ECCOMAS
2018

ECCOMAS
ECCM-ECFD
2018

SPECIAL TECHNOLOGY SESSIONS
EUROPE-CHINA PLATFORM IN AERONAUTICS

CIMNE

ECCOMAS

ECCOMAS
ECCM-ECFD 2018 Conference

Special Technology Sessions
Europe-China Platform
in Aeronautics

With the support of European Commission and the Chinese Ministry of Industry and Information Technology (MIIT)

An event of special interest to the ECCOMAS Industry Interest Group

Glasgow, June 2018

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ECCOMAS ECCM-ECFD 2018 Overview Aeronautics Special Technology Sessions *(Room: Etive)*			
Time	**Monday, 11th June**	**Tuesday, 12th June**	**Wednesday,13th June**
8:30 - 10:30	9:00 Opening Ceremony Plenary Lecture 1	9:00 Plenary Lectures 2 and 3	9:00 *Restricted EU-China Meeting at Univ. of Glasgow*
10:30 - 11:00	***Coffee Break***		
11:00 - 13:00	**Opening Session** **STS 04** **New Aircraft Configurations**	**STS 06** **Aircraft Structures, Structural Health Monitoring, Smart & Intelligent Systems**	**STS 07** **Platform for Aircraft Drag Reduction Innovation - PADRI**
13:00 - 14:00	***Lunch Break***		
14:00 - 16:00	Semi Plenary Lectures	**STS 03A** **Aeronautics Drag Reduction Technol.**	Semi Plenary Lectures
16:00 - 16:30	***Coffee Break***		
16:30 - 18:30	**STS 05** **New Aeronautical Materials**	**STS 03B** **Aircraft Noise Reduction Technol.** **STS 01+02** **Alternative Fuels and Advanced Propulsion Technologies**	**STS 08** **Hybrid Laminar Flow, Flow and Vibration Control in the EU-Project AFLoNext**

Special Technology Sessions
Europe-China Platform in Aeronautics
at the ECCOMAS ECCM-ECFD 2018 Conference
Glasgow/ UK 11 – 15 June 2018

Foreword and Introduction

Perspectives of Aviation
Aviation remains one of European's key high-tech industries with high investments in research and innovation. The continuous growth of air transport will further increase the sector's economic and social impact but will necessitate measures to mitigate its environmental footprint, in terms of emissions and noise pollution, as well as to ensure a safe and seamless travel.

ECCOMAS and Aeronautics
The ECCOMAS Congress 1996 in Paris introduced for the first time aeronautics Special Technology Sessions (STS) addressing research and technologies of industrial relevance. The large ECCOMAS Conferences are favouring traditionally international exchanges and are promoting advanced computational methods and digitalisation techniques as artificial intelligence and big data handling. Aeronautics has been for decades and is still an important application driver for computational methods and data handling.
For the STS of ECCOMAS senior experts organise their STS in relevant technology areas by inviting knowledgeable specialists from industry and research institutions as speakers. This ensures the high scientific and technical quality of the STS.

Europe-China Cooperation for ECCM-ECFD 2018
For ECCM-ECFD 2018, a joint organisation of the Europe-China Platform, coordinated by CIMNE and CAE identified technology themes of mutual interest, including many from the Chinese research network INNOVATE:

- Advanced propulsion technologies,
- Alternative fuels for aviation,
- Aeronautics drag reduction technologies,
- Aircraft noise reduction technologies
- New aircraft configurations,
- New (green) aeronautical materials,
- Aircraft structures and structural health monitoring,
- Smart and intelligent systems.

The following topics are discussed in the EU-China workshop at the Univ. of Glasgow, because they are not within the scope of ECCM-ECFD 2018:

- Air traffic management (ATM),
- Navigation and airport management,
- Aviation safety and security,
- Certification and Airline operations.

In addition, two STS present European research activities:

- Platform for aircraft drag reduction innovation – PADRI
- Hybrid laminar flow, flow & vibration control in the EU-Project AFLoNext

The aim of the aeronautics related STS is to provide an overview on the state of the-art and the technology trends in advanced numerical methods and digitalisation of aeronautics applications.

The new Europe-China Platform

The joint Europe-China Platform for technology dissemination represents the international extension of the European Platform developed in the EU-funded network E-CAero of Europe's aerospace related associations incl. ECCOMAS. In the Welcome Session Pedro Diez, Scientific Director of CIMNE and Yunhao Yin, Deputy Director of CAE will set the scene of the aeronautics research and address the experience and perspective of EU-China research cooperation.
A joint presentation of Sara Guttila (EUROMECH), Jordi Pons-Prats (CIMNE) and Liang Lv (AVIC) will explain the mechanism of this platform, which is expected to be used at ECCOMAS 2018 and also beyond.

Thanks to the Supporters

We would like first to thank the organizers of ECCM-ECFD 2018 for welcoming the aeronautics STS in the programme (Chris Pearce was our friendly contact!). Thanks also to the chairs and speakers of the aeronautics STS from Europe and China, as they ensure the STS quality by their effort.
We are grateful also to colleagues of CAE/AVIC, especially Dr. Xiasheng Sun, Yunhao (Fred) YIN and Ms. Huixi Li team for excellent organisation of the Chinese contributions and their precise inputs for the roadmap of technology topics. We will not forget:
- Kostas Kontis and his team of the University of Glasgow, for hosting the EU-China Workshop,
- the CIMNE Congress Bureau team, especially Cristina Vizcaya and Alessio Bazzanella for all their help in integrating the STS in the general programme.
- Dietrich Knoerzer for his help in STS preparation with his long experience.

We hope, you will enjoy reading and using this booklet and appreciating the interesting technical contributions of the Aeronautics STS.

The Editor Team of CIMNE and CAE

Special Technology Sessions – EU-China Platform in Aeronautics at the ECCOMAS ECCM-ECFD 2018 Conference

Glasgow/ UK, 11 – 15 June 2018

Welcome Address

On behalf of CIMNE it is my great pleasure to welcome all participants at the Special Technology Sessions in Aeronautics (STS) of the ECCOMAS ECCM-ECFD 2018 Conference organized by the Euro-China Platform.

ECCOMAS Congresses and aeronautics research have long traditional links, as the aeronautics industry of Europe had and still has a need for advanced computational methods especially in fluid dynamics, structure mechanics and, more recently, in digitalized systems. Aeronautics was and still is a front runner in the application of advanced numerical methods. Already the ECCOMAS Congress 1996 in Paris presented aeronautics special technology sessions (STS), which focussed on research and technologies of industrial relevance. With their orientation towards industrial applications the aeronautics STS played a successful role in numerous ECCOMAS Congresses until the last event in 2016 in Crete.

At the ECCM-ECFD 2018 Conference for the first time colleagues of aeronautics research from Europe and China organise jointly numerous STS with Industry. They address attractive technology areas of mutual interest, which have been identified in EU-China research networks such Aero China and GRAIN. Joint research projects as DRAGY, IMAGE or ECO-COMPASS within the EU-Programme Horizon 2020 contribute amongst others to the aeronautics STS. The European Commission and the Ministry of Industry and Information Technology (MIIT) of the Chinese Government support these EU-China collaboration activities since many years. The STS address important key technology areas in aeronautics. STS on aeronautics topics, which thematically do not fit to ECCM-ECFD 2018 as e.g. air traffic management, are presented in the EU-China Workshop hosted at the same time by the University of Glasgow.

All these joint activities are collaborative efforts of teams of universities, research centres and companies in the aeronautics field in Europe and China. They aim to deepen in the mutual knowledge on the capabilities and interests of the participating organizations for the solution of challenging multidisciplinary problems in aeronautics using computational and experimental techniques.

We look forward to continue research activities of experts from Europe and China on sustainable aeronautics technologies. We hope that this collaboration will continue receiving the interest and support of the European Commission and of MIIT, the corresponding funding organization in China.

The aeronautics related STS at ECCM-ECFD provide an excellent overview on the state-of-the-art, industrial challenges and the technology trends in numerical methods for aeronautical applications and their related validations.

We are grateful to the organisers of ECCM-ECFD 2018, especially to Roger Owen, Rene de Borst, Jason Reese and Chris Pearce for welcoming the aeronautics STS in the Conference, to the ECCOMAS President Michael Kleiber and the Executive Board for their continuous interest to STS activities.

We are also grateful to Professor Konstantinos Kontis from the University of Glasgow for kindly hosting some of the STS in the EU-China Workshop.

Eugenio Oñate
Director of CIMNE

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First of all, on behalf of the Chinese Aeronautical Establishment (CAE), I would like to extend my warm congratulations on the successful convening of this meeting, and to express my heartfelt thanks to people from all walks of life who are committed to the friendly cooperation between China and Europe in aviation science and technology.

The rapid development of the global air transport industry has brought opportunities and challenges to China-Europe aviation industries, as to significantly improve the level of aviation safety, to reduce aviation environmental impact, and to improve the overall efficiency. Only then can we maintain a safer, greener, and more efficient aviation industry in the next 20 years. Since 2005, under the intergovernmental cooperation mechanism between China and EU, by establishing a stable and efficient platform, China and EU has achieved encouraging results in conducting technical exchange and project cooperation and have also cultivated a number of innovative and international talents.

As the only national-level research institute in the Chinese aviation industry, as well as the only scientific research institution authorized by MIIT to engage in international science and technology cooperation under the intergovernmental framework, CAE has always been committed to promoting in-depth and extensive technical exchanges between the Chinese and European aviation science and technology communities, to support the rapid development of the Chinese aviation industry, to help China's aviation science and technology sector to gradually make its own contribution in China and the world aviation industry.

I sincerely hope this Conference a complete success, and hope that every representative of the conference will flash his wisdom in Glasgow and gain more cooperation opportunities! Thanks.

Dr SUN Xiasheng
Executive Vice President
Chinese Aeronautical Establishment(CAE)

Content

The EU-China Platform and the Special Technological Sessions

The EU-China Platform addresses investigation through a series of events on new methods, new tools and new technologies involving multinational research experts from Europe, China and third countries in areas of safe, secure and green aeronautics. The Platform will be coordinated by International Centre of Numerical Methods in Engineering (CIMNE) and the Chinese Aeronautical Establishment (CAE). Several core European and Chinese partners of the Platform consortium have been identified for their expertise in six Key Technologies (KT) linked to Challenges 3 and 4. Some of them have already been part of previous EU-China aeronautics research networks (AeroChina, AeroChina2, GRAIN, GRAIN2).

Open events of different KTs will be organized asynchronously by the European and Chinese KT co-chairpersons, jointly with the Chinese INNOVATE project.

Prospects of new methods, new tools and new technologies will be done through outcomes of open events. Dissemination of these activities will be implemented through an EU-China open platform. Innovative technology activities will consist of a series of open events to present and discuss about future research topics of the six Key Technologies (KT1-KT6), which address a number of sub topics. At ECCOMAS ECFD-ECCM 2018 Conference, the KT will be organized through a series of Special Technical Sessions (STS):

Session	Title	Link
STS01 and STS02	KT1: Propulsion Technology and Alternative Fuel including NOx and CO2 reduction, MDO, mission modelling, new energies for aviation.	STS1, STS2
STS03 and STS04	KT2: Flight Physics, including Flow Control, Noise, Design Tools, HPC and New Configurations	STS3A, STS3B, STS4
STS05	KT3: Green Aeronautical Materials and Aircraft Structures, and Health Monitoring	STS5
STS06	KT6: Smart and Intelligent Technology	STS6

Two other aeronautics topics are addressed in the STS07 and STS08 as flow control technologies for novel aircraft configurations (EU-project AFLoNext) and the platform for aircraft drag reduction innovation (PADRI) focused on a strut-wing configuration test case.

An additional EU-China Workshop is organized on 12th June in the University of Glasgow to addressing research topics with:

- KT4: Navigation and Air Traffic and Airport Management
- KT5: Flight Safety and Security

Agenda of the Special Technology Sessions

Monday, 11 June 2018

Room: Etive

11:00 – 11:30 Opening Session: Welcome Addresses and Introduction to the EU-China Platform

Chairs: Jacques Periaux (CIMNE, Spain), Huixi Li (CAE, China)
Co-Chairs: Gabriel Bugeda (CIMNE, Spain), Yunhao Yin (CAE, China)

- ***The Future of China-EU S&T Cooperation and the Potential Topics of Flight Physics***
  Yunhao Yin, Yuanyuan Wang (CAE, China)
- ***China-Europe Cooperation in Aeronautical Research: Ten Years on, and New Challenges to Face***
  Pedro Díez, Jordi Pons-Prats, Gabriel Bugeda, Jacques Périaux, Eugenio Oñate (CIMNE, Spain)
- ***International Collaboration Platform in Aeronautics: the EU-China Platform and ICARe Project***
  Sara Gutilla (Euromech, Italy), Jordi Pons-Prats (CIMNE, Spain), Liang LV (CAE, China)

Monday, 11 June 2018

Room: Etive

11:30 - 13:00 STS 04: New Aircraft Configurations

Chair: Ning Qin (Univ. Sheffield, UK) /Jacques Periaux (CIMNE, Spain)
Co-Chair: Song Fu (Tsinghua Univ., China)

- ***Overcoming Interference Wave Drag on Strut-braced Wing for Future Civil Air Transport at Transonic Speeds***
  Minsup Roh, Feng Xie, Ning Qin (Univ. Sheffield, UK)
- ***Preliminary Design of Strut Braced Wing Aircraft and Aerodynamic Optimization on the Junction Geometry***
  Runze Li, Yufei Zhang and Haixin Chen (Tsinghua Univ., China)
- ***Numerical Investigation of Shock Wave Propagation in Ducts With Grooves***
  Mehdi Mortazawy, Konstantinos Kontis and John Ekaterinaris (Univ. Glasgow, UK)
- ***Low Drag and Sonic Boom Aerodynamic Layout Design Technique Study for a Supersonic Business Jet***
  Wenqi Zhang (CAE, China)

Monday, 11 June 2018

Room: Etive

16:30 – 18:30 STS 05: New Aeronautical Materials

Chair: Xavier Martínez Garcia (UPC/CIMNE, Spain)
Co-Chair: Xiaosu Yi (ACC, China)

- ***Joint R&D of Composite Materials for Green Aviation***
  Xiaosu Yi (AAC, China)

- ***Eco-composites in Aeronautical Structures – Possibilities and Challenges***
  Xavier Martinez Garcia (UPC/CIMNE, Spain), Jens Bachmann (DLR, Germany), Gabriel Bugeda, Sergio Oller (CIMNE, Spain)

- ***Mechanical Properties and Effect of Residual Stress in Titanium Alloy Built by Laser Additive Manufacturing Process***
  Dong Dengke, Shaopu Su and Haiying Zhang (ASRI, China)

Tuesday, 12 June 2018

Room: Etive

11:00 – 13:00 STS06: Aircraft Structures and Structural Health Monitoring and Smart and Intelligent Systems

Chair: Marcello Kivel Mazuy (CIRA, Italy)
Co-Chair: Shihui Duan (ASRI, China), Shenfang Yuan (NUAA, China)

- ***Structural Optimization of a Variable Camber Leading Edge***
  Zhigang Wang, Yu Yang (ASRI, China), SUN Xiasheng (CAE, China)
- ***An Integrated Approach Aimed at Developing Innovative Products for Icing***
  Alessandra Lucia Zollo, Paola Mercogliano, Marcello Kivel Mazuy and Biagio Esposito (CIRA, Italy)
- ***Application of Structural Health Monitoring Technology in Aircraft Structure Ground Test***
  Shihui Duan, Yu Yang and Guoqiang Liu (ASRI, China)
- ***Probabilistic Data Mining for Aircraft Structural Health Monitoring***
  Shenfang Yuan, Jian Chen and Lei Qiu (NUAA, China)

Tuesday, 12 June 2018

Room: Etive

14:00 - 16:00 STS 03A: Aeronautics Drag Reduction Technologies

Chair: Feng Haiyong (FAI, China)

- ***Novel Concepts and Innovations for Drag Reduction***
  Wolfgang Schroeder (RWTH Aachen Univ., Germany)

- ***Numerical Study of Laminar Flow Control for Airfoil Based on Plasma Actuators***
  Ke Zhao, Yiju Deng and Haiyong Feng (FAI, China)

- ***Investigation on Nacelle Liner Drag and Acoustic Performance***
  Xiaodong Li, Chao Chen, Yin Liu, Mingyang Zheng (BUAA, China), Frank Thiele (CFD- Berlin, Germany)

- ***Eigenmode Optimization of a Contraction Channel Based on Stability Analysis***
  Yinzhu Wang (ZTU, China), Alejandro Martínez-Cava, Eusebio Valero (UPM, Spain), Yao Zheng (ZTU, China), Esteban Ferrer (UPM, Spain)

- ***Drag Reduction Technology Review***
  Jesus Garicano (UPM, Spain)

Tuesday, 12 June 2018

Room: Etive

16:30 - 18:30 STS 03B Aircraft Noise Reduction Technologies

Chair: Shia-Hui Peng (Chalmers, Sweden)
Co-Chair: Wenchao Huang (ASRI)

- ***Effects of Slat Parameters on Noise Characteristics of an Airfoil***
  Hongjian Wang (FAI, China), Wang Luo, Zhichun Yang (NPU, China)

- ***Challenges in Acoustic Liner Characterization, Optimization and Design***
  Hans Bodén (KTH Royal Inst. of Technology, Sweden)

- ***Recent Research in the Field of Aircraft Noise and Vibration Control***
  Qun Yan and Wenchao Huang (ASRI, China)

- ***Numerical Prediction of the Noise Reduction in a Tandem Cylinder Configuration Using DBD Plasma Actuators***
  Sahan H. Wasala, Amadeo Moran-Guerrero, Shia-Hui Peng (Chalmers, Sweden), Leo M.Gonzalez-Gutierrez (UPM, Spain), Lars Davidson (Chalmers Univ., Sweden)

Tuesday, 12 June 2018

Room: TBC

16:30 - 18:30 STS 01+02: Alternative Fuel for Aviation and Advanced Propulsion Technologies

Chair: Bhupandra Khandelwal (Univ. Sheffield, UK)
Co-Chair: Xiaoyi Yang (BUAA, China)

- ***Sustainable Drop-in Fuel Design with Alternative Aviation Fuel***
  Xiaoyi Yang (BUAA, China)

- ***Impact of Alternative Fuel Properties on Combustion Performance Using a Gas Turbine Combustor***
  Lukai Zheng and Bhupendra Khandelwal (Univ. Sheffield, UK)

- ***Research on Jet Noise of Mixers Configuration for Mixing Exhaust Nozzle***
  Fei Wu and Wanren Shai (AEEC CAE, China)

- ***A Methodology for Fully-Coupled CFD Engine Simulations***
  Charles Hirsch (NUMECA Int, Belgium)

- ***Matching Design of Aero Engine Cycle Parameters Based on Multidisciplinary Optimization Technique***
  Mingdong Cao, Weina Huang, Gangtuan Li (AECC GTE, China)

Wednesday, 13 June 2018

Room: Etive

11:00 – 13:00 STS 07: Platform for Aircraft Drag Reduction Innovation – PADRI

Chair: Daniel Redondo (Airbus, Spain)

- ***Definition and Computation of a Strut-Wing Configuration***
  Daniel Redondo (Airbus, Spain)
- ***Drag Reduction in a Wing-Strut Junction: Comparison between RANS and Hybrid RANS-LES Simulations***
  Pablo Cornejo (UEDC, Chile)
- ***Passive Flow Control Devices for Wave Drag Mitigation on Strut Braced Wings***
  Dumitru Pepelea (INCAS, Romania)
- ***Application of a Knowledge-Based Design Method and Passive Porosity for Drag Reduction on a Generic Strut-Braced Wing***
  Sally Viken, Richard Campbell, Michelle Lynde (NASA Langley, USA)
- ***Strut-braced Wing Compressibility Drag Improvements Using SU2***
  Brian Munguia, Jayant Mukhopadhaya, Juan J. Alonso (Stanford, USA)

Wednesday, 13 June 2018

Room: Etive

16h30 – 18h30 STS 08: Hybrid Laminar Flow, Flow and Vibration Control in the EU-Project AFLoNext

Chair: Dietrich Knoerzer (Brussels, Belgium)

- ***AFLoNext Hybrid Laminar Flow Control Flight Tests***
  Heiko von Geyr/ Geza Schrauf (DLR, Germany)
- ***AFLoNext: A Holistic Approach to Greener Aircraft***
  Daniel Redondo (Airbus, Spain)
- ***CFD Based Design and Full Scale Verification of Transport Aircraft Flow Separation Control within the AFLoNext Project***
  Jochen Wild (DLR, Germany)
- ***Computational Analysis of Aerodynamic Vibration and Control on Main Landing Gear Doors of A320 Aircraft***
  Shia-Hui Peng, Mats Dalenbring, Adam Jirasek (FOI, Sweden)

University of Glasgow

EU-China Workshop on Aviation, Air Traffic Management, Safety and Security

University of Glasgow, 12th June 2018

Workshop Objectives

The global air transport is growing steadily with more than four percent per year. In particular Europe and China are increasingly facing limited air space capacities and air traffic congestion problems. Therefore new and innovative technologies, methods and procedures are needed to scope with these challenges. In Europe SESAR, the Single European Space Air Traffic Management (ATM) Research, addresses these issues by large scale research and technology validation in line with national initiatives and industry.

This Workshop is hosted by the Division of Aerospace Sciences of the University of Glasgow and organised by the EU-China cooperation platform of the international research network ICARe of Horizon 2020. It will mainly address future perspectives and technologies of Air Traffic Management (ATM), safety and security and related systems of aviation.

This event profits from the experienced EU-China cooperation in aeronautics, especially from the joint expert group on ATM research, which was established in the network on greening technologies GRAIN2.

By presentations from both sides and expert discussions, this workshop shall contribute to identifying areas of coordinated research for future joint research initiatives. It addresses research themes in four key areas that need to be tackled.

Europe-China Platform

Programme of EU-China Workshop

9h00 – 9h20 **Opening Session**

- **Welcome by Professor Kostas Kontis, Dean for Global Engagement – East Asia & China and Head of the Aerospace Sciences Division (Univ. of Glasgow)**
- **Keynote Address by Mr Yunhao Yin, Deputy Director, Chinese Aeronautical Establishment (CAE)**
- **Introduction by Professor Jacques Periaux (CIMNE)**

9h20 – 11h00 **Session 1: Aviation Safety and Security**

Chairs: Dongyu ZHU (ARI, China)

- ***In-flight Icing Safety Research: From Clean to Iced Airfoil***
  Dongyu Zhu (ARI, China)
- ***Ensuring safe and secure aviation - ACARE Strategic Agenda***
  Sylvie Grand-Perret, Ovidiu Dumitrache (EUROCONTROL)
- ***Cyber security of existing and future ATM networks***
  Christopher Johnson (University of Glasgow, UK)
- ***Low Orbit Constellation Aeronautical Safety Surveillance System and the Application Prospect***
  Baoguo Wei, Hongjun Ye (State Key Lab, China)

11h00 – 11h20 ***Coffee Break***

11h20 – 12h40 **Session 2: Air Traffic Management**

Chairs: Pingyu DENG (CARERI, China).

- ***The Future of Multiple Remote Tower Operations Cost-Efficiency, Capacity and Safety Regulations***
  Lei Wang, Jingyi Zhang, Ruishan Sun, Wen-Chin Li, Peter Kearney (Cranfield Univ, UK)
- ***Greener Air Traffic Operation Architecture Development Based on MBSE Methods***

Haoliang Hu, Jizhi Mao, Xiaohui Yang (CARERI, China)

- ***Model and Dependability Driven Avionics Systems Design***
  Ming Mou, Wensheng Niu (ACTRI, China)

- ***SESAR – Europe's Approach to the Future ATM System***
  Ovidiu Dumitrache (EUROCONTROL)

12h40 – 14h20 ***Sandwich Lunch***

14h20 – 16h20 Session 3: Navigation and Green Trajectory Management

Chairs: Wen Chin Li (Cranfield University, UK)

- ***Data driven scheduling and path planning***
  Annalisa Riccardi, University of Strathclyde, UK

- ***The technology of Intelligent Flight Control Based on Machine Learning***
  Pengcheng Wen, Wensheng Niu, Changhao Zou, Ze Gao (ACTRI)

- ***Optimization of Green Trajectories to minimize Climate Change impact***
  Arturo Benito (UPM, Spain)

- ***Aircraft trajectory optimisation: towards greener flight operations.***
  Xavier Prats (UPC, Spain)

- ***Requirements of Avionic Systems to Support Green Trajectory***
  Lijun Zhu, Chen Qi, Haoliang Hu (CARERI, China)

- ***Air navigation services assets management with stochastic model checking***
  Michele Sevegnani (Univ. of Glasgow, UK)

16h20 – 16h30 Workshop Closing

Title and abstract of the contributions

Opening Session: Welcome Addresses and Introduction to EU-China Platform

The Future of China-EU S&T Cooperation and the Potential Topics of Flight Physics

Yunhao Yin

Chinese Aeronautical Establishment (CAE), Beijing, China

After 2020, with the change of environment and demand, China and EU will face new challenges and opportunities for collaborative innovation in aviation science and technology. In order to achieve a common vision, both parties need to develop synergies at various levels such as the top-level strategy, planning system, and management process, so as to further promote the international cooperation. We are willing to cooperate with the European side in the areas as aerodynamic design and optimization of the new concepts of civil aircraft, high-precision numerical simulation, refined aerodynamic design, and efficient flow control, to support the realization of the green aviation strategic goals.

中欧航空科技合作的战略前景及飞行技术的潜在合作方向

2020 年以后，随着环境和需求的改变，中国与欧盟在航空科技领域开展协同创新面临着新的挑战与机遇。为了实现共同的愿景目标，双方需要在顶层战略、计划体系和管理流程等多个层次开展协同互动，以进一步推动开展国际合作。中方愿同欧方在民用飞机新概念布局气动设计和优化，高精度数值模拟，精细化气动设计，高效流动控制等方面探索开展合作，支撑绿色航空战略目标的实现。

Opening Session: Welcome Addresses and Introduction to EU-China Platform

China-Europe Cooperation in Aeronautical Research: Ten Years on, and New Challenges to Face

Pedro Díez, Jordi Pons-Prats, Gabriel Bugeda, Jacques Périaux and Eugenio Oñate

CIMNE, Barcelona, Spain

Beginning in 2006, China – Europe cooperation in Aeronautics started with the first AeroChina project. It was a Cooperation and Support Action (CSA) funded by the European Commission. Since then, the ties have been strengthening with a second AeroChina project, and two GRAIN (Greener Aeronautics International Network) projects. All of them CSA (CCP in China). Six research projects have been born from this cooperation (MARS, COLTS, already finished, and IMAGE, DRAGY, EMUSIC and ECO-COMPASS as on-going projects). Multiple bilateral cooperation agreements have been born or strengthen from all those activities.
Since the China – Europe relationship is growing for more than 10 years, accumulated experience is large and new opportunities to face are challenging.

Opening Session: Welcome Addresses and Introduction to EU-China Platform

International Collaboration Platform in Aeronautics; the EU-China Platform and INNOVATE Project

Sara Gutilla[1], Jordi Pons-Prats[2] and Liang LV[3]

[1] EUROMECH, Italy,
[2] CIMNE, Barcelona, Spain,
[3] CAE, Beijing, China

As a continuation of a fruitful 10-year long collaboration between China and Europe in Aeronautics, CIMNE and CAE have decided to establish a web-based platform to share information and knowledge. This platform collects the background of AeroChina 1 and 2, and GRAIN 1 and 2 projects, as well as MARS, COLTS, DRAGY, IMAGE, ECO-COMPASS and EMUSIC projects. All of them were, and are funded by EC and MIIT. While the first 4 ones were CSA projects (CCP in China), the last ones are research actions. DRAGY, IMAGE, ECO-COMPASS and EMUSIC are on-going projects to last until 2019.

The web-based platform uses the experience and developments of the European CSA E-CAero, where a tool was developed and implemented.

A Web Platform is not a normal web site or portal. On the other hand, it is an integrated set of tools and applications that enable a user to access, download, upload, and share content and to use the available services. Euro-China Platform will allow to share information on joint events, activities and publications of the Aerospace Web Community. The main idea is to harmonize the existing information available online (on websites or on institutional repositories) so that the platform could be considered as a gateway to gather all useful information on Europe-China scientific relationship on Aerospace, either mirroring info from existing website or setting up new webpages/IT services.

STS 01: Advanced Propulsion Technologies

Research on Jet Noise of Mixers Configuration for Mixing Exhaust Nozzle

Fei Wu[1] and Wanren Shai[2]

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Key Words: Mixing exhaust nozzle, Jet noise, Splitter mixer, Lobed mixer, Semicircle cut lobed mixer.

In order to reveal the distribution of frequency spectrum and directivity for the mixing exhaust nozzle, Tam & Auriault's jet noise prediction is conducted for splitter base lobed and semicircle cut lobed mixer exhaust nozzle. The result shows that jet noise possesses obvious direction. Compared with splitter mixer, the reduced effect of jet noise with lobed mixer is better. Lobed mixer which have better ability of low-frequency noise reduction and the high-frequency noise increase by contrast with splitter mixer. The reduced effect of jet noise with Semicircle cut lobed mixer is better than base lobed mixer. The overall sound pressure level value of splitter mixer is less than that of lobe mixing exhaust nozzle at the directional angle smaller than 83° in this paper.

Matching Design of Aero Engine Cycle Parameters Based on Multidisciplinary Optimization Technique

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Key Words: Multidisciplinary, Integration, Matching Design, High Bypass Ratio.

The matching design problem of the aero engine cycle parameters was solved by using the coupled iteration of aircraft/engine integration and aero-engine multidisciplinary optimization method, which was based on the multidisciplinary optimization research ideas. The 250 kN grade take-off thrust engine installed on the B767-200ER was chosen as an example.

The optimization matching must consider two aspects, one of which is taking vehicle requirements as guidance and the other is to make optimization on engine cycle parameters under the premise of considering factors like engine weight, size, air system, material temperature limits, etc. Applying above research approach, aero engine cycle parameters matching design process based on multidisciplinary optimization would be shown as figure 1.

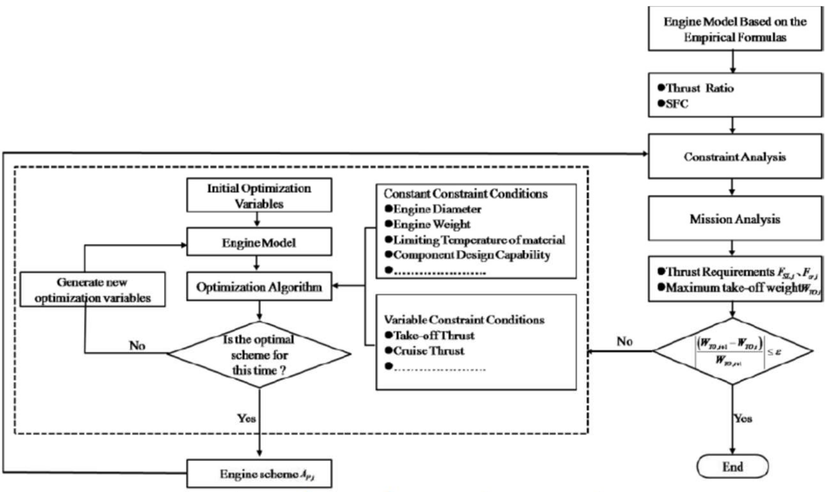

Figure 1: *Figure of Research Approach*

The optimization results showed that: under the premise that engine satisfying aircraft mission, size, weight, material temperature, etc., the maximum aircraft take-off weight of B767-200ER was reduced about 2.7% and the fuel consumption was reduced about 5.25%; the optimized engine weight was basically the same as that of the original PW4056 engine; the method and research ideas used in this paper were reasonable and feasible, and had good practical value for engineering.

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STS 01: Advanced Propulsion Technologies

Nonlinear Dynamic Model Based Transition Control Method of Aero Engines

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Key Words: Aero engine, Nonlinear control, Transition Control, Airworthiness, Safety assessment.

The transient controller of aero engine has been conventionally implemented as lookup tables, which is conventional but not flexible. A control method based on nonlinear dynamic model is proposed. A nonlinear model is built by rotor dynamics equation, pressure dynamics equation and temperature dynamic equation which can describe the steady and dynamic characteristics of aero engine. A transient controller is designed by nonlinear model predictive control and nonlinear dynamic model. Compared with lookup tables method, the nonlinear dynamic model based transition controller can implement precise control of fuel of aero engine, that can improve economy of transition processes. Surge margin, combustor pressure, and turbine inlet total temperature, involving safety, are used as restricted parameter that can ensure the safety of aero engine. The transition controller design problem can be transformed into a optimization problem of a constrained infinite time interval complex system by dynamic model and model predictive control method. The effectiveness of the proposed control method is validated through a detailed numerical study on DGEN380 test platform. Safety assessment is implemented, according to this architecture, which can provide evidence for airworthiness certification.

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STS 01: Advanced Propulsion Technologies

A Methodology For Fully-Coupled Cfd Engine Simulations

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The development of new generations of aircraft engines with reduced environmental impact heavily relies on high-fidelity 3D numerical analysis of the main engine components, compressor, combustion chamber, turbine and their interactions, including the transient and off-design behavior of the full engine.

Unlike component-by-component analysis, which requires separate assumptions for the pressure and temperature boundary conditions for each component, a fully coupled approach requires only knowledge of the compressor inlet and turbine outlet flow conditions. In addition, the engine rotation speed can also be varied during the simulation to converge to the correct balance of power between compressor and turbine.

This integrated approach provides a detailed description of the flow field inside the full engine at the desired operating point with one single CFD simulation.

The full engine simulation methodology can be developed at several levels: (1) RANS simulations with mixing-plane interfaces between components; (2) advanced RANS treatment with inputs from the nonlinear harmonic (NLH) methodology to allow for tangential non-uniformity, such as hot streaks entering the turbine nozzle from the combustor; (3) inclusion of the unsteady rotor-stator interactions, via NLH, in compressor and turbine stages; (4) coupling with LES simulations in the combustor.

The presentation will cover results from levels (1) and (2), as well as the initial steps towards level (3), applied to a micro-turbine gas engine including the HP compressor, combustor, HP and LP turbines and the exhaust hood.

Sustainable Drop-in Fuel Design with Alternative Aviation Fuel

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Key Words: GHGs Reduction, LCA, Refining process integration, Jet fuel, Alternative fuel.

Fuel compositions confine property specifications including volatility, fluidity, combustion, thermal stability, and lubricity characteristics. As jet fuels are composed of hundreds to thousands of different molecules including paraffins, cycloparaffins, aromatics, jet fuel compositions cannot carry out drop-in fuel design. Although the relationship between the chemical compositions of fuels and their properties are complex and interactive influence, artificial neural network (ANN) approaches were developed for drop-in fuel design. Moreover, drop-in jet fuel should comply with the reduction of GHGs emission in whole life cycle with economic competitiveness. The gap from alternative aviation fuel to sustainable drop-in fuel has been bridged by ANN system design and LCA.

From the insight of GHGs reduction, Beihang-AF3E model [1], an integrated computerized model, was develped for aviation fuel assessment on energy, environment, and economy. The system boundary, a whole life cycle of jet fuel integrates three main stages including feedstock, refining fuel, and combustion in engine of aircraft. Energy consumption and GHGs emission are calculated on per unit load and per unit flight range on the assumption of the maximum load and the maximum range[2,3]. The infrastructure construction in feedstock and refining fuel are involved in this assessment but without considering the manufacture and service life of engine and aircraft. The inputs and outputs related with the materials have been calculated by mass allocation method while the electricity utilization shares the emissions and energy consumption by energy allocation on jet fuels and by-products. Accordingly, an example of refining jet biofuel was modified coupling the requirement of GHGs reduction in life cycle.

From the insight of drop-in fuel design, the critical parameters in fuel compositions have been extracted as carbon distribution and classification, which can conduct directly for feedstock choice and refining process modification [4]. The relationships between the critical parameters with properties were established by ANN. The optimization methodologies of ANN design could be benefit to produce sustainable alternative jet fuel.

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STS 02: Alternative Fuel for Aviation

Drop-in Assessment of Alternative Aviation Fuel on Engine

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Key Words: safety criteria in engine, alternative jet fuel, integrated engine model, combustion diagnostic and simulation.

One of the most challenges in alternative aviation fuel is the lack of clear definition of drop-in fuel, which results in the key question - what kind of difference in fuel and combustion are acceptable in engine. Jet fuel should achieve to provide available thrusts by engines under both of unsteady and steady states in the whole flight envelope. Accordingly, as a result, engine in alternative fuel should conduct the duties at the conditions of flight envelop as petroleum-derived jet fuel including taking-off, climbing, cruising, landing. Performance critical parameters (PCPs) related with engine performance contain thrust, thrust response, specific fuel consumption, exhaust gas temperature, rotors axial force. The deviation of engine performance related with alternative jet fuel effects may lead to the changes of duration and reliability on combustor, hot section, fuel system, which can be integrated as safety critical parameters (SCPs). The critical key parameters of were extracted by fundamental process related with safety and performance on achieving the duty of engine in the whole flight envelop. For achieving the compliance verification of drop-in fuel, parameterization have been carried out for similar analogy. Based on the data of petroleum jet fuel, the integration of SCPs space formed the safety margin of engine as safety criterion while the integration of PCPs formed the work margin of engine as performance criterion which can be used as acceptable criteria to identify drop-in jet fuel [1].

Integrated engine models [2] coupled with three-dimensional transient combustor models were designed with the ability to simulate the engine performance and components interactions. The models can simulate the design performance and off-design performances with an example of the integrated engine model for a typical turbofan engine. Engine components include a fan, compressor, combustor, turbine, and nozzle. The models consist of a plurality of three-dimensional transient combustor sub-models and zero-dimensional transient component sub-models. The engine parameters of specific fuel consumption, thrust, and thrust response can be obtained from the simulation. Besides these engine parameters, individual component performance characteristics, and the working-fluid properties under different operating conditions in the engine, can also be outputted including the compressor exit pressure, turbine inlet temperature, turbine outlet temperature, mass flows and rotor speed under different operating conditions. This paper discussed a methodology to certify drop-in fuel by similar analogy.

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STS 02: Alternative Fuel for Aviation

Impact of Alternative Fuel Properties on Combustion Performance Using a Gas Turbine Combustor

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The University of Sheffield, UK

The tremendous expansion of the aviation demand combined with the energy crisis and the stringent environmental pollution regulations has promoted the development of the alternative fuels industry. A comprehensive understanding of the fuels science, combustion performance and environmental impact can point a positive direction for further alternative fuel development. The aim of this work is to evaluate the impact of fuel properties and composition on the combustion performance using a Rolls-Royce Tay gas turbine combustor, including, PM emissions, LBO and instability. The results could be crucial for future fuels and engines. Additionally, an innovative visual method used in this work has the potential to be used as a tool for PM and LBO determination. It contributes towards the development of tools for fuel performance evaluation.

Actively Reduced Airfoil Drag

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The flow over a DRA2303 wing section at a Reynolds number of Re = 400,000 is actively controlled by spanwise traveling transversal surface waves. The actuated low Mach number flow is investigated by a high-resolution large-eddy simulation. Approximately 75% of the solid surface on both sides of the wing section is deflected by a sinusoidal space- and time-dependent function in the wall-normal direction. The turbulence intensities and wall-normal vorticity fluctuations are significantly reduced and a shift from one-dimensional turbulence to two-dimensional turbulence is observed. Besides a viscous drag reduction by 8.6% with a strong decrease of skin friction in the favourable pressure gradient region and in an overall drag decrease by 7.5%, a slight increase in lift is achieved.

Numerical Study of Laminar Flow Control for Airfoil Based on Plasma Actuators

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Key Words: Plasma Actuators, Laminar Flow Control, Transition, Numerical Simulation

In this paper, the Numerical simulation method is used to study the control effect of dielectric barrier discharge plasma technology on the transition of the airfoil boundary layer. The phenomenological model is used to simulate the plasma actuators. The potential and charge density field of the plasma actuators are obtained by solving the Poisson equation, resulting in a volume force. The $\gamma - Re\theta$ transition model of 4 equations is used to simulate the process of laminar flow transition. The reliability of the plasma technology is verified by the flow past the plate. Finally, the numerical simulation of the laminar flow control of the airfoil boundary layer is carried out. The results show that the plasma technology can delay the airfoil transition point and reduce the drag, and its control effect is directly related to the excitation intensity and distribution of the plasma.

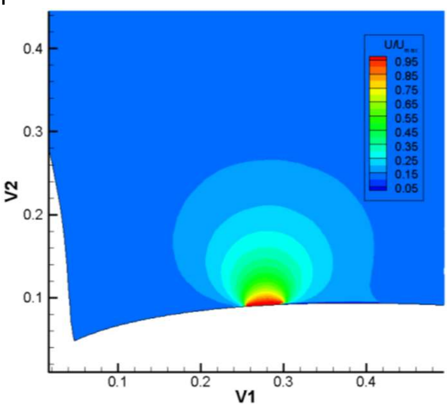

Fig. 1: The potential distribution of the airfoil

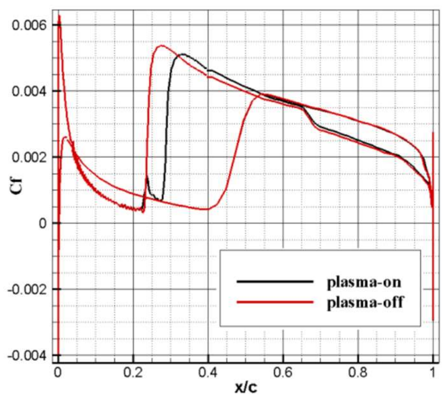

Fig. 2: Comparisons of the friction distribution plasma actuator

The potential distribution airfoil plasma actuator is shown in Figure 1 and Figure 2 shows the comparisons of the friction distribution, the figure shows the plasma actuator makes the transition position after the shift of 0.05c, effectively increasing the airfoil laminar flow area,

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STS 03A: Aeronautics Drag Reduction Technologies

Investigation on Nacelle Liner Drag and Acoustic Performance

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Keywords：Acoustic Liner, Flow Drag, Absorption Mechanism, Computational Aeroacoustics

Acoustic liner is one of the most important passive noise control techniques for aero-engine noise suppression. So far, most of research on liner has been focused on the improvement of acoustic absorption performance. However, its negative impact to aerodynamic performance is usually neglected. It is highly desirable to invoke a breakthrough on low drag liner design technique which could yield wider application in future aero-engine and airframe low noise design. This study conducted the drag generation mechanism and acoustic performance of acoustic liners with different configurations in the presence of grazing mean flow and high incident sound intensities by numerical simulation and experimental measurement. A drag balance is designed to measure the liner drag in the Beihang University grazing flow impedance tube (BGFIT). An in-house DNS solver is to be employed for the numerical simulation in the conjunction with a highly accurate computational aeroacoustics (CAA) approach. Through insightful analysis of investigation results from highly accurate numerical simulation and experiments, the underlying mechanism of drag generation and acoustic absorption of liners is anticipated to be uncovered and illustrated.

Eigenmode Optimization of a Contraction Channel Based on Stability Analysis

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Keywords: geometric optimization, eigenvalue problem, contraction channel, linear stability analysis

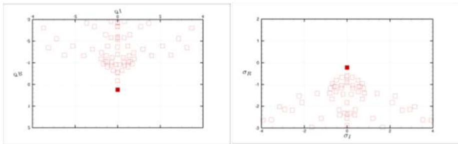
There are many applications in which the flow meets a sudden geometry contraction, an example is provided by the cooling flow in a compressor turbine blade. Evidence has shown that such contractions may cause some unfavourable pressure perturbations downstream, affecting the next blades and causing fatigue and loss of efficiency [1]. There have been several investigations aiming at understanding the flow behaviour in sudden contractions both numerically and experimentally. In numerical simulations carried out by Chiang and Sheu [2], and experimental investigations carried out by Cherdron and Soby, two recirculation bubbles of different sizes were observed on the two tip corners downstream the contraction stage. This flow configuration is unstable for certain flow parameters (Reynolds number and contraction ratios) which control the instabilities leading to the observed unsteady flows. Computational investigations have been performed to study flow bifurcation in the symmetric planar contraction channel. CFD simulations at different Reynolds numbers for 3 contraction ratios have been carried out, which confirm the presence of the pitchfork bifurcations. The critical Reynolds numbers of bifurcations are obtained. In this framework, the DLR-TAU code is employed to obtain the compressible base flow solution, from which the critical Reynolds numbers for the bifurcations have been found. This non-symmetrical flow topology can be analysed using global stability analysis, evaluating the influence of the Reynolds number of the flow as the main parameter that triggers the unstable phenomenon [3]. The eigenmodes responsible for the flow bifurcations are identified using stability analysis, and their amplification rates analysed. The real part of the eigenvalue stands for the amplification rate of the corresponding eigenmode, the optimization problem is simplified as minimizing the real part of the corresponding eigenvalue of a specific eigenmode of interest. Based on this assumption, the optimization problem is modelled as follows.

mind2D g(d;)

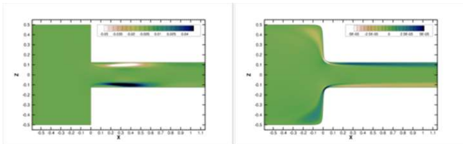
subject to : hi(d;) >= 0; for i = 1; :::; N (1) in which, d is the geometry parameters and is the model parameters in the flow field.

***Figure 1**: The optimization loop*

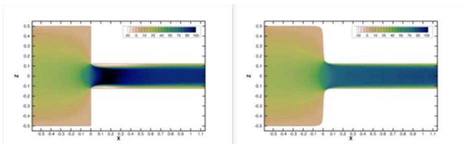
The objective function g(d;) = !r(d;), which is dependent on the geometry parameters d and the model parameters are minimized over all possible designs, subjected to constraints imposed on both geometry and the flow field. The optimization loop consists of surrogate model building and updating, geometry parametrization, mesh deformation, base flow solution, stability analysis and mode tracking. The main loop is started by building the initial surrogate model. Then, followed by the loop of optimization and surrogate model updating. The flowchart of the optimization is shown in figure 1. We can see in the eigenvalue spectrum shown in figure 2b in comparison with figure 2a that the amplification rates of the most unstable asymmetric mode is reduced and below zero after the optimization. The corresponding eigenvector is shown in figure 2d in comparison with figure 2c, from which we can find that the modes have been relocated from behind the tip corners to around the corner. And as shown in figure 2f and figure 2e, after the optimization, the flows are all symmetric and the sizes of the recirculation bubbles are either reduced greatly. In this study, an efficient optimization method based on stability analysis is developed for investigations on suppressing the modes responsible for unstable flow. The method consists of an optimizer, a dynamic updating surrogate model [4], a geometry parametrization method, a CFD solver, a stability analysis tool, an eigenmode tracking scheme and a mesh deformation module. This procedure is successfully applied to suppress the unfavourable modes in channel flows with geometry contraction. The optimised geometry, with rounded corners, is stable for critical Reynolds number that are 654% larger than for the original geometry.



(a) Original eigenvalue spectrum, (b) Optimized eigenvalue spectrum



(c) Original eigenvector, (d) Optimized eigenvector



(e) Original velocity contour, (f) Optimized velocity contour

Figure 2: *Comparison between original and optimized geometry configuration*

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STS 03A: Aeronautics Drag Reduction Technologies

Drag Reduction Technology Review

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Nowadays, there is an urgent need to decrease the environmental footprint of aircrafts, reducing noise generation levels and lowering gas noise emissions to the atmosphere. At the same time, the need for new, more energy-efficient configurations arises; the long term goal is flying longer distances carrying higher payloads at a reduced cost. In this scenario, Drag Reduction technologies may be one of the key aspects that will help aircraft industry to meet the energy-saving goals demanded by industry and society.
In this lecture, we review different technologies currently being applied to reduce drag. Ongoing efforts to understand the sources of skin friction, induced, interference, wave or turbulent drag are described. The knowledge thus gained can then be leveraged to lower drag, by means of either passive or active flow control strategies.

This endeavor relies both on the application of advanced measuring techniques and the efficient use of new computational algorithms on large computing facilities; the deeper insight into the flow physics gained through the use of this new tools is crucial to improve the efficiency of existing drag reduction strategies, and inspire novel flow control strategies. Indeed, recent advances in micro-electronic technology coupled to new optimization algorithms have enabled the fabrication of actuation systems and the conception of new aircraft configurations capable of manipulating, or even annihilating, some of the sources of drag, offering new opportunities to increase fuel efficiency of future aircrafts.

Literature review and experts consensus shows that the application of active control and the investigation of new configurations is considered of prime importance by industry, even though it is still at a very low Technology Readiness Level. Given the scale of the “Flightpath 2050” challenge, now is the appropriate time to investigate the potential of this technology and attempt to raise the TRL.

STS 03B: Aircraft Noise Reduction Technologies

Effects of Slat Parameters on Noise Characteristics of an Airfoil

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Key Words: Slat, Structure Parameter, Flow Features, LES, Flow-induced Noise.

Slat noise is largely dependent on its structure parameters such as geometric and morphing parameters. The investigation of the effects of these two types of parameters on the characteristics of flow field around an airfoil with slat and the induced noise can be an effective way to study and suppress the slat noise radiations. Three-element airfoil model 30P30N is employed to establish the model of investigation for analyzing the flow field and noise features.

Based on RANS and LES methods, steady and unsteady flow filed characteristics of the airfoil are studied for typical geometric (overlap, gap and rotation angle) and reshaped profiles (morphed trailing edge of slat seals the gap). The corresponding distribution of pressure and turbulent kinetic energy are obtained. FW-H acoustic analogy formulation is employed to solve the far-field noise radiation of the slat. The effects of various slat structure parameters on the far-field sound pressure level and its directivity characteristics are investigated. Finally, based upon the obtained characteristics of flow field and slat noise radiations, the interaction between slat noise suppression and corresponding lift change are analyzed and discussed. The results show that the variation of geometric and morphing parameters can effectively change the flow field mode around the slat and the airfoil. Choosing proper slat parameters, the far-field noise radiation can be reduced with little penalty for the lift performance of airfoil.

The current study demonstrates that it is a promising method for slat noise attenuation, through slat structure parameter adjustments and controls, which include slat setting and adaptive morphing parameter controls. These controls are dynamic and adaptive, which can be adjusted to different flight conditions. It can significantly weaken or even eliminate some of the slat noise sources while keeping the high aerodynamic performance of slat which is very important for normal functions of civil aircraft wings.

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STS 03B: Aircraft Noise Reduction Technologies

Challenges in Acoustic Liner Characterization, Optimization and Design

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Key Words: Acoustic liner, aero-engine, acoustic boundary layer, optimum impedance

Modern aero-engines with higher by-pass-ratios and lower fan speeds and sorter nacelles increases the demands for acoustic liners optimized for realistic operating conditions. Based mainly on the work within the IMAGE project the following topics will be discussed:

Models for liner impedance boundary conditions. There is experimental and theoretical research indicating that the commonly used impedance boundary condition is not sufficient to describe the physics including the effect of both flow and acoustic boundary layers. In addition there may be high acoustic excitation nonlinear effects.

Related to this experimental techniques used to measure the properties of flat liner samples will be discussed.

Liner impedances giving optimum damping for infinitely long uniform liner samples can be obtained using the theory developed by Cremer (1953) and Tester (1973) to include the effect of mean flow. Recent research at KTH has further developed this theory to remove the high frequency approximation inherent in the work by Tester. This will be compared to results using numerical simulations where optimization can be performed including reflections caused by the interface between hard and soft sections.

When an optimized liner impedance is obtained a model is needed to design a liner geometry which can give the optimum impedance. Such models will be discussed.

Finally, results from the IMAGE project will be presented as an example of this process.

STS 03B: Aircraft Noise Reduction Technologies

Recent Research in the Field of Aircraft Noise and Vibration Control

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Key words: aircraft, noise and vibration control

The increasing public demand for more safety and comfortable air transportation and seamless travel has pushed aviation industry to a new stage. It is foreseen that the aviation will keep grow, and will somehow increase the pace of social interactions in the future. Yet still, it also has brought a serious consideration on air vehicles reliability particularly for aircraft structural integrity under various loads and environmental factors, lifespan reliability and maintainability, etc. As well as the environmental impact particularly for the nuisance caused by noise in the airport surrounding and resident area that flight route covers, the acoustic quality and harshness inside cabin environment, etc. Both considerations in turn have motivated industry and research institutes giving more and more concerns and resources to breed innovative solutions.

From technical point of view, within the past decades, there have been numerous technical routines and particular solutions to address the need for safety and comfortable aviation, and many of them have been implemented in today's main aircraft in services. Beside the state of art, there are several other distinctive demands from wide body long-range aircraft and smaller sized aircraft/rotorcraft in general aviation, especially in conjunction with the considerations of weight reduction, fuel and space efficiency. This paper summarizes the recent research progress of aircraft acoustic and vibration control, especially those aims for future application in long-range wide body aircraft and general aviation. For instance, recent project in developing nacelle acoustic liner, engine vibration isolation, airfoil optimization for propeller noise reduction, self-adoptive vibration control and active noise control for cabin application.

Numerical Prediction of the Noise Reduction in a Tandem Cylinder Configuration Using DBD Plasma Actuators

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Keywords: Noise reduction, Aeroacoustics, Plasma actuation

With the exponentially growing popularity of air travel, some regions near airports are subject to high noise exposure. Aeroacoustic noise due to an aircraft landing gear is significantly high during the landing. Therefore, it is important to understand the mechanism of the landing gear noise and find innovative technologies to reduce noise levels. The mechanism of noise reduction was investigated computationally using pulse-modulated dielectric barrier discharge (DBD) plasma actuation on a tandem cylinder configuration; where two cylinders placed in stream-wise direction, which represent a simplified geometry of a landing gear. Two DBD plasma actuators has been used at top and bottom points of the front cylinder. The flow field was simulated solving the three-dimensional Navier-Stokes equations using IDDES method provided by the commercial CFD solver StarCCM+. The plasma eects were modeled according to the Suzen and Huang model [1] and also using a simple but satisfactory heuristic DBD plasma body-force model [2]. The Aeroacoustic predictions in the far field are conducted using FW-H method. Plasma flow on at 20kV shows slightly delayed flow separation from the first cylinder. A relevant noise reduction trend was predicted by the computations towards downwind direction.

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STS 04: New Aircraft Configurations

Overcoming Interference Wave Drag on Strut-Braced Wing for Future Civil Air Transport at Transonic Speeds

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There has been some renewed interest in the recent years on strut braced wing design for future transonic transport aircraft. This can leads to further reduction of the induced drag by taking advantage of high aspect ratio wing design. However, this design has to overcome the critical issue of the comparability effect at the wing strut junction at transonic cruise. Shock wave forms at the junction, which can lead to significant wave drag and can also trigger boundary layer separation, increasing the form drag. This paper presents a study of a flow control method to alleviate the shock wave at the strut wing junction.

First, the flow physics of strut braced wing in transonic airflow was analysed by computational simulation to predict the shock wave location and its impact on the wing. The Reynolds averaged Navier-Stokes equations are solved with the two-equation k-ε realizable turbulence model. An unstructured hybrid mesh was generated using POINTWISE meshing software. In order to ensure the mesh high-quality, a mesh independence study has been conducted. The simulation results showed that a strong shock wave forms at the junction between wing and strut. After the location of the shock wave is identified, fluidic vortex generators was implemented as a flow control method to alleviate the shock wave. The effectiveness of the fluidic vortex generator was assessed by another further RANS simulations. To obtain sufficiently accurate simulation results which can reflect the vortex developing flow, the meshes were further refined near the fluidic vortex generator area. The obtained simulation results showed that the shock strength can be significantly weakened with the application of the fluidic vortex generator, improving the aerodynamic efficiency of the strut braced wing.

STS 04: New Aircraft Configurations

Preliminary Design of Strut Braced Wing Aircraft and Aerodynamic Optimization on the Junction Geometry

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Keywords: Strut Braced Wing, Junction, Preliminary Design, Aerodynamic Optimization

Strut Braced Wing (SBW) aircraft configuration promises to gain high lift-to-drag ratio by reducing structural weight and lift-induced drag. This paper conducts a configuration optimization using an in-house preliminary design software, ACADO. The results show that the SBW aircrafts can supress wing deformation, and unload wing root bending moment or shear stress, which results to a smaller structural weight and enables a higher aspect ratio. The study shows that a SBW aircraft which shares the same payload of B777-200, can obtain a significant fuel consumption and maximum take-off weight reduction. Meanwhile, since the wing-strut junction region of the SBW aircrafts has the most significant influence on the interference drag, an aerodynamic optimization on the junction geometry of the PADRI platform (Platform for Aircraft Drag Reduction Innovation, 2017) is conducted to reduce shock wave strength and flow separation, a total 9.8 counts drag reduction is achieved.

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STS 04: New Aircraft Configurations

Low Drag and Sonic Boom Aerodynamic Layout Design Technique Study for a Supersonic Business Jet

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Keywords：Supersonic Business Jet, Sonic Boom Control, wide-speed domain optimization

Aiming at the aerodynamic layout design of the next generation civil aircraft, this paper starts from the aircraft mission positioning and demand analysis, and carries out the overall aerodynamic design technology research for a supersonic business jet. By using parameterization modelling method and grid automation, coupled with the traditional aerodynamic characteristics analysis and sonic boom numerical simulation analysis tools, the automatic optimization design process is built and the aircraft's wide-speed domain multi-objective collaborative aerodynamic design optimization is completed. The numerical analysis results show that the design result has good aerodynamic characteristics in wide-speed domain; at supersonic cruise condition, the peak value and shape of ground overpressure distribution are effectively controlled.

低阻低声爆超声速公务机气动布局设计技术研究

张文琦

中国航空研究院朝阳区小关东里 14 号，北京，中国摘要

针对下一代民机的气动外形设计，本文从平台使命定位与需求分析出发，针对一种超声速公务机，开展了总体气动设计技术研究工作，利用外形参数化建模与网格自动化方法，耦合传统气动特性分析与声爆数值模拟分析工具，完成了自动优化设计流程搭建及飞机气动外形宽速域多目标协同设计优化，数值分析结果表明：设计方案具有良好的宽速域气动特性；超声速巡航状态下，地面过压峰值和分布形态得到了有效控制。关键词：超声速公务机，声爆抑制，宽速域优化

STS 04: New Aircraft Configurations

Numerical Investigation of Shock Wave Propagation in Ducts with Grooves

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Keywords: Moving Shock Wave, Shock Diffraction, Shock Rejection, Pressure Waves

The pressure attenuation of moving shocks when they propagate in ducts is of great importance in a wide variety of applications, such as health, safety, and transportation. The objective of this research is to investigate the propagation of shock waves in ducts with roughness. The roughness is added in the form of grooves as in an existing experiment. Straight and branching ducts are considered in order to better understand the mechanisms causing attenuation of the shock and the physics behind the evolution of the complex wave patterns resulting from diffraction and rejection of the primary moving shock. A finite volume numerical method is used and further validated for several test cases relevant to this study. The computed results are compared with experimental measurements in ducts with grooves. Good agreement between high resolution simulations and experiment is obtained for the shock speeds and complex wave patterns created by the grooves. Time histories of pressure at various locations, and shock strengths are presented and compared with measurements. Different groove geometries have been tested in the numerical simulation in order to identify the shape that will better diminish shock strength. Animations of the computed results are shown to reveal salient features of the unsteady flow field.

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STS 05: New Aeronautical Materials

Joint R&D of Composite Materials for GREEN Aviation,
绿色航空复合材料技术的中欧联合研发

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关键词 KEYWORDS: 植物纤维 PLANT FIBERS, 松香基环氧 ROSIN-SOURCED EPOXIES, 绿色复合材料 GREEN COMPOSITES

今日航空工业中应用的碳纤维、玻璃纤维、以及树脂材料均来自化石资源，生物质资 源的纤维和树脂在航空工业还没有应用的先例。在中欧合作的框架下，一个名为 ECOCOMPASS 的项目为生物质材料潜在的航空应用掀开了序幕。本文将报告天然纤维材料用 作复合材料增强材料和芯材，生物质树脂用于替代传统的双酚 A 环氧树脂，以及这种绿 色复合材料在飞机次承力及内饰结构的考核验证进展等。与此同时，相应的防护技术也被 研究开发，以减低过程的环境影响，提高产品的阻燃性能，满足航空工业的安全要求等。建模仿真技术被用来优化材料的开发应用，"生命周期评价（LCA）"技术被引进来比较 绿色材料技术与现行传统材料技术的环境效应等。

Today, only man-made materials like carbon and glass fibres in conjunction with the fossil-sourced polymers are used to produce composite parts in aviation. Renewable materials like natural fibres or bio-sourced resin systems have not found their way into aviation, yet. In the China-EU cooperation framework, a joint project named ECO-COMPASS is going on aiming to evaluate the potential applications of the resource-friendly composite materials in the aviation. In the paper, natural fibres used for different types of reinforcements and sandwich cores, and the bio-based resins to substitute standard bisphenol-A based epoxies in secondary and interior structures will be presented and demonstrated. Adapted material protection technologies to reduce environmental influence and to improve fire resistance will be reported to fulfil the demanding safety requirements in aviation. Furthermore, modelling and simulation of chosen eco-composites aims for an optimized use of materials while a Life Cycle Assessment (LCA) aims to prove the ecological advantages compared to synthetic state-of-the-art materials.

Eco-composites in Aeronautical Structures. Possibilities and Challenges

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Key Words: Eco-composites, aeronautical structures, serial-parallel mixing theory, multiscale.

One of the main reasons that explain the exponential use of composite materials in aeronautical structures is their excellent ratio between mechanical performance and weight. However, if the environmental footprint of the structure is considered, a major drawback of composite laminates based on synthetic fibres is that they are very difficult to reuse once the structure reaches its life-span, and their disposal has a big environmental impact. In this scenario, composite materials made with natural fibres are an excellent alternative to conventional composites; and, although their mechanical properties are lower than those provided by synthetic fibres, many applications do not require of such high-end products, and they do require the weight reduction with a minimum environmental footprint.

Eco-compass project takes a wide look at the different eco-composites available for their use in aeronautical structures, with special attention to those composites that are suitable for secondary structures and interiors. The project evaluates the performance of different fibres, resins and cores; different composite configurations, from sandwich laminates to non-woven composites; and it also looks into several manufacturing processes. Material and composite evaluation is conducted with an intensive experimental campaign. The results obtained by the different tests conducted and the analysis made of those results will provide a comprehensive understanding of the available possibilities to use eco-composites in aeronautical structures.

The use of eco-composites in aeronautical structures requires improving the existing knowledge of these materials and their performance on their required applications, and also the development of numerical tools capable of predicting accurately their behaviour. Eco-compass project will use two different strategies to address this challenge. One is the use of a phenomenological homogenization, the serial parallel mixing theory [1]. This formulation will be used to characterize non-woven eco-composites, as it allows considering the existing dispersion and randomness in the fibre direction of the material, with an affordable computational cost. The second strategy used will be a numerical homogenization, based on a multiscale strategy [2]. This approach will be used to analyse sandwich structures, as it allows a defining a very detailed model of the composite micro-structure in order to account for the different component interactions.

The results obtained so far in Eco-Compass project show a promising future for eco-composites in the aeronautical field. The material performance obtained from the experimental campaign shows that these materials are suitable for their use in secondary structures and interiors of aerostructures; and the numerical analyses conducted have shown that the developed tools provide a good characterization of the material mechanical response.

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STS 05: New Aeronautical Materials

Mechanical Properties and Effect of Residual Stress in Titanium Alloy Built by Laser Additive Manufacturing Process

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Key Words: Laser additive manufacturing, Titanium alloy, Laser forming repair, Residual stress, Mechanical properties

Additive manufactured process can efficiently reduce the machining time and the cost of material of aircraft structures, yet the scattered property data limits its application in aerospace industry. This paper presents the static and fatigue mechanical properties of titanium alloy built by Selective Laser manufacturing (SLM) in three status: as-built, machined and Hot Isostatic Pressing. The corresponding damage evolution law and failure models can be obtained in this study. Residual stress induced by process was measured by neutron diffraction and X ratio methods. In addition, the static strength, detailed fatigue rating and crack growth rate were discussed with respect of process parameters; the static and fatigue properties of short beam fabricated by laser forming repair were also investigated by four-point bending test. Key conclusions are received: a) HIP and machining processes can produce the compressive residual stress, which improve the static and fatigue properties of SLM titanium material, and lower its crack growth speed; the specimens with laser forming repair process will have the similar properties to the forged ones.

Structural Optimization of a Variable Camber Leading Edge

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Key Words: Variable camber wing, Morphing, Leading edge, Optimization, NSGA-Ⅱ.

To meet the demands of aerodynamic efficiency in various flight conditions, traditional aircraft achieve the goal by deflecting the high lifting systems such as leading edge and trailing edge. However, with a stiff skin and internal skeleton this kind of structural configuration maintains a fixed shape even though the reduction of necessary lift caused by the fuel weight decline during cruise, which will lead to a still high level of drag. Morphing leading edge and trailing edge can adjust their contour shape to adapt to different tasks (cruise, taking-off, landing, etc.) and conditions (Mach number, height, etc.) and accomplish the aim of aerodynamic shape real-time optimization. In addition, the gapless and smooth surface of wings can debase the acoustic noise induced by friction between the tips of structure and the air, which can effectively improve the comfort of civil aircraft.

This paper illustrates a methodology for the structural optimization of a variable camber leading edge focusing on large-scale aircraft. Refer to a glass fibre reinforced composite skin, an optimal structure design method based on NAGA-Ⅱ is proposed to tackle the collaborative optimization issue involving diverse variables of the composite lay-ups, the position of joints and the size of actuator force. Results show that the method developed in this article can cope with the conflict between high bearing capacity and morphing accuracy and satisfy the need of engineering application.

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An Integrated Approach Aimed at Developing Innovative Products for Icing

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The design of many decision support systems has contributed to in-flight icing issues such as automation bias and trust miscalibration. The present lecture wants to examine whether these difficulties can be overcome by providing continually update information regarding the cloud system by means of nowcasting tools and remote sensors systems before the aircraft penetration. Improvements of the icing technologies such as in-situ ice detection systems and passive/active ice protection with low power consumption could be as much more efficient for aircraft icing safety related as much a continuous monitoring on icing contamination in terms of aerodynamic degradation will be possible. A status on CIRA nowcasting tool will be provided together with emerging technologies developed for aircraft ice protection with the goal to foreseen how the envelope of protection and avoidance capabilities of an aircraft in critical icing condition can potentially be improved.

Five areas will be tackled:

- Ice Detection & Protection: An overview of intelligent materials, smart structures, smart sensors and dedicated systems integration will be presented oriented to an easy detection and smart detection of ice formation.

- Ice Avoidance: An overview of potential integrated systems avoiding ice formation/accretion beyond admissible limits will be presented. The systems will be also oriented to optimize weight allocation, preserving aerodynamics performances and energy consumption. Moreover, safety requirements should be respected in accordance to current regulation (EASA/FAA, e.g. new specific issues will be highlighted).

- Ice Monitoring: Environmental perception and situational understanding of ice phenomena will be highlighted. Integrated systems oriented to a constant monitoring of the ice conditions in each critical part of the aircraft will be presented.

• Ice Forecast: Intelligent icing meteorological sounding alarm technologies will be analyzed in order to dispose of powerful instruments to predict ice formation and safe navigation in all weather conditions.

The core of the lecture then will be the analysis of an integrated approach aimed at developing innovative products, mainly oriented to ice monitoring and forecasting of icing. The approach/technologies will be based on:

- Different and integrated satellite products
- On board local data
- Available Experimental Ice phenomena knowledge/database.

Application of Structural Health Monitoring Technology in Aircraft Structure Ground Test

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Key Words: Structural health monitoring, Aircraft structure ground test.

Structural health monitoring (SHM) technology has experienced rapid development since the emergence of its concept, however, in the applications of aviation engineering it faces the bottleneck. The work about the recent progress on application of SHM in aircraft structure ground test in Aircraft Strength Research Institute of China (ASRI), which is to solve the above problems, is introduced in this paper. Based on the need of SHM in aircraft structure ground test, the strategy and status of SHM in ASRI is presented. For some problems in application of SHM in aircraft structure ground test, the researches in ASRI is presented. The problems that need to be solved are also discussed.

Probabilistic Data Mining for Aircraft Structural Health Monitoring

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Key Words: Probabilistic data mining, Structural health monitoring, Probabilistic damage diagnosis, Guided wave.

Structural health monitoring for aircraft structures has gradually turned from fundamental research to practical implementations. However, numerous uncertainties arise from practical engineering such as time-varying loads and boundary conditions may have great effects on structural health monitoring signals, which make it difficult for reliable evaluation of structural damages. To deal with these uncertainties, probabilistic data mining methods are attracting more and more attention and gradually applied to aircraft structural health monitoring. Probabilistic data mining methods quantify effects of the uncertainties and the damage with probabilistic models, and perform reliable damage evaluation with diagnosis method. This paper aims at discussing probabilistic data mining methods in aircraft structural health monitoring, as well as their applications to aircraft structures in practical engineering taking advantages of the guided wave based structural health monitoring.

STS 07 – PADRI: a Platform for Aircraft Drag Reduction Innovation

Chair: Daniel Redondo and Jacques Périaux

Organizers: Gabriel Bugeda (CIMNE), Jacques Periaux (CIMNE) , Jordi Pons-Prats (CIMNE) and Daniel Redondo (AIRBUS)

Session Abstract

Keywords: Hybrid laminar flow, flow control, vibration control, transonic aircraft

The main objectives of this STS is to invite lecturers who numerically contributed to the ECCOMAS Thematic Airbus Workshop last November 29-30, 2017 at CIMNE/UPC Barcelona. The contributors applied computational flow control technologies and optimization strategies to minimize shock wave and interference drag of a strut-wing junction region at cruise conditions.
A test case was proposed by Airbus- Spain with a baseline for computation that reproduces, even at low velocity, a typical shock wave pattern in the region of the strut-wing junction of an aircraft.
In order to simplify the problem, some constraints were set up, so that the geometrical modifications should be confined to a defined small region around the strut-wing junction, and the objective function was clearly explained in order to allow the comparison of computational data results among all the technology solutions proposed by participants.
A platform allowed all participants to compare on outputs and formats selected by AIRBUS their respective data results installed on a Database with respect to the reference (baseline) and to show the benefit of the chosen flow control technologies.
The Workshop intended to contribute to fill the gap between the different technology models and their application.
The format of PADRI STS consisted of 30 mns plenary lectures and presentations and analysis of numerical results achieved by contributors to the strut-wing Airbus test case Workshop with flow control and optimization for reducing drag interference. A second round PADRI2 early 2019 for improving achieved contributions with another baseline will be announced by AIRBUS during the STS.

STS 07: Platform for Aircraft Drag Reduction Innovation PADRI

Definition and Computation of a Strut-Wing Configuration

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There are many active flow control technologies whose objective is to mitigate adverse effects of the flow (turbulence, flow detachment, noise…). The strut wing concept is a platform to explore application of active flow control technologies for shock wave control at high speeds.

The strut wing test case is based on an unformatted geometry of an aircraft for 182 pax and 3000 NM with upper wing, supported by a strut. The aircraft geometry was simplified in order to remove any component with limited interaction with the problem of interest, or when they generate an unneeded complexity.

The main focus was put on the region of the strut-wing junction in cruise conditions, analyzing the shock wave and the interference drag in this particular region.

The definition of the best flow control device, which helps to diminish the shock and the drag, was the main objective and should be demonstrated through the analysis of the simulation results and the comparison with the reference test case. Computational data obtained by all the participants were presented and compared in order to assess the potential of the different technologies.

Results of the PADRI workshop in 2017, indicate that existing flow control technologies are not capable of completely remove a strong shock wave, but however, they can be applied to influence weaker shock waves in an optimized geometry which is flying off design point; which will be the objective of a second round which will be named PADRI2.

Drag Reduction in a Wing-Strut Junction: Comparison between RANS and Hybrid RANS-LES Simulations

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Key Words: RANS, Hybrid RANS-LES, Shock Wave-Boundary Layer Interaction

We performed a RANS and hybrid RANS-LES simulations of the proposed configuration. Results show a strong shock wave confined by upper and lower surfaces of strut and wing between 14,5 < y < 17,5. This shock wave trigger boundary layer separation in the upper surface of strut (14,5 < y < 17,5), a strong separation in the lower surface of wing (16,3 < y < 16,6) and the wave drag function > 1,1 (13 < y < 16,8). Based on these findings we purposed passive and active flow control to reduce wave drag. We estimate a Drag reduction of 3% and 5% considering the installation of passive and passive plus active flow control respectively. In a local model we analyzed the benefits and drawbacks of using a hybrid RANS-LES approach in problems involving shock wave-boundary layer interaction.

Passive Flow Control Devices for Wave Drag Mitigation on Strut Braced Wings

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Key Words: CFD, Shock Control Bump, Kuchemann Carrot, Passive Flow Control, Drag Reduction.

This study has the objective to analyze passive flow control technologies that can reduce the shock wave intensity and thus the interference drag in the strut-wing junction, in transonic flight. Two possible flow control devices were investigated by means of CFD, Kuchemann Carrot (KC) and shock control bumps (SCB). Also, a combination of these two configurations was studied.

When compared to the baseline, both KC and SCB were able to reduce the total drag but with complementary effects. In order to investigate further the benefits of both passive flow control devices by combining them, several configurations have been analyzed.

STS 07: Platform for Aircraft Drag Reduction Innovation PADRI

Application of a Knowledge-Based Design Method and Passive Porosity for Drag Reduction on a Generic Strut-Braced Wing

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Two passive approaches have been applied to the outboard juncture region of a generic strut-braced wing (SBW) with the goal of reducing the drag associated with the channel flow in this region. The first approach was using the CDISC design method, which is a knowledge-based design method that changes the geometry of an aerodynamic surface based on various flow and geometry constraints to improve the flow characteristics. This method was applied to the wing lower surface design region as well as the horizontal and vertical parts of the strut that fall within the design region defined by the workshop. Results indicate that drag reduction was achieved by reducing or eliminating the shocks in the design region, along with the associated flow separation. The second approach utilized the porous boundary condition option in the USM3D flow solver to define a series of porous patches on the wing lower surface. The effect of these patches, individually and in combination, was investigated parametrically. For many of the cases, the shocks in the design region were significantly reduced or eliminated; however, the transpiration through the porous surface causes the boundary layer to separate, thus increasing the profile drag on the wing and negating the reduction in wave drag.

STS 07: Platform for Aircraft Drag Reduction Innovation PADRI

Strut-braced Wing Compressibility Drag Improvements Using SU2

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** Professor

This presentation discusses our efforts to minimize the compressibility drag of the PADRI configuration using combinations of shape changes and flow control within the context of the SU2 analysis and optimization framework. The performance of the baseline configuration provided by the workshop organizers is assessed and the potential for improvements is discussed, including the allowable shape modifications, the transpiration boundary condition approach used to mimic flow suction/blowing through a perforated surface, and the shape deformation and optimization approaches used. The presence of the shock surface between the lower wing and the upper strut surfaces is largely caused by the convergent-divergent nature of the passages close to the junction and is largely dictated by inviscid considerations (after taking into account the displacement effects of the boundary layer). For this reason, we perform a series of inviscid and viscous / RANS optimizations to achieve the best possible results. Flow control, in the form of transpiration boundary conditions that can be imposed on specific portions of the surfaces can lead to effective shape changes / virtual thinning of the wing and struct surfaces and result in further reductions in shock strengths and compressibility drag. All analysis and optimizations are carried out using the finite volume RANS solver in the SU2 framework and the free-form deformation boxes and mesh deformation routines included with the software.

STS 08 – Hybrid Laminar Flow, Flow and Vibration Control in the EU-Project AFLoNext

Chair: Dietrich Knoerzer

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Session Abstract

Keywords: Hybrid laminar flow, flow control, vibration control, transonic aircraft

Hybrid laminar flow technology, that means the combination of natural laminar flow with flow control, represents the most promising way of reducing the friction drag of transonic aircraft and by this fuel reduction. Smart flow control can further achieve noise and vibration reduction and by this contribute enhancing environmental impact and even safety.

The large European project AFLoNext assessed the engineering feasibility of the hybrid laminar flow control (HLFC) technology for drag reduction by flight tests with an installation in the aircraft fin of an Airbus A320 and by a wing installation concept through means of large scale wind tunnel testing. The project demonstrated the engineering feasibility for vibrations mitigation technologies for reduced aircraft weight and noise mitigation technologies.

To improve aircraft performance along the whole flight regime, locally applied active flow control technologies on wing and wing/pylon junction were qualified in wind tunnels or by means of lab-type demonstrators.

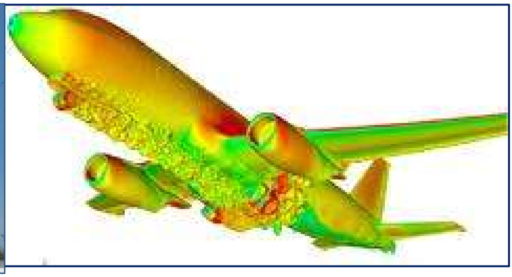
The greening of the air transport through the technologies investigated in the AFLoNext project includes:

- More eco-efficient aircraft design,
- Lower environmental footprint (noise and pollution),
- Improved aerodynamic efficiency,
- Improved aircraft performance and safety,
- Optimised manufacturing.

The papers of this STS will present key achievements on different numerical and experimental aspects of hybrid laminar flow, vibration and flow control

contributing to enhance aircraft performance and to reduce the environmental impact of future airliners.

AFLoNext flight test with HLFC installation on the fin of Airbus A320 (Courtesy: DLR)



RANS-LES CFD simulation obtained for Nose Landing Gear in Take-off condition (Courtesy: FOI)

Hybrid Laminar Flow Control (HLFC) – Flight Test (FT): Preparation, testing & first results

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Key Words: *Hybrid-Laminar-Flow Control, Flight Test*

In the current context of air traffic worldwide, aerodynamic efficiency is of key concern. AFLoNext "Active Flow Loads & Noise control on next generation wing" [1] is a five-year collaborative research project, started in 2013 and was funded by the European Union's 7th Research Framework Programme FP7 (2007-2013) under the grant agreement n°604013, with the objective of proving and maturing highly promising flow control technologies for novel aircraft configurations.

The AFLoNext concept is based in six Technology Streams (TS), which cluster the targeted technologies and their associated contributions to advanced aircraft performance as follows:

- **TS1 Hybrid-Laminar-Flow-Control on wing and fin**
- TS2 Active Flow Control on outer wing
- TS3 Active Flow Control on wing/pylon
- TS4 Active Flow Control on wing trailing edges
- TS5 Noise reduction on flap and undercarriage
- TS6 Vibration mitigation / control in undercarriage area

Bringing TS1 into focus in view of this paper, AFLoNext aimed to prove the engineering feasibility of the HLFC technology for drag reduction on vertical tail plan (VTP) in flight test on the DLR A320 ATRA (Advanced Technology Research Aircraft). Within TS1 (Hybrid-Laminar-Flow-Technology) the advanced simplified suction system has been flight tested the first time in Europe with the objectives of proving system functionality, of gaining first operational experiences and of validating and verifying the applied design tools and processes. The conceptual idea of the simplified HLFC-system was proposed by Prof. K.-H. Horstmann within the European project ALTTA [2] and its functionality has been successfully demonstrated in a large scale wind tunnel test at flight Reynolds numbers with the German national project HIGHER-LE, funded by the German Federal Ministry for Economics and Technology BMWi within the National Aeronautics Research Programme LuFo IV, 2nd Call.

With the success of the flight tested system a large brick towards Technology Readiness Level 4 of this technology is available and provides the base for further technology improvements within European research and industrial technology development programmes.

Hybrid-Laminar-Flow-Control (HLFC) is one of the key technologies for significant reduction of fuel burn (up to 9% fuel savings for long range aircraft) and emissions. The basic idea behind hybrid-laminar-flow-control is to apply a very small amount of boundary layer suction through a micro-perforated skin to stabilize the laminar boundary layer. The surface region of applied suction is followed by a region which further stabilizes the boundary layer by a tailored shape of the surface. Both measures combined shift the extension of the laminar boundary layer, and hence the region of low friction drag, significantly downstream until transition from a laminar into a turbulent boundary layer generating higher skin friction drag occurs. Within AFLoNext an innovative HLFC-system has been designed, manufactured and qualified for flight test in a research team of 12 European partners from industry, research, academia and SMEs:

Figure 1: *Consortium for the HLFC-VTP research within the AFLoNext Project*

The simplified HLFC-system has been installed on the DLR A320 flight test aircraft ATRA on the middle segment of the VTP (see Figure **2**). Suction power is generated by either a passive or an active system, consisting of an actuator adjusted flap or a four-stage compressor respectively. Infrared cameras, installed in the horizontal tail plan, allow the detection of transition locations, pressure distributions are recorded at two cross sections of the fin, hot-film arrays are used to monitor the boundary layer status of the attachment line and the highly instrumented HLFC-leading edge allows a clear verification of the functionality. Advanced inflight data processing technologies enable highly efficient flight testing.

Flight tests have been conducted in the northern Germany in the time between April and May 2018. Inflight data monitoring evidently showed proper functionality of the HLFC-leading edge.

Figure 2: *DLR Airbus A320 ATRA Flight Test Aircraft prepared for AFLoNext flight test campaign*

The following figure exemplary shows an Infra-red image taken, outlining the laminar extension of the boundary layer. The leading edge itself is not visible in the image. Transition is here delayed to x/c~43%:

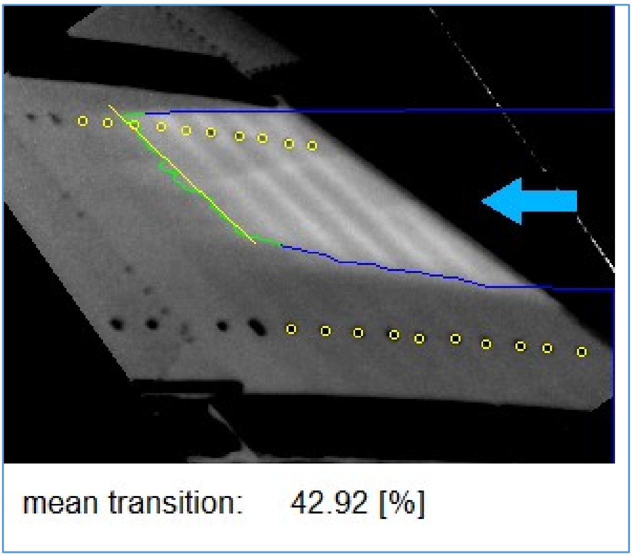

Figure 3: *Exemplary infra-red image at the right side of the VTP for almost symmetrical flow conditions (Ma=0.8, FL350, side slip angle = -0.15°).*

The presentation will give a detailed view of the HLFC-design, the systems installed in the aircraft for flight testing and exemplary some very first results.

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AFLoNext: A Holistic Approach to Greener Aircraft

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Key Words: Laminarity, Flow Control, Passive Noise Control

This presentation shows the scope of AFLoNext as a technology demonstrator vehicle. Greener aircraft concept is supported by many different technologies which are requested to reach a high maturity level before being allowed to be installed in a serial aircraft. AFLoNext project has studied and matured flow control technologies for laminarity, active flow control, passive noise control and vibration mitigation & control up to high maturity levels (Technology Readiness Level (TRL) 4 – 5).

All these technologies have experienced a huge maturity leap forward, with the clear objective of the handover of the most promising technologies to a fully integrated large scale demonstrator for reaching TRL 6 and higher and to be implemented in the serial production of products in the next decade.

CFD Based Design and Full Scale Verification of Transport Aircraft Flow Separation Control within the AFLoNext Project

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Key Words: Flow Separation Control, CFD Methods, Cruise Drag Reduction

Active flow separation control research over the past 20 years has revealed a strong potential to improve the aerodynamic behaviour of aircraft. In contrast to passive devices, the controllability and the use only on demand suggests performance benefits due to the ability to adjust the aerodynamics to the flight condition. Nevertheless, active flow separation control lacks application in civil transport aircraft, mainly due to the maturity of underlying systems and the risks associated with failure and availability of the active flow control system.

Within the EC funded research project AFLoNext, active flow separation control has been further matured especially to address flow separations in areas where passive means are not appropriate. Specifically, two areas on the wing of transport aircraft have been addressed. First, the integration of large diameter engines for the reduction of fuel consumption and noise detrimentally disturb the leading edge flow by the need to a larger interruption of the leading edge high-lift device. Second, the uprising new designs of wing tips for cruise drag reduction incorporate curved leading edges making it impossible to install classical leading edge devices. While the project aims to mature the active flow separation control technology on a real scale aircraft level and to answer questions related to the reliability of such systems under harsh environmental conditions, the design and validity of the application have been analyzed by detailed numerical studies applying CFD methodology.

The activity of multiple partners with different numerical methods also benchmarks the current CFD technology regarding the predictive capabilities for the simulation of active flow separation control.

The contribution will give an overview on the design and validation of the numerical CFD methods performed within the AFLoNext project, which last but not least culminated in a large demonstration wind tunnel test of real scale active flow control under real aircraft flight conditions, thus achieving a maturity level TRL 4 at the end of the just finalized project.

STS 08 – Hybrid Laminar Flow, Flow and Vibration Control in the EU-Project AFLoNext

Computational Analysis of Aerodynamic Vibration and Control on Main Landing Gear Doors of A320 Aircraft

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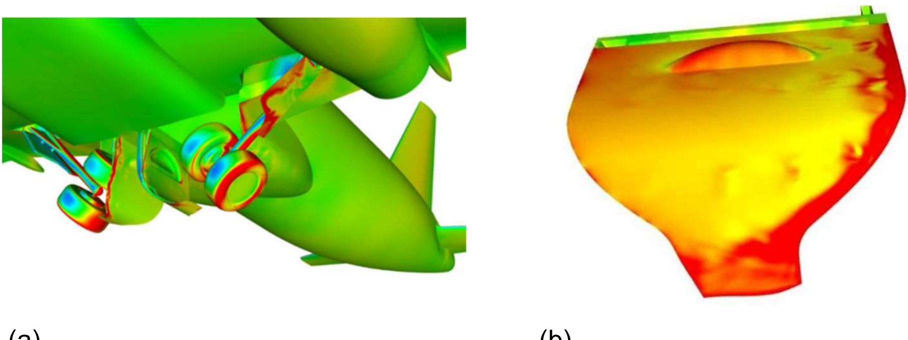
Greener next-generation aircraft rests on the development of technologies enabling improved aircraft performance in terms of aerodynamic efficiency enhancement, noise and loads reduction, as well as of vibration mitigation in areas with complex unsteady flow interaction. Over the recent decade, much effort has been dedicated to all these and other related technical investigations. One of the remarkable collaborative effort in Europe is the EU FP7 large-scale integrated project, AFLoNext (2013 - 2018, Active Flow-, Loads- and Noise Control on Next Generation Wing. Web-site: www.aflonext.eu), targeting on these aforementioned technical aspects for a synthesis and driving further towards the most promising and matured industrial solutions for more eco-efficient aircraft designs. The project has involved 40 partners, coordinated by AIRBUS, consisting of six technical work packages (WPs). One of the WPs targets on technologies of mitigating vibration in the undercarriage area of aircraft, where extensive unsteady vortex motions are present during the deployment of landing-gear systems under take-off and landing conditions. The LG systems are configured with structural components in complex layouts, including LG wheels, trunks, struts, housing-bay walls and LG doors. These components generate massive vortex motions interacting with each other and, consequently, inducing significant dynamic loads and causing structural vibration associated closely with unsteady surface pressure fluctuations.



(a) (b)

Figure: *Illustration of resolved instantaneous surface pressure. (a) On the undercarriage surface; (b) Outer surface of MLG door (incoming flow from right to left). Note that areas colored with “red” correspond to large values of – Cp.*

This work reports a part of viable computational investigation in the AFLoNext project on the aerodynamic vibration of aircraft undercarriage systems, which has been exploited in the design of control devices for vibration mitigation that have been examined further in flight test. The A320 aircraft Main Landing Gear (MLG) doors, exposed to intensive vortex motions in the Nose Landing Gear (NLG) wake, was taken in the analysis, using CFD (Computational Fluid Dynamics) and CSM (Computational Structural Mechanics) techniques, to explore aerodynamic excitations. To supress the excitation levels and, consequently, mitigating related structural vibration modes, computational simulations were further conducted in the design and evaluation of relevant aerodynamic flow/vibration control devices. In the numerical simulations, hybrid RANS-LES modelling was adopted to predict unsteady aerodynamic loads on the MLG door (MLGD) surface, induced by resolved upcoming large-scale vortex motions. In conjunction with finite element analysis of structural responses, the results have shown that fairly large deformation of the MLGD structure is predominantly caused by aerodynamic flow excitations, which interact with the first structural mode at a relative low frequency. The deployed control device supports a mitigation of the structural deformation. Comprehensive details will be reported in the presentation of the computational results and analysis.

Europe-China Platform

EU-China Workshop on Aviation, Air Traffic Management, Safety and Security

Univ. of Glasgow, 12th June 2018

The EU-China Workshop is hosted by the Division of Aerospace Sciences of the University of Glasgow and organised by the EU-China cooperation platform of the international research network ICARe of Horizon 2020.

This event profits from the experienced EU-China cooperation in aeronautics, especially from the joint expert group on ATM research, which was established in the network on greening technologies GRAIN2.

By presentations from both sides and expert discussions, this workshop shall contribute to identifying areas of coordinated research for future joint research initiatives. It addresses research themes in four key areas that need to be tackled.

On the following pages the abstract of the papers given at the Workshop can be found sorted by the workshop sessions that follow the list of aeronautics topics of mutual interest.

In-flight Icing Safety Research: From Clean to Iced Airfoil

从冰形到气动外形的飞行安全评估研究

Dongyu Zhu 朱东宇

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Keywords: flight safety, aircraft icing, icing wind tunnel test, simulation, 3D scanning

Icing has been widely recognized as a big threat to the flight safety and performance of aircraft, even small amounts of ice accretion can lead to dramatically aerodynamic degradation. Reducing dangers to aircraft flying in icing conditions was recommended as the most wanted list of transportation safety improvements, and icing is also an important part in certification. Ice can occur on leading edge of airfoil, reshape the aerodynamic profile and negatively affect the flight performance, leading to a loss of performance or even an accident. Aiming to more accurate evaluation of in-flight icing safety, a systematic method should be developed, from clean to iced aerodynamic profile. Discussions were made on numerical icing simulation, icing wind tunnel cloud generation, ice shape measurement and iced aerodynamics, the current state and progressing were outlined. This paper developed a method which can evaluate icing effect from a clean to iced airfoil, and provided a more accurate iced aerodynamic test method, which can enhance flight safety in icing conditions

中国航空工业气动力研究院 中国航空工业气动力研究院 中国航空工业气动力研究院 中国航空工业气动力研究院 中国航空工业气动力研究院 皇姑区阳山路 皇姑区阳山路 1 号，沈阳中国 号，沈阳中国 号，沈阳中国

关键词：飞行安全，飞机结冰，冰风洞试验，三维扫描

结冰是飞行安全的主要威胁之一，即使是很小量的结冰也可能导致飞机性能的严重损失，被列为美国交通运输部 2010 年急需解决的问题之一。结冰的主要危害是在翼面前缘结冰，改变飞机气动外形，进而是气动特性恶化，轻则影响飞机性能，重则导致事故。为了更精确评估结冰带来的安全危害，需要建立从冰形到气动外形的系统性评估方法。本文针对基于 CFD 的冰形计算方法、冰风洞云雾模拟方法、结冰外形获取方法、结冰前后气动特性分析方法等进行讨论，分析了各方法的技术现状及发展趋势，提出了从结冰外形到气动外形的翼型结冰及其气动特性影响研究方法，旨在通过研究建立更精确的结冰影响评估方法，为结冰飞行安全提供保障。

EU-China Workshop – Session 1: Aviation Safety and Security

Ensuring safe and secure aviation - ACARE Strategic Agenda

Sylvie Grand-Perret, Ovidiu Dumitrache

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ACARE , the Aviation Council for Research and Innovation in Europe, has developed in 2017 an update of its Strategic R&I Agenda. This agenda supporting the Flight path 2050 vision drives R&I actions along the five key aviation challenges: 1) Meeting societal needs, 2)Maintaining and extending industrial leadership, 3) Protecting the environment and the energy supply, 4) Ensuring safety and security, 5) Prioritising research, testing capability and education. Whilst aviation is recognised as the safest mode of transport, the lecture will drive you in the safety and security challenge, addressing in particular the emerging risks to aviation and ACARE plan to address them.

Research on Safety Analysis Technology of Enhanced Vision System Based on Probabilistic Model Checking

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Nowadays, a limited range of vision of pilots is a major factor attributing to severe flight accident.

A study suggests that about 75% accidents during approach and landing phases happened due to pilots' conducting uncorrectable precision approach. 85% accidents are led by pilots' loss of situational awareness. All the accidents shared the same reason that pilots flied with a lower visibility. To solve the problem, enhanced vision system (EVS) was invented in response to the development of advanced technology. EVS enhanced the stability of precision approach and flight path, strengthened safety of aviation flight and lowered work load of pilots. However, too much reliance on EVS leads pilots ignoring other systems on situation awareness. Thus, EVS failure to meet performance requirements will have an adverse effect on flight safety. To avoid this, a target for proving the safety and reliance of EVS is set during safety analysis from the beginning of system design to the end of aircraft life span. Collecting necessary data through avionics full-duplex switched Ethernet (AFDX) and the increasing complexity make EVS too difficult to meet the requirements of the system safety assessment by using traditional methods Therefore, formal analysis based on probabilistic model checking is presented to analyze the safety of EVS in this paper to identify the system requirements and design specification so as to further build the nominal system model. EVS captures the infrared scene information of the aircraft through the detector module and transmits that to the non-uniformity correction module where flight data are received through AFDX, approach phase is judged and non-uniformity correction is conducted. After the correction, the data will be transmitted to image processing module where the image is processed and video format is conversed. Monitoring software located on the interface control module will then compare the image through non-uniformity correction with the image through processing. If the data are consistent, the video images will be output through A818. Results show that this safety analysis method based on the probabilistic model checking can simplify EVS and improve the efficiency of system quantitative safety analysis. And the analysis results can be further incorporated into the display system to support its safety assessment process.

EU-China Workshop – Session 1: Aviation Safety and Security

Cyber security of existing and future ATM networks

Christopher Johnson

University of Glasgow, UK

In this talk I will illustrate recent attacks on national critical infrastructures and then explain the implications for ATM as we move towards new concepts of operation. Key issues include supply chain vulnerabilities and the increasing use of Commercial off the shelf (COTS) components. I will outline some potential solutions and stress the need to enhance international resilience as we cannot eliminate the possibility of successful attacks from a growing range of threat actors.

Chris Johnson is Professor and head of computing at Glasgow University. He has held fellowships from NASA and the US Air Force. He has been one of ten scientific advisors to the SESAR programme for almost a decade. He also runs the cyber security and forensic labs for the U.K. civil nuclear industry

Low Orbit Constellation Aeronautical Safety Surveillance System and the Application Prospect

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Key Words: Ubiquitous network perception, Safety surveillance, Satellite borne ADS-B, Global flight tracking.

Based on "ubiquitous network perception", the concept of "integrated grid surveillance" was proposed to construct a global covered low orbit constellation PNTRC network, which focused on the problem of real time continuous safety surveillance of Transportation Aviation. The satellite borne ADS-B diversity reception, satellite borne GNSS receiving and orbit determination, intersatellite link number transmission and satellite and ground link number transmission were used perceive any flight plane around the world, that making it a user node in the space-earth integration network. Therefore, location information of multi users is perceived in real time to form the trajectory of aircraft safety surveillance and airspace situation. The key technologies included the integrated design technology of satellite to ground integrated surveillance network, concurrent aviation surveillance information, high-speed data transmission technology, large capacity satellite borne ADS-B surveillance information concurrent reception technology and the verification would be based on air ADSB signal detection and surveillance information intersatellite transmission. In the nearly future, the wide area aviation surveillance application based on this system will fully support the construction and operation of the global flight tracking system, which would significantly improve the technology level of the international civil aviation safety surveillance, and form the international aviation standard.

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EU-China Workshop – Session 2: Air Traffic Management

The Future of Multiple Remote Tower Operations Cost-Efficiency, Capacity and Safety Regulations

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Keywords: Air Traffic Management, Cost Efficiency, Multiple Remote Tower Operations, Safety Assessment

The innovative technology of remote tower will allow air traffic services (ATS) be delivered remotely without direct observation from a local tower. Based on the concept of remote tower operations, multiple remote tower operations (MRTO) offer further solutions for cost efficiency and safety of air traffic services for small and medium size of airports. The advanced technology will allow one air traffic controller (ATCO) control two or more airports at the same time during low traffic volumes. ATCO's use Out the Window visualisation (OTW) supported by radar data processing (RDP), electronic flight strips (EFS) and a communications network to provide air traffic services. The feasibility of controlling two airports in parallel was demonstrated successfully with a special focus on the visual attention of ATCOs and the controller working position design (CWP) related to ATS task by Cranfield University and Irish Aviation Authority and won the award of European Commission entitled the 2017 Single European Sky Award of "Performance - Cost Efficiency: Multiple Tower Operations by Single ATCO". The research objectives are (1) to develop applicable regulations of certifications; (2) to validate the capacity and safety of air movement and surface movement controls; (3) to maximize the cost-efficiency and safety of multiple remote tower operations. China is a huge country and lots of airports which are under modernization. The innovative concept of multiple remote tower operations can maximize the cost savings recognized through the implementation of Remote Tower services. The anticipated impacts from this project will significantly improve the quantitative and qualitative of air traffic services to the isolated regions where are most located at remote areas of China. The research of multiple remote tower operations will benefit not only to China, but also to all European countries by facilitating the transportation of people, goods, medical care and services to the isolated territories to improve capacity of air traffic management, cost-efficiency and aviation safety by advanced technology.

EU-China Workshop Session 2: Air Traffic Management

Greener Air Traffic Operation Architecture Development Based on MBSE Methods

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Keywords： Model-based system engineering, 4-D trajectory, Air traffic management, Greener aviation

Greener air traffic operation system is a multi-agent, multi-service and multi-node complex system involving various areas such as engineering, economy and policy. System of Systems (SoS) engineering methods are required to analyze the system. Traditional system engineering approach based on documents suffers from shortcomings like vagueness and ambiguity in textual description, thus this paper utilizes model-based system engineering (MBSE) architecture development process to develop greener air traffic operation system architecture. A whole 4DT-based flight path is recognized as typical operation scenario. The stakeholders and the information exchange among them in the scenario are identified. Models such as high-level operation concepts, sequence diagrams and state machine diagrams are built in proper order, and simulation tools are used to conduct graphic and visualized simulation & verification of operation scenario based on the models. The development process finally leads to explicit, unambiguous and structural system requirement list, clarifying the ATM system requirements to support the operational concepts of greener aviation, and guiding the future system development process.

Model and Dependability Driven Avionics Systems Design

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Key Words: Avionics, Model-based system Engineering, Dependability.

The rapid evolution of avionics system is spurring the change of its development mode, and the model-based system engineering (MBSE) has become the key to improve the avionics system engineering and embedded software engineering. This paper will introduce the technique framework of model and dependability driven avionics systems design, including the model-based avionics system and software development process, model-based avionics system dependability analysis and the consideration for MBSE supporting tools chain. Based on this introduction, the key technology involved in Model and Dependability Driven Avionics Systems Design, such as model-based dependability analysis, heterogeneous model simulation and verification, Smart & Safety & Security avionics development environment are discussed. At last, this paper introduces the technique discussion happened between AVIC ACTRI and European ANSYS subsidiary. Through joint technology research, this paper tries to provide an overall technical solution for model and dependability driven avionics system design.

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SESAR – Europe's Approach to the Future ATM System

Ovidiu Dumitrache

EUROCONTROL, Brussels, Belgium

Performance requires change. By 2035, projections say that European Aviation will serve over 2 billion passengers per year. But this only if we build the Network that can accommodate, which is not the case with the one we have today. The concept behind this evolution is the Single European Sky and SESAR is the technology programme behind it, with the European ATM Master Plan describing how the ATM community, well, plans to deal with this challenge, from research, through development and into implementation, having set very ambitious targets:

- 10% less CO2
- Triple airspace capacity
- Halve the costs of ATM
- Improve safety by a factor of 10

Data driven scheduling and path planning

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The recent world has seen an explosion of available data, from structured data as the one gathered from sensors, experiments or direct measurements, to unstructured data as the one that can be extrapolated from online resources, reports and surveys. The engineering world is shifting from model-centred simulations to the assimilation of data into the engineering process of modelling, decision making and optimisation. This opens up a wide area of research where large datasets are used to fine tuning engineering models, design uncertainty sets and infer knowledge about unknown parameters.

Robust data-driven decision making is going to substitute traditional methods of robust optimisation where exact problem parameters and distributions of uncertain variables are known or assumed to be known a priori. Optimisation processes run on models, whose inputs are assumed to be exact or subject to erroneous estimation of distributions, can lead to solutions that are infeasible or far from the real optimum. The lecture focus on strategies to overcome this problem by introducing real data into the optimisation process of scheduling and route planning. The optimisation of air traffic control networks and airport scheduling for passengers, aircraft and operations are examples of aeronautical applications where a variety of freely available historical datasets from US and UK civil aviation services are available. An overview on a project just started on this topic as well as established results on a work done in the health sector will be presented.

The Technology of Intelligent Flight Control Based on Machine Learning

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Key Words: Flight Control, Machine Learning, ANN, Fuzzy Decision.

With the introduction of AI, the technology of auxiliary flight and autonomous flight based on machine learning, which has developed rapidly, has been highly valued by academia and industrial circles. On one side, it could reduce the pilot workload, helping the pilot to cope with severe weather conditions and emergencies better, and then improve the safety of flight. On the other hand, it could even replace the pilot, cutting down the pilot's training & use costs and solving the problem of pilot's shortage, meanwhile ensure the corresponding task capacity.

Nowadays, most researches of intelligent flight control are about rules-based control. However, their application scenarios are very limited and the establishment of rules is very difficult. The recent control methods based on machine learning are mainly about low-level behaviour learning (e.g. the mapping between flight states and relative actions), not involving the high-level intention learning (e.g. the dynamic route adjustment).

This paper presents a new model, in which both the low-level learning and the high-level learning are taken into consideration coordinately. According to the flight stages of take-off, cruise and landing, three clusters of neural networks are built respectively to bridge the gap between flight states and relative actions. At the same time, the idea of fuzzy decision is introduced to implement the top intervention to make a dynamic route adjustment when the route deviates from the predefined target to a certain probability.

In the X-Plane flight simulation experiment environment, as the test carrier, the Cessna aircraft successfully completed the optimal route flight under different wind conditions, which proved the correctness and practicability of the presented model.

Finally, the future work and some proposals for China-EU cooperation are addressed.

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Optimization of Green Trajectories to minimize Climate Change impact

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Keywords: Green Trajectories, Flight Optimization, Flight Plan, Climate Change Impact

Commercial operators try to optimize each individual flight profile by putting together historical and forecast information in a flight plan. The amount of available data is managed by the aircraft Flight Management System, allowing the crew not only the calculation of the flight plan details but also change its features during the flight, when receiving additional information or changes in the original one. Typical target is minimize the cost to the airline. This may include a number of factors like fuel consumption, variation of maintenance and crew cost with the flight time and, in some cases, a value of the economic repercussions of delays.

From the environmental point of view, the FMS can minimize the fuel consumption and, consequently, the amount of CO2 emitted. However, the impact of flights in climate change includes other factors, like Nitrogen Oxides emissions (NOx), Condensation trails (contrails), aerosols emissions, water vapour and induced cirrus clouds. The global relevance of those additional factors on climate change may be as important as the direct effect of the CO2 emissions. The effects of the different factors are not homogeneous and do not depend directly of the fuel consumption. Therefore, an optimum trajectory for climate change may not be the minimum fuel one

The purpose of this work is analyse and select those climate change factors that can be modelled and included in the aircraft instrumentation and develop a model allowing flight planners and crews select the trajectories with minimum impact on climate change.

Aircraft trajectory optimisation: towards greener flight

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Mitigate the environmental impact of aviation is one of the major challenges for all air transportation stakeholders. New or enhanced solutions in the fields of aerodynamics, materials, propulsion, or fuels will certainly contribute to reduce emissions and noise in future aircraft developments or retrofits. Aircraft trajectory management, however, plays also an important role and can contribute to mitigate the environmental impact of aircraft operations in the short-medium term. The planning and execution of aircraft trajectories is intimately linked with air traffic management (ATM) processes and systems, which may restrict certain aspects of the trajectory. This presentation will focus on a software framework developed by UPC that is able to optimise or simulate aircraft trajectories, while taking into account a comprehensive set of ATM and operational constraints. Several examples are given showing how this framework has been used in diverse applications, including SESAR or CleanSky projects, with a common aim: computing optimal environmentally friendly trajectories.

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Requirements of Avionic Systems to Support Green Trajectory

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Keywords：Air traffic management, 4D trajectory-based operation, Avionics, Greener aviation

The rapid growth of global air transport as well as an increasing concern about environmental impacts of aviation presents challenges for aviation engineers to improve current air traffic management (ATM) system designs. Among the proposals for future ATM operations, 4D trajectory-based operation has been identified as a vital approach to achieve enhanced safety and efficiency of flight and an enabling technology for future air operations. To implement this concept, progress in both ATM and avionics systems are required. This paper discusses the requirements of airborne avionic systems that are essential for the implementation of 4DT-based operations, including necessary flight management system (FMS) capabilities, requirements of cockpit control and display systems, and application of new technologies in communication, navigation and surveillance systems.

Air navigation services assets management with stochastic model checking

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When an asset fails in a critical air navigation service, how urgent is a repair? If we repair within 1 hour, 2 hours, or n hours, how does this affect the likelihood of service failure? Can a formal model support assessing the impact, prioritisation, and scheduling of repairs in the event of component failures, and forecasting of maintenance costs? These are some of the questions posed to us by a large organisation and here we report on our experience of developing a stochastic framework to answer them. We define and explore logic properties concerning the likelihood of service failure within certain time bounds, forecasting maintenance costs, and we introduce a new concept of envelopes of behaviour that quantify the effect of the status of lower level components on service availability. The resulting model is highly parameterised and user interaction for experimentation is supported by a lightweight, web-based interface.

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