Additive Manufacturing activities in CleanSky – An Update

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EASA European Aviation Safety Agency

Additive Manufacturing Workshop
Cologne, 7th November 2019

www.cleansky.eu www.easa.europa.eu

Contents

- Introduction to Clean Sky Initiative
- Additive Manufacturing for Integrated Technology Demonstrators
- Example of activities / projects concerning new manufacturing methods
- Way forward

Tackling key environmental challenges

Environmental Objectives*

- $-CO_2$ TO -20% -30%
- $-NO_x$ TO -20% -30%
- TO -20% -30%

vs today's best aircraft (2014)

While building industrial leadership and ensuring mobility

Clean Sky
JOINT UNDERTAKING

Clean Sky 2 Programme Set-up

EU Funding: ~1.8bn€
Private Members: ~2.2bn€

Innovative Aircraft Demonstrator Platforms (IADPs)

Large Passenger Aircraft

Regional Aircraft

Fast Rotorcraft

Integrated Technology Demonstrators (ITDs)

Airframe ITD

Engines ITD

Systems ITD

Eco-Design

Technology Evaluator

Small Air Transport

Transverse Activities (TAs)

CS2 Major Demonstrators

Breakthroughs in Propulsion Efficiency


Very High Bypass Ratio (VHBR) Large Turbofan
TRL 6 - 2023


Ultra-High Propulsive Efficiency (UHPE)
TRL 5+ - mid-2022


Advanced Geared Engine Configuration (HPC and LPT technology demonstration)
TRL 5 - 2023


Business aviation / short range Regional Turboprop
TRL 5 - 2022


Light weight and efficient Jet-fuel reciprocating engine [Small Aero-Engine]
TRL 6 - 2019


Reliable and more efficient operation of small turbine engines [Small Aero-Engine]
TRL 6 - 2019


Hybrid Propulsion Ground Test Bench
2020


Novel Aircraft Configuration & Scaled Flight Test
2021

Advances in Wings and Aerodynamics


Adaptive Wing Integrated Demonstrator Flying Test Bed
2022


Integrated Wing Technologies Flying Test Bed
2020 & 2023


Advanced Laminar Flow on Wings and Empennage


Laminar Nacelle Virtual
TRL 5 – 2019

Innovative Structures and Production Systems


Advanced Rear End Demonstrator
2023


Functional Cabin & Cargo Demonstrator of new integrated systems


Next Generation Multifunctional Fuselage Demonstrator automated cabin assembly & structure integration


Advanced Lower Center Fuselage Demonstrator


Regional Aircraft Fuselage / Pax Cabin Integrated Demonstrator


Affordable aerostructures for Small Air Transport


Advanced Small Aircraft Wing Box in Out-of-Autoclave CFRP
2020

Future Cockpit and Flight Guidance Systems


Disruptive Cockpit Demonstrator (Function preparation test)
2023


Active Regional Cockpit
2020


BizJet Enhanced Cockpit Concept
2022


Avionics for Extended Cockpit Demonstrator -
2020


Affordable SESAR Compliant cockpit for Small Aircraft

More Electric Aircraft & Systems


Regional Aircraft 'Iron Bird' Systems Integration – 2021


Innovative Electrical Wing - 2021


Electric Drive Landing Gear System [E-LDG]


Advanced Electrical Environmental Control System [E-ECS] Demonstrator


Full Chain demonstration: Electrical power generation, distribution and usage

Novel Aircraft Configurations


NextGenCTR demonstrator – Next Generation Civil


RACER - Rapid And Cost-Effective Rotorcraft

Optimal Passenger Environment


Full Scale Mock-up of Business Jet Office Centered Cabin
2021


Innovative Cabin & Cargo Systems Technologies
2021

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Additive Manufacturing for Integrated Technology Demonstrators

From Cleansky to Cleansky2….

Additive Manufacturing for Thermoplastics

- Stereo-lithography
- Selective Laser Sintering (SLS)
- Fused Deposition Modelling

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Additive Manufacturing of Metallic Materials

- Binder jetting
- Material extrusion
- Powder bed fusion
- Directed Energy Deposition
- SLM
- EBM
- DLD

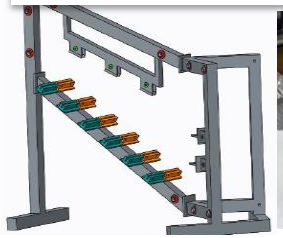
A/C seat covers

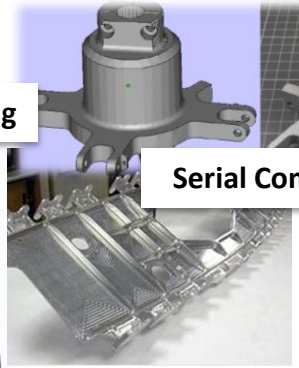
A/C piping

Interiors

Clean Sky 2

Assembling Tooling





Serial Components

- Clean Sky contributed to the development of AM processes towards to Aviation standards. Nowadays, new generation aircrafts are incorporating hundreds of printed parts (mainly for interiors) .
- As step forward, CleanSky2 research activities are targeting AM for serial components and/or for heavy complex A/C structural items. This is very challenge as for the A/C certification aspects.

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Additive Manufacturing for Integrated Technology Demonstrators

- More than 18 Clean Sky 2 projects and about 10Me funding
- More than 40 entities (universities, SME and Industries) across 12 EU and Associated Countries

MAIN AREAs of INTEREST

- Chemical and (Micro)mechanical studies for manufacturing process optimization
- Modelling and simulations methods for AM
- Manufacturing Process optimization
- Validation of AM manufacturing processes at high TRL

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Expected Goals in CLEANSKY2

- AM manufacturing Process Optimization for reliable operations.
- To improve Mechanical performances of AM components (Fatigue, Erosion, shape deviation)
- Weight reduction in comparison with current design (e.g To reduce 25% the weight of individual parts of metallic airframe structures)
- Reduction of manufacturing costs.
- Reduction of time-to-market of A/C parts due to the design optimisation (e.g accounting for distortions as alternative to current trial and error approach).
- Manufacturing of Complex items joint-less
- Waste Reduction. Additive Manufacturing technologies will boost the optimisation of the design following the eco-design considerations Moreover, the buy to fly ratio will be improved and the use of raw material will be reduced.

EASA European Aviation Safety Agency

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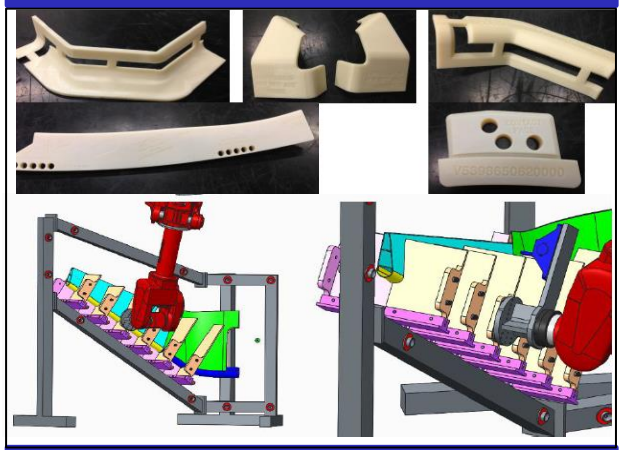
AM for competitive Business-jet and Large Aircraft

- Technology affordable for serial production
- Low Cost Manufacturing (Assembling tooling)
- Lighter A/C Components
- Manufacturing of complex geometries joint-less.
- Waste Reduction

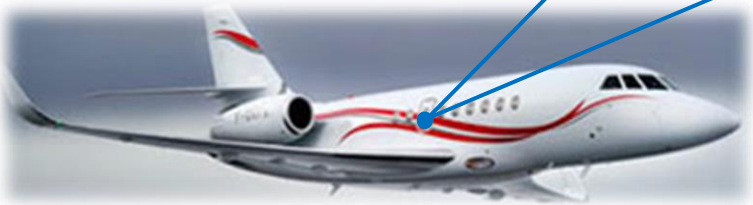
Hinge, Main Exit Door of Business Jet

Powder Bed Fusion (PBF) - Aluminium

Tooling for winglet and TE assembling



Fused Deposition Modelling (FDM) - Thermoplastic



Bracket for A350 XWP (*)

Selective Laser Melting (SLM) - Ti-6Al-4V

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(*) "http://www.3dprinter.net/airbus-incorporate-3d-printing-technology-aircraft-manufacturing."

AM for Regional and Small Aircraft Transport

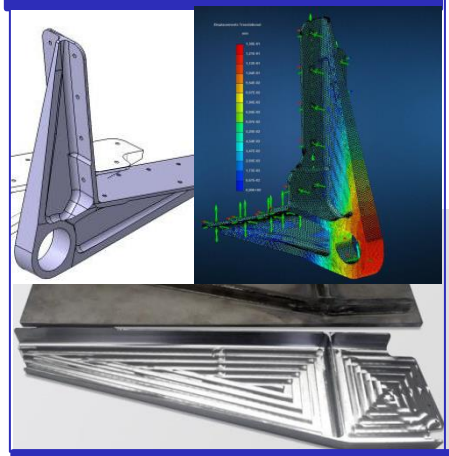
- Technology affordable for **low volume production**
- **Low Cost** Manufacturing technology
- Complex geometries joint-less.
- **Large components** for A/C and/or Helicopters

Novel Tilt-rotor Drive System housing

Engine Ducts and fairings

Powder Bed Fusion (PBF) - Aluminium

NLG Support fitting



Electron beam manufacturing - TI-6AL-4V

A main drive system housing is a large part, so alternative, innovative approach will be investigated, in the field of Directed Energy Deposition DED.

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AM supporting next generation A/C engines

- AM will be a breakdown technology for next generation engines (VHBR, OR)

Turbines

Structures

Transmissions

Additive manufacturing titanium fan wheel for Environmental Control System

Selective Laser Melting (SLM) - Ti-6Al-4V

- Achieved results are promising in terms of mechanical, fatigue, corrosion as well as environmental impact and manufacturing costs.

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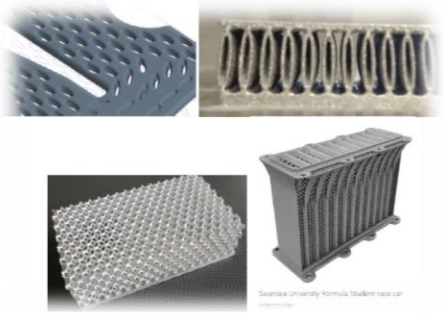
Way forward…

OPTIMIZATION OF THE SELECTIVE LASER MELTING-SLM PROCESS

To conduct studies on the systematic adaption of laser and process parameters for specific geometric features that are relevant to topology optimized designs of metal aircraft parts and particular to fittings of cargo doors (e.g AlSi10Mg).

COMPLEX COMPACT HEAT EXCHANGER DESIGN.



New fin shapes/ structures Channels and connections can be thought for performance enhancement and complex shape realization, facilitating integration. Predictive models or laws (thermal and pressure drop) to be developed. Characterization and experimental validation on samples.

A/C COMPONENTS DESIGN AND MANUFACTURING

Design and manufacturing (by means of additive manufacturing technologies) and qualification of components (as wing seals, fuselage structural fitting) to obtain the Permit to Fly. Parts shall be delivered for complete flight demonstrator and for on ground full scale test.

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Way forward…

- Components will be manufactured to fit with Aeronautical quality standards. Interactions with Certification authorities are also expected for those technologies that are part of flight demos.

- CS2 projects (e.g Innovative alloy development for structural part fabrication with Additive Manufacturing Technology – AlForAMA) will contribute to the validation of AM standards as identified by CEN/TC 438, ISO TC261 and ASTM F42:
  - Qualification and certification methods
  - Design guidelines
  - Test methods for characteristics of raw materials
  - Test methods for mechanical properties of finished AM parts (such as non-destructive testing)
  - Material recycling (re-use) guidelines
  - Standard protocols for round robin testing
  - Standard test artefact, enabling a comparison of AM processes, materials and machines on a part level
  - Requirements for purchased AM parts
  - Harmonization of existing ISO/ASTM terminology standards

- Strong interactions with AM-Platform (European Technology Platform in AM) are also expected to account for standardization of processes as developed in past EU projects (e.g FP7- SESAM project).

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CleanSky promoting Additive Manufacturing research Activities

Additive Manufacturing Demonstrator showed at Le Bourget (June 2015)

Additive Manufacturing Demonstrator showed at Le Bourget (June 2017)

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Clean Sky 2 Workshop on

Additive Manufacturing in Aviation

Aachen, January 23-24, 2019

CleanSky2 Workshop on Additive Manufacturing in Aviation

Fraunhofer ILT
Steinbachstrasse 15, 52074 Aachen

Key Topic for the day

Industrialization of Additive Manufacturing in Aviation, Status, Future Approaches & Demands

09.30 h	*Registration & Coffee*		
10.00 h	**Welcome & Introduction**		
10.00 h	**Fraunhofer, CS2JU, AIR Coordination Team**	Torsten Moll, Paolo Trinchieri, Vittorio Selmin Antonio Hernandez, Jérôme Lery, Maria Weiland	10′
10.10 h	**Session 1: Certification & Quality**		
10.10 h	**EASA**	Simon Waite	40′
10.50 h	**SGS**	Olaf Günnewig	15′
11.00 h	**Session 2: Airframe Manufacturers**		
11.00 h	**Airbus**	Remedios Carmona	40′
11.40 h	**Dassault Aviation**	Célia Hasholder, Matthieu Pachoutinsky	20′
12.00 h	**LISI Aerospace AM**	Jules Barot	20′
12.20 h	***Questions & Answers***		25′
12.45 h	*- Lunch -*		
13.30 h	**Session 3: Engine Manufacturers**		
13.30 h	**Safran**	Bénédicte Valette,	20′
13.50 h	**GKN Aerospace**	Marko Bosman	20′
14.10 h	**MBZ Toolcraft**	Christoph Machowetz	20′
14.30 h	**GE-Avio / GE Additive**	Paolo Calsa, Massimiliano di Domenico	40′
15.10 h	***Questions & Answers***		15′
15.25 h	*- Coffee -*		
15.40 h	**Session 4: Supply Chain & System Technology**		
15.40 h	**LPW**	Phil Carroll	20′
16.00 h	**Trumpf**	Wilhelm Meiners, Jeroen Risse	20′
16.20 h	**PTC**	Christoph Braeuchle	20′
16.40 h	**Siemens**	Omar Fergani, Benjamin Rescher	20′
17.00 h	***Questions & Answers***		15′
17.15 h	**Closing Session**		
17.15 h	**Fraunhofer**	Andres Gasser, Torsten Moll	15′
17.30 h	**On-site Additive Manufacturing Facilities** *(Guided Tour in Groups)*		2x25′
18.30 h	*10 min Walkway to Dinner Place*		
19.00 h	*Networking Dinner*		
19.00 h	**Networking Dinner** *& Labs open on demand*	Photonics Cluster, 3rd Floor (Atrium & Foyer) Campus-Boulevard 57, 52074 Aachen	

Key Topic for the day:
Synergies & Gaps in the Clean Sky 2 Projects on Additive Manufacturing

For each Project Presentation, please consider:

- **Description & Objectives**
- **Status & Results achieved**
- **How has LCA been addressed?** (LCA = Life Cycle Analysis)
- **Next Steps & Exploitation**

08.30 h	*Registration & Coffee*				
09.00 h	**Welcome & Introduction**				
09.00 h	**Introduction**			Torsten Moll (Fraunhofer)	10′
09.10 h	**LCA for AM Component w/ Bionic Design**			Bastian Schäfer (Airbus)	20′
09.30 h	**Session 6 - CS2 Project Presentations on AM** *(Key items see above)*				
09.30 h	#01	**LPA-WP-1.5.3 Intro**	LPA	Marta Solares Canal (Airbus)	5′
09.35 h	#02	**FLOWCAASH**	LPA	Alberto Echeverria, (Lortek) Irene Ventureira (Sonaca)	35′
	#03	**ALFORANA**	REG		
	#04	**DISTRACTION**	AIR		
	#05	**IAWAS**	AIR		
10.10 h	#06	**Intro on EWIRA**	REG	José Manuel Márquez (Airbus)	5′
10.15 h	#07	**EWIRA**	REG	Nick Cruchley (MTC)	25′
	#08	**ADDMAN**	AIR		
10.40 h		***Questions & Answers***			20′
11.00 h	*- Coffee -*				
11.15 h	**Session 7 - CS2 Project Presentations on AM** *(cont'd)*				
11.15 h	#09	**AIR-WP-C-3.6**	AIR	Klaus Hoschke (Fraunhofer)	15′
11.30 h	#10	**Intro + ALM Fairing**	AIR	José Manuel Márquez (Airbus)	30′
12.00 h	#11	**OUTCOME TiAl6V4**	AIR	Fernando Lasagni, Sergio González López (Catec) WEBEX	25′
	#12	**OUTCOME Polymer**	AIR		
12.25 h	#13	**FAMOUS / MANTA**	AIR	Gideon Heuer (GKN Aerospace)	15′
12.45 h		***Questions & Answers***			10′
13.00 h	*- Lunch -*				
13.45 h	**Session 8 - CS2 Project Presentations on AM** *(cont'd)*				
13.45 h	#14	**ENG-WP-9.1**	ENG	Nicolas Jeuland (Safran)	15′
	#15	**CfP09 topic** (Roughness)	ENG		
14.00 h	#16	**MAESTRO**	ENG/SAT	Giacomo Senatore (GE Avio)	35′
	#17	**START**	ENG/SAT		
	#18	**NEWTEAM**	LPA		
	#19	**FRC-WP-2C6**	FRC		
14.35 h	#20	**AMATHO**	FRC	Ali Gokhan Demir (Politecnico Mi)	20′
14.55 h		***Questions & Answers***			15′
15.10h	*- Coffee -*				
15.30 h	**Closing Session**				
16.00 h		***Summary, Exchange, Next Steps***			30′
16.00 h	*- End of Workshop -* (Labs open on demand till 16.30)				

Fraunhofer

n Sky

CleanSky2 Workshop on Additive Manufacturing in Aviation

- First type of this AM Workshop at European Level and led by CS2; being very useful to put in a common forum all the constrains, issues, expectations and topics to be tackled among the Aviation Industry, new comers and the Authorities

- AM technology involves different actors in the different steps of the value chain (from the powder to the component manufactured)

- Type Certificate Holders (TCH) perspectives, the overall objective is to produce a safe certified product

- It is a “must” to involve the contributors from the very beginning to keep the level of safety of the final product

- The final end of the Industry is to enhance the application of this technology in a competitive manner and enhancing the value to the customer

- Environmental impact is another element to be considered in the End to End process and concepts as re-cycling could be a key factor of success

- Follow-up of such workshop recommended to progress on market maturation of the technology

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Thank you
for your attention

See more information
on www.cleansky.eu

info@cleansky.eu
www.cleansky.eu

Clean Sky 2

AIRBUS
AIRBUS HELICOPTERS
AgustaWestland A Finmeccanica Company
Alenia Aermacchi A Finmeccanica Company
DASSAULT AVIATION
DLR
AIRBUS DEFENCE & SPACE
evektor
Fraunhofer
LIEBHERR
MTU Aero Engines
PIAGGIO AERO
Rolls-Royce
SAFRAN
SAAB
THALES

Disclaimer

The content of this presentation is **not legally binding.** The proposed content/approach is based on the consultation with the "National States Representative Group" and the "Task Force " of the *Clean Sky 2* Programme Proposal