THALES

Additive Manufacturing within Thales

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EASA - FAA Additive Manufacturing Workshop 2019

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ALM INTRODUCTION

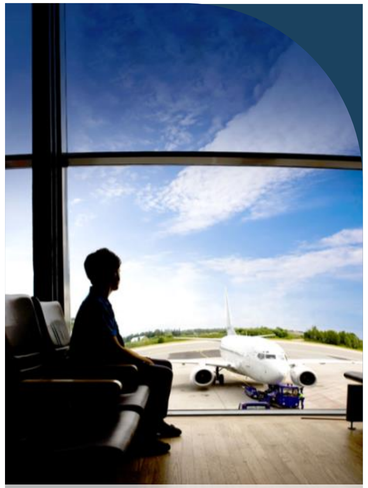
APPLICATION EXAMPLES

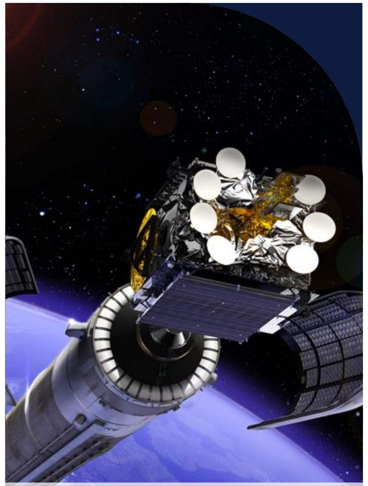
ALM BARRIERS

CLEARINGS IN THE “JUNGLE”

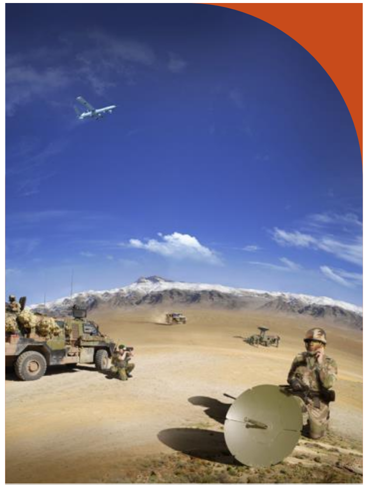
Thales Overview

DUAL MARKETS
Military & Civil


AEROSPACE


SPACE


GROUND TRANSPORTATION


DEFENCE


SECURITY

TRUSTED PARTNER FOR A SAFER WORLD

Thales Overview

Company Footprint

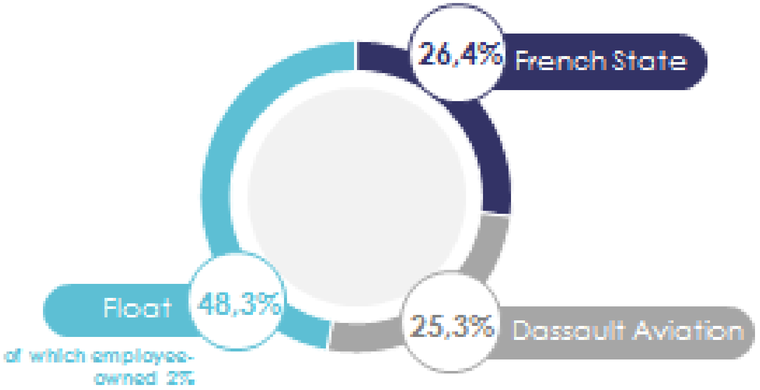
Employees
60,000

Global presence
56 countries

Self-funded R&D
675 million euros

A balanced revenue structure

Shareholders



AM within Thales

- International AM Network
- National AM Communities
  - Aligned to business lines
- Global training team
- Central Metallic Facility
- Distributed Plastic Capability
- External networks
  - MTC, IUK, GFAS, AMAZE, AMANDE, KALM…

The Thales 3D Industrial Competence Centre in Casablanca

METAL 3D PRINTING: THALES CREATES A GLOBAL CENTRE OF EXPERTISE IN MOROCCO

08.09.2017 SHARE

Thales supports Morocco's ambition to progress in the aerospace sector and is inaugurating its industrial Competence Centre in Casablanca, specialising in metal additive manufacturing, also known as metal 3D printing. This plant will become a platform allowing the international requirements of the Group and its customers to be met.

Inauguration took place in September 2017

“Thales 3D Morocco”

- Casablanca, Morocco
- PBF-L - Aluminium & Titanium
- "Industry 4.0"
- Brand new purpose built facility

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ALM INTRODUCTION

PARTS UNDER STUDY

ALM BARRIERS

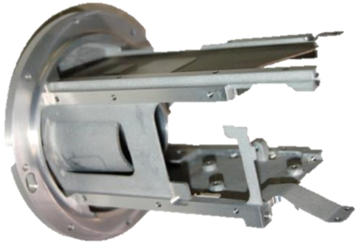
CLEARINGS IN THE "JUNGLE"

Most of Thales Group entities concerned by ALM worldwide

AVIONICS

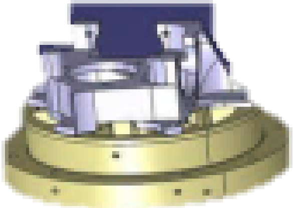

Pitot probes


Heat Sink


IR sensor support


AoA Probes


Wave guides


Gyro and Sensor support

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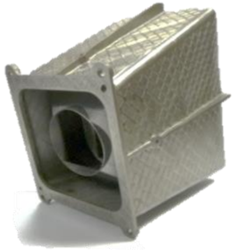
Antenna tripod

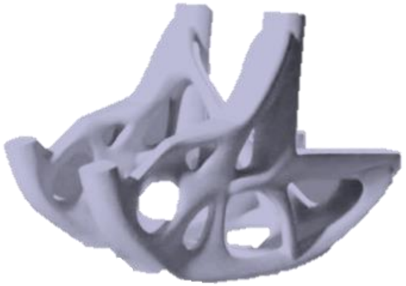

Ku-Horn support


Tubular support


Optical baffle


Aluminum & Titanium parts

DEFENSE


Radar antenna support


CW100RF horn


Honeycomb structure


Energy focalisation system

Ex 1: First Investigations on Pitot Probes

Pitot probes are located outside of the Aircraft and submitted to extreme conditions

- T = -55°C to T+ 600°C under static ground conditions(heating)
- Corrosion, Abrasive wear, Shocks
- Icing Conditions

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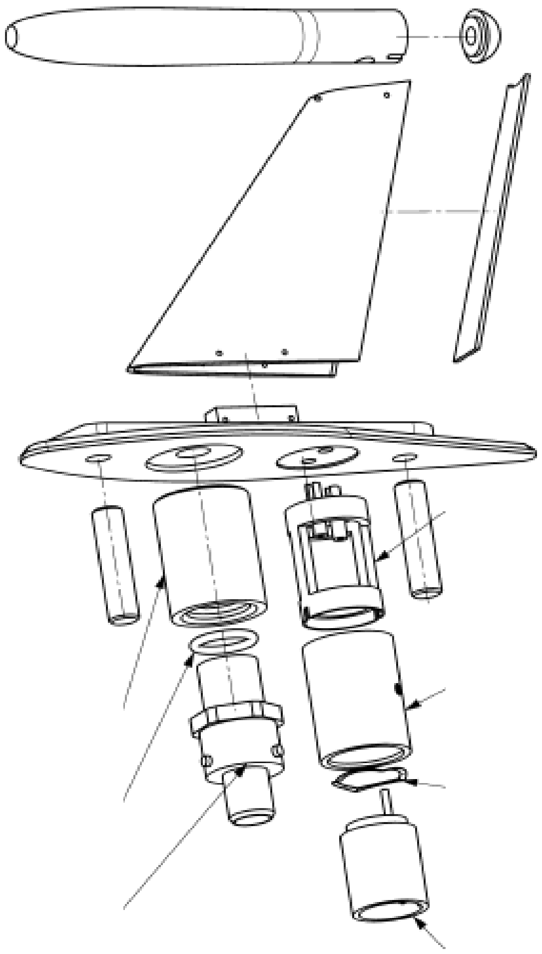
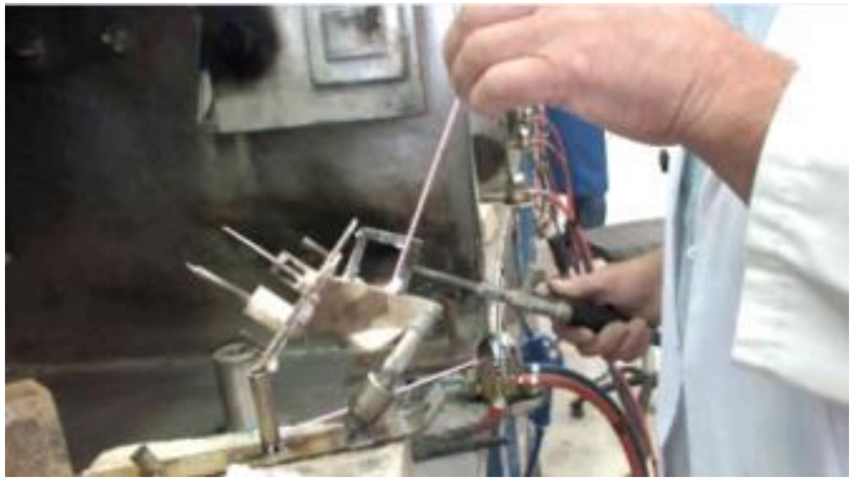
Pitot Probes : Current Situation



The probe is composed of 19 parts and needs several critical manufacturing steps



Tough competition with the US probes providers

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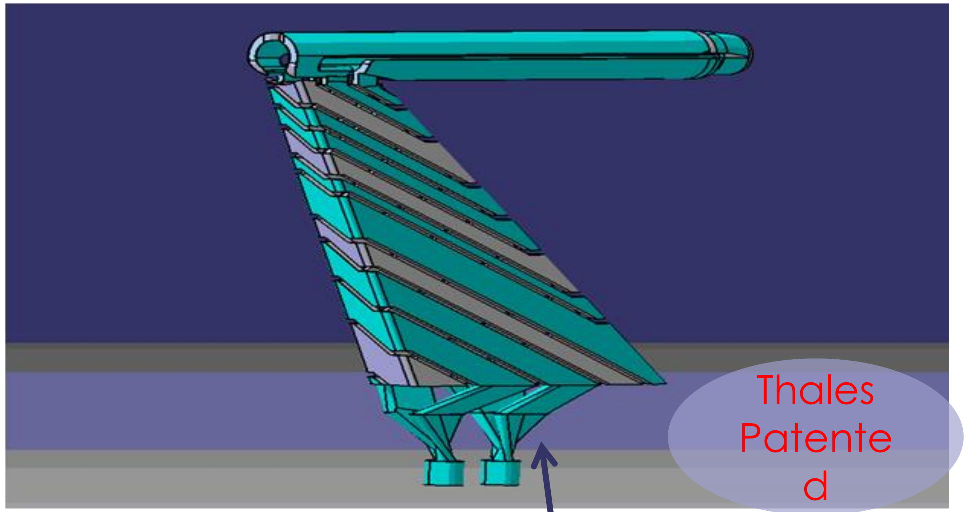
Principle and Benefit of ALM : Phase Change Heating

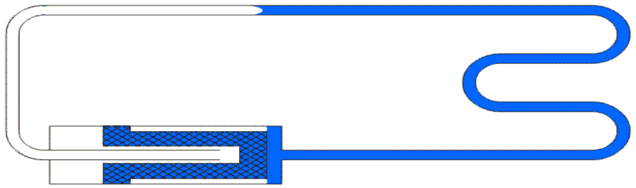
- Phase Change Systems based on Loop Heat Pipes(LHP) allow to transfer heat with a very high efficiency
- ALM permit to replace the heating wire by simple channels produced in one single shot
- The Combination of both technologies offers new opportunities

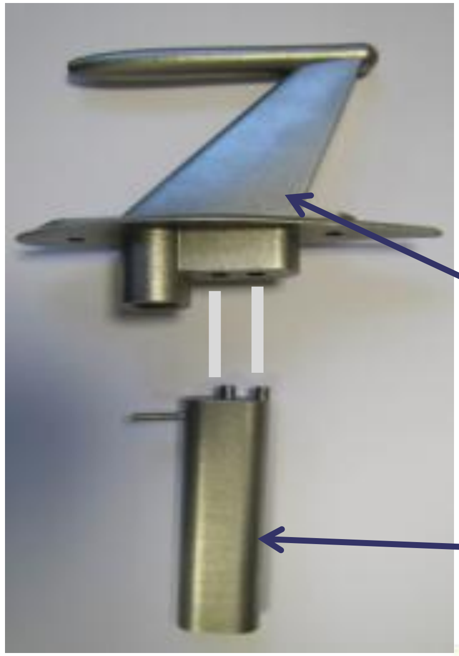


Channels

Additive Manufacturing

Phase Change Systems (LHP)





The probe acts as a condensor

Evaporator

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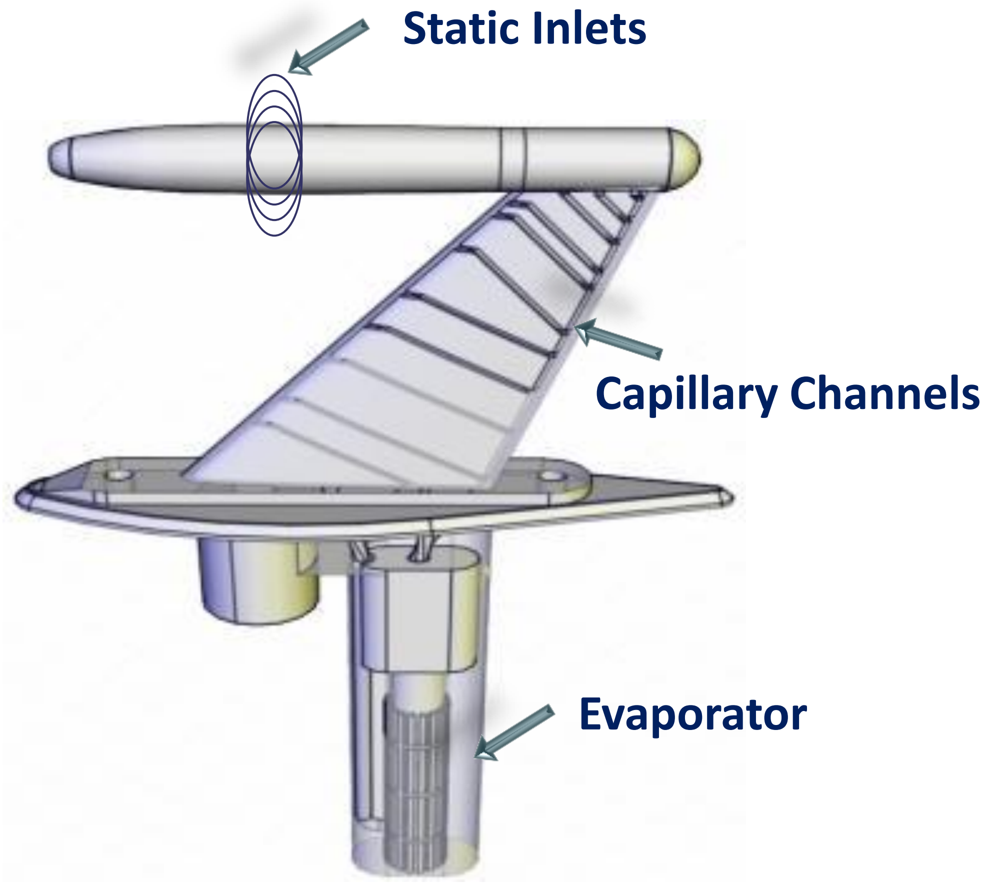
Principle and Benefit of ALM : Phase Change Heating

Phase Change and ALM Breakthrough

- Benefit on purchased parts: 25 %
  - 68 % of parts reduction (monobloc probe)
- Benefit on Manpower: 25 %
  - 76 % less producing steps
  - No critical process
- 92 % gain on Lead Time



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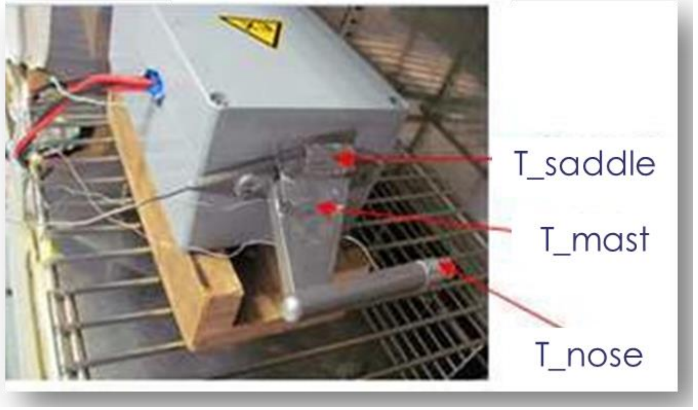
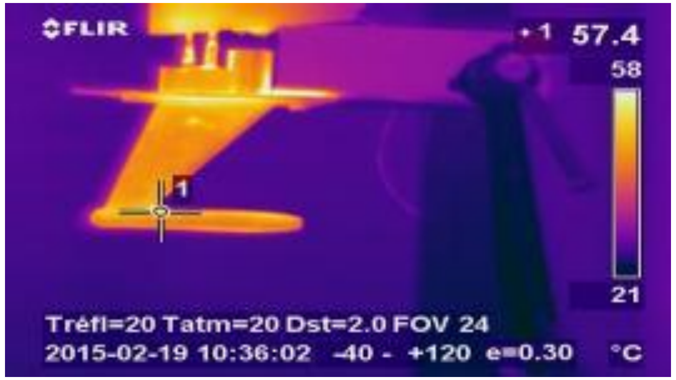
Experimental tests on the first prototypes in wind tunel

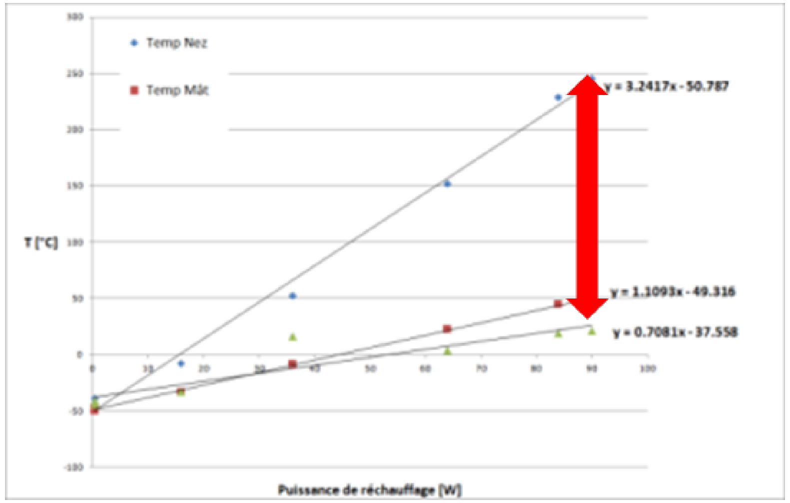
Tests



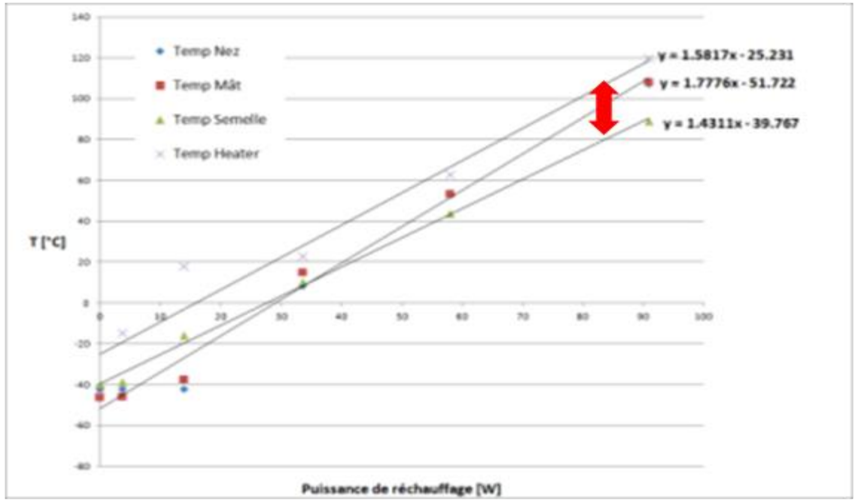


Climatic chamber

Results



Classical design with electrical heating



New design with phase change

More homogeneous behavior with the phase change system

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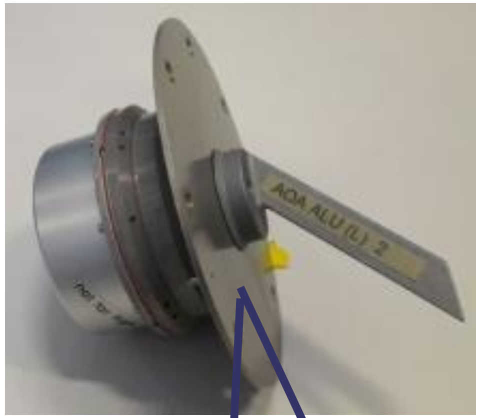
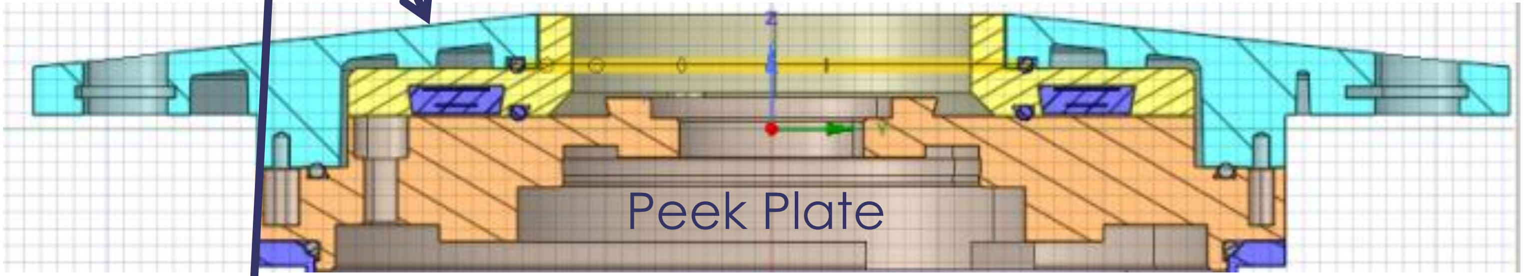
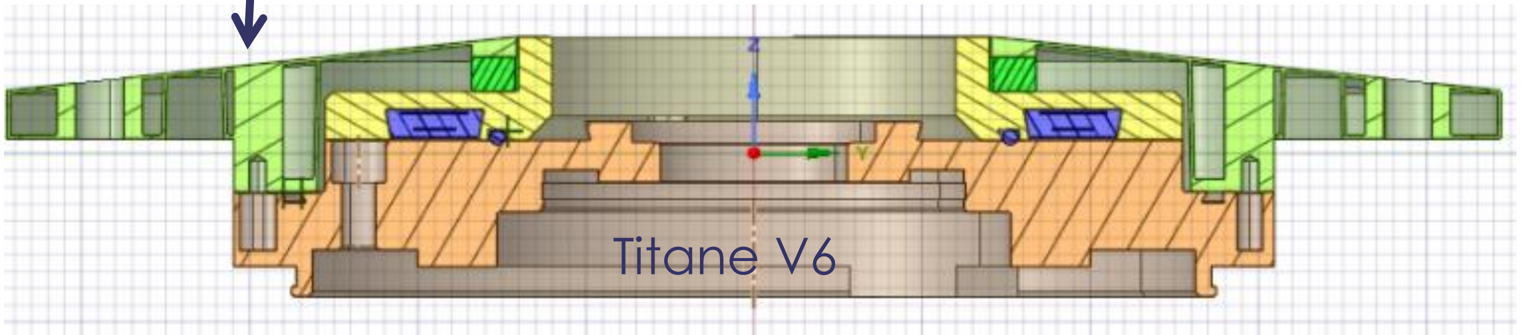
Ex 2: AOA (Angle of Attack) Attachement Plate



Context
- Initial design: PEEK plate 450GL30 (glass fiber reinforced)

Issues
- Creep under constraints and environement
- Stability of the painting
- Long terme mechanical behavior





Challenge :
- Peek thermal conductivity: 0,3W/mK

TA6V: 6,2 W/mK (20x higher)

Benefits :
- TA6V weel known material and qualified by TAS
- Wear resistancy TA6V -> PEEK
- Mechanical resistancy TA6V > peek
- Creep risk reduction and improvement of the stability
- Lead time

Methodology:
Thermo-ectrical coupling with simplified hypothesis

Topological optimisation with Optistruct (ALTAIR)

-h ~50 W/m2K

-Text -55 °C

Ex 2: AOA (Angle of Attack) Attachement Plate: Lattice Structure

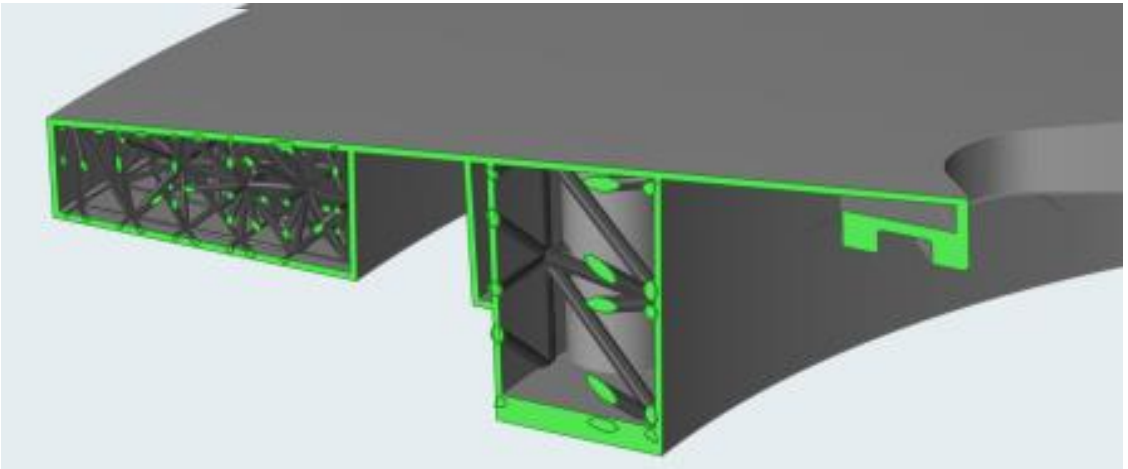


Figure 1: Vue en coupe de la plaque en titane

Figure 2: Vue de dessus de la plaque en titane

Lattice structure aims:

- Improvement of the stiffness without impact the thermal behaviour of the product.
- Lattice structure: High resistancy, low themal conductivity

The weight of the TA6V plate solution is about 250g -> Peek solution 245g

Ex 2: AOA (Angle of Attack) Attachement Plate : Resuts and statement

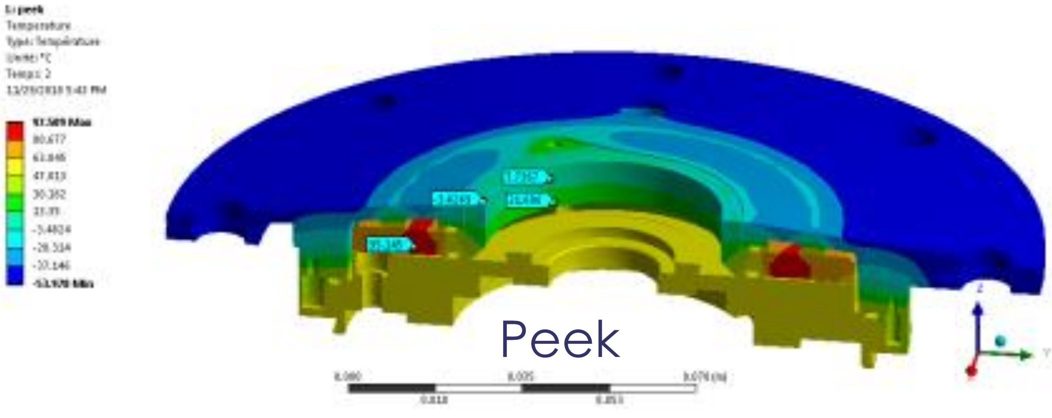
Results obtained

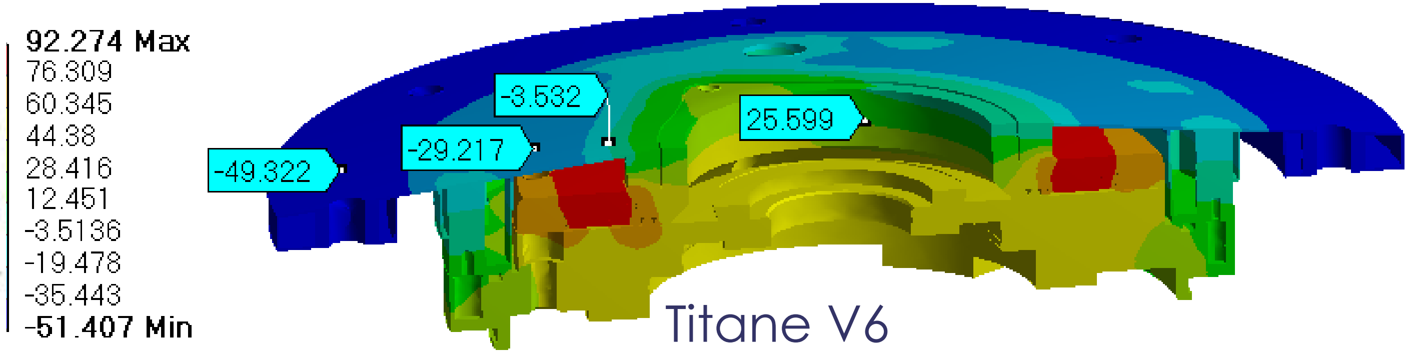
- 4 mechanical and thermal optimizations have been needed to converge to a solution
- The thermal behavour is equivalent to the PEEK design

	P (W)	Tmoy (°C)	DP /ref peek (W)	DT /ref peek (°C)
Peek	61	39	/	/
titane V1	85	31	24	-8
titane V2	61	38	0	-1
titane V6	58	40	-3	1

Statement – Reamining work

- Optimize the cost efficiency compare to the injection process
- Calibrated the mechanical and thermal performances of the lattice structure for the simulations





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ALM INTRODUCTION

PARTS UNDER STUDY

ALM BARRIERS

CLEARINGS IN THE "JUNGLE"

Main identified barriers for ALM in Avionics

Challenges

- Additive Manufacturing is one of the pillar of industry 4.0.
- ALM is considered as a 'special process ' that needs to be under control from beginning to end
- Several SMEs are disappearing by lack of applications, there is a need to make ALM an industrial process

Identified show stoppers

- Material and Part Qualification and certification
- Improvement of economical productivity and efficiency through new generation of machines with multiple lasers and the automation and integration in 4.0 manufacturing plants
- Reproducibility (machines, plants, etc) through integrated continuous controls and a better management of the parameters (big data) to minimize the final expensive controls
- Range of material available in ALM -> Concentrated on few alloys which doesn't cover the majority of electronics applications in aeronautics

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To overcome these barriers Thales AVS is participating and managing several collaborative programs

AMANDE (National)

- Acquisition of base parameters for the 5 usual materials : Al, Ti, Ni, Cu, S. Steel
- Harmonization of the specifications for powders and controls
- Application on various use cases

ALMEE FUI (Regional)

- Aluminum supply chain development
- Adaptation of 3DS machines for the new Al Alloys developped by Thales and Constellium
- Optimization of the parameters on Addup machines

KADD (ALM Qual/ Certif)
with FR Aerospace main players

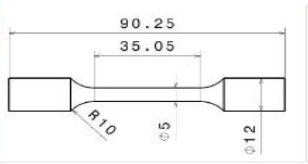
AEROPRINT (in preparation)
with Dassault Aviation
Improvement of ALM effectiveness pilot lines

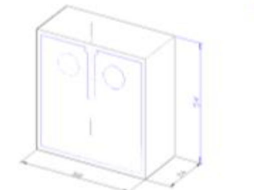
PACKCOOL EDA (European level) — **ALM application to the Packaging/Cooling of MIL Equipment**

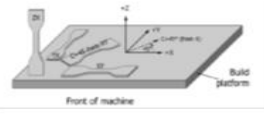
Standardization of qualification activities proposed for the probes

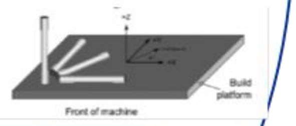
ALM QUALIFICATION

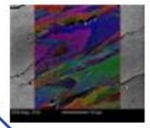
Generic Process and Material Qualification and Specification

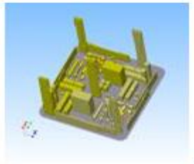












Performed on test specimens for one material # 400 Tests

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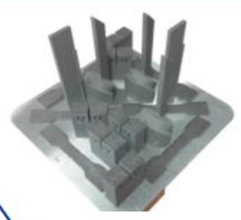
Part qualification Specification

Example of source change

Nb Batches > 3 batches					
Requirements		Test Method	Test frequency		
Properties	Chapter		Parts	Specimens	Frequency
Part Chemical compositions		Concentric Ring Probe ASTM D257-99, ASTM 11.11-2001, IEC 61340-5-1	x		1 per batch as specified in the drawing set
Aspect (surface conditions cosmetics defects)		Visual inspection with the naked eye ISO 16348	x		each part 100 %
Dimensions		Dimensional and geometrical verification NF EN ISO 14253-1	x		each dimension of the drawing
Density		Relative density evaluation according to NF EN ISO 3369	x		each part 100 %
Internal defects		Tomography according to NF EN 61675-1 and 2 Radiographic testing according to NF EN 12681	x		1 per batch as specified in the drawing set the parts should be taken in different positions on each batch (4 corners and one at center)
Metallurgical state		Microstructure observation, MEB EBSD+EDX, Optical microscope	x		1 per batch as specified in the drawing set the parts should be taken in different positions on each batch (4 corners and one at center)
Hardness		ISO 6507 Vickers	x		To be performed on one witness specimen and compare to the PMQS
Surface roughness		Profilometre Ra, Rp, Rz, W, AW ISO 4288	x		1 per batch as specified in the drawing set the parts should be taken in different positions on each batch (4 corners and one at center)
Tensile properties Rm, Rp0,2, A%E		Tensile test on machined according to NF EN ISO 6892-1		x	To be performed on Z direction (TP7), on the full height (3 height), different positions (coins, center) and compare to the PMQS Quantity/config = 6



Performed in the Manufacturing plant 3 Batch min

+

Part QUALIFICATION

Product Functional and Environmental Qualification

Requirement	Standard, Category and test levels
Climatic environment	
Low operating temperature High operating temperature Non operating tests	DO-160B [N1] Section 4 Cat. D2
Temperature variation	DO-160B [N1] Section 5 Cat. C
Altitude	ABD0007 [C3] (-1 000 to 45 000 ft)
Humidity	DO-160B [N1] Section 6 Cat. B
Explosion proofness	DO-160B [N1] Section 9 Cat. X
Waterproofness	DO-160B [N1] Section 10 Cat. W
Fluids susceptibility	DO-160B [N1] Section 11 Cat. X
Sand and dust	DO-160B [N1] Section 12 Cat. D
Fungus	DO-160B [N1] Section 13 Cat. F
Salt fog	DO-160B [N1] Section 14 Cat. S
Icing	See appendix 3
Mechanical environment	
Shocks (operational and crash)	DO-160B [N1] Section 7
Vibration	ABD0007 [C3] § 3.9 Cat. 3 Curve C random spectra
Windmilling / Tire burst	First natural frequency shall be above 27 Hz
Constant acceleration	ABD0007 [C3] § 3.12
Electrical environment	
Power input	DO-160B [N1] Section 16 / ABD0013 [C5]
Voltage spike	DO-160B [N1] Section 17
Lightning indirect effects	ABD0007 [C3] Appendix 2 (single stroke test Level L)

Standard environment qualification

⇒ **FLIGHT TESTS/ Certification**

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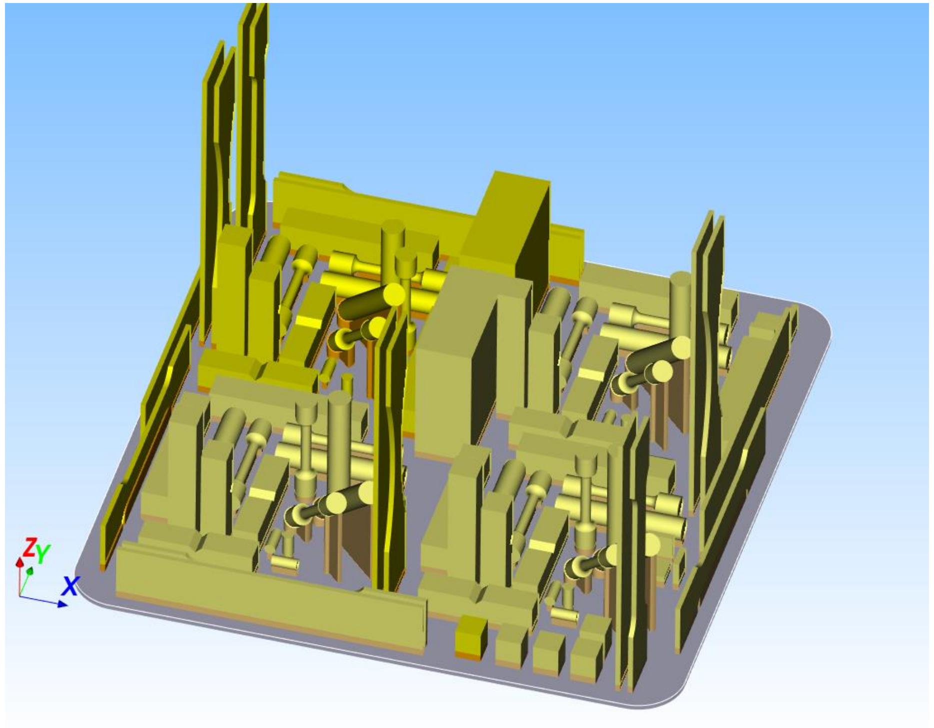
Tests overview: Material qualification

STANDARD	Specimen type	Specimen orientation	Surface treatment U : Machining T: Tribofinishing	Heat Treatment T6* : Quench SR : Stress relief	Number of specimens	Number of specimens / test
Tensile test ISO 6892	Plate - TP7 shear modulus, Poisson's ratio, tensile strength	ZX	U/T	T6 / SR	6 / parameter	72
		XZ	U/T	T6 / SR		
		YZ	U/T	T6 / SR		
	Tor 4 (round, Ø4) shear modulus, Poisson's ratio, tensile strength	Z	U/T	T6 / SR	6 / parameter	96
		45°XYZ	U/T	T6 / SR		
		Y	U/T	T6 / SR		
		X	U/T	T6 / SR		
Axial Fatigue ASTM E466	Plate - FPE Kt=1,036 120MPa	ZX	U/T	T6 / SR	3 / parameter	36
	Plate - FPE Kt=1,036 100MPa	ZX	U/T	T6 / SR		
	Plate - FPE Kt=1,036 80MPa	ZX	U/T	T6 / SR		
Fracture Toughness K1C ISO 12737	2MATECH specimen	ZX	U	T6 / SR	6 / parameter	12
Chemical composition ISO 209	10mm^3 cubes	-	T	-	6	6
Thermal conductivity ASTM E1461	10x10x2.0 mm specimen	XY / ZX / ZY	U	T6 / SR	6 / parameter	36
Density ISO 3369	10mm^3 cubes	-	T	T6 / SR	6 / parameter	12
Thermal Dilatation ASTM E228	Cylinder Ø4,h=10mm	X/Y/Z	U	T6 / SR	6/ parameter	36
Charpy-V Test ISO 12737	Charpy-V specimen	X/Y/Z	U/T	T6 / SR	6/ parameter	72
						378

T6* : solution 530 < T°< 540° 8h<time< 12h
Waterquench < 70°
Tempering 152<T°<173° 3<time<10h



New aluminium alloy adapted to the probes applications : 6061 TH

Probes's material requirement

Thermal Conductivity

	Thermal Conductivity (W/mk)
AlSi7Mg0,6 T6	150-160
6061 T6	190-200

Compatibility to the hard anodic oxidation

Salt fog resistance unsatisfying with AlSi7Mg0,6 alloy :
- Specification > Class 10 after 500h
- Class 8 after 500h

Mechanical Properties – Bulk state

	Rm(Mpa)	Re(Mpa)	A%	Module de Young (Gpa)
6061 TH AVS	410	350	4	73
Scalmalloy	365	300	19	63
6061 T6 (Laminé)	290	240	6 à 10	69
6061 T6 (Barre Filée)	260	240	8	69
AlSi7Mg0,6 T6	310	240	3	72

- Those properties could be easily imlproved by a tempering heat treatments   Cf Scallmalloy

Thermal conductivity

	Thermal conductivity (W/m.k)
6061 TH AVS + HT	170
Scalmalloy + HT	90-100
6061 T6 (Laminé)	167
6061 T6 (Barre Filée)	167
AlSi7Mg0,6 T6	140-150

Source: MatWeb et ApWorks

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ALM INTRODUCTION

PARTS UNDER STUDY

ALM BARRIERS

CLEARINGS IN THE “JUNGLE”

Different parts but a familiar struggle

R&D/Initial parts

Company Process

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Clearings in the "Jungle" or layby

Collective Consolidation around "Business as usual" topics

- A continuous idea….

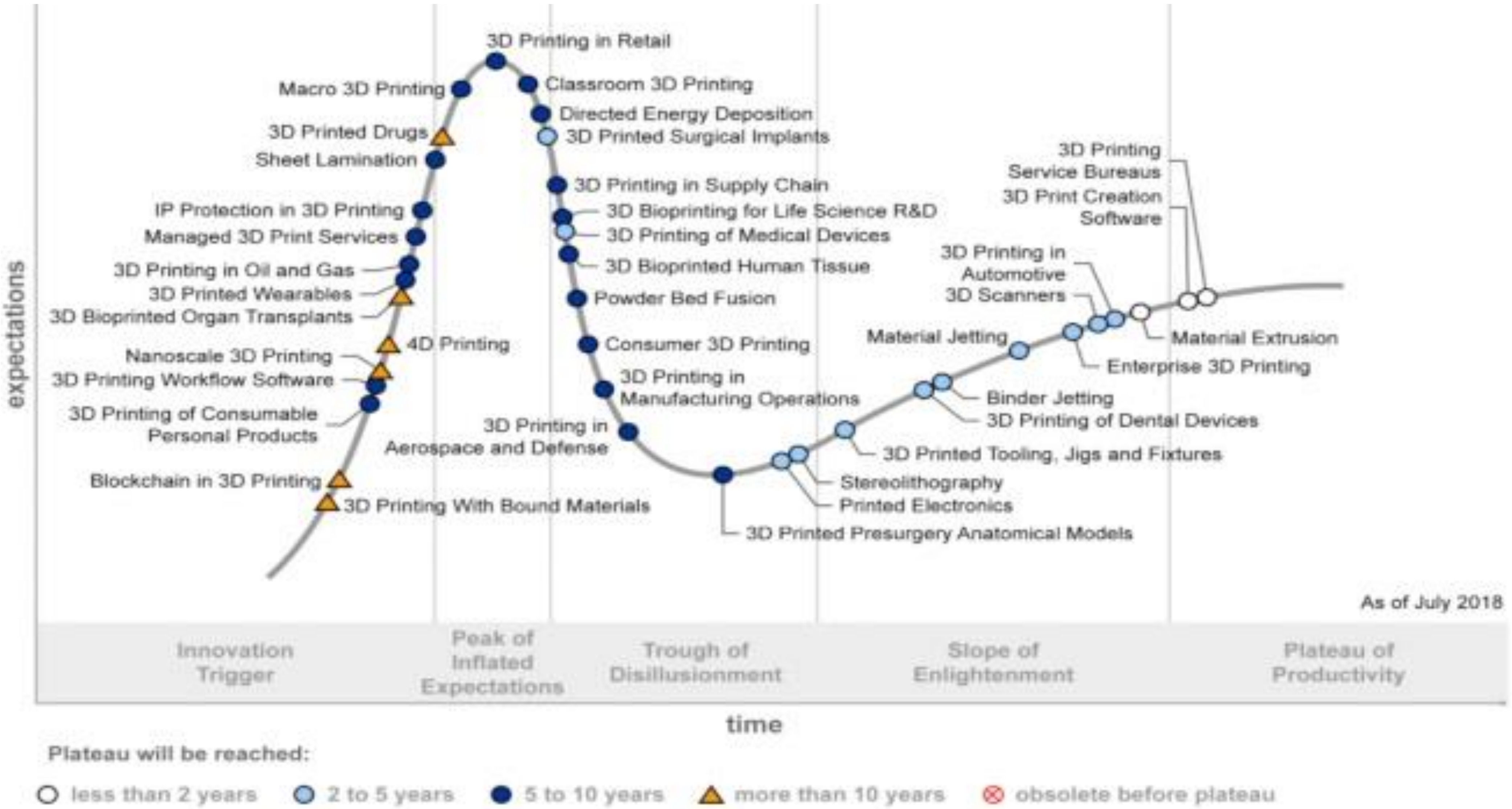
If a topic is "business as usual" across industry, do we still maintain a competitive advantage if our company remains a silo?

- Or would we benefit more by working within a peer group to reduce process waste? Such as within our supply chain interactions?

Don't remain a silo for every topic

We will still go and lay our own tarmac….

In your business, what became “Business as usual” in 2018?



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Clearings in the “Jungle”

If we’ve reached a clearing or layby with others and

- Those in that clearing have all invested time and money to learn
- In our clearing, we’ve mastered different types of machete/road layer

With those in our clearing, would now be a good time to discuss:

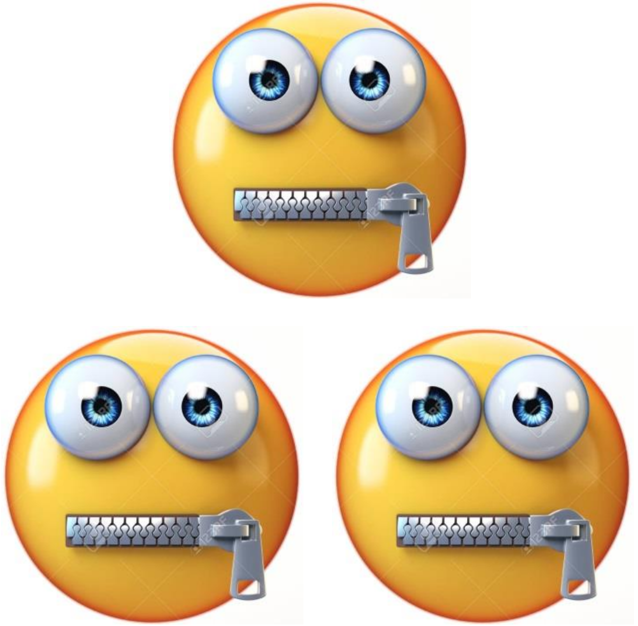
- Left hand vs Right hand use?
- The need for gloves and glasses?

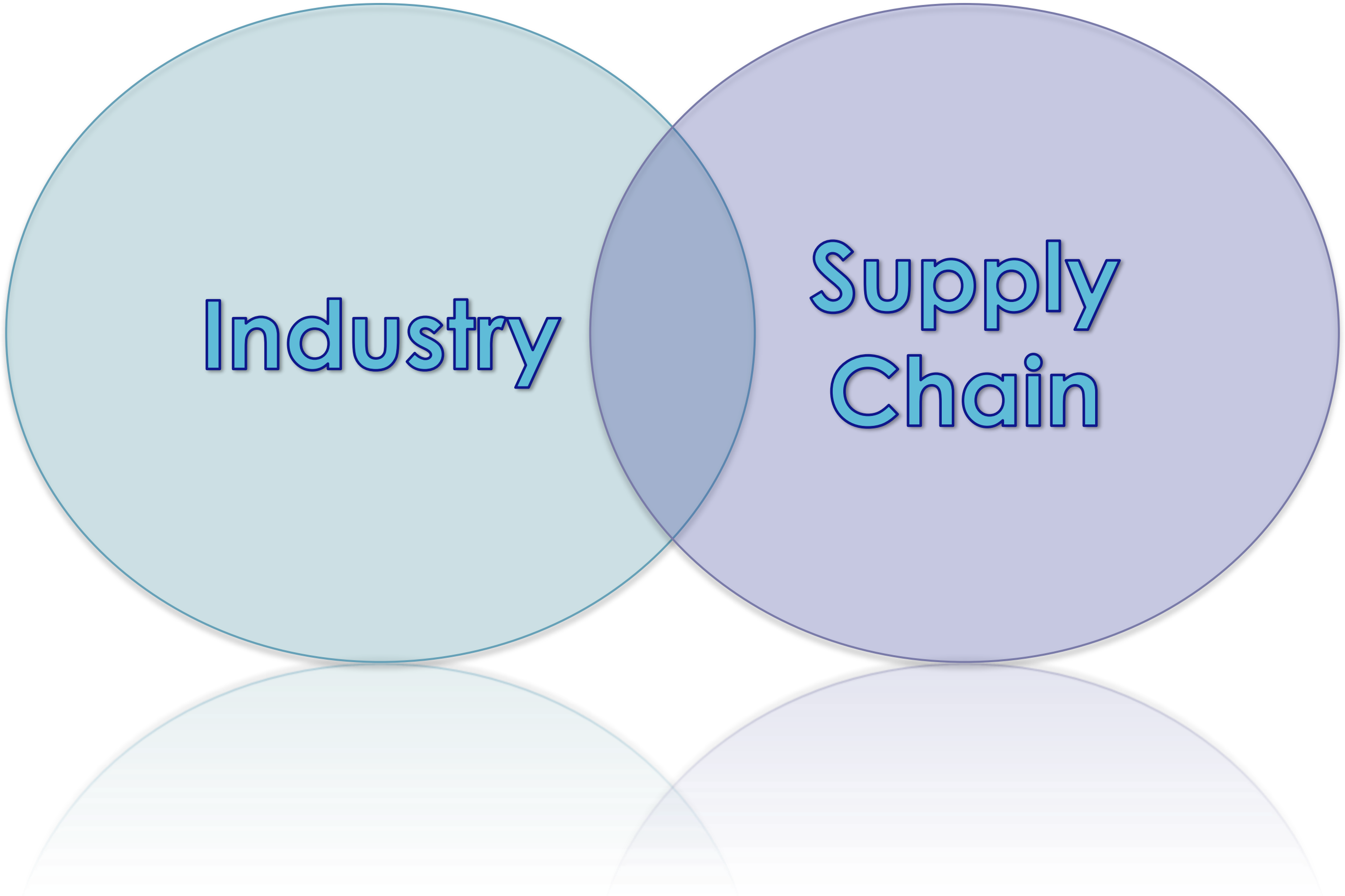
Who is in your clearing for a given “business as usual” topic?

- Not a route to fund future research

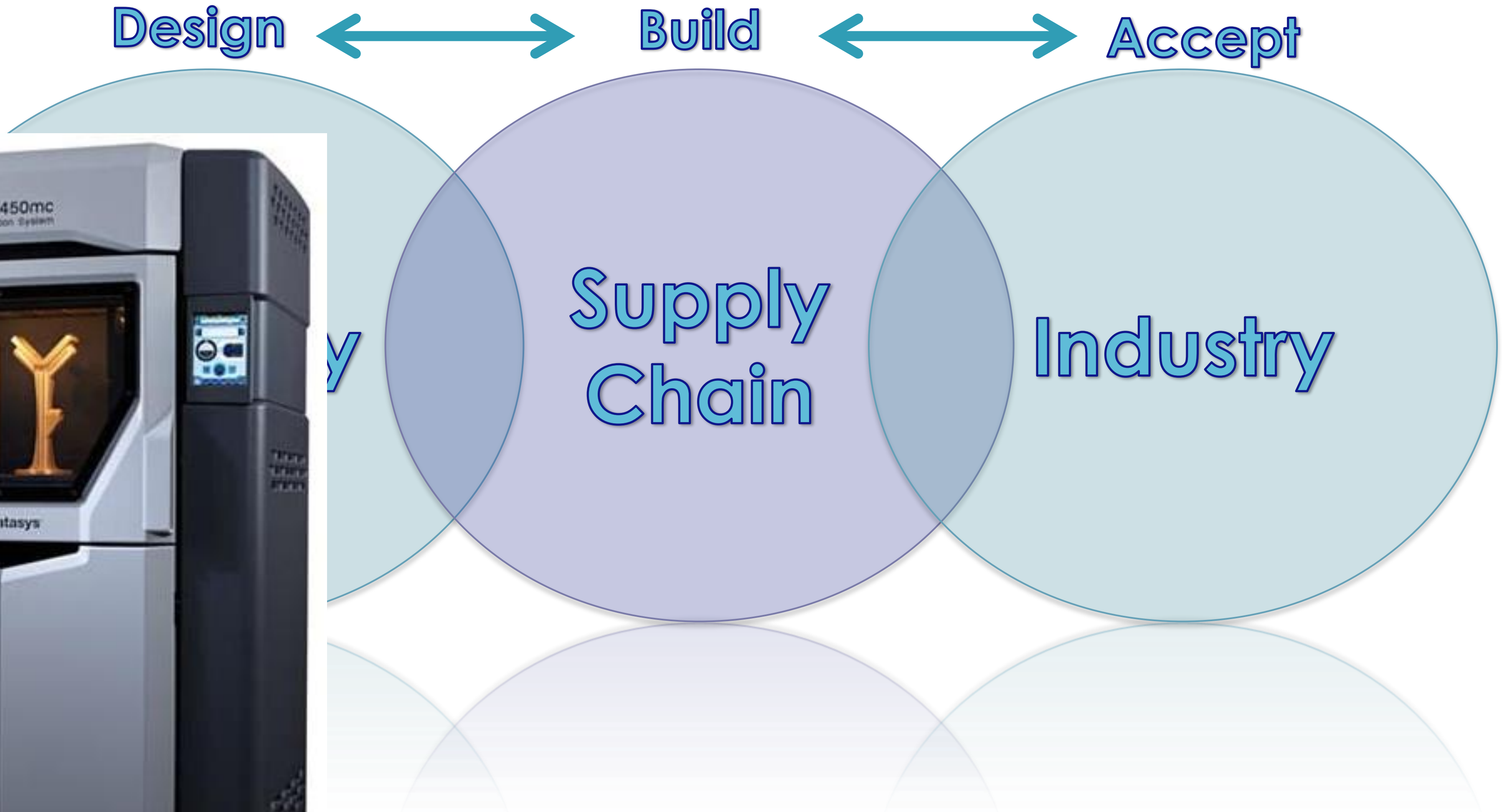
7 Companies

No NDAs, No ££ exchange



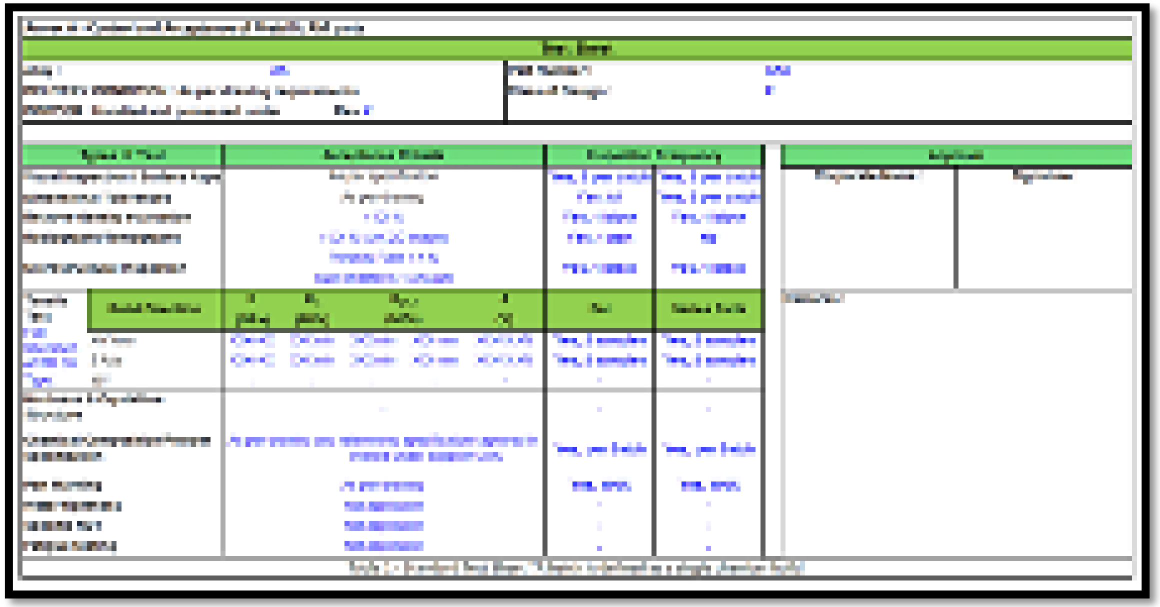


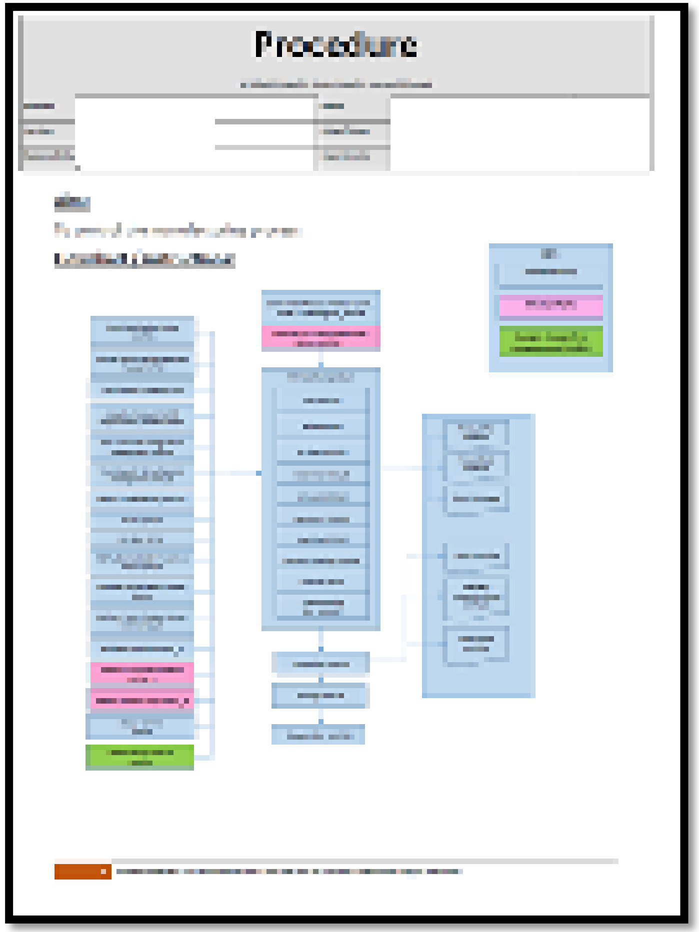
Find areas of common ground



Companies were interested?

- Initial Proposal: Feb 2019
- Call for partners, via suppliers
- First meeting: Sept 2019
- Two outcomes:





- Second Meeting: Feb 2020

Think globally, act locally

Collective Consolidation around "Business as usual" topics

- A continuous idea….
- Find your peer group, has to be beneficial for both
- No doubt, avoid areas relating to future roadmaps or the "game changing" topics
- Focus on "Business as usual" areas,

If a topic is "business as usual" across industry, do we still maintain a competitive advantage if our company remains a silo?

- Or would we benefit more by working within a peer group to reduce process waste within our supply chain interactions?

Don't remain a silo for every topic

We will still go and lay our own tarmac….

Questions?

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