ACHEON NEWSLETTER # 1 - AUGUST 2013

DID YOU EVER IMAGINE THAT EUROPEAN RESEARCH COULD MAKE YOUR FLIGHT MORE COMFORTABLE?

ACHEON develops an innovative propulsion technology for future green air transport

Background

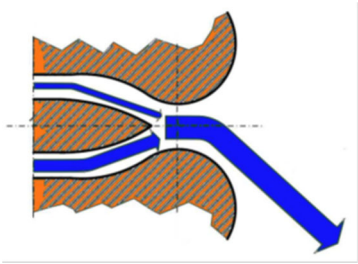
Jet deflection systems are important in enabling novel concepts of air vehicle design with enhanced performance, manoeuvrability and shorter and safer take-off and landing to be realised. They will allow the exploration of radical new concepts of aerial vehicle design realising advanced concepts which have been previously postulated throughout the history of aviation but could not be realised because of the lack of an effective and affordable jet vectoring system.

ACHEON (Aerial Coanda High Efficiency Orienting-jet Nozzle) explores the feasibility of a novel propulsive system for aircraft which is expected to overcome the main limitations of traditional systems related to typical jet deflection systems. It aims to verify a novel propulsive system, which can be the fundamental element of future breakthrough innovation in air transport involving propulsion including costs and propulsion.

The Rationale

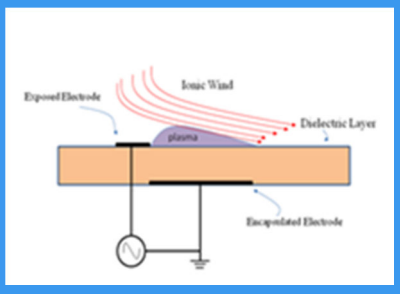
The ACHEON concept is based on the integration of two core technologies:

- The HOMER (High-speed Orienting Momentum with Enhanced Reversibility) nozzle produces a controllable deflection of a synthetic jet, with the ability to maintain a predefined direction and to change this direction arbitrarily as a function of momentum (or velocity) of two fundamental air streams and the geometric configuration of the nozzle The angle formed between synthetic jet (synthetic jet is formed and governed by two air streams) and the axis of nozzle can be controlled by momentum of two primitive jets. It is controlled by difference in the momentum of two jets. HOMER overcomes the limitations of common Coanda effect nozzles by the capability of producing a dynamic control of deflection angle based on a technology patented by the University of Modena and Reggio Emilia.



- PEACE (Plasma Enhanced Actuator for Coanda Effect) produces active precision control of the Coanda adhesion to a surface by means of BSD technology (Dielectric Barrier Discharge) which allows control of the adhesion of the synthetic jet by an active control system. PEACE is a low cost and easy to integrate system that will improve the precision of the overall system controls. The technology has been studied by University of Beira Interior. A plasma actuator consists of two offset thin electrodes that are separated by a layer of dielectric insulator material.

One electrode is exposed to the air. The other is fully covered by a dielectric material. The electrode exposed to air is assumed to be a loaded by a high voltage, where as an electrode buried under the dielectric is expected to be grounded. A high voltage as potential (high amplitude - several kV) and high frequency (typically several kHz) Ac voltage is supplied to electrode. The ionized air (plasma) in the presence of the



electric field produces an attraction/repulsion on the surrounding air. Ionized particles are accelerated and transmit momentum, through collision, to the neutral air particles in plasma region over the covered electrode. As a result, surrounding air is accelerated on the surface of the electrode.

The integration of the HOMER nozzle with the PEACE actuator is a potentially disruptive technology in propulsive system design and applications. This is compensated for by ACHEON allowing new aerial vehicle architectures and possibilities extending current technological limitations based on the effective control and use of the Coanda effect.

The Expected Results

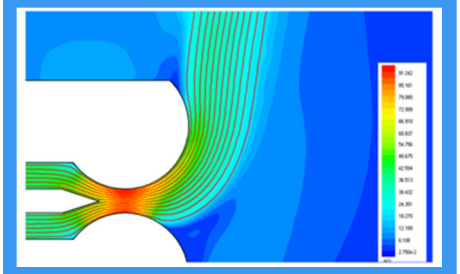
ACHEON explores new concepts such as diffused propulsion systems and more radical solutions for future all-electrical aircraft. The ACHEON thrust vectoring propulsive system that could produce a wide range of future innovative aircraft concepts with enhanced capabilities of short take-off and landing, enhanced manoeuvrability, improved efficiency and reduced environmental impact.

Inside ACHEON … updates about the current research achievements

The project scientific approach relies upon CFD simulations coupled with experimental validation in order to prove the feasibility of the system and to define the optimal configurations, the operative regimes and the possible limitations related to its application. In particular, the project will verify if this system can be applied as aerial thrust vectoring propulsion applicable to conventional and unconventional aerial vehicle configurations. The results will be compared with existing technologies in terms of technological readiness, costs and barriers that could prevent future developments.

ACHEON Preliminary System Design

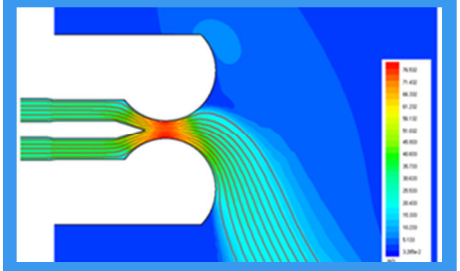
The preliminary CFD analysis aims to identify the flow and geometric parameters for the design of such nozzle. The road map of the design parameters has been defined. Computations have been performed to find the relation among the flow and geometric parameters and also could serve as guidelines for the experimental validation and the further analysis to design such nozzle. The range for the flow velocity has been identified in order to have the maximum thrust normal to the flow. Preliminary results suggest that for VTOL (Vertical Take-Off and Landing) application the flow velocity will be in compressible range. The study has been started from the



incompressible flow velocity to at the verge of compressible flow (M= 0.3). The force normal to the flow direction can contribute to the lift force. The normal force is maximum for the range of velocity ratio from 1.8-2.5. This assumption is going to be validated experimentally. Through this computational study the approximate range of the maximum force have been investigated, which is vital for the design of such nozzle for maximum lift force. The flow visualization has been given through velocity contours from for some selected cases. However, the general flow phenomena would be the same for all cases. Now, these contours reveal the fact that highest velocity occurs at the exit of the nozzle attached to the upper curvature of the nozzle. These techniques can be applied to maximize the normal thrust.

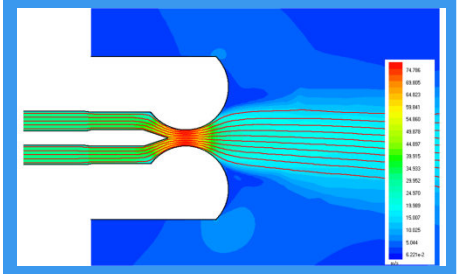
Further the boundary layer analysis on the curved surface is needed through experimental testing. The conceptualization of the flow geometric parameter in one equation is a major milestone so that one can determine the ratio of thickness of boundary layer to the radius of curvature. Another step is to develop the correlation for such flow based on experimental database. Reproducibility of the experiments is of vital importance as the surface roughness also influences the jet deflection angle should be accounted in the development of the correlations. The error analysis should also perform after each set of experiment. Other flow parameters should be calculated through the experiment. The correlation will be developed after the experimental database for calculation of thrust and deflection angle. The mathematical model can be developed through the observation of the flow parameters, which have strong influence on the flow.

ACHEON System Simulations



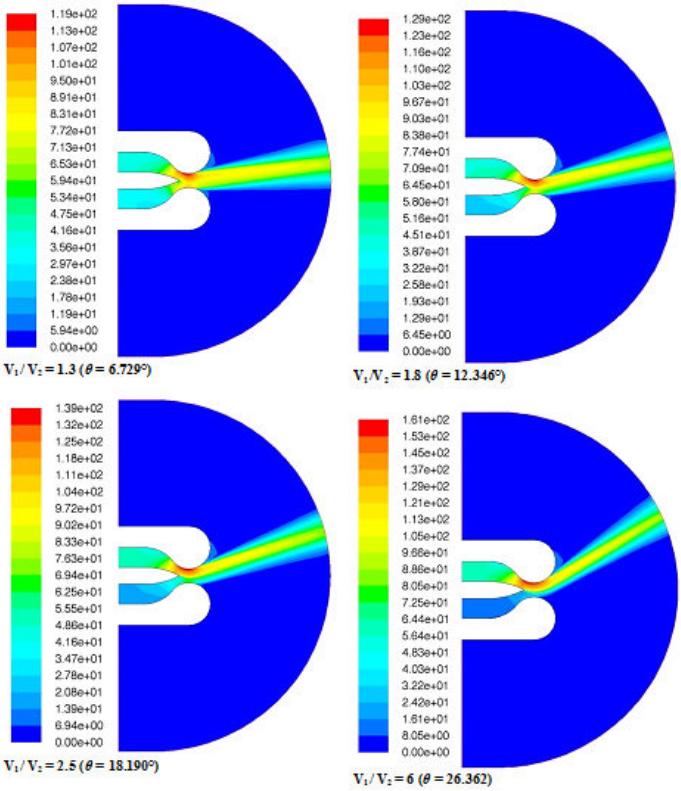
The Consortium is studying aircraft design and computational fluid dynamics (CFD) in an effort to develop more effective jet nozzles for propulsion. UBI explores different functionalities in design configurations, which will then be performed in various software and multi-physics simulations.

The System Simulation work collected the ideas, concepts and elements developed by the partners and started to provide a systemic view. This work included a preliminary CFD evaluation for developing the preliminary geometries of the HOMER nozzle. The geometries were analyzed by CFD to verify the effect of nozzle geometry. This resulted in a detailed study on the effects of the geometry and temperature on the operation of the Coanda nozzle surfaces. It has been found that there are two mechanisms which influence the flow behavior; both have contrary effect on the flow. One is buoyancy effect and another is the thermal diffusivity effect. It was concluded that, the increment of the thermal diffusivity have prolonged separation of the boundary layer, while buoyancy effect trigger the earlier detachment of the flow from the curved surface.

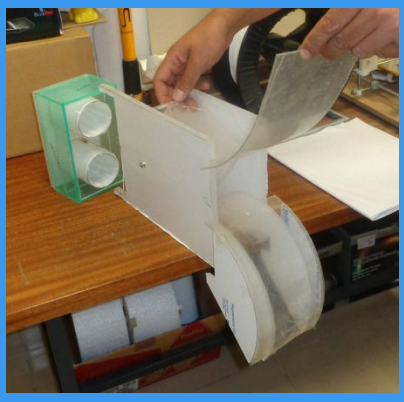


NIMBUS provided insights into possible architectures in which to include the HOMER nozzle. Based on these comments UNIMORE and UBI developed a systemic analysis for the ACHEON nozzle. Actually, in order for that the nozzle can operate in needs to be feed with two airstreams. These airstreams must be produced by axial turbofans. The system view incorporates thus two components: the electric turbofans and the nozzle. The system thus defined need to operate in similar conditions to the ones predicted in the parametric detailed analysis. UBI made an extensive analysis on the operation of electric fans, including their characteristic curves, concluding on the definition of the typical fan exit flow conditions. These conditions are the actual conditions to be implemented at the HOMER nozzle inlet. A fully 3D CFD computation was thus performed in order to analyze the combined effect of the fan and nozzle. This resulted in finding that swirl velocity could compromise the operation of the nozzle.

Tangential velocity (swirl) must be reduced by stator vanes or using counter rotating fans. This data were discussed and further incorporated into the developed experimental facility.



Velocity contours for Vav = 35m/s showing the different angle for different velocity ratio



Experimental Validation

ACHEON investigates a novel way to orient the propulsive force, without having the need for moving elements. This is expected to be achieved by exploiting the Coanda effect, which diverges the air jet. In addition, it is proposed that such air jet diverging process can be improved by incorporating the boundary layer plasma actuators. We are working to ensure the validation of the CFD simulations for the focused experiments, which are currently under design, and are in selection process based on the most appropriate performed CFD simulations. These CFD simulations will be experimentally validated with high quality measurements and one of them is involving the PIV fluid flow field measurements.

The work performed follows 3 main directions:

1) The basic Coanda effect to be fully realized:

- To find parametric geometrical shapes in order to enable efficient deviation of the stream jet,
- More importantly, to achieve the adequate strength and orientation angle of the thrust force - find out the flow regimes at which this is accomplished,
- To investigate the boundary layer with related turbulence models, where CFD results will be validated experimentally.
- To research the boundary layer control using a plasma actuator, based on the Dielectric Barrier Discharge (DBD) phenomena, and to find how much DBD can be exploited to achieve higher deviation of streams.

2) ACHEON based propulsion for UAV-s is considered for experimental testing, and it is in discussion:

- Aerodynamically adapted ACHEON propulsion unit to be designed for the selected UAV model,
- Wind tunnel tests might be performed for proving such complex UAV solution.

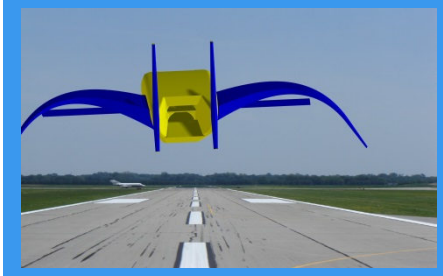
3) Radio Controlled model to show effectively testing of the ACHEON solution

- Virtual mock-up of the flight animation (like flight simulator)
- Physical radio controlled model (for example, like a scaled down flight experiment)
- To study interference between the radio-controlled unit and the envisaged plasma actuator unit.

Preliminary Technology Evaluation

The preliminary analysis has been performed, and the terms defining modeling and simulation aspects are becoming more concrete, and their influence for defining the experimental setup and the related equipment is in progress. In particular it is important to plan the flying demonstrators.

The purpose of the Technology Evaluation, is to provide a detailed verification of

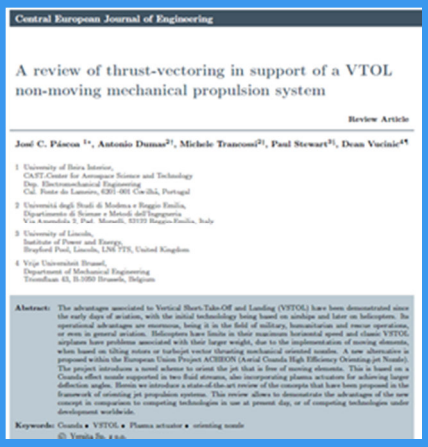


ACHEON's technology against both traditional and innovative future aircraft configurations. The key objective is to identify the advantages that the ACHEON technology brings with its advanced propulsive concept in all aspects of the aircrafts operations and its environmental impact. It is also an objective to consider how ACHEON will perform under the various operating regimes that current and future aircraft will encounter. This will include environmental issues such as operation in snow, rain, sand and dust as well as FOD. Safety is also a consideration, current twin aircraft have exceptional safety records that must be met or bettered by ACHEON.

In this, the first phase of the study, various aircraft types have been studied with the aim of identifying three different application areas and their associated state of the art. The three classes identified are MAV's/UAV's, Military VTOL Fast Jets and Medium Transport Aircraft. A study of historic and current aircraft was conducted including the many early VTOL experimental aircraft from the 50's and 60's. Some of these were truly innovative and in many cases were not realisable due to the technological limits of the day. They do however provide some truly innovative solutions by challenging the accepted norm.

Although ACHEON can be utilised with current jet technologies its true advantage will be realised as an enabling technology for the All Electric Aircraft as originally foreseen by Cronin et al. As a purely electric technology there is no need for high temperature materials allowing the exploitation of lighter materials with improved performance and tolerance to future environmental effects such as volcanic ash and high altitude ice ingestion.

The current work is now focusing on novel twin spool electrically powered axial compressors and the necessary control systems to regulate the two mass flow rates into the nozzle. Consideration is also being given to the arrangement of any intermediate plenum stage and particle separation. A small twin spool demonstrator is being considered as a means of providing important calibration data for the models. This will provide the basis for the future work where various configurations, both traditional and novel, are evaluated to determine the economic and technical advantages.


Central European Journal of Engineering

A review of thrust-vectoring in support of a VTOL non-moving mechanical propulsion system

Review Article

José C. Páscoa [1]*, Antonio Dumas[2], Michele Trancossi[2], Paul Stewart[3], Dean Vucinic[4]

1 University of Beira Interior, CATCenter for Aerospace Science and Technology Dep. Electromechanical Engineering Cal. Fonte do Lameiro, 6201-001 Covilhã, Portugal

2 Università degli Studi di Modena e Reggio Emilia, Dipartimento di Scienze e Metodi dell'Ingegneria Via Amendola 2, Pad. Morselli, 42122 Reggio Emilia, Italy

3 University of Lincoln, Institute of Power and Energy, Brayford Pool, Lincoln, LN6 7TS, United Kingdom

4 Vrije Universiteit Brussel, Department of Mechanical Engineering Pleinlaan 43, B-1050 Brussels, Belgium

Abstract: The advantages associated to Vertical Short-Take-Off and Landing (VSTOL) have been demonstrated since the early days of aviation, with the initial technology being based on airships and later on helicopters. Its operational advantages are enormous, being it in the field of military, humanitarian and rescue operations, or even in general aviation. Helicopters have limits in their maximum horizontal speed and classic VSTOL airplanes have problems associated with their larger weight, due to the implementation of moving elements, when based on tilting rotors or turbojet vector thrusting mechanical oriented nozzles. A new alternative is proposed within the European Union Project ACHEON (Aerial Coanda High Efficiency Orienting-jet Nozzle). The project introduces a novel scheme to orient the jet that is free of moving elements. This is based on a Coanda effect nozzle supported in two fluid streams, also incorporating plasma actuators for achieving larger deflection angles. Herein we introduce a state-of-the-art review of the concepts that have been proposed in the framework of orienting jet propulsion systems. This review allows to demonstrate the advantages of the new concept in comparison to competing technologies in use at present day, or of competing technologies under development worldwide.

Keywords: Coanda • VSTOL • Plasma actuator • orienting nozzle

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A Review of the Thrust Vectoring in Support of a VTOL non-moving mechanical propulsion system

The advantages associated to Vertical Short-Take-Off and Landing (VSTOL) have been demonstrated since the early days of aviation, with the initial technology being based on airship and later on helicopters. Its operational advantages are enormous, being it in the field of military, humanitarian and rescue operations, or even in general aviation. Helicopters have limits in their maximum horizontal speed and classic VSTOL airplanes have problems associated with their larger weight, due to the implementation of moving elements, when based on tilting rotors or turbojet vector thrusting mechanical oriented nozzles. A new alternative is proposed within the ACHEON Project. The review article introduces a detailed state-of-the-art review of the concepts that have been proposed in the framework of orienting jet propulsion systems. This review allows demonstrating the advantages of the new concept in comparison to competing technologies in use at present days, or of competing technologies under development worldwide. The review paper has been published by Prof. Pascoa (UBI) in the Central European Journal of Engineering issue of July 2013.

http://link.springer.com/article/10.2478%2Fs13531-013-0114-9

ACHEON Showcased at AERO FRIEDRICHSHAFEN 2013

The ACHEON project has been presented at AERO Friedrichshafen. A stand has been to showcase the HOMER nozzle mock-up showcasing the ACHEON thrust vectoring technology to the general aviation community.

On 26 April 2013, the project has been presented also during the workshop "Cruiser/feeder airship and innovative propulsion for greening the future EU transport" jointly organized jointly by the MAAT, ACHEON and CROP FP7 projects. For more information, please download the book of abstract:

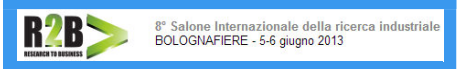
http://www.eumaat.info/app/download/5786241210/Brochure_Abstracts_web.pdf?t=1367323258

NIMBUS develops innovative UAV configuration for the ACHEON Experiments

On 17th to the 23rd of June 2013, Nimbus launched in Le Bourget a new model of fixed-wing in the mini UAV segment to integrate ACHEON concept in the field of unmanned aircrafts. Further developments are under study and object of patent: this project will make it possible to fly with no moving parts and promise to reduce fuel consumption during the cruise. Nimbus will present at SAE International Aerotech (Montreal) a paper titled "Regulatory and standardization for unconventional aircraft

in light UAV segment. The Paris Air Show 2013 is the world's oldest and largest air show held every odd year at Le Bourget Airport in north Paris, France. The demonstrator has been hosted by the stand of the Torino Piemonte Aerospace cluster.

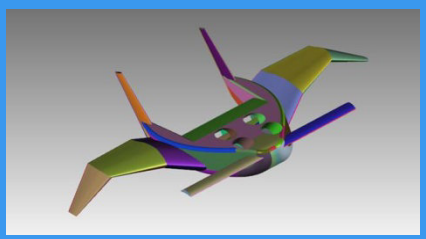
Public Demo of the HOMER Nozzle Mock-up at the Fair R2B



UNIMORE unveils the ACHEON project at the Research To Business Forum (R2B) in Bologna on 6-7 June 2013 delivering a public demonstration of the jet deflection capabilities of the HOMER nozzle. UNIMORE research team and REI had several bilateral briefings meetings with SMEs interested in ACHEON technology transfer for complementary industrial applications, such as: 1) material deposition, sandblasting, varnishing; 2) Appliances: washers, dryers, dishwashers, etc.; 3) Acclimatization and Industrial plants: air distribution, car washers, street sweeping and washing, cyclone filtering; 4) Agriculture: sprinklers, sprayers, etc.

ACHEON at SAE Aerotech in Montreal

The ACHEON Consortium will be presenting scientific communications in the 'Unmanned Aerial Vehicles' session at the SAE Aerotech 2013 in Montréal, Canada. The congress theme 2013 is 'Aviation Leadership for a Sustainable Future'. At SAE thousands of the world's top aerospace professionals gather at the SAE AeroTech Congress & Exhibition – the essential aerospace event where the aerospace community prepares for future challenges and opportunities. This exclusive event provides an invaluable opportunity for ACHEON to develop important business relationships within the international aerospace industry to upstream our technology. The Consortium expects also to have consultation meetings with Canadian R&D players for international cooperation, especially with Laboratoire de recherche en commande active, avionique et aéroservoélasticité (LARCASE) coordinated by Prof. Ruxandra Boetz.



At SAE Aerotech, the ACHEON researchers will be presenting the following papers:

"Mathematical modelling of a two streams Coanda effect nozzle", M. Trancossi, S. Maharshi, D. Fregni

"Computational Study of Coanda Adhesion Over Curved Surface", M. Subhash, A. Dumas

"Parametric CFD Study of the Coanda Based Thrust Vectoring Nozzle", D. Vucinic, A. Suñol Jiménez; M. Trancossi

"Mathematical Modeling of Coanda Effect", M. Trancossi, A. Dumas, D. Vucinic

"ThermoJet an Old Concept Which Can Prelude a Future Green Air Transport", M. Trancossi; J. Pascoa

The papers will be published in the SAE 2013 Aero Tech Congress and Exhibition proceedings, Montreal, Quebec, Canada, September 2013.

PROMO-AIR - Promoting Aeronautics Innovation and Research

According to the major European Industries the European Aeronautics community has a shortage of high quality engineers. Promo-Air is an FP7 Project aiming at raising the interest of young Europeans towards scientific and technical studies in the field of Aeronautics and Air Transport

The consortium is raising interest of teenagers in aeronautics-related studies through improving the image of an aeronautics career and stimulating their interest through the presentation of attractive educational material and hands-on experiences in Universities throughout Europe. The educational material will be assembled by taking into account the research achievements of recent and current R&D Aeronautics and Air Transport related projects. The developed educational material will include films, serious games and e-brochures to be disseminated through the internet (e.g. social networks and other websites) and through Universities.

By raising interest for aeronautics among students, the project will promote the scientific, technical studies and careers in aeronautics and air transport research and industry. With the help of Promo-Air activities, more students will realize how interesting careers in aeronautics and air transport are.

The ACHEON project via its joint cooperation with the MAAT Airship Project will make available to PROMO-AIR videos, animations and technical drawings that might be useful to be transformed in educational content or as supporting teaching materials.

Get inspired by visiting: http://www.promo-air.eu/

Further Readings

"CFD validation of the Coanda based thrust vectoring nozzle", D. Vucinic, A. Suñol, M. A.Bidakhvidi, S. Vanlanduit, ACEX, Madrid, July 2013

WO2013005132 – Nozzle Capable of Deviating a Synthetic Jet in A Dynamic and Controllable Manner with No Moving Mechanical Parts and a Control System thereof - http://patentscope.wipo.int/search/en/WO2013005132

About Us

ACHEON is run by a public-private consortium made of 6 organisations: 4 Universities, 1 Technology Transfer Organization and 1 Research intensive SME (Nimbus S.r.l) from 4 European Countries (IT, PT, UK, BE). The scientific project coordinator of the is Prof. Antonio Dumas from the Università degli Studi di Modena e Reggio Emilia (UNIMORE).

The consortium is looking to establish industrial collaborations with engine and aircraft manufacturers, and system integrators. This will enable to move the project beyond scientific feasibility and towards their goal of technological advancement in developing and validating the ACHEON technology.

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Contact us

Prof. Antonio DUMAS
University of Modena and Reggio Emilia
Via Amendola 2, Pad. Morselli
I-42122 Reggio Emilia, Italy
antonio.dumas@unimore.it