CEAS
Council of European Aerospace Societies

BULLETIN AEROSPACE EUROPE

25 DECEMBER 2021:

HURRAH FOR EUROPE !

WEBB LAUNCHED SUCCESSFULLY

- **ON 25 DECEMBER 2021 AT 12:20 UTC, THE JAMES WEBB SPACE TELESCOPE LIFTED OFF ON ARIANE 5 TO UNLOCK SECRETS OF THE UNIVERSE**
- **THIS LAUNCH ON AN ESA PROVIDED ARIANE 5 ROCKET WAS PERFORMED BY ARIANESPACE ON BEHALF OF ESA FROM EUROPE'S SPACEPORT IN FRENCH GUIANA**

CEAS

The Council of European Aerospace Societies (CEAS) is an International Non-Profit Organisation, with the aim to develop a framework within which the major European Aerospace Societies can work together.

It was established as a legal entity conferred under Belgium Law on 1st of January 2007. The creation of this Council was the result of a slow evolution of the 'Confederation' of European Aerospace Societies which was born fifteen years earlier, in 1992, with three nations only at that time: France, Germany and the UK.

It currently comprises:

- 12 Full Member Societies: Czech Republic (CzAeS) – France (3AF) – Germany (DGLR) – Italy (AIDAA) – Netherlands (NVvL) – Poland (PSAA) – Romania (AAAR) – Russia (TsAGI) – Spain (AIAE) – Sweden (FTF) – Switzerland (SVFW) – United Kingdom (RAeS);
- 4 Corporate Members: ESA, EASA, EUROCONTROL and EUROAVIA;
- 8 Societies having signed a Memorandum of Understanding (MoU) with CEAS: AAE (Air and Space Academy), AIAA (American Institute of Aeronautics and Astronautics), CSA (Chinese Society of Astronautics), EASN (European Aeronautics Science Network), EREA (European association of Research Establishments in Aeronautics), ICAS (International Council of Aeronautical Sciences), KSAS (Korean Society for Aeronautical and Space Sciences) and Society of Flight Test Engineers (SFTE-EC).

CEAS is governed by a Board of Trustees,
with representatives of each of the Member Societies.
Its Head Office is located in Belgium: c/o DLR –
Rue du Trône 98 – 1050 Brussels. www.ceas.org

AEROSPACE EUROPE

Since January 2018, the CEAS has closely been associated with six European Aerospace Science and Technology Research Associations: EASN (European Aeronautics Science Network), ECCOMAS (European Community on Computational Methods in Applied Sciences), EUCASS (European Conference for Aeronautics and Space Sciences), EUROMECH (European Mechanics Society), EUROTURBO (European Turbomachinery Society) and ERCOFTAC (European Research Community on Flow Turbulence Air Combustion).

Together those various entities form the platform 'AEROSPACE EUROPE', the aim of which is to coordinate the calendar of the various conferences and workshops as well as to rationalise the information dissemination.

This new concept is the successful conclusion of a work which was conducted under the aegis of the European Commission and under its initiative.

The activities of 'AEROSPACE EUROPE' will not be limited to the partners listed above but are indeed dedicated to the whole European Aerospace Community: industry, institutions and academia.

WHAT DOES CEAS OFFER YOU ?

KNOWLEDGE TRANSFER:

- A structure for Technical Committees

HIGH-LEVEL EUROPEAN CONFERENCES:

- Technical pan-European events dealing with specific disciplines
- The biennial AEROSPACE EUROPE Conference

PUBLICATIONS:

- CEAS Aeronautical Journal
- CEAS Space Journal
- AEROSPACE EUROPE Bulletin

RELATIONSHIPS AT EUROPEAN LEVEL:

- European Parliament
- European Commission
- ASD, EASA, EDA, ESA, EUROCONTROL, OCCAR

HONOURS AND AWARDS:

- Annual CEAS Gold Medal
- Medals in Technical Areas
- Distinguished Service Award

YOUNG PROFESSIONAL AEROSPACE FORUM
SPONSORING

AEROSPACE EUROPE Bulletin

AEROSPACE EUROPE Bulletin is a quarterly publication aiming to provide the European aerospace community with high-standard information concerning current activities and preparation for the future.

Elaborated in close cooperation with the European institutions and organisations, it is structured around five headlines: Civil Aviation operations, Aeronautics Technology, Aerospace Defence & Security, Space, Education & Training and Young Professionals. All those topics are dealt with from an overall European perspective.

Readership: decision makers, scientists and engineers of European industry and institutions, education and research actors.

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■ American Institute of Aeronautics and Astronautics (AIAA)
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■ European Aeronautics Science Network (EASN)
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■ Association of European Research Establishments in Aeronautics (EREA)
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■ International Council of the Aeronautical Sciences (ICAS)
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■ Society of Flight Test Engineers (SFTE-EC)
www.sfte-ec.org/

SIX SOCIETIES IN EUROPEAN AEROSPACE SCIENCE AND TECHNOLOGY RESEARCH CLOSELY LINKED WITH CEAS (ECAERO-2):

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■ ECCOMAS: European Community on Computational Methods in Applied Sciences
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■ ERCOFTAC: European Research Community on Flow Turbulence Air Combustion
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■ EUCASS: European Conference for Aero-Space Sciences
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■ EUROMECH: European Mechanics Society
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■ EUROTURBO: European Turbomachinery Society
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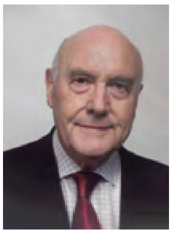
EDITORIAL



Jean-Pierre Sanfourche
Editor-in-Chief

HURRAH FOR EUROPE!

The successful launch of the James Webb Space Telescope was performed on Christmas Day: what a wonderful present for the European space community! It can be considered as the event of the decade that demonstrates once again the extreme reliability of Ariane 5. Each successful launch of Ariane is a big event but this one was emblematic for the same reason as Rosetta ((2004) and between 2008 and 2014 ATV-1 to ATV-5 resupply missions to the ISS, because it committed Europe with the worldwide space community.

It had been a great honour to be chosen by NASA for the launch of this historic mission intended to enable humanity to take in the continuity of HST (Hubble Space Telescope) a new giant step forward in its knowledge and understanding of the Universe. Yes indeed a great honour, but also a huge responsibility, taking besides into consideration the fact that the development of JWST had lasted 25 years, and its total cost reached $9.7 billion.

We all new knew that the eyes of the world would be focused on the Ariane 5 launch pad of the Guiana Space Centre at the fateful time.

The success is the result of a 20-year preparation conducted by the European teams from ESA, Arianegroup, Arianespace, CNES and industry, hand in hand with NASA, a remarkable example of large-scale international collaboration. In addition to the launch itself, several important works performed by European teams are to be highlighted, among others: the measures taken to provide an exceptionally orbital injection towards the second Lagrange point L2, the sequence of separation of the telescope from the rocket's upper stage, the special fairing cleaning, the adapter for the satellite designed and built in compliance with the large available space within the fairing. All those works concurred to ensure perfect compatibility between Ariane5 and its passenger.

In the very difficult times we are living due to the long sanitarian crisis, we more than ever need exceptional events capable of generating enthusiasm, optimism and fighting spirit. These are precisely feats such as the JWST mission which will encourage the most brilliant scientific students to choose take up career in the aerospace domain. Feats like JWST will also serve as reference and inspiring examples for all researchers and engineers involved in the present high-level aerospace programmes and projects all aimed at taking up the challenges in front of us.
The editorial committee of the AEROSPACE EUROPE bulletin begins this New Year with the intention to continue reporting in a permanently improved manner on the most important air and space topics as naturally as on the life of CEAS.

Dear members of the CEAS community, please receive our best wishes for 2022.

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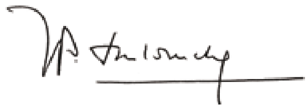


CONTENTS

INTERVIEW WITH CEAS PRESIDENT FRANCO BERNELLI

By Jean-Pierre Sanfourche, Editor-in-Chief

Franco Bernelli Zazzera
CEAS President 2021-2022

JPS – The AEC2021 Aerospace Europe Conference co-organised by CEAS and PSAA was recently held in Warsaw from 23 to 25 November: what is your general judgement about its realization?

Franco Bernelli - AEC2021 was the first in-person event organized by the CEAS since the outbreak of the Covid pandemic. Therefore, I am extremely grateful to the PSAA who accepted the challenge and risk of the organization, together with the Łukasiewicz Research Network - Institute of Aviation and the Warsaw University of Technology. Anticipating what could have been the global health situation, the organization was planned from the start in hybrid mode, allowing for a mix of online and on-site presentations. Unfortunately, there was a rapid increase in Covid infections in many countries in the few weeks leading up to the event, creating stronger travel restrictions and forcing many attendees to return to participation online rather than on-site.

Overall, about 50% of the presentations were online. The local organizing committee did a great job of handling even the last-minute changes in presentation mode and the mix of online and on-site presentations was handled very smoothly and hassle-free.

The participants on site appreciated the quality of the venue, extremely comfortable and with excellent logistics. Even with a small number of participants on site, the discussions within the session during the informal breaks were stimulating and useful and, in this regard, I think that the event should still be considered a success because it gave the opportunity to get out of the virtual meeting mode for those who have managed to travel.

How much these discussions will generate new ideas and projects is not yet known, as usual the scientific success of a conference is not measurable immediately after the end of the event.

JPS – Could you express the main messages which emerged from the conference sessions?

FB - Even in a smaller format compared to past editions of the conference, the sessions touched on many different topics and all the sessions I attended saw interesting presentations and debates. I would like to highlight two themes that were presented in the plenary conferences.

The first concerns the plenary session held by the president of the Air and Space Academy, on the relationship between air transport and the climate challenge. The messages included in the presentation cover technological aspects, business models and institutional arrangements that all together can contribute to the decarbonisation of the aviation sector. This necessarily requires a political approach at the international level, as air transport is by its nature a means of long-distance transport and is for the most part an international activity.

The second relevant topic concerns the active control of flow, loads and noise on the new generation wing, which is the activity of the AFLoNext project. This is a four-year project coordinated by Airbus with the aim of demonstrating and maturing highly promising flow control technologies for new aircraft configurations to achieve a qualitative leap in improving aircraft performance and therefore in reducing environmental impact. The challenging objectives were addressed by a massive project consortium of forty European partners from fifteen countries. The project received the CEAS Technical Award.

JPS - In these times of profound transformations, the definition of the new skills to be developed in order to prepare in the best possible manner the future engineers to take up the multiple challenges in front of them is an urgent mission. This topic was dealt with during AEC2021: what are the top messages on which you especially bring your mind?

FB - Competence analysis for the aerospace sector was a relevant theme of the conference, which covered 2 sessions.

In particular, the focus was on skills for the space sector, which is currently rapidly evolving, both from a technological point of view and for the potential applications. The most interesting presentations showed how curricula have evolved in recent times and how it is possible to integrate adequate experimental and practical activities on small satellites, for which the timeframes from conception to launch and operations are now compatible with a Master curriculum. Furthermore, the integration of a mix of skills ranging from engineering to Earth sciences, law, medicine, social sciences was presented in a new European University concept, which seamlessly connects the traditionally unconnected domains of upstream satellite technologies and downstream satellite applications.

The evolution of skills is essential to keep pace with the evolution of companies and their business models. The latter aspect was analysed with a very specific example relating to a limited geographical area, however allowing to highlight the impact of digital technologies as enablers of disruption in companies and favouring new business models.

JPS - I am personally convinced that in addition to STEM acquisitions, it is essential for our future engineers to acquire the passion for innovation and creativity, as well as the entrepreneurial spirit. If you agree with me, how could CEAS bring a significant contribution to the development of this philosophy in European Aerospace Universities and Higher Schools?

FB - First, let me say that I totally agree with the statement. Innovation and creativity, obviously supported by strong technical skills, are fundamental enabling factors for a successful professional career and for the progress of the entire sector. From my knowledge of universities across Europe this is recognized, and most institutions include formal lectures on innovation and creativity in their programs and are also setting up dedicated administrative and support structures to foster the entrepreneurial spirit of students and young graduates. In many circumstances students are also encouraged to develop their own innovative activities, in the form of student associations or participation in international student competitions.

In this rapidly changing environment, the CEAS could contribute by providing a forum for the exchange of experiences and results, similar to how we do in a "standard" scientific conference. It could take the form of a special session at a future CEAS Conference or/and a CEAS-sponsored competition with a final event at a CEAS conference. By having EUROAVIA as a partner, the dissemination of information among European students will be easy and smooth.

JPS - What is your appreciation of CEAS after your first year of presidency and what are the three priority objectives you want assign to CEAS management for this New Year 2022?

FB - No doubt the year was complicated. There were changes in the people involved on the boards or committees under the auspices of the CEAS and of course we were all still mostly connected online rather than able to meet in person. This had an impact on the number of activities that could be planned and completed over the course of the year.

Now the CEAS has a new chair of the Aeronautical Branch, a new chair of the Space Branch, a new editor-in-chief for the Space Journal, and the new general manager has become familiar with the processes of the CEAS. This lays a solid foundation for the future. I am pleased to note that all newcomers to the CEAS have already shown that they are proactive and willing to contribute in the best spirit of cooperation.

I foresee that, at least for the first quarter, the presence activities will still be reduced to a minimum. However, the CEAS can strengthen its internal organization, and, with the contribution of the new Branch Chairs, the technical committees should be reorganized and possibly stimulated to propose activities, since at the moment only some of them are really active. New technical committees could also be set up, depending on inputs received from CEAS member societies.

A second challenge is to identify a stable methodology to collect and record all CEAS conference proceedings, which are now not catalogued or managed by the member society organizing the specific conference. This is apparently a simple process, but it requires a careful understanding of the implications of publishing rights in CEAS journals.

A more challenging goal that I would like to pursue in 2022 is to open a constructive dialogue with other European associations that declare principles and objectives similar to the CEAS. In 2021 we opened a dialogue with AAE, EREA and EUCASS, continuing the dialogue towards common actions would be beneficial for our reference community.

AEC2021 – THE AEROSPACE EUROPE CONFERENCE 2021 TOOK PLACE IN WARSAW FROM 23 TO 25 NOVEMBER

By Beata Wierzbienska-Prus, PSAA & CEAS

The conference successfully took place in Warsaw at premises of Łukasiewicz Research Network – Institute of Aviation. It was organised by Polish Society of Aeronautics and Astronautics (PSAA) together with the Council of European Aerospace Societies (CEAS), Politechnika Warszawska and Institute of Aviation.

L: CEAS President Franco Bernelli during his opening speech – R: PSAA President Tomasz Goetzondorf-Grabowski

It was conducted in a hybrid mode:

- 22 **sessions** were conducted: 8 full on-site, 8 full on-line, 6 mixed;
- We listened to many **presentations**: 40 on-line and 46 on-site:
- As well as 5 **keynote lectures**: 1 on-site and 4 on-line.

The keynote lectures

- Andreas Strohmayer: "Challenges for aeronautical research in this decade" (on-line)
- Martin Wahlich: "Active Flow- Loads- and Noise- Control on next Generation Wing - Overview and Results" (on-site)
- Fayette S. Collier: "Towards Environmental Sustainability in Aviation" (on-line)
- Michel Wachenheim: "Air Transport and Climate Challenge" (on-line)
- Arne Seitz: "Fuselage BLI Propulsion Integration - Insights from H2020 CENTRELINE" (on-line)

During AEC2021 the CEAS Award 2020 Ceremony was held

- The **Gold Medal** was awarded to **Sergey Chernyshev** in recognition of his outstanding contribution to the advancement of aerospace in Europe. Sergey L. Chernyshev played an exceptional role in long-term promotion of Russian involvement and support European cooperation in aeronautics Research and Development.

L: Franco Bernelli – R: Martin Wahlich

- **CEAS Woman in Aerospace Award** was presented to Valerie Dosch, a winner of the contest project for students "How to promote STEM careers among the youngest generation?".
- **Technical Award** was attributed to the team of the **AFLoNext project**.

The main motto for the conference was 3R triptych "Restore, Rethink, Redesign"

AEC2021 contained the following topics: digitalization, artificial intelligence, electrical aircraft, hybrid propulsion, alternative fuels, H2propulsion and design of the future aircraft.

The conference also covered the typical topics for aerospace conferences such as General Aviation, UAV's, Space Technologies and others.

BRITTA SCHADE SUCCEEDS TO TORBEN HENRIKSEN AS CHAIR OF THE SPACE BRANCH

During the latest CEAS Board of Trustees meeting, Britta Schade, Head of Product Assurance and Safety Department at ESA, was nominated Chair of the CEAS Space Branch, succeeding to Torben Henriksen. The CEAS bulletin is pleased to introduce Britta Schade by publishing here below her latest interview with ESA Room magazine.

INTERVIEW WITH MS BRITTA SCHADE, ESA, ROOM MAGAZINE

How are space applications making our life better? And what is the role of standardization in contributing to it?
Space applications became an essential part of the European infrastructure and they are providing key services for the European citizens. In the domain of Navigation, the space infrastructure is enabling unprecedented accuracy and coverage, serving all terrestrial and airborne logistics. Earth Observation facilitates accurate weather forecasts and better models of the Earth's ecosystem to manage climate change. Moreover, it is a significant part of our safety and logistics system of systems. Furthermore, in the domain of Telecommunications, space technology enables the global telecommunication system, which we use on a daily basis, just to mention few examples.

Without the upstream and downstream standards, we would not have been successful in design, development, testing, launching and operating these systems essential to our day-to-day life.

What would you indicate as the most relevant and promising areas of work in the field of space standardization?
We need to make the distinction between upstream (used for design, development, launching and operation of space systems) standards and downstream (exchange, processing and utilization of space mission data) standards. While the upstream standards are well established, we need to keep the standardization system in par with very fast technology evolution in order to keep the European Space Industry competitive at a global scale.
In the context of downstream standards, I am seeing many promising areas emerging. This combined with wide participation from the industry shows that companies are seeing downstream standards as a source of their future competitiveness. Working together in the field of downstream standards will be the key issue as we introduce e.g. autonomous driving to the European roads.

While considering the differences between "new space" and "classic space" which domain remains the most challenging to the European standardization community?
Privately funded "New Space" activities have been emerging dramatically in recent years. In that context of "New Space", the dialogue between the supplier and customer is sometimes not based on the classic flow down of the requirements. I believe that the main thing in this diverse ecosystem is to maintain the dialogue between agencies and industry and to take the lessons learned, from both the successes and the failures in "New and Classic Space" and feed it back to the common standardization system.

You are personally very much involved in CEN and CENELEC's standardization activities. What does your role as JTC 5 chair entail? And how is the work organised both within the European standardization system and ESA?
The role of JTC5 – the Joint Technical Committee Space - entails developing a set of coherent standards covering space activities, both for flying objects and utilisation of signal (natural or artificial) for on-ground activities. The JTC5 gathers experts from public and private stakeholders institutions specialized in various fields. Today more than 130 standards are published by the JTC5.

ESA (and you personally) is an active member of the European Cooperation for Space Standardization

(ECSS). What is the aim and the main expectations from the project?

The aim of the ECSS is to enforce the ease of trade between organisations, while allowing interoperability and strengthening competitiveness of the European space actors. The expectation is to be in line with all the technological state-of- the-art and to maintain the spirit of the ECSS in the years to come, which is a strong collaboration between the European space agencies and industry.

What is Europe doing in terms of interoperability and how is it interacting with global space actors? In particular, what is its approach towards China and Japan, which have proven to have a strong interest for international standards?

ECSS has several requests from Japan for translation of our standards, which we positively answered. We are starting the discussion for developing standards for joint mission with China in the domain of Science and Space Exploration.

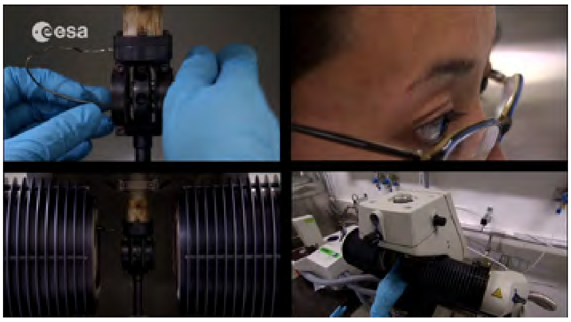
ESA is a valued partner worldwide. We develop with NASA and the European Industry the European Service Module (delivering propulsion and life support for the American crew module for four astronauts) for the Artemis missions to the Moon, and with JAXA, the Japanese Space Agency, we launched BepiColombo to Mercury. Whenever worldwide agencies are collaborating in a common mission (ISS with several partners, ExoMars with Russia, Earthcare with JAXA, James Webb Telescope with NASA, SMILE with China), we develop a set of interface standards to ensure interoperability of the hardware.

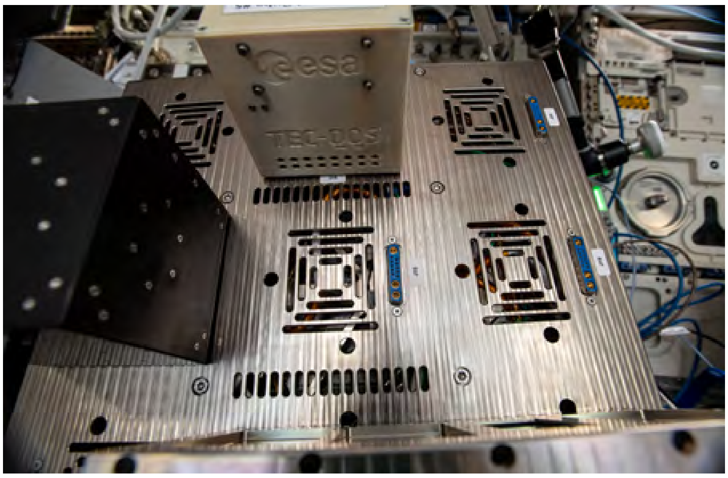
The European GNSS is a big European project potentially leading the way to new applications. Why is it of strategic importance for European space strategy?

It is of paramount importance for Europe to have access to highly accurate navigation data, made available for the first time under civilian rather than a military authority. Navigation is key parameter for civilian and military and mastering this technology will allow Europe to be independent of any foreign authority.

What is your personal advice to students that want to pursue aeronautics as a field of study?

We are now in a new space era where humanity will achieve new dimensions of the exploration and operations. Aeronautics, Spacecraft Engineering and all related disciplines are definitely an exciting field of study with a great future. The dream is alive, returning to the Moon, going to Mars, mining celestial bodies. Be a part of it!





OUTLINE OF THE LATEST ISSUES OF THE CEAS SPACE JOURNAL AND THE CEAS AERONAUTICAL JOURNAL

The journals were created under the umbrella of the Council of European Aerospace Societies (CEAS) to provide an appropriate platform for excellent scientific publications submitted by scientists and engineers. The German Aerospace Centre (DLR) and the European Space Agency (ESA) support the Journals, which are published by Springer Nature.

The **CEAS Space Journal** is devoted to excellent new developments and results in all areas of space-related science and technology, including important spin-off capabilities and applications as well as ground-based support systems and manufacturing advancements.
The **CEAS Aeronautical Journal** is devoted to publishing new developments and outstanding results in all areas of aeronautics-related science and technology, including design and manufacturing of aircraft, rotorcraft, and unmanned aerial vehicles.

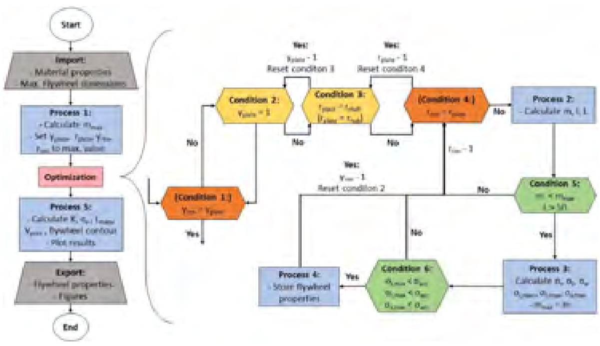
Both journals play an increasingly important role in representing European knowledge in aerospace research. Nevertheless, the biggest challenge is still to attract an acceptable number of high caliber scientists and engineers to submit articles for publication. Therefore, we invite you and your colleagues to contribute to the development of these journals by publishing your hard-earned results. Papers which are considered suitable will be subjected to a comprehensive blind peer-review process for potential publication in the CEAS Journals.
A list of articles published in the latest issues of both CEAS Journals is attached.

The Managing Editors:
– Andrea Dieball
– Cornelia Hillenherms
– Wilhelm Kordulla
– Stefan Leuko
– Johan Steelant

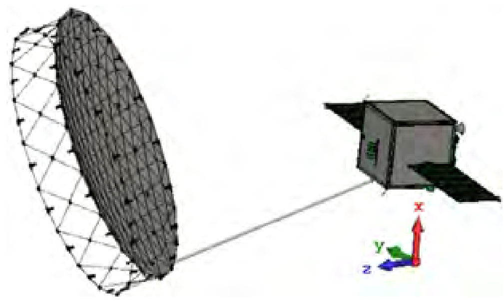
CEAS SPACE JOURNAL

Volume 13, Issue 4, October 2021

TOMARES - TOPOLOGY OPTIMIZATION OF AN ADDITIVE MANUFACTURED REACTION FLYWHEEL DESIGNED FOR AN EARTH-OBSERVATION SATELLITE
L. M. Lottes, N. Kaiser, N. Gossens, H. W. Oelze & C.Braxmeier / Published online: 06 January 2021 (Open Access)



MODIFIED DESIGN OF THE DEPLOYABLE MESH REFLECTOR ANTENNA FOR MINI SATELLITES
O. Sushko, E. Medzmariashvili, L. Filipenko, A. Tsiklauri, G. Medzmariashvili, M. Nikoladze, Sh. Tserodze, D. Vasylenko, O. Shpylka, S. Khoroshylov, S. Martyniuk & V. Vasyliev / Published online: 13. January 2021`



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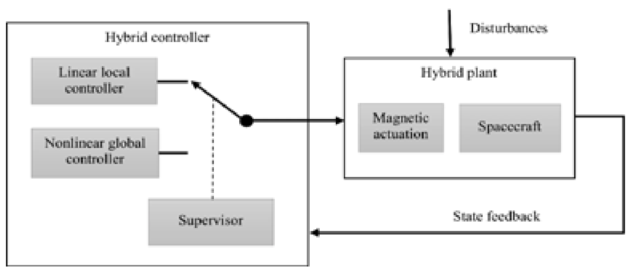

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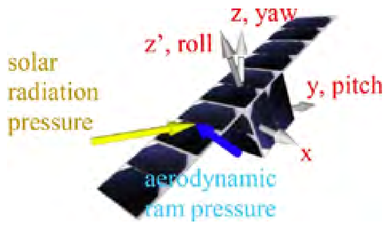

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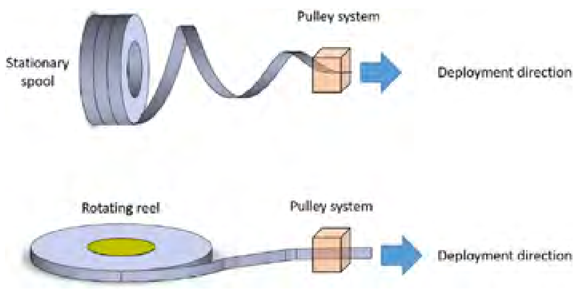

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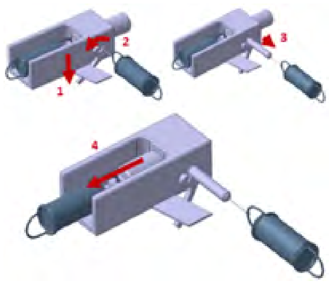

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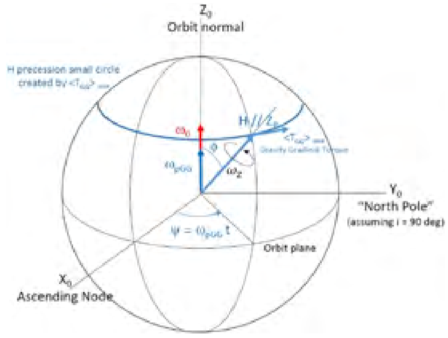
A. Published online: 13 April 2021



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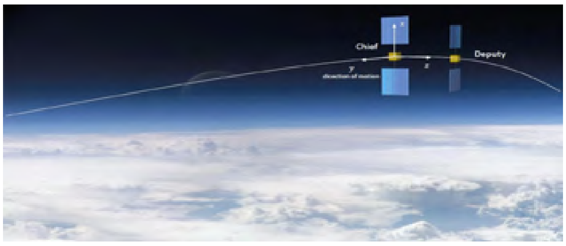

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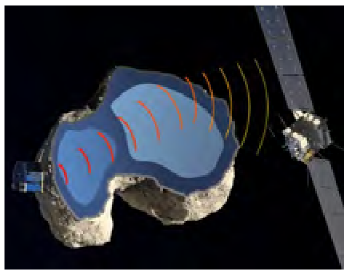

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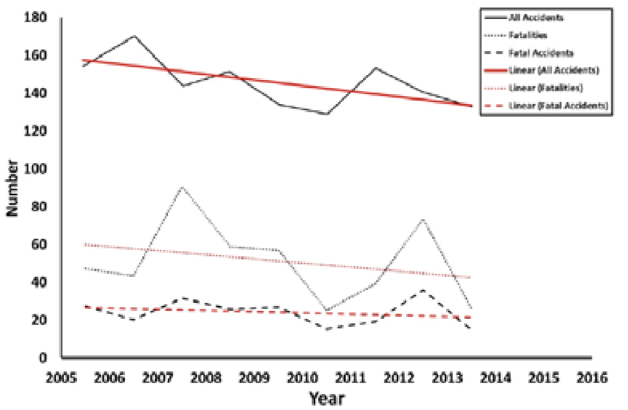

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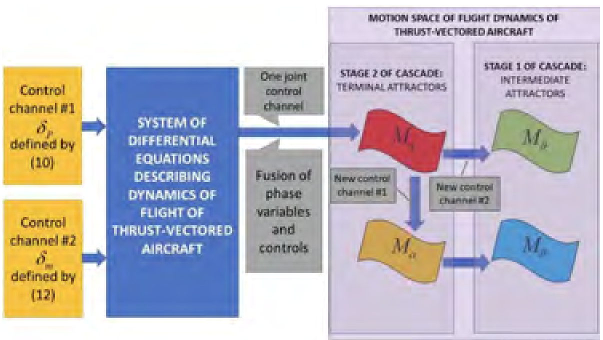

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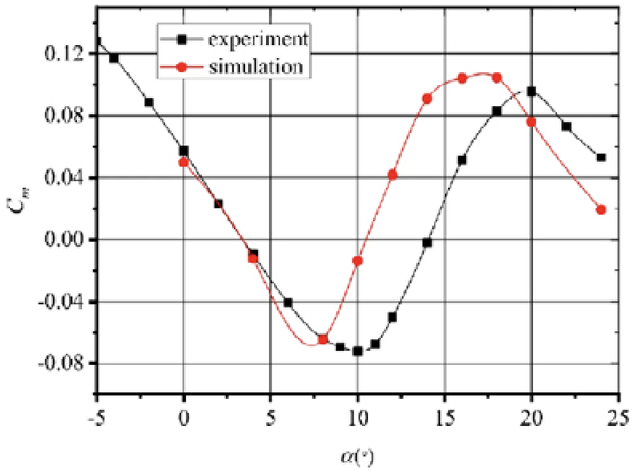

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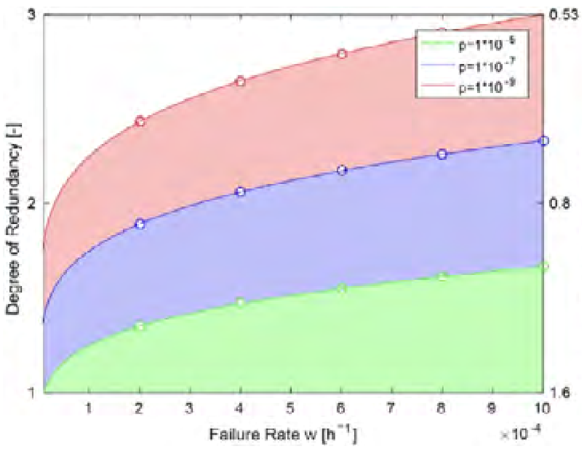

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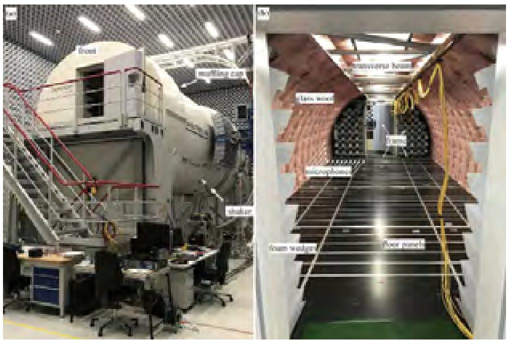

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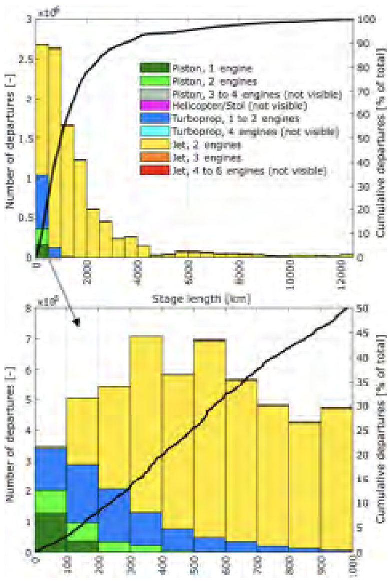

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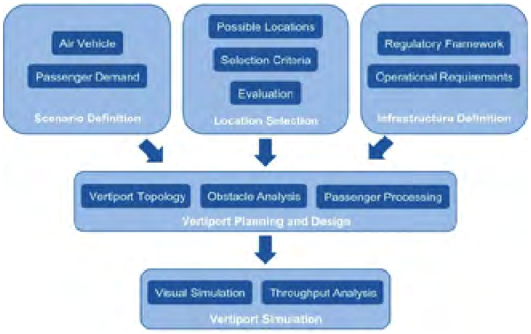

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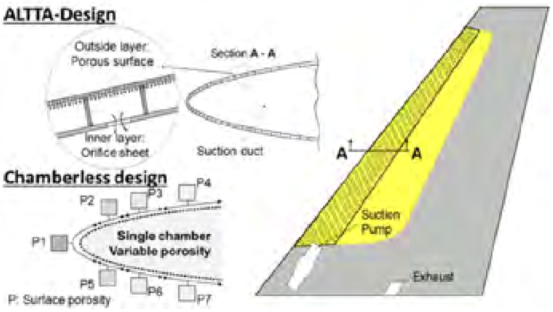

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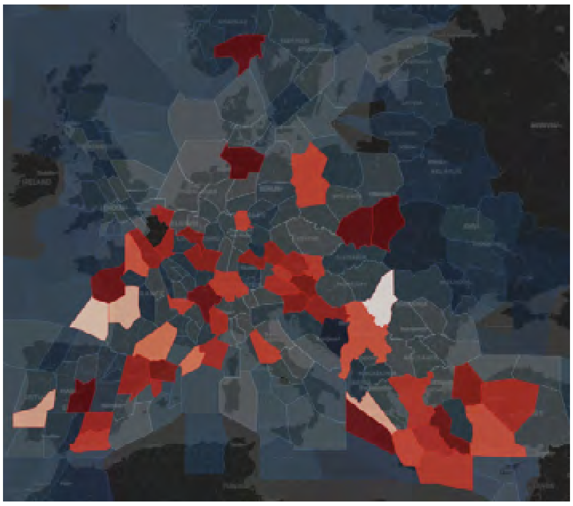

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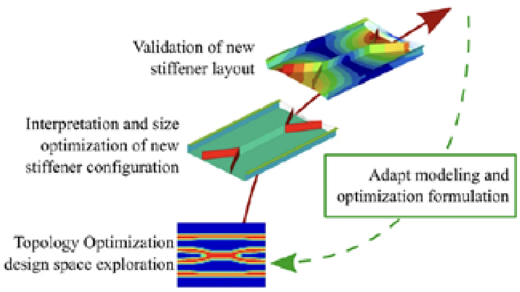

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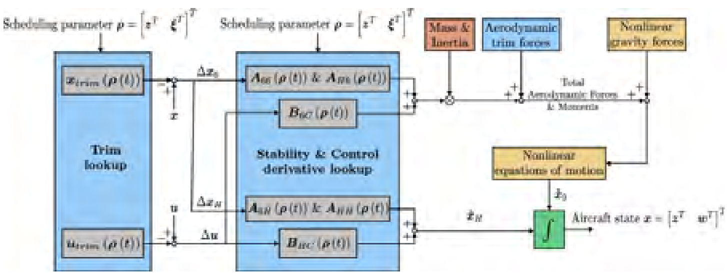

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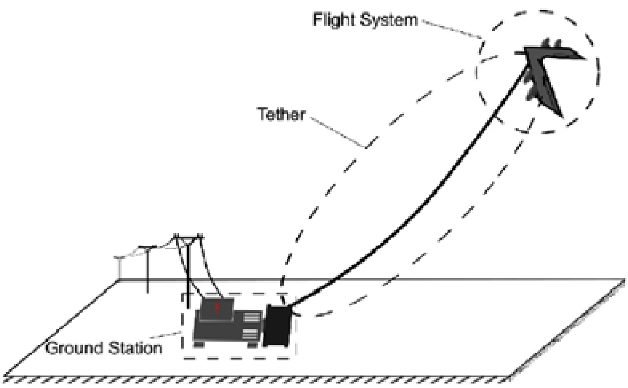

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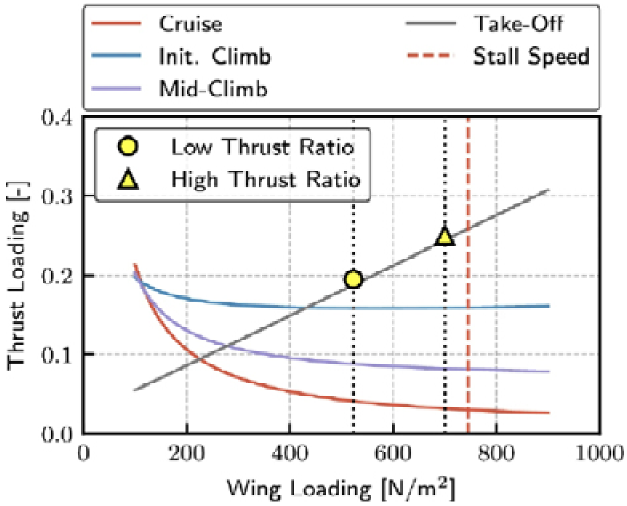

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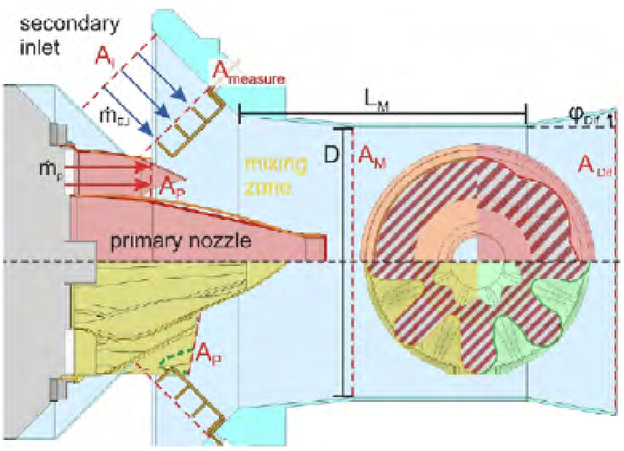


CORRECTION TO: EVALUATION OF AN ADVANCED SLUNG LOAD CONTROL SYSTEM FOR PILOTED CARGO OPERATIONS

Daniel Nonnenmacher & Hyun-Min Kim / Published: 04 August 2021 / Now published with Open Access (the Original Article was published on 03 July 2020 without Open Access)

IS NEW SPACE A PARADIGM SHIFT?

By Prof. Walter Peeters

Prof. Walter Peeters
Professor in Space Business and Management and President-Emeritus of the International Space University (ISU), Strasbourg, France.

After obtaining a PhD in engineering and an MBA, Walter Peeters joined ESA after activities in industry. He was Head of the Coordination Office of the European Astronaut Center before being detached to ISU where he became professor, later nominated as Dean and was elected as President of ISU serving from 2011-2018.

His publications cover articles on commercial space topics, New Space economy, space tourism and inter alia a book on Space Marketing (Kluwer, 2000) and an IAA Report on Suborbital Spaceflight (IAA, 2014).

His present activities are focusing on New Space and Entrepreneurship, which led to the creation of a Space incubator in ISU which is now operational.

INTRODUCTION

Initially, New Space was considered by many actors in the commercial space sector as a logic effluent from the ongoing commercialization trend of the sector. However, in line with the evolution of space activities from governmental ('Space Race') to commercial space, there are many reasons to consider New Space as another paradigm shift.

Schematically we can divide this evolution in three phases, as is shown in ***Figure 1*** below.

The first phase, called Primary Loop in Figure 1, can be labeled as the government driven period. Whereas there is no doubt that prestige was the main political driver of the Space Race, it deserves to be recalled that in parallel many scientists were convinced already in the 1950s about a more sustainable conquest of the space frontier, over and beyond political motives (1).

During this period, considerable government funding was supplied by, at that time, the US and USSR governments to put the first satellite in space (Sputnik, USSR, 1957), the first human in space (Y. Gagarin, USSR, 1961) and the first human on the Moon (N. Armstrong, USA, 1969).

We can illustrate this funding aspect by looking at the NASA budget in function of the federal budget in this period as per ***Figure 2***.

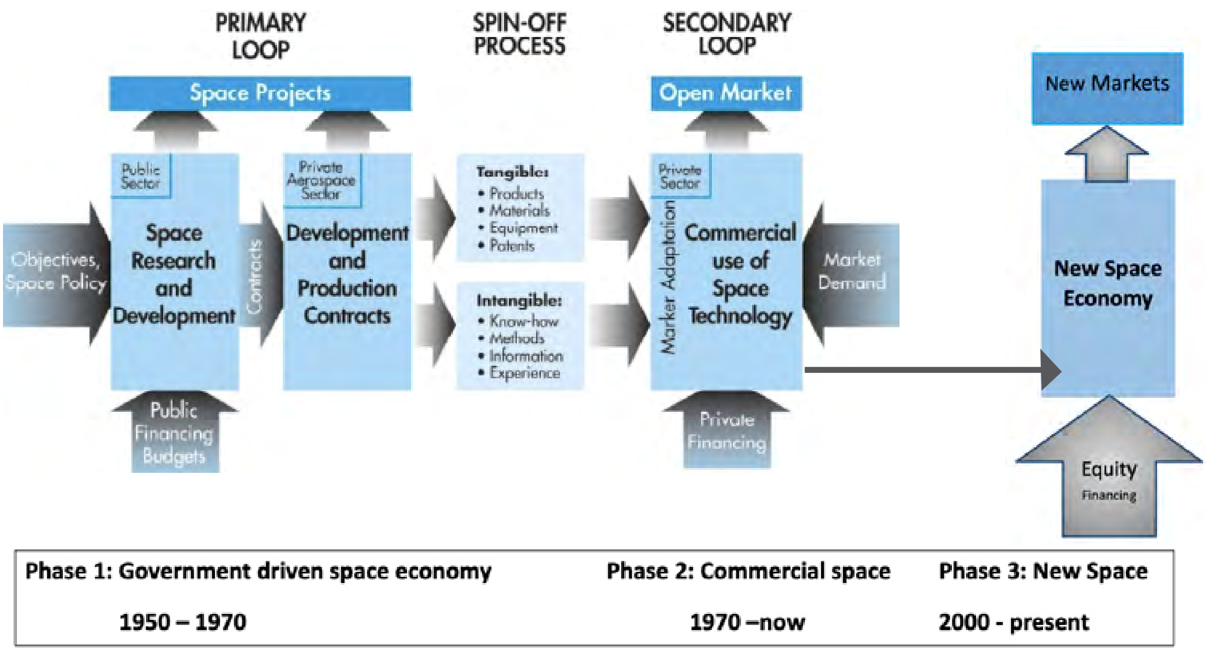


Figure 1. Three phases of Space Business (1950-2021).

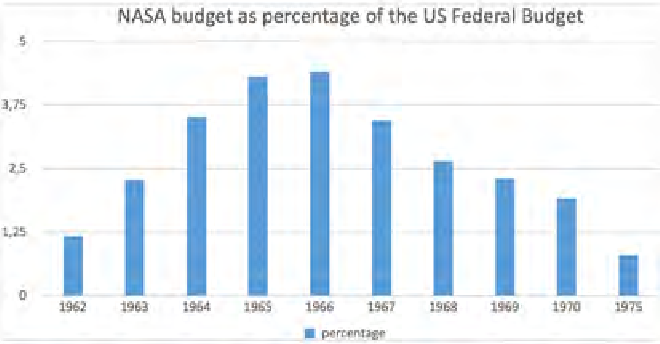


Figure 2: NASA Budget as a Percentage of the U.S. Federal Budget (2, 3).

To put this in a perspective, the present NASA budget recently ends up around 0.5% of the general budget, so nearly 9 times less than at the peak in 1966.

Most of these budgets were translated in big contracts to US Space industry, employing thousands of specialists. Evidently, once these budgets decreased, also the number of contracts decreased rapidly after 1966. To guarantee stability and keep the workforce, those companies which had gained a large experience from these mega-contracts started to look at market demand and developed satellites to satisfy this demand. In particular the telecommunication needs were identified and, using the know-how, large space companies started to build big geostationary satellites for satellite operators worldwide. This extended into other areas as well, so that the present commercial space sector is approximately ¾ of the total space sector nowadays, hence 3 times bigger than the governmental sector.

When the term New Space became common, at the end of the 1990's, several commercial space actors objected to the statement that this was a new phenomenon and insisted instead to consider New Space as part of the ongoing space commercialization. There are, however, sufficient arguments to consider the New Space Economy as a separate phenomenon in addition to the ongoing commercial space sector.

The purpose here is not to go in academic discussions based upon Organization Theory, but we cannot avoid touching upon some opinions and subsequent definitions related to this.

From an Organization Theory perspective New Space has been extensively discussed and described in different papers, with an overview given in (4).

One definition covering the novelty dimension, in combination with the different financial structures of New Space companies, has been proposed by this author as follows (5):

Private companies which act independent of governmental space policies and funding, targeting equity funding and promoting affordable access to space and novel space applications.

An important aspect of New Space is that creative start-ups try to open new markets via these novel applications and solutions, very often in Low Earth Orbit (LEO) in view of lower launch costs.

Comparing two Ecosystems

The start of the New Space economy can in broad terms be related to two major driving forces:

1. The application of existing space data, provided by public systems such as GNSS and Earth Observation satellites, often combined via novel and creative algorithms to serve a specific (niche) market,

2. The development of satellite constellations in Low Earth Orbit (LEO) based upon smallsats, replacing the previous satellites in Geostationary orbit (GEO).

We can relate this both to the underlying rationale to bring products to the market with relatively low Capital Expenditure (CAPEX) as the New Space entrepreneurs need equity financing from business angels and Venture Capitalists. In practice this means to be able to convince equity investors to fund endeavors, based upon a business plan that foresees an attractive return for those investors the next 3-5 years, hence low initial capital needs. So, R&D costs had to be minimized and satellites were developed with low redundancy and minimum shielding, using a maximum of commercial-of-the-shelf (COTS) components. Launch costs were reduced by launching as secondary payloads or in grouped launches (so-called rideshare launches).

Table1: Differences between 'Traditional' and 'New' Space Approaches

Characteristic	Traditional Space	New Space
Main Driver	Hardware Production	Software Application
Orientation	Techno-push	Application oriented
Design characteristics	High reliability and redundancy	Simple design, shorter lifetimes
Design philosophy	Customized	Standardization
Engineering	High Quality, High cost	Low-cost, low mass
Launch	Dedicated launcher	Shared launch
Orbits	Mainly geostationary orbit	Mainly low earth orbits
Intellectual Property	Patent protection	Technological advantage
Risk aspects	Risk Adverse	Accept business risks
Internal Organization	Hierarchical	Matrix
Financing	Company funds, debt financing	Equity financing

All this leads to simple designs, limited lifetimes and unavoidable launch delays which were driven by the availability of the prime payload, but also to a strong reduction in costs which made faster return on investments possible, attracting equity financers. Shorter lifetimes were also based upon the opinion of New Space entrepreneurs that rapid changing technology was not anymore compatible with geostationary satellites, often designed for up to 10-15 years operation.

Systematically, if we compare this New

Space ecosystem with the traditional approach, we could sketch the differences in broad lines as per table 1 hereafter:

A good example of this New Space approach can be found in **fig. 3**, showing the cost-efficient loading of the standardized Starlink smallsats in one Falcon 9 rocket.

Figure 3: New Space approach example: 60 Standardized Starlink satellites loaded in one Falcon9 launcher (www.Starlink.com)

Based upon this evolution, there are several disruptive prospects involving smallsats. Examples of these evolutions are highlighted below.

- Mega-constellations such as those announced for internet-from-space. It is expected that mass-production will considerably reduce manufacturing costs at the same time allowing high-performance space applications. Furthermore, the constellations will make use of multiple orbit inclinations to gain global coverage.
- Smallsats at geostationary Earth orbit (GEO) with shorter lifetimes, coupled with new advances in Software Defined Radios (SDRs) and support electronics. These new "smallGEOs" can respond to shortening technology development cycles, and potentially operate in clusters. The present example are the reconfigurable Quantum satellites, developed for European Telecommunications Satellite Organization (Eutelsat) with flexible in-orbit reprogrammable features.
- Space-wide-webs as an extension of the world-wide-web, by merging terrestrial networks with smallsat based space networks, covering terrestrial needs in underserved areas, and extending services to satellites and space stations.
- Lego-satellites defined as robust smallsats launched in stacks and assembled in space by robotic operations to perform as large objects but spreading the risk in case of a launch failure and the costs considerably. Large space telescopes are an example of this application which is under study.

Clearly, equity investors believe in NewSpace business. Equity investments in space start-ups was in the order of $130 billion U.S. dollars in 2019 (6). As a point of comparison, this figure was only, according to the same source, around $20 billion U.S. dollars in 2014, showing an exponential growth.

It shall be noted here that this picture will be changing soon as many of the emerging New Space companies of last years (such as SPIRE, PLANET, Rocket Lab, Astra, etc.) are presently, or are envisaging, to be noted on the stock exchange via the so-called SPAC (Special Purpose Acquisition Company) accelerator mechanisms rather than by traditional public offering campaigns.

Evolution and Outlook

In a recent forecast (7), Euroconsult makes the following assumptions for the coming decade (2022-2031) for smallsats with a mass of less than 500 kilograms (kg).

- Some 1400 of those smallsats will be launched yearly the next decade (already more than 1200 were launched in 2020 with a growing trend);
- The average mass will grow from 140 to 180 kg;
- More than 80% of those Smallsats will be part of the aforementionned megaconstellations like OneWeb, Starlink, Kuiper, Telesat LEO, etc.
- Most of these constellation satellites will be launched with dedicated ride-share launchers, such as Falcon 9;
- But many others, which have to be put in specific orbits, will be launched by Microlaunchers, another important aspect of the New Space economy (**fig 4**.).

Figure 4. Example of a New Space Micro launcher under development (Courtesy: ISAR)

A report (8) analyzed the different predictions made about the growth of the space sector. The different forecasts are compared in **Table 3**.

Whereas the Compound Annual Growth Rate (CAGR), representing the expected growth over the next years, may be considered high in some cases, a space economy of over 1 trillion$ can be expected by 2040.

However, as far as the expected growth is concerned, we cannot ignore three major factors. The first, space departments in large space companies are linked to aeronautical consortia and benefitted from the increasing sales of planes. The drop in tourism due to COVID has a serious impact in that sector where drastic reductions are taking place now. A very visual example is the termination of the Airbus A380 production line. The second,

Table 3. Space Economy Turnover Forecasts for 2040. Source: (8).

Institution	2016	2040	CAGR
UBS	340 B$	926 B$	4.3%
Morgan Stanley	339 B$	1,100 B$	4.9%
US Chamber of Commerce	383.5 B$	1,500 B$	6%
Goldman-Sachs	340 B$	>3,000 B$	9.5%

governments needed to do strong efforts to support the economy and had to accept debts, which need to be repaid. The figures for the United States and European governments are presently over one trillion U.S. dollars; a similar amount is spent on lending plans by the International Monetary Fund (IMF). The third, NewSpace start-ups are confronted with delayed or reduced income, and at the same time unexpected expenses.
Government budgets the coming years will come under pressure in view of the loan repayments (although luckily for the economy present interest rates are not high). This will have a direct effect on large scale projects, which will have at least a delayed start. Several planned constellations will have to revise the business plans and possibly we will see mergers and acquisitions leading to reductions of the number of satellites to be launched.

Nevertheless, this will result in important future possibilities for the private New Space companies:

- Space Agencies, with stagnating budgets, will concentrate on technology development and basic science research, leaving the field open for New Space companies to concentrate on applications (as an example, the NewSpace company named SPIRE concentrating now on weather forecasting).
- Also, in exploration activities outsourcing to New Space companies is already taking place (as an example see the transport of cargo and astronauts to the ISS by SpaceX).
- Even the development of smallsat launchers will be left to New Space companies with initial support of government funding (an example is the European Space Agency (ESA) and the German Space Agency (DLR) competition supporting private companies to develop smallsat launchers).
- The market will orient to more affordable solutions for space projects, an area where lean New Space companies excel (examples are IoT (Internet of Things) applications and the broadband LEO constellations).

CONCLUSION

As represented in Table 1, there are sufficient differences between traditional space and New Space to justify labeling this transition as a paradigm shift.
Not only are many new start-up companies involved, using equity financing, but the relatively low production costs, using simple design and a maximum of COTS components, combined with lower launch costs has also a secondary effect that space activities can easier migrate to emerging countries. We could even claim that New Space might help to democratize the space economy, facilitating a shift from vested space nations to emerging space countries.
Creative New Space actors have developed a wide range of novel applications in the different segments of the space economy, even in exploration activities. This way they are becoming a third component in the space market, next to Governmental space activities and the Commercial traditional sectors.
This makes New Space attractive for early-stage equity investors which are interested in a relatively fast return for their investments and are, hence, less interested in long development and amortization periods, as is the case with large geostationary satellites.
There are few doubts that the space economy will reach a turnover of 1 trillion$ or more by 2040. There is equally no doubt that, with the financial burdens of the present pandemic, New Space will become an important part of this turnover based upon the aforementioned paradigm shift.

Notes

(1) Snead, J.M., Spacefaring Logistics Infrastructure. The Foundation of a Spacefaring America. Astropolitics, 6.1 (2008) 71-94

(2) NASA, Wiki, available under https://nasa.fandom.com/wiki/Budget_of_NASA (last accessed 11.5.2021)

(3) Smith, M.S., "U.S. Space Programs: Civilian, Military, and Commercial" (2006). Congressional Research Service Reports. 6. SpacePolicyOnline.com, 2019 available under https://spacepolicyonline.com/topics/commercial-space-activities/ (last accessed 12.11.2021)

(4) Davidian, K., Definition of NewSpace, New Space 8(2), Editorial (June 2020) 53-55

(5) Peeters, W., Towards a definition of New Space? The entrepreneurial perspective. New Space 6(3), 187-190, (2018)

(6) Space Capital, Space Quarterly Investment 2020, available under https://www.spacecapital.com/publications/space-investment-quarterly-q1-2020 (last accessed 14.08.2021)

(7) Euroconsult, Prospects of the Small Satellite market, 7th ed. (Euroconsult, Paris, 2021)

(8) IDA, Measuring the Space Economy, IDA Document D-10814, IDA Science and Technology Policy Institute, Washington (March 2020)

DLR LAMPOLDSCHAUSEN COMBINES ITS SUCCESSFUL SPACE FOCUS WITH FORWARD-LOOKING ENERGY RESEARCH

By Michael Füting

DLR Lampoldshausen combines its successful space focus with forward-looking energy research. Hot run of the main stage engine Vulcain 2.1 on the test facility P5. Copyright: DLR Lampoldhausen

Energy-intensive applications are both the origin and future of hydrogen research, which has been an integral part of spaceflight for several decades. Researchers at the DLR Institute of Space Propulsion in Lampoldshausen are modelling the entire process, from the generation of renewable hydrogen to storage and liquefaction, all the way through to the testing of hydrogen in rocket propulsion systems. This work is making a major contribution towards achieving future sustainable spaceflight; meanwhile, the knowledge gained in working with hydrogen is being transferred to sectors including energy, mobility, air transport and shipping. Furthermore, this work is also kindly acknowledged by Hydrogen Europe Research, the leading European grouping on Fuel Cells and hydrogen technologies.

DLR entered into its partnership with ZEAG Energie AG to set up research and demonstration platform for the renewable production of hydrogen in the H2ORIZON project. Copyright: DLR Lampoldhausen

The DLR Institute of Space Propulsion has unique expertise within Europe in the development and operation of engine test stands – propulsion systems for rockets and space systems have been tested and refined at Lampoldshausen since 1959. This research forms part of the European space programme. Thanks to its Ariane range of launchers, Europe is now able to launch satellites into orbit for a wide range of applications using its own resources, thereby securing the competitive and independent access to space that is essential for the unrestricted use of satellite data. The transfer of expertise and technologies in the field of hydrogen at the Institute of Space Propulsion encompasses many aspects, from the transfer of application-oriented technologies to cooperation projects with companies, universities and spin-offs. As climate change becomes an increasingly urgent global concern, the demand for low-emission technologies is on the rise. Several years ago, DLR teamed up with ZEAG Energie AG, the operator of the most powerful wind farm in southwest Germany, with the goal of finding ways to make spaceflight and its large consumption of hydrogen greener.

THE ORIGINS AND FUTURE OF ENERGY INTENSIVE HYDROGEN APPLICATIONS

The hydrogen concept devised by DLR in Lampoldshausen is based on generating hydrogen through electrolysis using energy from renewable sources. When DLR entered into its partnership with ZEAG Energie AG, the aim was to set up a research and demonstration platform

for the renewable production of hydrogen as part of the **H_2ORIZON** project.
The initiative produces climate-neutral hydrogen using 100 percent wind power by directly connecting a Polymer Electrolyte Membrane Electrolysis (PEMEL) system to the Harthäuser Wald wind farm. The project also incorporates two natural gas cogeneration units in which the green hydrogen can be burned for research purposes while also providing power for the site. **H_2ORIZON** received funding from the Baden-Württemberg State Ministry of the Environment, Climate Protection and Energy; DLR received 342,000 euros in funding, which was invested in project development, implementation planning and the commissioning of accompanying scientific studies.

DLR is now expanding the 'Zero emission – Hydrogen Site Lampoldshausen' project, which focusses on the production and uses of green hydrogen. The Baden-Württemberg State Ministry for Economic Affairs, Labour and Tourism is providing 16 million euros in funding for the project. The goal is to sustainably supply the DLR Lampoldshausen site with renewably generated hydrogen and to test the entire hydrogen process chain under the specific conditions of an energy-intensive site for testing space propulsion systems. To ensure efficient use of all hydrogen systems at the site, DLR scientists are working on optimised designs and operations. Artificial intelligence (AI) algorithms are increasingly being used in addition to conventional methods of optimisation, enabling automated learning from current and historical operating data and continuous improvement of process control. As AI-based 'health monitoring' can identify abnormal behaviour and system changes very rapidly, it promises further gains in the efficiency and safety of the technologies being researched.

APPLYING HYDROGEN TECHNOLOGY IN PRACTICE

The activities of the Zero Emission project revolve around three themes: "Green Spaceflight", "Carbon-neutral Site" and the "H2 Technical Centre". These are aligned with research questions in order to achieve additional benefits not only for DLR, but for the entire region and beyond.

As the future of hydrogen lies in energy-intensive applications, it makes sense to use the hydrogen generated by climate-neutral means for spaceflight. In the "Green Spaceflight" area, researchers are expanding production capacity to create up to 300 tonnes of green hydrogen per year at the Lampoldshausen site. From 2024, it will also be possible to generate green cryogenic liquid hydrogen on site using a hydrogen liquefier. This will be used for Ariane launcher engine testing during experiments on large-scale test stands and for trialling new technologies based on liquid hydrogen.
The project also seeks to make DLR Lampoldshausen carbon neutral, with an emphasis on the sustainable supply of electricity and heat, and the use of fuel cell-powered vehicles inside and outside the 51-hectare site. Using a mobile hydrogen test filling station, researchers will investigate issues related to hydrogen supply for innovative propulsion systems for future mobility. As part of DLR's research, a future energy supply system for Lampoldshausen is being designed and optimised, all with the aim of creating a sustainable, zero-carbon energy supply for the site.
The third core theme addresses the expansion of test activities at Lampoldshausen to fields beyond spaceflight.

The green hydrogen, produced by the H2ORIZON facility is processed, compressed and directly filled into special transport vehicles for distribution. Copyright: DLR Lampoldhausen

The Roland Berger study 'Potential of the Hydrogen and Fuel Cell Industry in Baden-Württemberg', commissioned by the federal state, has identified a need for test stand capabilities for hydrogen technologies. DLR will therefore use its unique expertise in handling large-scale hydrogen test stands and existing safety infrastructure to create a research and development platform for hydrogen technologies. The "H2 Technology Centre" will enable partners from industry and scientific research to develop and assess hydrogen-based systems and components such as compressors, tanks and micro gas turbines under real conditions for use in the hydrogen industry. The modular test environment will make it possible to respond flexibly to customer requirements. The project is therefore facilitating technology transfer to business and promoting collaboration with other research institutions.

LOOKING BEYOND THE SHORT-TERM: THE "HN-F -HYDROGEN HUB"

The short-term requirement for testing options can be covered by the "H_2 Technology Centre". In the long term, DLR Lampoldshausen will become home to the "HN-F Hydrogen Hub", a centre for testing, applications and transfer that will assist small and medium-sized enterprises with the development and testing of innovative hydrogen technologies, from initial brainstorming to getting systems and components market-ready. The "HN-F-Hydrogen Hub" project is being funded as part of the development concept 'Heilbronn-Franconia on the way to the future – change in a rural region'. Heilbronn University of Applied Sciences, the Technical University of Munich (TUM), the Fraunhofer Institute for Industrial Engineering (IAO) and the DLR Institute of Space Propulsion are working together under the direction of Wirtschaftsförderung Raum Heilbronn GmbH (Heilbronn Economic Development Corporation) to provide companies and municipalities with direct added value through application-oriented scientific development, transfer activities and project-related guidance in order to promote regional structural change in energy at different levels. By creating testing options with gaseous and, in particular, liquid hydrogen that are unique within Europe, the project will provide access to a neutral test environment that meets the needs of the regional hydrogen economy and encourages companies to establish themselves nearby. The flagship initiative also gives the DLR Institute of Space Propulsion an opportunity to leverage decades of experience in the construction, planning and operation of large hydrogen systems, including all upstream and downstream processes such as risk analysis simulation and the conducting of tests.

About the DLR Institute of Space Propulsion

The DLR Institute of Space Propulsion in Lampoldshausen operates large test facilities for rocket engines. These test systems span the entire range of test requirements, from the testing of components to engines and entire rocket stages. Tests are conducted for research and development purposes, as well as for qualification and characterisation. Recently, DLR engineers tested the Vulcain 2.1 main stage engine and the Vinci upper stage engine for the Ariane 6 on the P5 and P4.1 test stands on behalf of ArianeGroup. Tests for the complete cryogenic upper stage of Ariane 6 are currently being prepared on the P5.2 test stand. These tests mark an important milestone in the development of the future European launch vehicle Ariane 6, which will ensure ongoing independent access to space for Europe.

ZERO EMISSION PROJECT

"Green Spaceflight"

- 2,3 MW PEMEL for 860kg green GH2/d
- Installation of a hydrogen liquefier

"Carbon-neutral Site"

- Optimized design for carbon neutral energy system
- Mobile hydrogen research fueling station + fuel cell car
  > Research topics on hydrogen mobility

"H2 Technology Centre"

- Modulare, flexible test environment for hydrogen applications from research and industrial partners

THE ROADMAP TO TRUE ZERO: TARGETING AVIATION'S TOTAL ENVIRONMENTAL IMPACT

By Nikhil Sachdeva, Roland Berger Senior Manager and Global Lead for Sustainable Aviation

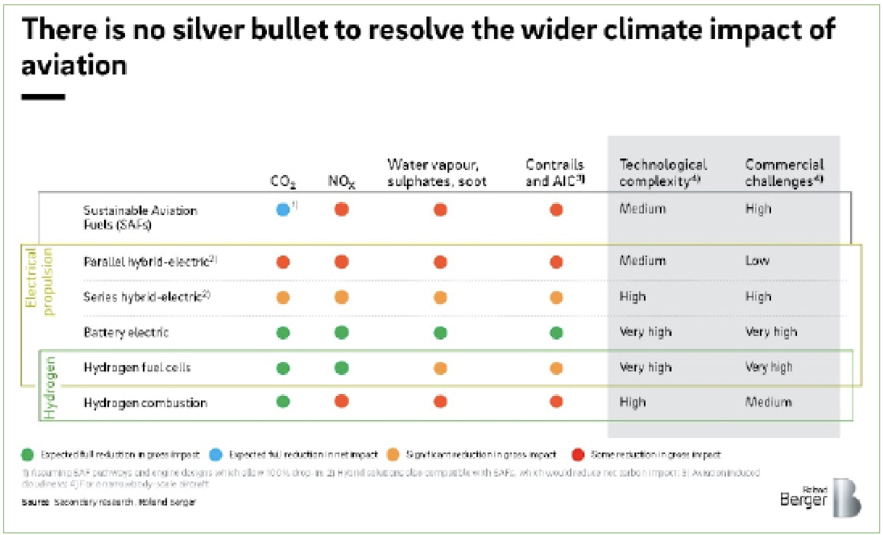
COP26 was seen by governments and private business alike as an opportunity to take a step forward in climate action – and the aerospace & aviation sector was no exception, seeing plenty of activity. The US set the target of achieving net zero GHG emissions from aviation by 2050. NASA, Boeing and Alaska Airlines joined forces to compare the full suite of emissions when burning conventional fuels vs 100% SAFs. Brazil's Embraer threw down the gauntlet in Regional Air Mobility launching Energia Family of 4 sustainable aircraft concepts. The start-up Wright Electric announced plans to launch the Wright Spirit, a 100-seat electric jet, by 2026. In the UK, the Aerospace Technology Institute FlyZero project released their concept aircraft, a 150-seat hydrogen powered jet. IAG returned to transatlantic flying, replacing its traditional B747 route with a 35% SAF-fuelled A350, reducing total emissions per passenger by 50%, while also signing a 10-year SAF purchasing agreement with Velocys. In addition, there were a host of SAF commitments by airlines, globally.

However, was COP26 enough of a pivotal moment for the sector? There is still no consensus on a global roadmap to decarbonise, uncertainty abounds on what future aircraft technology and aviation networks will look like – and crucially, there is no agreement on how to quantify and contend with non-CO_2 effects.

Like anything in business, only that which gets measured gets done. While decarbonisation is essential and must remain a priority, carbon dioxide (CO_2) is not the only greenhouse gas released by aviation which contributes to global warming. There are many other pollutants and effects, from NOx to particulates, contrail cirrus and aviation induced cloudiness. Unfortunately, the non-carbon effects are less clearly understood than carbon and remain much more difficult to quantify. In effective radiative forcing terms, *latest research* suggests total impact of approximately three times that of carbon alone. In global warming potential terms, this ranges between two to four times, depending on the timeframe considered. Significant error bars complicate the issue further.

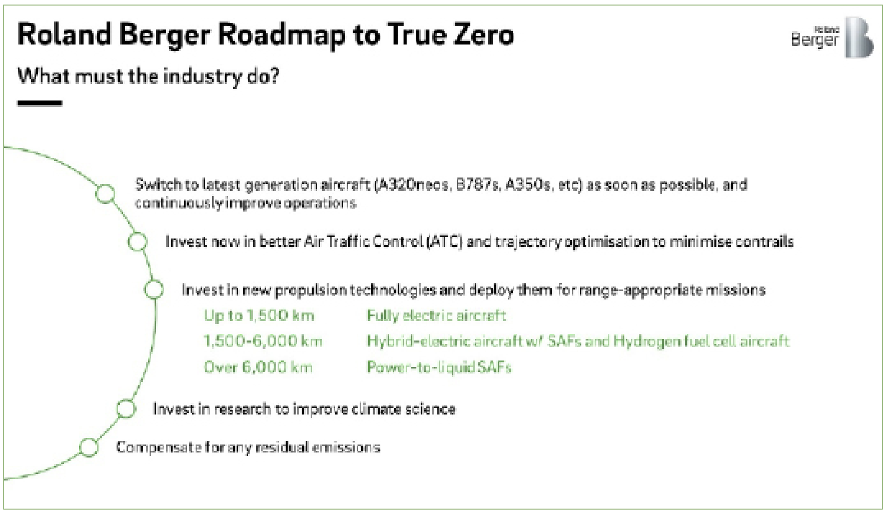
However, while scientific uncertainty remains over the exact quantum of non-CO_2 effects, the practical reality is quite clear: both CO_2 and non-CO_2 effects contribute to warming and are extremely important to mitigate. For aviation to remove its total environmental footprint, the industry must work to tackle both carbon and non-carbon effects with equal emphasis and aim for a 'True Zero'. If this holistic picture is not taken into account in making critical decisions in the coming few years, we may face the issue of having decarbonised, only to realise that we missed – or possibly exacerbated – the impact of non-carbon effects.

Despite the scale of the problem, there is unfortunately no 'silver bullet' or single solution which can conceivably address the whole challenge and achieve True Zero, while retaining and maintaining a functioning aviation ecosystem.



Three categories of solutions exist: novel sustainable aviation fuels (SAFs) such as Power-to-Liquid eKerosene, aircraft electrical propulsion and hydrogen propulsion. While SAFs are a net-zero carbon solution, they do not sufficiently address other radiative forces. While parallel and series hybrids are a step in the right direction on all effects, only battery electric can completely remove them in operation but is technologically and commercially extremely difficult to deliver for large commercial aircraft. Hydrogen options are also indeed very promising but do not sufficiently address all warming effects: hydrogen fuel cells are a nearly True Zero solution but still produce large quantities of water vapour and potentially contrails, while hydrogen combustion, though technologically somewhat less complex, would also still produce NOx.

So how can aviation completely remove its environmental impact? We at Roland Berger propose the Roadmap to True Zero: a 5-step plan to minimise aviation's annual environmental footprint by 2050.

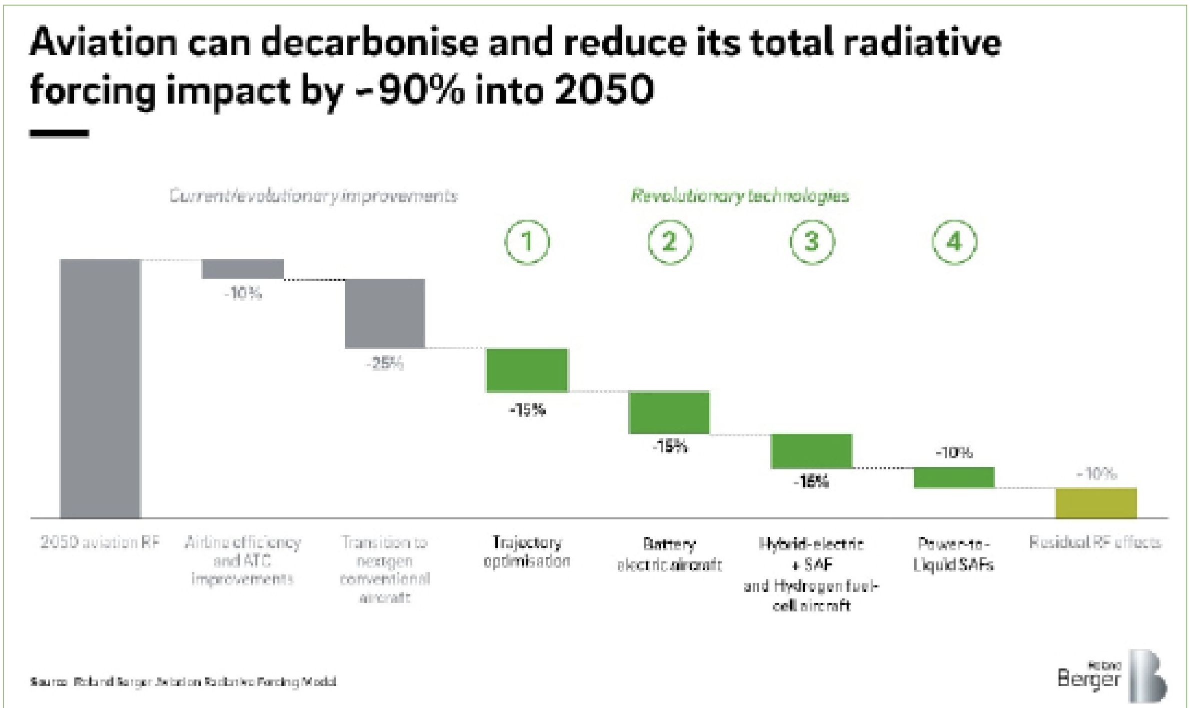


First, airlines must continue on their existing path to keep improving their operations and keep switching to the latest aircraft. Second, we need continued investment into smoother air traffic control – but also, crucially, an investment into trajectory optimisation, which is essentially air traffic control for contrail minimisation. Third, the aerospace sector must invest heavily in not one but three categories of aircraft technology, broken down by flight mission requirement: battery-electric aircraft for the shortest flight segments, SAFs powering the longest flights performed by the largest aircraft, and hybrid-electric and/or hydrogen propulsion serving the all-important narrowbody segment. Fourth, and in parallel, the sector must keep investing in research to continuously improve climate science so we can keep refining our understanding of the problem and a strategy for the solution. Finally, for whatever emissions are remaining, we recommend compensating for the residual, for example, via rigorous certified offsetting.

The impact of these improvements can be best measured against aviation's 2050 environmental footprint.

Airline operational improvement measures (such as aircraft weight reduction, best cruise speed adherence and continuous descent) and **ATC improvements** (such as the Single European Skies initiative) are estimated to be worth an estimated 10% of aviation's 2050 footprint, driven by a 10% expected reduction in fuel burn.

The impact of **replacing aircrafts with the latest generation** in their category (such as the A320neo, B737 MAX, B787 and A350) is significant. While airlines are currently in dire straits, the aviation sector will hopefully recover strongly in due course, and airlines should endeavour to transition to the best in class aircraft as soon as possible, with an environmental impact reduction worth around 25% by 2050. This relatively high impact is due to the sheer number of very inefficient classic generation aircraft still flying (for example, 35% of the pre-Covid US fleet was classic generation aircraft), and due to the significant reduction in soot and particulates (and thus partial reduction in contrails) afforded by the latest generation of engines.



Next is **trajectory optimisation**, wherein flights are redirected to minimise contrails, by flying lower and avoiding high risk pockets of air. While this can increase fuel burn slightly, the impact in contrail reduction can be significant, resulting in an estimated 15% reduction in total environmental impact, with no major aircraft or engine technology changes required.

Up to this point in the roadmap, significant impact is already possible – all without the inclusion of new aircraft technologies. However, any further improvement does require revolutionary aircraft platforms.

Battery electric aircraft are applicable to shorter ranges and smaller aircraft, up to 1,500 km, and since they remove fuel burn completely, they eliminate all emissions from the sectors they fly in (assuming batteries are charged with renewable energy), with an impact of around 15%.

In the narrowbody segment, up to 6,000 km, we anticipate **both hybrid and hydrogen aircraft** to play equally important roles. Given the scale of the narrowbody market, we expect a bifurcation in aircraft technology with aircraft manufacturers taking on different strategies – we therefore forecast this segment will be addressed by 50% hybrid and 50% hydrogen aircraft. Hybrids will burn not kerosene but SAFs (such as Power-to-Liquid eKerosene), which on a net basis can completely decarbonise. Hydrogen fuel cell aircraft will decarbonise completely in gross emissions but will increase water vapour emissions and not completely remove contrails. In total, the net impact of these aircraft is around 15%.

Finally, for the largest aircraft performing long-haul journeys, the only viable solution expected into 2050 is **sustainable aviation fuels**. These can decarbonise completely, albeit only on a net basis – with unfortunately minimal improvements in non-CO_2 effects. Considering both net CO_2 and non-CO_2 effects, this is worth 10%.

This leaves approximately 10% of aviation's total environmental footprint in 2050. This remainder is made up of mainly NOx and contrail effects – and, crucially, we have completely decarbonised. We recommend that the effects of these emissions are compensated in other ways, such as through **rigorous and certified offsetting**.

Our proposed Roadmap to True Zero is one of many paths that can be considered. Some improvements which are not covered in the roadmap include air traffic concepts such as formation flying, network concepts like replacing long-haul flights with connecting flights, and the impact of new carbon market incentives such as 'carbon equivalent pricing'. These ideas could indeed be complementary but have not been considered in preference of focusing on technological changes while keeping the network and market structure constant.

In conclusion, we strongly believe that a combination of solutions does exist that can tackle aviation's CO2 and non-CO2 impacts and pave the way to a genuine True Zero. Today's focus is on decarbonisation, and while this must remain the priority, non-carbon effects cannot be ignored. However, there is no silver bullet or one-size-fits-all solution. The Roland Berger Roadmap to True Zero thus deploys a mixture of conventional and revolutionary technologies for range-specific missions, including electric, hydrogen and SAFs where they can have the greatest impact, and 'low hanging fruit' improvements such as trajectory optimisation. By applying the Roadmap to True Zero, aviation can completely decarbonise by 2050, and its total environmental footprint can be reduced by 90%, with just 10% remaining to be compensated through methods like offsetting to achieve True Zero.

To find out more about the Roadmap to True Zero and to discuss it further, contact the author at nikhil.sachdeva@rolandberger.com or connect with Nikhil Sachdeva via LinkedIn. To read the latest analysis in electrical propulsion and other new aviation propulsion technologies, please visit the Roland Berger website, where you can also subscribe for regular updates.

About Roland Berger: Roland Berger is the only management consultancy of European heritage with a strong international footprint. As an independent firm, solely owned by our partners, we operate 50 offices in all major markets. Our 2400 employees offer a unique combination of an analytical approach with an empathic attitude. Driven by our values of entrepreneurship, excellence and empathy, we at Roland Berger are convinced that the world needs a new sustainable paradigm that takes the entire value cycle into account. Working across competence teams, all relevant industries and business functions we provide the best expertise to meet the most profound challenges of our time and the future. The Roland Berger Aerospace & Defence has been running a Sustainable Aviation working group since 2016, and has been active in researching, sharing insights and developing sustainability and decarbonisation strategies, helping clients achieve a net-zero aerospace and aviation industry, and helping to propel the development of sustainable aviation technologies including Hydrogen Propulsion, Sustainable Aviation Fuels and Electrical Propulsion.

This article is a reproduction of Nikhil Sachdeva's article in GreenAirOnline in September 2020, https://archives.greenairnews.com/www.greenaironline.com/news8d01.html?viewStory=2733

SESAR INNOVATION DAYS SHOWCASES NOVEL CONCEPTS TO MAKE AVIATION SMARTER AND SUSTAINABLE

THE ELEVENTH SESAR INNOVATION DAYS

Multimodality, climate neutral aviation and urban air mobility were just some of the research themes to be presented during the 11th SESAR Innovation Days (SIDs), which took place on 6-9 December as a virtual conference. Results stemming from the showcased projects have the potential to push the boundaries of air traffic management (ATM), making it smarter and more sustainable in the coming years, participants heard.

In its eleventh edition, the SESAR Innovation Days has showcased some of the breakthrough concepts from the SESAR Joint Undertaking's exploratory research portfolio, as well as novel outcomes from the broader ATM research community.

Altogether, the conference featured more than 30 posters and 30 papers, covering wake vortex detection, data-driven methods for safety and resilience prediction, climate-optimised trajectories, capacity sharing in virtual centres, drone traffic management, among other research topics.

The concepts presented reflect Europe's vision to make its airspace the most efficient and environmentally-friendly sky to fly in the world, contributing to the long-term sustainability of the aviation industry and its recovery from the COVID crisis.

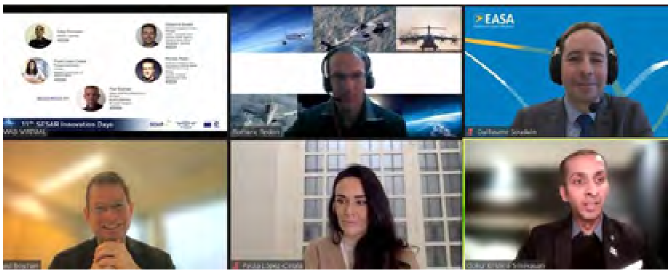
DIGITALIZATION, MULTIMODALITY, ARTIFICIAL INTELLIGENCE

"The pandemic has highlighted the urgent need to move ahead with the **digital transformation** of air traffic management in Europe, to build greater resilience, scalability and sustainability into the system," said Richard Frizon, Executive Director ad interim of the SESAR Joint Undertaking. "This requires the continuing engagement of the ATM research community, young talent and strong collaborations like those on display at the SESAR Innovation Days."

Researchers [in ATM] have a double objective to work on; the decarbonisation of aviation and digitalisation, said Eamonn Brennan, Director General, EUROCONTROL, who gave the opening keynote. "What's different today is that these are no longer regarded as separate objectives; we have to have digitalisation done in a way that reduces our carbon footprint. So whatever we develop and implement has to be innovative, but it has to be productive, add capacity and decarbonise all at the same time", he added.

We also must think **multimodal,** and move away from modernising modes of transport in isolation of one another. That was the message passed by Carlo Borghini, Executive Director of Europe's Rail Joint Undertaking, in his keynote address. A multimodal transport system, offering seamless mobility services, is an essential component of smarter and more sustainable mobility in Europe, he argued. The topic was also the focus of a conference panel, which looked at progress made towards multimodality and what steps need to be taken to speed up its delivery.

The conference also dedicated a session to the application of **artificial intelligence** in ATM. The panel of experts discussed the limitless potential of AI to support the automation of air traffic control, but underlined the need for an approach that is human-centric and progressive in order for these applications to be reliable, safe and certifiable.



THE SESAR YOUNG SCIENTIST AWARD CEREMONY

Fittingly, the conference closed with the SESAR Young Scientist Award ceremony, celebrating the next generation of aviation and ATM researchers. The 2021 edition of the award widened its scope, recognising scientific excellence in two categories; post doctorates ("PhD"), and undergraduate and master students ("students"). The top prize in the **students category** went to **Chen Xia**, Universidad Politécnica de Madrid, who addressed conflict anticipation and resolutions to mitigate the risk of mid-air loss of separation. The jury commended Xia for the approach taken and the remarkable level of knowledge and accuracy shown in her thesis.

Philippe Monmousseau, ENAC, won first prize in the **PhD category** for his work on performance-based assessments in air traffic management. The jury commended him for his scientific rigour and for expanding the conventional key performance indicators to include passenger-centric data and interfaces with other modes of transport.

More about SESAR Innovation Days
More about the Young Scientist Award

NEW SESAR 3 JOINT UNDERTAKING PROMISES TO BE BIGGER, BOLDER, BETTER

On 14 December 2021 in Brussels, took place the official launch of the SESAR 3 Joint Undertaking (SESAR 3 JU), marking a new chapter in modernising European air traffic management (ATM). Bringing together the EU, Eurocontrol, and more than 50 organisations covering the entire aviation value chain, including drones, this new European partnership will invest more than EUR 1.6 billion between now and 2030 to accelerate, through research and innovation, the delivery of an inclusive, resilient and sustainable Digital European Sky. Building on the achievements of its predecessor, the SESAR 3 JU will drive an ambitious programme to make Europe's aviation infrastructure fit for the digital age, while offering quick wins to contribute towards the sector's net zero ambitions.

Drawing upon a wide pool of multidisciplinary expertise spanning the length and breadth of Europe, the SESAR 3 JU will develop and deliver innovative solutions across nine flagship areas of research and innovation (R&I), accommodating a diverse array of air traffic, from air taxis and delivery drones to commercial airliners and military aircraft.

The portfolio of R&I activities will be structured according to an **innovation pipeline**, composed of exploratory and industrial research, large-scale demonstrators and a fast-track mechanism, to accelerate market uptake of the most promising and competitive solutions.

The new partnership will also act as catalyst for speeding up the transition towards climate neutral aviation, focusing on solutions that can be implemented rapidly and that can bring environmental benefits in the short to medium term, ahead of a ramp-up in use of sustainable aviation fuels. It will also aim to introduce solutions that allow for a more flexible and resilient infrastructure that is capable of withstanding unpredictable shocks like COVID-19.

Key to the success of the SESAR 3 JU will be close cooperation with regulatory and standardisation bodies, notably the European Union Aviation Safety Agency (EASA) and EUROCAE, in order to accelerate solutions into implementation, while working closely with the SESAR Deployment Manager.

Also critical will be creating synergies between research and innovation activities at European and national level, which will be facilitated with the establishment of a States' Representative Group to monitor the progress of the JU in line with the Horizon Europe and the Commission's top priorities, including the "Sustainable and Smart Mobility Strategy", "European Green Deal" and a "Europe fit for the digital age".

Speaking on the occasion of the first meeting of the SESAR 3 JU Governing Board, Director General of Directorate-General for Mobility and Transport (DG MOVE) and Chair of the SESAR 3 JU Governing Board, Henrik Hololei said: *"The aviation sector has to accelerate its transition to a sustainable and digital future. But I have no doubt that working together with this goal in mind, we will make it. Air traffic is recovering steadily following the pandemic, there is a rapid rise in new entrants like drones, and the aviation network is under increasing pressure to reduce emissions and address the issue of lack of scalable capacity. The public-private partnership has shown that it serves as a catalyst to speed up this transition towards a green, climate neutral and digital Europe, and to make our European industry more competitive and more resilient."*

SESAR 3 JU Executive Director ad interim, Richard Frizon said: *"The combination of the climate and COVID crises means that collaboration and the pooling of resources is more important than ever, since industry-wide challenges can only be overcome together. The new SESAR 3 JU offers the best means to coordinate efforts, bringing together the critical mass of resources, expertise and agile structure needed to deliver the Digital European Sky."*

More on the SESAR 3 JU:
Watch the SESAR 3 JU animation
Read the SESAR 3 JU brochure

OCCAR IS EXTREMELY PLEASED TO ANNOUNCE THE DELIVERY OF THE 100TH AIRCRAFT A400M AIRCRAFT TO OCCAR PARTICIPATING STATES

OCCAR-EA is extremely pleased to announce the delivery of the 100th A400M Aircraft to OCCAR Participating States. The Aircraft (MSN113) was delivered from the Final Assembly Line in Seville on 9 November 2021 to the German customer.

The above table excludes deliveries of 4 aircrafts to Malaysia, the first export sale. This has been followed very recently by the sale of 2 A400M to Kazakhstan, confirmed in September 2021, and the sale of a further 2 aircrafts (with an option for an additional 4 aircraft) to Indonesia, announced by AMSL on 19 November.

	Germany	37/53
	United Kingdom	20/22
	France	18/50
	Spain	11/27
	Turkey	9/10
	Belgium & Luxembourg	5/8

Much work has still to be done in the production phase, with a further 70 aircrafts due to be delivered by 2030, plus a retrofit programme to bring all aircraft up to the common final standard. This delivery of the 100th aircraft signifies a great achievement for the Programme, demonstrating successful cooperation between A400M Participating States, AMSL and OCCAR-EA. OCCAR-EA remains committed to supporting Nations' fleets and Industry through the life of the A400M.

If you want to learn more about the A400M programme, please visit the websites:
www.occar.int
www.occar.int/100th-a400m-aircraft-delivered?redirect=/news%2523news

AIRBUS ZEPHYR – THE WORLD'S LEADING SOLAR-ELECTRIC UAS

THE FIRST STRATOSPHERIC UAS OF ITS KIND, ZEPHYR PROVIDES A PERSISTENT AND ADAPTABLE SOLUTION, UNLIKE OTHER UNMANNED AIRCRAFT. ITS PERSISTENCE ENABLES A CAPABILITY OF FLYING CONTINUOUSLY FOR MONTHS AT A TIME, AT AROUND 70,000FT, ABOVE WEATHER AND CONVENTIONAL AIR TRAFFIC. IT IS A **HAPS**: A HIGH ALTITUDE PLATFORM STATION, AND IS THE ONLY HAPS TO HAVE DEMONSTRATED DAY/NIGHT LONGEVITY IN THE STRATOSPHERE:

- **Zephyr is the world's leading solar-electric stratospheric Unmanned Aerial System (UAS), with a wingspan of 25m and weighs less than 75kg.**
- **Having already taken to the stratosphere and breaking multiple world records, Zephyr is an innovative solution currently under development by Airbus.**
- **Zephyr will bring new See, Sense and Connect capabilities to commercial, institutional and military customers**
- **Zephyr relies on solar energy, with secondary batteries charged in daylight to power overnight flight. Thanks to this Zephyr's flight time is carbon neutral.**

ZEPHYR'S ADVANTAGES

Zephyr addresses the need for a cost effective way to provide both persistence and wide satellite like reach, along with the accuracy, station keeping and re-tasking flexibility typically inherent in conventional drone systems.

- **Persistence:** Zephyr's persistent flight is unrivalled, combining the persistence of a geostationary satellite, while maintaining the maneuverability similar to that of a traditional aircraft or UAS. During a 2018 test flight Zephyr achieved a record 25 days, 23 hour and 57 minute endurance, without refueling.
- **Latency:** Zephyr is close enough to ground stations to have little latency and offer a near real-time service
- Complementary to existing solutions: Filling the gap between ground towers, conventional aircraft and satellites, Zephyr is positioned perfectly to complement and enhance existing infrastructure.
- **Safe and secure:** Zephyr has been at the forefront of integration of stratospheric UAS into airspace, gaining civil and military approvals in five countries, across four continents.
- **Beyond Line of Sight (BLOS) Capabilities:** After take-off and ascent into the stratosphere within eight hours, Zephyr will navigate to the desired location, which may be hundreds or thousands of kilometers away. Zephyr will be controlled from a Ground Control Stations anywhere in the world using BLOS capabilities.

CAPABILITIES

Zephyr will bring new See, Sense and Connect capabilities to military, commercial and institutional customers.

SEE & SENSE

Zephyr has wide visual payload coverage of 20 by 30km footprint which enables it to provide a range of continuous surveillance to meet mission requirements as well as high resolution imagery and video capture for intelligence gathering.
Sensors located in the stratosphere can readily detect changes in the environment, gathering more precise data.

CONNECTIVITY

Zephyr has the potential to provide communications to the most unconnected parts of the world. No other aerial solution offers direct to device 4G/5G on a persistent day and night basis, complementary to existing infrastructure.

ZEPHYR: CONNECT BEYOND

> click to the picture to see the video

Zephyr shapes the future of connectivity. Delivering new services, new business models and new opportunities to the connectivity market. Zephyr is flexible, scalable and connects beyond

NASA'S SPACE X CREW-2 AND CREW-3 DRAGON MISSIONS

■ CREW-2 - NOVEMBER 9, 2021 AT 03:33 UTC: SPACE X CREW-2 ASTRONAUTS RETURNING FROM THE ISS SAFELY SPLAH DOWN IN GULF OF MEXICO

ESA astronaut Thomas Pesquet, left – NASA astronauts Megan Mc Arthur and Shane Kimbrough – JAXA astronaut Aki Hoshide, right – are seen in the SpaceX Crew-Dragon Endeavour spacecraft onboard the GO Navigation shortly after having landed in the Gulf of Mexico off the coast of Pensacola, Florida. This Crew-2 mission was the 2nd operational mission of Crew Dragon spacecraft and Falcon 9 rocket to the ISS as part of the NASA's Commercial Crew Programme. Credit: NASA/Aubrey Geminiani

■ THE ESA ASTRONAUT THOMAS PESQUET

Thomas Pesquet was born in February 1978 in Rouen, France.

- In 2001 he received a master's degree from ISAE-SUPAERO, France, majoring in spacecraft design and control. He spent his final year before graduation at Ecole Polytechnique, Montréal, Canada.
- In May 2009 he was selected as an ESA astronaut.
- On 17 November 2016 he was launched to the ISS for his 6-month 'Proxima Mission' as a flight engineer for Expeditions 50 and 51. He returned to Earth on Soyuz MS-03 on 2 June 2017 after having spent 197 days in space.

- On 28 July 2020 he was assigned to 2nd SpaceX Crew-Dragon 'Alpha Mission'.

- Crew-2 mission - Launch 23 April 2021 at 09:49:02 UTC – Return splash down on November 9, 2021 at 03:33 UTC – Total mission duration = 199 days 17 hours. He performed 4 EVAs to install new solar array equipment and upgrade the ISS's power system. He now holds the European record for most cumulative hours spent space walking: about 40 hours. On October 4, he became ISS commander.

proxima alpha

■ CREW-3: NOVEMBER 11, 2021 AT 02:03:31 UTC: LAUNCH OF SPACE X CREW-3 MISSION TO THE ISS

The SpaceX Falcon 9 rocket, with the Crew Dragon atop, soars upward after liftoff from Launch Pad 39A at NASA's Kennedy Space Center in Florida on Nov. 10, 2021. Aboard the Crew Dragon are SpaceX Crew-3 astronauts Raja Chari, commander; Tom Marshburn, pilot; and Kayla Barron, mission specialist; along with Matthias Maurer, ESA (European Space Agency) astronaut and mission specialist. Launch time was at 9:03 p.m. EST.
Photo credit: NASA/Kim Shiflett

The Expedition 66 crew poses for a photo after SpaceX Crew-3's arrival to station. Credit: NASA TV

The ESA astronaut Matthias Maurer

Matthias Maurer was born in Sankt Wendel (Saarland), Germany in March 1970.
Graduated from the Gymnasium Wendalinum in Sankt Wendel in 1989, he then followed a long study programme in materials science and technology in different institutions: Saarland University, Germany; University of Leeds, UK; the European School for Materials Technology, Nancy (EEIGM/INPL), France; and UPC Barcelona, Spain. In 2004 he graduated with doctorate in materials science engineering from the Institute of Materials Sciences of TU Aachen, Germany.
He earned several national awards in the field of materials sciences. He formally joined the European Astronauts Corps in 2015.
In December 2020 he was officially assigned to his first ISS mission known as 'Cosmic Kiss'.
After Thomas Pesquet, he is the second ESA astronaut to fly under NASA's Commercial Crew Programme.

■

THE GALILEO CONSTELLATION GROWS BIGGER AFTER SUCCESSFUL LAUNCH 11

EUSPA/PR/21/05 PRAGUE, 5 DECEMBER 2021

Two new Galileo satellites were successfully launched from the European spaceport in Kourou, French Guiana on 5 December 2021 at 01:19 CET, bringing the number of Galileo satellites launched to a total of 28 satellites, thereby enabling the provision of more robust services and precise signals across a range of industries.

On 5 December 2021 at 01:19 CET, the Soyuz launcher VS-26, successfully lifted off from Kourou, French Guiana, for a nearly four-hour voyage till the separation of the Galileo satellites 27-28 from the rocket. The Galileo Launch 11 is the first of a series of 6 launches (with two satellites per launch), which will allow Galileo to deliver greater accuracy to existing users and open up new market opportunities.

The Galileo satellites were ejected from the upper stage of the launcher at 05:09 CET, and are currently managed by the EU Agency for the Space Programme (EUSPA) and its industrial team, in charge of the satellite operations from the separation of the Launch vehicle onwards, as part of the Launch and Early Orbit Phase (LEOP).

The LEOP is one of the crucial phases of a space mission during which the spacecraft is launched and put into the correct orbit and the first satellite elements are gradually switched on and tested. Over the following days, the EUSPA team in charge of the satellite operations after separation from the launch vehicle will be maneuvering the satellites for the first time from the dedicated Galileo Control Center in Oberpfaffenhofen, Germany until they are precisely placed into their home orbit at 23 220 km. Upon commissioning and rigorous in-Orbit tests, the spacecraft will enter into the Galileo service provision.

Undertaken by a European partnership, the European Commission manages Galileo, with EUSPA overseeing Galileo operations and service provision and ESA as the design authority overseeing its development, procuring satellites, and the ground segment.

"Today we can proudly celebrate another milestone achieved by the European Union's most ambitious and largest industrial project, Galileo" says EUSPA Executive Director, Rodrigo da Costa. The successful addition of satellites 27-28 to the world's most precise positioning system is a very important step for our more than 2 billion users around the world and is the result of a robust collaboration between us, the European Commission, the European Space Agency (ESA), and our industrial partners. I would like to express my deepest gratitude to all the parties involved, who are working relentlessly to ensure the success of the mission."

About the European Union Agency for the Space Programme (EUSPA)

The European Union Agency for the Space Programme (EUSPA) provides safe and secure European satellite navigation services, promotes the commercialization of Galileo, EGNOS, and Copernicus data and services and coordinates the EU's forthcoming governmental satellite communications programme GOVSATCOM. EUSPA is responsible for the security accreditation of all the EU Space Programme components. By fostering the development of an innovative and competitive space sector and engaging with the entire EU Space community, EUSPA contributes to the European Green Deal and digital transition, the safety and security of the Union and its citizens, while reinforcing its autonomy and resilience.

For more information:

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25 DECEMBER 2021, THE JAMES WEBB SPACE TELESCOPE LIFTED OFF SUCCESSFULLY ON ARIANE 5

THE WEBB'S PRECISE LAUNCH

The Ariane5 rocket's performance was perfect, hanging with accuracy the successive sequences from the beginning - the Vulcain 2 engine ignition and EAP ignition and liftoff – to the instant when Webb separated from the Ariane 5 upper stage 27 minutes and 7 seconds after liftoff. At T+ 29 minutes and 8 seconds, Webb solar array was successfully released and fully extended. Soon after, the array went power positive and began charging up its batteries to allow Webb generate and operate under its own power.

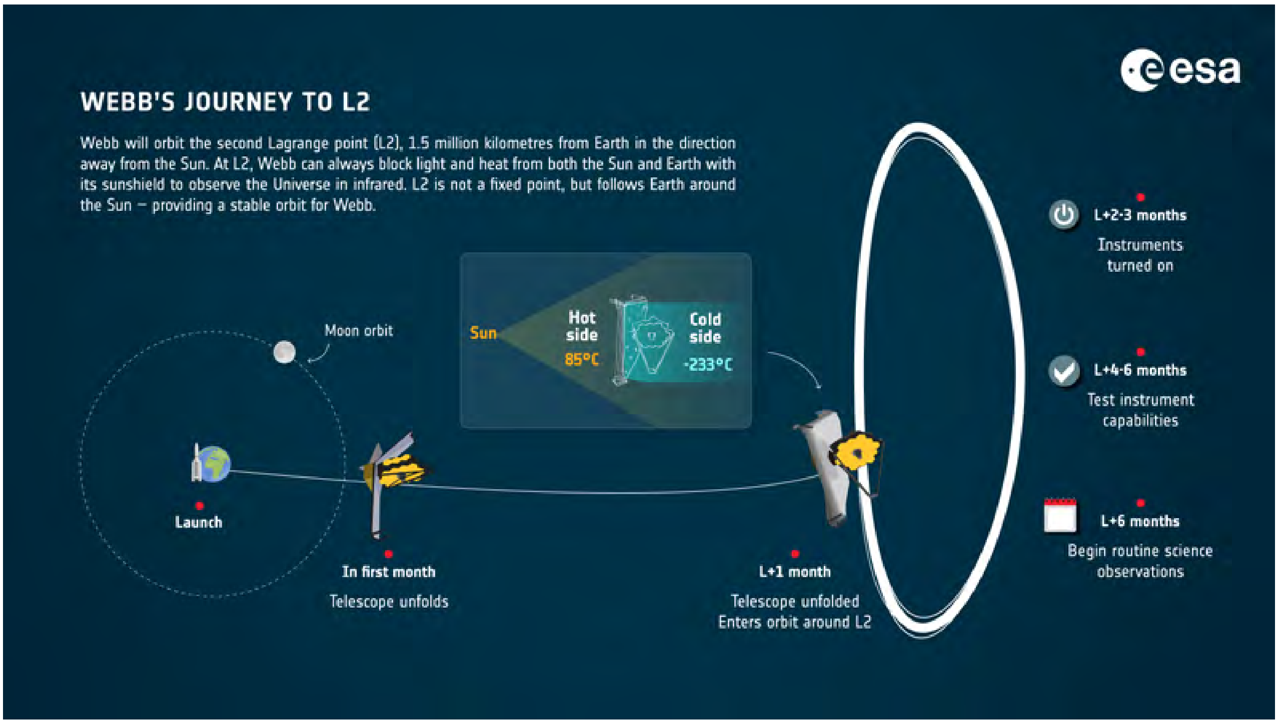
Two days after the launch of the JWST and completion of two mid-course manoeuvre, the Webb team has analysed its initial trajectory and determined that the observatory would have enough propellant to allow support of science operations in orbit for more than a 10-year lifetime, i.e. twice the specified lifetime.

This extra propellant is largely due to the precision of Ariane 5 launch which exceeded the requirement needed to put Webb on the right path, as well as the precision of the first mid-course correction manoeuvre – 65-minute burn after launch – that added about 20 m/s to the Webb's speed.

A second correction manoeuvre occurred on 27 December, adding approximately 2.8 m/s to the speed of Webb. The accuracy of the launch trajectory had a positive effect on the timing of the solar array deployment. In effect Webb being already in the correct attitude after separation from the Ariane's second stage, the solar array was able to deploy approximately one minute and a half after separation, nearly 29 minutes after launch.

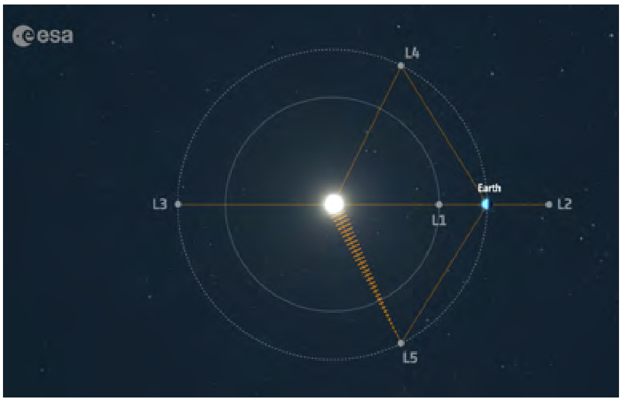
So, less propellant than originally planned will be needed to correct Webb's trajectory towards its final orbit around the 2^{n}d Lagrange Point.

Now until the 29th day after launch – 23 January 2022 – Webb is travelling to its destination, the 2nd Lagrange Point



WHAT IS L2?

There are 5 Lagrange Points: they are positions in space where the gravitational forces of a two-body system like the Sun and the Earth produce enhanced regions of attraction and repulsion. They are used by spacecraft to reduce propellant consumption needed to remain in position.



Astronomy lagrange points

WHY IS WEBB GOING TO L2?

Webb's optics and science instruments must be kept ultra cold by flying such its sunshield always shades them from the heat of the Sun. Earth and Moon – at a point in space where those celestial bodies appear in roughly in the same place.

The second Lagrange Point L2 is placed 1.5 million km from Earth. Webb will orbit this point in a 100,000 km diameter "halo" pattern, perfect for Webb's shady mission.

JWST: THE SCIENTIFIC SUCCESSOR TO HUBBLE

Webb is often presented as the replacement of Hubble. It is not exact because Webb is the scientific successor to Hubble because its scientific goals are in fact motivated by results from Hubble. Webb will primarily look at the Universe in the infrared while Hubble primarily operates at optical and UV wavelengths. The work in IR spectrum will allow scrutinise farther the Universe. Besides the mirror of Webb is much bigger than the Hubble's one.

To know JWST's Main characteristics, consult https://www.esa.int/Science_Exploration/Space_Science/Webb_factsheet

TO FOLLOW THE 29-DAY WEBB'S JOURNEY TOWARDS L2

https://jwst.nasa.gov/content/webbLaunch/whereIsWebb.html

https://jwst.nasa.gov

Webb is unpacked inside a dedicated facility at Europe's Spaceport in French Guiana after the complete telescope arrived from California by ship two month before launch. Here the telescope is set upright in vertical position. Copyright: ESA/CNES/Arianespace

AEROSPACE ENGINEERING AT THE UNIVERSITY OF BRISTOL

By Professor Jonathan Cooper

The Department of Aerospace Engineering at the University of Bristol (UOB) is one of Europe's leading academic institutions in this field, being well known for our teaching and research. The Department was set up 75 years ago at the behest of the Bristol Aircraft Company. Bristol is the centre of the UK's aerospace industry which has helped us to forge very strong industrial links.

VITAL STATISTICS – OUR RESEARCH ACTIVE DEPARTMENT CURRENTLY COMPRISES:

- 50 academics (Faculty)
- 60 post-doctoral research assistants
- 250 PhD students
- 40 postgraduate masters
- 650 undergraduate students.

Most of the undergraduates graduate with a four year Masters of Engineering (MEng) accredited degree which encompasses the fundamental engineering sciences, covered in the earlier part of the course, and more specialist aerospace engineering focused options taught in the final two years. A fully instrumented glider is used to provide flight experience for the students coupled with the use of flight simulators to reinforce material from the flight dynamics modules and flight test procedures.

University of Bristol Flight Testing Glider.

Group design is a theme that runs throughout all four years of the course with design, make and build exercises being a key element in the first two years, including a wing build exercise that comprises structural and aerodynamic design and testing with actuation elements. In the final year, the groups split into fixed wing, rotary wing and space themes and teams of 8 students work with engineers from industry to complete a challenging design challenge.

2nd Wing Design, Build and Test Exercise (Credit Will Beth)

The Faculty of Engineering prides itself on the interactions with local industry via the Industrial Liaison Office; all first year students have an industrial mentor who works for one of nearly 80 companies who provide support through structured tutorials and site visits.

The last few years have been challenging due to COVID 19 epidemic, with a lot of teaching being transferred online and a large amount of recorded material is now available across all parts of the course. At Bristol we pride ourselves on **hands-on teaching**, so in September 2020 we posted "lab-in-a box" kits to all first year students' homes and recordings of lab experiments being performed are also available when students are unable to attend the laboratory classes in person.

Postgraduate taught degrees include MScs in Aerial Robotics and Advanced Composites, complementing purely research MScs in Aerospace Engineering and Global Environmental Challenges. Many of our doctoral students are based in the Centres for Doctoral Training (CDTs) in Composite Science, Engineering and Manufacturing, Composite Manufacture and Future Autonomous Robotic Systems. The CDTs provide a 4 year route towards achieving a PhD and include the first year comprising a series of taught modules, coupled with a short project, before moving onto the main 3 year research dissertation.

Other PhD students follow the more traditional UK route of a 3.5 year PhD focusing purely on research, taking advantage of the world-leading research at Bristol which is supported by excellent computational and experimental facilities including a new 6 component wind tunnel balance, aero-acoustic and jet-noise wind tunnels. Most of the research is supported via EU H2020 and Clean

Sky projects, the UK Engineering and Physical Sciences Research Council (EPSRC) and also the UK Aerospace Technology Institute (ATI). A lot of these projects are industrially led and are good examples of the impact that the quality of the research from the Department has directly aided industry.

Our key areas of research cover the areas of flight research, composites, fluid dynamics and aerodynamics, and dynamics and control.

• FLIGHT RESEARCH

The **Flight Research Laboratory** ("FlightLab") https://flight-lab.bristol.ac.uk/ brings together over 40 researchers, students and support staff in the theme of aerial robotics. Their research encompasses a wide range of activities including unconventional sensing & actuation systems, trajectory optimization, intelligent flight control, applied machine learning, multi-agent systems, unmanned traffic management, autonomous navigation & path planning, electrical propulsion system optimization, morphing structures, trustworthy system design & operations, aerial manipulation, and bio-inspired aerial vehicles. We also apply aerial robotics in a wide range of fields including **volcanology, meteorology, agriculture, radiation monitoring, infrastructure inspection and endangered species tracking**. FlightLab enjoys a unique range of facilities for aerial robotics, supporting a spectrum of activities from indoor flight of small multi-rotors to outdoor flight of large fixed-wing platforms. We operate a dedicated aerial robotics laboratory at the University's Clifton campus, supported by two full-time technical specialists and providing specialist rapid-prototyping, assembly, testing and maintenance facilities for drones from 20 g to 20 kg in size. Standard fixed-wing and multi-rotor platforms are available as well as custom-designed platforms including hybrid configurations. These can be flown at the nearby Fenswood Field Robotics Test Facility supported by our experienced and qualified resident pilots. The Flight Research Laboratory participates in the Bristol Robotics Laboratory (BRL: http://www.brl.ac.uk) partnership with the University of the West of England, including shared use of BRL's 4,500 sqm dedicated facility on Frenchay Campus. The laboratory houses our 180 sqm instrumented indoor flight arena.

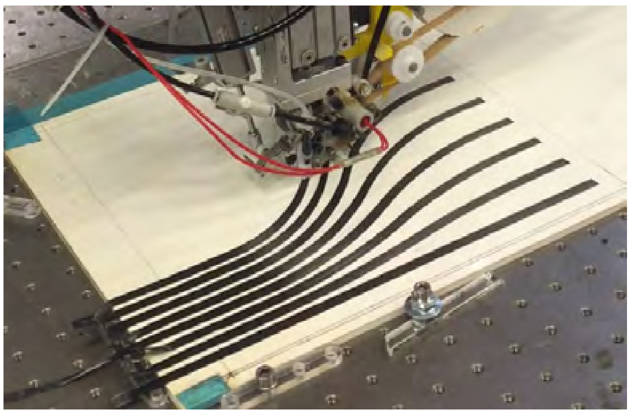
Flying Drones to Gather Scientific Data from Volcanos (Credit Bristol Flight Lab)

• COMPOSITES

The **Bristol Composites Institute** (BCI) http://www.bristol.ac.uk/composites/ is a world-leading institute for composites research and education, combining cutting-edge fundamental science with strong industrial links for exploitation and technology transfer. The research focusses upon three themes: Manufacturing and Design, Structures and Materials.

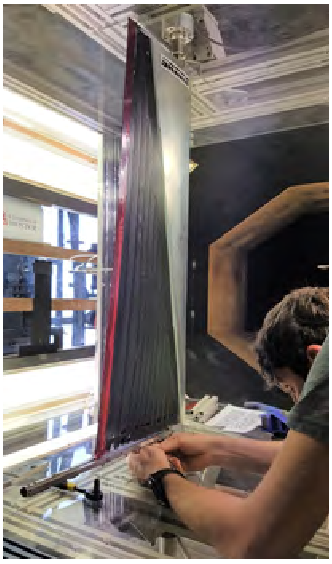
Manufacturing and Design - Our research centres around Design for Manufacture, from novel material forms that facilitate forming, through detailed process understanding and novel machines to factory operations. There is a focus on developing the means to turn ideas into hardware through efficient design and manufacturing practices. We build an in-depth understanding of current processes and develop novel and innovative manufacturing approaches, to deliver improvements in cost, quality and functionality across a range of industries.

Continuous Tow Shearing (CTS) is a novel automated fibre placement (AFP) technology developed by Dr ByungChul (Eric) Kim at the Bristol Composites Institute (BCI), which has a defect-free fibre steering capability. Differently from the conventional AFP process that bends the tow for steering, its patented mechanism applies in-plane shear deformation to a fibre tow continuously fed into the head, so that all fibres in the tow can be realigned along the same curved path without buckling.



Continuous Tow Shearing (CTS) automated fibre placement (AFP) technology (Credit Eric Kim)

Structures - Our research into the mechanical performance of composites encompasses novel numerical methods, novel structural configurations, advanced analysis techniques, multi-functionality and data rich experimentation. An understanding of the driving physical phenomena helps us build and validate models to predict the characteristics of composite structures. This research is deployed in a range of activities from blue sky projects to industrial application. As part of the Horizon 2020 funded Shape Adaptive Blade for Rotorcraft Efficiency (SABRE) program, an extensive wind tunnel test campaign at the University of Bristol showed the ability of morphing blades that can actively change their camber, chord, and twist to generate significant changes in lift with low drag penalty.



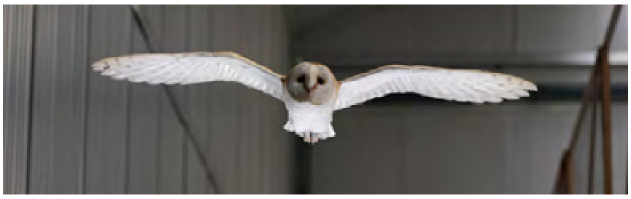
SABRE Morphing Wind Tunnel Model (Credit Ben Woods)

Materials - Here, our research centres around Design for Manufacture, working with novel material forms that facilitate forming, through detailed process understanding and novel machines to factory operations. The Materials team brings together academics with interdisciplinary background enabling us to approach challenges from different angles and come up with novel solutions. We research advanced composites for extreme engineering environments and various multifunctional smart materials.

- **FLUID DYNAMICS AND AERODYNAMICS**

The **Fluid and Aerodynamics Research Group** addresses challenges arising from the fundamental nonlinearity of fluids, and their interaction with the natural and human environment. We are building on a long history of major contributions to computational fluid dynamics and experimental aerodynamics. Computational research within the group focuses in the area of computational aero and fluid dynamics and we have developed steady and unsteady numerical simulation methods for 20 years. Research has been in various fields, including developing efficient time and space marching schemes, low speed codes for propeller and wind-turbine design, theoretical and computational modelling of asymmetric vortex shedding, direct numerical simulation methods, boundary layer integration methods, viscous-inviscid interaction, free surface flows, unsteady fixed and rotary wing flows, reduced order modelling and system identification, combustion modelling, aeroelasticity and aeroservoelasticity, grid generation, adaptation and deformation, parallel processing and visualisation.

The Faculty of Engineering at the University of Bristol has some of the best and most unique wind tunnel facilities in the country, including an Aeroacoustic wind tunnel, a low-turbulence wind tunnel, a pressure-neutral acoustic wind tunnel for propeller research, a high-speed subsonic and supersonic jet facility, and a large 7'x 5' close-circuit wind tunnel *(see page 38)*. These facilities are used to validate the numerical modelling studies.

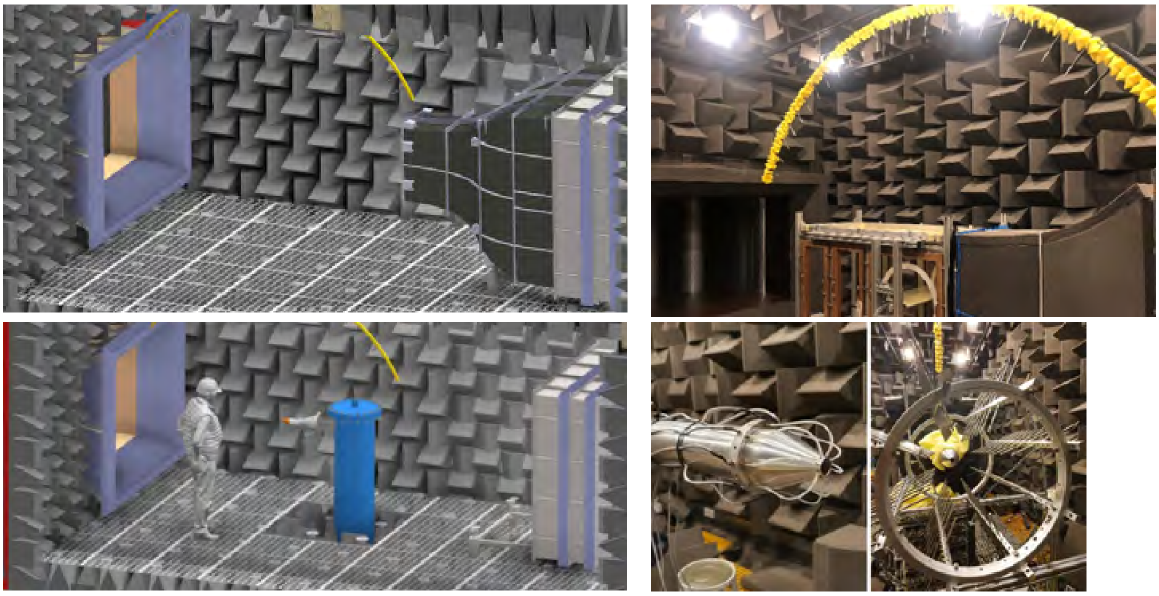


Barn Owl in-flight (Credit Cheney et al 2020)

Owl Wind Tunnel Model (Credit Nick Smith)

Bio-Inspired Flight research led by Dr Shane Windsor investigates aerodynamic, sensing and control aspects of animal flight and how we can use bio-inspiration to improve engineered technologies, particularly in the area of small scale unmanned air vehicles (UAVs). The research is inherently multidisciplinary, using techniques from both aerospace engineering and biology to study animal flight and to develop new technologies based on understanding the principles involved with biological systems. We use a range of different experimental, analytical and numerical approaches.

The world-leading Aeroacoustics research team led by Prof. Mahdi Azarpeyvand develops state-of-the-art theoretical, numerical, and experimental methods to in-

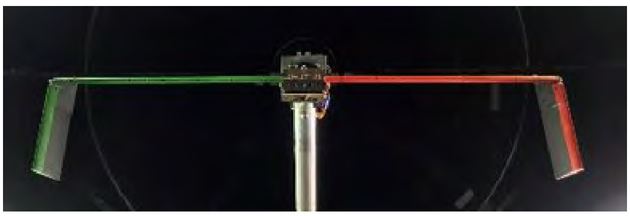


Aeroacoustics Facilities – Aeroacoustic Wind Tunnel and High Speed Jet Facility (Credit Mahdi Azarpeyvand)

vestigate the aerodynamic and acoustic performance of different aerodynamic components. The aeroacoustics team is involved in several large UK, EU and industrial research activities, with the aim to better understand the aerodynamic noise generation mechanisms and to develop robust noise mitigation methods.

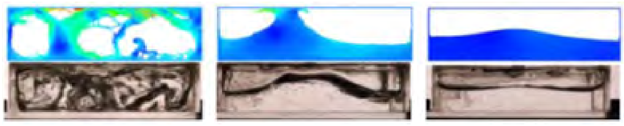
- **DYNAMICS AND CONTROL**

The Dynamics and Control Group addresses research problems relating to modelling, simulation and control of civil, mechanical and aerospace engineering systems. The research group focuses on the development of advanced analytical techniques in combination with numerical simulations and a strong element of experimental testing. n order to build more cost-efficient, less resource-intensive structures, typical operating envelopes are expanding, resulting in larger deflections and requiring analysis techniques that can handle nonlinearities in a rigorous manner. The Group is developing design tools that will not only allow structures to be designed to operate in their nonlinear region and so potentially transform their operating envelope. These tools will even allow the design of structures that actively exploit dynamic nonlinearities to give a major step change in their performance.



Semi-Aeroelastic Hinge Rolling Rig (Credit Fintan Healy)

Other work considers the modelling and exploitation of fixed wing and rotorcraft aeroelastic deflections to reduce in-flight loads and hence enable less fuel burn. UoB has been a key contributor to the development of the "Semi-Aeroelastic Hinge" concept which enables longer wing designs for improved aerodynamics whilst being able to meet airport gate limits and also without increasing gust and manoveure loads. Recent work has shown that the concept also has significant benefits for roll performance.



SPH and Experimental Photos of Three Different Phases of Sloshing Due to Transient Response (Credit Joe deCourcy and Lucian Constantin)

The SLOW-D H2020 collaborative project aiming to investigate the use of fuel slosh to reduce the design loads on aircraft structures. This goal will be achieved through investigating the damping effect of sloshing on the dynamics of flexible wing-like structures carrying liquid (fuel) via the development of experimental set-ups complemented by novel numerical and analytical tools. UoB has performed numerous experiments using fundamental test rigs to understand the underlying physics of the vertical sloshing process and the added damping that the impacts provide to the structure.

AMONG UPCOMING AEROSPACE EVENTS

2022

FEBRUARY

07-09 February – ATCA – **ATCA Annual Conference & Exposition – Washington, D.C.(USA)** – AWalter E. Washington Convention Center – https://www.atca.org/annual/

15-18 February – Singapore – **Singapore Air Show** – Asia Largest Aerospace and Defense Event – Singapore 498760 – Changi Exhibition Centre – 9, Aviation Park Road – https://www.singaporeairshow.com

MARCH

02-04 March – AIDAA – **9th International Symposium on Scale Modelling** – Napoli (Italy) – https://issmg.sciencesconf.org

02-05 March – AeroAsia – **Leading Show for General Aviation** – Zhuhai (China) – Zhuhai International Airshow Center – https://www.aero-expo.com/

05-12 March – IEEE – **2022 IEEE Aerospace Conference** – International Conference for Aerospace Experts, Academics, Military personnel and Industry leaders – Big Sky, Montana (USA) – Yellow Stone Conference Center – https://www.aeroconf.org

07-11 March – ESA-ESTEC – **ICAM22 – 1st International conference on Advanced Manufacturing for Air, Space and land Transportation** – ONLINE EVENT – https://atpi.eventsair.com/icam22/

28-30 March – ACI-EUROPE – **13th ACI-EUROPE Regional Airports Conference & Exhibition** – Palermo (Italy) – Palermo Airport – https://www.aci-europe.org/events.html

APRIL

04-06 April – ICSSA – **3rd International Academy of Astronautics Conference on Space Situational Awareness** – Madrid (Spain) – Parque Tecnologico de Madrid (PTM),C/Santiago Grisolia, n° 4 – https://reg.conferences.dce.ufl.edu/ICSSA

04-08 April – ESA-ESTEC – **NAVITEC2022 – 10th Edition of Navigation Conference** organized by ESA in coordination with CNES, DLR and Bundeswehr University Munich – https://atpi.eventsair.com/

11-14 April – IERCOFTAC – **EDRFCM – European Drag Reduction and Flow Control** – Paris (France) – CNAM – https://www.ercoftac.org/events/

13-15 April – ESA-ESTEC – **8th European Space Cryogenics Workshop** – Innovation and Challenges - Noordwijk (NL) – ESTEC – https://atpi.eventsair.com/

27-30 April – AERO Friedrichshafen – **The leading show for General Aviation** – Friedrichshafen (Germany) – Messe Friedrichshafen Exhibition Centre – https://www.aero-expo.com

MAY

03-05 May – CEAS/DGLR – **CEAS EuroGNC 2022**– Biannual conference for community researchers and practitioners in te field of aerospace GNC – Berlin (Germany) – TU Berlin – https://eurognc2022.dglr.de – Contact: michel.geimar@dglr.de

08-13 May – ESA-ESTEC – **SOIDT2022 – Space Optics Instruments design & Technology** – IPoltu Quatu (Italy) – https://atpi.eventsair.com/

10-12 May – ESA-ESTEC – **ARSI-KEO – Advanced Remote-Sensing Instruments - Instruments & subsystems + 5th Ka-band EO radar missions (KEO)** – ESTEC (NL) – www.arsi-keo.com

11-12 May – FSF – **BASS2022** – Business Aviation Safety Summit 2022 – Savannah, GA (USA) – Convention Center – https://flightsafety.org/event/

15-20 May – ESA/CNES/ONERAI – **ISMSE15 – 15th international Symposium on Materials in the Space Environment** – Leiden (NL) – Naturalis Biodiversity Centre – https://atpi.eventsair.com/ismse15/

16-19 May – CEAS/ESA – **HiSST2022 – 2nd international Conference on High-Speed Vehicle Science and Technology** – Bruges (Belgium) – Oud Sint-Jan – *https://ceas.org/2nd-international-conference-on-high-speed-vehicle-science-and-technology/*

16-20 May – ESA-ESTEC – **4S Symposium 2022 – Small Satellites Systems and Services –** Vilamoura (Portugal) – https://atpi.eventsair.com/

23-25 May – NBAA/EBAA – **EBACE 2022 – 2022 European Business Aviation Convention & Exhibition** – Geneva (Switzerland) – Geneva's Palexpo – Geneva International Airport – https://ebace.aero/2022/about

JUNE

30 May -**01** June – Elektropribor – **ICINS 2022 – 29th Saint Petersburg International Conference on Integrated Navigation Systems** – Hold by the State Research Center of the Russian Federation – Saint Petersburg (Russia) – 30, Malaya Posadskaya UL – www.elektropribor.spb.ru/en/conferences/1520

02-03 June – SAE International – **AEROCON2022** – Organised by SAEINDIA - Autonomous Airborne Systems – Trends, Challenges and Opportunities - Bangalore (India) – https://saeindia.org/aerocon2022/ - https://www.sae.org/

05-09 June – ECCOMAS – **ECCOMAS Congress 2022 – 8th European Congress on Computational Methods in Applied Sciences and Engineering** – Oslo (Norway) – https://www.eccomas.org/

13-17 June University Madrid/CEAS – **IFASD 2022** – International Forum of Aeroelasticity and Structural Dynamics – Madrid (Spain) – https://eventos.uc/go/IFASD2022

14-17 June – AIAA/CEAS – **28th AIAA CEAS Aeroacoustics Conference** – Southampton (UK) – Venue TBC – https://www.aerosociety.com/events-calendar/

19-23 June – ESA-ESTEC – **FAR2022 – 2nd International Conference on Flight Vehicles, Aerothermodynamics and Re-Entry Missions** – Heilbronn (Germany) – https://atpi.eventsair.com/far2022

21-24 June – AIAA – **ICNPAA2022 –** Mathematical Problems in Engineering Aerospace and Sciences – Prague (Czech Republic) – www.icnpaa.com/index-php/icnpaa/ICNPAA2020

21-27 June – AIAA – **AIAA Aviation Forum –** AIAA Aviation and Aeronautics Forum and Exposition – Chicago, IL (USA) – Hilton Chicago – https://www.aiaa.org/aviation/

22-25 June – BLDI – **ILA BERLIN 2022 – International Air Show – Motto: INNOVATION AND LEADERSHIP IN AEROSPACE –** Berlin (Germany) – Berlin ExpoCenter Airport – New HYBRID CONCEPT at BER Airport with focus on Innovation, Technology and Sustainability – https://www.ila-berlin.de/en

23-25 June – ESA-ESTEC – **2022 ESA Workshop on Aerospace EMC –** Postdam (Germany) – https://atpi.eventsair.com/emc-2022/

24-26 June – ICCIA – **ICCIA2022 –** 7th International Conference on Computational Intelligence and Applications – Nanjing (China) – Nanjing Tech University – www.iccia.org contact: iccia@zhconf.ac.cn

JULY

27 June – **01** July – AIAA – **AIAA Aviation Forum and Aeronautics Forum and Exposition** – Chicago, IL (USA) – Hilton Chicago – Event in presence and Online – https://www.aiaa.org/aviation

27 June – **01** July – EUCASS/3AF – **EUCASS Conference –** Lille (France) – Grand Palais Bold Halle – https://www.eucass.eu

16-24 July – COSPAR – **COSPAR2022 - 44thAssembly of the Committee on Space Research (COSPAR) and Associate Events –** ATHENS (Greece) – Megaron International Conference Centre – MAICC – https://www.cosparathens2022.org/

18-22 July – FIA2022 – **Farnborough International Air Show –** Farnborough (UK) – https://www.farnboroughairshow.com/fia2022/

SEPTEMBER

04-09 September – ICAS/FTF/Innovair – **ICAS2022 – 33rd Congress of ICAS (International Council of the Aeronautical Sciences** – Hosted by FTF and Innovair – Stockholm (Sweden) – www.icas2022.com – www.ftfsweden.se – www.innovair.org

05-09 September – ERF/CEAS – **ERF2022 – 48th ERF – Winterthur (Switzerland)** – Zurich University of Applied Sciences ZHAW – www.erf2022.ch – https://rotorcraft-forum.eu/

13-16 September – EUROMECH – **EFMC14 – 14th European Fluid Mechanics Conference** – Athens (Greece) – University Patras – www.efmc.14 - https://euromech.org

18-22 September – IAF – **Hosted by CNES – IAC 2022 – 73rd International Astronautical Congress** – Space for @ll – Special attention will be paid to students and young people – Paris (France) – Paris Convention Centre – https://iac2022.org

OCTOBER

18-21 October – EASN – **12th EASN International Conference - Innovation in Aviation and Space for Opening New horizons** – Plenary Talks – Thematic Sessions – Technical Workshops – Barcelona (Spain) – Universitat Politecnica de Catalunya – https://easnconference.eu