TAI

Turkish Aerospace Industries Inc

September 2017

ESTABLISHMENT

1974	1984	2005	2017
Establishment of TUSAŞ	Establishment of TAI	Nationalization of TAI Merger of TAI and TUSAŞ	Vision 2023
%100 Turkish	%51 Turkish %49 General Dynamics	%100 Turkish *% 54.49 TAFF* *%45.45 SSM* *%0.06 TAA*	

SUBSIDIARIES

- %50.52 TEI – TUSAŞ MOTOR SANAYİİ A.Ş. / TUSAŞ ENGINE INDUSTRIES INC.
- %5.56 AIRBUS MILITARY
- %100 TAI USA
- %50.00 tci CABIN INTERIOR®
- %100 TAI Hamburg

VISION & MISSION

Vision

Becoming a «World Brand Aerospace Company» with indigenous products and global competitive power

Mission

Providing solutions for national security requirements in the aerospace sector and leading the development of industry

Values

Honesty and Integrity

Innovation

Efficiency/Effectiveness

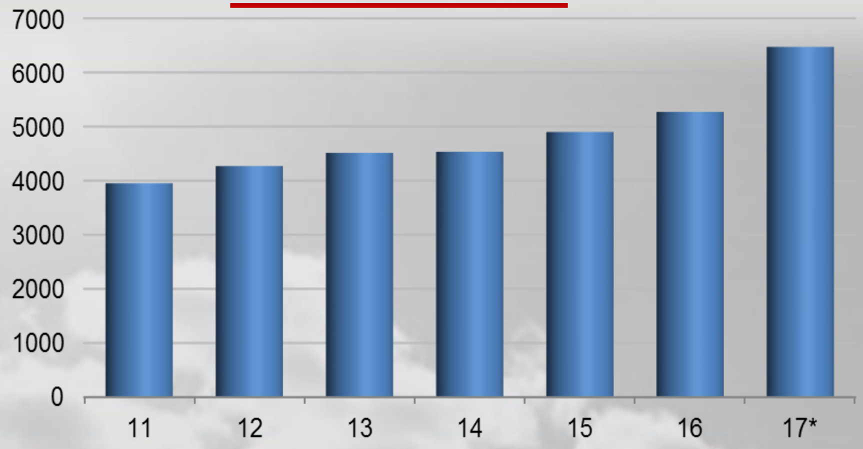
Shareholder Satisfaction


Facilities : 4 million sqm (1.236 acre)
376.000 sqm (70 acre) under roof
Technoparks
ITU
METU
Technopark Istanbul
TAI
Balgat

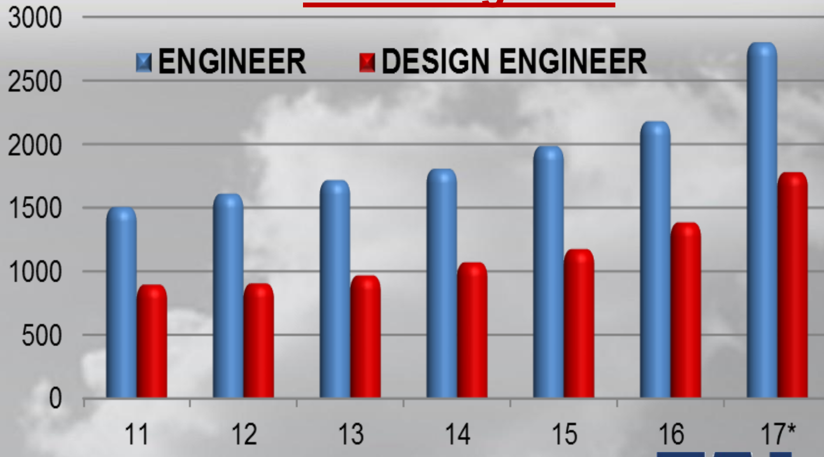
REVENUES & HUMAN RESOURCES

Sales

Total Personnel



Total Engineer



* *Planned*

TAI

INTERNATIONAL CUSTOMERS

BOEING

BOMBARDIER

LOCKHEED MARTIN

SIKORSKY
A LOCKHEED MARTIN COMPANY

NORTHROP GRUMMAN

SPIRIT AEROSYSTEMS

AIRBUS

Fokker

LEONARDO

PAG

THALES

TAI is accredited to the stringent quality standards in the aerospace business

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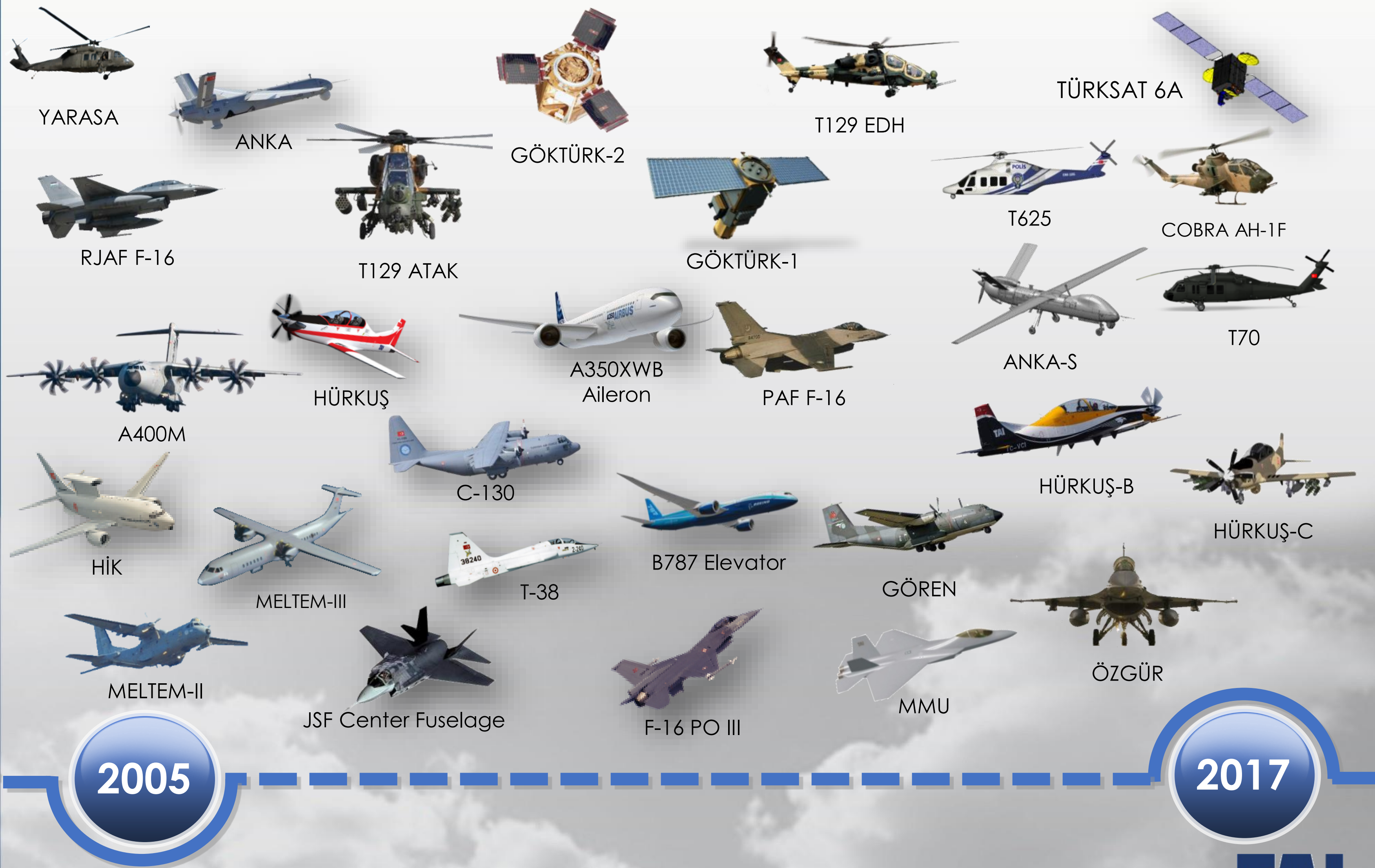
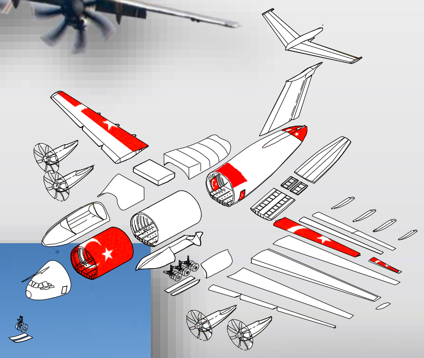
MAJOR PROGRAMS



PROGRAMS

MILITARY PROGRAMS

Airbus A400M



F35 Joint Strike Fighter (JSF)

INDUSTRIAL PARTNER

SOLE SOURCE OUTSIDE USA

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COMMERCIAL PROGRAMS

Airbus - A320 Series Section 18&19

SOLE SOURCE SUPPLIER (Section 18)

Airbus - A350 XWB Aileron

SOLE SOURCE - RISK SHARING PARTNER

Airbus - A330 Rudder

SOLE SOURCE SUPPLIER

COMMERCIAL PROGRAMS

Boeing - B787

Elevator ***(Mnfg.)***

Cargo Barrier ***(Mnfg.)***

SOLE SOURCE SUPPLIER

Boeing – B737, B747, B767, B777

SINGLE AND TWIN AISLE AIRCRAFT AEROSTRUCTURES

Leonardo - AW139 Fuselage

MAIN SUPPLIER

Bombardier C Series Fixed Trailing Edge

SOLE SOURCE SUPPLIER

HÜRKUŞ - BASIC TRAINER

Max.Operating Speed	295 kts / 0,55 M
G Limits	+7g/-3.5g
Service Max Ceiling	35,500 ft
First Flight	29 Aug 2013
EASA CS 23 Certification	11 July 2016
Initial Weapon Release	30 March 2017

HÜRKUŞ-C

New Generation Light Attack / Reconnaissance Aircraft

TURKISH FIGHTER AIRCRAFT-X (TF-X)

- The Program has been initiated to develop a new 5th Generation Fighter Aircraft
- Under the program model, TAI, Turkish Air Force and SSM will work as a team. Contract for Phase-1 was signed.
- Within the scope of Foreign Collaboration, BAE Systems was selected.

C-130/T-38 MODERNIZATION & SYSTEMS INTEGRATION

C-130

Before

After

T-38

Before

After

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T129 ATAK

- Multi-Role Combat Helicopter
- Precision Strike
- High & Hot Performance
- Combat Proven in Turkish Army inventory
- TAI owns the Marketing Rights

TAI

T625

- "Utility Helicopter" for Military / Paramilitary / Commercial use.
- 6.000 kg MTOW, twin engine, 2 crew + 12 pax.
- First Flight in 2018.

T70

- "T70 Utility Helicopter" (developed from Blackhawk S70i platform).
- 109 "T70 Helicopters" to be delivered in the next 10 years.
- TAI (Prime Contractor), Sikorsky Aircraft (Subcontractor).
- Extensive contribution of Turkish Industry.

HELICOPTER MODERNIZATION & SYSTEMS INTEGRATION

Before

After

Before

After

Rear Cockpit

Forward Cockpit

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TAI FLIGHT SCHOOL

- Private Pilot License (PPL)
- Commercial Pilot License (CPL)
- Military / Paramilitary Pilot Training
- Instructor Pilot Training (FI)
- Type Rating and Refresher Training
- Night Flight Authorization

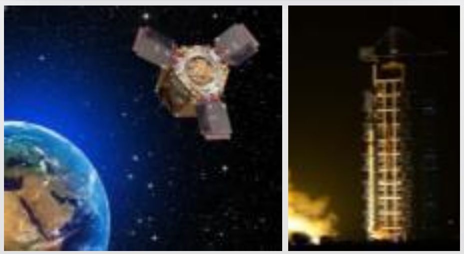
Selected by Turkish Armed Forces and National Police Department

ANKA UAS

Service Ceiling	**30,000 ft**
Endurance	**24 Hours**
MTOW	**1700 kg**
Payload	**200+ kg** **EO/IR Camera** **SAR/ISAR** **ELINT/COMINT**
Powerplant	**155 HP**
Range	**LOS / BLOS**

TAI SATELLITE PORTFOLIO

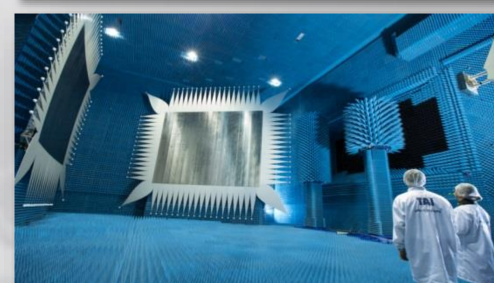
Göktürk I



Göktürk II

- Göktürk – 1 Project
  - Earth Observation Satellite & Ground Segment
  - Design workshare
  - Assembly, test and integration workshare
- Göktürk – 2 Project
  - Earth Observation Satellite & Ground Segment (TAI design)
  - Joint development with Tübitak
- Göktürk – 3 Project
  - Preliminary Design for earth observation satellite and ground segment with SAR payload
- Türksat 6A
  - Ku and X Band Communication Satellite
  - Joint development with TÜBİTAK Space and ASELSAN

SPACE SYSTEMS AIT CENTRE



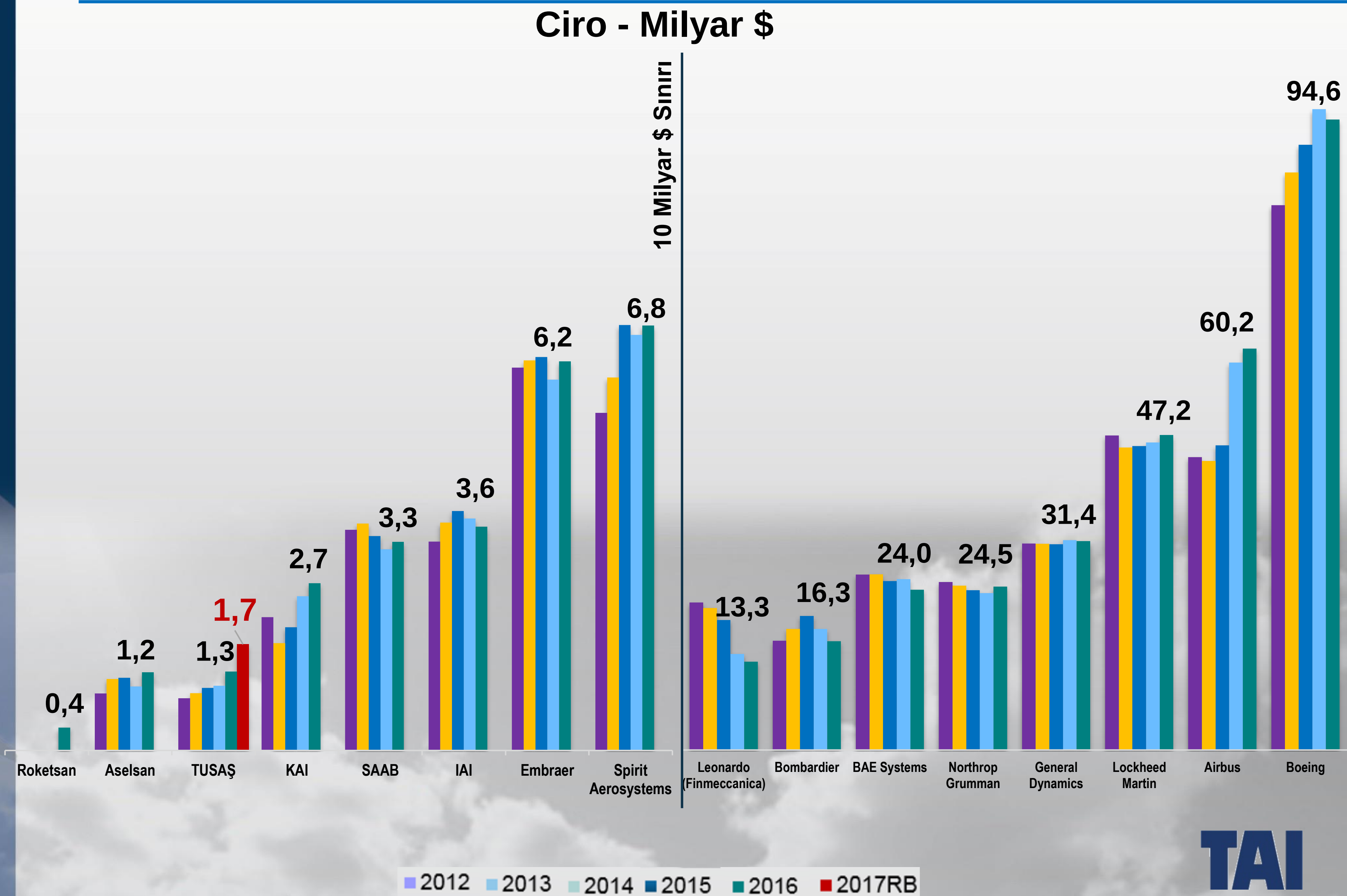
The AIT Centre will be operated by TAI and provide services to national and international space programs.

TAI

September 2017

FINANCIAL PERFORMANCE

TAI'S FINANCIAL STATUS AMONG RIVAL COMPANIES



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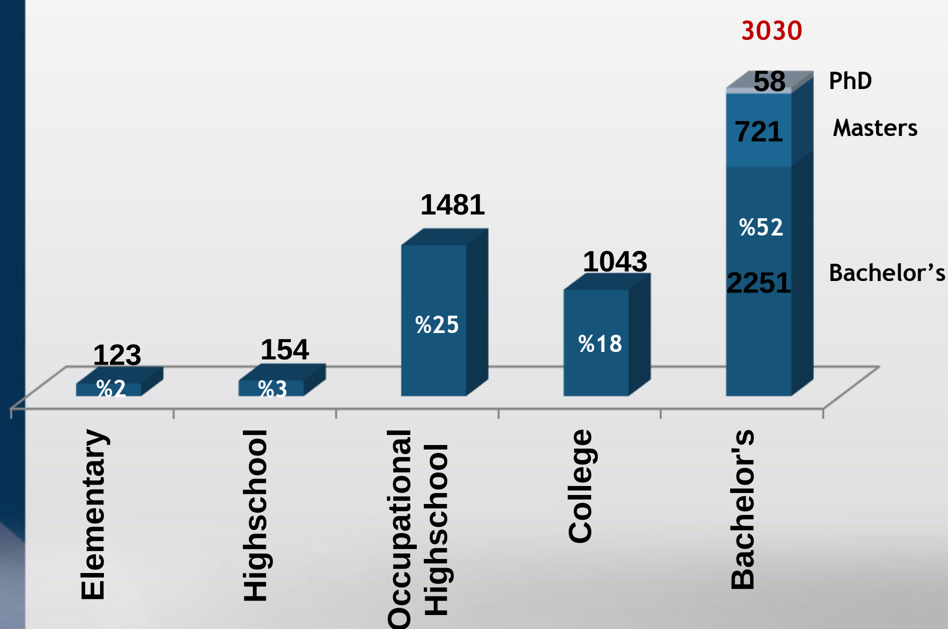
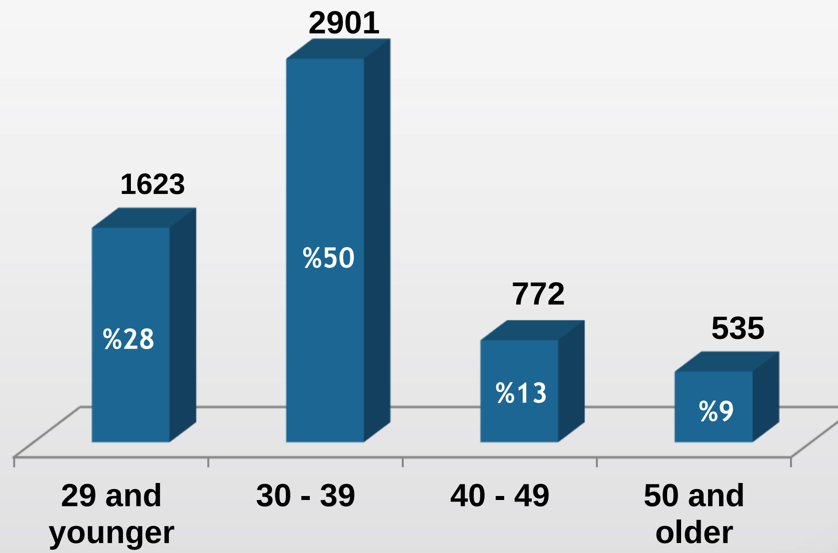
HUMAN RESOURCES

MANPOWER STATISTICS

EDUCATIONAL LEVEL



AGE DISTRIBUTION



EDUCATIONAL LEVEL BASED ON ROLES

	UNIVERSITY		COLLEGE	OCCUPATIONAL HIGHSCHOOL	HIGHSCHOOL	ELEMENTARY
	ENGINEER	OTHER				
MANAGERIAL	398	69			1	
ENGINEER	1647	24				
SPECIALIST	323	283	23	11	5	
TECHNICIAN	6	211	937	1327	43	80
OTHER	6	63	83	143	105	43
TOTAL	**2380**	**650**	**1043**	**1481**	**154**	**123**

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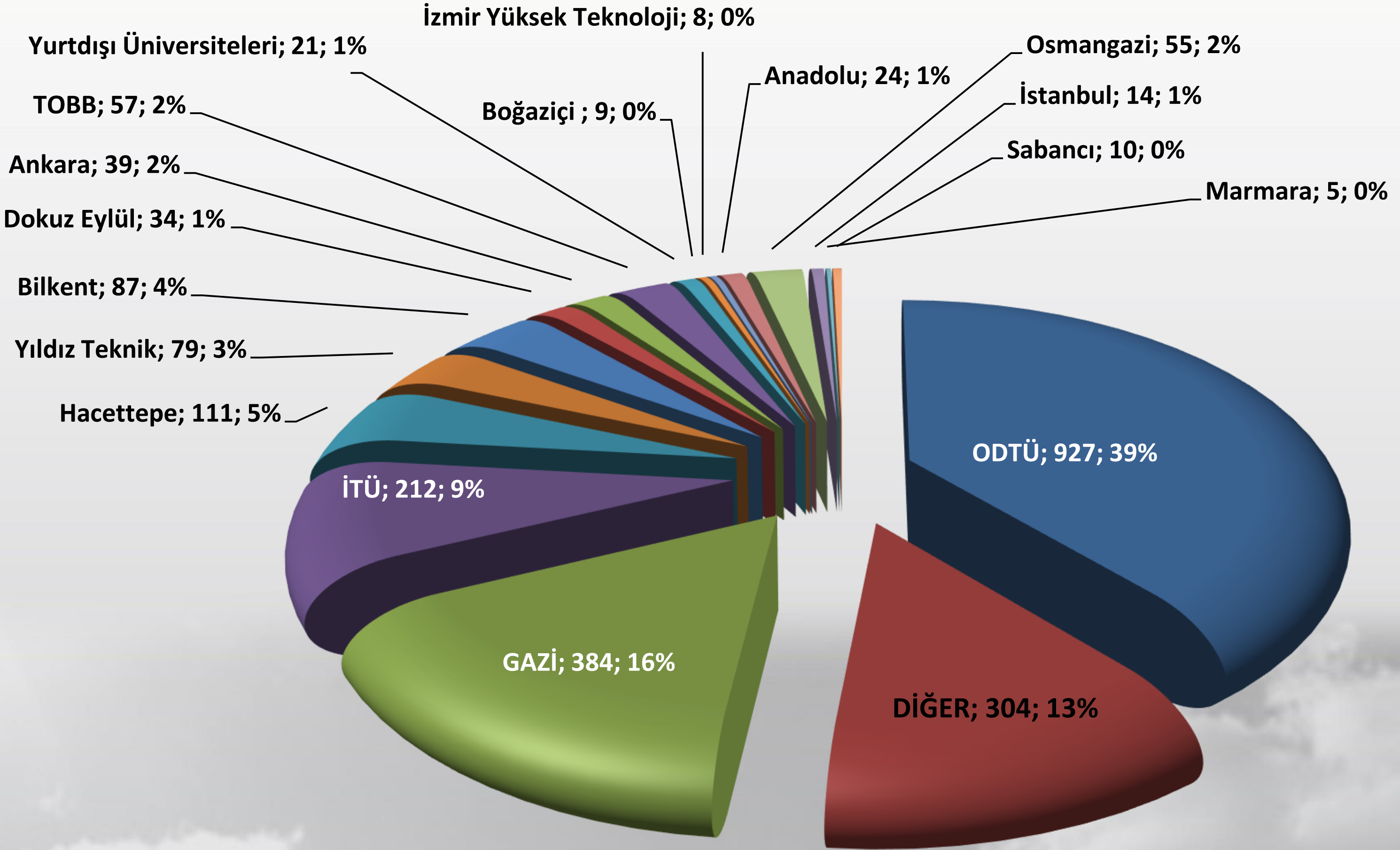
DISTRIBUTION OF ENGINEERS BY GRADUATION



TOTAL : 2.380

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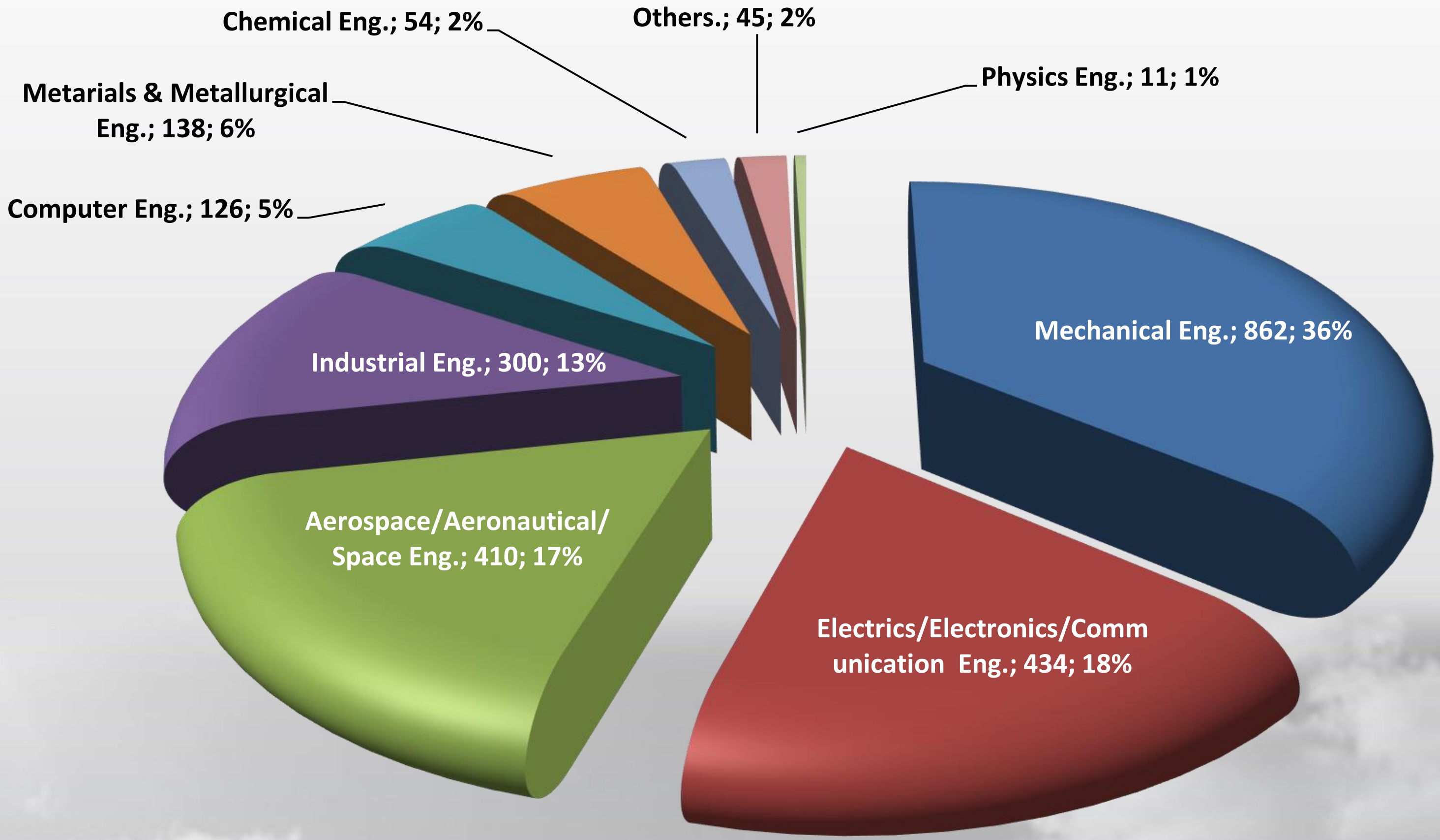
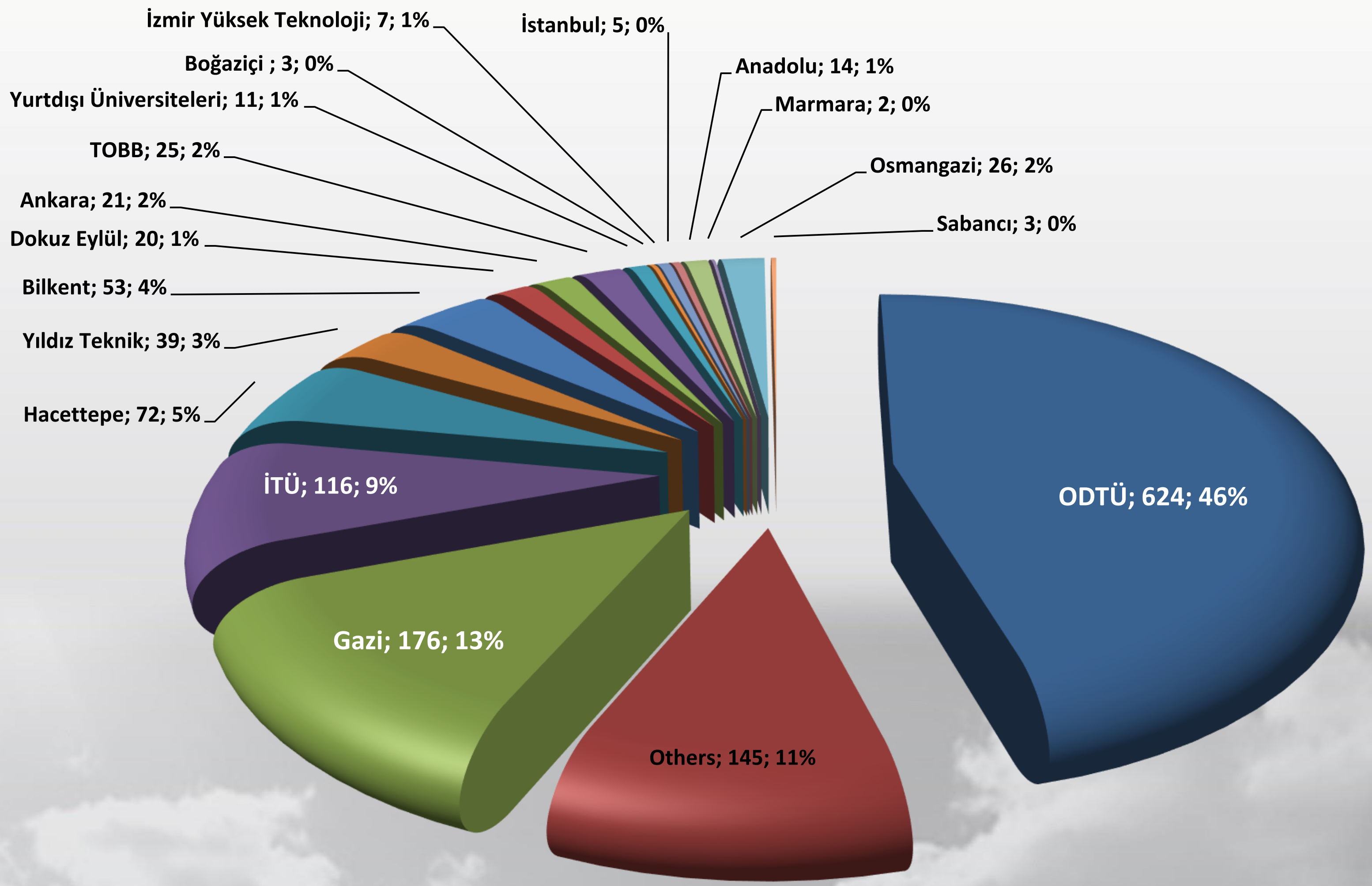
DISTRIBUTION OF ENGINEERS BY PROFESSION



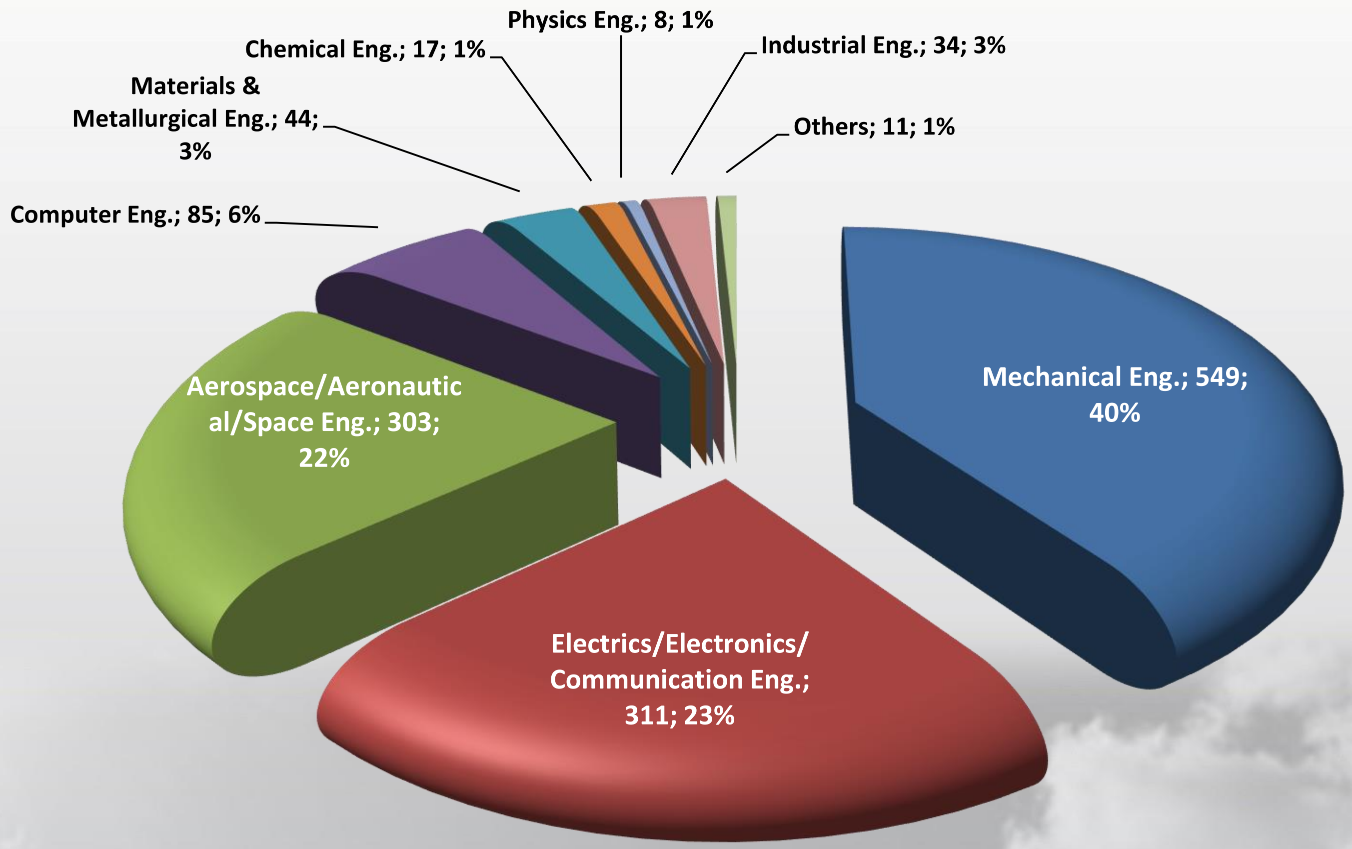
TOTAL : 2.380

DISTRIBUTION OF R&D ENGINEERS BY GRADUATION



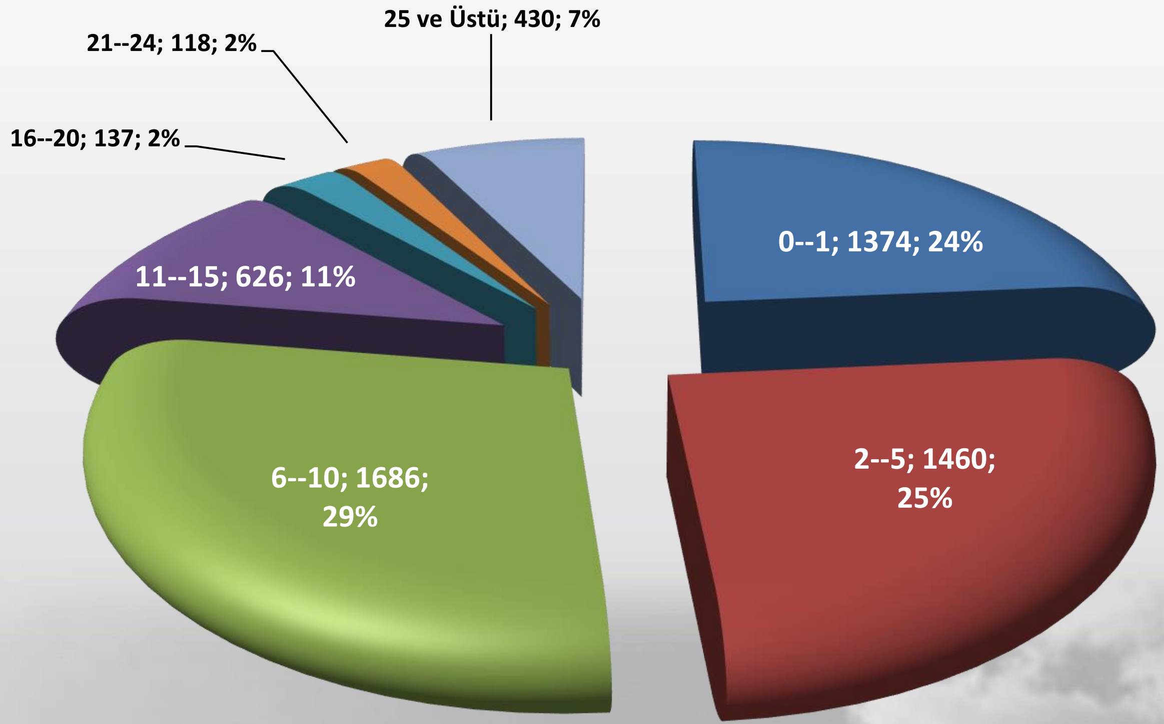
TOTAL : 1.362

DISTRIBUTION OF R&D ENGINEERS BY PROFESSION



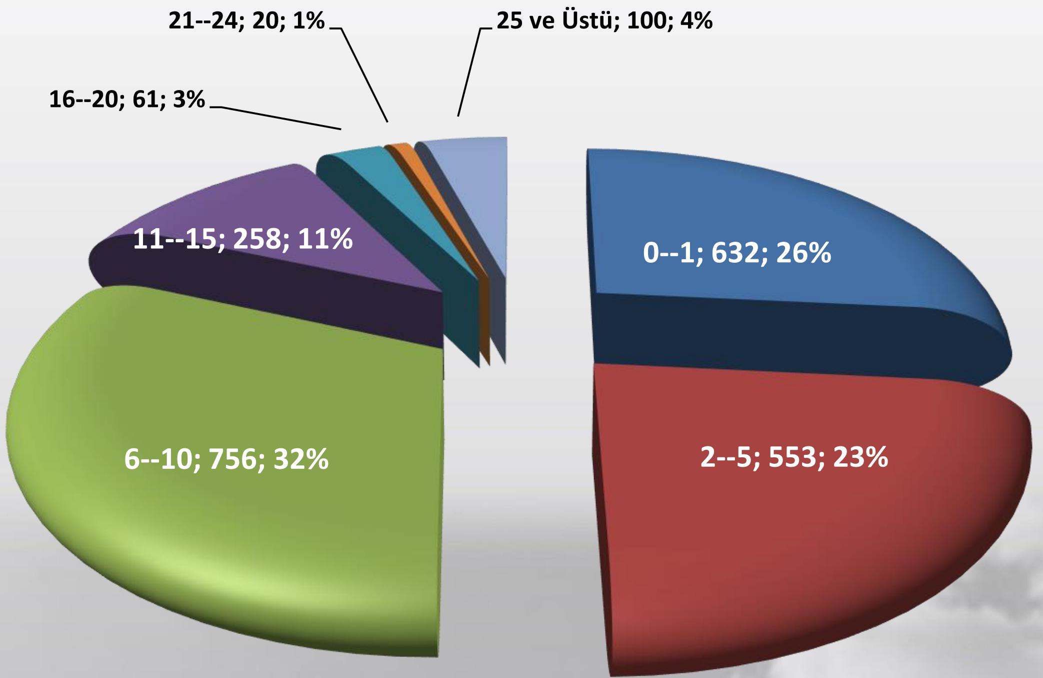
TOTAL : 1.362

PERSONEL DISTRIBUTION BY SENIORITY



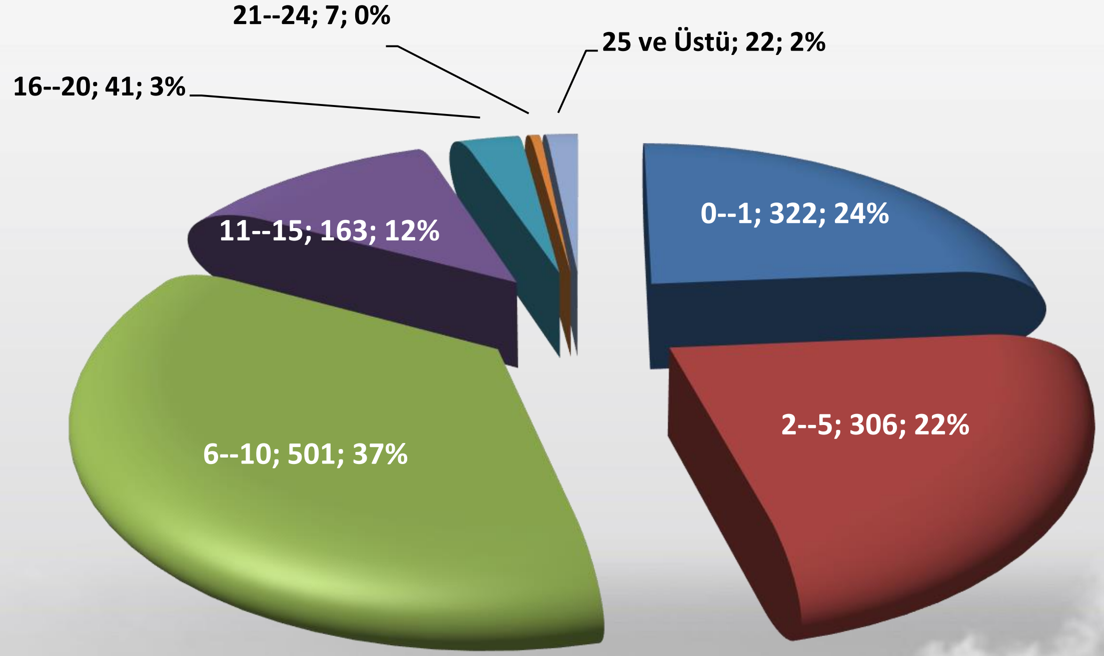
TOTAL : 5.831

DISTRIBUTION OF ENGINEERS BY SENIORITY



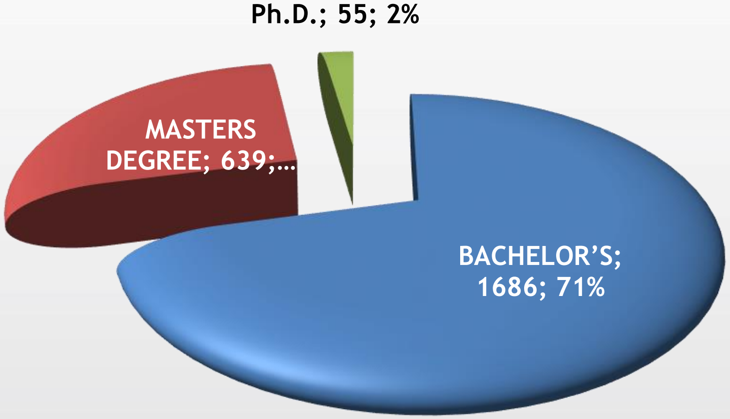
TOTAL : 2.380

DISTRIBUTION OF R&D ENGINEERS BY SENIORITY



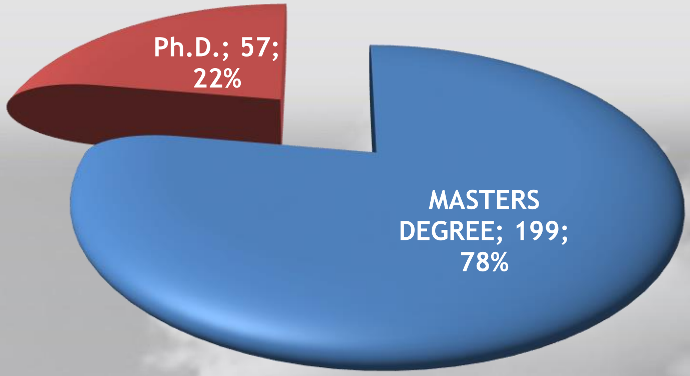
TOTAL : 1.362

EDUCATIONAL LEVEL OF ENGINEERS



TOTAL : 2.380

PERSONEL CURRENTLY ATTENDING A HIGHER EDUCATION PROGRAMME



TOTAL : 256

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Material usage history of Aviation Industry

Early Years of Aviation

In a little over a century, aircraft have gone from delicate constructions of wood, wire and fabric to high speed, high-tech machines made from a complex mix of cutting-edge materials.

First aircraft made by Wright brothers was ‘Wright Flyer 1’. Wreight Flyer 1 was made by using wooden frames, finely woven cotton cloth, mild steel metal fittings and wires.

Early Years of Aviation

In 1915, The J1, the world's first all-metal aircraft designed by engineer Hugo Junkers

At a time when aircraft were made to be as light as possible – using **wood, steel wires and canvas** – the idea of a plane made entirely of **metal** still seemed technically and financially unfeasible.

1920s-1930s: the transition to metal

One of the first civil airliners made of aluminium, the G 24.

Junkers found that steel made the J 1 tough and durable, but heavy and sluggish to handle. He turned his attention to **aluminium**, which had emerged at the start of the 20th century as a viable manufacturing material. **Lightweight and strong**, it is a third the weight of steel, making it ideal for aircraft.

Post-war (II.World War): new metals

As high-speed jet aircraft became more common, aerospace engineers began to look **beyond steel and aluminium**. Because of its strength-to-density ratio and resistance to corrosion, fatigue and high temperatures, **titanium** represented an appealing, but rare and very expensive, material.

De Havilland Comet

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1970s-1980s: carbon fibre takes off

The AS350 Écureuil helicopter adopted fibreglass for its main rotor-head

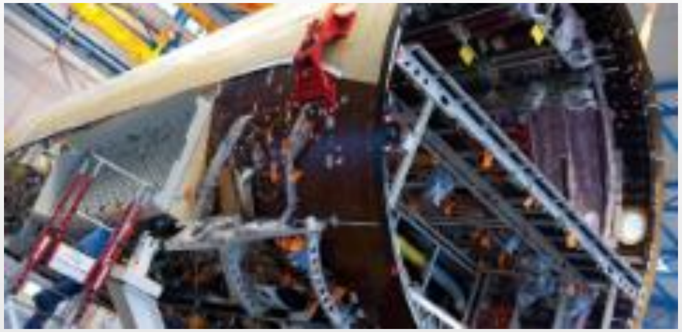
Glass fibre-reinforced plastic, or **fibreglass**, was the first **lightweight** composite material to be found in aircraft.

Carbon fibre-reinforced plastic would prove a truly revolutionary material for aviation. It offers a better **strength-to-weight ratio** than metals, as well as less sensitivity to fatigue and corrosion.

1990s-present day: a composite world

The Tiger has the distinction of being the first all-composite helicopter developed in Europe

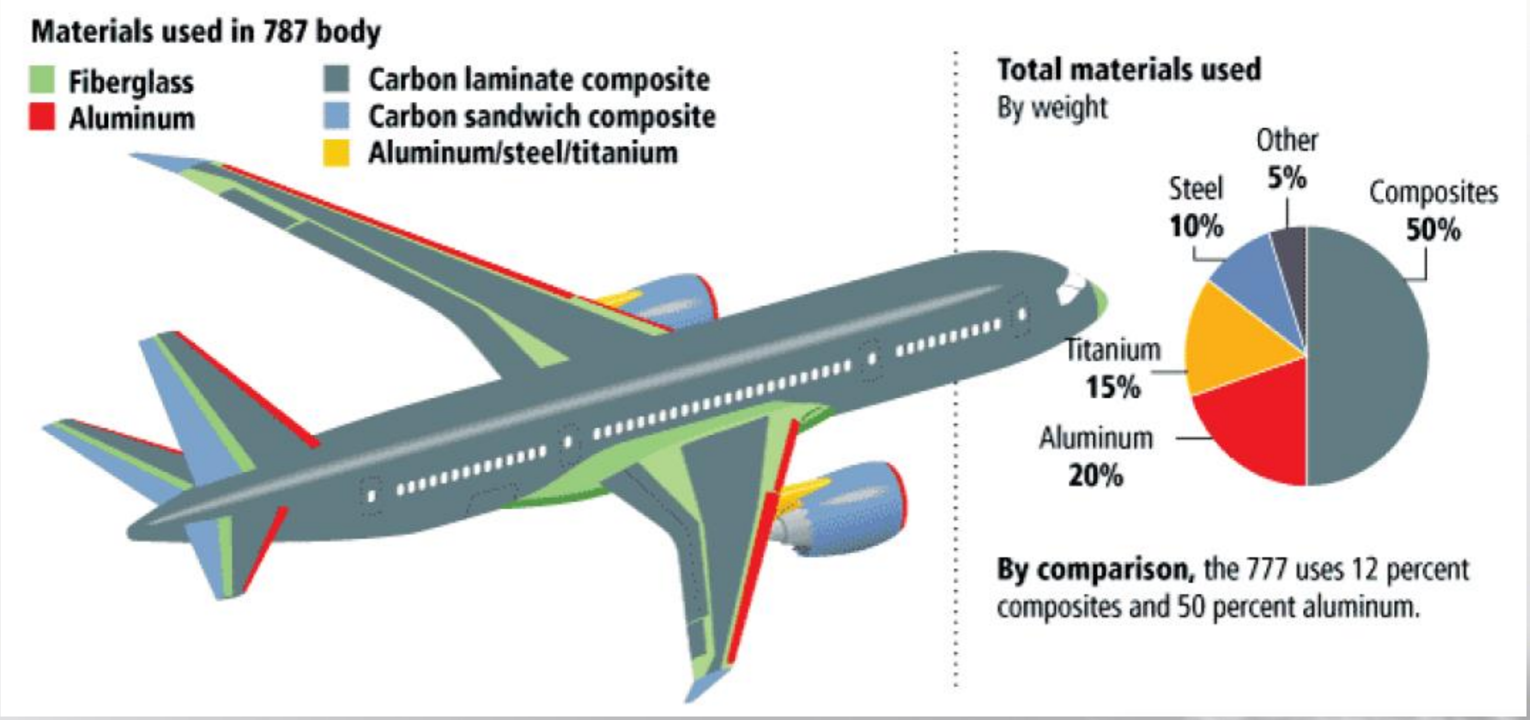
1990s-present day: a composite world



The A350 XWB widebody jetliner is made of more than **50% composites**, giving it a 25% reduction in fuel burn versus its aluminium competitors.

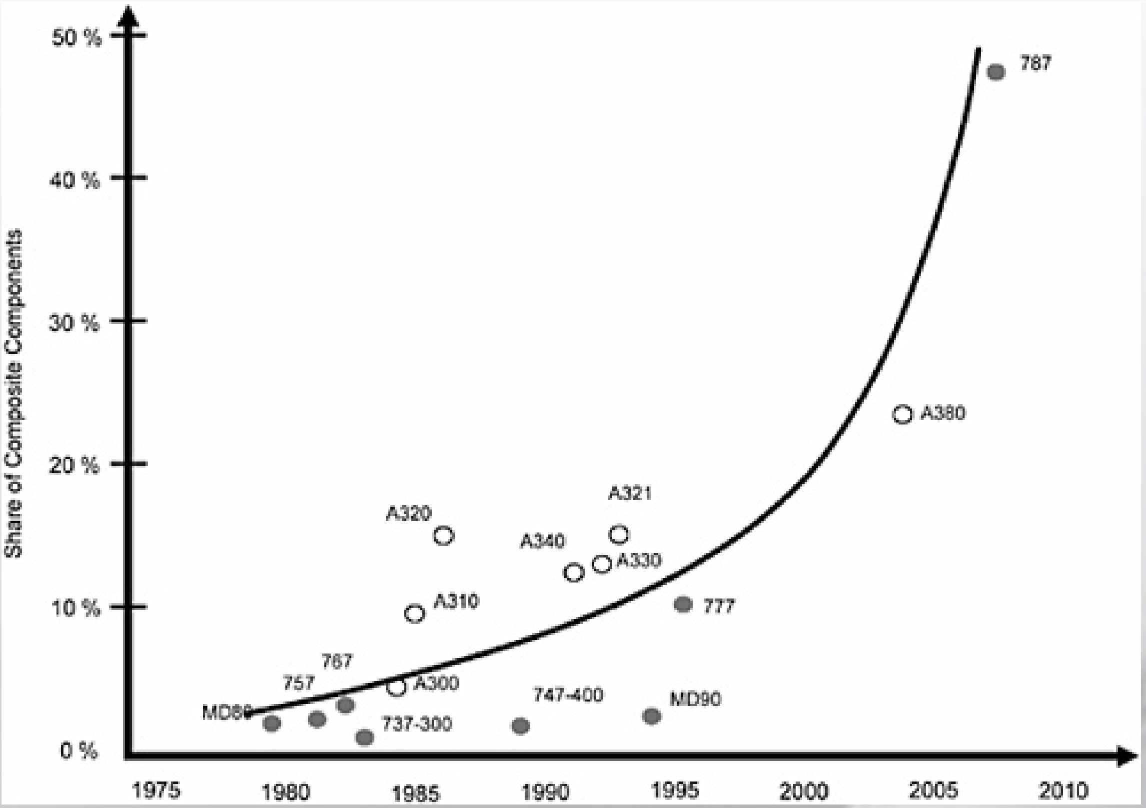
Metals have not become obsolete, though: the **A350 XWB still has parts made of steel and titanium**, while almost 20% is made from aluminium-lithium. This advanced alloy uses **lithium**, the world's lightest metal, to decrease the weight of aluminium while **improving its strength, toughness, corrosion resistance** and forming characteristics.

1990s-present day: a composite world



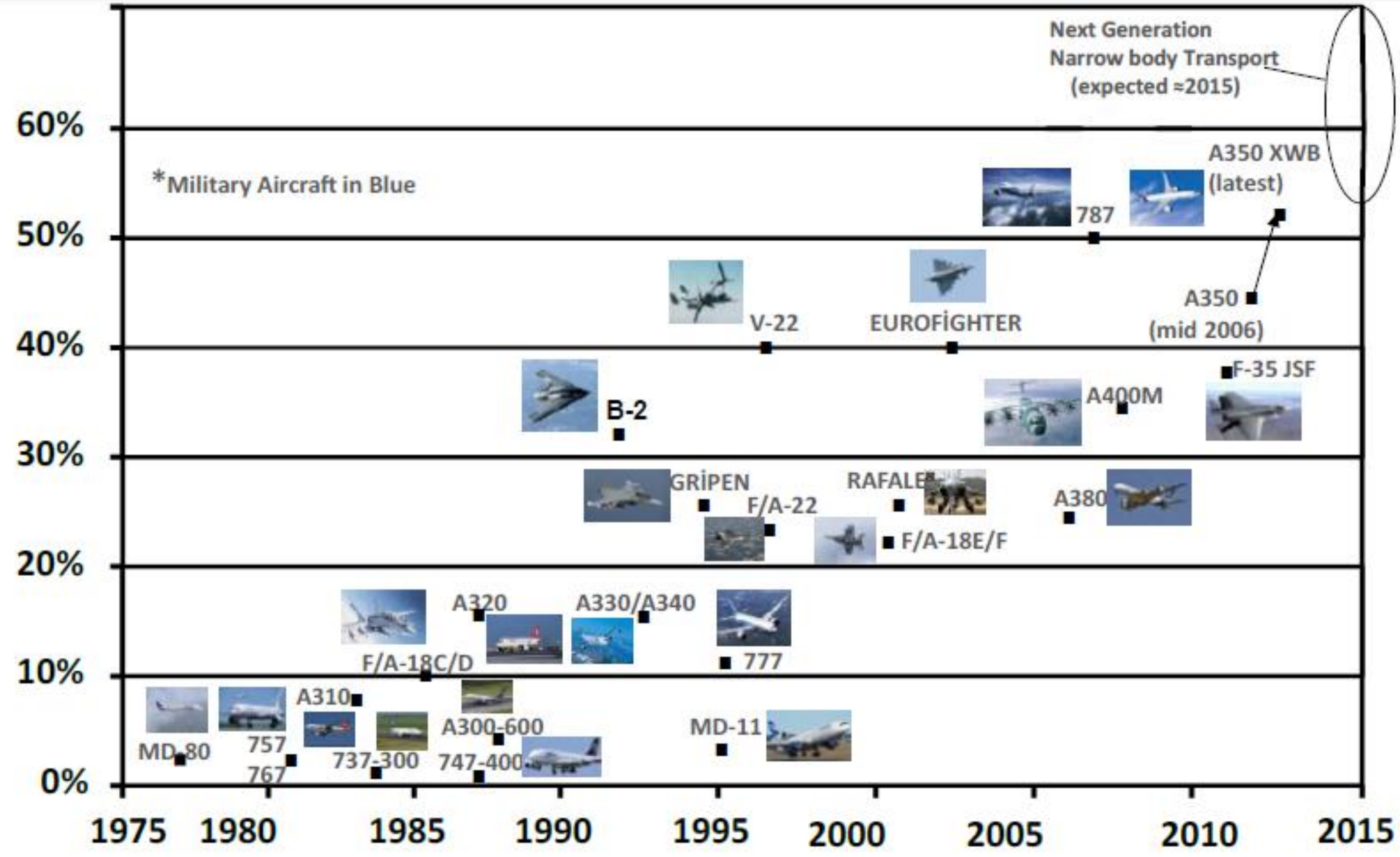
The Boeing 787 (Dreamliner) was introduced in 2011. Boeing 787 consists of **%50 composite** eventhough Boeing 777 which was introduced in 1995, consists of about **%12 composite** materials. This difference shows how composite usage in aviation is changing rapidly in recent years.

Difference in composite usage by years



In this graph, it is seen that composite usage in aircrafts increasing exponentially.

Aircraft Composite Content For Seleceted Airframes



- *Chronology of Composite Material Usage in Aircraft*





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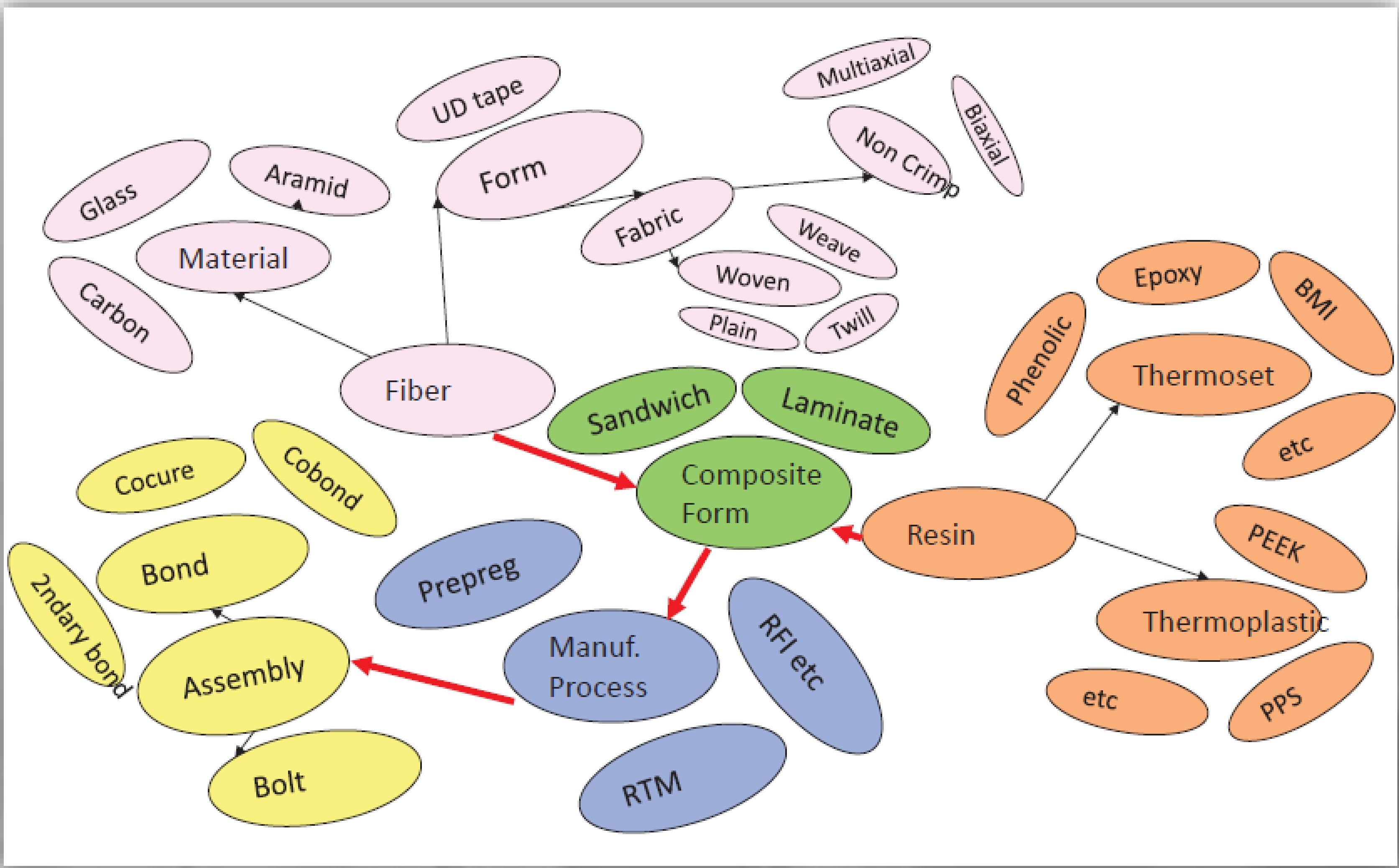
An overview on the use of composite parts in the aerospace industry

Index

Composites



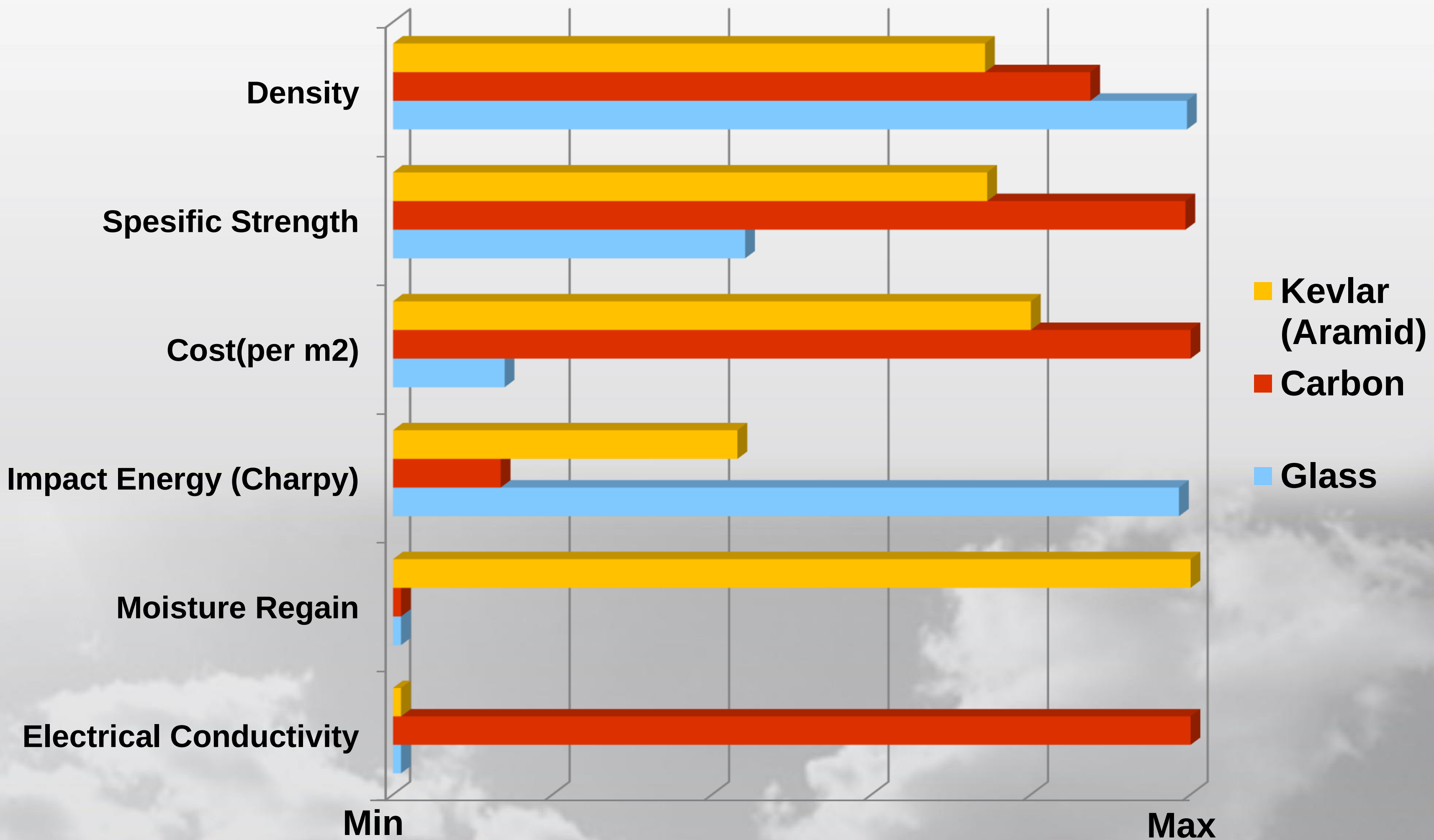
UD tape
Multiaxial
Biaxial
Non Crimp
Form
Glass
Aramid
Fabric
Material
Weave
Woven
Carbon
Plain
Twill
Epoxy
BMI
Phenolic
Thermoset
Fiber
Sandwich
Laminate
etc
Cocure
Cobond
Composite Form
Resin
Bond
Prepreg
PEEK
2ndary bond
Manuf. Process
RFI etc
Thermoplastic
Assembly
etc
PPS
Bolt
RTM

Composites

COMPOSITE

- **Fiber**
  - Carbon
  - Glass
    - E-Glass
    - S-Glass
  - Aramid
- **Matrix**
  - Polymer
    - Thermoset
    - Thermoplastic
  - Metal
  - Ceramic

Composite Material's Properties



Composite vs Metal

- Design Principles

Composite	Metal
Material properties depend on fiber direction	Material properties change with L, LT, ST directions
Low density	Relatively high density
Low coefficient of thermal expansion (CTE)	High coefficient of thermal expansion (CTE)
Flexible manufacturing	Easy assembly
Resistant to corrosion	Not resistant to corrosion
Affected by temperature and humidity	Not affected by humidity
High material cost	Relatively low material cost
Sensitive to UV radiation	Resistant to UV radiation
Low electrical conductivity	High electrical conductivity
Difficult repair	Easy repair
High fatigue performance	Low fatigue performance

Composite vs Metal

- Material Properties

Composite	Metal
Mechanical Properties	
• Generally B-basis material allowables are used • For each composite material values change and are needed to be generated	• Both A-basis and B-basis material allowables are used
Environmental Factors	
• Due to environmental factors (temperature and humidity), a knock down factor (≈15%) is used for the mechanical and physical properties • Resistant to corrosion	• Not affected by environmental factors • Sensitive to corrosion
Inspection	
• Difficult to inspect the VID & BVID inside the laminate	• Defects can be inspected more easily
Manufacturing	
• During lay-up there is a risk of contamination by foreign object	• There is not a risk of contamination by foreign object

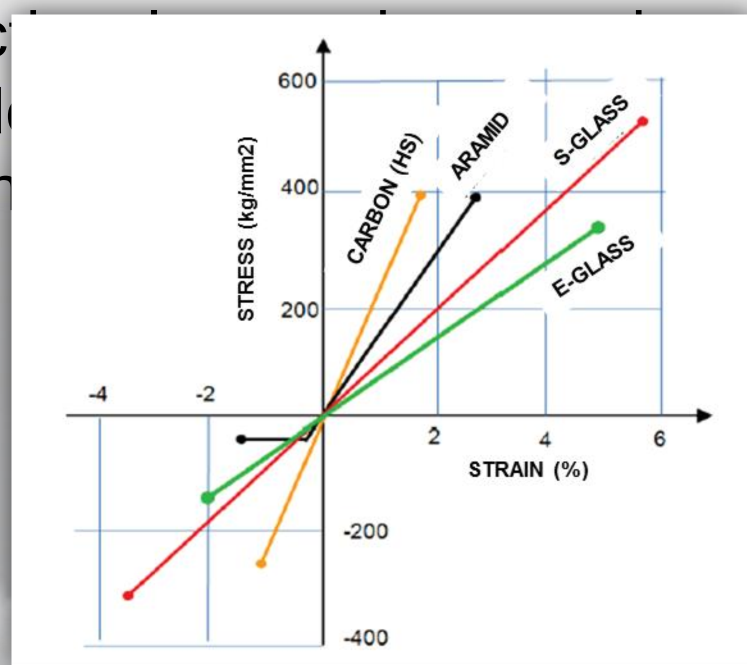
Composite vs Metal

- Mechanical & Physical Properties

Material	Tension Strength (kg/mm²)	Modulus (GPa)	Density (kg/m³)	Specific Strength (X10⁶mm)
CRES 17-4PH	143	222	7760	18.4
Steel 4340	222	226	7800	28.5
Aluminum 2024-T3	50	82	2800	18
Aluminum 7075-T6	63	80	2800	22.5
Titanium 6AL-4V	107	125	4430	24.1
E Glass	400	82	2600	154
Carbon Fiber T300	410	265	1750	234
Carbon Fiber T800	630	340	1750	360
Graphite Fiber P120	306	936	1970	155
Kevlar 149	400	204	1440	278
Kevlar 49	322	124	1470	219
Kevlar 29	322	65	1440	224

Fiber

- The reinforcement will give the material its strength and rigidity;
  measured by stress and elastic modulus respectively
- Fibers work better when they are in tension
- Unlike isotropic materials like steel and aluminum; fiber reinforced
  poly… has direct…
- The … of FRP d… e fiber and … tion of th… olymer (FC…



Fiber

- Carbon

Carbon Fiber	T300	T300J	T400H	T700S	T700G
Tensile Strength (kg/mm²)	360	430	450	500	500
Tensile Modulus (E) (Gpa)	230	230	250	230	240
Strain (ε) (%)	1.5	1.8	1.8	2.1	2.0

SM

Carbon Fiber	T800	T800S	T1000G	M30S	M30G
Tensile Strength (kg/mm²)	560	600	650	560	520
Tensile Modulus (E) (Gpa)	294	294	294	294	294
Strain (ε) (%)	1.9	2.0	2.2	1.9	1.7

IM

Carbon Fiber	M35J	M40	M40J	M46J	M50J	M55J	M60J
Tensile Strength (kg/mm²)	480	280	450	430	420	410	400
Tensile Modulus (E) (Gpa)	343	392	377	436	475	540	588
Strain (ε) (%)	1.4	0.7	1.2	1.0	0.8	0.8	0.7

HM

- Glass

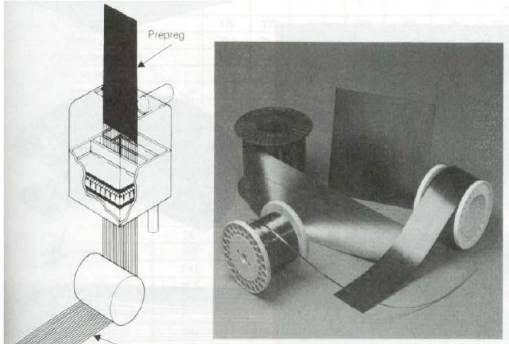
Designation	Means	Property
E	Electrical	Low electrical conductivity
S	Strength	High strength
C	Chemical	High chemical durability
M	Modulus (E)	High stiffness
A	Alkali	High alkali or soda lime glass
D	Dielectric	Low dielectric constant

Glass Fiber	Density (kg/m³)	Tensile Strength (kg/mm²)	Tensile Modulus (E) (GPa)
E-Glass	2550	204	80
S-Glass	2500	484	89

Fiber Forms – Unidirectional (UD) Tape

- A single ply is called a lamina
- A laminate comprises more than one lamina
- Plies of UD tape (i.e. lamina) laid at angles, usually 0,+45,-45 & 90° to give a laminate to satisfy design (e.g. loading) requirements
- Plies are available in different areal weights & cured ply thickness (cpt)
  - Tape for A400M aileron & spoilers:
    - Areal weight 196g/m2
    - Cured ply thickness 0.184mm
- Fibers (filaments) “bundled” into tows
- Typically tows comprise of 6000 (6k) or 12000 (12k) fibers
  - Each fiber is in the region of 7 microns dia.

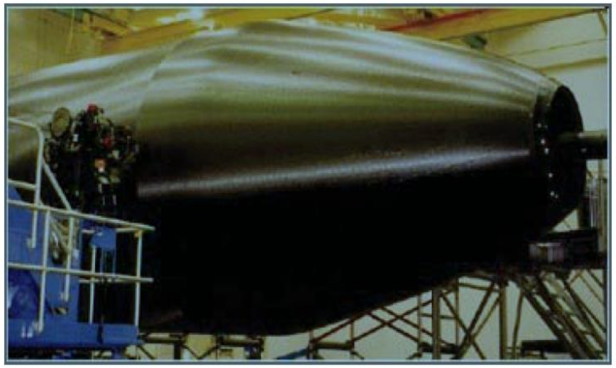
- High strength & stiffness
- Low drape



APC-2 product forms. Left to right, single tow tape, 9 in (216 mm) wide prepreg, preconsolidated laminate and 6 in (140 mm) wide prepreg.

JSF Air Duct

A350



B787 Fuselage

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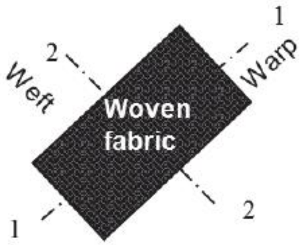
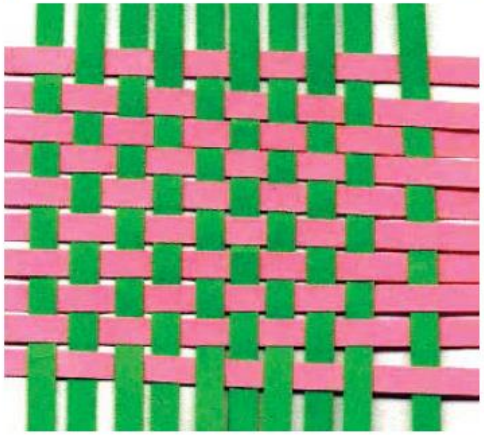
Fiber Forms – Woven Fabric

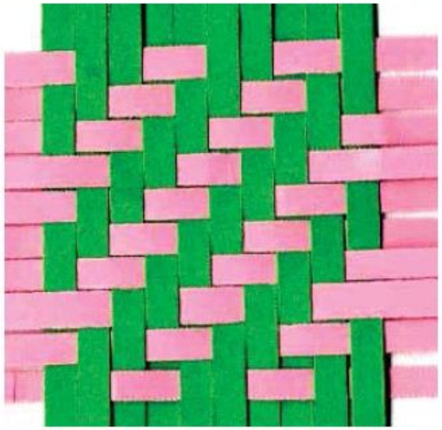
- A fabric ply can be considered comprising a "layer" at 0° (warp) and one at 90° (weft)
- Plies available in different weave styles, areal weights & cured ply thickness (cpt)
  - e.g. fabric for A400M aileron and spoilers:
    - 5 Harness Satin (5HS) weave
    - Areal weight of 280 g/m2
    - Cured ply thickness of 0.280 mm
- Typically tows have 3k or 6k fibers



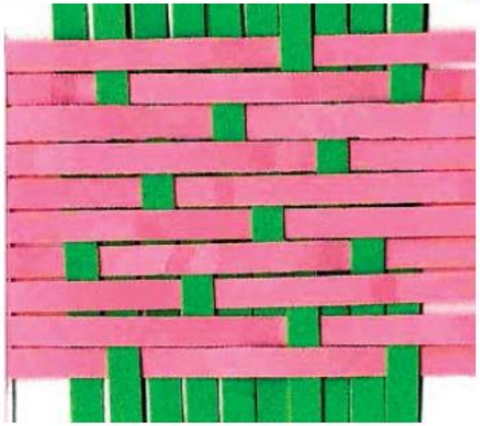
- Lower strength & stiffness than tape
- High drape - Complex curvature
- Fibers are Crimped
  - Weft direction has lower strength



Plain Weave (PW)



2x2 Twill



5 Harness Satin (5HS)

Matrix

- The matrix supports and bonds the fibers and keeps them in position
- The matrix provides
  - ILSS
  - IPSS
  - Compression Strength
  - Compression After Impact (CAI)
- Typical matrices are:
  - Polymer/Resin
  - Metal
  - Ceramic
- Resin comprises:
  - Polymer
  - Hardener
  - Catalyst
  - Accelerator etc.
- The polymer is the fundamental part of the resin, there are two main types:
  - **Thermoset**
  - **Thermoplastic**

Matrix – Thermoset vs Thermoplastic

Thermoset	Thermoplastic
Low viscous when uncured, but re-meltable	Highly viscous, needs temperature, but re-meltable
From low-end to high-end applications	From low-end to mid-end applications
Relatively slow process	Potentially fast process
High labor cost	Low labor cost
Low to high investments	High investments
The most known	Well known for low-end reinforcement (Injection Molding)
Refrigerated storage of 1 component systems or room temperature storage and final mixture of 2-component systems	Room temperature and long-term storage (under UV-protection)
Refrigerated transportation	Almost no transport restriction
Handling and transport only according to REACH	No restriction according to REACH
Low to medium processing temperature <180°C	High processing temperature >200°C
Additives necessary to meet FST requirements	Low flammability, smoke and toxicity (FST)

Matrix - Thermosets

Characteristic	Polyester	Phenolic	BMI	Cyanate-Ester	Polyamide	Epoxy	Toughened Epoxy
Processability	√√	√	√√	√√	√	√√	√√√
Mech props	√	√	√√	√√	√√	√√√	√√√
Toughness	x	x	√	0	√	√√	√√√
Tack			√	0	√	√√√	√√
Drape			√		√	√√√	√√√
Dam Tol	√	√	x	0	x	√√	√√√
Cost	√√	√√	√√		x	√√	√

- Epoxies (inc. Toughened Epoxies) are the most widely used thermoset:
  - Service temperature up to 100°C
  - Best structural characteristics of thermosets
  - Easy to process
- Bismalemides (BMIs) offer higher temperature applications:
  - Service temperature up to 180°C
  - Easy to process

Matrix - Thermoplastics

- Properties
  - High Toughness
  - Recyclability
  - Low Flame and Smoke
  - Room Temp Storage
  - Reformable

- Low Cost Manufacturing
  - Able to make parts quickly
    - Thermoforming
    - Press
    - Autoclave
  - Able to join parts quickly
    - Welding

Property	TC1100 PS Poly-phenylene Sulfide	TC1110 PEI Poly-ether-imide	TC1200 PEEK Poly-ether-ether-ketone
Service Temp. (°F)	200 - 300	300 - 400*	300 - 350
Moisture Absorption	Very Low	Average	Low
Solvent Resistance	Excellent	Poor	Good/Excellent
Rel. Prepreg Cost	1x	1.5x	2x
Toughness	Average	Excellent	Above Average
Density (g/cc)	1.35	1.27	1.29
FST	Pass	Pass	Pass
Process Temp (°F)	625 - 675	625 - 675	725 - 775
Polymer Structure	Semi-Crystalline	Amorphous	Semi-Crystalline
Tg (°F)	194	423	289

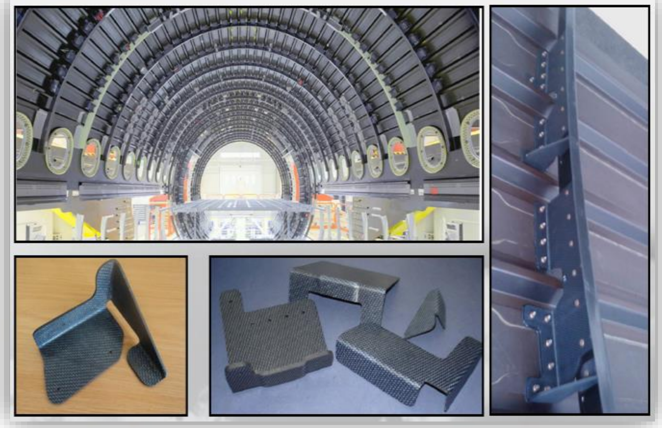
* Note - Service/use temp is lower than Tg due to amorphous nature of the polymer

Matrix - Thermoplastics

Gulfstream
Vertical Stabilizer

A340 & A380
Wing Leading Edge

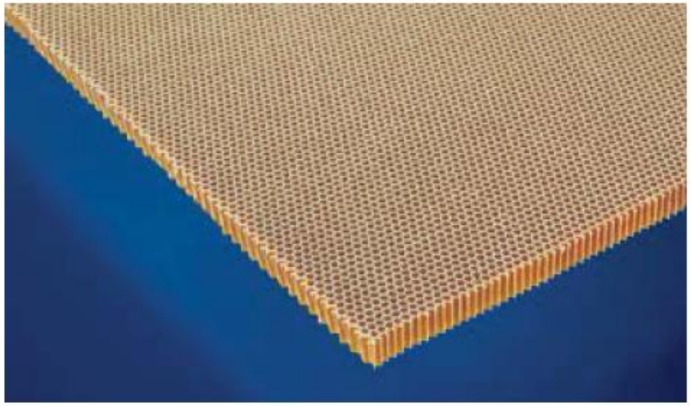
A350
Clips
Brackets



B737
Galley
Smoke Detector Pan
Brackets & Ribs
Acoustical Tiles

Core Structures

- Honeycomb Cores
  - Aramid
  - Glass
  - Metal



- Foam
  - PMI
  - PS
  - PUR
  - PVC

- Syntactic Core
  - Epoxy

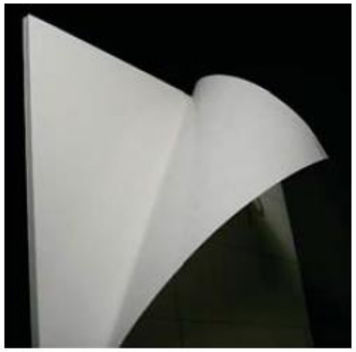
Adhesives

Forms
Film Adhesives
Foam Adhesives (Core Splicing)
Paste Adhesives
Liquid Adhesives

Chemical Base
Epoxy
Polyurethane
Acrylic
Cyanoacrylate
Phenolic

Liquid

Film



Foam

Paste

Composite Materials Processing

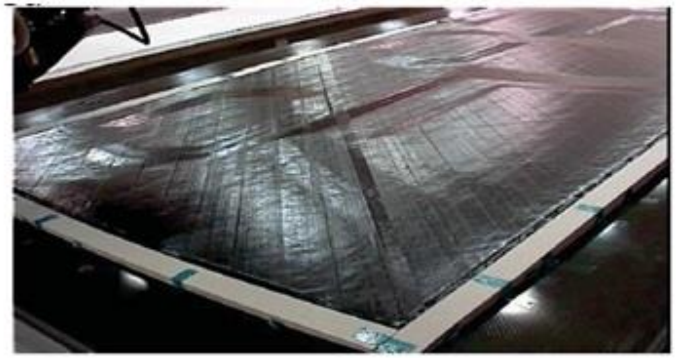
PREPREG

RESIN FILM

RESIN INFUSION
- Resin Transfer Molding (RTM)
- Liquid Resin Infusion (LRI)

Composite Materials Processing – Prepreg Technology

- 125 or 180 °C curing prepregs (48 -400 g/m2) are used
- Most widely used technique
- Lay up methods:
  - HLU (Hand Lay up)
  - ATL (Automated Tape Laying)
  - AFP (Automated Fiber Placement)



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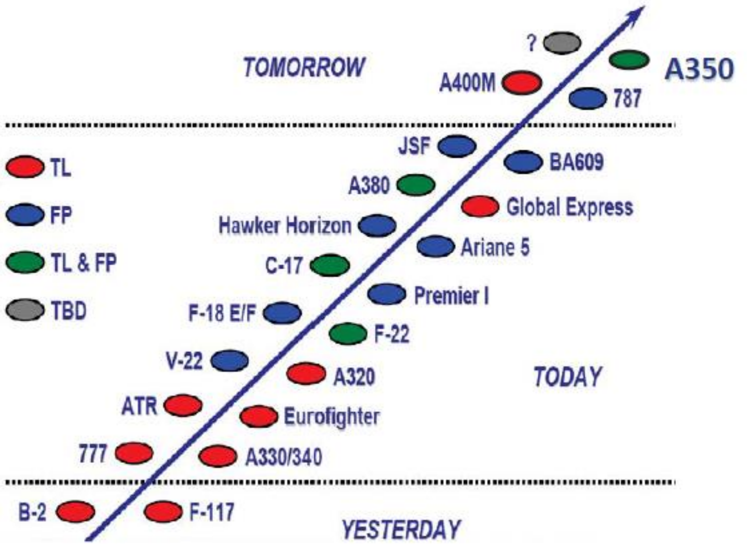
Composite Materials Processing – Prepreg Technology

- Advantages of ATL & AFP
  - Reduced labor cost
  - Reduced material scrap
  - Reduced manufacturing time
  - Improved composite structure quality
  - Precise & repeatable
  - AFP enables the manufacturing of complex shapes with desired radius



Composite Materials Processing – Prepreg Technology

- Parts manufactured by ATL
  - Wing skins
  - Flight control systems
  - Elevator skins

A330/A340 Tail Skins

B787 Wing Tip

Boeing 777 Horizontal Stabilizer Skin Panel Lay up

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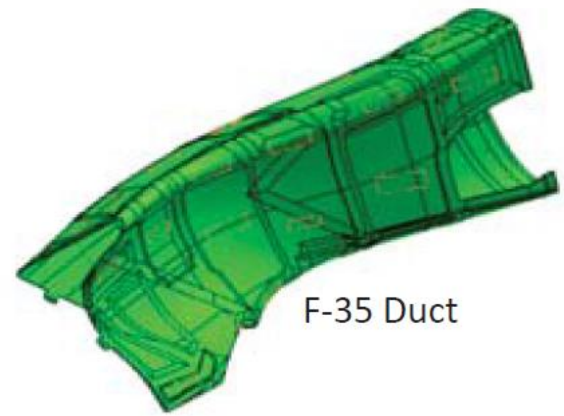
TAI is a subsidiary of TAFF and an affiliate of SSM

Composite Materials Processing – Prepreg Technology

- Parts manufactured by AFP
  - Fuselage skins
  - Engine cowlings
  - Ducts



F-35 Duct

A380 Rear Fuselage

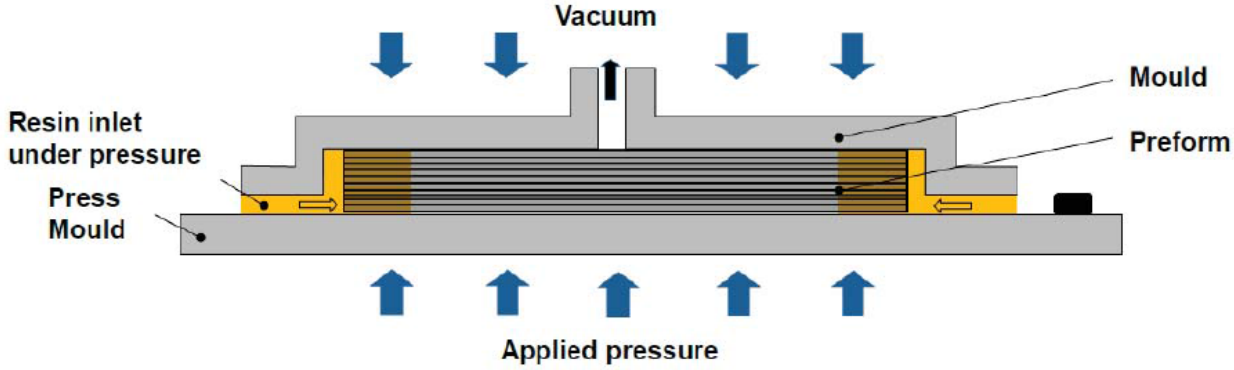
B787 Fuselage Sect. 43

Composite Materials Processing – Prepreg Technology

- B787

Composite Materials Processing – Resin Infusion

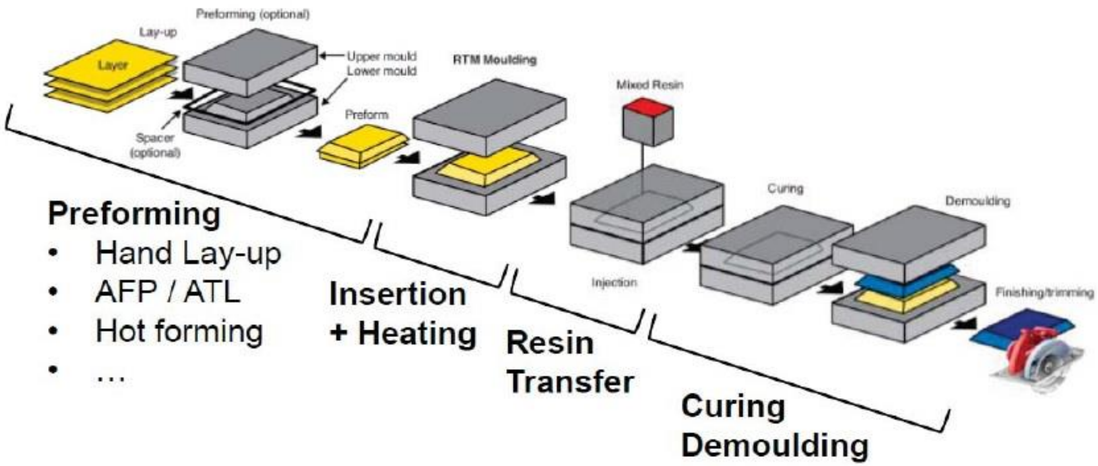
- Resin Transfer Moulding (RTM)
  - Closed mold / High dimensional tolerances / good surface finish
  - Automated process for relatively high volumes



Reliable process – full automation available

Composite Materials Processing – Resin Infusion

- Resin Transfer Moulding (RTM)



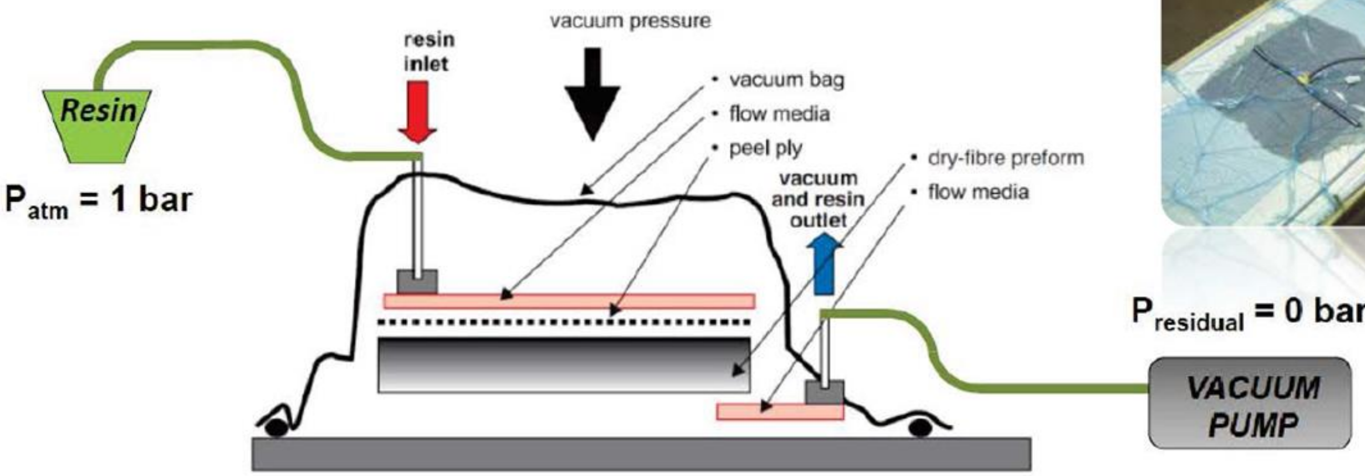
ANKA FLAPERON

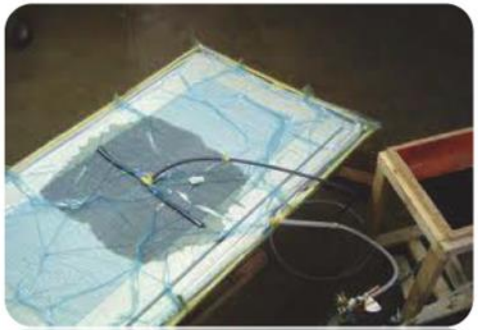
ANKA RUDDERVATOR

HÜRKUŞ RUDDER TRIM TAB

Composite Materials Processing – Resin Infusion

- Liquid Resin Infusion (LRI)
  - Single-sided mould + specific vacuum bag set-up + vacuum pressure





Large surface components are possible
Lower cost in infrastructures & tooling

3-D Woven Usage in Aerospace

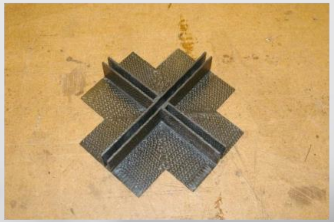
3-D woven composites are, exactly as their name implies, structures that are woven in three dimensions. In addition to the X and Y dimensions that every woven fabric has, 3-D woven fabrics include weaving through the thickness, or the Z axis. This results in the production of complex, single piece structures.

Advantages

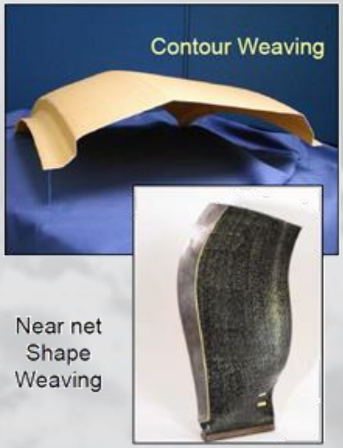
- Weight Reduction : Up to 30%
- Elimination of Delamination : 2D composite problem
- Reduced Crack Risk : Since there is no empty pocket
- Lower Production Times : Near net shape 3D preforms
- Decreased Size Limitations : Larger parts than conventional prepreg composites

Disadvantages

- Prototype testing and tooling costs
- Damage and distortion of fibres during weaving

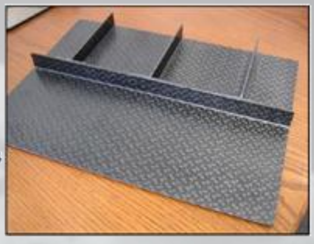


3D Woven "Intersecting Pi"



Near net Shape Weaving

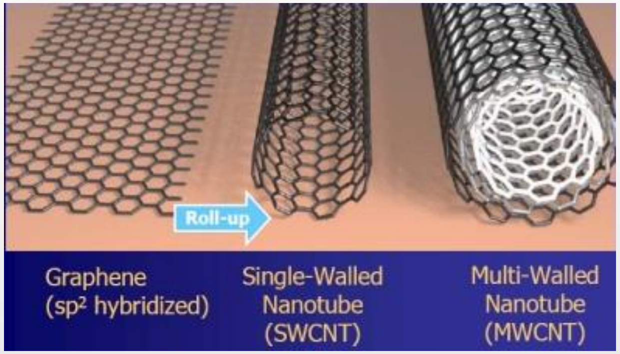
Integrally Woven Structures

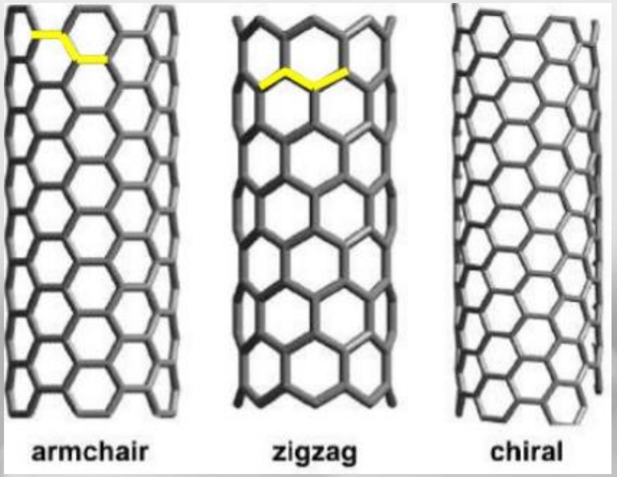


Carbon Nano Tubes Usage in Aerospace

Usage of Carbon nanotubes

- Structural improvement (leading to reduced weight on aircraft)
- Aircraft Icing mitigation
- Lightning strike protection & EMI shielding
- Morphing aircraft applications





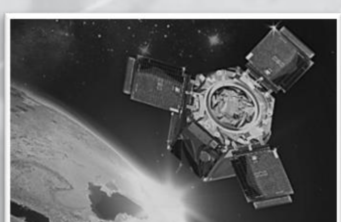
Advantages

- Extremely small and lightweight
- Resources required to produce them are plentiful, and many can be made with only a small amount of material
- Resistant to temperature changes
- Improves conductive, mechanical, and flame barrier properties of plastics and composites.

Disadvantages

- Extremely small, so are difficult to work with
- Relatively expensive to produce the nanotubes



TAI

Composite applications in TAI

Composite Applications In TAI

- Composite Programs in TAI

	Designed in TAI	Manufactured in TAI
A350 Aileron	✓	✓
A400M Aileron, Spoiler	✓	✓
ANKA	✓	✓
Bombardier C series	X	✓
JSF	X	✓
A330 Rudder	X	✓

Several Structural Manufacturing Technologies in TAI

COMPOSITE TECHNOLOGIES

Fiber Placement Machines

ATL Machine

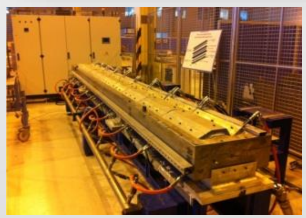
5-axis+catcher Waterjet

Precision Milling Machine

COMPOSITE TECHNOLOGIES

Autoclaves

(RTM&VARTM)



Hot Forming Press

Compaction Press

MACHINING TECHNOLOGIES

Skin Surface Milling

5-axis Routing & Drilling

5-axis High Speed Machining

5-axis Core Cutting Machine

ASSEMBLY TECHNOLOGIES

ARM

ADS

Robotic Drilling

Robotic Coating

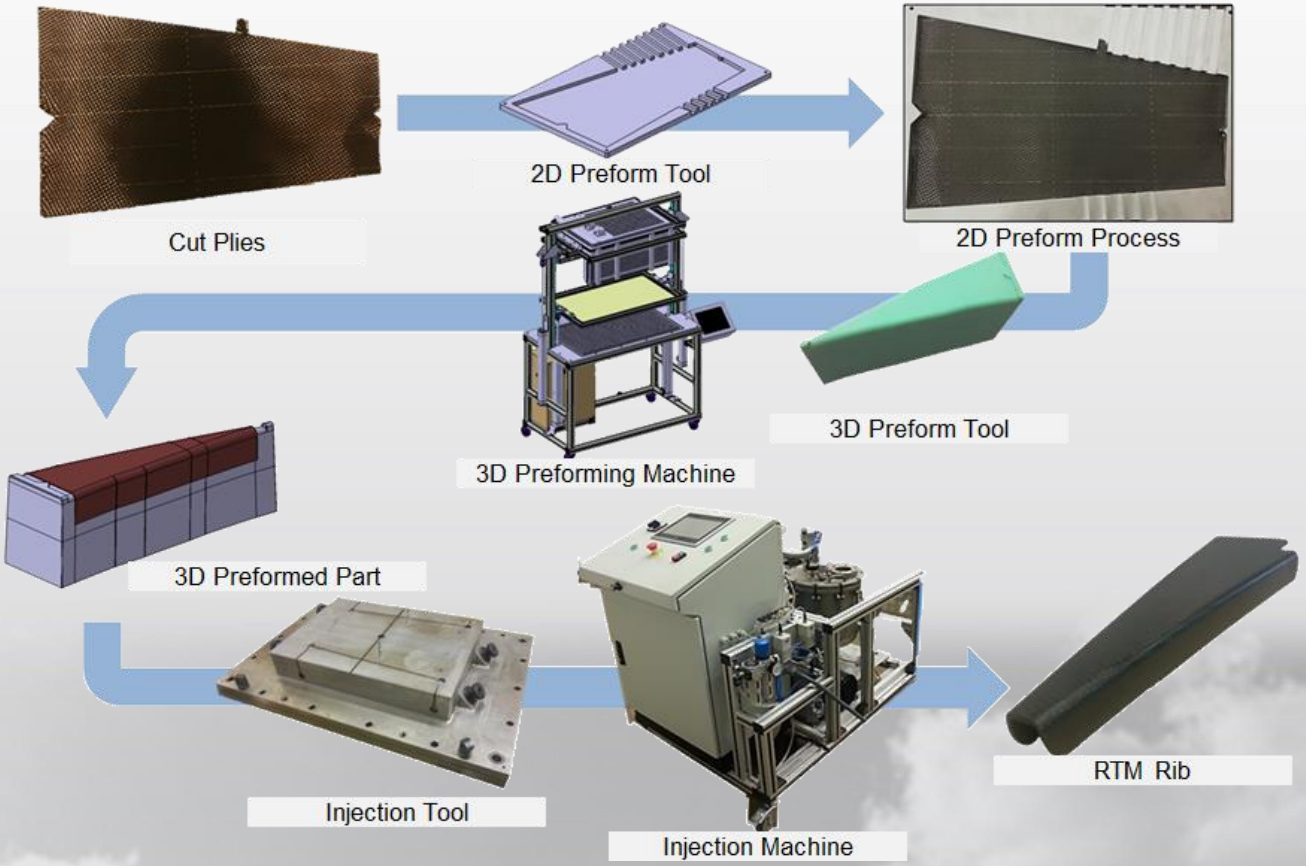
JSF

TAI has been producing JSF's various composite parts such as skin panels & air duct since 2008.

AFP (Automated fiber placement) machines are used for production of left, right and rear side of air duct.

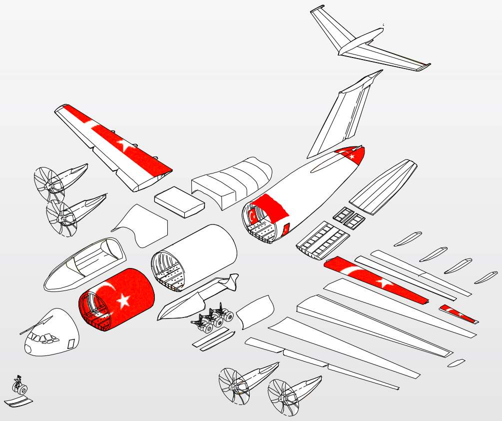
JSF Air-duct produced by AFP

AIRBUS A350 / A400M



RTM rib production flow graph is shown above. First, carbon plies are cut and preformed by preform tool 2D and 3D respectively. 3D formed part tool and injection tool are combined together to inject resin to the 3D formed carbon fibric. Under 180°C temperature and 3 bar pressure RTM rib is produced.

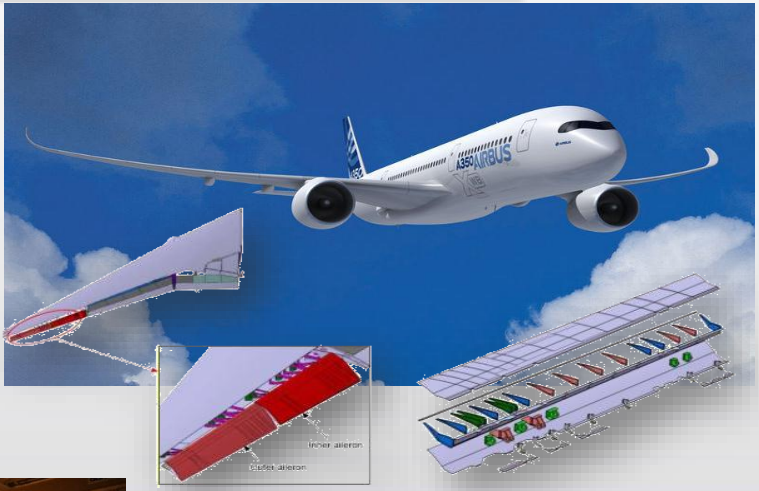
AIRBUS - A400M PROGRAMI



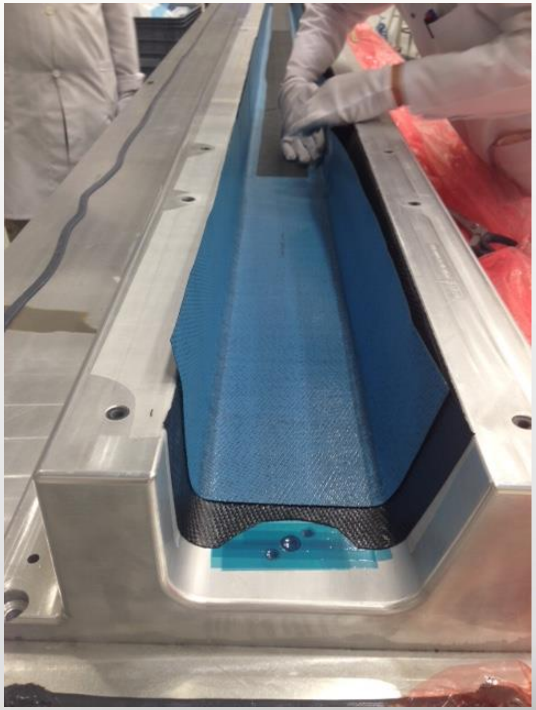
Components of A400M that designed and manufactured by TAI are indicated as red in picture above. Some of these components consist of composite materials such as aileron and spoiler.

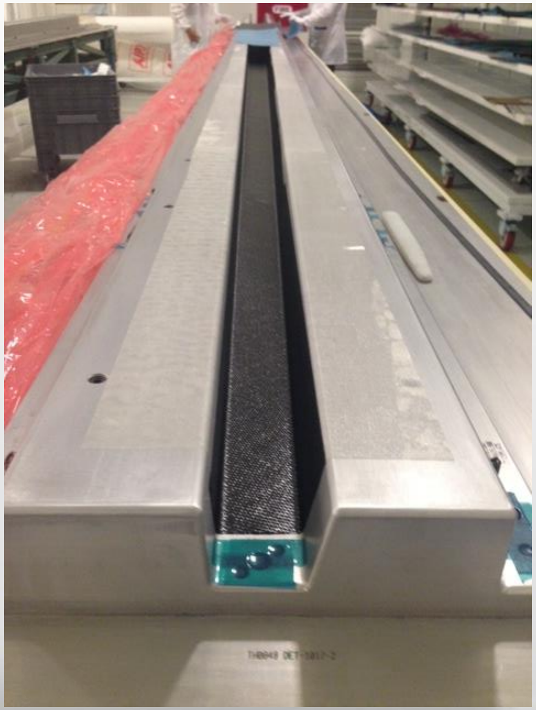
AIRBUS PROGRAMLARI
(Geniş Gövde Uçak Programları)

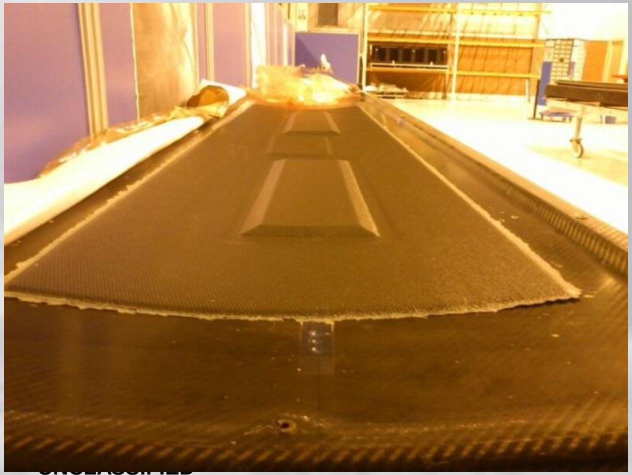
Airbus A350-900/1000 Aileron Tasarım ve Üretim Programları



ANKA



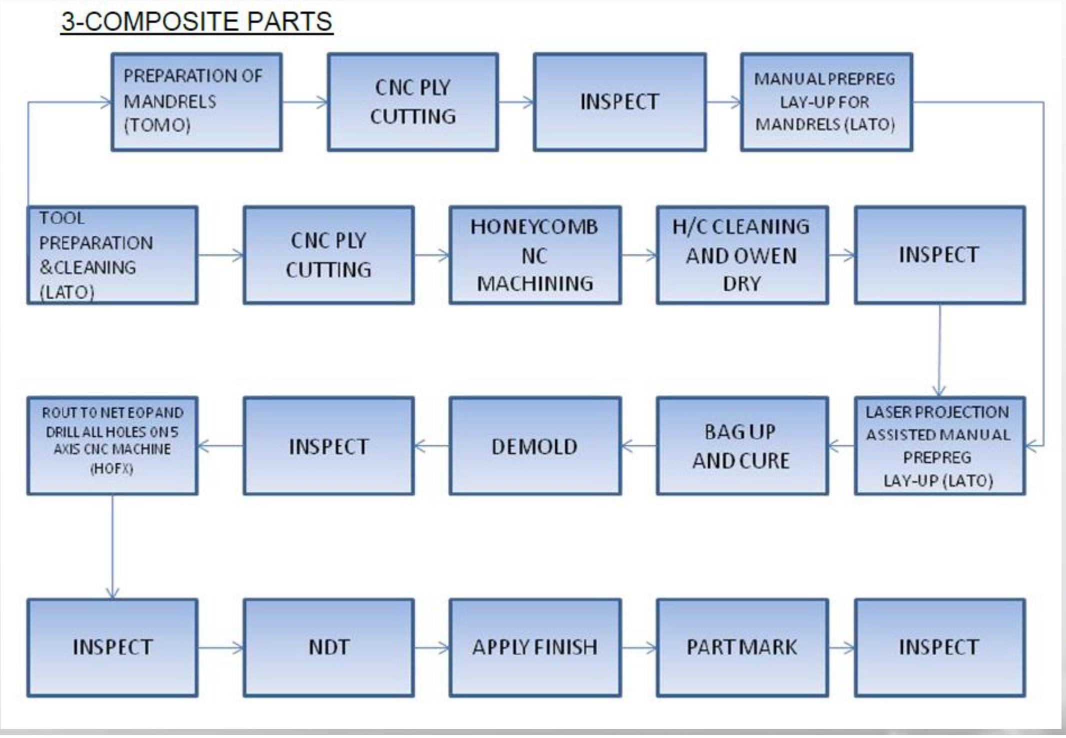


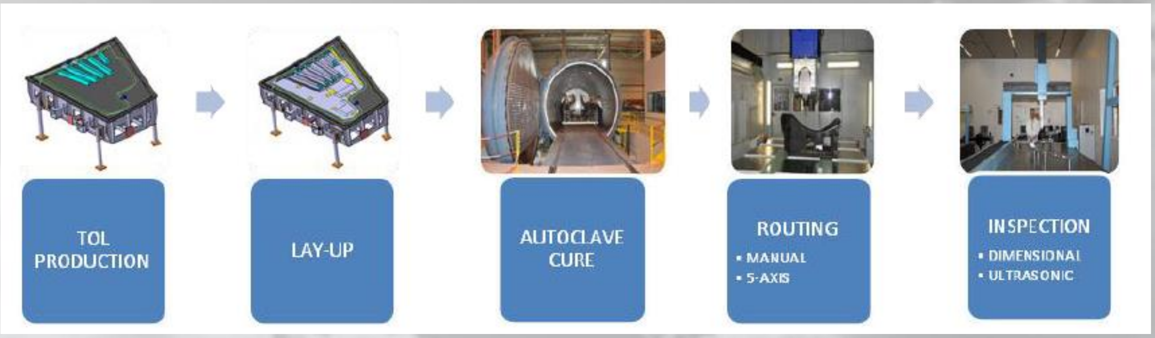


Anka spar is made by pre-preg CFRP composite. Plies laid-up onto spar tool and placed into autoclave after.

Anka panels are consists of pre-preg monolithic CFRP on outer layers and aramid honeycomb inside.

BOMBARDIER

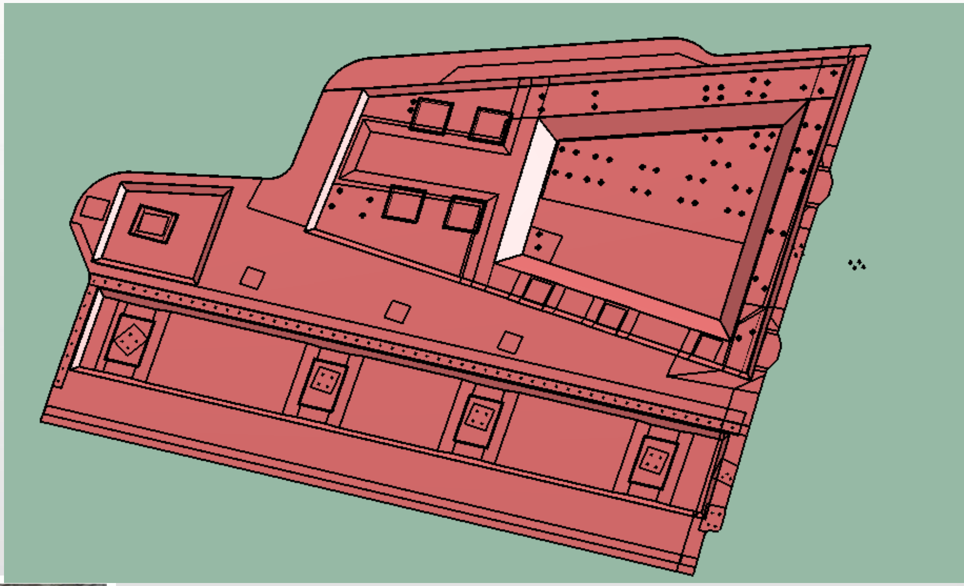




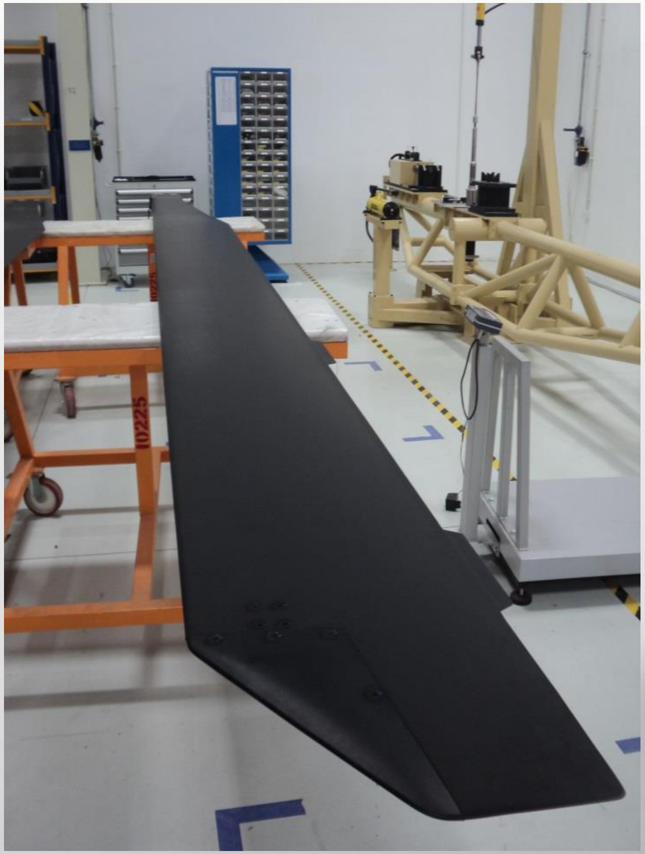
Manufacturing flowchart of composite MLG door of Bombardier C series.

BOMBARDIER

This MLG door panel is produced in TAI. Panel consists of pre-preg monolithic CFRP on outer layers and aramid honeycomb inside.



ATAK



Atak helicoper’s main rotor blade

Atak helicoper’s tail rotor blade

Atak helicoper’s rotor blades are made by pre-preg CFRP outer surface and composite foam & glass fibre material inside hot press manufacturing process.



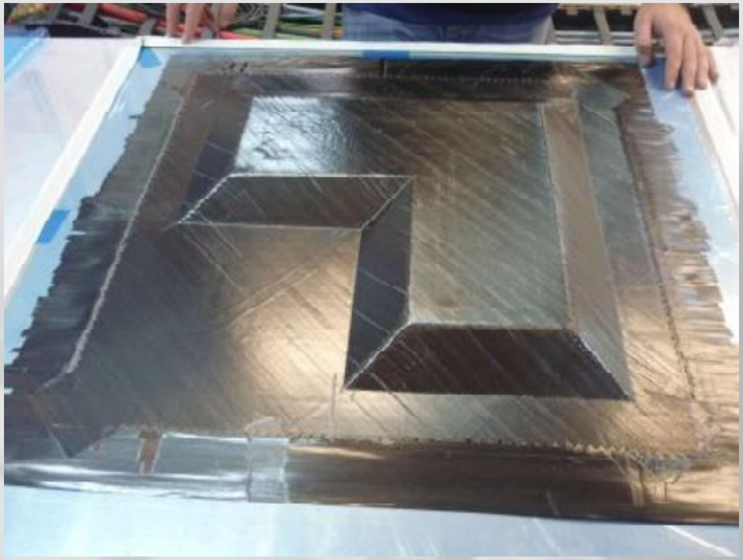


TAI

Special Manufacturing Technologies used in TAI

AFP PRODUCTION CAPABILITY

- Currently, 3 AFP are operational inside TAI facility.
- 2 more machines (8x1/4'' tow configuration) will be added to TAI machine inventory.
- High ramp-up will be supported. Hand lay-up will be optional, and design adapted to cover both methods.



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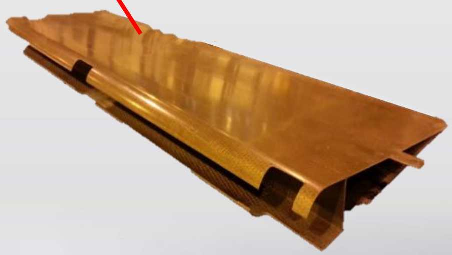
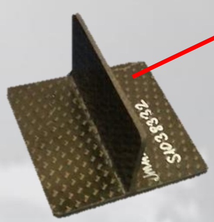
RTM APPLICATIONS IN TAI

(More than 80 different parts are in production now for Turkish UA

- ✓ Up to 2 meters long integrated wing movables produced one-shot RTM for Turkish UAV



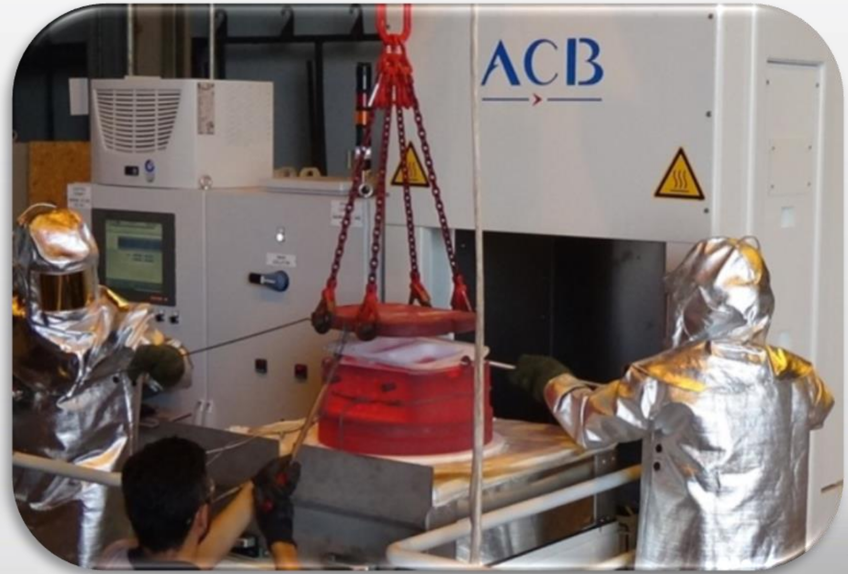
- ✓ Turkish UAV wing T-Brackets

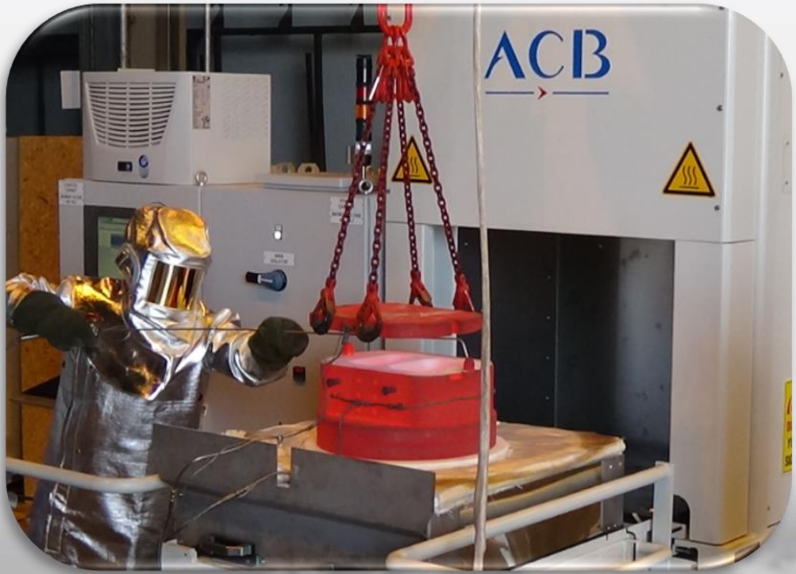


- ✓ Integrated wing movable trim tabs of Turkish Trainer Aircraft

SUPERPLASTIC FORMING (SPF) – DİLEK PROJECT

TAI INITATED A PROJECT WITH SSM & TEI IN 2014. PROJECT HAS BEEN COMPLETED IN 2017.

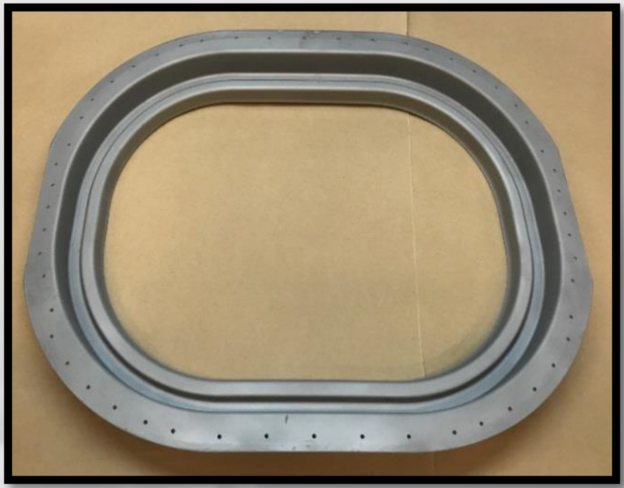




- FEASABLE FOR TITANIUM FORMING,
- HEATING CAPACITY UP TO 1000°C,
- CAPACITY OF 60 TONNES(METRIC)
- HAVING DIFFUSSION BONDING CAPACITY BESIDES SPF CAPABILITES,
- 580 mm DIAMETER CERAMIC PLATEN (480mm EFFECTIVE PRODUCTION DIAMETER)

TAI

SUPERPLASTIC FORMING (SPF) – DİLEK PROJECT



WINDOW FRAME PRODUCED BY SUPERPLASTIC FORMING METHOD IN TAI

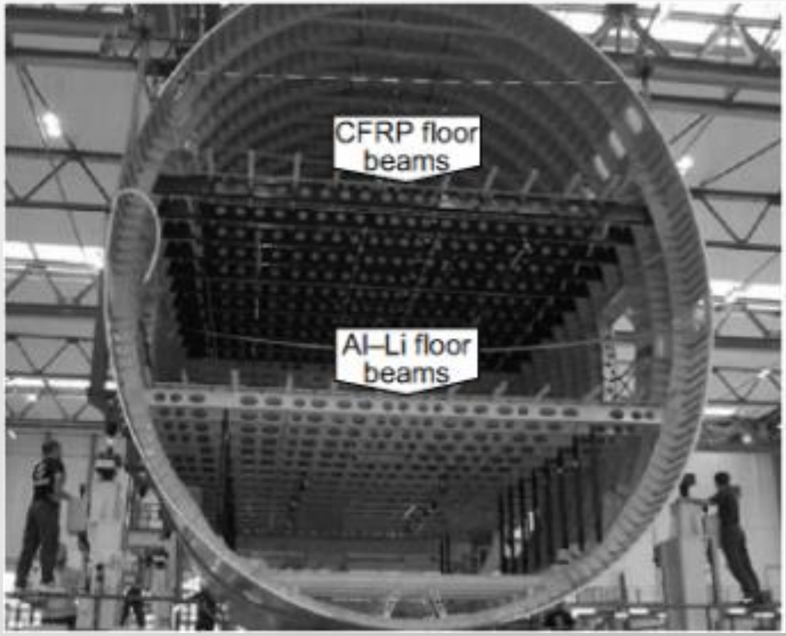




Advanced metallic material usage in Aircraft Industry

Advanced Metallic Apllications

- Al-Lithium Alloy Usage in Aircraft Industry



A380 FUSELAGE

Advantages

- %10 lighter and %5 stronger than conventional Al alloys.
- High resistance to fatigue crack growth.
- Better corrosion resistance

Disadvantages

- High material cost
- Fast crack initiation.
- Strong anisotropy

Al-Li is used on the Airbus A380 and A350, Boeing 787 and Bombardier C Series airliners, and on Gulfstream G650 and Bombardier Global 7000/8000 business jets.

Advanced Metallic Apllications

- Superplastic forming and diffusion bonding usage in Aircraft Industry

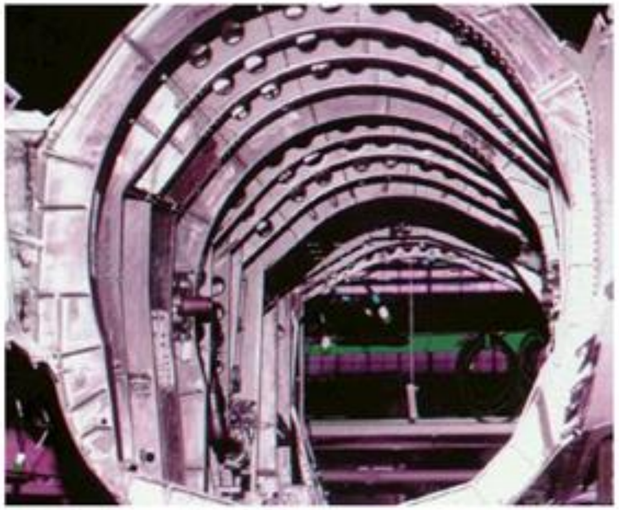
Application field of SPDB listed below;
Heat exchanger duct, Landing gear doors, Engine fan blades
Engine nacelles, Ecs ducting, Leading edges of airfoils, Engine access doors, Cargo bay floors, Fuselage tunnel covers, Heat shields

Advantages

- Low number of detail parts and fasteners, low weight
- Near net shape components with complex configurations
- Applicable to various materials
- Low residual stress occurs in the formed parts

Disadvantages

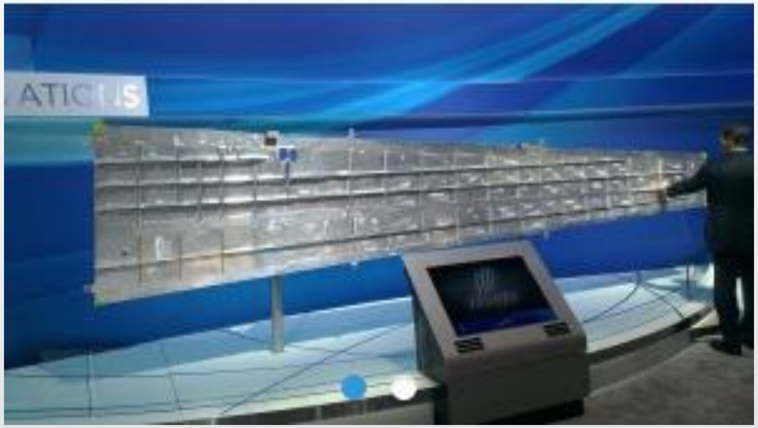
- Long process time
- Inhomogeneous material thickness
- High tool material cost
- Secondary finishing operation required


F-15C/D conventional aft fuselage


F-15E SPF/DB aft fuselage

Advanced Metallic Apllications

- Integrated Skin&Stringer applications



Manufacturing Methods

- Vacuum assisted machined panels
- Shot peening formed skin panels
- Extruded skin-stringer integrated panels
- Metal bonded panels

Honda jet-HA420-wing skin

Galaxy business jet-wing skin

UNCLASSIFIED

Metallic & Composite Structures

Composite Structures

Advantages

- Low assembly cost
- High fatigue performance
- Resistant to corrosion
- Relatively low weight
- Ease of manufacturing complex shape

Disadvantages

- Diffucult to repair
- Relatively high material cost
- Low electrical conductivity
- Diffucult to inspect ımpact

Metallic Structures

Advantages

- Low material cost
- High electrical conductivity
- Ease of repair
- Not affected by humidity

Disadvantages

- Low corrosion resistant
- Relatively low fatigue performance
- Relativly high density
- High assembly time
- Welding technology is not usually applicable

Metallic & Composite Hybrid Structures

FIBER METAL LAMINATE

- A fiber metal laminate (FML) is one of a class of metallic materials consisting of a laminate of several thin metal layers bonded with layers of composite material. The fibre/metal composite technology combines the advantages of metallic materials and fibre reinforced matrix systems. This allows the material to behave much as a simple metal structure, but with considerable specific advantages regarding properties such as metal fatigue, impact, corrosion resistance, fire resistance, weight savings, and specialized strength properties.
- Fibre Metal Laminates have been successfully introduced into the Airbus A380.
- ARALL has been developed for the lower wing skin panels of the former Fokker 27 aircraft and the cargo door of the Boeing C-17.
- ARALL 3 material is currently in production and flight test on the C-17 cargo doors and GLARE is selected for the Boeing 777 impact resistant bulk cargo floor.

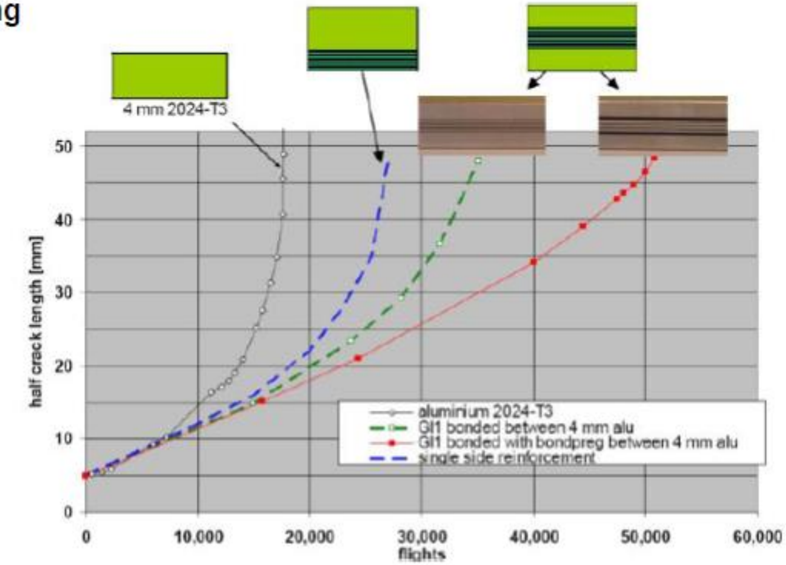
Fokker's tradional, non-automated production of GLARE fuselage panels

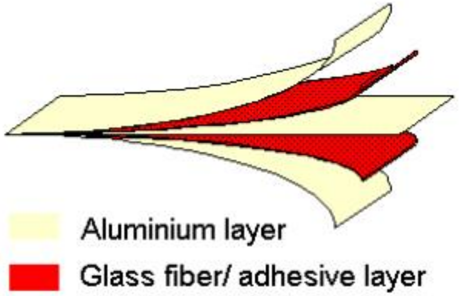
Glare Fuselage Panel Usage in A380

Glare is a sandwich material constructed from alternating layers of aluminum and glass fiber with bondfilm

- **Weight reduction: 15 to 30%,**
- **Excellent Fatigue Resistance,**
- **Improved Impact Resistance,**
- **Excellent Fire Resistance Behavior,**
- **Lightning Strike Capability.**

GLARE® shell with bonded stringers and doublers; A380 section 18, main deck panel

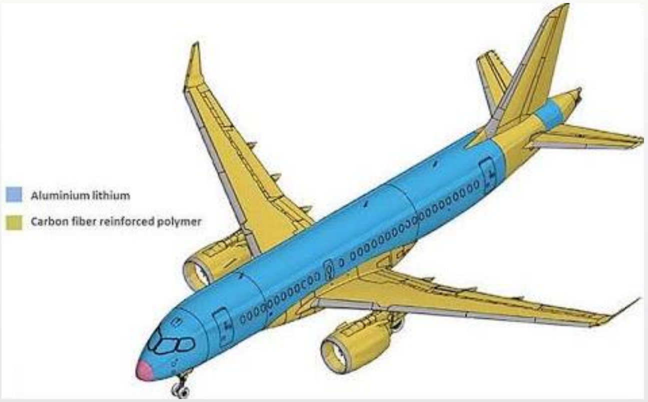


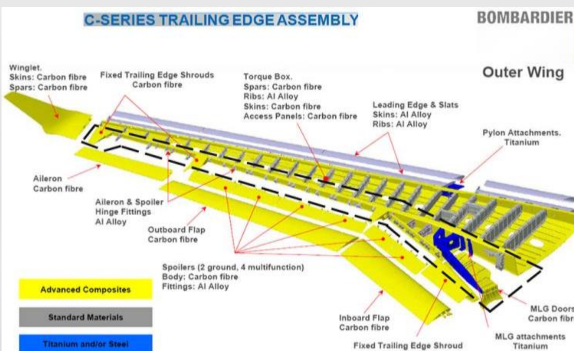


EADS Deutschland Gmbh, corparate research center

- Glare Fuselage Panel Usage in A380 Aircraft

Bombardier C series





Carbon fibre composite and Al-Li alloy metallic structures are used Bombardier C series aircraft.

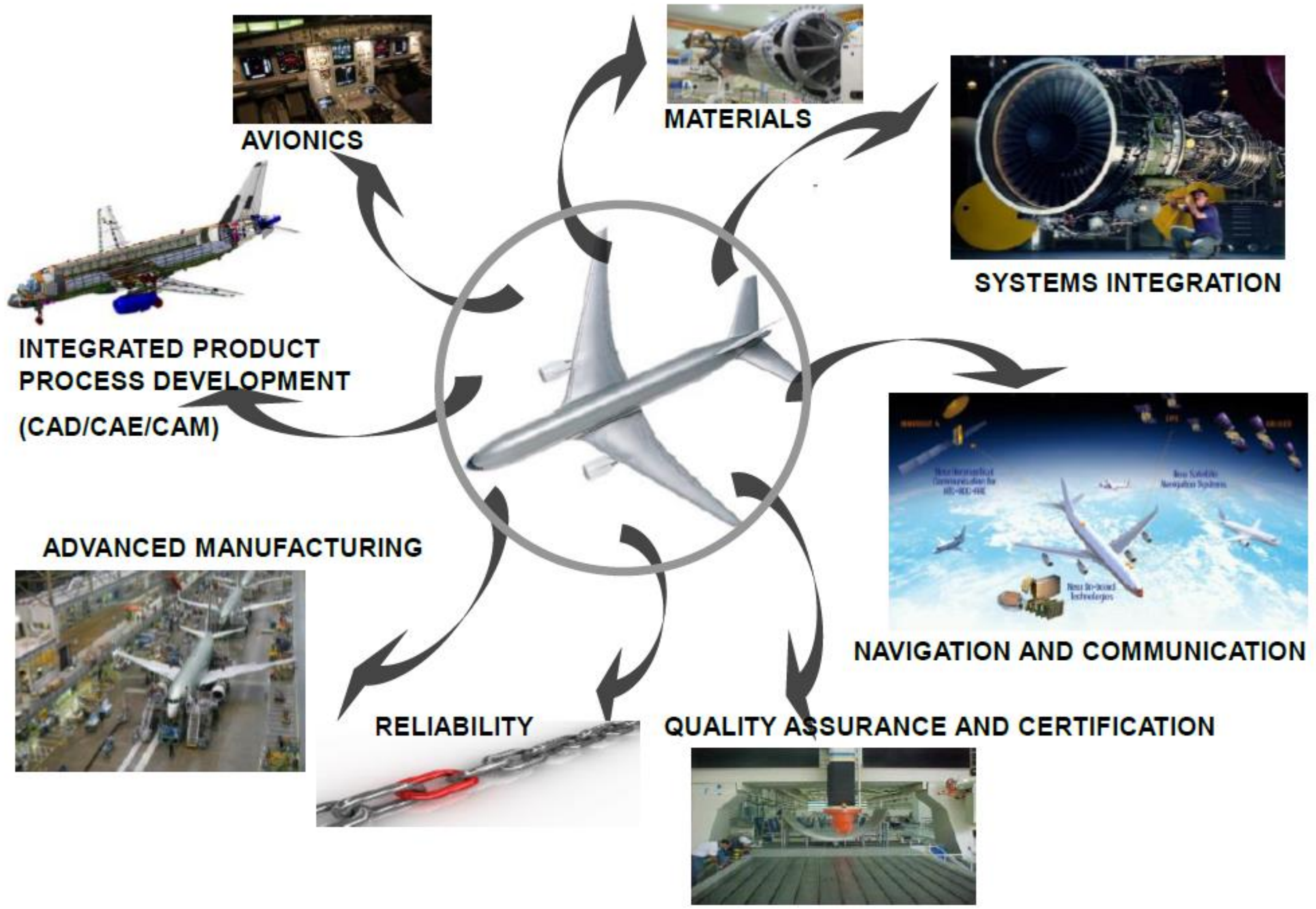
Wing

The structure of the wing's main load bearing torque box is carbon fibre spars and integrally stiffened upper and lower wingbox covers, creating a tapered cantilever beam. All these primary structures are resin transfer infused (RTI) carbon fibre. C Series is the first aircraft into the market with this technology, which is different from other carbon fibre wings in that they all use prepreg material.

Fuselage

The C series will use an Al-Li alloy in its central fuselage, lighter than traditional Al but jus as easy to repair.Combined with the other novations, the fuselage helps make the C series up to 2000 pounds lighter than current aircraft and produces up to %20 fewer greenhouse-gas emissions

Technologies and disciplines related with Aircraft

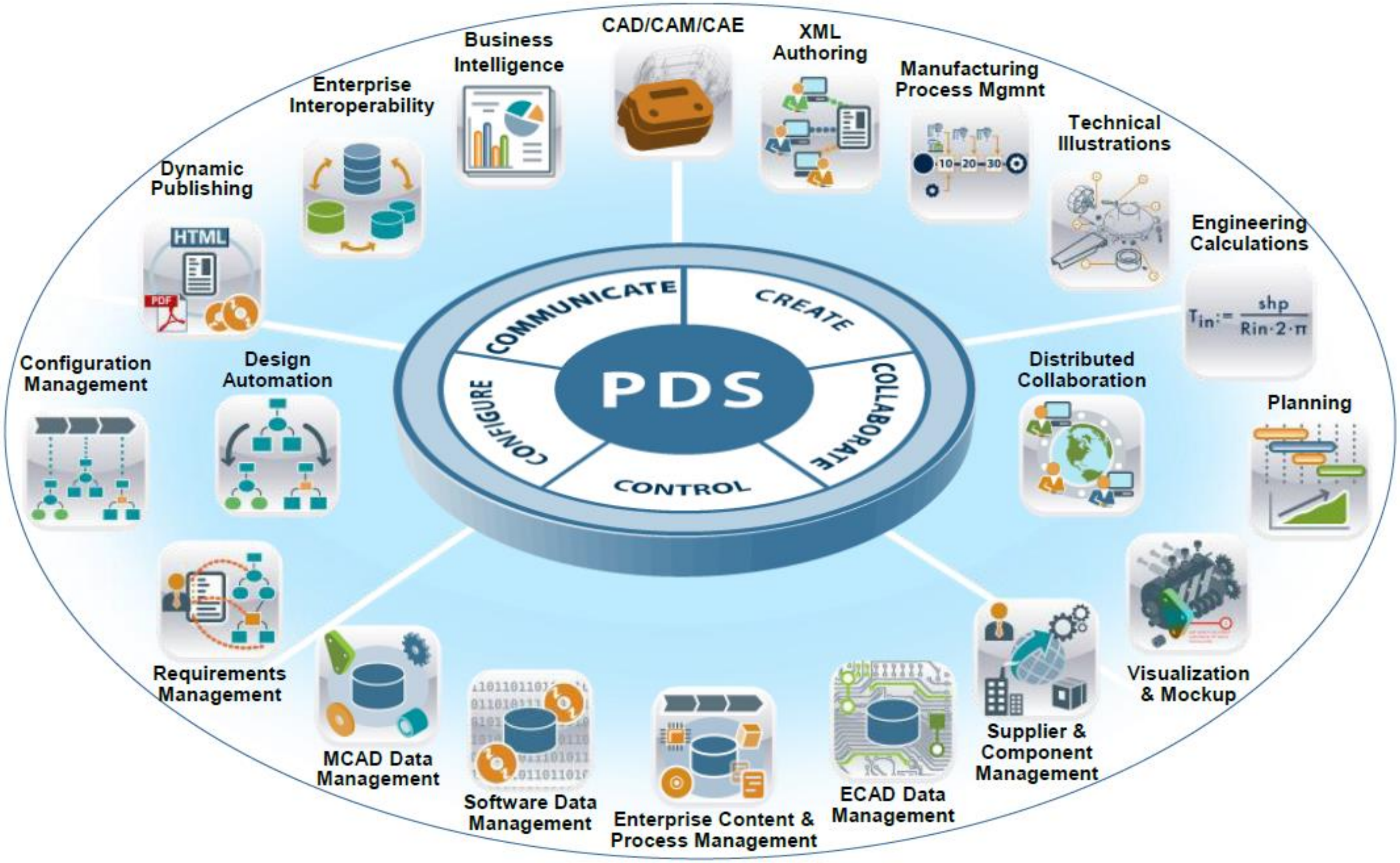


Commercial Transport Aircraft Design, Development, Certification, Production and Operation (Life Cycle) utilizes several technologies and disciplines which are mainly developed as spin-off technologies of aerospace industry itself in decades.

Aircraft Production Break-Down

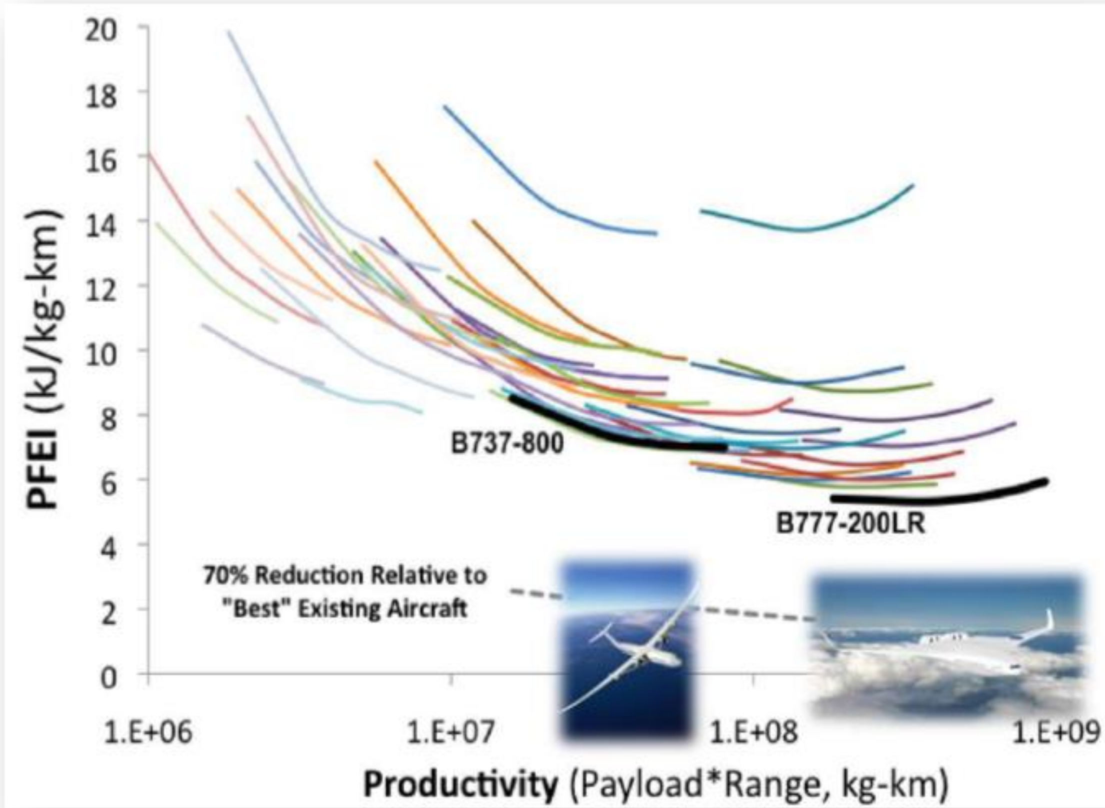
- *The pyramid of the highly diversified supply chain of systems, major assemblies, components and parts of CTA production.*

Product Life Cycle Management

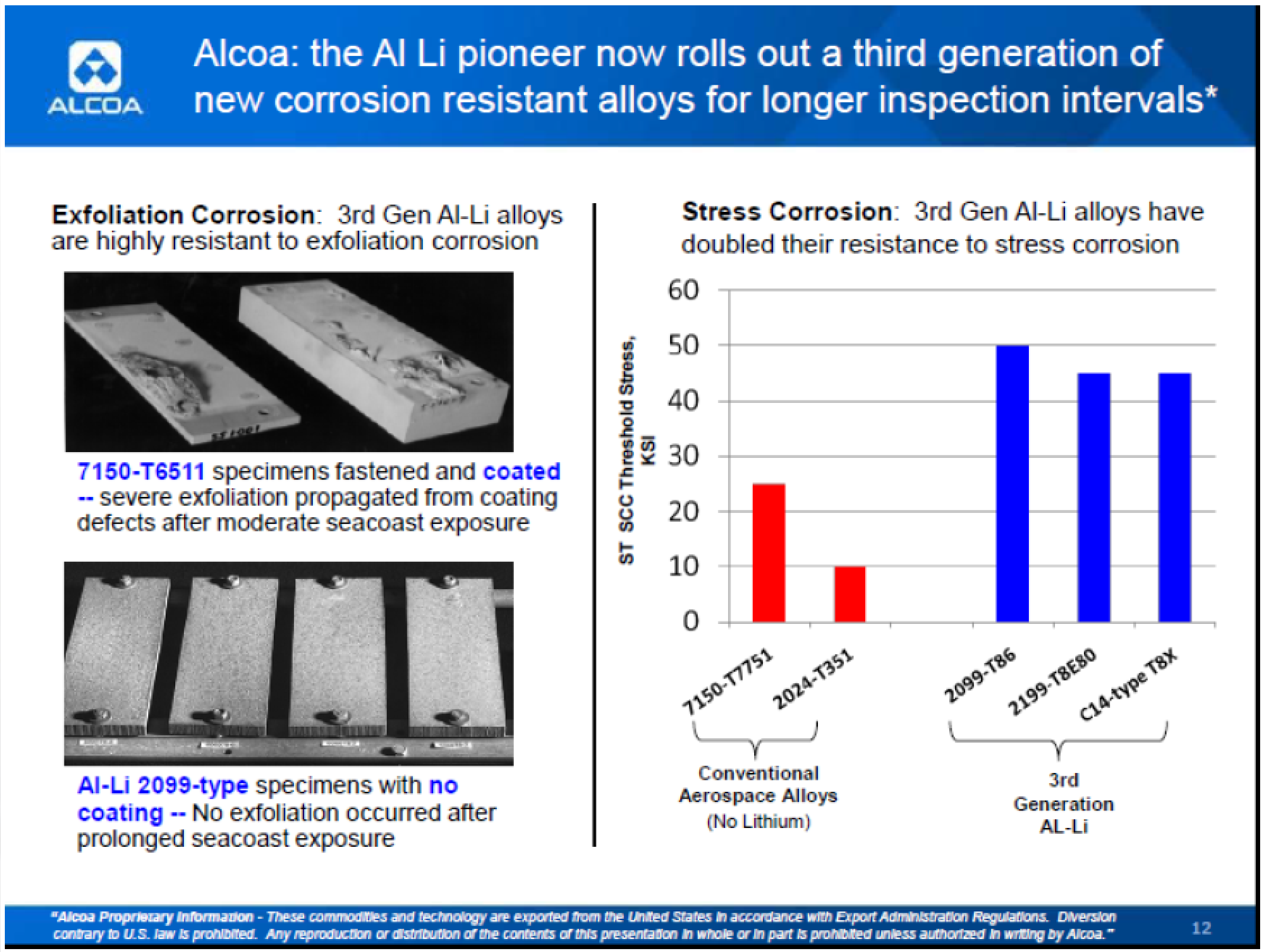


- Product Life Cycle Management (PLM) provides engineering design, analysis, documentation and the integration of the overall product information environment with tools also named as Product Development System (PDM) (Provided by Mr. Mustafa Ceren, Informatik, Turkey).

Fuel Burn Goals



- Commercial Transport Aircraft Fuel Burn Goals for 2030-2035 70 % reduction in total fuel burn per seat-mile [5], [6].



- *Chronology of Aluminum Alloys Development and Aluminum Lithium Alloys (Copyright of Alcoa Company).*

Composite Material Usage in A350 XWB

- Composite Material Usage in Aircraft Industry, Airbus A350 XWB Aircraft, Copyright of Airbus

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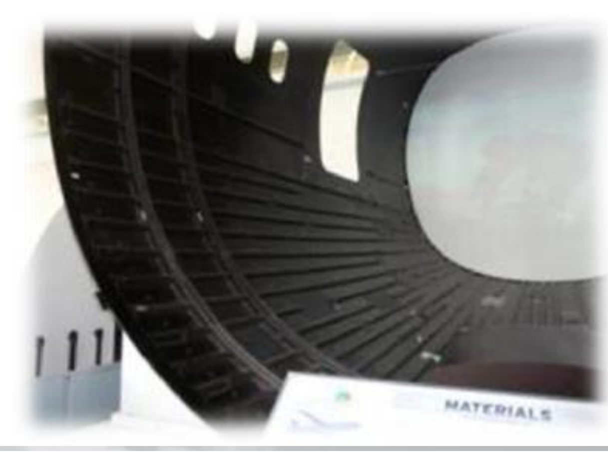
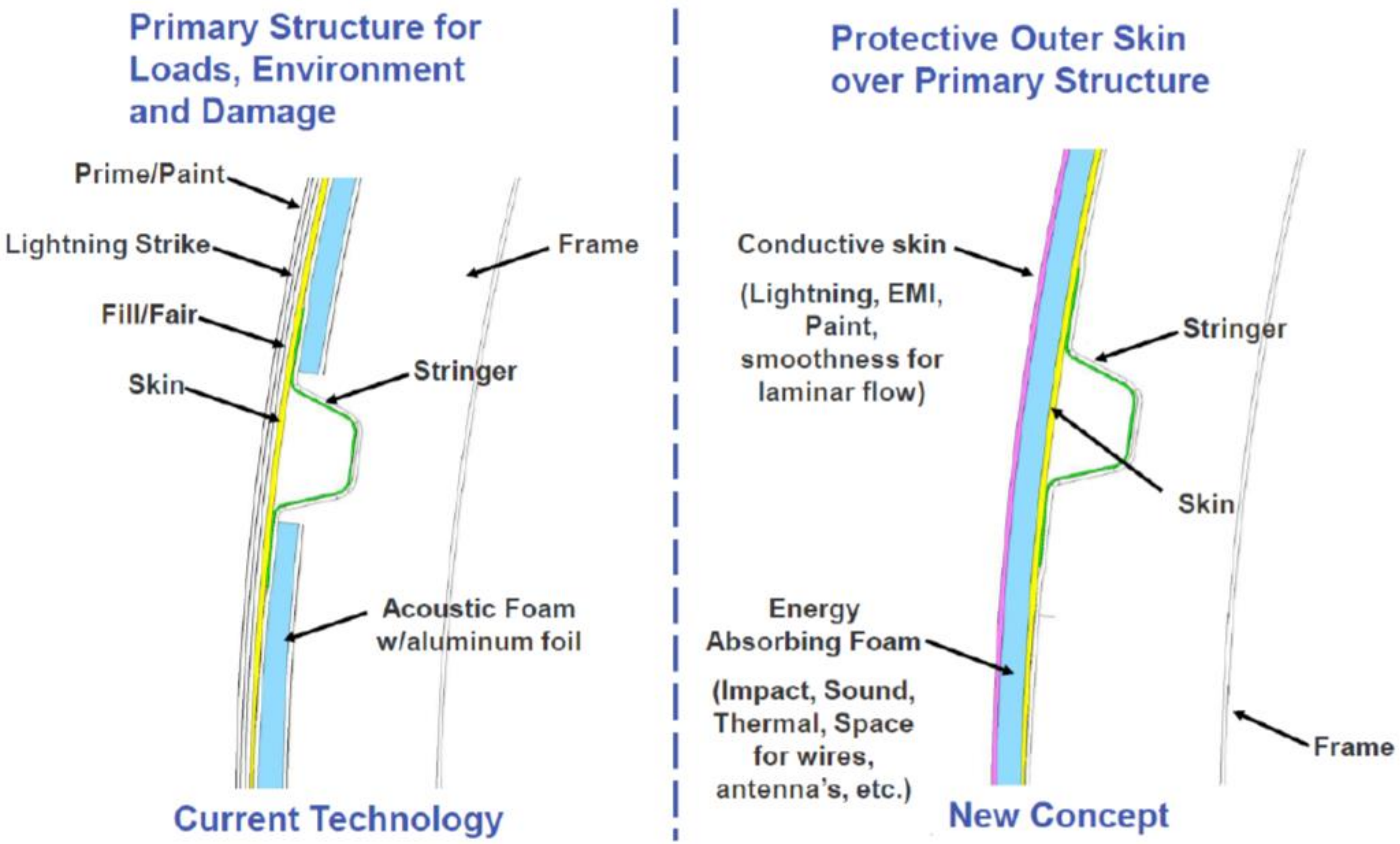
Composite Material Usage in Boeing 787



Composite Material Usage in BOEING 787 Aircraft, Copyright of Boeing Commercial Airplanes,

Composite Conductive Skin-Stringer Panel



- New Composite Conductive Skin-Stringer Concepts with Energy Absorbing Foam

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