Titanium Aerospace Demand & Integrated Supply Chain

ITA – Paris, France
April 2016
An increasing backlog, reaching 10 years of production

January 2016
Orders & Deliveries

Orders: 16,360
Deliveries: 9,542
Backlog: 6,818

+4,500 A320neo ORDERS
>180 A330neo ORDERS
BACKLOG VALUE
1 TRILLION US$ = 1,000,000,000,000 US$

Deliveries
Orders

Volume  Industry  Lean  Supply Chain  Cooperation
Shift in priorities / constraints

From **Engineering / development** Focus

To **Industrial / delivery** Focus

- **Volume**
- **Industry**
- **Lean Supply Chain**
- **Cooperation**
Airbus : Titanium needs

Every working day, Airbus products manufacturing requires around **30 tons** of Titanium (2014 consumption)

New aircraft models require more Titanium:
The input weight of Titanium is **18 times** higher on A350 XWB than on A330

All incremental development (NEO’s) to support optimisation of Aircraft performance involves new Pylon, where Titanium is key

Composite is a new major player in Aircraft manufacturing, Titanium demand is linked

→ **Titanium is key for Airbus**

Spend evolution 2013 => 2020(*)
- Forging: +50%
- Casting: +10%
- Titanium: +180%

(*)estimation

Supplier locations

Volume  Industry  Lean Supply Chain  Cooperation
Titanium strategy
Way forward

- **Boost competitiveness**
  - Investigate all opportunities to improve the **Total Cost of Ownership** of flying parts

- **Prepare the future**
  - **Innovation** and new technologies
  - Technological **trade-offs**
  - To **push** the most **competitive solutions** forward
  - **Supplier development**

- **Deliver on commitments**
  - **Stable and robust supply**

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**Volume**  |  **Industry**  |  **Lean Supply Chain**  |  **Cooperation**
Smart Sourcing supports a leaner and cost effective Supply Chain

- Double sourcing
- Duplicated production means
- Flow simplification (lean)
- Manufacturing alternatives (ALM, FSW, …)
- Optimize material management consumption
- Buy to Fly improvement

A Supply chain robust by design
Airbus Supply Chain Community

1. Engineer Cost out of the Supply Chain

2. Generate value by **alignment** with key suppliers across the Airbus Supply Chain Community
Titanium: engineering and manufacturing challenges

- Qualification of Additive Layer Manufacturing
- Buy to fly improvement: “Dead Zones”
- Development/Innovation: Ti for HT
Titanium: engineering and manufacturing challenges

Technical Qualification

Qualification of Additive Layer Manufacturing
Potential Business Case for ALM

**ALM**

- **Net Shape Manufacturing**
  - High Material Efficiency
  - Reduced material procurement
  - Recurring Cost Saving
  - -$x/m/yr Recurring Costs

- **Digital Manufacturing**
  - No Part Specific Tooling
  - Geometric Freedom
  - Product Performance Enhancement
  - +$x/m/yr Revenue
  - Short Lead Time
  - Reduced Development Costs
  - -$x/m/yr Non-Recurring Costs
  - Low Part Specific NRC
R&T overview per manufacturing technology

**- PLASTIC -**

- **FDM**
  - FDM-Head
  - Heating
  - Motor
  - Build sheet
  - Tip
  - Material canister
  - Support material
  - Model material

- **SLS**
  - Explore, understand (PA, PEK, …)

**- METALLIC -**

- **EBM**
  - Powder feed roller
  - Build envelope platform
  - Powder feed cartridge

- **LBM / SLM**
  - Mature (Ti); development (Ni/Inconel, Al)

**High Deposition Rate Technologies**

- Techno down selection ongoing

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The Horizon and Beyond – Vision for ALM Technology

- 2018: Topology Optimised Parts
- 2020: High Deposition Rate
- 2025: Hybrid Deposition & Machining
- 2030+: Multi-Material Structures & Systems
AIRBUS approach to introduce ALM technology

• Stepwise approach for introduction of ALM technology (post R&T):

**Step 1:** Capitalise experience on manufacturing Process
Non-PSE Parts
Titanium Parts
Same part design
Part Qualification*

PSE: principal structural element
* Pending process qualification

**Step 2:** Introduce Process Qualification (internal)

- **Step 2.1**
  - Non-PSEs
  - Process qualification
  - Optimised design

- **Step 2.2**
  - PSEs with Mult. Load Path
  - Part Qualification*
  - Same part design

**Step 3:** Introduce optimised design, extend to any kind of parts
All Parts
Optimised design
Process Qualification (external)
Extend to Nickel based and aluminium Parts

• Parts made of Electron Beam and Laser Beam technologies
• Hot Isostatic Pressing (HIP) Process systematically applied
What is a qualification?

- The qualification process consists of demonstrating that a part/material/process complies with the requirements of the relevant referential and production process and is performed in a robust and reproducible way.
- Basic requirement of EN 9100, Airbus Quality Assurance General Requirements.
- The result of Qualification is always a “Couple”.

The demonstration is performed by means of
- Technical Qualification by the Responsible Engineering
- Industrial Qualification by the Quality Organization
Approach for ALM qualification

1st step: PART qualification: “Blank qualification”

- qualification of couple blank/manufacturer site and machine type
- similar to what is done today for castings and forgings
- selected when in house techno maturity is low or when quantity of parts is low

2nd step: PROCESS qualification

- qualification of powder and couple process/shop
- similar to what is done today for forming, shot peening,…
- generally followed by a first part qualification (FPQ)
- selected when techno maturity is high and when quantity of parts is high.
PART Qualification in accordance with AIRBUS Standards

Each Specified Item or blank from each manufacturer site/machine type is technically qualified.

**Approach for qualification**

**Specified Item/Blank**
- Couple
- Manufacturer Site/Machine

**Part specific**
- Drawing
- Loads
- Test requirements
- …

**Supplier**
- Frozen manufacturing route
- Heat Treatment
- Testing (tensile, µCT)

1 Qualified Part
Approach for qualification

PROCESS Qualification in accordance with AIRBUS Standards

Technical Qualification of Manufacturing Processes is not linked to specific parts

Qualified Powder

- Chemical exam.
- Micrographic exam.
- AIMS specification for Powder

Qualified Process

- Material properties versus process parameter
- Testing e.g. Tensile...
- Process requirements
- AIPS / AIPI specification for process

Many parts can be manufactured within a process qualification
Qualification routes – Powder & Testing

Powder:

- **Parts Qualification**: managed by supplier who will provide powder source and demonstrate powder quality according to specification
- **Process qualification**: powder will be purchased by the supplier against an Airbus internal specification
- **Specification** will contain at least: chemical composition, flowability, morphology, size and size distribution and continuous quality control mechanism

Testing:

- Generic and process qualif.
- Part qualification
- Serial production
Titanium: engineering and manufacturing challenges

Buy to fly improvement: “Dead Zones”
Buy to fly ratio in Metallic – US dead zone reduction

US Dead zone reduction on plates and forgings (Titanium first, and Aluminium) → +/- 3mm not inspected on product surface, and generally removed by machining.

Two ways to handle /analyse

- Analysis of historical inspection data (defect type and location in raw material, billets, plates,…) and assessment of the risk to get defect in this Dead zone.

- US inspection improvement to reduce the thickness of this “not inspected” material (multi zone, multi probe, …)

In order to make this cost reduction initiative a success:
→ suppliers cooperation and inputs are essentials
DZ reduction: the probabilistic approach

• **Objective:** define the probability of finding internal defects in the DZ region of billet material
• **Difficulty:** the DZ is by definition an uncontrolled volume of material.
• **Idea:**
  - determine the probability of presence of defects in the complete volume of the billet
  - establish probabilistic law covering the defects presence function of the position in billet radius
  - extrapolate with this law to the probability of presence in the ultrasonic dead zone region.

Supplier data needed!
Probalistic approach – F&DT

1. Probability of defect of size > x in part received by Plant
   Determined using statistics established from inputs provided by Material suppliers.

2. Probability that defect(s) is in DZ only
   Determined from the ratio between DZ and total volume, or using defect distribution.

3. Probability that defect(s) is not found by LPI
   Probability that defect is close enough to the surface to be detected by LPI.

4. Probability that defect(s) remains after milling
   BtF ratio may be considered

5. Probability that defect(s) is in fatigue sensitive area
   Assume numerous fatigue sensitive details (e.g. plate with fastener holes every 25mm, or long fillet radius).
Titanium: engineering and manufacturing challenges
A350 APF (Aft Pylon Fairing) lower shell in titanium

**Context:**

- Improved engines (NEO): lower shell part will experience temperatures max. 590°C and cont. above 500°C.
- Baseline for this part: 6242 sheets
- Parts mainly sized by sonic fatigue and static loading. However, minimal fatigue properties are required
Keynote take away

- Airbus’ order book offers a bright perspective to its Supply Chain looking forward.

- Market demand calls for an important delivery volume increase.

- To fulfil customers' expectations, a step change in the way of working with and within the supply chain is mandatory towards industrial excellence at competitive costs.

- Communication, anticipation and simplification between Airbus and its Supply Chain will be the key enablers to success.

- Airbus Procurement and Engineering are already onboard.

- Such improvements will ensure our common and sustainable competitiveness.