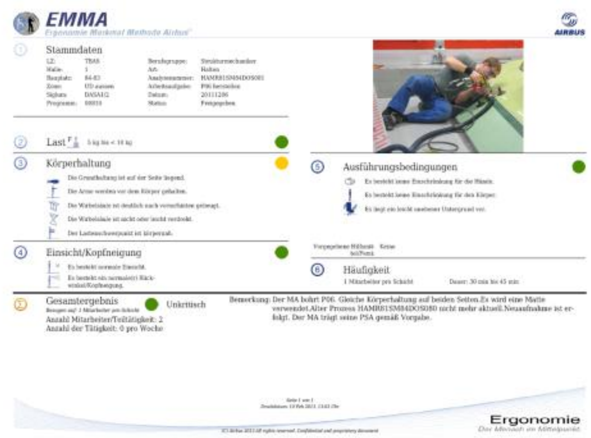
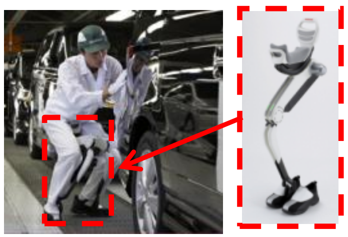
Human Centred Production



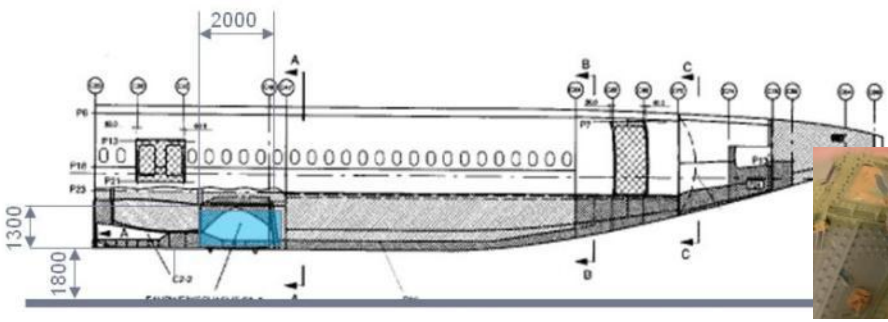


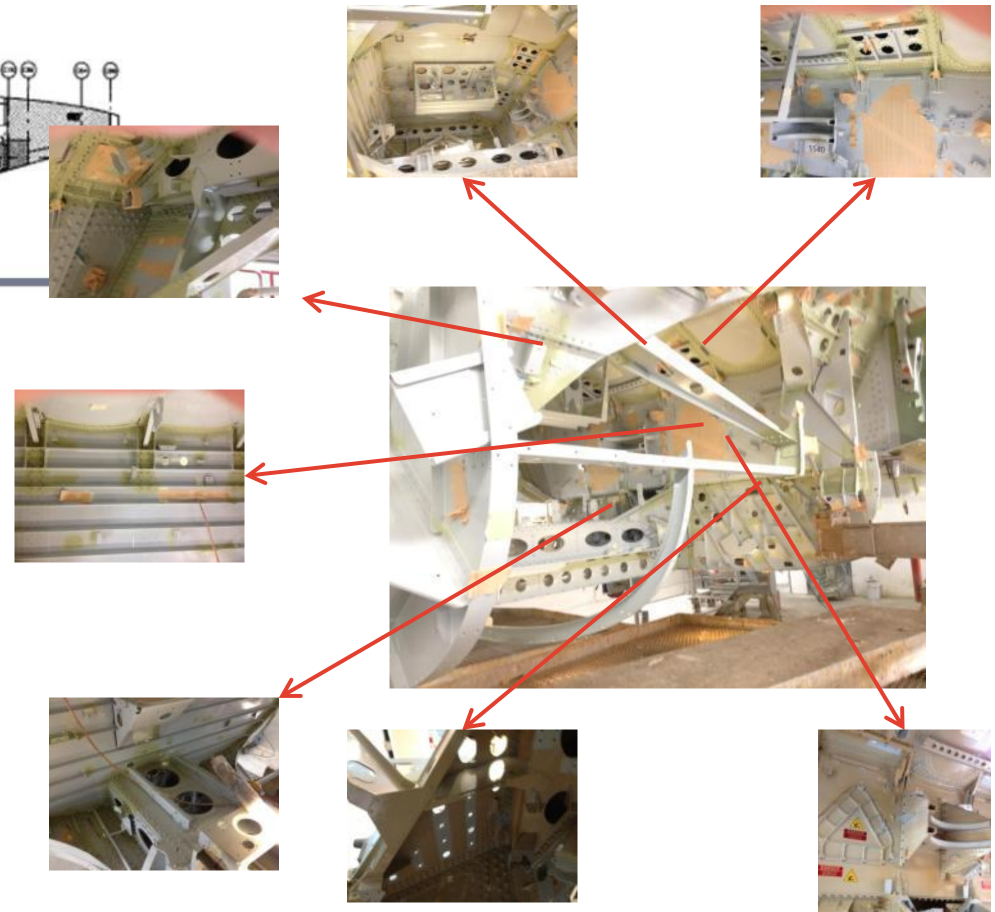


Needs

- Enable “real” human/machine interaction
- Copy human motions for remote execution or learning mode

Human Centred Production
Automated Surface Protection





- Komplexe Geometrie
- Flexible Einsatzorte
- Off-line Programmierung
- Explosionsschutzanforderungen im Arbeitsbereich
- Räumliche Nähe zwischen Mensch und Maschine
- Kurze Rüstzeiten, diverse Werkzeuge
- Verschiedene Materialien
- Kleine Arbeitspakete mit geringer Häufigkeit

Ziel der Automatisierung ist eine Reduzierung der manuellen Applikationstätigkeiten um 75%.

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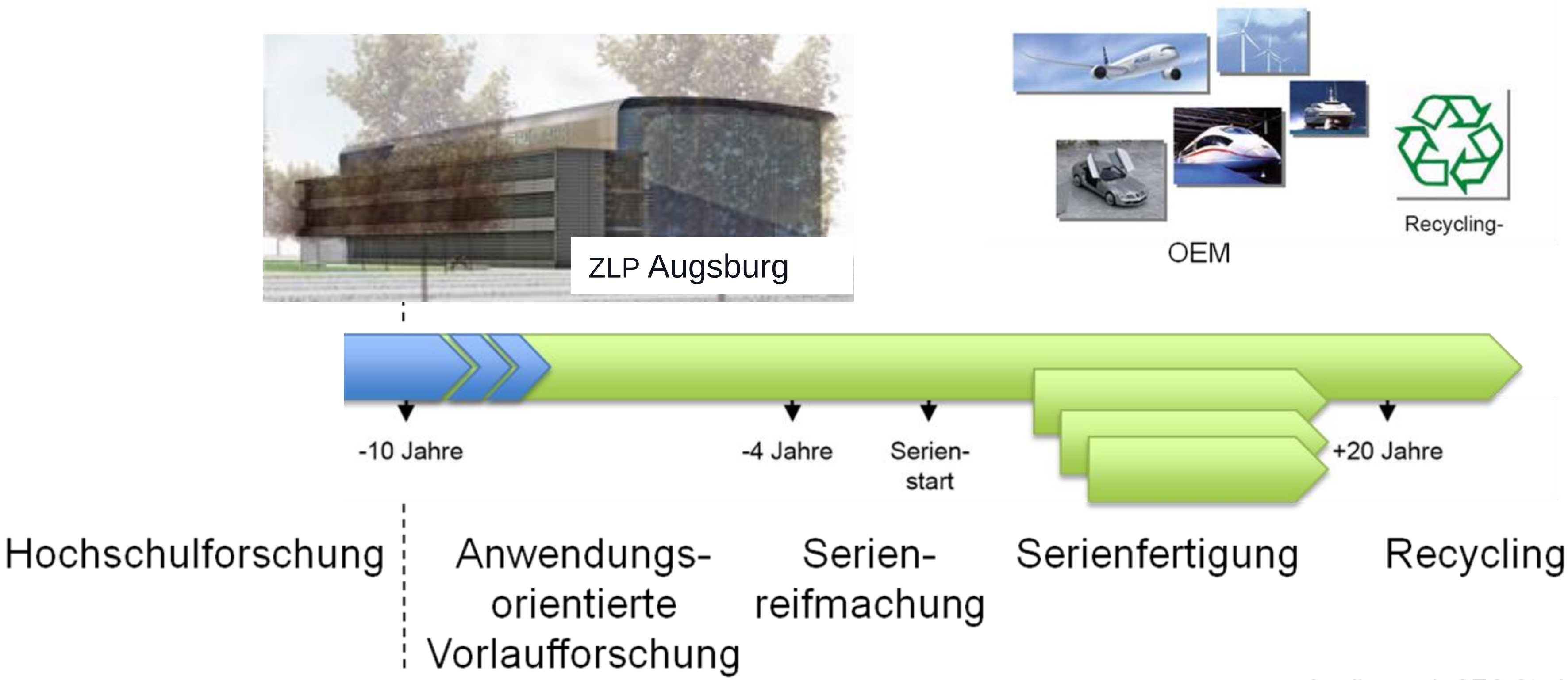
Table of Contents

Technologiezentren im Entwicklungszyklus



Quelle: nach CTC Stade

Technologiezentren im Forschungsumfeld von Airbus/EADS

Nantes

Madrid

Stade

Augsburg ?

Filton

Hamburg (under construction)

Technologiezentren mit unterschiedlichen Kompetenzprofilen und Partnernetzwerken.

Table of Contents

Summary

- Airbus has accumulated by a step-by-step approach experience along the composite process chain – from part manufacturing to assembly
- Development efforts must not be focused on new technologies only, but also on continuous improvement of existing products and processes
- Process automation as a basic strategy must be carefully analysed to exploit the full potential for composite and metallic light-weight structures
- Variety of remaining composite research & industrialisation needs involving automation
- Need for flexible collaborative systems for assembly and system installation
- Potential for close industrial research collaboration for between ZLP Augsburg and Airbus