



IMPLEMENTATION AND QUALIFICATION OF ADDITIVE MANUFACTURING PROCESS EVALUATION AND CRITIQUE

Special Process Implementation and qualification

Abstract

The scope for improving the current turn-around time for manufacturing of spare parts and parts required to support aftermarket in-service issues has taken a significant change in investigating opportunities for innovation within Safran Seats. The leadership drive to implement additive manufacturing or 3D printing of non-critical plastic parts of Aircraft Suites has put this topic on priority. Some of the challenges that needed to overcome were, implementing, coordinating, manufacturing, testing, qualification, certification, approval of special process of additive manufacturing by the regulatory body European Aviation Safety Agency (EASA). Critical evaluation during the implementation of this special process is further discussed in this report.

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Abbreviations

DOA	- Design Organisation Approval
EASA	- European Aviation Safety Agency
ECHA	- European Chemicals Agency
FAA	- Federal Aviation Authority
HOA	- Head of Airworthiness

Introduction

The opportunity to improve customer satisfaction and boost business profits are always top priorities for all companies. Safran Seats is no different and the leadership decisions in driving the innovation opportunities has been commendable and impeccable. In 2019, Aftermarket Business Unit of Safran Seats was considered for improvement because of its direct customer interactions, handling in-service issues and sales of spares. The ability to manufacture complex shapes is the biggest advantage of additive manufacturing.

Quick delivery turn-around of the non-critical parts and spares for replacement are the basis for introducing Additive Manufacturing. Additionally, additive manufactured parts shall comply to all the regulatory requirements listed in the EASA presentation (Simon Waite (EASA), 2016) to ensure the parts are safe and airworthy. Safran leadership team have laid out a systematic plan to set-up the additive manufacturing, which includes machines, process qualification, testing, certification and requirements for regulatory approvals.

EASA released a Certification Memorandum (Cert Memo EASA, 2017) to give information to the Design and Production Organisations willing to implement additive manufacturing. The information included the applicability of Part 21 requirements and the Certification Specification requirements.

The additive manufacturing technique that Safran chose is Fused Filament Fabrication technology by Fused Deposition Machine (FDM). Safran adopted the same qualification plan as created by Stratasys, the machine manufacturer, in “America Makes” project under the Federal Aviation Authority (FAA).

Supplier management has also been an important area during the implementation of Additive manufacturing, due to the complexity of the process and the consistency in producing the parts. The Build material and the mechanical and chemical properties are to be controlled to qualify the materials and the parts subsequently.

The understanding of innovation and to introduce additive manufacturing into the business (Kahn, 2018), is a great opportunity for the entire company although it is started with aftermarket innovation. Safran Seats has taken a step whereby each employee should provide two innovations per year.

Principal Drivers

Following are some of the major driving factors considered during the evolution of this new additive manufacturing technology. These are not the only driving factors and are not limited.



1. New Business Opportunities

Safran management is always looking for new opportunities across all aspects of the business. One of the best opportunities that is available in the recent times is the additive manufacturing. Therefore, improving the customer satisfaction. The business widens and opens up new opportunities with the existing customers or perhaps attract new customers. Where there is a requirement or request for manufacturing a new part, some of the equivalency and qualification tests to be performed in order to prove the additive manufactured parts can be used as a replacement.

2. Aftermarket Sales

Spares supply is one of the major chunk of Aftermarket business, where the company makes profit. Aftermarket in-service issues in which plastic non-critical parts failed need to be addressed quickly. With the introduction of additive manufacturing, the lead time for spares supply is reduced, compared to conventional manufacturing (Ex. Vacuum forming of plastic parts where tooling and other accessories, drilling, machining, trimming etc are involved). The manufacturing of complex parts of non-critical in nature, can easily be manufactured with additive manufacturing in one single setup and in one single machine. Safran has considered to produce plastic parts that are non-critical. The tooling costs for Vacuum Formed of plastic parts is completely eliminated with the use of additive manufacturing of the same parts. In-service issues are also addressed at a quite rapid rate by making the products available quickly with additive manufacturing compared to the conventional manufacturing methods.

It not only reduces the lead time, but also increases productivity.

3. Competition

To be highly competitive in the market, Safran Seats management has foreseen to adopt this new technology for the aftermarket business to start with. Airlines always seek on-time delivery of the spares and other parts that fail during in-service issues. If these parts are not supplied on-time, risk of losing business to other suppliers are inevitable.

Challenges

Additive Manufacturing is considered as a special and evolving process. Hence, fresh process qualification, material qualification, equivalency testing (3D printed vs original part) and machine qualification had to be done in order to get the EASA approvals.

EASA audit due to the implementation of additive manufacturing as a significant change to the process of Design Organisation was planned for getting approval for additive manufacturing. Compliance to regulatory requirements of Part 21 and Certification Specifications addressed in the Certification Memorandum, (Cert Memo EASA, 2017) and in the presentation of EASA (Simon Waite (EASA), 2016)

NADCAP approved material Ultem 9085 Airbus grade was considered for 3D printing, as it is recognised by FAA, Boeing and Airbus. The reason for considering the same material as graded and recognised by Airbus, Boeing etc is because of the acceptance criteria. The chances of acceptance of the materials used are more, as there is already a confidence level built within the aviation industry.

Safran Seats staff needed to be trained on Stratasys Fortus 900 machine (STRATSYS, n.d.) considered as the machine for manufacturing the parts. The machine was qualified by Prismadd, a WeAre Group company. The operator need to be qualified and should be appropriately trained to handle any small maintenance activities and adjustments within the realm of the operator.

Communication across different sites and the suppliers involved because of the time differences between America and Europe.

Risks

Cost involved on initial investment on the machine, series of qualification testing, certifying the parts to the stringent regulatory airworthiness requirements.

Communication across different Safran business units in United Kingdom and France and suppliers facilities like, machine supplier, testing facilities (e.g. Static testing, Flammability testing, environmental testing, etc), test witnessing activities, travel, material suppliers and regulatory body during the process of implementation.

Testing with different directions of 3D printing and determining the right direction of the print.

Consistency in Build material and Support material that come in the canisters. Control of the material has been one of the biggest challenge during the qualification process. Controlling the batch and lot numbers of the materials. The raw material needed to be consistent to produce the same results during the manufacturing and testing of the articles. Hence, the “batch” and “lot” of the raw material mattered the most in terms of the raw material.

Determination of pull force of the canisters to determine their quality

Temperature control of the printing.

Storage conditions of the materials.

Ability of the machine to manufacture the parts consistently.

Software control of the machine. The version or the revision of the software must be controlled as it could lead to changes in the federate and strength of the parts. This is also a guidance as laid out in the certification memorandum (Cert Memo EASA, 2017).

Design requirements.

Process Improvements

Material requirements including different colours and painting.

Material process requirements

Flammability requirements

Mechanical requirements of the manufactured parts.

Equivalency testing to determine the characteristics and strength of the 3D printed part against the originally manufactured part.

Determination of key characteristics and monitoring them.

Determination of machine parameters and control.

Key determinants

The machine manufacturer, Stratasys were constantly involved in the installation and training on the machine and manufacturing.

Since the additive manufacturing machine and the technology is a new process, operator training on the usage of the machine was planned and executed appropriately to make sure everything was in place before starting manufacturing. This also includes the trouble shooting of certain errors for smooth functioning of the machine.

On the drawings, the direction of printing need to be shown along with a note pointing to the Safran Seats process specification.

Determination of tolerances by the engineers working on them need to be trained. Since this is a new process of manufacturing the part, the tolerances could vary from the normal conventional manufacturing of Vacuum forming. Hence, series of parts were produced to see the variation in the dimensions and hence to determine the tolerance zone.

Co-ordination between the French team was also a key determinant where communication needed to be spot on.

Testing requirements for mechanical, flammability, etc were all established in order to comply to the regulatory requirements (Simon Waite (EASA), 2016) over a period of time.

Leadership commitment and drive towards developing the process has been so determined and encouraging. A close monitoring of the funding was done at the management level to keep the spending appropriate.

Regular communication and daily meetings by all parties involved, including EASA, helped develop the process.

Machine qualification planning, process qualification planning and timely application to EASA for the approvals are also the key determinants, where everything was new and were determined at each and every step of the development.

The materials chosen should be REACH compliant (European Chemicals Agency, n.d.) and the documentation from the supplier must be checked to make sure the materials or when they are processed pose no health hazard.

Processes and Technologies

The processes involved in the qualification of this new process additive manufacturing were all established by the test and certification departments to comply to the regulatory requirements. The software version and updates were controlled as part of the qualification process. Any updates to the software needs requalification of the parts with all tests to be repeated to qualify and certify the parts.

The control of melt flow rate, canister pull force, moisture content, filament diameters with applicable tolerances, pellets are all new for the people involved, during the additive manufacturing implementation. The machine had to be qualified prior to production of parts.

Extent of external resources

The research team within Safran Seats based in America and France were key partners during the development of additive manufacturing. Meetings had to be conducted late in the evenings across multifunctional departments along with suppliers spread across these three sites. Lack of mobility devices like laptops was the biggest disadvantage at that time and needed to stay in office after office hours to support meetings.

Data transfer across the different sites and the suppliers had to be managed via large file transfers.

Leadership and Management drive

This is a leadership initiative to target a quick turn-around time for the spare parts and parts failed during in-service issues.

The direct involvement of the leadership has yielded great results in terms of implementing the process, meeting the customer demands and quick turn-around with the deliveries. The team involved were encouraged at every step of the development. Weekly follow up meeting by the leadership team to understand the status of the development had a positive impact on quick implementation.

Relationship of the Design Organisation with the Production Organisation to make ensure Production Organisation manufactures the parts as per the approved design data provided by the Design Organisation. This is the regulatory requirement (EASA, 2022) by the EASA. Any part or a component need to be manufactured by a regulatory body approved Production Organisation within EU states or with a bilateral with EASA. The design data is approved by the EASA Design Approved Organisation. Only then, can the Production Organisation be able to manufacture in accordance with the approved design data. The leadership of both Design and Production Organisation need to make sure such an arrangement was in place prior to manufacturing of the parts.

Process consideration as Best Practice

All multifunctional disciplines as quoted in journal article “Mixing Practices to Create Transdisciplinary Innovation: A Design-Based Approach” (Dorst, 2018), were involved during the development of the additive manufacturing process. The disciplines involved are Flammability, Mechanical Certification covering Static and Dynamic areas in the UK, Research and Technology team based in America, production organisation team at France, Test facilities (Flammability, Mechanical & environmental testing) machine manufacturers and material suppliers.

My Personal view

"We can't solve problems by using the same kind of thinking we used when we created them" by Albert Einstein (1879–1955) quoted in journal article "Mixing Practices to Create Transdisciplinary Innovation: A Design-Based Approach" (Dorst, 2018).

The above quote is perfectly suits this report, as I was also involved in the development of the process and the procedure.

General Training

Lack of upfront training to the basic working principle, capabilities and limitations of the additive manufacturing process was something that needed to be addressed to improve the maturity levels of the process and to reduce the implementation time.

We had to explore ourselves through supplier websites, EASA websites to trace out the requirements, regular meetings, etc.

From our side, four people were involved and all of us were independently working on different sections of the process like, Certification, Regulatory requirements, Flammability and Process preparation. A general overview of additive manufacturing to the four of us in one training session would have saved a lot of time. Instead, we all went through individually leading to enormous time spent on the understanding the basic working principle, capabilities and limitations of the additive manufacturing process. Likewise, other staff working in other sites as well would have faced the same issues, which takes the project more towards right. The plan took us to finish the whole activity in 150 days including testing and EASA audits.

Independent Monitoring of the process

Internal Independent system monitoring (ISM) audit (Dominique Roland, 2011) should have been conducted prior to EASA audit to make sure the process is matured. This gives confidence to the personnel involved and to EASA about the process maturity.

Work instruction

A simple work instruction or a flow chart could be more beneficial for understanding rather than full text of the process.

Manufacturing

Manufacturing innovation, product design innovation (Kahn, 2018) need to be considered to improve the surface finish of the parts manufactured.

Marketing and Product innovations

A potential to increase aftermarket business for many customers and for producing many different parts is possible through effective communications and relationship with the customers. Marketing innovation needs to be followed to widen the scope of additive manufacturing (Kahn, 2018).

Conclusion

The understanding of the innovations (Kahn, 2018) is absolutely important in order to make a clear distinction between the improvements, invention, etc.

3D printing or additive manufacturing is one such management innovation example that has led to the product realisation in just around 150 days.

Risk based approach in innovation strategy can yield much better results as evidenced in the additive manufacturing innovation. Consider, analyse and mitigate all the risks upfront to make sure we are in that 90% confidence level in the innovation.

Every activity has an innovation in the industry. Not just limited to product design innovation. The innovation can be applied to purchasing, marketing, certification, testing, business innovation, safety, quality, human resources, facility etc.

Safran considers innovation as one of the main pillars for progress. As an initiative towards innovation, the leadership has assigned different teams of different disciplines to innovate and solve the existing problems within their business units. Whilst doing, Safran also conducted a workshop wherein all disciplines/departments come together and critique each teams work and suggest improvements. This is a great workshop where transdisciplinary innovation (Dorst, 2018) came together and critiqued the work of the colleagues.

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