

Operations

our passion makes ideas fly...



Manufacturing Engineering

2. Augsburger Produktionstechnik-Kolloquium

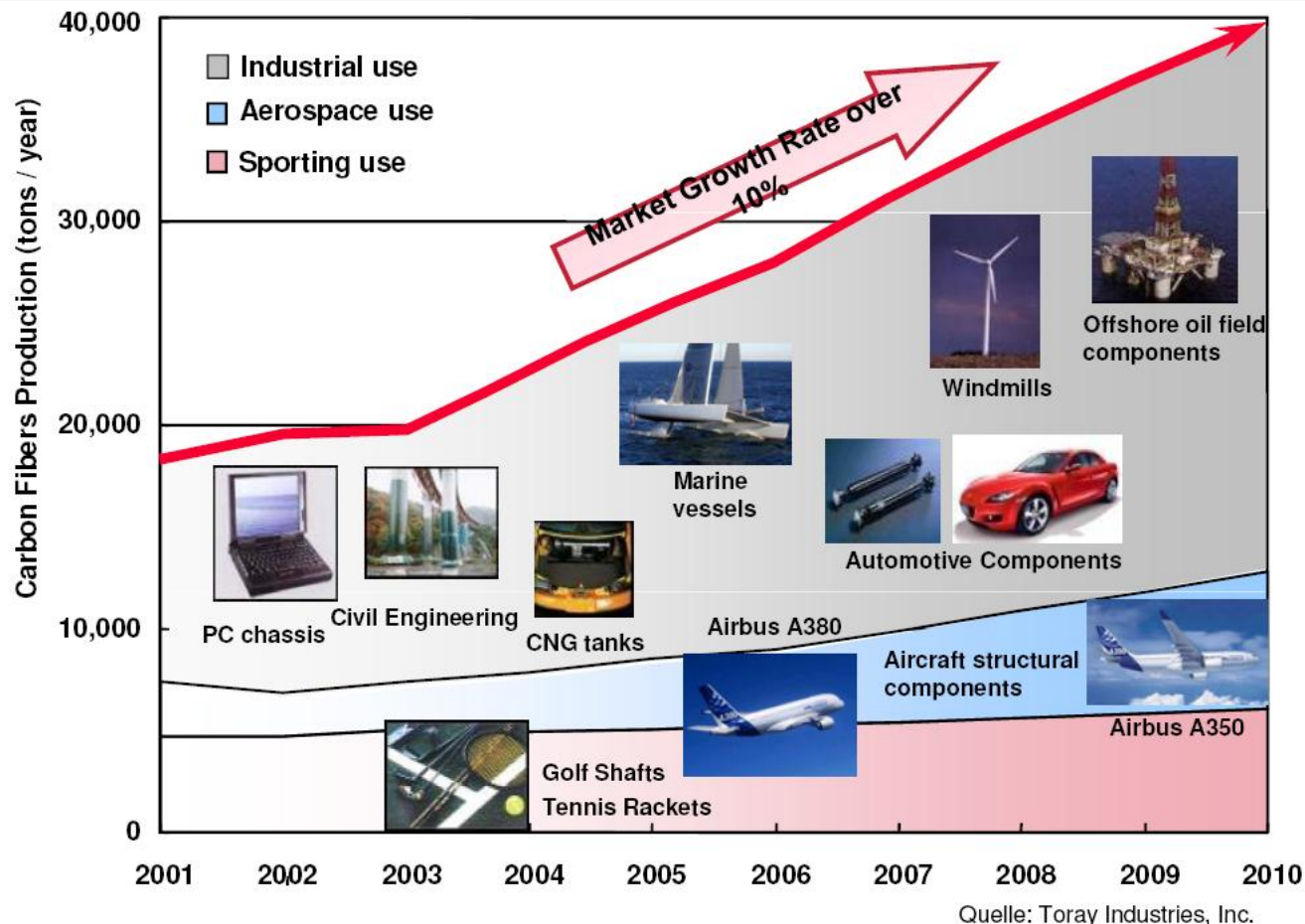
Automatisierungsbedarfe in der CFK-Produktion

Presented by
Jörg Petermann

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Applications of composites



~5% Air traffic growth

Growing market for composite materials
Rising importance of other industries

Composite structural weight evolution in Airbus fleet

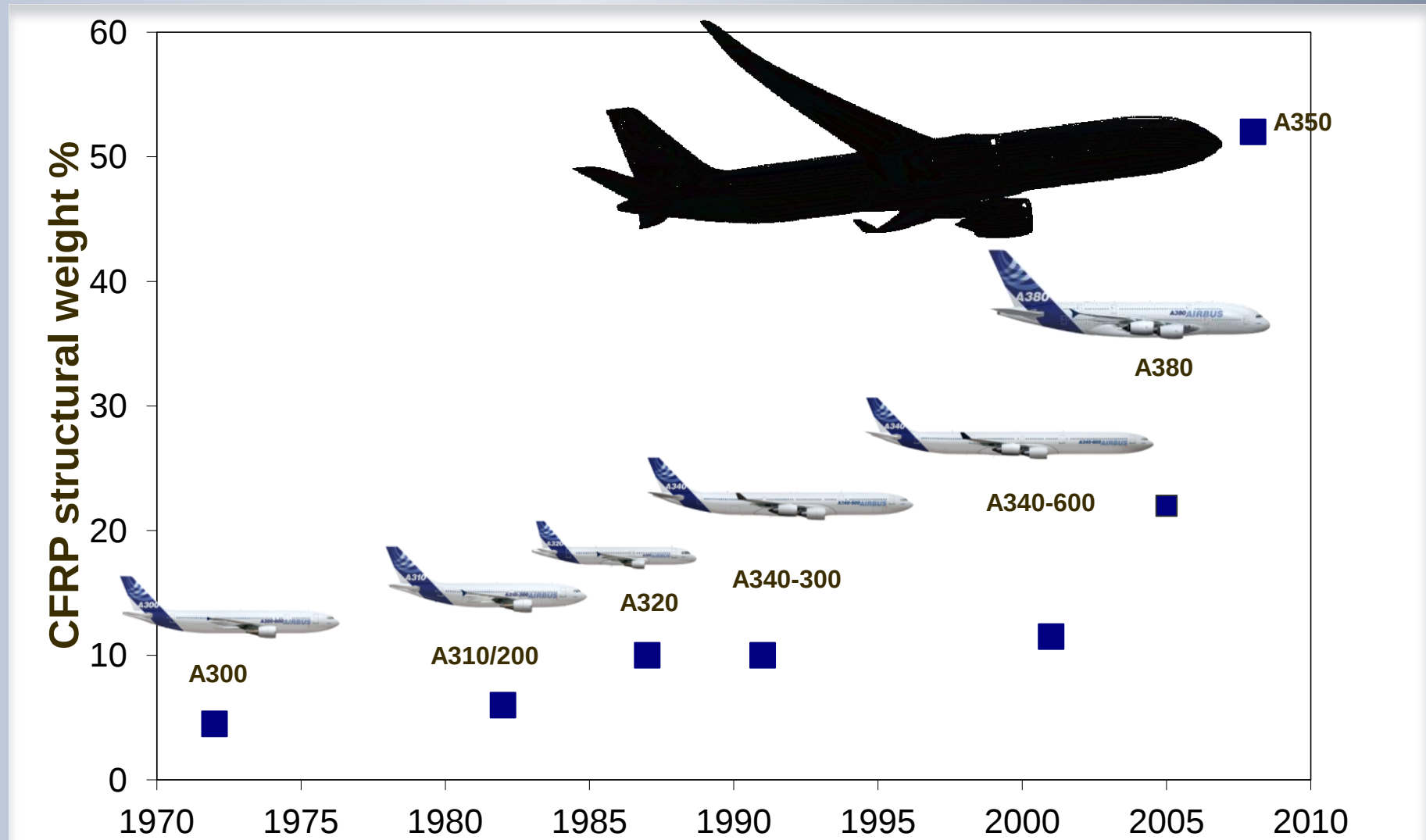


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- **Automated tape laying**
- **Automated RTM**
- **Automated structure assembly**

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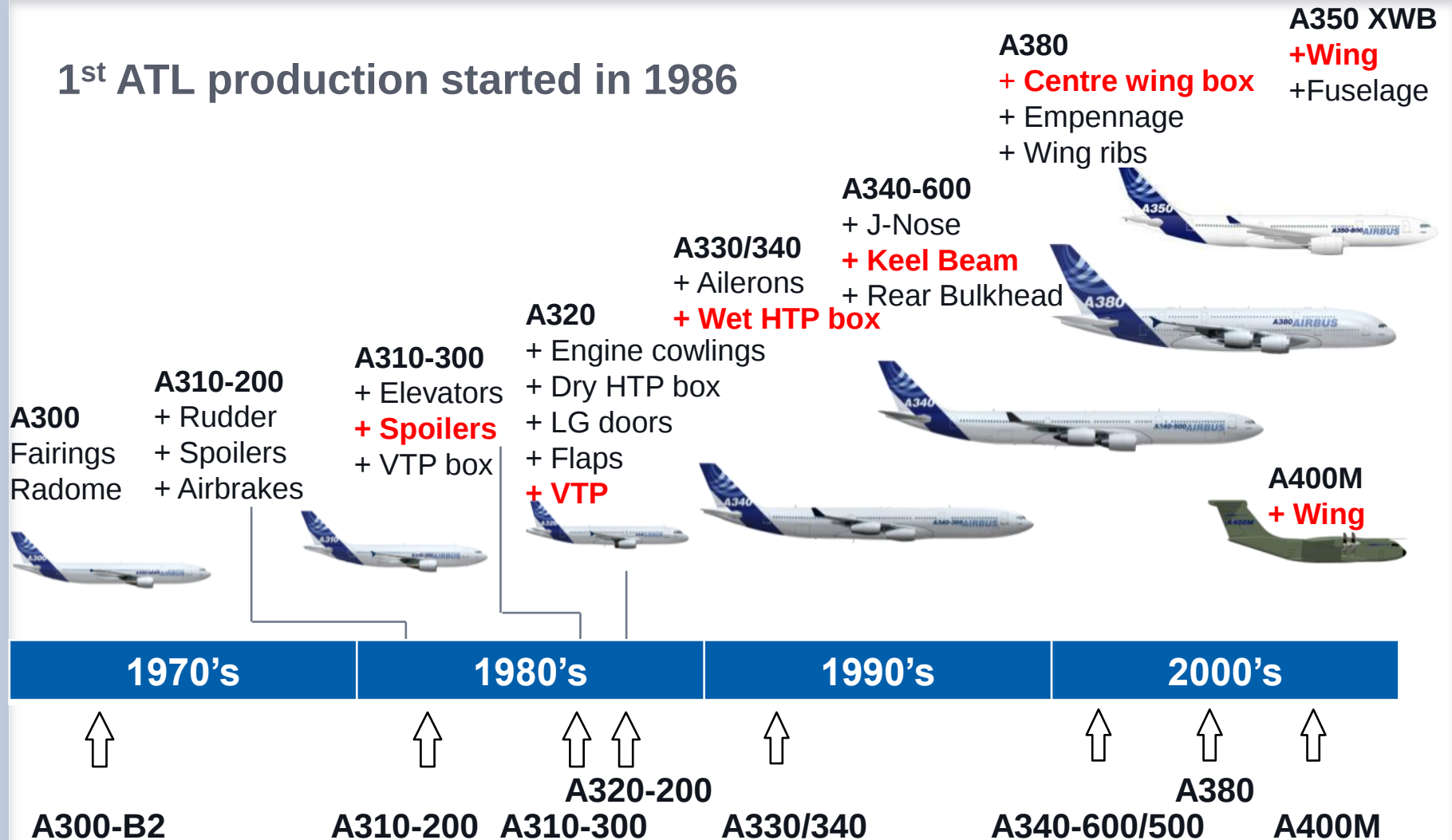
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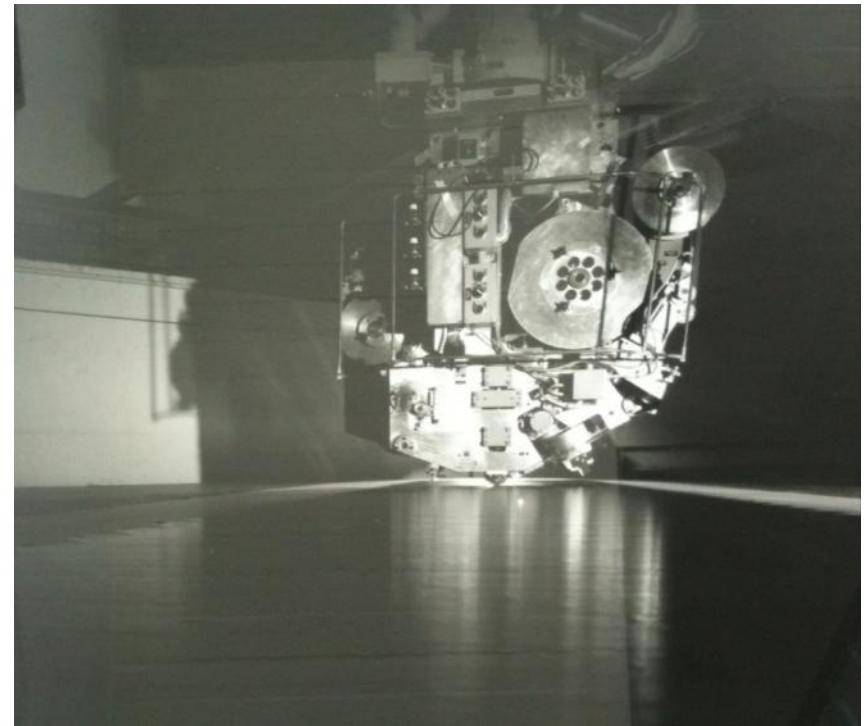
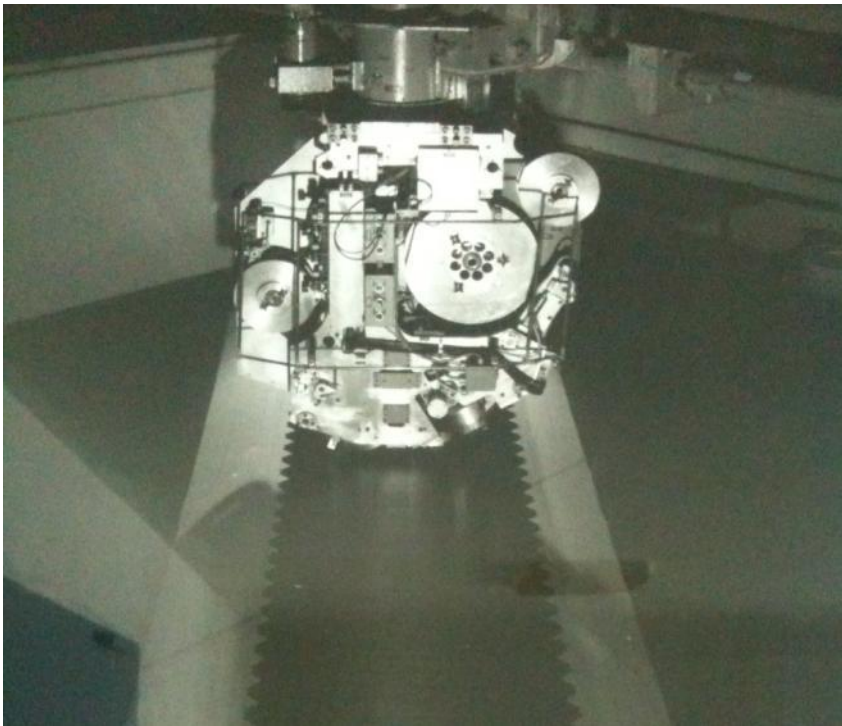
Automation in Composites Manufacturing

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 prepreg
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)

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

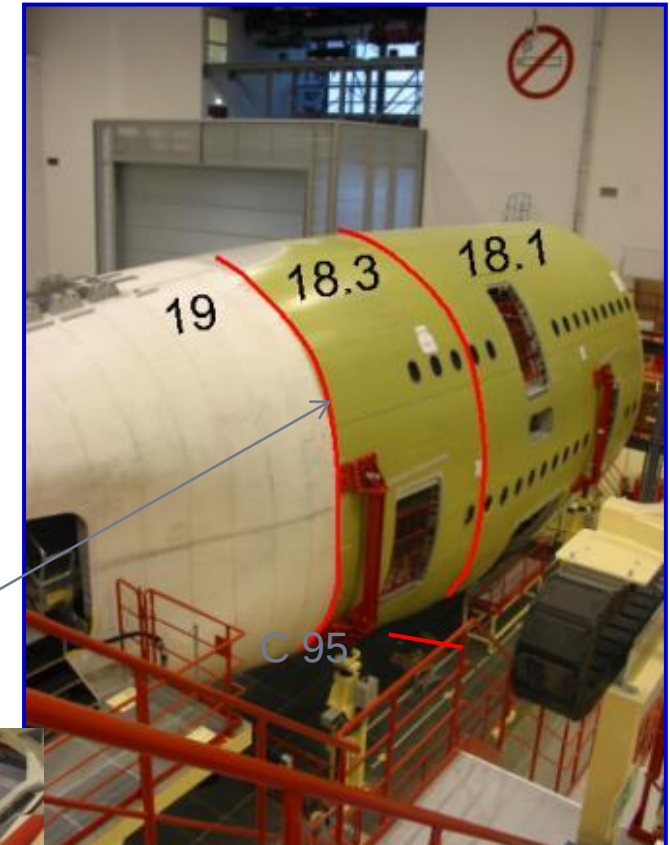


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Product Policy

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

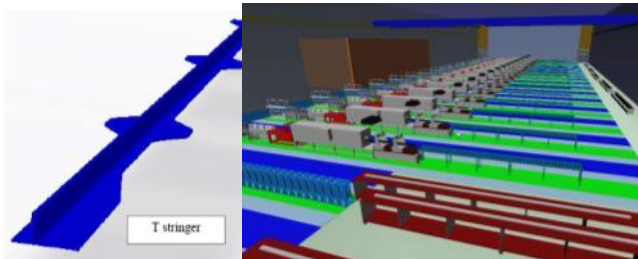
with respect to:

- **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

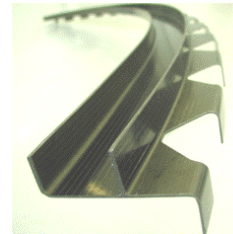
Automation strategy as a multi-variant optimisation problem.

Automatisierungsstrategie 1/3

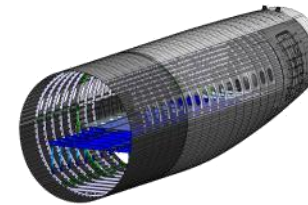
Welcher Automatisierungsgrad für welche Produktionsrate?



ca. 920 km Stringer p.a.



ca. 180.000 Spante p.a.



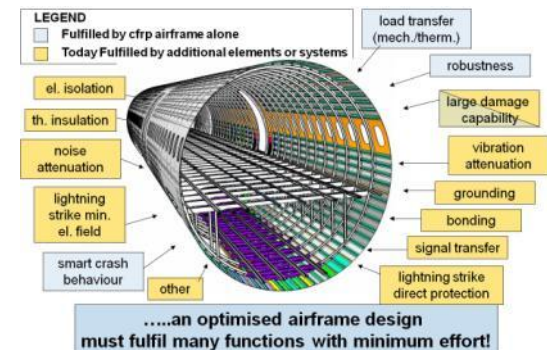
ca. 40 a/c p.m.

Welcher Automatisierungsgrad für welche Bauteilkomplexität (Bauweise vs. Werkstoffe)

Fuselage overview - Materials



Materialmix

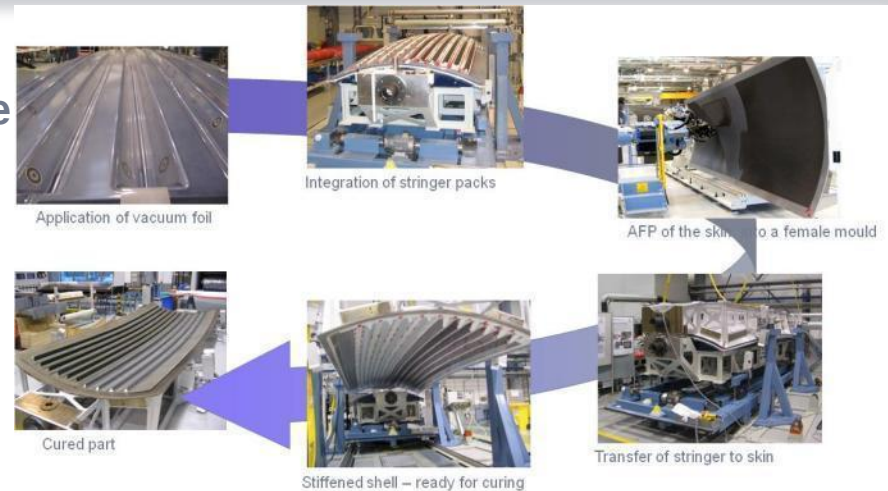


Funktionsintegration

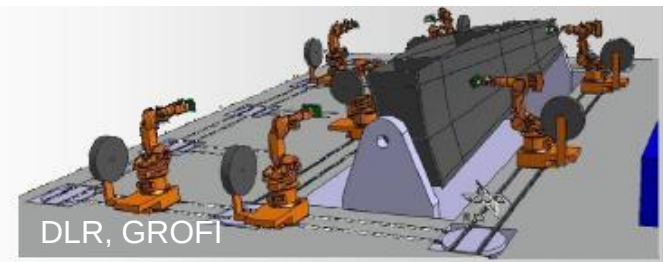
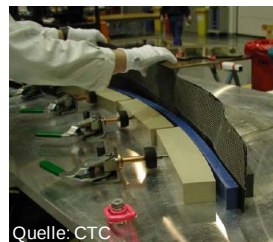
Automatisierungsstrategie 2/3

▪ 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 IPAM



Source: Dust Control

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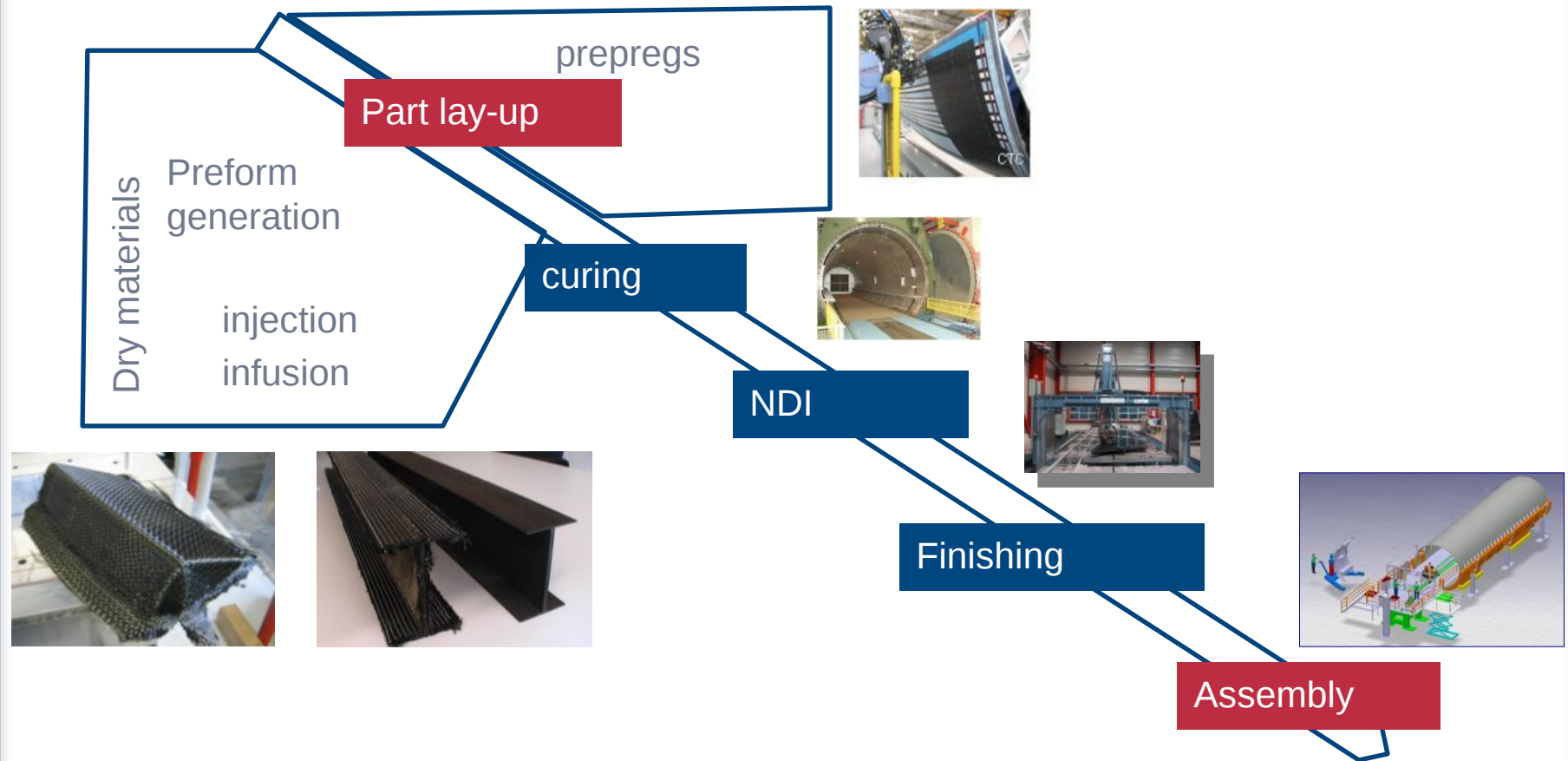
4 Examples for automation needs

- **Along composite process chain**
- **Human centred production**

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Composite Process Chain



Lay-up by ATL/AFP

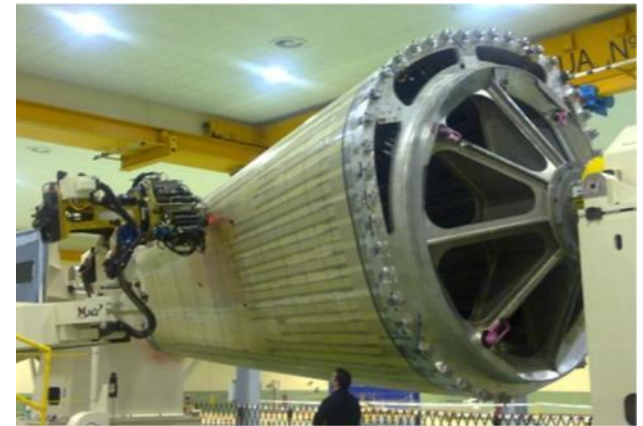
State of the Art

- ✓ 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 Trockenfaserhalbzeugen 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 Multiaxialgelegten
- 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

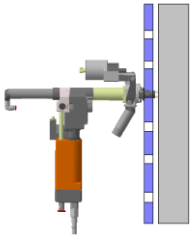


The pictures shown are only examples for visualization and have no link to the statements on this slide

Drilling possibilities for external junctions (with countersinking)

CURRENT / BEST PRACTICE

**Concentric collet
+
Thick template**



**Crawler robot
(double curved)**

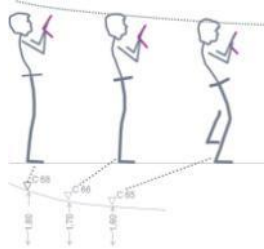


FUTURE NEED

System requirements:

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

Human Centred Production



EMMA
Ergonomische Methodik Methode Arbeit

Stammdaten

U.Z.	TSAB	Beschreibung	Strukturmechaniker
Wahr	2	Art	Wahr
Standplatz	64-67	Anschlusssystem	HAND11ENAD00000
Zone	100	Arbeitsanforderung	PSA für den Betrieb
Objekt	DIN 11200	Datum	20111206
Prozess	00010	Wahr	Festlegung

Last F_{g} 0 kg bis < 10 kg

Körperhaltung

Die Grundhaltung ist auf der Seite liegend.
Die Arme werden von dem Körper gehalten.
Die Werkzeuge sind deutlich nach vorne gehalten.
Die Werkzeuge sind nicht oder leicht nach unten.
Der Lastschwerpunkt ist im Bereich.

Einrichtungsanforderung

Es besteht eine Einrichtungsanforderung.
Es besteht eine Einrichtungsanforderung.
Es besteht eine Einrichtungsanforderung.

Gesamtergebnis

Bewertung mit 1 Mitarbeiter pro Schicht
Anzahl Mitarbeiter/Teilzeit: 2
Anzahl der Tätigkeiten: 0 pro Woche

Ausführungsbedingungen

Es besteht eine Einrichtungsanforderung für den Betrieb.
Es besteht eine Einrichtungsanforderung für den Betrieb.
Es besteht eine Einrichtungsanforderung für den Betrieb.

Häufigkeit

Vorgeschrieben: 1 Mitarbeiter pro Schicht
Tatsächlich: 1 Mitarbeiter pro Schicht
Dauer: 30 min bis 45 min

Bemerkung

Der MA hat die PSA für den Betrieb. Die Körperhaltung ist auf der Seite liegend. Es wird eine Note von 1 bis 5 vergeben. Die PSA ist nicht oder leicht nach unten. Der MA trägt eine PSA gemäß Vorgabe.

Seite 1 von 1
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Ergonomie
Die Arbeit am Arbeitsplatz

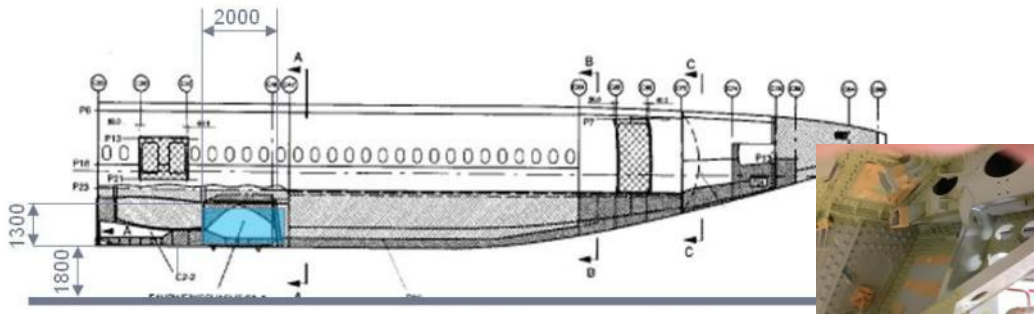
Needs

- 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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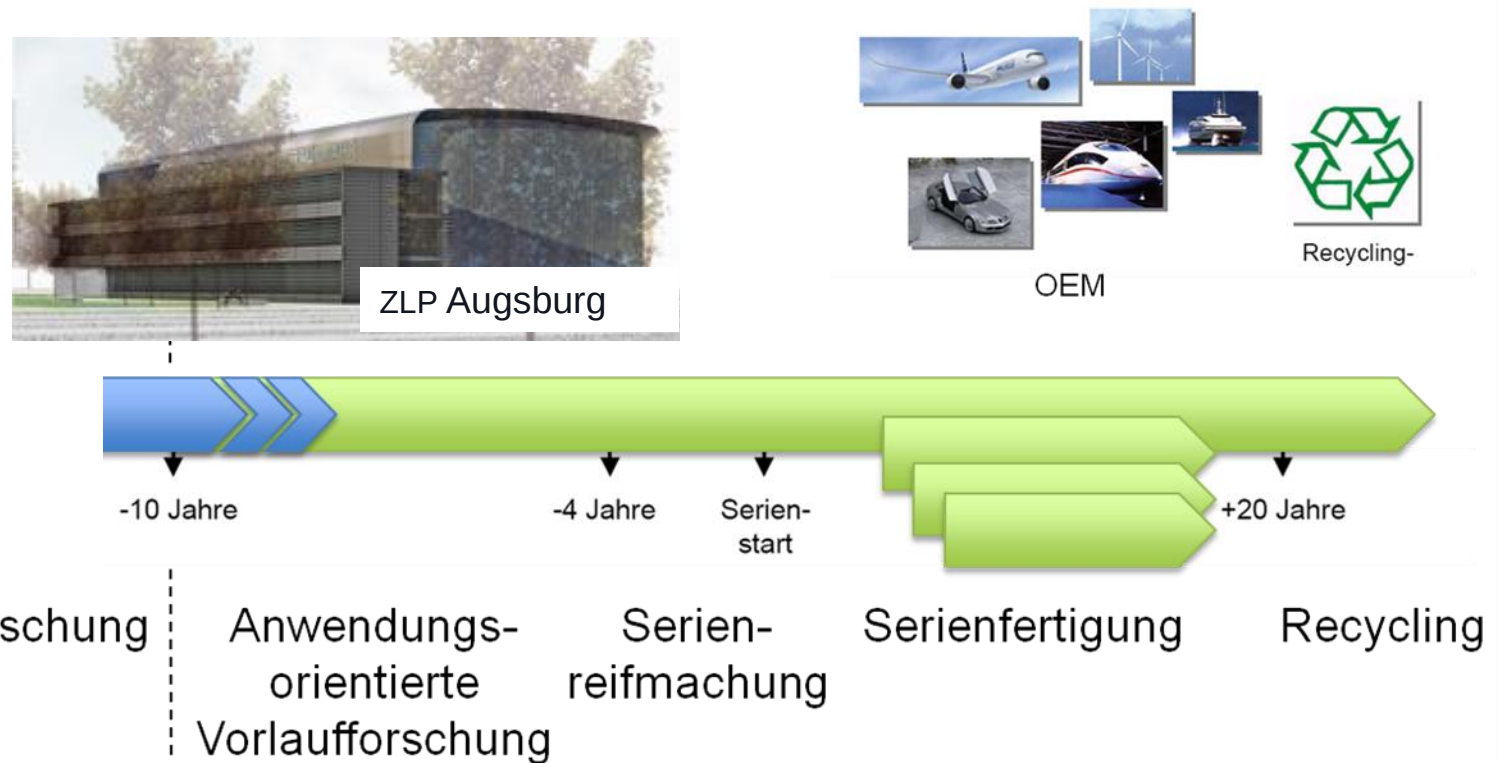
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Technologiezentren im Entwicklungszyklus



Quelle: nach CTC Stade

Technologiezentren im Forschungsumfeld von Airbus/EADS

Nantes



Madrid



Stade



Augsburg ?



Hamburg (under construction)



Filton

Technologiezentren mit unterschiedlichen Kompetenzprofilen und Partnernetzwerken.

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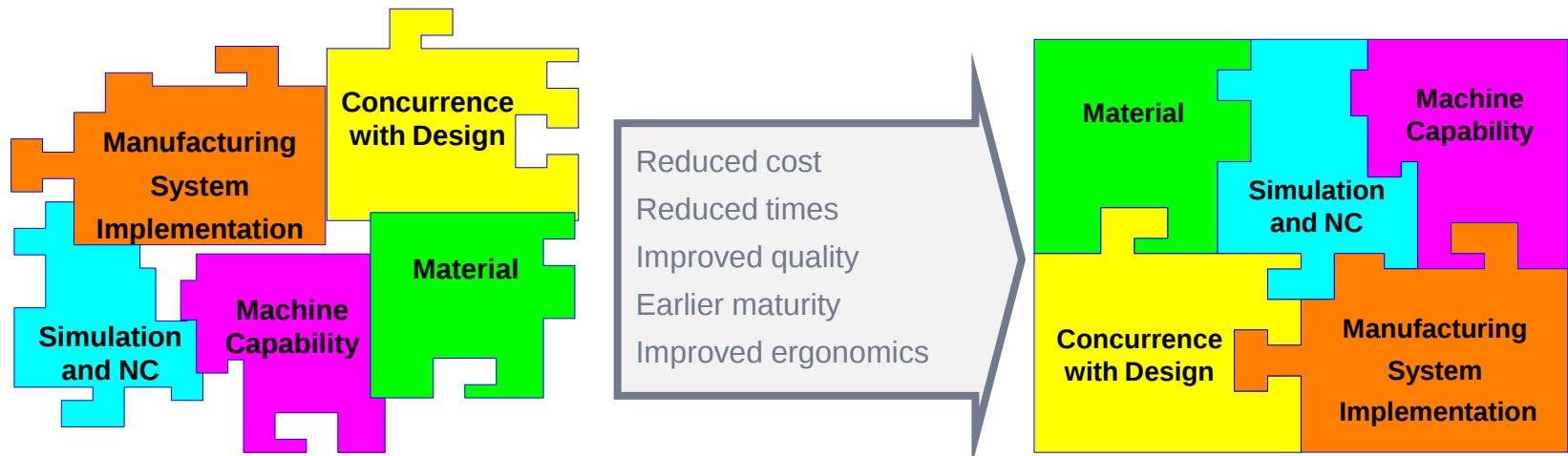
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Summary

- 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





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