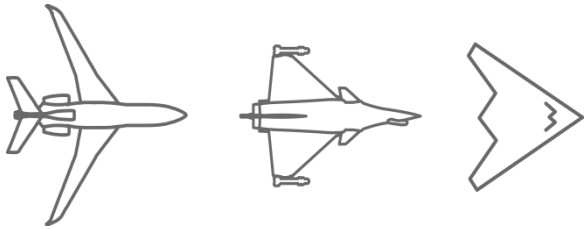


Dassault Aviation

EASA -FAA Workshop on Additive Manufacturing

November 5th to 7th , 2019 – Cologne

HIGHER TOGETHER™

Attendees

- **Dassault Aviation**
  - Célia HASHOLDER — DA AM Specialist
  - Victor BUREAU — Falcon 6X Certification Engineer

Where we are now?

Metallic Application on Dassault's aircrafts

Rafale	Neuron	Falcon
		
Serial production for military hardware	UCAV functional prototype	Serial production for civil applications
Right in the scope	Perfectly in the scope	Not often in the scope
First metal part : 2004 First serial metal part: 2014	Large metallic use : 2012	Still in progress : 2019

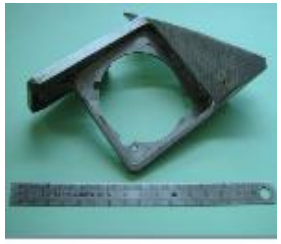
Where we are now?

→ Progressive introduction driven by cost reduction

1988 SLA

2004

1rst part in Laser Beam Melting (LBM) on Rafale for test



2006

Qualification SLS PA classe 3 1st p art on F2000/900

2007

SLS completion parts

2012

nEUROn 53 parts LBM TA6V 40 plastic parts Selective Laser Sintering

+

Qualification ULTEM completion part

2015

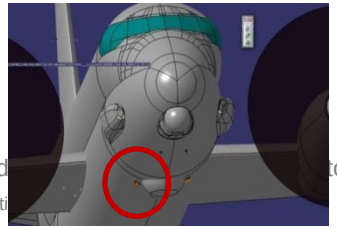
Qualification SLM 316L class 2 et 3

2016

Qualification EBM TA6V class 3

Start in 2018

On-going qualification SLM AS7G06 class 3



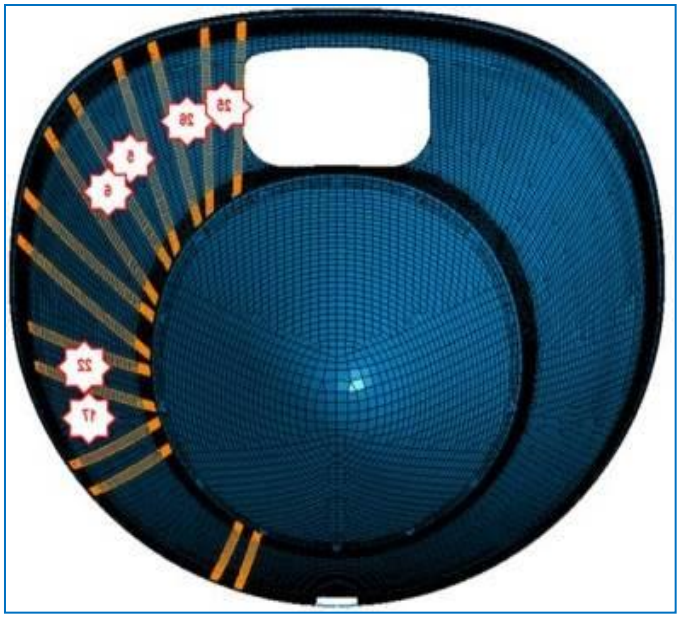
Where we are now?

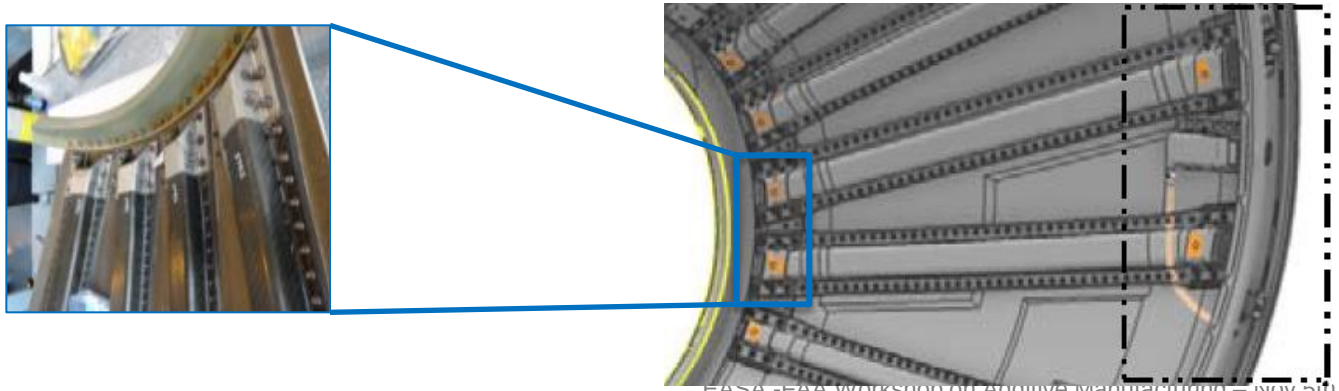
Civil Application

- First experience on Falcon 6X with Ω-shaped fittings on nose cone stiffeners to ensure safe behaviour in case of birdstrike.
- Second experience on Falcon 6X with cascades (~grids) to improve engine airflow orientation with deployed thrust reverser.
- Both of them are titanium components made with electron beam melting.
- Falcon 6X is under Type Certificate process.

Where we are now?

Pictures of nose cone radius blocs





Experience of certification

Key lessons learned

- Complete qualification campaign has been found adequate to EASA expectation.
- Due to the novelty of the AM process, the scope of the qualification was much larger than required for the targeted parts compared with conventional processes.

Key technology blockers

- Key parameters of the process are not all well-known. Therefore the variability is high leading to very low design values.
- Qualification process are based on frozen set of parameters whereas the technologies is still evolving everyday.
- Certification process need to be adjusted to the part criticality.
- Certification process need to be standardized among the TCH.

Experience with EASA

F6X Type Certification

- Nose cone fittings:
  - Presentation during a certification meeting for EASA familiarisation with the design element, the manufacturing process and the various hypothesis.
  - EASA published a CRI in early 2017 with the following content:
    - Appendix 1: Specific questions related to DA application, thanks to familiarization. Questions had been based on the draft CM-S-008.
    - Appendix 2: FAA General Memorandum published in mid-2016 about the AM process used for the fittings
    - Appendix 3: Draft final version of EASA CM on Additive Manufacturing CM-S-008
  - DA answered the CRI by taking into account Appendix 1. FAA Memorandum had been deemed irrelevant due to:
    - publication date vs F6X reference date
    - F6X nose cone fittings application is extremely simple and thus differences between Appendices 1 and 2 are not applicable.
  - EASA closed the CRI

Experience with EASA

F6X Type Certification

- Reverse cascades:
  - New design on F6X, no presentation to EASA yet,
  - Therefore no discussion about the process to be applied yet.
  - Criticality to be discussed first.

Experience with FAA

F6X FAA Type Validation

- Nose cone fittings:
  - FAA has validated content of EASA CRI based on EASA CM
  - FAA has published a cover IP

- Reverse cascades:
  - New design on F6X, no presentation to FAA yet, but FAA relies on EASA activities on F6X project.

Experience with other NAAs

F6X NAAs Type Validation

- No application yet

Industry opinion

- Because the certification approaches for AM is currently being built for manufacturers over the world, DA expects that all considerations to be managed during certification are dealt with Primary Authority (EASA for DA). This implies that authorities would make their requirements consistent from one to any other (EASA, FAA, TCCA, CAAC, ANAC…).
- DA would like to discuss about the most efficient approach to meet certification requirements for the process qualification. Additive manufacturing is no more than a process to be implemented in the industry like another one. Extreme rigor for less critical parts with high safety margins has never reached such a high point so far and it is DA wondering why this would change for AM.
- DA hopes that credit can be taken from any aeronautical international standardization and valuable experience to ease some AM qualification processes for parts to be certified.

DA industrial opinion

Difficulties	How to improve
Lack of uniformity within end users	Common materials specifications (ex: international and industrial working group)
New process: HIP or tomography often used but expensive	Special process: controls and manufacturing route to be adapted to the criticality of the part Better knowledge of the defects
Qualifications freeze a set of • Raw material (powder), • Process (manufacturing parameters), • Machine (soft and hard), • Supplier Any change in the set requires a re-qualification ! But machines are improving fast → How to ensure qualification sustainability ?	*Now:* To ensure the durability of a soft qualified *Long term:* Improve the process robustness Identify the first order physical parameters to be independent of the soft and machine
Absorb the costs of qualification	To coordinate specification between TCH, to share qualification common basis (ex: static, powder, metallurgy…)