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IAT Institute for Aerospace Technology

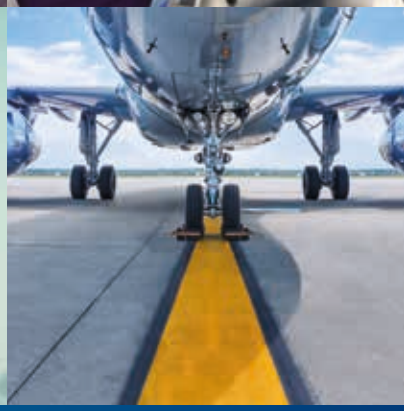
Clean Sky

Clean Sky 10th Anniversary




Compendium 2008-2018



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Introduction

The Institute for Aerospace Technology, University of Nottingham has a strong history of working closely with the aerospace industry on basic and applied research contributing to major system level demonstrations.

Clean Sky has provided a valuable framework for strengthening our work with major aerospace companies in Europe facilitating the delivery of technologies based on a long-term roadmap for the benefit of European society. Clean Sky has allowed university research to be integrated into the research and development programmes of industry and provided industry with a process and system to select and deploy the best in class solutions into their development programmes.

Our success in Clean Sky and Clean Sky 2 is thanks to our ability to understand industry requirements and their research needs through our Institute for Aerospace Technology.

Eric Dautriat, then Executive Director of the Clean Sky JU, presenting a plaque confirming the University as a Member of the Clean Sky Joint Undertaking since 2008 at Farnborough International Airshow 2016

Our key strengths in Clean Sky are:

- Our large team of post-doctoral Research Graduates allows us to deliver research and meet industrial needs
- We have been able to deliver high quality work that is grounded in real world problems that we can present to our undergraduate and postgraduate students
- Our work is equipping industry with high quality staff as well providing interesting research problems to solve
- Our PhD Graduates are award winning in Clean Sky, two consecutive years running
- We've hosted a number of high profile events including the Systems for Green Operations Annual review, technical workshops on key enabling technologies for More Electrical Aircraft and several Steering Committees.
- We are delivering 21 Clean Sky Projects worth €42m
- We have four core partner projects across all three Integrated Technology Demonstrators (ITD)
- The East Midlands region is in the top ten of participants in Europe.

The Institute for Aerospace Technology at University of Nottingham is very proud to be marking our 10 year anniversary in Clean Sky this year, and we thank all of our partners, academics and researchers for their continued commitment and drive.

Professor Patrick Wheeler
University of Nottingham

Overview of Clean Sky at Nottingham 2008-2018

Current Clean Sky 2 projects:

Core partner projects:

AERIS
ASTRAL
EMINEO
GAINS

Partner projects:

ACHIEVE
AOrbit
ASPIRE
DevTMF
ENIGMA
ESTEEM
INSTEP
MALET
MARQUESS
POCOL
STIMULANT
TRADE
VADIS

Clean Sky Joint Undertaking

The Clean Sky Joint Undertaking was established in 2008 as a Public Private Partnership to deliver research and innovation to serve the aeronautical industry in Europe.

Membership of the Joint Undertaking comprises a mixture of Private Members and the European Commission. The Private Members define the scope of activity that will enable industry to deliver the ambitious goals set out in the European Strategic Research and Innovation Agenda and conduct these activities. The European Commission provides the framework and the finance to administer the vast programme of activity for the public good.

This has been delivered by two programmes: Clean Sky (one) and Clean Sky 2.

Clean Sky (one) was a €1.6Bn programme supporting six research areas called “Integrated Technology Demonstrators (ITD). Each ITD was led by two industrial companies, who were supported by more than seventy “Associate Partners”. This programme was supported through the European Union’s Framework Programme 7 to target very significant environmental gains. Namely: 30% reduction of CO2, at least 6dB less perceived noise per operation and 60% less NOx emissions.

Clean Sky’s success at bringing together the Aeronautical supply chain and providing a top-down programme to deliver the ambitious environmental goals led to the evolution of the programme under the EU Horizon2020 Programme and the formation of Clean Sky 2.

Clean Sky 2 is a €3.6Bn programme that builds upon the success of Clean Sky by enabling technologies to be accelerated into aircraft development programmes with the addition of Innovative Aircraft Demonstration Platforms (IADP) for Large Passenger Aircraft, Regional Aircraft and Fast RotorCraft to complement three ITDs focussing on Engines, Systems and Airframe.

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Overview of Clean Sky at Nottingham 2008-2018

Our aerospace people are helping to shape the future through the Clean Sky Clean Sky Joint Technology Initiative (JTI) the major EU and industry funded programme to develop technologies that will reduce aircraft energy use and fly these technologies in everyday life.

Only recently our industry partner Safran, commented that our green taxiing motor was

> “a highlight of Clean Sky 1.”

The University of Nottingham has won 21 projects amounting to €42 million in Clean Sky 2 putting the East Midlands region in the top ten of participants in Europe.

Read more in the latest “Clean Sky working together with the Member States and Regions” brochure online at: www.cleansky.eu

21 projects
amounting to
€42 million
in Clean Sky 2

Clean Sky 1

The University of Nottingham was Associate Partner in the Clean Sky Joint Technology Initiative (€1.6bn programme) within the Systems for Green Operations Integrated Technology Demonstrator (ITD). Nottingham was the only University in Europe to be an Associate Partner in its own right.

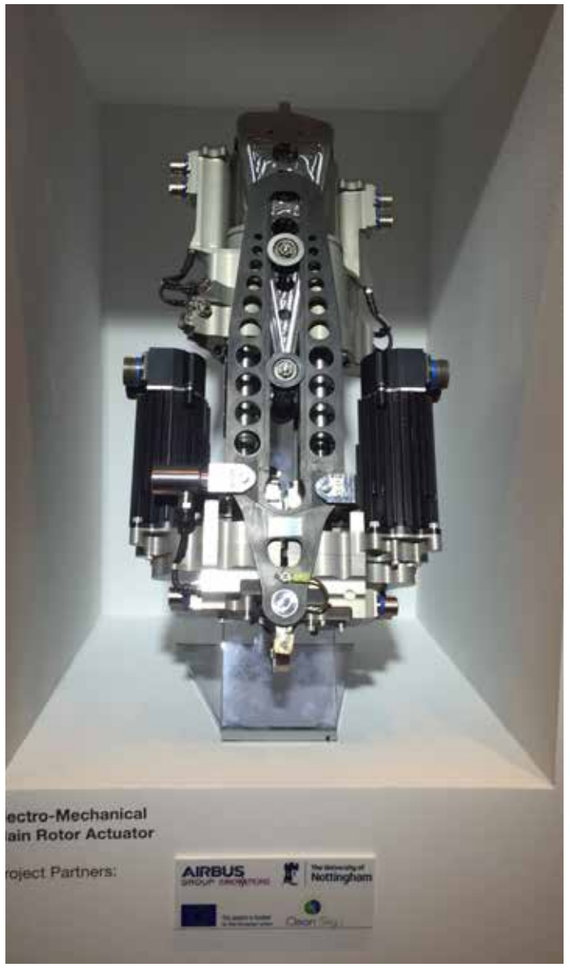
In addition to our Associate Partner work, the University participated in Clean Sky via projects secured through Calls for Proposal activity in:

- Aircraft Electrical Generation System with Active Rectification and Health Monitoring (AEGART)
- Multi-source regenerative systems power conversion (REGENESYS)

Our aerospace specialists at Nottingham have already demonstrated their ability to create aircraft components and systems to pass Technology Readiness Level (TRL) gate reviews as follows:

- Novel Power Electronics Modules for Aircraft applications to TRL6
- Green Taxiing wheel actuator for Smart Operations on Ground to TRL5
- Helicopter Electro-Mechanical Actuation System (HEMAS) with power converter and electrical motor hardware components up to TRL5
- ARC fault detection and mitigation to TRL4.

Our University Clean Sky team members sit on the Governing Board of the Joint Undertaking and have been the only University to sit on this top level committee.



Clean Sky 2

The University of Nottingham is a Core Partner and Member of Clean Sky 2 (€4bn programme) in the Systems, Airframes and Engines ITD, where researchers are working with established aerospace Primes and Supply Chain organisations on topics such as:

- Technology bricks for More Electric Aircraft
- Design and Manufacturing of Advanced Wing for Compound Helicopters
- Advanced Hybrid Ice Protection Systems
- Two-phase Flow for Aero-Engine Bearing Chambers

The University has secured in total 21 projects through Clean Sky 2 and is working on several key platforms including:

- Airbus Helicopters RACER
- Leonardo NexGen Civil TiltRotor
- Rolls-Royce Ultrafan
- Safran next generation turboprop
- Airbus future fuselage
- Leonardo future turboprop

New calls for proposals under Clean Sky 2 will run until 2019. To discuss a potential proposal contact the IAT team.

Strong partnership with industry

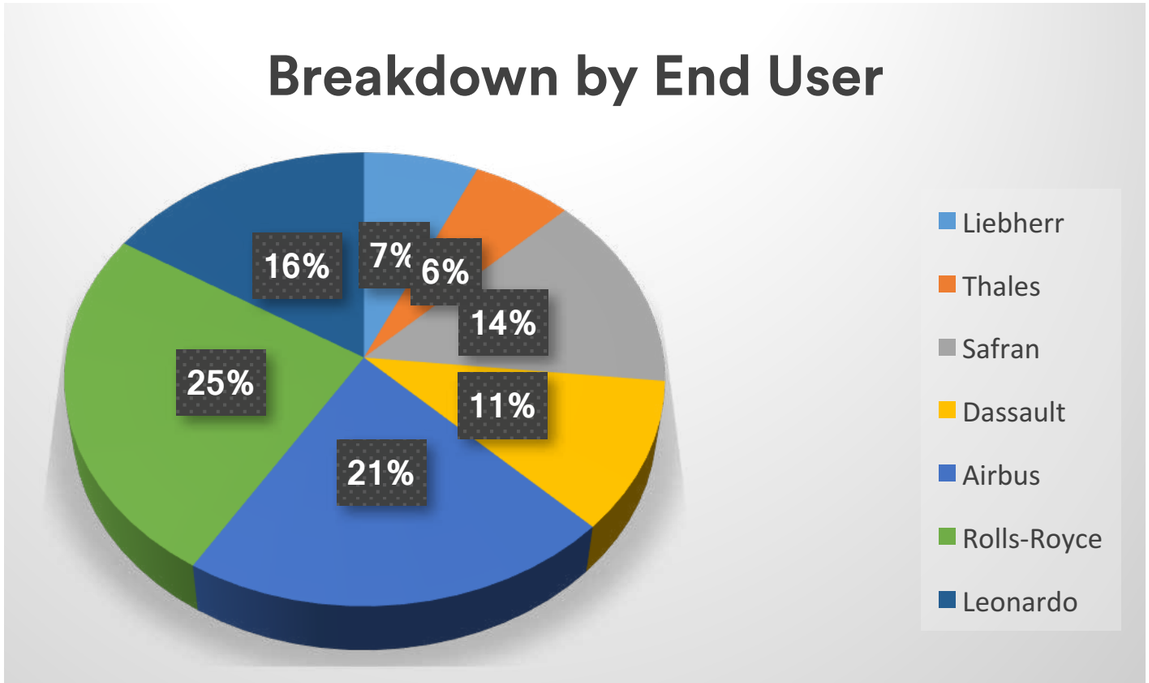
Clean Sky 2 has fostered close collaborative working between the University and leading aerospace Tier 1 and Primes in Europe. Through its work in Clean Sky 2, the University is contributing to each major demonstrator within the programme, including:

The University has secured in total 21 projects through Clean Sky 2 and is working on several key platforms including:

- Airbus Helicopters RACER
- Leonardo NexGen Civil TiltRotor
- Rolls-Royce Ultrafan
- Safran next generation turboprop
- Airbus future fuselage
- Leonardo future turboprop
- E-Fan-X

The graph below illustrates the spread of Clean Sky Leaders that the University is delivering its scientific and technological insight to across the €42m portfolio of work under this flagship programme.

In addition to these Clean Sky Leaders, the University is working with nearly forty different partners in these projects including at least 20 small/medium enterprises across 7 different Nations.



Our facilities

Aerospace Technology Centre (ATC)

Based on University Park, the Aerospace Technology Centre (ATC) is a dedicated research and knowledge transfer centre on University of Nottingham Innovation Park (UNIP), adjacent to Jubilee Campus. The 1800m² facility provides:

- unique facilities for application-focused research (TRL 4-6)
- support application-focused, integrated research at a size & complexity not possible within any other UK institution
- house multi-disciplinary projects that build on our world-leading fundamental research
- provide space for large-scale demonstrators
- strengthen relationships with industry partners
- support integrated projects that evolve towards large-scale demonstrators

To discuss opportunities at the Aerospace Technology Centre contact us using the details on page 24.


Aerospace technology Centre (ATC)


Aerospace Research Centre

Aerospace Research Centre

The Aerospace Research Centre is a dedicated laboratory space of 800 m² and further specialist facilities for power device packaging research and for reliability studies, which was specifically designed and developed to be the home of our Clean Sky 1 Systems for Green Operations activity. Dedicated electronic supplies provide emulation of variable frequency generation systems up to 270 kW and we have dynamometers from 800 kW at 1500 rpm to 49 kW at 120,000 rpm. The facilities have been recognised as an EU Marie Curie Training Centre.

The breadth and depth of our activities in core power electronics research has equipped the Group with the capability to undertake ambitious system integration and proof-of-concept demonstration. Examples include a fully integrated Silicon Carbide matrix converter, which holds a world record 20kW/litre for power density in ac-ac conversion, integrated drives in which the power electronics is embedded into the electrical machine end-winding space and UNIFLEX, a 500kW, modular, electronic substation.

Electrical drives facilities include a comprehensive set of instrumented drive test rigs reaching the following power nodes:

- 850kW @ 3000rpm (funded by ERDF, £222k)
- 60kW @ 20,000rpm
- 40kW @ 120,000rpm
- 150kW @ 35,000rpm
- 300kW @ 200rpm
- 130kW @ 2700rpm

Additional equipment includes California Instruments programmable power supplies, Precision manufacturing facilities for high performance machines including: Hard/Soft bearing balancing, Precision EDM, VPI facilities, Magnetic Material Characterisation Setup and eat transfer and airflow test rigs and precision measurement. A suite of environmental chambers able to test motor drives at representative application environmental conditions and able to investigate accelerated lifetime degradation are also available.

In the news

Our research and our people involved in Clean Sky have enjoyed occasions for celebration over the last 10 Years most notably our Best Clean Sky PhD Winners.

The Best Clean Sky PhD awards students whose work contributes to the Clean Sky Programme and acknowledges the importance of young scientists for the greener aviation of the future.

The Clean Sky Best PhD Award distinguishes young scientists who've recently completed a PhD thesis in the field of aeronautics within a Clean Sky Project. The award is intended to highlight an outstanding achievement by a young person at the start of their scientific career.

The University of Nottingham is proud to have consecutively won 1st prize in the Clean Sky best PhD award in 2016 and 2017.

Dr Tao Yang at the Award Ceremony at Berlin Airshow with fellow prizewinners and distinguished members of the Clean Sky Joint Undertaking

2016 Winner

Dr Tao Yang was endorsed with this honour for his research on novel modelling techniques to enable faster prediction of aircraft electrical system behaviour. Dr Yang has since become a member of academic staff at the University and is lead investigator on two Clean Sky 2 projects.

2017 Winner

Dr Fai Gao won the award for his thesis contributing to aircraft electrical systems' architecture, controls and power distribution based on a projected future high-voltage DC network, as opposed to the present day 28 volt network.

Dr Fei Gao with his supervisor, Professor Serhiy Bozhko

Our Clean Sky 2 projects

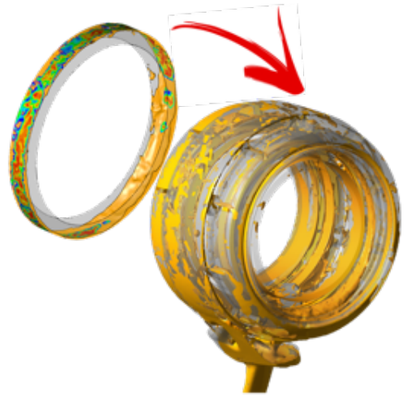
Core partner projects:

AERIS

Advanced simulation of two-phase flow in aero-engine bearing chambers and internal gearboxes (AERIS)

AERIS - Advanced simulation of two-phase flow in aero-engine bearing chambers and internal gearboxes (AERIS) brings together two leading exponents of CFD from the academic and industrial background with the aim of developing, optimising and validating the detailed computational models of fuel and airflow in aero-engine bearing chambers and internal gearboxes.

For more information about the AERIS project please contact the project Principal Investigator
Dr Richard Jefferson-Loveday
richard.jefferson-loveday@nottingham.ac.uk



ASTRAL

Design and Manufacturing of an Advanced Wing Structure for Rotorcraft Additional Lift

Design and manufacturing of an advanced wing structure for rotorcraft additional lift – Each half-wing insures a significant part of the rotorcraft lift and support a Propeller Gearbox, It includes a flap and a drive shaft is installed in the wing box. The activities cover the structural design according to Airbus Helicopters specification (including aerodynamic surface), the stress analysis, the manufacturing and the tests before first flight.

For more information, about the ASTRAL project please contact the project Principal Investigator
Professor Svetan Ratchev
svetan.ratchev@nottingham.ac.uk

EMINEO

Electrical Machines and DrIves for NExt generatiOn Aircraft

EMINEO provides the technology building blocks to enable the development of More Electric Aircraft. This includes the development of Power Electronics, Electrical Machines, Electrical Drives, Aircraft Electrical Architectures and their Reliability and Packaging.

For more information about the EMINEO project please contact the project Principal Investigator
Professor Pat Wheeler
pat.wheeler@nottingham.ac.uk

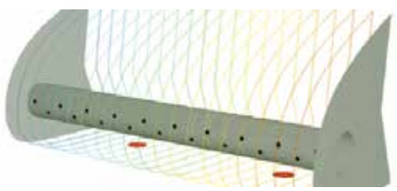
Professor Pat Wheeler presenting during the 1st EMINEO Workshop – November 2017

GAINS

Green Airframe Icing Novel Systems

The Green Airframe Icing Novel Systems (GAINS) consortium brings world-leading ice protection experts together from across the European Union to develop and demonstrate optimised next generation ice protection technology. The consortium is targeting an unprecedented 90% reduction in power consumption and reductions in weight and cost for future aircraft system platforms.

For more information about the GAINS project please contact the project Principal Investigator Professor **Kwing-So Choi**
kwing-so.choi@nottingham.ac.uk
or visit the project website http://gains.meggitt.com



Partner projects:

ACHIEVE

Advanced mechatronics devices for a novel turboprop Electric starter-generator and health monitoring system.

The aim of ACHIEVE is to develop an innovative mechatronic system that is able to perform motoring, generating, power transmission, diagnosis and communications. The system will be efficient, reliable, compact and lighter and hence contributing towards higher performance, more efficient and greener turboprops.

For further information about ACHIEVE please
contact the project Principal Investigator
Dr Tao Yang
tao.yang@nottingham.ac.uk

AOrbit

Orbiting Journal Bearing Rig Test

AOrbit will design, build and operate a test rig for journal bearings and process the data obtained to provide the most useful information possible to support the development of suitable bearing systems for high-performance, high-reliability and low-weight speed reduction gearboxes for ultra-high bypass ratio aero-engines of the future. Our overarching aim is to meet this requirement and additionally to propose engineering refinements where appropriate to enhance the development of such journal bearings for the context in light of lessons emerging from the experimentation.

For more information, about the AOrbit project
please contact the project Principal Investigator
Professor Seamus Garvey
seamus.garvey@nottingham.ac.uk

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ASPIRE

Advanced Smart-grid Power Distribution System

The ASPIRE Consortium brings together their world-leading expertise in aircraft Electrical Power Systems (EPS) and Power Electronics (PE) in order to design, develop and manufacture an innovative DC/DC resonant cellular converter with automatic inversion functionality. This will be a key component in the creation and demonstration of an advanced Electrical Power Distribution System (EPDS) with Enhanced Electrical Energy Management (E2-EM) capability.

For more information about the ASPIRE project
please contact the project Principal Investigator
Dr Mohamed Rashed
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DevTMF

Development of Experimental Techniques and Predictive Tools to Characterise Thermo-Mechanical Fatigue Behaviour and Damage Mechanisms

DevTMF takes the collective technical expertise and experience of working on thermo-mechanical fatigue (TMF) problems related to large aero-engines from three major centres of TMF research, namely Linköping, Swansea and Nottingham Universities in order to perform the activities of this topic.

For more information about the DevTMF project
please contact the project Principal Investigator
Dr Chris Hyde
christopher.hyde@nottingham.ac.uk

ENIGMA

Supervisor Control for Enhanced ElectrIcal EnerGy MAnagement

The ENIGMA project will address the development of the Centralized Smart Supervisory (CSS) controller by means of formal and methodological approaches.

The ENIGMA team brings together leading aerospace systems companies, through United Technologies Research Centre Ireland and Aeromechs, and leading academic institutions, The University of Nottingham and Università degli Studi della Campania “Luigi Vanvitelli”, whose track record and complementary skills will ensure innovative development and later commercial exploitation of the developed CSS.

For more information about the ENIGMA project please contact the project Principal Investigator
Professor Serhiy Bozhko
serhiy.bozhko@nottingham.ac.uk

ESTEEM

Advanced Energy STorage and Regeneration System for Enhanced Energy Management

ESTEEM Consortium brings together their world-leading expertise in aircraft Electrical Power Systems (EPS), Power Electronics (PE), advanced control systems, modelling and simulation for aerospace applications, Energy Storage System (ESS) and smart and Enhanced Electrical Energy Management (E2-EM) strategies to design, develop and manufacture an innovative Energy Storage and Regenerative System ESRS with embedded supercapacitors Energy Storage Device (ESD) for smart energy management of a regenerative Electro-Mechanical Actuator (EMA) emulator.

For more information about the ESTEEM project please contact the project Principal Investigator
Professor Serhiy Bozhko
serhiy.bozhko@nottingham.ac.uk
or **Dr Mohamed Rashed**
mohamed.rashed@nottingham.ac.uk

INSTEP

INnovative SmarT Electric Power Distribution

The INSTEP Consortium will bring together their world-leading expertise in aircraft Electrical Power Systems (EPS) and Power Electronics (PE) in order to design, develop, manufacture, test and provide qualification for flight of an innovative Power Distribution Units (PDUs) for safe control and protection of both High-Voltage Direct Current (HVDC) and Low-Voltage Direct Power (LVDC) electrical generation systems. This will be a key component in the creation and demonstration of a Next Generation Civil Tilt Rotor aircraft.

For more information about the INSTEP project please contact the project Principal Investigator
Professor Serhiy Bozhko
serhiy.bozhko@nottingham.ac.uk

MALET

Development of MODELICA Libraries for ECS and Thermal management architectures

The focus of this project is the development of Modelica libraries (Dymola compatible) to simulate Electrical Environmental Control System (E-ECS) architectures including thermal management perimeter. The MALET project is developing an optimized model to simulate vapour cycle systems (VCS) and liquid loop systems at both steady state and transient operational conditions.

For more information about the MALET project please contact the project Principal Investigator
Dr Chris Hill
chris.hill@nottingham.ac.uk

MARQUESS

Multiscale Analysis of AiRframe Structures and Quantification of UncErtaintieS System

MARQUESS focuses on developing multiscale models for the design and analysis of aircraft structures to reduce the number of physical tests that need to be performed on aircraft structural components.

For more information about the MARQUESS project
please contact the project Principal Investigator
Professor Arthur Jones
arthur.jones@nottingham.ac.uk

POCOL

Power Conversion Units for LifeCraft demonstrator

The growth of Power Electronics has been driven by the demand for more electrical solutions in a very diverse range of application sectors, including transport electrification, energy generation, transmission and distribution, consumer electronics and lighting, industrial motor drives.

For more information about the POCOL project
please contact the project Principal Investigator
Dr Michael Galea
michael.galea@nottingham.ac.uk

STIMULANT

Surface Integrity Conscious High-Performance Hybrid Machining for Safety-Critical Superalloy Aeroengine Parts

STIMULANT aims to develop and demonstrate "surface integrity conscious" hybridisation of machining processes for safety-critical aero engine parts that is able to deliver a step-change in Material Removal Rates (MRR) and reduction in production costs. STIMULANT will take key knowledge at different levels of maturity that exists within Consortium, and progress it, via Standard Features (StdFs) methodology, to the demonstration on "engine-like" safety critical parts.

For more information about the STIMULANT project
please contact the project Principal Investigator
Professor Dragos Axinte
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TRADE

Turbo electRic Aircraft Design Environment

TRADE proposes the integration of three new aspects into aircraft/engine conceptual design. First, an advanced structural model quantifies the impact of the installation of heavy equipment on the sizing of the aircraft structure. Second, refined on-board system models capture design and performance trades in electric power systems, gas turbines, and thermal management. Finally, an operational and mission model enables flight dynamic analyses and an assessment of handling qualities of diverging aircraft configurations. All improvements build on extensive model assets of the consortium members.

For more information about the TRADE project
please contact the project Principal Investigator
Dr Chris Hill
chris.hill@nottingham.ac.uk

VADIS

Variance Aware Determinate assembly Integrated System

The VADIS project aims to develop innovative and ground breaking assembly methods and solutions for cost effective wing manufacture for the future regional aircraft based on reverse engineering, intelligent process adaption, and variability aware processes and tooling. The project will develop and implement new digital design and simulation techniques, combined with future highly efficient, informatics rich and quality-driven cost-effective manufacturing solutions which will be rigorously tested and validated to deliver an integrated future wing box assembly cell.

For more information, about the VADIS project
please contact the project Principal Investigator
Professor Svetan Ratchev
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Our topic managers

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ZODIAC AEROSPACE
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GE Aviation

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This publication is available in alternative formats:
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Printed July 2018.