BULLETIN

# AEROSPACE EUROPE

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## ENSURING FUTURE SUSTAINABILITY OF SPACE OPERATIONS:THE ORBITAL DEBRIS

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CEAS
COUNCIL OF EUROPEAN AEROSPACE SOCIETIES

## 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: 3AF (France), AIAE (Spain), AIDAA (Italy), AAAR (Romania), CzAeS (Czech Republic), DGLR (Germany), FTF (Sweden), NVvL (The Netherlands), PSAA (Poland), RAeS (United Kingdom), SVFW ( Switzerland) and TsAGI (Russia);
- 4 Corporate Members: ESA, EASA, EUROCONTROL and EUROAVIA;
- 7 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) and KSAS (Korean Society for Aeronautical and Space Sciences).

*The 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

Besides, 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 so-called '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 their 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

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

EDITORIAL COMMITTEE
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sanfourche.jean-pierre@orange.fr
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**Design & Page Setting :** Sophie Bougnon
sophie.bougnon1@sfr.fr

## THE OFFICERS OF THE BOARD IN 2019:

**President:** Zdobyslaw Goraj
goraj@meil.pw.edu.pl
**Vice-President, Finance:**
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cornelia.hillenherms@dglr.de
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pierre.bescond@laposte.net
**Vice-President, Awards and Membership:** Kaj Lundahl
klundahl@bredband.net
**Director General (including Financial Management):**
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mercedes.oliver-herrero@airbus.com
**Chairman of the Aeronautics Branch:** Christophe Hermans
**Chairman of the Space Branch:**
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torben.henriksen@esa.int

## FULL MEMBERS:

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6,rue Galilée – F-75016 Paris
Tel.: + 33 (0) 1 56 64 12 30 – www.3af.fr
**President:** Michel Scheller
**Secretary General:** Louis Le Portz
**CEAS Trustees:** Michel Scheller
gestionmembres@aaaf.asso.fr
Pierre Bescond
**Executive Secretary :**
Anne Venables
secr.exec@aaaf.asso.fr

### ■ Asociación de Ingenieros Aeronáuticos de España (AIAE)

COIAE. Francisco Silvela 71,
Entreplanta - 28250 Madrid (Spain) –
Tel.: + 34 91 745 30 30
info@coiae.es - www.coiae.es
**President:** Mrs Estefanía Matesanz Romero
**CEAS Trustees:**
Mrs Mercedes Oliver Herrero
Mrs Estefanía Matesanz Romero
**Secretary:** info@coiae.es

### ■ Associazione Italiana di Aeronautica e Astronautica (AIDAA)

Casella Postale 227 – I-00187 Roma
V.R. – Tel / Fax : +39 366 144 21 31
info@aidaa.it – www.aidaa.it
**President:** Prof. Erasmo Carrera
Politecnico di Torino - DIMA
Corso Duca degli Abruzzi 24 - 10129
Torino, Italy
erasmo.carrera@polito.it
**Secretary General:**
Prof. Cesare Cardani info@aidaa.it /
cesare.cardani@polimi.it
**CEAS Trustees:** Prof. Leonardo Lecce
leonardo.lecce@unina.it and
Prof. Franco Bernelli Zazzera
franco.bernelli@polimi.it
**Secretary:** Daniela Vinazza
daniela@aidaa.it

### ■ Aeronautics and Astronautics Association of Romania (AAAR)

220D Iuliu Maniu Ave - 061126 Bucharest 6 – Romania, P.O. 76, P.O.B. 174 –
www.aaar.ro
**President:** Prof. Virgil Stanciu
vvirgilstanciu@yahoo.com
**Vice-President and CEAS Trustee:**
Dr Eng. Valentin Silivestru
valentin.silivestru@comoti.ro
**CEAS Trustee:** Prof. Ion Fuiorea
ion.fuiorea@comoti.ro

### ■ Czech Aerospace Society (CzAeS) Novotneho lavka 200/5

110 00 Prague, Czech Republic
oslcr@csvts.cz - www.czaes.org
**President and CEAS Trustee:**
Assoc. Prof. Daniel Hanus,
CSc, EUR ING, AFAIAA
hanus@csvts.cz
**Vice-President and CEAS Trustee:**
Assoc. Prof. Jan Rohac, PhD

### ■ Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V. (DGLR)

Godesberger Allee 70 – D- 53175
Bonn – Tel.: + 49 228 30 80 50
info@dglr.de – www.dglr.de
**President:** Prof. Rolf Henke
**CEAS Trustees:** Dr Cornelia Hillenherms – cornelia.hillenherms@dlr.de
and Philip Nickenig -
philip.nickenig@dglr.de
**Secretary General:** Philip Nickenig
**Executive and Team Assistant:**
Susanne Frank -
susanne.frank@dglr.de
**Conference Manager:** Torsten Schilling – torsten.schilling@dglr.de

### ■ Flygtekniska Föreningen (FTF) – Swedish Society for Aeronautics and Astronautics

Kaj Lundahl -
c/o SSC Box 4207 – SE-171 04 Solna
T: +46-8-627 6200
klundahl@bredband.net
**President:** Captain Roland Karlsson
St - Persgatan 29 5tr, SE -
602 33 Norrköping
Tel.: + 46(0)11 345 25 16
+ 46 (0)705 38 58 06
rkrolandk@gmail.com
**CEAS Trustees:**
– Kaj Lundahl
– Prof. Petter Krus : Linköping University SE - 58183 Linköping – petter.krus@liu.se – +46 13 282 792 – +46 708 282 792 (mob)
**Secretary:** Björn Jonsson – FMV AL Flyglogistik – SE-115 88 Stockholm, Sweden – bjorn.jonsson@fmv.se

### ■ Nederlandse Vereniging voor Luchtvaarttechniek (NVvL)

c/o Netherlands Aerospace Centre
Anthony Fokkerweg 2
NL- 1059 CM Amsterdam
Tel.: + 31 88 511 3055 (secretariat)
nvvl@nlr.nl – www. nvvl.org
**President:** Christophe Hermans
**CEAS Trustee:** Christophe Hermans
christophe.hermans@dnw.aero
**Secretary General and CEAS Trustee:** Fred Abbink –
f.j.abbink@planet.nl

### ■ Polish Society of Aeronautics and Astronautics (PSAA)

Nowowiejska 24 – 00-665 Warsaw –
Poland – Phone : +48 660 009 804
http://psaa.meil.pw.edu.pl/
**President:** Pawel Stezycki:
pawel.stezycki@ge.com
**Vice-President:** Miroslaw Rodzewicz:
miro@meil.pw.edu.pl
**CEAS Trustee:** Tomasz Goetzenford-Grabowski
**General Secretary:** Andrzej Zyluk
**Treasurer:** Jacek Szumbarski
**Coordinator for Foreign Relations:**
Zdobyslaw Goraj –
goraj@meil.pw.edu.pl
**Administrative Officer:**
Beata Wierzbinska-Prus

### ■ Royal Aeronautical Society (RAeS)

No.4 Hamilton Place – London
W1 J 7 BQ – United Kingdom
Tel.:+ 44 (0)20 76 70 4300
raes@aerosociety.com
www.aerosociety.com
**President:** Rear Adm Simon Henly
CEng FRAeS

**CEAS Trustee:** Emma Bossom
emma.bossom@aerosociety.com
**Chief Executive:** Sir Brian Burridge

**■ Schweizerische Vereinigung für Flugwissenschaften/Swiss Association of Aeronautical Sciences (SVFW)**
ETH Zurich – Institute of Fluid Dynamics – Ms Bianca Maspero
CH 8092 Zurich – www.svfw.ch
**President and CEAS Trustee:**
Dr Jürg Wildi: juerg.wildi@bluewin.ch
**CEAS Trustee:** Dr Georges Bridel
c/o ALR, Gotthardstrasse 52, CH
8002 Zurich
georges.bridel@alr-aerospace.ch

**■ Central Aerohydrodynamic Institute Russian Aerospace Society (TsAGI)**
1, Zhukovsky St. – Zhukovsky,
Moskow region, 140 180,
Russian Federation
**Chief Scientific Officer:**
Sergey L. Chernyshev, D.Sc.
ved@tsagi.ru – www.tsagi.com
**CEAS Trustee:** Evgeni Andreev –
andreev@tsagi.ru
evg_andreev@tsagi.ru

## CORPORATE MEMBERS:

**■ ESA**
8-10, rue Mario Nikis - F-75015 Paris
**CEAS Representative:** Torben Henriksen – www.esa.int
**■ EASA**
Konrad - Adenauer - Ufer 3
D-50542 Cologne (Germany)
Tel.: +49 (221) 8999 0000
http://easa.europa.eu
**CEAS Representative:**
Erick Ferrandez
**■ EUROCONTROL**
Rue de la Fusée 96 - Brussels 1130
**CEAS Representative:** Marc Bourgois
http://www.eurocontrol.int
**■ EUROAVIA**
Kluyverweg 1 - 2629 HS, Delft, NL
**President and CEAS Representative:** Juan Manuel Lora Alonso
juan.alonso@euroavia.eu
Tel.:+ 39 366 81 70 482
**CEAS Representative:**
Daniele Vangone
daniele.vangone@euroavia.eu –
www.euroavia.eu

## SOCIETIES HAVING SIGNED A MOU WITH CEAS:

**■ Académie de l'Air et de l'Espace (AAE)**
1, avenue Camille Flammarion –
F-31500 Toulouse
www.academie-air-espace.com
**■ American Institute of Aeronautics and Astronautics (AIAA)**
12700 Sunrise Valley Drive
Suite 200, Reston
VA 20191 – 5807 USA
megans@aiaa.org - www.aiaa.org
**■ Chinese Society of Astronautics (CSA)**
CSA Zhang yao – WANG Yiran,
n° 8, Fucheng Road, Haidian district
P.O. Box 838
100 830 Beijing, China
Csa_zhangyao@sina.en
wanggyr@spacechina.com
www.csaspace.org.cn/
**■ European Aeronautics Science Network (EASN)**
**President:** Prof. Spiros Pantelakis
EASN Prof.Spiros Pantelakis
Rue du Trône 98 – 1050 Brussels,
Belgium – www.easn.net
**■ Association of European Research Establishments in Aeronautics (EREA)**
**Chairman:** Catalin Nae – INCAS
**EREA Secretary:** Anne-Laure Delot –
ONERA, anne-laure.delot@onera.fr
**■ International Council of the Aeronautical Sciences (ICAS)**
**President:** Susan Ying
**Executive Secretary:** Axel Probst
c/o DGLR – Godesberger Allee 70 –
D- 53175 Bonn
icas@icas.org – www.icas.org
**■ Korean Society for Aeronautical and Space Sciences (KSAS)**
Room 1001, 635-4
Yeogdam-Dong
135-703 Gangnam
Gu Republic of Korea
ksas@ksass.or.kr
http://eng.ksas.or.kr

## SIX SOCIETIES EUROPEAN AEROSPACE SCIENCE AND TECHNOLOGY RESEARCH CLOSELY LINKED WITH CEAS:

**■ EASN: European Aeronautics Science Network**
**Chairman:** Prof. Spiros Pantelakis (University of Patras)
spiros.pantelakis@easn.net
**Vice Chairman:** Zdobyslaw Goraj
(Warsaw University of Technology)
goraj@meil.pw.edu.pl

**■ ECCOMAS: European Community on Computational Methods in Applied Sciences**
Edificio C-1, Campus Norte UPC
c/Gran Capitan s/n
08034 Barcelona (Spain)
www.eccomas.org/
eccomas@cimne.upc.edu
**President:** Michal Kleiber
mkleiber@ippt.pan.pl

**■ ERCOFTAC: European Research Community on Flow Turbulence Air Combustion**
www.ercoftac.org/
**Chairman of Executive Council:**
Prof. Ananias Tomboulides
ananias@googlemail.com

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www.eucass.eu
**EUCASS President:** Walter Zinner
(Airbus Defence and Space)

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www.euromech.org
**President:** Prof. Gertjan van Heijst
G.J.F.v.Heijst@tue.nl

**■ EUROTURBO: European Turbomachinery Society**
www.euroturbo.eu/
**Chairman:** Prof. Francesco Martelli
francesco.martelli@unifi.it

# EDITORIAL

*Jean-Pierre Sanfourche*
*Editor-in-Chief*

## ABOUT AEROSPACE EUROPE CONFERENCE 2020

Since its establishment as a legal entity in January 2007, the Council of European Aerospace Societies (CEAS), has hold six conferences: Berlin 2007, Manchester 2009, Venice 2011, Linköping 2013, Delft 2015 and Bucharest 2017. They were called 'CEAS European Air & Space Conferences'.

The Assembly of Trustees of CEAS has decided to henceforth call this event AEROSPACE EUROPE CONFERENCE. This new title is more than a cosmetic measure, it in fact clearly expresses that the CEAS intends its biennial conference not only to its members but more widely to the whole European aerospace community.

The first AEROSPACE EUROPE CONFERENCE (AEC) is being co-organised by CEAS and the French Association of Aeronautics and Astronautics (3AF). AEC2020 will feature 3AF 3rd Greener Aviation, CEAS 7th Air & Space Conference and the 8th edition of Aircraft Noise and Emissions Reduction Symposium (ANERS). Hosted by the 3AF, AEC2020 will take place in Bordeaux (France) from 25 to 28 February 2020.

**Greener Aerospace Innovative Technologies and Operations for a Human Friendly Environment**

In order to optimise the efficiency and interest of the event, the choice has been taken for each edition to limit its scope by concentrating on a limited number of themes. For AEC2020, the GREENER thematic will constitute the core of the conference. The 3AF which has already achieved two Greener Aviation conferences is well placed to manage the project.

The aeronautics technical sessions will cover all the aircraft, engines, equipment and system technologies, as well as air transport operations, with a view to reducing greenhouse gases' emissions, local pollution and noise.

The numerous works conducted within Clean Sky and SESAR (Single European Sky ATM Research) programmes will of course be largely presented and debated.

As regards precisely noise and emissions reduction, the subject will also be dealt with in the frame of the joint AIAA-3AF ANERS symposium.

Besides, the conference is expected to offer additional transversal topics and synergies between aviation and space towards a greener and cleaner environment.

Concerning space, technical sessions will cover all major subjects relating to this domain.

Supporting the development of a long-term vision, this high-level technical conference will allow the different actors of air transport and space activities to present and discuss the solutions to answer the challenges they are facing.

**Why Bordeaux?**

From a touristic point of view, Bordeaux is a particularly attractive town.

Bordeaux is a highly strategic aerospace sector. From the big names in the sector – Airbus, Dassault Aviation, Thales, SAFRAN, SABENA, ArianeGroup – to cutting edge subcontractors, the area of Bordeaux offers a wide range of expertise and key technology in the aerospace systems, both civilian and military.

The management team of AEC2020 is already well in place and at work, highly motivated to realise quite a successful European aerospace event.

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*La place de la Bourse à Bordeaux © M.BOSREDON*

# CEAS annual report 2018

COUNCIL OF EUROPEAN AEROSPACE SOCIETIES

## CEAS Trustee Board and officers

End of 2017 the membership of the Greek aeronautical society HAES of CEAS was terminated unfortunately. No other changes occurred in the membership of the Trustee Board.

The CEAS board of officers was as follows:
- Christophe Hermans (president)
- Cornelia Hillenherms (VP finance)
- Pierre Bescond (VP external relations and publications)
- Kaj Lundahl (VP awards and membership)
- Mercedes Oliver (director general)
- Torben Henriksen (branch chair space)
- Christophe Hermans (branch chair aeronautics)

### CEAS @WORK

We continued our efforts on harmonizing, strengthening, promoting and facilitating effective knowledge transfer and information exchange at a European level with engagement of students and young engineers. The Aerospace Europe dissemination platform, our top-class journals, thematic events and of course our Aerospace Europe conference are important means to strengthen the European aeronautics and space communities.
The 40$^{th}$ Trustees Board Meeting of the Council of European Aerospace Societies was held on 5 and 6 February 2018 at the Politecnico di Milano, Milan (Italy). On 30 August a CEAS officers telecom was conducted, followed by a regular Trustee Board meeting on 16 November at Eurocontrol in Brussels (Belgium). At this occasion also the CEAS General Assembly 2018 took place. At its 41$^{st}$ TBM Zdobslaw Goraj of the Polish Society PSAA was elected as the new CEAS president for 2019.

In order to achieve our mission to be Europe's foremost aeronautics & space community (i.e. Aerospace Europe) bringing together member societies and corporate partners with the aim to further the advancement of aerospace sciences and engineering, a number of strategic actions have been defined:
- Maintain balanced membership basis across Europe (owner: Pierre Bescond).
- Increase recognizable value for individual members of CEAS member societies and MoU partner professionals, with special emphasis towards student and young professionals (owner: Franco Bernelli). For this purpose a CEAS academic committee will be established with the purpose to:
  - Organize yearly PhD conference (20/30 thesis per year) together with PEGASUS.
  - Publish PhD event papers in CEAS journals.
  - Set-up European quality system for higher education together with PEGASUS.
  - Support the CleanSky Academy in selecting best PhD thesis.
- Raise impact of CEAS scientific / technical journals (owners: Cornelia Hillenherms and Rafael Bureo).
- Support our corporate member's, SESAR and Clean Sky dissemination approach. It is necessary to make the links more institutional. A first step would be to propose them to be MoU partners (owner: Christophe Hermans).
- Open Access to CEAS batched conference papers not published in journals on AEROSPACE EUROPE platform. Clean Sky Academy has asked for support dedicated to aeronautical research (owner: Cornelia Hillenherms).

We welcomed Beata Wierzbinska-Prus (PSAA) who is now employed by CEAS on a part time basis providing administrative support with focus on events organized and/or batched by CEAS. One of the first achievements is the operability and availability of the E-CAero tool for conferences management for any partner. The tool has been benchmarked during the preparations of the International Conference on High-Speed Vehicle Science and Technology.

### CEAS HONOURS AND AWARDS

The CEAS award 2019 winner, unanimously selected by the Board, is Prof. Ric Parker (chairman of board of the Clean Sky Joint Undertaking and former director of Research and Technology at Rolls Royce).
The highly recognized "CEAS Aeroacoustics Award" this year was presented to prof. Sjoerd Rienstra of the Eindhoven University of Technology (the Netherlands) during the aeroacoustics conference in Atlanta (USA). The award for the best student paper in aeroacoustics was granted to Peter Baddoo of the department of applied mathematics and theoretical physics of the University of Cambridge (UK).

### CEAS BATCHED THEMATIC EVENTS

On a regular basis the CEAS Technical Committees, in close cooperation with our national member societies, organize international thematic events in several fields. Besides an impressive list of events organized by our national member societies, the following CEAS batched


events have taken place:

- 24th AIAA/CEAS Aeroacoustics Conference
- 44th European Rotorcraft Forum (ERF)
- EASN – CEAS international workshop on "Manufacturing for Growth & Innovation" at the University of Glasgow (UK)
- 22nd Aeroacoustics Workshop 'Aircraft Noise Generated from Ducted or Un-Ducted Rotors'
- 1st CEAS 'International Conference on High-Speed Vehicle Science and Technology' (HiSST).

## AEROSPACE EUROPE BULLETIN

The CEAS bulletin has changed its appearance, its name and editorial content! From this year onwards it is called the 'Aerospace Europe Bulletin', better reflecting its purpose. Jean-Pierre Sanfourche, as managing editor, again succeeded in getting 4 extensive issues published with interesting articles on relevant aeronautical subjects. The bulletin over time is also serving as a valuable archive of the activities of the society.

## CEAS AERONAUTICAL AND SPACE JOURNALS

The number of paper submissions to our journals is steadily growing and we are working on increasing the geographic distribution of the authors in some fields.

We are very grateful for the efforts of Olga Trivailo, managing editor of the Space Journal, who took on new duties at DLR. As her successor, we have welcomed Stefan Leuko (DLR).

CEAS Space Journal is already included in the Emerging Sources Citation Index (ESCI). This new index in the Web of Science™ Core Collection provides earlier visibility for sources under evaluation and thus leads to measurable citations and more transparency in the selection process. The next step in the process would be applying for an Impact Factor. The CEAS Aeronautical Journal is close to application for ESCI inclusion.

The two editorial teams again managed to attract and process 88 new interesting articles issued in four complete volumes of both our journals. Summaries of the CEAS Space Journal articles can be found following the link http://link.springer.com/journal/12567/9/ and for the CEAS Aeronautical Journal at https://link.springer.com/journal/13272/8/.

The journals are truly prominent, successful and influential, as can be concluded from more than 10.000 full text articles downloads yearly!

## CEAS AEROSPACE EUROPE CONFERENCE 2019

The Board of Trustees decided that the organisation of the first Aerospace Europe Conference (the 7th edition of the biennial CEAS Aerospace Conference), will be delegated to the French Association of Aeronautics and Astronautics (3AF). Initially foreseen in October 2019, but since too many other aerospace events will take place in 2019, it was decided to hold it in early 2020 in Bordeaux (France). Starting in an even year, the rule to hold the Aerospace Europe Conference in the odd years will be resumed in 2021.

## INTERNATIONAL COOPERATION

We have intensified the discussions with EASN to jointly organize biennial European aerospace conferences. A high level general framework for a common approach has been agreed upon in principle, but time was too short to finalize the negotiations without jeopardizing both our organization's efforts for our (individual) 2019 events.

The 'Clean Sky academy', with institutional participation of amongst others CEAS, on 27 April during the Berlin Air Show has awarded Kevin Prieur (Centre National de la Recherche Scientifique, CNRS) with the gold award, Christoforos Rekatsinas (University of Patras) with silver and there was a tie between Rainer Groh (University of Bristol) and Vittorio Memmolo (University of Naples), who both received a bronze award.

We signed a Memorandum of Understanding with the Chinese Society of Astronautics CSA to establish a mutually beneficial relationship between both our organizations. CSA is recognized as a representative, large and professional aerospace organization located in China with 179 institutional members, 23,451 individual members and 39 technical committees. The collaboration focusses on the coordination, mutual support and encouragement of cross-attendance to aerospace events and the promotion of technical exchanges between the two organizations.

Christophe Hermans, 12 December 2018
CEAS president 2017 & 2018

# RESEARCH AND TECHNOLOGY: EUROPE'S RESPONSE TO THE CHALLENGES FOR AVIATION

**By Dr.-Ing. Dietrich Knoerzer**

*Dietrich Knoerzer:*
*· Independent Aeronautics Consultant,*
*· Former Scientific Officer for Aviation, Directorate-General for Research & Innovation, European Commission*

## 1. INTRODUCTION

Civil air transport represents an important motor of the global economy and has doubled about every fifteen years despite any crisis of global scale. The share of civil aircraft produced in Europe was comparably modest until the late eighties and even the joint European initiative Airbus had commercially difficult times in the first 20 years of its existence. This paper wants to analyse how Europe's aviation could overcome the difficulties among others by research and technology (R&T) and became able to scope with the challenges to aviation.

## 2. THE CHALLENGES FOR AVIATION

**Global competitiveness**

The dominance of the US industry especially in the markets of airplanes, aero-engines and on-board equipment was overwarming until the late eighties. Only the new modern aircraft as the A320 and the A330/340 with their advanced technologies as fly-by-wire, two men cockpits and composite primary structures contributed to raise continuously the European share on the global market. Nevertheless several of the European producers of regional and commuter aircraft had to seize the market in the nineties (e.g. Fokker, Dornier, Saab, Short Brothers), often because of global competition and changed market requirements. Since then for about 20 years Airbus and Boeing had a duopoly in the large global market of airliners with more than 100 seats. Since a few years the China with the C919 and Russia with the MS21 aim to enter the market. These aircraft and also the joint wide-body aircraft project C929 were and are developed with the substantial government support.

**Environmental Challenges**

Global warming, mainly caused by rising $CO_2$ emissions with all its consequences is one of the most challenging issues for mankind. Aviation with its steady growth of more than 4 % per year [1] is one of the contributors of greenhouse gases.

In November 2017 the International Civil Aviation Organisation (ICAO) declared its commitment at the World Climate Conference in Bonn "to achieve the sector's global aspirational goal of carbon-neutral growth from 2020".

As *Fig. 1* shows, all today feasible measures are not sufficient to achieve this commitment from 2020. Consequently economic compensation measures will be needed. Therefore ICAO decided to introduce the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which will become operational through a pilot phase (2021-2023), followed by a first phase (2024-2026) for those States that have volunteered to participate in the scheme [2]. The second phase (2027-2035) will apply to all States. ICAO also has determined eligible emissions units, which airlines will purchase in order to meet their offsetting requirements under CORSIA. There remain doubts that these measures will provide sufficient funding for greening measures that compensate the aviation growth after 2020.

**The European air transport system**

The steadily rising air traffic and the increasing congestion in the air space and at the large airports of the metropolitan areas require a larger operational capacity for Europe's air space combined within enhancing measures for safety and security.

The European Union is on its way to establish the Single European Sky (SES), which is expected to ensure the safe and efficient utilisation of airspace and the air traffic management system within and beyond the EU. SES is supported by the Single European Sky ATM Research (SESAR) Programme, which will provide advanced technologies and procedures with a view to modernising and optimising the future European air traffic management (ATM) network.

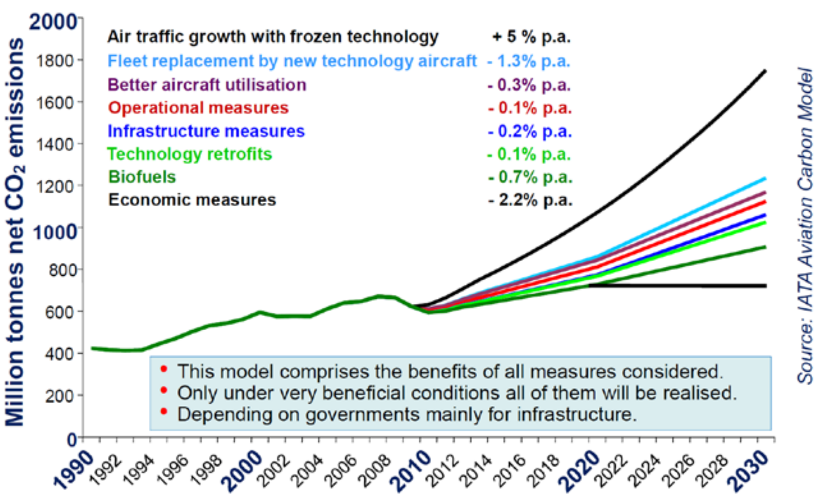


*Fig 1: Contribution of different measures reducing $CO_2$ emission from commercial airlines global fuel burn*

## 3. AERONAUTICS RESEARCH IN EUROPE

### European Research

In 1973 the Group for Aeronautical Research and Technology in Europe (GARTEUR) was founded by Government agreements. Today seven countries are involved in GARTEUR: France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom mainly through their national aerospace research establishments. GARTEUR has conducted numerous collaborative R&T projects for defence, dual use and civil applications with funding by limited separate national budgets.

In 1987 a group of nine European aircraft manufacturers from seven countries performed a study on the future needs of research and technology (R&T). This joint study of European cooperative measures for aeronautics research and technology (EUROMART) was co-funded by the European Commission and let in 1989 to the pilot phase of specific aeronautics research within the 2nd Research Framework Programme of the EU with the modest budget of 35 million Euro (ECU). Through the different Framework Programmes this European aeronautics R&T programme became a success story within an increasing budget and technological impacts, because Europe's industry and research community learnt to cooperate by sharing know-how as far as possible without violating the different commercial interests of the R&T cooperation partners.

In Horizon 2020 (2014 – 2020) the EU budget for aeronautics and air transport accumulates to nearly three billion Euro covering R&T activities from cooperative upstream research to technology demonstration through the large public-private-partnership Clean Sky. It includes also 585 million € for joint undertaking SESAR (*Fig. 2*). The reasons for the success of the joint research projects are the common source of funding for all project partners and the collaborative R&T effort, which allows a faster technological progress than by the limited resources of the individual research partners alone.

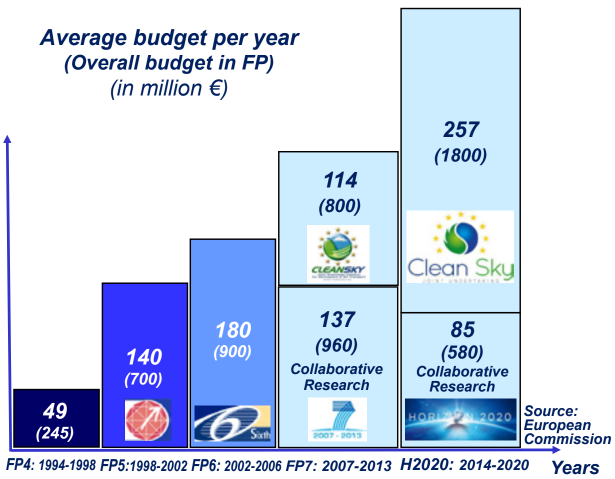


*Fig 2: Development of the aeronautics R&T budget within the EU Research Framework Programmes. In Horizon 2020: Additional 585 million € contribution to SESAR.*


*Fig 3: Europe' strategic approach for aviation: Vision 2020, Flightpath 2050 and Strategic Research & Innovation Agenda (Update 2017)*

### National Research of the Member States

The national aeronautics research activities of the EU Member States have the main objective to strengthen the competence and competitiveness of the country's industry and research institutions. They are often complementary to the research programmes on EU-level but normally limited to national cooperation. Between the German aeronautics R&T programme LuFo and the related Austrian programme TAKE-OFF a cooperation of projects with mutual interest takes place, however without cross-border transfer of funding. Other national aeronautics R&T programmes exist in France, Spain, Sweden, the United Kingdom and others.

### Europe' strategic initiative in Aeronautics

In 2000 a high-level group under the EU Commissioner Philippe Buisquin set up the Vision for 2020 for European Aeronautics and identified the main challenges and goals for future aviation *(Fig. 3)*. The Vision 2020 gained world-wide attention and let to similar initiatives e. g. in the USA. The Advisory Council for Aeronautics Research in Europe (ACARE), which was established in 2001 and involved all aviation stakeholders, developed the Strategic Research Agenda (SRA) for aeronautics in 2002. The SRA gave guidance for the research programmes on European and Members States' level and was updated in 2004 and 2008 due to changed boundary conditions and challenges for aviation (e.g. for security).

In 2011 Europe's new Vision for Aviation Flightpath 2050 was published with a long-term perspective until 2050 [3]. Based on Flightpath 2050 the SRA was reviewed and became the new Strategic Research & Innovation Agenda (SRIA) in 2012 and was updated in 2017 *(Fig. 3)*. The SRIA gave the guidance for the R&T priorities to aviation stakeholders and for Europe's Horizon 2020 and national research initiatives.

Europe's Vision for Aviation, Flightpath 2050 defines highly ambitious goals, which can be summarised under two main goals:

**1. Maintaining global leadership:**

- Providing the best products and associated services in aeronautics and air transport;
- Ensuring the competitiveness of European industry,

supported by a strong research network and balanced regulatory framework;
- Maximising the aviation sector's economic contribution and creating value;
- Attracting the best people and talents.

**2. Serving society's needs, which includes amongst others:**
- Meeting societal and market needs for affordable, sustainable, reliable and seamless transport system for passengers and freight with sufficient capacity;
- Protecting the environment and enabling the use of sustainable energy and alternative energy sources;
- Ensuring safety and security;
- Providing opportunities for highly qualified and skilled jobs in Europe.

Under the environment goals Flightpath 2050 requires technologies and procedures available in 2050 that allow
- 75% reduction in $CO_2$ emissions per passenger kilometre,
- 90% reduction in NOx emissions, and
- 65% reduction in perceived noise emission of flying aircraft.

These reductions are relative to the capabilities of typical new aircraft in 2000.

## 4. TECHNOLOGICAL ACHIEVEMENTS

**Achievements of European aero-engine R&T**

For reaching the ambitious environmental goals of ACARE in the field of aero-engines, nine large scale EU projects addressed the critical technologies with a total budget of about 600 million € in the years 2000 to 2018. By addressing all key engine components together with other projects, these integrated projects (e.g. LEMCOTEC, ENOVAL or E-BREAK) achieved significant improvements relative to new engines or aircraft operated in the year 2000 [4]:
- $CO_2$ reduction by 25 – 30 %,
- NOx reduction of 65 – 70 %,
- Noise reduction by 9 dB.

The next generation of aero-engines is expected to incorporate most of these achievements.

**NOx reduction of modern aero-engines**

As NOx emitted in the upper atmosphere can last several weeks and destroys the Ozone layer, the ICAO Committee on Aviation Environmental. Protection (CAEP) prescribes stringent limits for the NOx emission of modern aero-engines.
The numerous research activities in Europe ensure that the ACARE goal (-80% in 2020) and the CAEP limits can be met by the future generation of aero-engine combustors *(Fig. 4)*.

**$CO_2$ reduction by laminar flow technologies**

For the $CO_2$ emission reduction the technique of keeping the flow around the airframe as far as possible laminar is the most promising single technology with a drag reduction potential of more than 10%, leading to a similar fuel saving potential. Numerous research projects have proven this and assessed the potential. In 2018 within the Clean Sky programme a large scale flight test with an Airbus A340 was performed on natural laminar flow at transonic speed *(Fig. 5)*. With modified outer wings not only the aerodynamic improvement were investigated, but also different manufacturing concepts were tested. It is expected, that the next generation of new airliners will enhance its performance by using the potential of laminar flow technology.

Modern aircraft as the Airbus A350XWB *(Fig. 6)* use already many of the new technological achievements of Europe's R&T activities, such as:
- Composite primary structures for wing and fuselage;
- Integrated and modular avionics architecture;
- Electro-hydraulic actuators;
- Computational design methods and advanced testing techniques for the aerodynamic shape optimisation.

## 5. FUTURE PERSPECTIVES

**Ensuring Europe's role in aviation**

Following Flightpath 2050, the European aviation industry has to ensure its leading place in the world. It

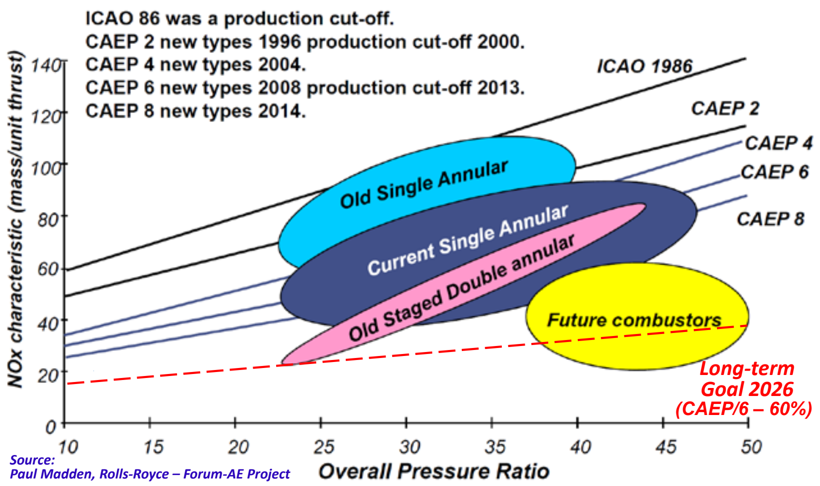


*Fig. 4: Significant progress in NOx emissions reduction could be reached for aero-engines [5].*

has to make sure that in future it remains globally recognised for its innovative, sustainable and highly competitive aircraft, aero-engines, systems and services.
Environmental protection will remain a prime driver for the development of new aircraft and for the future air transport system.
Until now the European and trans-national co-operation in research and innovation improved significantly Europe's position in aeronautics and air transport and should continue to do so.

World-wide international research co-operation is needed to tackle the challenges for aviation on a global scale as on safety and environmental issues.
In 2017 the SRIA was updated reflecting changed or additional challenges to aviation [6]. Beside the need for competitiveness and the demanding environmental targets, a number of new issues need to be tackled through research and innovation, such as:
- Security and cybersecurity threats, e.g. to aircraft equipment or ATM systems;
- Developments in digitalisation and big data;
- New mobility system concepts and vehicle types including remotely-piloted aircraft systems (RPAS)
- Availability of appropriate research and test infrastructure and of a capable work force.

**Towards Horizon Europe**
In 2021 the new Framework Programme for Research and Innovation of the European Union 'Horizon Europe' will be launched. The preparation process has started, and aviation research and innovation will find its place within the cluster 'Climate, Energy and Mobility' of the Pillar 2 'Global Challenges and Industrial Competitiveness' of the Commission proposal for 'Horizon Europe' (2021 - 2027).

*Fig. 5: The Airbus A340-001 with modified outer wings for the laminar flow flight tests of Clean Sky in 2018 (©Airbus)*

*Fig. 6: The Airbus A350XWB uses numerous advanced technologies of European R&T activities (©Airbus)*

Analysing the best practice of aeronautics research in previous EU Framework Programmes, the future European research and innovation in aviation should be based on the following pillars of research activities with a well allocated budget share:
- Basic research and break-through technologies;
- Medium-size collaborative projects for research & technological development;
- Large-scale integrated projects for technology validation, and
- Public-private-partnership initiatives for large-scale technology demonstration and innovation as Clean Sky or SESAR.

## 6. CONCLUSIONS
Research and technology were key factors for the successful development of Europe's aviation in the last thirty years. European research cooperation financed through the European Union played a significant role in this development. Technological achievements and the latest generation of aeronautics products have proven that ambitious goals, as defined by Europe's Vision, can be met.
By the Vision Flightpath 2050 and the SRIA 2017 all aviation stakeholders and Europe's politicians have sound instruments of guidance in hand for planning future R&T activities in aviation. They all are well advised to use them.

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# AN EXAMPLE OF CLEAN SKY R&T PROJECT : BREAKTHROUGH LAMINAR AIRCRAFT DEMONSTRATOR IN EUROPE (BLADE)

**The Breakthrough Laminar Aircraft Demonstrator in Europe (BLADE) is an Airbus project within the European Clean Sky framework to flight-test experimental laminar-flow wing sections on an A340.**

## DESIGN

Natural laminar flow is opposed to hybrid laminar flow artificially induced through hardware. It is difficult to industrialise a wing smooth enough with very low design and manufacturing tolerances and aerodynamically robust enough to sustain the laminar flow in operations, with leading edge retractable slats, fasteners, surface deformations and dirt, de-icing fluid and rain droplets contamination disturbances. The 9 m metallic outboard section with a carbon fiber reinforced plastic upper laminar flow surface is isolated from the rest of the wing and has two ailerons on each side. Its wing sweep is around 20° for a Mach 0.75 cruise instead of 30° for Mach 0.82-0.84, laminar flow is expected along 50% of chord length instead of just aft of the leading edge, halving the wing friction drag, reducing the overall aircraft drag by 8% and saving up to 5% in fuel on an 800 nm (1,480km) sector.


*The A340 flight demonstrator*

*The left laminar flow wing section*

## DEVELOPMENT

The demonstrator took off on 26 September 2017. In April 2018, after 66 flight hours, drag reduction is better than expected at 10% and laminar flow is more stable than anticipated, including when the wing twists and flexes. Both wings with their carbonfibre upper sustainably generate the desired effect, while the carbonfibre left wing leading edge and metallic right wing leading edge have small differences in aerodynamic effects. The aerodynamic benefits could be sustained at Mach 0.78 up from Mach 0.75 and next-generation single-aisles could use from the late 2020s. Test will continue until 2019 and will include wing contamination and a fixed Krüger flap.

Morphing flaps should be flight tested from May 2020.


*The smooth surface of the BLADE aircraft's outer wing section. Source: Airbus*
*Airbus photo blade wing P.Pigeyre/Master Films*
*the laminar wing based on Bjorn's Corner: Laminar flo*

## BLADE IS ACCELERATING THE INDUSTRIALISATION OF FUTURE LAMINAR WINGS

The here below poster highlights the main milestones crossed by the BLADE project from 2011 to 2017.


*Synthesis written by J.-P.-S. from information available on the Web*

# TIME FOR A CONCEPTUAL CHANGE OF ATM/CNS?

**Emilien Robert and Pascal Barret – CNS Experts, EUROCONTROL**

## CONTEXT

Air transport plays a major role in the social and economic development of communities, regions and the world. The demand for passenger and freight operations is expanding geographically and growing in response to markets and demographics. Studies conducted in North America, Europe and the Pacific regions predict very similar patterns of activity in the years ahead, with air traffic movements expected to increase from 2.4 billion passengers in 2010 to 16 billion passengers in 2050 (IATA, Vision 2050).

Considering 2050, growth in air traffic requires new operational improvements enabled by enhanced ground, airborne and satellite infrastructure in order to improve safety, capacity, cost efficiency, security, environmental and spectrum sustainability. By this date, aviation will have entered into a new age in which Digitalisation, Connectivity and Automation and Global systems will be the overarching characteristics.

Furthermore, the increasing use of airspace by other categories of aircraft such as RPAS, with potentially millions of additional objects, in the sky needs to be properly addressed. This is to ensure full interoperability as regards, amongst others, Communication, Navigation and Surveillance aspects.

Communication, Navigation and Surveillance infrastructures remain the corner stones for any future development in ATM and U-Space (Unmanned Space). The evolutions of the C, N and S infrastructures have been widely addressed in international and European strategic documents such as the EU Aviation Strategy, Flight Path 2050, the ICAO GANP or the European ATM Master Plan. However, these evolutions are mostly considered separately for each domain whereas the interdependencies and interconnections between the CNS current and future technologies require a more global approach.

The C-N-S separation between the three domains comes from the early days of aviation and remains an important safety principle. Developed during the days of single systems, the logic is that if one part of CNS has a complete failure, the other two parts enable, as a minimum, safe landing of aircraft. This has led to functions such as the designation of one specific SSR transponder code to indicate loss of communication. With increasing levels of traffic, a significant failure of one of the CNS elements is no longer an option. This is why each CNS element has increased its level of reliability and safety by adding redundant and diverse systems or multiple system layers. Both the safety philosophy and the increasing complexity of CNS have led to COM, NAV and SUR developing their systems independently, without much consideration of other CNS evolutions. Because of the current mix of digital and analogue technologies, performance based concepts and the introduction of GNSS in multiple areas of CNS, the traditional CNS safety concept separated per domain is becoming difficult to maintain.
As a response to the impending interconnection of the infrastructure and application, the SESAR program developed the integrated CNS concept. The aim is to address the challenges of CNS integration and also to extract opportunities for the ATM system from this integration. Integrated CNS is about considering the C, N and S domains as one. Applying such concept to the CNS applications would lead to the integration of the individual C, N and S Performance Based concepts into a common and harmonized Performance Based CNS framework. Concerning the CNS infrastructure, this concept would imply that one domain could be used as a support for another domain. Ultimately, the infrastructure might be integrated into one single system providing the C, N and S services, though such a system would need to meet safety and performance requirements, and ensure full interoperability.

## AN INTEGRATED CNS ROADMAP AS GLOBAL VISION AND FIRST STEP

The initiation of such a change, impacting the C-N-S core concept, needs to start with a roadmap showing a vision developed for the long-term CNS architecture with an identified transition path. This roadmap has been developed through the combination of both a top-down and a bottom-up approach.

The *top-down* approach identified the required CNS changes to support the SESAR key performance improvements targeted by the 2015 edition of the European ATM Master Plan. This approach did not consider Communication, Navigation and Surveillance as independent domains but assessed how CNS would need to be integrated and adapted to meet the future ATM challenges. It led to the development of the SESAR CNS vision and eight strategic directions:

1. Increasing digitalisation, connectivity and higher automation levels
2. Implementing a safe, secure and resilient infrastructure
3. Moving from physical assets management to CNS services
4. Developing Performance Based and Integrated CNS concepts
5. Combining satellite-based, airborne, and ground-based CNS
6. Rationalising the legacy infrastructure
7. Increasing Civil-Military synergies and dual-use
8. Ensuring an efficient and long-term availability of suitable spectrum.

The *bottom-up* approach describes the current Communication, Navigation and Surveillance applications and infrastructure and provides a status on the operations and technology being currently developed by SESAR. Given that a minimum of 10 to 15 years is required to develop, standardise, certifie and start deploying a new technology in aviation, the identification of the on-going development gives the short to mid-term CNS evolution and provides valuable clues on the future CNS systems.

The association of both the top-down and bottom-up approach led to:

- **The development of the integrated CNS concept:** the bottom-up approach indicated that technologies would need to be shared between Communication, Navigation and Surveillance domains, GNSS being the most obvious example. Equally, the top-down approach identified the need to bring the three domains together.
- **The definition of the Minimum Operational Network concept:** initially introduced by the US FAA to describe the evolution of their VOR network, this concept has been generalized to the CNS infrastructure and could be defined by "A fair rationalisation of the legacy infrastructure down to a point where it can still operate as a backup or provide an efficient support".
- **The definition of a long-term CNS architecture** translating the CNS SESAR vision into tangible elements. The infrastructure layer shall include a backbone of recent and global technologies in the form of **secured CNS Services** (Multi-datalink, GNSS, ADS-B/C, advanced avionic and SWIM), supported by **Minimum Operational Network** of legacy infrastructure. The operational layer will bring together **Performance-Based CNS** applications, including Performance Based Aerodrome Operating Minima *(figure 1)*.
- **The development of a transition path** in the form of a stepped approach, that will bridge the current infrastructure and applications with the long-term operations, while being consistent with other road-mapping activities, such as the ICAO Global Air Navigation Plan.
- **The identification of an intermediate step, in the form of CNS services**, within the 2025-2030 timeframe, and composed of a multi-datalink, the use of dual-frequency and multiple GNSS constellation supporting all phases of flight, and the implementation of a composite surveillance.
- **The identification of the CNS rationalisation opportunities:** along with the CNS infrastructure evolution, some systems may be decommissioned, other can be rationalised.

## FROM ROADMAP TO IMPLEMENTATION

The CNS evolution foreseen and described in the CNS roadmap will need the coordination of various activities managed by multiple stakeholders and institutions responsible for:

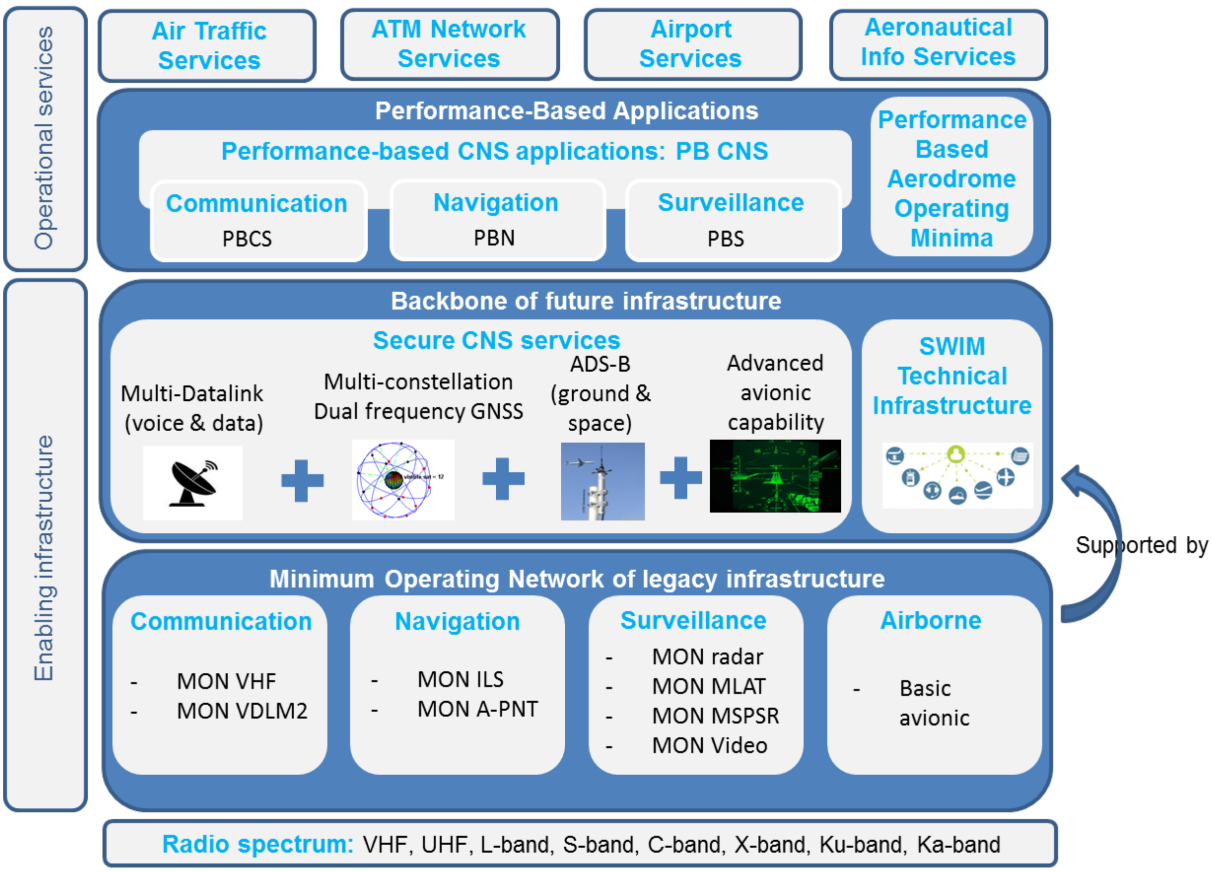



*Figure 1: CNS long-term architecture*

- **Finalising the development of the intermediate step:** toward multi-datalink, dual frequency and multiple constellations for all phases of flight, and composite surveillance; through regional modernization program and standardisation.
- **Supporting the integrated CNS concept** at global aviation level, developing a CNS performance based framework allowing for future applications.
- **Deploying secure CNS services:** the combination of space, airborne and ground-based infrastructure will provide global services. Security requirements need to be implemented to mitigate cyber-threats.
- **Rationalising the legacy infrastructure** at national level while optimising cross-border synergies.
- **Operating the infrastructure** under the appropriate governance, ensuring a fair representation of all stakeholders.
- **Monitoring the CNS performances**, including the use of aeronautical radio frequencies.
- Ensuring the efficient **allocation of scarce CNS resources** across Europe, while securing the long-term availability of suitable radio spectrum through cooperative engagement in the global spectrum environment
- **Ensuring global interoperability**, including civil-military dimension and the seamless integration of new entrants.

All of these activities are included in the role and responsibilities of multiple stakeholders and institutions. However, such a deep transformation can only be achieved through a continuous coordination at multiple technical and decisional levels via dedicated working groups and appropriate governance.

## TOWARDS A COLLABORATIVE AND JOINT APPROACH?

EUROCONTROL organized and hosted a 2 days CNS Symposium in October 2018 where all stakeholders came together to look CNS as one unique value chain. The aim of the Symposium was to create a common vision for CNS and to identify jointly workable ideas. The format of this event was dedicated to all stakeholders in order for them to speak and share their concerns and to build a consolidated vision. It took a careful look at emerging services and worked out how to cater for new entrants on the scene. Particular emphasis was given on how to guarantee global interoperability for manned and unmanned craft, for civil and military airspace users.

The unusually large number of registered participant – 350 – representing Institutions, ANSPs, CNS services providers, Airspace Users, Industry, Research and Training centers together with their request for a follow-up event, is symptomatic of the need for sharing concerns on CNS evolution but also for further and stronger coordination at technical, operational and institutional levels.

Although the CNS roadmap and strategy was widely agreed and supported by all participants, it became evident that the ATM community must generate more trust about reliable implementation planning. Industries need long-term investment plan to develop new technologies and a fair level of certainty on the deployment timeframe is required.

One of the most repetitive message from the participants was the need for a strong but collaborative and joint leadership at European level, and the need to collectively work in a program management approach with all the stakeholders to prepare the future.

**The overall conclusion agreed by all, paves the way for the work ahead to support this CNS evolution and to succeed in this conceptual change:**

*"STATU QUO is not an option! Our duty is to make it happen".*

### ACRONYMS

| | |
|---|---|
| **ADS-B** | Automatic Dependent Surveillance Broadcast |
| **ADS-C** | Automatic Dependant Surveillance Contract |
| **ANSP** | Air Navigation Service Provider |
| **A-PNT** | Alternative Positioning Navigation and Timing |
| **ATM** | Air Traffic Management |
| **CNS** | Communication, Navigation and Surveillance |
| **FAA** | Federal Aviation Administration |
| **GANP** | Global Air Navigation Plan |
| **GNSS** | Global Navigation Satellite System |
| **IATA** | International Air Transport Association |
| **ICAO** | International Civil Aviation Organization |
| **ILS** | Instrument Landing System |
| **MON** | Minimum Operational Network |
| **RPAS** | Remotely Piloted Aircraft System |
| **SESAR** | Single European Sky ATM research |
| **SSR** | Secondary Surveillance Radar |
| **SWIM** | System Wide Information Management |
| **U-SPACE** | Unmanned - Space |
| **VOR** | VHF Omnidirectional Range |

# TIGER HELICOPTER: WELL PREPARED FOR THE NEXT DECADES...

**By Martin Ramelow, OCCAR**

*Figure 1: German, French & Spanish Tiger Helicopter - Copyright: Airbus Helicopters Tiger*

## INTRODUCTION

The TIGER, originally planned by France and Germany as an anti-tank helicopter, has been further developed into a new generation multirole attack helicopter ***(Fig. 1)***. Developed in Europe by the company Eurocopter, now Airbus Helicopters, it operates in Europe in three different variants (UHT for Germany and HAP/HAD for Spain and France) and one in Australia (ARH), adapted to the different operational needs of the countries. Whilst supporting Nations' needs as much as necessary, especially regarding armament capabilities, the different TIGER variants are nevertheless based on a common platform, representing around 70% of common parts offering significant cost savings in term of Life Cycle Cost to Nations.
The management of the TIGER Programme for France, Germany and Spain the three Participating States has been assigned to OCCAR-EA, which is in charge of development and production contracts and responsible for the majority of the in-service activities. At OCCAR-EA, the TIGER Programme Division (PD) is managing the TIGER helicopter throughout the whole life, covering all the different phases of the programme, from the programme preparation to the disposal ***(see figure 2)***.

## THE TIGER HELICOPTER

Initially, France and Germany planned to procure a total of 427 TIGER Helicopters (212 UHT for Germany, 115 HAP & 100 HAD for France). Nevertheless, with the first production contract, placed in 1999, 80 Support Helicopters Tiger (UHT) were supposed to be produced for Germany and 70 HAP + 10 HAD for France. In 2004, Spain entered into the programme by ordering 24 HAD helicopters while France reviewed its requirements to 40 HAP and 40 HAD. Pursuant to national decisions made in 2014 and 2015, Nations have further downsized this contractual figure of 184 helicopters to the following current order breakdown: 68 UHT for Germany, 71 HAD for France and 18 HAD + 6 HAP for Spain.

TIGER production is almost complete; the last German Helicopter was delivered in July 2018 and the last deliveries for Spain and France are expected at the beginning of 2019. As of today, Airbus Helicopters has delivered 157 helicopters to the Participating States' end-users (68 UHT, 6 HAP/E, 16 HAD/E, 40 HAP/F & 27 HAD/F).

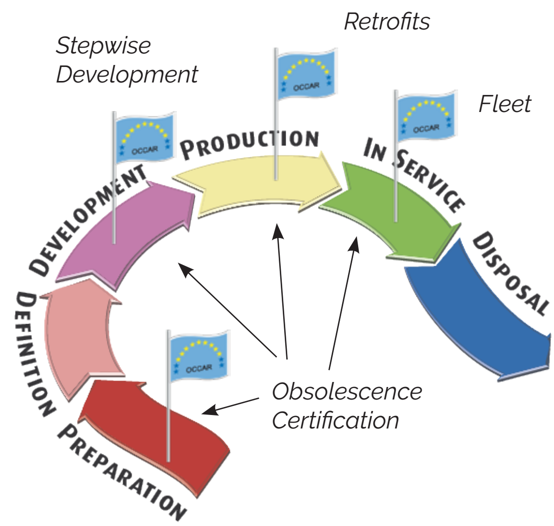



*Figure 2: The different phases of the TIGER Programme*

## A STEPWISE DEVELOPMENT

As for many new weapon systems, development of the HAP and UHT TIGER variants was made in a step-by-step approach, allowing the end-users to train and familiarise themselves with the new helicopter capabilities in a progressive manner. The purpose of that stepped approach was to continually check that the helicopter development complies with the contractual specifications, based on Nations' requirements.
Starting with basic flying capabilities in a so called "step 1" configuration, further weapon capabilities have been

*1. Unterstuetzungshubschrauber TIGER is the German variant of the TIGER helicopter*
*2. Hélicoptère d'Appui et de Protection is the first version of French and Spanish variant of the TIGER helicopter*
*3. Hélicoptère d'Appui et de Destruction is the second version of French and Spanish variant of the TIGER helicopter*
*4. Armed Reconnaissance Helicopter is the variant that is operated by Australia.*

qualified within the next configuration. The full contracted configuration was achieved with the "step 2/3" versions qualified by OCCAR in 2008.

The HAD qualification activities were also performed in steps. The first qualification step (Block 1) was achieved in December 2014 and Block 2 qualification as the second step, was achieved in mid-2017.
With the delivery of the different configurations to the end users, helicopters that had been delivered with an earlier configuration will need to be aligned with the later delivered configurations. The helicopters have to be retrofitted and will not be available for the end-users and operations during such time. This had to be accepted as a trade-off between earlier delivery in an interim configuration and later delivery, but in the final configuration.

## FIELD PROVEN

The TIGER helicopter is fully combat proven and has been deployed by all Nations in a wide range of missions in Afghanistan, Libya, Somalia and Mali where it was operated in highly demanding environments like naval or sandy conditions. It showed in the different theatres its robustness and reliability under aggressive conditions. The TIGER helicopter has fully demonstrated its capabilities and has become an essential asset to be deployed to support ground forces.

## FLEET AVAILABILITY

The greatest benefit of international cooperative armament programmes is the sharing of common development and support activities, whenever possible, to reduce their life cycle costs. Therefore, from the beginning the TIGER Participating States decided on a common approach for the support of the Tiger fleet. The broad scope of OCCAR's support includes a wide range of services such as spares procurement, repair activities, scheduled maintenance, configuration management, obsolescence management, training means, technical documentation and engineering and logistic support activities.
The TIGER helicopter has demonstrated its high performance in operations. Now, one of the main challenges facing the Programme stakeholders is to ensure the fleet availability required by the end-users. To meet this need all elements with an impact on the fleet availability were analysed in 2014, which led to the development of different improvement action plan. In this frame, the TIGER maintenance plan, based on a calendar/flight hours major inspection plan, was reviewed to better answer the current TIGER usage and the end-users' constraints:

- by increasing the interval between major inspections, and;
- by decoupling the calendar and flight hours related maintenance tasks to allow more flexibility to nations for their fleet management.

The results of such a change of the maintenance concept will be deployed to all end-users end of this year, decreasing the maintenance efforts to be performed by the end-users and reducing the fleet unavailability for scheduled maintenance. Further investigations increasing the flight hour based interval were contracted by OCCAR in November 2018.
Additional more global investigations have been performed by OCCAR, together with Nations, in the past years on a new support strategy that should request, from Industry, a change of its business model, with more engagement and responsibility.

## OPTIMISATION OF CERTIFICATION

The TIGER helicopter, managed as a legacy programme, is certified independently by the three Nations following national and differing airworthiness regulations. Therefore, all modifications with an impact on the Tiger Type Certificates have to be assessed and approved independently by the three National Military National Airworthiness Authorities (NMAA).

This adds complexity both to governmental and industrial co-operation and requires time. The airworthiness certification process leaves the full responsibility on the shoulders of each NMAA and does not allow Nations to take full benefit of the multinational programme savings. Setting up a common airworthiness environment, based on the European Military Airworthiness Requirements (EMAR), harmonised in the frame of the European Defence Agency's MAWA forum, and about to be implemented in three compatible national airworthiness regulations, is an opportunity to optimise certification activities within the TIGER Programme. As a first step, preparations for mutual recognition between NMAA have begun. Once the national authorities have mutually recognised each other, they will be able to build on their partner authorities' work, which will reduce the required effort for each individual authority.

The implementation of EMAR compatible regulations will enable national military airworthiness authorities to grant privileges to industry and thus provide more responsibility, but also more flexibility to industrial partners in the mid-term, which should lead to a further increase in efficiency.

## OBSOLESCENCE

As for all armament programmes developed over decades, one of the main challenges of the OCCAR TIGER PD is related to obsolescence. With steadily increasing limitations in the use of hazardous or banned materials due to environmental regulations, the short production cycles of electronic components and the end of the TIGER series production, the number of obsolescence cases is significantly increasing. During serial production a reactive obsolescence strategy has been applied.

Because of the changing requirements in the purely In-Service Phase the reactive approach does not allow, in some cases, a sufficient timeframe to perform the re-design activities, if needed. In this case, such obsolescence cases could have an impact on the fleet availability. Accordingly, OCCAR and Nations have decided to implement the proactive obsolescence management strategy for obsolete critical Line Replaceable Units (LRUs). The aim of such a proactive strategy is to predict obsolescence cases as early as possible, in order to have sufficient time to initiate mitigation activities. Non-obsolete critical LRUs will remain under reactive surveillance. This distinction ensures the optimised balance between economical constraints and risk reduction, delivering a value for money solution to the Participating States. Proactive obsolescence management will be performed by closely monitoring the helicopter and its critical equipment, down to the lowest component. The dedicated work for these surveys will be contracted via the main contractor to the vendor/supplier level. Proactive obsolescence management is aimed to give nations and OCCAR more reaction time and allow them to apply the best solution. Proactive obsolescence management is seen as an important success factor for the continuous supportability of the TIGER fleet.
Another opportunity to solve the high amount of obsolescence cases, especially for avionic parts, is to undertake a midlife upgrade for the current helicopter design.

## A NEW CHALLENGE FOR THE FUTURE – TIGER MID LIFE UPGRADE

To remain at the cutting edge of attack helicopters in the world over the next decades, the Participating States are considering an upgrade to their TIGER helicopter fleets with new and enhanced capabilities. This Mid Life Upgrade (called Mark III), if the decision is confirmed by 2020, will be performed to meet Nations' operational requirements beyond 2020 and to operate the TIGER helicopter (by addressing most of the obsolescence) through to 2040.

In 2015, OCCAR signed, on behalf of the Participating States, a contract for an initial architecture study to investigate different potential architectures. This study was completed in 2017.
As a result of this initial study, Nations were able to decide on different helicopter concepts which allowed them to consider the combination of equipment, functions, performances that best suit their operational needs and budget.

Before launching the development phase, some de-risking activities remained to be performed in some complex areas, in order to secure the development and to allow Industry to commit on performance levels to be achieved during the development phase.
OCCAR-EA has launched this de-risking phase on behalf of France, Germany & Spain by placing two contracts with a consortium composed of Airbus Helicopters Tiger, Thales AVS and MBDA. The aim of this phase is to de-risk the obsolescence treatment of the current TIGER helicopters, as well as the implementation of new capabilities.
The deliverables from these contracts, which will last 18 months, shall provide the Participating States a technical baseline to decide on the initialization of the development of a Mid-Life Upgrade (MkIII). MkIII will integrate advanced technologies such as a new avionics suite and an improved weapon system, allowing TIGER to maintain superiority on the battlefield for the next decades. The duration of the de-risking is 18 months.
The MkIII programme, which will encompass Development, Retrofit activities and the initial In Service Support for the first two years, is challenging and will require significant involvement of all stakeholders in order to meet Nations' timeline for the first helicopter deliveries, planned in 2025 to 2027 and beyond for the three Nations.
The MkIII programme is a clear example of successful collaboration between Nations, in fact it is a new step forward to demonstrate the benefits of cooperation during the In Service Phase for a programme which started 20 years ago. Aiming to continue with that collaboration, OCCAR will put all its knowledge and experience to ensure that MkIII is commonly tackled by the three Nations as a whole to save costs and maximize Through-Life capabilities.

Moreover, the MkIII programme will be a great opportunity to consolidate the European Defence Industry and to boost collaboration between European companies.

## CONCLUSION – NOT A FROZEN PICTURE

The TIGER helicopter has already demonstrated its performance to the end-users and is a great example of a successful programme, lead by OCCAR, on behalf of France, Germany and Spain.
But far from being a frozen picture, the TIGER programme is now engaged in the process of its Mid-Life Upgrade, with some new challenges to take up!

■

# ENSURING FUTURE SUSTAINABILITY OF SPACE OPERATIONS: THE ORBITAL DEBRIS PROBLEM

By Christophe Bonnal, CNES

**The first ever launch to orbit was precisely 60 years ago! The beginning of the Space Odyssey began on Oct. 4th 1957 with the launch of Sputnik 1, opening the field for all the space applications that we enjoy today, telecommunications, localization, environment, defense, science...**

## An Ever Growing Orbital Population

However, one has to realize that this maiden flight also marked the very first step of orbital pollution: on the very same orbit as the 82 kg little satellite was the main stage which brought it to orbit, the 6.5 tons Semiorka Block A, and even a small 100 kg fairing which protected Sputnik during the atmospheric ascent. Nearly 99% of the mass injected into orbit for the first space launch had no useful function. We can go even a bit further: Sputnik emitted its famous beep-beep during 21 days, but has spent a total of 92 days in orbit before reentering the atmosphere: it means that the satellite had no useful function during three quarters of its orbital life. The definition of orbital debris (or space debris) is an artificial object, in orbit, non-functional. The example of Sputnik underlines the three main sources of orbital debris: old satellites, launcher upper stages, and objects linked to launch operations, left in orbit knowingly, such as fairing, optical caps, clamp-bands...

Since 1957, the number and mass of objects in orbit has drastically increased.

It is obviously a sign of good health of the space sector and the rapid expansion in the number of associated space-based applications, but it is also a real concern...

The mass of objects in orbit has increased linearly since 1957, reaching nearly 8,000 tons today *(See upper panel of Figure 1 page 21)*. The number of cataloged objects (large enough to be tracked reliably from ground, typically 10cm in Low Earth Orbits (LEO) or 1 m close to Geostationary Orbit - GEO) has reached now 20,000, with a clear tendency to increase! *(Lower panel in Figure 1 page 21)*. Such rapid growth of mass and number of objects in orbit may look surprising, as the number of successful orbital launches has strongly decreased since the Cold War period (140 in 1967 but only 52 in 2005), and as the regulations aiming at controlling the increase in orbital population were instituted at international level starting in 1995, more than 20 years ago.

These figures may appear disturbing, but one has to keep in mind that outer space is vast and the corresponding average spatial density is very small, reaching a maximum of 0.1 object per million cubic km in the most densely populated region in LEO. In addition, it provides a unique perspective to note that the 8,000 tons of orbital debris objects is equivalent to the mass of the Eiffel Tower.

*This picture of the man made debris in orbit around the Earth shows just how crowded. Copyright NASA.*

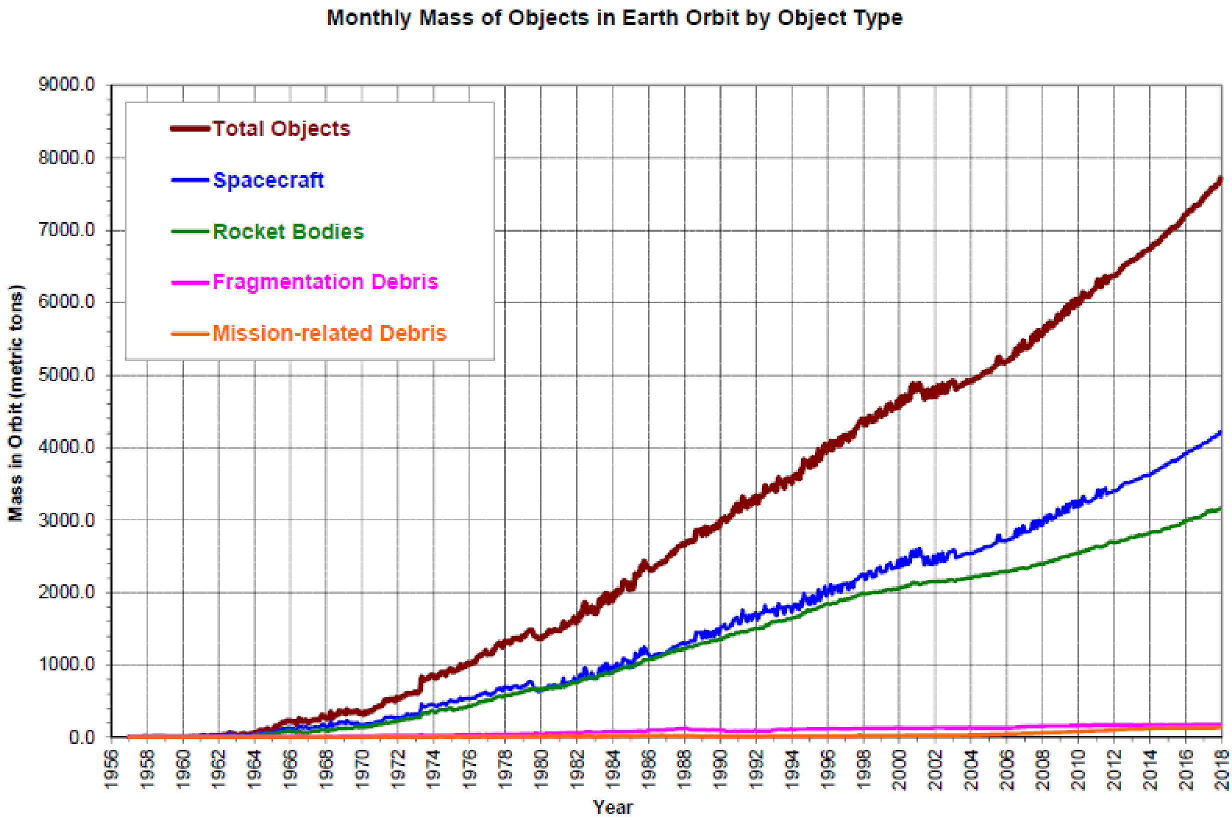
Nevertheless, these objects have three very distinctive characteristics: orbital lifetime, velocity and casualty risk at reentry. Once an object is in orbit, it generally remains there for a long time; for instance, a satellite placed at 1,000 km altitude will remain there for 1,000 or 2,000 years. Meanwhile, it travels at orbital velocity, close to 8 km/s or 30,000 km/h. At these velocities, the accumulated probability of collision integrated over thousands of years produces a significant collision risk. Last, any object placed into LEO is bound to fall back to Earth, potentially posing risks to people and properties.

## Orbital Debris Raise two Major Problems

### 1. UNCONTROLLED ATMOSPHERIC REENTRY OF LARGE SPACE OBJECTS POSES A RISK TO POPULATIONS

During reentry, debris are fragmented by the very high dynamic pressure, proportional to the square of the velocity, then these fragments are exposed to very high thermal fluxes, proportional to the cube of the velocity, due to the friction of air molecules which lead to melting and sublimating of materials. Unfortunately, this destruction is generally incomplete and some 10 to 20% of the total mass of the debris may survive reentry, depending on its construction. Refractory materials, such as Titanium, Carbon or types of steel, do not melt during reentry and impact the surface of the Earth.

Hopefully, Earth is covered 71% with water, the rest being composed mostly of large desert areas (densely populated zones only represent 3% of the surface), so the risk to populations remain very low. Approximately one large satellite or launcher stage reenters into the atmosphere



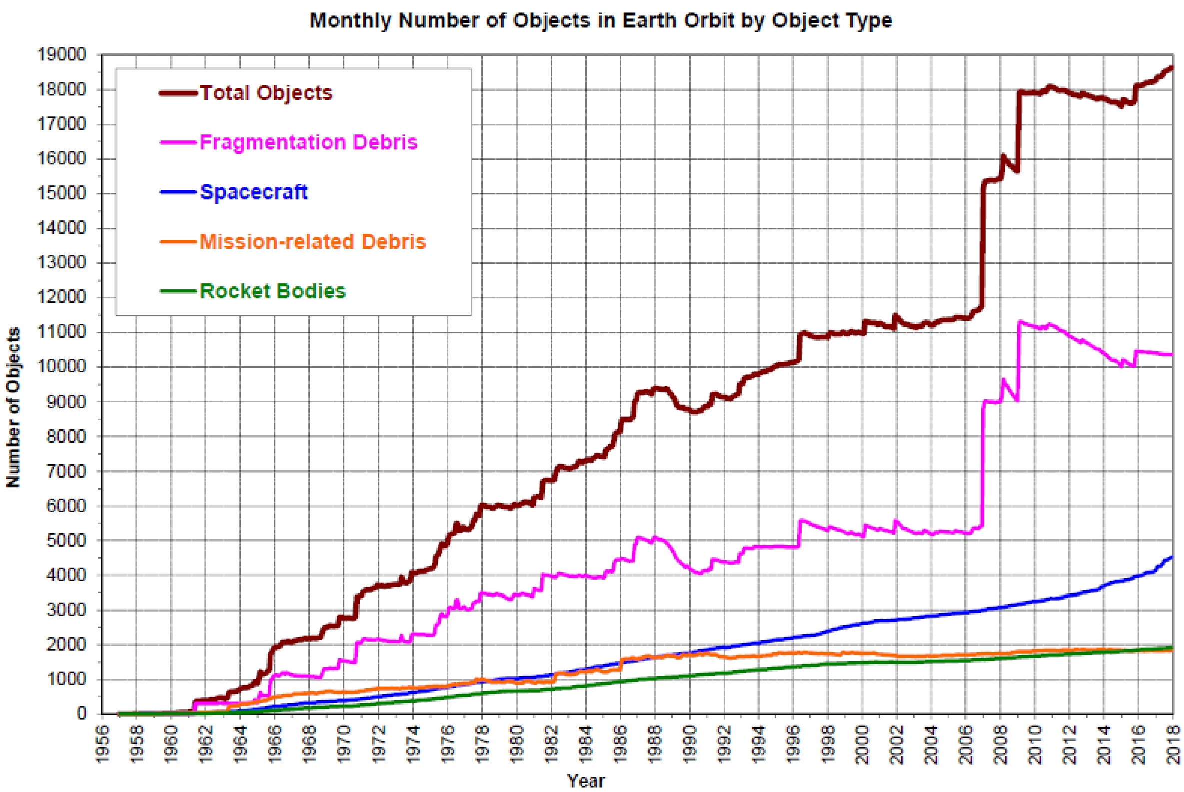




*Figure 1: Evolution of the mass and number of cataloged objects versus*

Figure 2: Typical debris found on ground (NASA)

per week, posing a risk of 1 chance out of 10,000 to hurt someone. As of today, there has never been any identified victim, but we have numerous examples of large debris found near inhabited zones, such as the various elements of a Delta 2 upper stage presented in *figure 2*. It is now a real « Damocles sword » problem: we continue to launch large stages or satellites knowing perfectly that they will end up reentering randomly, generating risks to overflown populations.

## 2. COLLISION RISK IN ORBIT

Collisions generate different consequences depending in the objects involved and the other satellites that operate in the vicinity. It is both an issue of safety and economic risk as there are so many operational satellites supporting the global economy now.

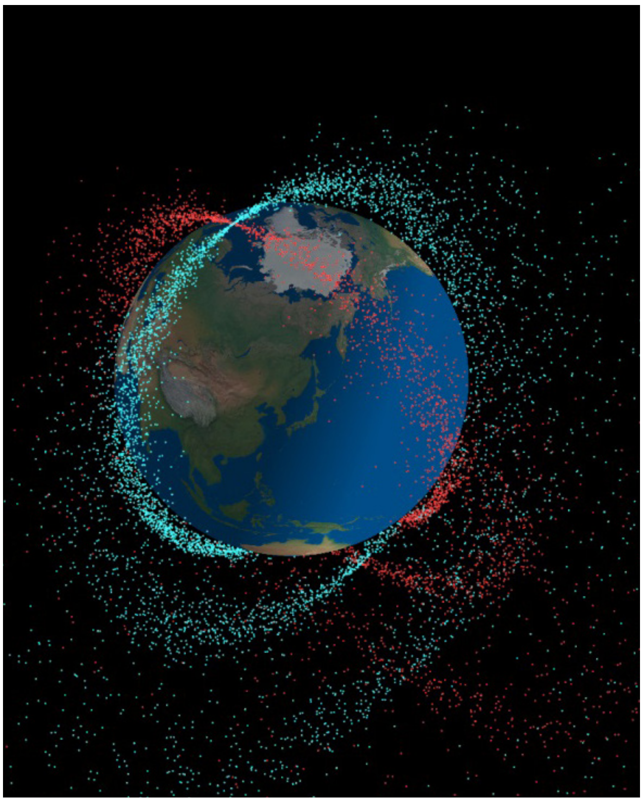


Figure 3: Debris larger than 1 cm resulting from collision of Iridium 33 (blue) – Kosmos 2251 (purple). (©The Aerospace)

One can identify several different potential risks.

A collision between a small, un-cataloged, debris fragment and an active satellite can cause the functional loss of the spacecraft. Indeed, the kinetic energy released during a collision is extremely high: a collision with a 1 mm debris has an energy of 1 kJ, equivalent to a bowling ball launched at 100 km/h. Such an impact can terminate a satellite's mission if it were to impact the On-Board-Computer. Several studies on this hazard have shown that the probability of losing a satellite due to a collision is about 5% during its operational lifetime; space debris has been identified as the primary cause of satellites losses in orbit. These lethal, nontrackable debris are in essence "invisible", so there is no way to prevent such collisions.

Collisions among very large objects (i.e., included in the cataloged population) are less likely to occur with estimates that they will occur every 5 to 8 years, however, they are likely to generate a very large number of new debris which in turn increases the collision risk in orbit. This proliferating feature of collisional fragmentations raises the potential risk of an uncontrolled increase of the number of debris over time. This regeneration effect following collisions, well presented in the film Gravity (by Alfonso Cuaron in 2013), raises the risk of an uncontrolled increase of the number of debris; this phenomenon, known as the Kessler Syndrome, could lead to an un-controllable situation, even if we stopped any space activity in the future ! The collision between the two satellites, Iridium 33 and Kosmos 2251, in February 2009 generated over 2,200 cataloged debris and likely 10,000's of smaller ones *(Figure 3 from The Aerospace)*. Simulations led by NASA, then followed by 7 agencies from IADC (International Agencies Debris Coordination Committee) show that even if we stop completely any space activity, the number of orbital debris will increase exponentially in the coming years!

**Hopefully, there are a certain number of measures aiming at limiting the number of orbital debris in the future.**

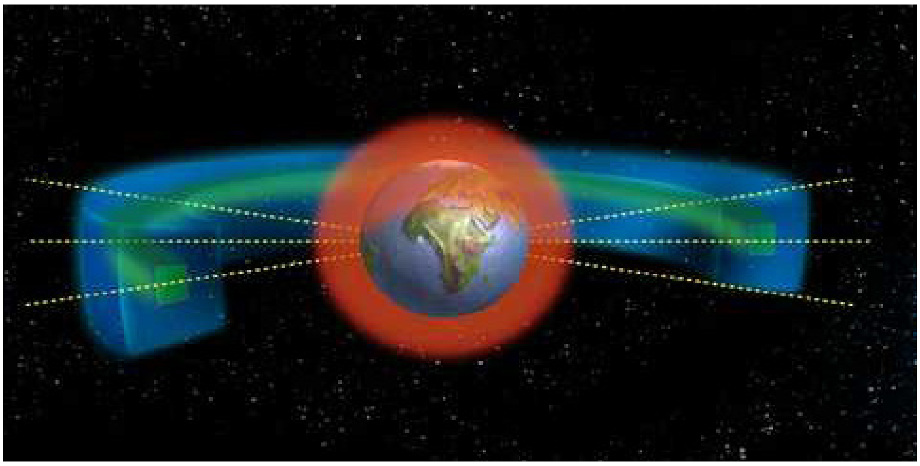


*Figure 4: Protected zones: Low Earth Orbits (red) – Geostationary region (blue). (CNES)*

## An International Set of Efficient and Agreed-upon Requirements

The first measure, fundamental, is to set rules at international level in order to prevent the generation of new debris during future space operations. These recommendations, called « space debris mitigation », can be summarized into five high level actions.

**First**, it is compulsory to limit the generation of debris during normal launch operations, and to avoid any voluntary destruction of satellites in orbit (54 identified as per today).

**Second**, one shall avoid accidental explosions in orbit by passivating all space objects left in orbit, i.e. by eliminating any stored energy such as residual propellants, tank pressurization, battery energy or despinning fly- wheels.

**Third ,** it is also necessary to limit orbital life of space objects: it is required that satellites and launcher upper stages remain on orbit less than 25 years after their operational life in the two protected zones, LEO and GEO *(see figure 4)*.

**Fourth**, satellite operators are directed to prevent in-orbit collisions when information is available with adequate precision and when the satellite is maneuverable.

**Last**, it is recommended to minimize the risk posed to people and property on Earth posed by un-controlled atmospheric reentries of space objects; to that extent, an operator should perform a controlled reentry for any mission that poses a risk to people on Earth's surface larger than 1 chance out of 10,000.

These rules can be found in numerous texts, both at national and international levels. Their origin can be found in the initial reflections led by NASA as early as 1978, then in Europe by 1987, leading to the first national standards, mainly from NASA (1995), NASDA (now JAXA, in 1997) and CNES (1999).

The first text adopted at international level is known as « IADC Guidelines », collection of recommendations prepared by the Inter-Agency Space Debris Coordination Committee grouping the (now) 13 main space agencies, adopted unanimously in 2002, revised in 2007. A similar standard at European level was finalized in 2000 and approved in June 2004. The IADC Guidelines have been adapted by the space committee of UN, the COPUOS (Committee for Peaceful Use of Outer Space), resolution adopted during a UN plenary session in 2007.

France has been the first country to elaborate a real law dealing with the subject, the FSOA (French Space Operations Act, or LOS, Loi portant sur les Opérations Spatiales), which entered in force in 2010, revised in 2017.

Last, a set of ISO standards dedicated to space debris have been published since 2011, mainly the ISO 24113 which acts as the highest level standard; this document, if it could effectively be rendered applicable to all operators and constructors, would allow an efficient slow in the increase of space pollution.

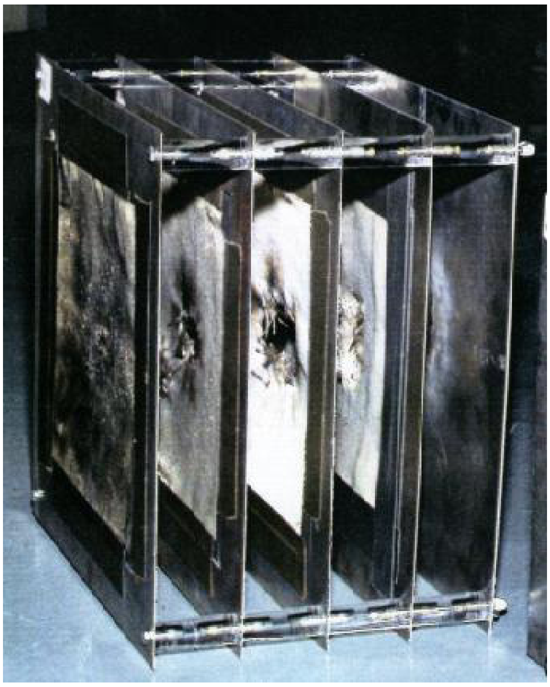


*Figure 5: Example of a protective shield against impacts from small debris (NASA)*

Unfortunately, these rules are very badly followed today: the observed level of compliance is roughly 55% at international level, and this figure may even be a bit optimistic as it includes all the small satellites launched at low altitude, reentering the atmosphere rapidly. If one considers only spacecraft above 600 km altitude, the compliance level is lower than 20%.

## Protection Against Impacts

A second measure used by operational spacecraft to reduce the impact effects of small orbital debris is shields. If you place a certain number of metal or Kevlar® sheets, or even dense foams, in front of a structural wall, they will shatter debris into smaller pieces, leaving a cloud of tiny particles to impact the main structure without piercing it. There are a variety of design approaches for shields depending on the type of debris to be stopped, the orbit of the shielded satellite, its orientation, and the criticality of the components on the spacecraft to protect. Many tests are performed throughout the world, each testing different configurations optimal for the given specific spacecraft. Ground tests are performed using light gas guns, often two-staged, propelling small projectiles to velocities up to 12 km/ (current record held by Thiot Ingénierie…). Figure 5 displays an example of such a shield composed of several sheets of « slowing » materials; debris comes from the left of the figure, as the wall to be protected is on the right.

Unfortunately, can only protect a system up to impactors of 1 cm in diameter. This means that there is a range of debris from 1 to 10 cm in LEO that are lethal but nontrackable. As a result, this risk cannot be avoided. The impact shields also require additional volume, mass, and cost and may also create system problems such complicating thermal management of the satellite. Practically, they are currently deployed mostly on crewed modules such as the ISS, the European ATV, and the Japanese HTV.

### AVOID THE AVOIDABLE (EXPRESSION ADAPTED FROM THE CNES COO MOTTO…)

An efficient measure consists in avoiding collisions with operational satellites, equipped with on-board propulsion, for which the probability of collisions is a priori computable. It is a very complex activity, as one need to « propagate » the orbits of all the potentially dangerous objects over several days in order to identify possible collisions.

As an example, the COO in CNES Toulouse (Operational Orbitography Center) is composed of a team working 7/7-24/24 in order to protect some fifteen CNES satellites, together with some other spacecraft registered to the service called CAESAR (Conjunction Analysis and Evaluation Service: Alerts and Recommendations). It is a very impressive task: in 2017, CNES had to deal with no

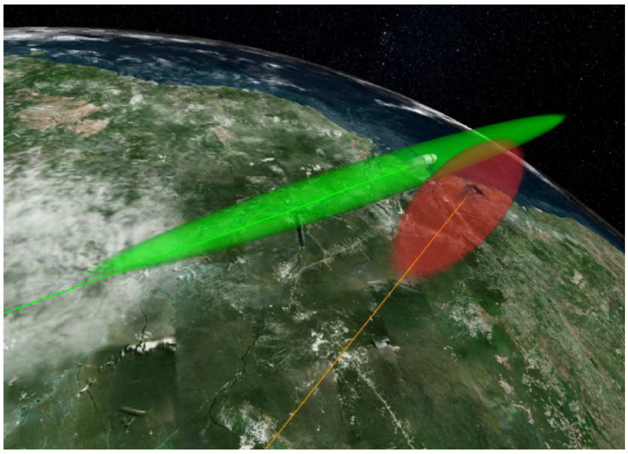


*Figure 6: Artistic view of the intersection of two covariance matrixes (AGI)*

less than 2.5 million Conjunction Data Messages! The statistical computations are very complex, based on collision probabilities determined by the covariance matrixes of each object *(see figure 6 from AGI)*. Every alert triggers an analysis of the impactors trajectory, winding back in the past, and can require dedicated measurements coming from the French Space Surveillance System which is composed of several radars (including GRAVES, Grand Réseau Adapté à la Veille de l'Espace) and telescopes (the 3 TAROT telescopes dedicated to the surveillance of the geostationary orbit). These analyses enable to identify a very large number of false alerts, but often confirm the need to maneuver a satellite in order to lower the probability of a collision.

### RETRIEVE THE MOST DANGEROUS OBJECTS FROM THE MOST CRITICAL ORBITS

A significant measure, studied now since more than 15 years, consists in retrieving form the most crowded orbits a certain number of very large debris potentially dangerous, i.e. susceptible to generate the largest number of secondary debris following a collision: such measures are known as ADR (Active Debris Removal).
This strategy follows the findings of studies made first by NASA, published in 2010, then by most of the IADC delegations: if one assumes that the mitigation measures are very well complied to (no fragmentation in orbit, 25-year rule in LEO), then the retrieval of 5 to 10 properly chosen large debris from the most populated orbits is enough to stabilize the orbital population.
A very large number of potential technical solutions for ADR have been proposed, studied, and even tested on ground or during 0g flights, aiming to demonstrate how to clean space *(see figure 7)*. Without being exhaustive, one can subdivide these solutions following various categories.

**First**, there are a few contact-less solutions, for instance using a "virtual electrostatic leash" or a laser to raise the orbit of old satellites abandoned in GEO.
**Second**, numerous solutions are derived from fishing techniques, using hooks, harpoons, nets, to capture a

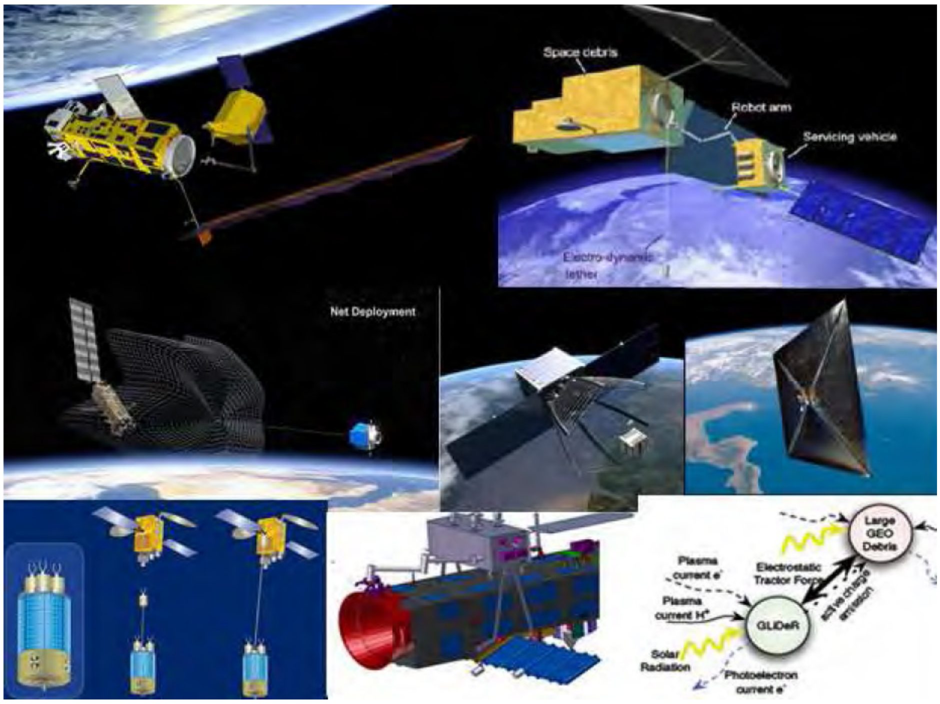



*Figure 7: A few examples of Active Debris Removal solutions.*
*Top to bottom, left to right: MDA, JAXA, Airbus DS, EPFL, Uni. Surrey, Airbus DS, ESA, Uni. Colorado*

debris then to pull it using a long tether until it reenters in a controlled manner in the atmosphere.

**Third**, the family of drag augmentation approaches aim to increase the drag on the debris in order to reduce its orbital lifetime. For example, an inflatable device or a large sail can increase the area exposed to the atmosphere in the direction of orbital motion.

It is also possible to install an Electro Dynamic Tether on the debris that through its interaction with Earth's magnetic field generates Lorentz forces to slow the debris, thus reducing its orbital lifetime.

All of these solutions, however, have the drawback of inducing uncontrolled reentry of the debris which could potentially pose a risk to people and property on the ground.

**Last**, more conventional solutions consist of grappling a debris then deorbiting it in a controlled way to atmospheric reentry though a propulsive maneuver. While there have been many approaches to grapple a large derelict object (e.g., nets, clamps, sticky tentacles, etc.) in preparation for a deorbit burn, a robotic arm is still the most viable approach.

The technical maturity of these solutions is evolving quickly with numerous demonstrations having already been performed, including in orbit. The main problems are, therefore, not technical but rather financial, as such operations would be very expensive without clearly identifying a business plan enabling money making commercial activities. There are also numerous legal hurdles linked to the responsibility of the operations and potential liability from trying to do the right thing. There are even military concerns as procedures to execute ADR appear to be similar to activities related to potential military space operations.

These questions are actively considered within several Working Groups at international level, mainly at COPUOS with the initiative LTSSA (Long Term Sustainability of Space Activities). The first ADR activities could take place faster than expected thanks to the arrival of Space Tugs: several of these multipurpose orbital vehicles are currently under development, mainly in USA and in France, and deorbiting a large debris could be the last action of such a tug after several orbital operations and integrated as part of its end of life maneuver.

## JUST-IN-TIME COLLISION AVOIDANCE BETWEEN LARGE NON-MANEUVERING DEBRIS

An additional measure has been under study these last years, consisting at avoiding predictable collisions between large derelicts. The basic idea here is that in case of an upcoming collision event in the following couple of days (in reality, a probability of collision higher than an allowable threshold), a mission is carried out aiming at deviating very slightly the trajectory of one of the two debris to avoid the collisions, (or restore acceptable margins). In terms of orders of magnitude, if the action takes place 24 hours before the predicted collision and if one wants to have a 1 km margin, the corresponding ΔV is less than 4 mm/s, very low compared to the orbital velocity of the debris, in the order of 8 km/s.

Several approaches of the so-called Just-in-time Collision Avoidance (JCA) are under study, mainly in USA and France, consisting for instance in a cloud of gas/dust/particles spread in front of the debris thanks to a sounding rocket, aiming at briefly increasing the drag and

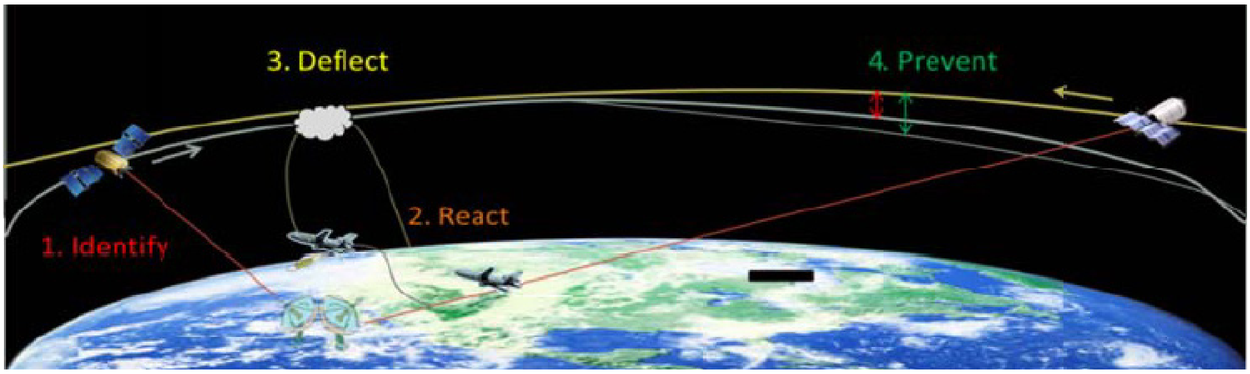



*Figure 8: Simplified scheme describing a JCA procedure (Integrity Applications)*

slow the debris. These methods are very promising as they appear to be much simpler to realize than ADR, and they would be used only in case of a highly probable collision, typically every 5 or 6 years.

Other techniques, also jointly studied between USA and France, are based on orbital lasers to deviate debris using very short but intense pulses, vaporizing locally the surface of the debris and slightly modifying its velocity.

## A PREOCCUPYING SITUATION

As a conclusion, one has to recognize that the situation is… improvable!

The mass and number of debris in orbit continues to grow without any sign of decrease, as the international regulations approved more than 15 years ago are very badly complied to; there are still numerous collisions and fragmentations in orbit every year, in addition to dozens of large objects released nominally during launch operations, in addition to satellites and upper stages.

Short term future also raises numerous questions.

First, we are currently witnessing a rapid increase in the number of small satellites deployed in orbit. These cubesats are game-changers, smart satellites taking full advantage of miniaturization, offering a large number of space applications with very low cost development, production and launch. As a consequence, several hundreds of them are launched each year, but in most of the cases they have no propulsion, therefore no capacity to avoid collisions and to reduce their orbital lifetime. As an example, the Indian launcher PSLV has orbited 104 cubesats in one single launch in February 2017.

Large constellations raise a different problem: there are plans to launch such small satellites (140 to 500 kg) by thousands, to generally very stable orbits. As an example, the large constellation One Web will start deploying by beginning of 2019 nearly 1,000 internet satellites on a 1,200 km circular highly inclined orbit, stable for thousands of years (satellites developed by Airbus DS and launched by Arianespace). And this may be just the beginning: Boeing has announced its own constellation with 2,900 satellites; SpaceX did the same with a first constellation of 4,400 satellites and a second one with 7,500… In total, the American FCC (Federal Communication Commission) has received requests for a total of nearly 17,000 new satellites to be launched in the coming ten years (let us recall here that there are only 1,400 active satellites today). Operators are often newcomers to space operations with more experience with Silicon Valley processes than space safety concerns. Many of them, as mentioned previously, are well aware of all the space debris mitigation rules and are even proposing more stringent guidelines on themselves than are currently codified in global debris mitigation guidelines.

The years ahead of us may be critical, as we need to keep the situation under control. If every launcher and spacecraft operator complies perfectly with the current regulatory framework, if cubesats are launched exclusively in short-lived orbits, and if operators of large constellations effectively act as they claim they will, then everything will be fine and the long term sustainability of our precious space activities, so strategic for our everyday' s lives, will be guaranteed.

***Christophe Bonnal***
*• CNES Senior Expert*
*• Chairman of EUCASS 2019 Technical Committee*
*• Chairman of IAA & IAC Space Debris Committee*
*• French delegate to IADC, ECSS and ISO*
*• Emeritus Member of the French Association of Aeronautics and Astronautics (3AF)*

***To know more:***

***- IAA Situation Report on Space Debris – 2016 http://www.iaaweb.org/iaa/Scientific%20Activity/sg-514finalreport.pdf***
***- « La pollution spatiale », C. Bonnal, Belin 2016, ISBN : 978-2-7011-5792-4 (in French)***

# EUROAVIA – PREPARING THE YOUNG AEROSPACE GENERATIONS

**By Francesco di Lauro, President of the International Board of EUROAVIA 2018/2019**

It is not so rare that students, during their academic career, feel the need to learn something different to become competitive in a more and more globalized and changing market. The aerospace field makes no exception. Nowadays, between a fluid dynamics exam and a flight mechanics class, students are already looking for new challenges, for experiences which can boost their academic, professional and personal lives. And on the other side, industry and institutions want young students to be competitive and well trained. They need it because the youth are the future of the aerospace sector. This is valid today and was valid in 1959 when a group of students, to achieve a broader collaboration across Europe, decided to lay the foundations of EUROAVIA.

Since then, EUROAVIA has aimed to pursue this goal, providing its members lots of technical opportunities and fostering cultural enrichment through its international network.

## EUROAVIA TO REPRESENT AEROSPACE STUDENTS IN EUROPE

Next year, EUROAVIA will celebrate its 60th anniversary. Being one of the oldest international student associations, it is clear that EUROVIA assumes the key role to represent the European students interested in aviation and space to the main institutional bodies. Besides being part of CEAS, EUROAVIA has, over the years, gained recognition from different stakeholders like the Clean Sky Joint Undertaking. Clean Sky, funded by the EU's Horizon 2020, is the largest European research programme with the aim to reduce the pollution produced by aircraft. In this context, EUROAVIA has become the official representative of the students' community at the European Commission level.

And through the European Commission, EUROAVIA has also achieved for the first time the access to the Erasmus+ Grants to further sustain the international activities of the association. This was a crucial step for the organisation and an incentive to do even more.

Many enterprises are innovating and changing their business models towards a more digitalised future. In this context, EUROAVIA would like to undertake the same digital transformation process, thus pushing and increasing the digital capabilities of young students. This can be achieved through IT focused workshops and events and through a stronger connection with the industry and all the involved actors.

## CONNECTION WITH THE INDUSTRY

Opportunities is the key word here. Students want to refine their skills and put into practice what they learn at the universities. For this reason, EUROAVIA has always provided its members with lots of technical workshops and symposia with the help of experts and professionals coming from the industry. As a clear example, in collaboration with Airbus and ArianeGroup, EUROAVIA is organising the first edition of the Sloshing Rocket Workshop, a competition where student teams will be challenged to design a small and low-cost reusable rocket which is destabilized by the movement of the water stored inside. Airbus and ArianeGroup experts will introduce the problem of the sloshing to the teams via webinar lectures and they will evaluate the reports submitted, giving a professional feedback.

In the end, this competition will be beneficial both to students, who are going to boost their knowledge and their skills on the topic, and to Airbus, who is looking for out-of-the-box ideas coming from the young generations. This is the spirit and the role of EUROAVIA: tighten together students and professionals in a collaborative European setting, offering opportunities and training the aerospace professionals of tomorrow.

# CEAS 2018 GENERAL ASSEMBLY

The CEAS 2018 General Assembly took place in Brussels at EUROCONTROL Head Quarters on Friday 16th of November, chaired by CEAS President Christophe Hermans.

## CEAS ANNUAL REPORT

President Hermans presented the CEAS Annual Report 2018: *see pages 6-7.*

## FINANCE

Director General Mercedes Oliver-Herrero presented the 2017 Balance, the 2018 accounts and the 2019 budget. All were approved with no modifications.

## MEMBERSHIP

No changes intervened: no admittance of new members, no discharge of existing members.

## DISCHARGE OF TRUSTEES

The General Assembly approved unanimously the discharge of the Trustees for previous financial year.

## RESIGNATION – RE-ELECTION – NOMINATION BOARD OF TRUSTEES

The General Assembly approved unanimously:

- The resignation of the following Trustees: Elisabeth Dallo (AAAF), Paul Eijssen (NVvL), Miroslaw Rodzewicz (PSAA) and David Chinn (RAeS).
- The re-election for a 2-year period as CEAS Board of Trustees members of: Mercedes Oliver Herrero (AIAE), Leonardo Lecce (AIDAA), Kaj Lundahl (FTF), Christophe Hermans (NVvL), Zdobyslaw Goraj (PSAA), Emma Bossom (REeS), Georges Bridel (SVFW).
- The appointment, for a 2-year period as CEAS Board of Trustees members of: Michel Scheller (3AF), Fred Abbink (NVvL), Tomasz Goetzendorf-Grabowsli

## CEAS 41ST TRUSTEES BOARD MEETING

**Welcome**

Philippe Merlo, Head of Civil-Military ATM coordination at EUROCONTROL, welcomed the attendees. He mentioned in particular the intention of EUROCONTROL to actively support the CEAS activities, its conferences and publications.

**Approval of minutes**

The minutes of the 40th Trustees Board Meeting (Milano, February) were approved with no modifications;

**Election end Confirmations of Officers**

*President and Vice-Presidents*

The election of CEAS President and Vice-Presidents was done according to Article 9.3 of CEAS Statutes:

- Mr Christophe Hermans expressed his willingness to cease as CEAS President. Prof. Zdobyslaw Goraj was proposed as candidate by Dr Georges Bridel on behalf of SVFW. Prof. Zdobyslaw Goraj was unanimously elected as CEAS President for a 1-year term, starting on 1st of January 2019.
- Dr Cornelia Hillenherms, Vice-President Finance, appointed in 2016 for a 2-year term, had previously expressed her willingness to continue in her position. Her election was approved unanimously.
- Mr Pierre Bescond, Vice-President External relations & Publications, appointed in 2016 for a 2-year term, expressed his willingness to continue in his position. His election was approved unanimously.

*Aeronautical Branch and Space Branch Chiefs*

According to Article 9.3 of CEAS Statutes – "The two Branch Chairs will be appointed by the Board upon proposal of the President" – no change having been proposed, the two present chairs will continue in 2019:

- Christophe Hermans for the Aeronautical Branch;
- Torben Henriksen for the Space Branch.

## REVIEW OF ACTIONS IN COURSE

Many actions are in course of achievement for quality improvement. They were all reviewed during the meeting. Among decisions taken, three are mentioned here below:

- Preparartion of the Aerospace Europe Conference which will take place in Bordeaux (France) in early 2020.
- Distribution system for the Bulletin: it will be based on Mailchimp, including registering, subscription and unsubscription. Its entering into operation is expected for the first quarter of 2019.
- A CEAS Committee including RAeS, EUROAVIA, and academic background has been established to:
  - Organise yearly PhD conference together with PEGASUS;
  - Publish PhD event papers;
  - Organise a European quality system for higher education together with PEGASUS;
  - Support Clean Sky Academy in selecting PhD theses.

- Become Member of IAF (International Astronautical Federation) in early 2019.

## AWARDS

- CEAS 2019 Award: the decision to attribute it to J. Richard Parker was unanimously approved *(See next page 30)*.

*Synthesis written by J.-P.-S.*

■

# NOMINATION OF PROFESSOR RICHARD J. PARKER , CENG FRAeS TO 2019 CEAS AWARD

ROYAL AERONAUTICAL SOCIETY

**STATEMENT OF JUSTIFICATION**

During Professor Parker's tenure at Rolls-Royce, he built a broad portfolio of competitive products differentiated by world class technology, resulting in Rolls-Royce becoming No.1 in the wide-body airliner engine and large corporate aircraft engine markets and No.2 in the Defence aero-engine market.

The Rolls-Royce philosophy of "invent once, use many times" has been actively pursued by Prof. Parker with many technologies and capabilities developed in one sector transferred to others. For example, hollow titanium fan blades for Civil Aerospace applied to Defence (on JSF LiftSystem®) and advanced 3D computational fluid dynamics developed for aerospace applied in Marine.

The flow of technology has been achieved through promotion and growth of the Rolls-Royce University Technology Centre (UTC) model, now 31 UTCs globally with 800 staff (450 studying for doctorates) enabling the company to form long-lasting and mutually beneficial relationships with leading academic institutes. This network has created a cross-cultural working environment in areas of science, applied research, staff training, and technology transfer.

The UTC network is widely recognised as the exemplar for efficient and effective university & industry collaboration, and has been vital in providing technology support for product development in addition to fundamental research. In addition to opening new centres in the UK, UTCs have been developed in Norway, Sweden, Germany, Italy, USA, Korea and Japan, all under Professor Parker's tenure.

Under his stewardship the annual number of patent applications has risen from 250 to 600 highlighting the focus on development and capture of valuable and innovative intellectual property.

Having been involved from the earliest discussions on the Joint Technology Initiatives well in advance of FP7 [and the Clean Sky Joint Undertaking as one of these 5 ground-breaking proof-of-concept PPPs], Prof Parker's astute judgment, vision and leadership has been of resounding importance to the success of the Joint Undertaking and Clean Sky programmes. As Chairman from May 2014 his contribution has been instrumental: Prof Parker led the JU through the formative period of preparing, proposing and successfully launching the €4billion Clean Sky 2 programme under H2020, while "tending to business" in terms of ensuring the initial Clean Sky programme under FP7 was brought to a resoundingly successful close. His technical and scientific judgment, management experience, leadership and consensus building skills across a wide array of stakeholders, extensive network throughout the industry, and political antenna have greatly served not only the JU and its members, but the entire aeronautical community.

**CITATION**

Through his astute technical and scientific judgement, vision and leadership, Prof Ric Parker CEng FRAeS has made an outstanding contribution in serving the European aerospace community.

**CAREER SUMMARY / CV**

**Professor Richard J. Parker**, CBE, FREng, FRAeS, FIMechE, former Director of Research and Technology, Rolls-Royce Group

European CTO (Chief Technology Officer) of the Year-2014, Richard (Ric) Parker was appointed Director of Research & Technology, Rolls-Royce Group in January 2001, and is based in Derby, United Kingdom. He is responsible for direction and co-ordination of Research & Technology programmes across all the Rolls-Royce businesses, worldwide.

Ric joined Rolls-Royce in 1978, and has held various posts including Chief of Composites and Ceramics, Chief of Compressor Engineering, Managing Director Compressor Systems and Director of Engineering & Technology, Civil Aerospace.

Ric was awarded a CBE in the 2013 New Year's Honours List for "Services to Engineering". Ric is a Fellow of the Royal Academy of Engineering, a Fellow of the Royal Aeronautical Society, a Fellow of the Institute of Physics and a Fellow of the Institution of Mechanical Engineers. He is a Liveryman in the Worshipful Company of Engineers.

Ric gained a BSc in Physics at Imperial College, London in 1975 and an MBA with distinction at Loughborough University in 1992. He has Doctorates (honoris causa) from Pusan National University, Korea and Nanyang Technological University, Singapore; and from Loughborough University, Sheffield University and Heriot Watt University, in the UK. He is a visiting Professor in Aerospace and Transport Technology at Loughborough University and an Honorary Professor in Materials Engineering at Birmingham University, UK. Ric is married to Jenette, has two daughters, and lives in Littlcover, Derby, UK.

**REFEREES**

- Colin Smith HonFRAeS, former Director, Engineering & Technology, Rolls-Royce
- Mike Goulette FRAeS, formerly Rolls-Royce, Council member & Chair of Branches Committee, Royal Aeronautical Society
- Ron Van Manen, Programme Manager Clean Sky 2 at Clean Sky Joint Undertaking

## MOU WITH CHINA

CEAS has signed a Memorandum of Understanding with the Chinese Society of Astronautics (CSA), a large and professional aerospace association with 179 institutional members, 23,451 individual members and 39 technical committees. The intention is to establish a mutually fruitful relationship between both our organisations. The terms of the agrreement are reproduced here after.

**1**

CEAS

Memorandum of Understanding

Between

The Chinese Society of Astronautics
P.O. Box 838,
Beijing, 100830
China

(hereinafter called CSA)
and

The Council of European Aerospace Societies
C/o DLR Brussels office
98 Rue du Trône
1050 Bruxelles
Belgium

(hereinafter called CEAS)

**1. INTRODUCTION**

This Memorandum of Understanding (MOU) between the Council of European Aerospace Societies (CEAS) and the Chinese Society of Astronautics(CSA) establishes a mutually beneficial relationship between the two organizations.

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

**2**

It presently comprises twelve Trustee Member Societies with a combined roughly 35.000 individual members: 3AF (France), AAAR (Romania), AIAE (Spain), AIDAA (Italy), CzAeS (Czech Republic), DGLR (Germany), FTF (Sweden), NVvL (Netherlands), PSAA (Poland), RAeS (United Kingdom), SVFW (Switzerland), TsAGI (Russia), and four Corporate Members: EASA (European Aviation Safety Agency), ESA (European Space Agency), EUROAVIA and EUROCONTROL (Belgium).

Following its establishment as a legal entity conferred under Belgium Law, this association began its operations on January 1st, 2007. Its basic mission is to add value at a European level to the wide range of services provided by the constituent Member Societies, allowing for greater dialogue between the latter and the European institutions, governments, aerospace and defence industries and academia.

The 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.

The main objectives of CEAS are as follows:

- Obvious European focal point fostering knowledge dissemination in aerospace
- Active partner in European Aerospace Education, Research and Innovation
- Strengthen unique European label for aeronautical events and publications
- Coordination of biennial large scale European aerospace event with MoU partners and member society's support, attracting policy makers (European level), captains of aerospace industry and University scientists
- Support member societies and technical committees organizing thematic events with focus on mono-disciplinary engineering

The CSA was founded in 1979. It is a non-government and non-profit academic organization. CSA has 179 institutional members and 23,451 individual members and 39 technical committees. The objective of CSA is to expedite the development and

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popularization of space science and technology with professionals and technicians. The main tasks of CSA

- to organize national and international symposia, forum, conferences to promote space exchange and cooperation
- to conduct aerospace policy research and provide decision-making consulting and technical services
- to play an active role in the popularization of space science, offering all kinds of activities, upbringing the successors to the space cause
- to edit, publish and distribute "Journal of Astronautics" (bimonthly) and "Space Exploration" (monthly) published in Chinese, "Advances in Astronautics Science and Technology" in English and other books, publications, conference proceedings
- to be member-oriented and discover, recommend and award aerospace professionals and technicians
- to offer the training and continuing education to aerospace professionals and technicians

**2. PURPOSE**

CSA and CEAS have agreed to establish this Memorandum of Understanding (MOU) to better serve the common interests and welfare of their respective memberships.

CSA and CEAS enter into this Memorandum of Understanding as a result of the benefits obtained with the implementation of mutually agreed upon operating programs during the specified term of the initial MOU.

**3.SCOPE**

This MOU covers the activities of CSA, as a recognized representative professional aerospace organization located in China, and the activities of CEAS, as a recognized professional representative of the aerospace community in Europe. Both organizations and their members will work on a bilateral and multilateral level on international activities whenever appropriate.

**4.COOPERATIVE ACTIVITIES**

The collaboration between CEAS and CSA includes the following activities:

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- ✓ Coordination, mutual support and encouragement of cross-attendance to aerospace events of the two Parties where CEAS hosts/organizes when event is in Europe
- ✓ CSA hosts/organizes when event is in China

- Promote technical exchanges between the two organizations, such as:
  - ✓ Publication exchanges,
  - ✓ Mutual exchange of information about future activities
  - ✓ Cooperation between technical committees,
  - ✓ Representatives at identified events

In addition, CSA will collaborate with individual society members of CEAS, and expects to continue with this type of bilateral interaction as part of its international outreach activities.

**5. IMPLEMENTATION**

This MOU will become valid for an initial period of five years upon the approval of the appropriate governing bodies of both organizations and signed by authorized officers thereof.

All formal correspondence between organizations will be directed to the President of CEAS, c/o DLR – Rue du Trône 98 – 1050 Brussels (Belgium), Belgium, and to the Vice President and Secretary General of CSA, PO Box 838, Beijing, 100830, China.

The implementation of this MOU, or any supplemental agreements or work plans, will be made in accordance with the articles of this MOU and shall be agreed upon and entered into by the appropriate governing bodies of both organizations.

Amendments to this MOU may be made at any time, but mutually confirmed in writing

| | |
|---|---|
| Mr. Wang Yiran<br>Vice-President & Secretary General | Christophe Hermans<br>CEAS<br>President |
| Date: 2018.10.2 | Date: Oct 2, 2018 |
| Signature: | Signature: p.o. P. Bescond<br>Pierre BESCOND<br>VP External Relations |

## AMONG UPCOMING AEROSPACE EVENTS

# 2019

## JANUARY

**05-06** January – AIAA- **2nd AIAA Geometry and Mesh Generation Workshop** – San Diego, CA (USA) – www.aiaa.org/Events

**05-06** January – AIAA- **Aircraft and Rotorcraft System Identification Engineering Methods for Manned and UAV Applications with Hands-on Training Using CIFER ®Course** – San Diego, CA (USA) – www.aiaa.org/Events

**07-11** January – AIAA- **AIAA SciTech Forum (AIAA Science and Technology Forum and Exposition)** – San Diego, CA (USA) – www.aiaa.org/Events

**17-18** January – ESA- **D/OPS ESOC Industry Work shop – Darmstadt (Germany)** – ESA/ESOC – https://atpi.eventsair.com

**23-24** January – CLEANSKY- **Clean Sky 2 Workshop on Aviation Additive Manufacturing – Aachen (Germany)** – Fraunhofer Institute for Laser Technology – www.cleansky.eu/event/

**28** January - **1st** February – ESA- **ESA Satcom Final Presentation Days – Noordwijk (NL)** – ESA/ESTEC – https://atpi.eventsair.com

**30-31** January – EUROCONTROL - **Network manager User Forum 2019 – Brussels (Belgium)** – EUROCONTROL/HQ – https://www.eurocontrol.int/events

## FEBRUARY

**11-12** February – ESA/CNES - **Space Cost Engineering Conference – Noordwijk (NL)** – ESA/ESTEC – https://www.esaconferencebureau.com

**19-20** February – EASA - **Rotorcraft structures Workshop 2019 – Cologne (Germany)** – EASA/HQ – https://www.easa.eu/

**19-21** February – ESA- **2019 Conference on Big Data from Space – BiDS'19** – Munich (Germany) – Alte Kongresshalle Munich – https://www.bigdatafromspace2019.org/

## MARCH

**02-09** March – IEEE/AIAA – **2019 IEEE Aerospace Conference – Big Sky, MT (USA)** – Yellowstone Conference Center - www.aiaa.org/Events - www.aeroconf.org

**05-07** March – FSF/SAA – **SASS 2019 – 5th annual Singapore aviation Safety Seminar – Singapour (Singapore)** – Singapore Aviation Academy – https://flight-safety.org/events/

**11** March – CANSO – **CANSO CEO Strategy Summit – Cybersecurity in ATM – Madrid (Spain)** – https://www.canso.org

**12-14** March – ESA – **ESCCON – European Space Components Conference – Noordwijk (NL)** – ESA/ESTEC – https://atpi.eventsair.com/

**12-14** March – EUROMECH – **New Challenges in Finite Element Technology from the Perspective of Mechanics and Mathematics – Aachen (Germany)** – https://euromech.org/

**12-14** March – ACI/The World Bank – **ACI 11th Annual Airport Economics & Finance Conference & Exhibition – London (UK)** – Radisson Blu Portman Hotel - https://www.aci-europe.org

**12-14** March – CANSO/ATCA – **World ATM Congress 2019 – Madrid (Spain)** – Feria de Madrid – https://www.worldatmcongress/2019

**13-15** March – EUROMECH – **Composite Manufacturing Processes – Lyon (France) IPSA** – https://euromech.org/

**18-20** March – ACI-EUROPE – **28th ACI-EUROPE Commercial and Retail Conference & Exhibition – Reykjavik (Iceland)** – Hepal Harpa – www.aci-europe-events.com/

**25-27** March – 3AF/Cosponsored by AIAA – **54th 3AF International Conference on Applied Aerodynamics - Aerodynamics at Off-Design Conditions – Paris (France)** – www.aiaa.org/Events - http://3af-aerodynamics2019.com

**26-29** March – ERCOFTAC – **ETTM12 – 12th International ERCOFTAC Symposium on Engineering Turbulence Modelling and Measurements – European drag Reduction and Flow Control Meeting – Bad Herrenalb (Germany)** – Haus der Kirche – https://www.ercoftac.org/events/

## APRIL

**02-04** April – IATA – **SFO 2019 – Safety and Flight Operations Conference 2019 – Barcelone (Spain)** – Crowne Plaza Barcelona – Fira Center – https://www.iata.org/events/

**03-05** April – RAeS – **Structures for Electronic and Electric Hybrid Aircraft – London (UK)** – Queen Mary University – https://www.aerosociety.com/events-calendar/

## AMONG UPCOMING AEROSPACE EVENTS

**03-05** April – CEAS/AIAA – **2019 EuroGNC – 5th CEAS Conference on Guidance, Navigation & Control** – Milan (Italy) – www.eurognc19.polimi.it

**08-12** April – EUROTURBO – **ETC2019 – 13th Conference on Turbomachinery Fluid Mechanics and Thermodynamics** – Lausanne (Switzerland – EPFL – www.euroturbo.eu

**09-10** April – CLEANSKY – **Clean Sky Private Public Partnership. Aeronautics research in Europe at its best – High-Level Conference – Brussels (Belgium)** – The Hotel, Bd de Waterloo 38 – https://www.cleansky.eu/events

**10-12** April – CANSO – **CANSO Global ATM Operations Conference – Langen (Germany)** – Host: DFS – https://www.canso.org

**10-13** April – AERO Friedrichshafen – **Global Show 2019 for General Aviation – Friedrichshafen (Germany)**– Friedrichshafen Airport – www.aero-expo.com/aero-en/

### MAY

**02-03** May – FSF – **64th Business Aviation Safety Summit – Denver, Colorado (USA)** – https://flightsafety.org/events

**07-09** May – AIAA – **AIAA Defense Forum – Defense and Security Forum – Laurel, MD (USA)** – www.aiaa.org/Events

**13-17** May – ESA – **Living Planet Symposium 2019 – How EO contributes to science and society, how disruptive technologies and actors are changing the traditional EO landscape** – Milano (Italy) – Milano Congressi – https://www.esa-conferencebureau.com

**20-23** May – AIAA/CEAS – **Aeroacoustics 2019 – 25th AIAA/CEAS Aeroacoustics Conference** – Delft (NL) – TU delft – www.aiaa.org/events/

**21-23** May – EBAA – **EBACE 2018 – European Business Aviation Conference and Exhibition** – Geneva (Switzerland) – Geneva's Palexpo – http://ebace.aero/2019/

**27-29** May – Elektropribor – **26th Saint Petersburg International Conference on Integrated Navigation Systems (ICINS2019)** – Saint Petersburg (Russia) – www.elektropribor.spb.ru/icins2019/en

**27-30** May – European Commission – **AERODAYS2019 – Europe's Technological Achievements for a Sustainable Future of Aviation – Bucharest (Romania)** – Romanian Palace of Parliament – www.tandemaerodays19-20.eu

### JUNE

**04-05** June - FSF – **7th Annual Safety Forum – Brussels (Belgium) –** https://flightsafety.org/events

**10-13** June - IFASD – **International Forum on Aeroelasticity and Structural Dynamics 2019 –** Savannay, Georgia (USA) – Westin Savannah Harbor – https://aiaa.org/

**11-13** June - 3AF/SEE – **ETTC 2019 – European Test and Telemetry Conference – Toulouse (France)** – http://www.ettc2019.org

**12-14** June - AIAA – **TiS2019 – The 6th International Conference on Tethers in Space – Madrid (Spain)** – Universidad Carlos III de Madrid - www.aiaa.org/Events - http://eventos.uc3m.es/go/TiS2019

**16-20** June - ESA/DLR – **24th ESA Symposium on European Rocket and Balloon Programmes and Related Researches –** Essen (Germany) – Atlantic Congress Essen, Messeplatz, 3 – https://www.esaconferencebureau.com

**17-21** June - AIAA – **AIAA Aviation Forum – AIAA Aviation and Aeronautics Forum and Exposition –** Dallas, TX (USA) - www.aviation.aiaa.org/

**17-23** June - SIAE – **International Paris Air Show (IPAS) –** Le Bourget (France) – https://www.siae.fr

**18-20** June - EASN/GMI Aero – **CPD Seminar – Bonded Composite Repair of Aircraft Structures – Paris (France)** – www.gmi-aero.fr

### JULY

**01-04** July – EUCASS – **EUCASS 2019 – 2019 Edition of the biennial European Conference on AeroSpace Sciences** - Madrid (Spain) – Universidad Politecnica de Madrid (UPM) – https://eucass.eu

### AUGUST

**19-23** August – AIAA – **AIAA Propulsion and Energy Forum and Exposition** - Indianpolis, IN (USA) – www.aiaa.org/events

## AMONG UPCOMING AEROSPACE EVENTS

### SEPTEMBER

**03-05** September – EASA – **Area 100 KSA Workshop – Cologne (Germany)** – EASA/HQ – https://www.easa.europa.eu/

**03-06** September – EASN – **9th International Conference on Innovation in Space & Space – Athens (Greece)** – National Center for Science Research Demokritos (NSCR) – Agia Paraskeir – https://www.easn.net

**09-12** September – AIDAA – **XXV International Congress AIDAA** – Rome (Italy) – Faculty of Civil and Industrial Engineering of the Sapienza University of Rome – https://www.aidaa2019.com

**24-26** September – SAE International – **AEROTECH Europe Congress & Exhibition – Bordeaux (France)** – https://sae.org/

### OCTOBER

**08-09** October – FTF – **Aerospace Technology Congress 2019 – Sustainable Aerospace Innovation in a Globalised World – Stockholm (Sweden)** – Stockholm Waterfront Congress Centre – WWW.FT2019.SE

**15-17** October – IATA – **Global airport and Passenger Symposium 2019 – Warsaw (Poland)** – https://www.iata.org/events/

**15-17** October – Aviationweek – **MRO-EUROPE – Maintenance and Repair Overhaul Conference and Exhibition – London (UK)** – https://mroeurope.aviationweek.com

**15-20** October – Seoul – **Seoul Adex 2019 – Seoul International Aerospace and Defense Exhibition 2019** – Seoul (South Korea) – Seoul Airport – Seongnam Air Base – www.milavia.net/airshows

**21-25** October – IAC – **70th International Astronautical Congress** – Space: The Power of the Past, the Promise of the Future Washington, D.C.(USA) – Convention Center – www.iac2019.org/

### NOVEMBER

**04-08** November – COSPAR – **4th COSPAR Symposium – Small Satellites for Sustainable Science and Development** – Herzliya (Israel) – Hotel Daniel – http://www.cospar2019.org/

**06-09** November – ESA – **7th Intenational Conference on Astrodynamics Tools and Techniques (ICATT)** – Oberpfaffenhofen (Germany) – DLR Centre – https://www.esaconferencebureau.com

**17-21** November – Dubai – **Dubai Airshow 2019 – Connecting the Aerospace Industry** – Dubai –UAE) – Dubai World Central – Al Maktoum, Jebel Ali – www.dubaiairshow.aero

BULLETIN
AEROSPACE EUROPE


**Save the date!!**

**TandemAEROdays19.20 – Bucharest event**

**May 27-30, 2019 – Romanian Palace of Parliament**

## Europe's Technological Achievements for a Sustainable Future of Aviation

As the first AEROdays host in Central and Eastern Europe, Bucharest offers both a prominent location for the event – the Romanian Palace of Parliament – and an open environment for regional synergies in aerospace research and education, confirming the rapid expansion and development of a coherent European strategy in the transportation sector, especially in the aeronautics and air transport area. Furthermore, the TandemAEROdays19.20 concept supports a clear political message for joint industrial cooperation policies in the aviation sector across the rotating Presidency of the EU Council, as the coordinated events in Romania and Germany will show the cooperative effort while reflecting each country's mandate and boundary conditions.

Four days of plenary and technical sessions, several planned visits to major local research and industrial facilities, and plenty of social networking opportunities will bring together a wide and comprehensive range of speakers and attendants for a ground breaking event in Bucharest.



CEAS
COUNCIL OF EUROPEAN AEROSPACE SOCIETIES