Design Engineering & Innovation

ETIHAD AIRWAYS ENGINEERING

MADE IN UAE - FIRST CERTIFIED 3D-PRINTED AVIATION PART

28 Sept. 2017

Stephan Keil &
Dr. Khaled Motagaly

STRATA A Mubadala Company

SIEMENS Ingenuity for life

VPS VARTAN PRODUCT SUPPORT MIDDLE EAST LLC

D2MSOLUTIONS

الهيئة العامة للطيران المدني GENERAL CIVIL AVIATION AUTHORITY

OUTLINE

Overview of Etihad Airways Engineering

Why 3D Printing for Airlines?

Overview of the pilot project

- Objective, Selected Parts, Equipment & Material
- Team & Certification Model
- Etihad Engineering 3D Printing Approvals

Design & Certification Process

- Process Development
- Design Consideration & Applicable Regulations
- Testing Campaign

Summary

OUR ENGINEERING GROUP

Where we add value

P145 Maintenance Support

- Damage Tolerance Assessments
- Design Deviation Orders
- Technical Requests
- Repair Solutions
- AOG Recovery
- Aircraft Records
- Systems
- Avionics
- Engine, APU

Technical Services

- Aircraft Modification Programs
- Aircraft Transition Management
- Fleet Documentation Management
- Pre-Purchase Technical Consulting
- AOG Desk & AOG Consulting
- Maintenance Control Center (MCC) Services

Technology & Innovation

- MRO Efficiency
- Health Management
- Fuel Efficiency
- Weight Reduction
- Testing & Development
- Intelligent Cabin Technology
- Scholarships and fellowships
- Research Funding
- Industrial Plateau

P21 J Design & Development

- Layout Reconfigurations (**STCs**)
- Interior Trim & Finish
- Cabin Systems
- Livery Design
- Structures

P21G Parts Manufacture

- External Markings
- Interior Decals
- Seat covers
- Floor Boards
- Linings

Business Partnerships & Consulting

- Business Development
- Project Management
- Innovation Design
- Technology Development

Our P21 Approvals

EASA

Terms of Approval 21J.163 — ETIHAD AIRWAYS ENGINEERING L.L.C.
Issue 5, 13/11/2015

Terms of Approval
Design Organisation Approval Certificate
EASA.21J.163

1 Scope of approval

This Design Organisation Approval has been granted for:

- designing major changes to large aeroplanes in accordance with the applicable type-certification basis and environmental protection requirements, in the following areas:
  - Cabin interiors
  - Galleys or other interior equipment
  - and related structure, environmental systems and electrical systems;
- designing minor changes and minor repairs to large aeroplanes in accordance with the applicable type-certification basis and environmental protection requirements, in the following areas:
  - Cabin interiors
  - Galleys or other interior equipment
  - Structure
  - Avionics
  - Installation of avionics equipment
  - Electrical systems
  - Environmental systems
  - Hydro-mechanical systems
  - Power plant/fuel system;
- designing minor changes and minor repairs to turbine engines and APU's in accordance with the applicable type-certification basis and environmental protection requirements;
- demonstrating and verifying the compliance with the applicable type-certification basis and environmental protection requirements; and
- demonstrating to the Agency this compliance.

2 Categories of products

Large aeroplanes
Turbine engines
Auxiliary Power Units (APU)

4 List of products

[Not applicable]

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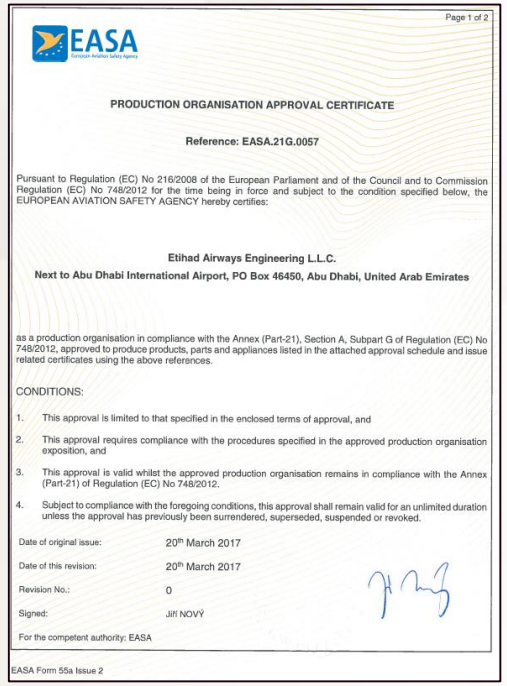
P21-J



EASA

PRODUCTION ORGANISATION APPROVAL CERTIFICATE

Reference: EASA.21G.0057

Pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council and to Commission Regulation (EC) No 748/2012 for the time being in force and subject to the condition specified below, the EUROPEAN AVIATION SAFETY AGENCY hereby certifies:

Etihad Airways Engineering L.L.C.
Next to Abu Dhabi International Airport, PO Box 46450, Abu Dhabi, United Arab Emirates

as a production organisation in compliance with the Annex (Part-21), Section A, Subpart G of Regulation (EC) No 748/2012, approved to produce products, parts and appliances listed in the attached approval schedule and issue related certificates using the above references.

CONDITIONS:

1. This approval is limited to that specified in the enclosed terms of approval, and
2. This approval requires compliance with the procedures specified in the approved production organisation exposition, and
3. This approval is valid whilst the approved production organisation remains in compliance with the Annex (Part-21) of Regulation (EC) No 748/2012.
4. Subject to compliance with the foregoing conditions, this approval shall remain valid for an unlimited duration unless the approval has previously been surrendered, superseded, suspended or revoked.

Date of original issue:	20th March 2017
Date of this revision:	20th March 2017
Revision No.:	0
Signed:	Jiří NOVÝ

For the competent authority: EASA

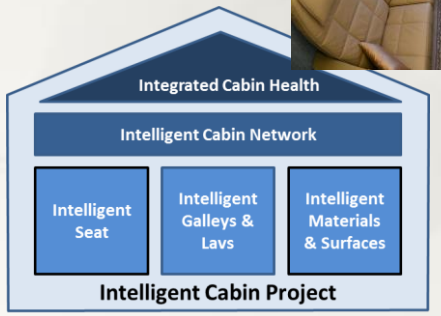
EASA Form 55a Issue 2

P21-G

- Only Major Mod Approval EASA DOA in MENA.
- Only Production EASA POA in the MENA
- First Airline MRO EASA Approved for 3-D Printing
- Only Flammability Testing Lab in MENA

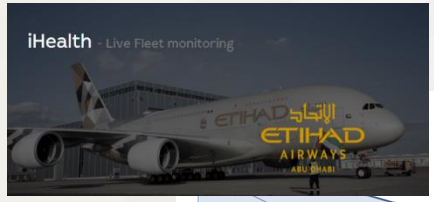
INNOVATIONS FOR AIRLINE & MRO

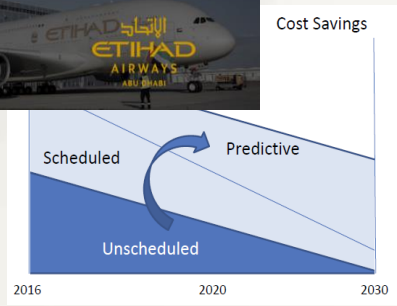
Intelligent Cabin



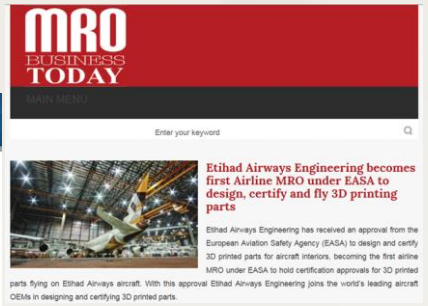
Etihad Flying Testbed

Predictive Maintenance



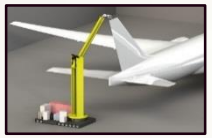


3D Printing



Next Gen IFC

MRO Efficiency



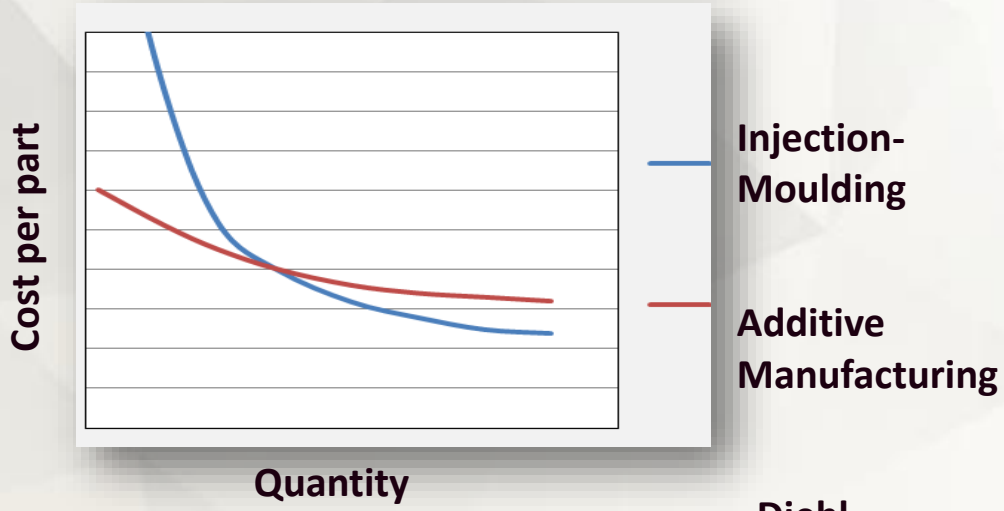
3D PRINTING FOR AIRCRAFT INTERIORS

3D Printing for Cabin Parts

- Shorter lead time & out of production parts
- Design Improvements: Integrate multiple parts, solve recurring failure issues, lighter parts
- Suitable to production of small volumes
- Limited material selections

Current Status

- Cerification is the main challenge!
- Airlines are in concept/prototype mode
- OEMs with certified parts including Airbus, Boeing, Diehl, BAE, etc.



Airbus

Diehl

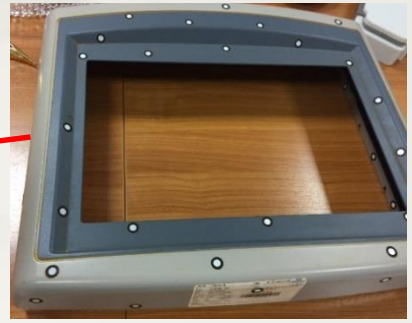
BAE

PROJECT OVERVIEW

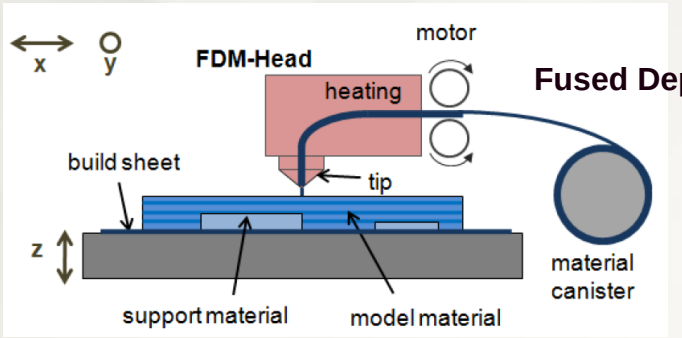
Target: "Make the First 3-D Printed, **Made in UAE** (Designed & Produced), **Certified** Aircraft Cabin Plastic Part and deliver it at GMIS on **27 March 2017**"

Parts Selected

777 LCD Shroud



Equipment & Material



Fused Deposition Modelling

TEAM & CERTIFICATION MODEL

Design & Certification

الإتحاد
ETIHAD
AIRWAYS
ENGINEERING

- End User
- EASA/GCAA Design Org Approval (DOA)
- Define Design, Print Parameters, Cert approach & Test Plan
- Revise DOH & DOP for 3D printing
- Define Manufacturing process standards process, material, machine and site.
- Obtain EASA & GCAA Approvals for 3D Printing Design & Certification
- Qualify manufacturing site
- Material & Part Testing
- Issue Approved Design Package

Manufacturing

STRATA
A Mubadala Company

- Project Sponsor
- Manufacturing site with QMS and ISO
- Set up production site and trained personnel
- Define Internal 3D Printing process
- Work with GCAA & VPS to qualify Strata 3D Printing manufacturing site
- Produce part under VPS GCAA MOA approval

- *Etihad Engineering has now acquired EASA P21G Production Approval*

ETIHAD DOA 3D PRINTING EASA APPROVAL

- Using its Major Part 21J Design Approval and extensive material testing, Etihad is the now first Airline MRO under EASA to have approval to design, certify and fly 3D-Printed Cabin Parts

- 777 Monitor Shroud – First Made and Certified 3D-Printed Part in the UAE & MENA will be handed to government VVIP on March 27-28 during the GMIS Conference in Abu Dhabi

3D PRINTING INDUSTRY

Jeff Wilkinson, Etihad Airways Engineering CEO, explains how the airline are ready to push the use of additive manufacturing,

> *The biggest challenge for the use of 3D-printed parts in aviation is certification and we are ready to tackle it and make it a reality. Etihad Airways Engineering will be using its expertise and major design certification approval to design and certify the first 3D-printed part for aircraft cabin in the UAE.*

MRO BUSINESS TODAY

MAIN MENU

Enter your keyword

Etihad Airways Engineering becomes first Airline MRO under EASA to design, certify and fly 3D printing parts

Etihad Airways Engineering has received an approval from the European Aviation Safety Agency (EASA) to design and certify 3D printed parts for aircraft interiors, becoming the first airline MRO under EASA to hold certification approvals for 3D printed parts flying on Etihad Airways aircraft. With this approval Etihad Airways Engineering joins the world's leading aircraft OEMs in designing and certifying 3D printed parts.

PROCESS OVERVIEW

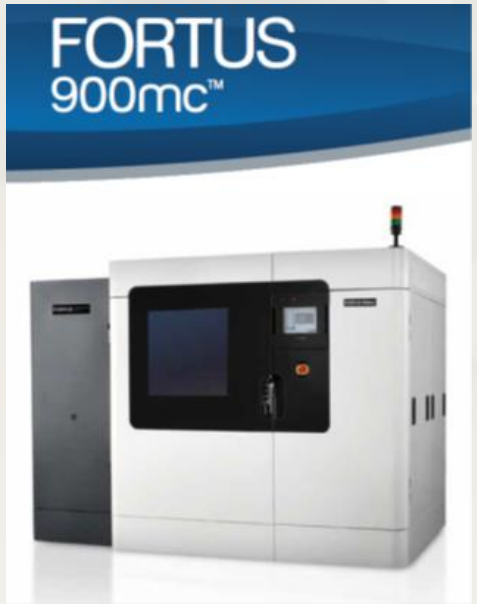
Material

ULTEM™ 9085
PRODUCTION-GRADE THERMOPLASTIC FOR FORTUS 3D PRODUCTION SYSTEMS

Understand & Qualify Material

+

Machine & Process



Understand & Qualify Machine & Process

=

Part

Test & Certify Part

Strata 3D Printing Site Process & Procedures

Close link between Design and Production

Etihad AM Standards: Specifications for Material, Print Parameters, Machine, Site & Process

PROCESS DEVELOPMENT

DO AM Standards

ETIHAD AIRWAYS ENGINEERING	DESIGN PROCESSES & SPECIFICIATION Standards for Additive Manufacturing of Cabin Plastic Parts	Ref: DOA/101 Page: 2 Issue: 00 Date: JAN 2017

TABLE OF CONTENTS

Manufacturing Procedures

STRATA

Aditive Manufacturing Etihad Interior Cabin Plastic Parts

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1 SCOPE AND PURPOSE

The purpose of this document is to define the build principle of Additive Manufactured cabin plastic parts ref EYEng_DOA_101.
This work instruction is to accompany the production work order as a Manufacturing Aid where referenced.
Further references can be taken from the OEM Fortus 900mc user guide for safe operations.
Only competent trained personals are allowed to operate the fortus 900mc and anyone operating this machine must be fully aware of the associated hazards.

2 TABLE OF CONTENT

DESIGN CONSIDERATIONS & APPLICABLE REGULATIONS

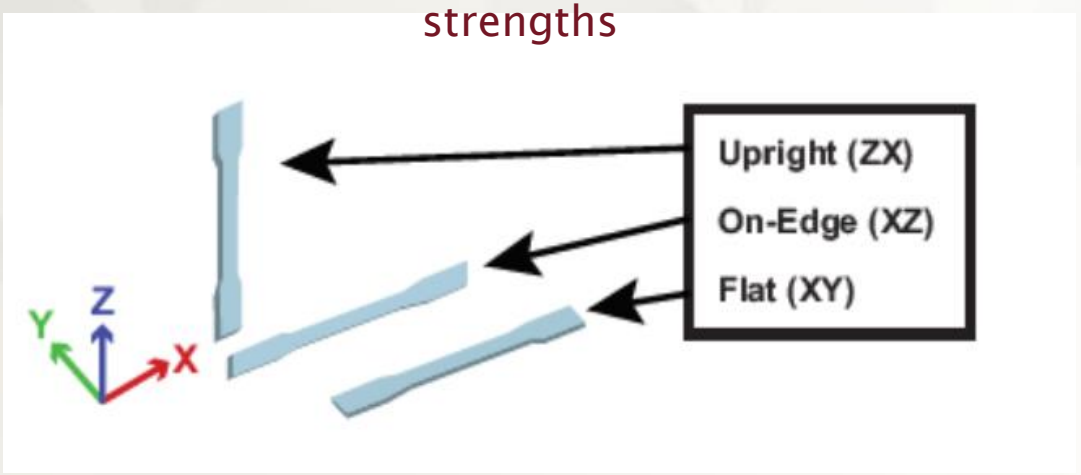
FDM Process considerations

- Anisotropy – Impact of build direction (lower strength in Z-direction)
- Porosity – Impact of Air gaps and contours; impact on surface quality & material properties
- Support structure types (sparse, surround & stabilized)

Applicable Cert Requirements

- Flammability
  - CS 25.853(a): Vertical Burn
  - CS 25.853(d): Heat Release & Smoke Density
- Loading for retention of mass for emergency landing
  - CS 25.789 & CS 25.561
- Design & Construction
  - CS 25.603: Materials
  - CS 25.605: Fabrication Methods
  - CS 25.613: Material Strength Properties

It is CRITICAL to design & test with knowledge of the technology limitations & strengths



TESTING CAMPAIGN

Coupons Testing

- Tension
- Compression
- Vertical Burn
- Heat Release
- Smoke Density
- Environmental (humidity & chemical contamination)

Part Testing

- Static loads for retention of mass during crash landing

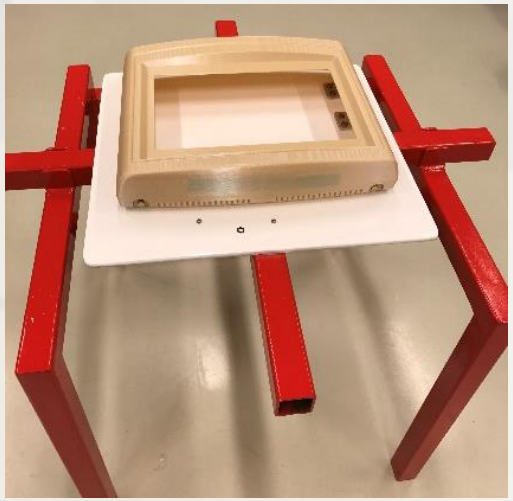
- Fixed Parameters: Raster angle, air gap, contour
- Varied Parameters: build directions (X, Y & Z), thickness, support structure type, painted and unpainted
- Over 300 coupons tested for pre-cert and cert (approx. 60 for flam testing).

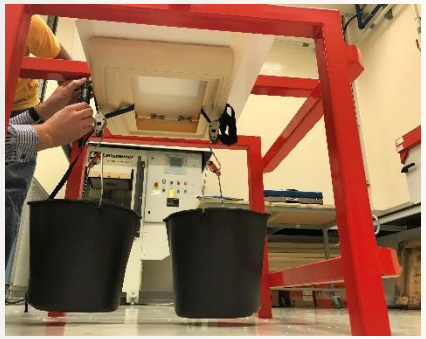
TESTING CAMPAIGN

Tensile Test

Vertical Burn

Part Static Loads





SUMMARY & WHAT IS NEXT …

- First made in UAE certified 3-D Printed part for aviation was successfully developed in only 5 months, EYE is thanking EASA for their support
- Main tasks included process development, authority approval, extensive testing campaign to design and certify the part
- The 3D Printed part is 20% lighter and 30% cheaper with very fast TAT compared to conventional manufacturing
- One of the main successes of this program is the collaboration of 2 major entities from Abu Dhabi (Etihad Airways & Mubadala/Strata) to develop and demonstrate new capabilities
- Approvals and design capability are already in use for other projects for revenue generation and cost reduction at Etihad Airways Engineering. Will also be utilized for other airlines and potentially OEMs as well
- Ongoing partnership with OEMS for new Printers & Materials testing and qualification to enable faster and cheaper aircraft cabin printed parts