CEAS
Council of European Aerospace Societies

BULLETIN AEROSPACE EUROPE

THE FIRST EDITION OF THE AEROSPACE EUROPE CONFERENCE "AEC2020" WAS HELD IN BORDEAUX (FRANCE) FROM 25 TO 27 FEBRUARY - OBJECTIVE: TO REVIEW IN DETAIL THE GREENER AEROSPACE INNOVATIVE TECHNOLOGIES AND OPERATIONS FOR A CLEANER ENVIRONMENT – A VERY SUCCESSFUL EVENT ATTENDED BY NEAR TO 500 EXPERTS FROM ALL OVER THE WORLD

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;
- 8 Societies having signed a Memorandum of Understanding (MoU) with CEAS: AAE (air and Space Academy), AIAA (American Institute of Aeronautics and Astronautics), CSA (Chinese Society of Astronautics), EASN (European Aeronautics Science Network), EREA (European association of Research Establishments in Aeronautics), ICAS (International Council of Aeronautical Sciences), KSAS (Korean Society for Aeronautical and Space Sciences) and Society of Flight Test Engineers (SFTE-EC).

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.

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- A structure for Technical Committees

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- 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

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- 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.

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President's Message

Zdobyslaw Goraj
CEAS President

ABOUT AEC2020: CEAS ROLE AND IMAGE

AEC2020 was perfectly organised in the Congress Centre located at the Bordeaux outskirts. More than 400 participants not only from Europe, but also from USA, China, South Korea and other counties presented a high number of high-standard papers. Having in mind the violent spreading of the covid-19 coronavirus, it was really the last moment to hold our biennial Conference. And unfortunately, all technical visits planned on the last day, Friday 28 February, were cancelled, following the recommendations expressed by the French Ministry of Health and the French Foreign Office.

AEC2020 was organised by the French Association of Aeronautics and Astronautics (3AF) together with AIAA and CEAS as the main co-organiser. CEAS of course has played the key role all over the three days of the event. Two of the five plenary sessions were chaired by CEAS officers: plenary session 2 by Christophe Hermans and plenary session 5 was by me. CEAS had a booth in a very well located place, where our bulletins 'AEROSPACE EUROPE' and the information about our activities were offered to all delegates. Beata Wierzbinska-Prus, our administrative support person, played quite an essential role at the registration desk and in partly offering the information service in CEAS booth. During the closing ceremony, Prof. Tomasz Goetzendorf-Grabowski, PSAA President, invited all participants for the next biennial CEAS Conference, AEC2021, which will take place in the Institute of Aviation, Warsaw, Poland.

The whole conference was dominated by presentations and papers dedicated to greener aviation. Most of keynote lectures were also related to climate-neutral aviation, green bizjet and clean aeronautic-space technology. From my personal perspective I would like to mention the fascinating presentation delivered by Alain Rousset, President of the "Nouvelle Aquitaine" Region. Most notably, he spoke about the importance of research for novel technologies with a view to controlling the climate change, thinking to future generations. It does not happen very often that local politicians and territorial actors show such a long-term vision and appreciate research as the most important activity to prepare for a better future of our society.

I wish to address my congratulations to the 3AF association for the remarkable work it accomplished to organise in a so good manner this successful AEC2020. Within the 3AF, this is Dominique Nouailhas who has played the central role:

"Dear Dominique, Please accept my warmest congratulations for perfectly organized AEC2020. It was really a great success and will be a baseline for future organisers!"

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AEC2020 TOOK PLACE IN BORDEAUX, FRANCE, FROM 25 TO 27 FEBRUARY 2020

By Jean-Pierre Sanfourche, Editor-in-Chief

The **AerospaceEuropeConference2020**, organised by the French Association of Aeronautics and Astronautics (3AF *Association Aéronautique et Astronautique de France)* on behalf of the Council of European Aerospace Societies (CEAS), held in Bordeaux from 25 to 27 February, was very successful.

The venue was the prestigious Bordeaux Congress Centre located in Bordeaux-Lac.

© 3AF

© 3AF

The event had been supported by a number of industrial companies and institutions.

The mention "very successful" is justified because it was attended by near to 500 delegates from all over the world: France 115; Germany 80; UK 39; Italy 29, Belgium 28; NL 28; Japan 20; Romania 18; Spain 17; USA 16; Russia 14; Poland 9; Portugal 9; Sweden 8; Israel 7; China 6, with

Reception desk – On the right, B. Wierzbinska-Prus (CEAS Administrative Support Person) works together with her French Colleagues © Zdobyslaw

CEAS booth, from left: W. Ostachowicz, Z. Goraj, Ch. Hermans, T. Goetzendorf-Grabowski and M. Oliver-Herrero © Zdobyslaw

in addition some participants from Ireland, Czech Republic, Turkey, South Korea, Switzerland, Austria, Taiwan, Ukraine and Algeria.

In total, about 350 technical high-level papers were presented.

It has to be noticed that an important delegation from China had been initially foreseen, 70 delegates, but due to the coronavirus epidemic the organisers were obliged to reduce it to 6 only.

Approximately 200 delegates came from industry, and 300 from academia and research establishments.

Besides we had pleasure in observing the presence of a high number of students and young professionals.

Unfortunately, for coronavirus epidemic reasons also, the technical visits (Dassault Aviation – Thales – Arianegroup) as well as the Wine Tour in Blaye programmed for the Friday 28 February had to be cancelled.

GENERAL BACKGROUND

To pave the way for a single European aerospace conference, the CEAS and the French Association of Aeronautics and Astronautics (3AF) had decided to join forces to launch the very first edition of Aerospace Europe Conference: AEC2020.

AEC2020 featured three main events: ANERS, Greener Aviation and Space.

- The CEAS and the American Institute of Aeronautics and Astronautics (AIAA) hold the 8th edition of their regular symposium ANERS (Aircraft Noise and Emissions Reduction Symposium). Supporting the development of a long-term vision, the objective of this high-level technical Symposium is to review challenges and opportunities faced by manufacturers, local communities, air carriers, airports, governmental institutions, and non-governmental organisations in addressing noise and emissions abatement and to discuss holistic solutions that will alleviate the pressures associated with air traffic.
- In the recent years, the 3AF had hold two important conferences about Greener Aviation in close liaison with Clean Sky JU, this part of AEC2020 was therefore its third edition.
- The previous six CEAS Conferences (2007 Berlin, 2009 Manchester, 2011 Venice, 2013 Linköping, 2015 Delft, 2017 Bucharest) comprised two parts, Air and Space, this is the reason wнy they were called 'CEAS Air & Space Conference'. So, AEC2020 being the 7th edition of the CEAS biennial conference, it covered both aeronautics and space, focusing on environmental issues.

AEC2020 WAS STRUCTURED AROUND FIVE PLENARY SESSIONS:

• **Plenary Session 1 – 25 February morning - Opening**
Chair: Christian Mari, 3AF, Chair of AEC2020
Welcome by Louis Le Portz, President of 3AF
Alain Rousset : President of Nouvelle Aquitaine Region

• **Plenary Session 2 – 25 February afternoon**
Chair: Christophe Hermans, DNW (NL)
Keynote Speech 1: The Space Climate Observatory: a great deal – Jean-Yves La Gall, President of CNES (France)
Keynote Speech 2: Clean Sky towards climate-neutral aviation – Axel Krein, Executive Director Clean Sky JU

• **Plenary Session 3 – 26 February**
Chair: Rafael Bureo Dacal, ESA/ESTEC
Keynote Speech 3: Common aeronautics-space Technologies – Pascale Ehrenfreund, DLR Chair
Keynote Speech 4: Space electric propulsion – José Gonzalez del Amo, ESA/ESTEC
Round Table 1: From research to flight bridging the Death Valley – Moderator: Philippe Landiech, CNES

• **Plenary Session 4 – 27 February**
Chair: Valérie Guénon, Director of Environmental Policy, Safran University
Keynote Speech 5: Green bizjet technological developments within aronautical research programmes – Bruno Stoufflet, CTO Dassault Aviation and Vice President of CORAC
Keynote Speech 6: The route to sustainable aviation – Paul Stein, CTO Rolls-Royce
Round Table 2: Electrohybrid propulsion – Moderator: Rolfe Henke, DLR Executive Board Member for Aeronautics Research

• **Plenary Session 5 – 27 February afternoon – Closing**
Chair: Zdobyslaw Goraj, TU Warsaw, CEAS President
Keynote Speech 7: Civil Aviation in Horizon Europe – status and view from the European Commission – Hervé Martin, Head of Unit "Low Emission Future Industries", Directorate General for Research and Innovation, Clean Planet, European Commission

- Best Paper Award Ceremony
- The CEAS Award Ceremony

OPENING - WELCOME

The conference was opened by Christian Mari, Chair of AEC2020.

Opening ceremony – Christian Mari (Chair of AEC-2020) © Zdobyslaw

Then, President Louis Le Portz presented the hosting society, the French Association of Aeronautics and Astronautics 3AF.

Opening ceremony – Louis le Portz (3AF President) © Zdobyslaw

Then Alain Rousset, President of the "Nouvelle Aquitaine" Region, highlighted the density of aerospace activity in South-West of France, most notably in Bordeaux, and delivered a brilliant plea in favour of research, which needs to be more and more intensified for properly solving the difficult constraints aerospace is facing, in particular environmental, and more generally for preparing the best possible future for the next generations.

Opening ceremony – Alain Rousset – the "Nouvelle Aquitaine" region President
© Zdobyslaw

TECHNICAL PAPERS: EACH PLENARY SESSION WAS DIVIDED INTO THREE PARTS:

- ANERS
- Aeronautics
- Space

ANERS TOPICS included: Noise Impact: the ANIMA programme (Aviation Noise Impact Management through Novel Approaches) - Alternative Fuels - Green Operations AERONAUTICS TOPICS included: Aerodynamics - Materials and Structures – Composites - Hybrid/electric propulsion and aircraft - Electric powered aircraft - On board energy management and alternative power sources - Research infrastructure for greener and safer aviation - Low noise - Acoustic liners - Manufacturing, Testing monitoring and certification - New aircraft configurations - Numerical simulation, and optimisation of novel aircraft concept - High speed transport and environment - Urban air mobility and its impact on the environment – Autonomous aircraft operations – Satellites communications and Operations, software and robotics – Testing, design methods and concepts – Clean Sky Technology Evaluator

SPACE TOPICS included: Clean space, space debris – Materials and advanced manufacturing for space applications – Structures, thermal and mechanisms - Environmental control and life support in space – Space aerothermodynamics – Space propulsion – Space Guidance Navigation and Control (GNC) – Mission design and space systems – Testing

SEVEN KEYNOTE SPEECHES:

See pages 10 to 46.

THE CLOSING SESSION

The Closing Session included:

- the Keynote Speech "Clean Aviation in HORIZON EUROPE – status and views from the European Commission", which was delivered by Hervé Martin, Head of Unit "Low Emission Future Industries" at the Directorate General for Research and Innovation, Clean Planet, European Commission;

- the conclusive speech delivered by Zdobyslaw Goraj, CEAS President;

Closing ceremony – CEAS President Zdobyslaw Goraj
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Closing Ceremony – CEAS President Z. Goraj expresses the words of thanks for 3AF – the main organiser of AEC-2020 on the hands of Dominique Nouailhas – the main architect of organisational success of the conference
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- the invitation of Prof. T. Goetzendorf-Grabowski, President of PSAA, to the next CEAS Conference AEC2021 which will take place in Warsaw, Poland, in Autumn 2021.

Prof. T. Goetzendorf-Grabowski – President of PSAA – invites to the next AEC-2021, to be held in Warsaw, Poland. © Zdobyslaw

Cocktail Party held in Bordeaux county hall, from left: Z. Goraj, T. Goetzendorf-Grabowski, M. Kowalski, B. Wierzbinska-Prus, Sergey Chernyshev and W.Ostachowicz. © Zdobyslaw

Discussion after key-note lecture given by Hervé Martin - European Commission, Head of the Unit "Low Emission Future Industries"
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THE BEST PAPER AWARDS CEREMONY

• IN AERONAUTICAL BRANCH

Best Paper Award Ceremony in the Aeronautical Branch
Valérie Guénon presents the award to Vlad Ciobaca (DLR Braunschweig) and his co-authors for their work accomplished in aerodynamics: "CFD and Wind Tunel Tests for Local Active Flow Control at the Wing-Pylon Nacelle Junction".
© Zdobyslaw

• IN SPACE BRANCH

Best Paper Award Ceremony in the Space Branch
The Award was delivered to Mr Andrea Valmormida for the paper "Deployment Requirements for Deorbiting electrodynamic Tether Technology". This paper has been coproduced by the University of Padova, SENER and the University Carlos III.
© Zdobyslaw

THE SPACE CLIMATE OBSERVATORY: A GREEN NEW DEAL

By Jean-Yves Le Gall, President of the French Space Agency (CNES)

Ladies and Gentlemen,

The space industry is well used to addressing issues of international importance. Whether studying the Sun with Solar Orbiter, launched earlier this month, exploring Mars with ExoMars and Mars 2020, set to depart to the red planet in July, or returning to the Moon with the Artemis programme in which we will be key partners, such challenges spur us to push the boundaries of science and technology, which is something that engineers like you will easily appreciate.

CLIMATE CHANGE

But today, the challenge facing us is climate change. President Macron reaffirmed this priority in Chamonix on 13 February and the European Union is advocating a Green Deal to transform Europe's economy and gear it towards sustainable development. CNES is integral to France's desire, first expressed nearly 60 years ago by President Charles de Gaulle, to place our country in the vanguard of space science.
CNES is today Europe's leading space agency and has over the years forged ties with other national space agencies all over the world, from the United States to China and the United Arab Emirates to Israel, India and Singapore. This world-embracing vision is what drives our ambition, be it in the field of Earth remote-sensing satellites, in missions to explore our solar system and beyond, or more broadly in our laser focus on innovation.

A MOON WITH A VIEW

But to get back to the theme of my talk today, I would like to show you what National Geographic photographer Brian Skerry believes is the most important picture ever taken. Take your minds back to Christmas Eve of 1968, as astronauts Frank Borman, Jim Lovell and Bill Anders begin orbiting the Moon. Bill Anders grabs hold of his camera and takes this picture of Earthrise—a picture that would spur ecologists into action and sow the first seeds for a global perspective of our development. In 1994, Carl Sagan would write: "That's home. That's us. […] To my mind, there is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly and compassionately with one another and to preserve and cherish that pale blue dot, the only home we've ever known."

On his return to Earth on 12 April 1961, Yuri Gagarin put it no better, and ESA astronaut Thomas Pesquet took pictures from the International Space Station to open our eyes once more to the beauty and fragility of this planet. Space has therefore become a great tool for broadening our perspective and seeing things more clearly from afar. This philosophy led us in 2017 at the first One Planet Summit to submit a proposal to President Macron to create the Space Climate Observatory, or SCO.

ONE PLANET SUMMIT

Building on the strong momentum created by France, the COP 21 conference in 2015 and then the One Planet Summit two years later reaffirmed the commitment of stakeholders from all horizons—governments, international organizations, development banks, NGOs, foundations, investors and territories—to tackle climate change, for we can no longer stand by and watch as it plays havoc with our environments and lives. It had therefore become urgent to prepare ourselves to mitigate these effects and adapt our societies to the changes afoot in agricultural ecosystems, in forests and on our shores.
In response to these planet-wide challenges, CNES proposed to engage the efforts of the world's space agencies behind a strong initiative through the framework of the One Planet Summit. They committed to step up their cooperation and actions in the field of climate change, to address its impacts and monitor ecosystems in order to inform decisions at global and local scales. This initiative led to the adoption of the Paris Declaration creating the SCO signed by 23 space agencies, UNOOSA, UNDP and the European Commission.

SPACE CLIMATE OBSERVATORY

The Space Climate Observatory is part of this effort to deliver data, information, models and tools to inform decisions on coping with the impacts of climate change. We must now use the long record of in-situ and space-based climate measurements that we have established to respond to the challenges facing us at local level and in our daily lives. We also possess a wealth of local socio-economic data on populations, infrastructures, towns and cities.
While the first signs of change on a global scale—such as rising temperatures and sea level, and more intense severe weather events—are already identified, what about their impacts on countries, regions, cities and villages? How can we exploit the legacy of Earth remote-sensing data such as France's SPOT World Heritage 30-year archive to come up with change scenarios out to 2030, 2050 and even as far as 2100? How can we ensure interoperability between these sources of data to model as precisely as possible the consequences of rising coastal waters, urban heat islands, disappearing mountain snow cover and water stress?

FRANCE AS A KEY PLAYER

The SCO will have to address these issues and challenges by delivering products and indicators at the appropriate territorial scale. And it will have to do this in coordinated fashion, working with space agencies and large international organizations alongside existing major international climate programmes. Operating downstream of these international programmes, the SCO will help nations prepare for climate change, build realistic scenarios and monitor the impacts being felt locally now and in the future. This ability for nations to specifically analyse the consequences of global changes at the scale of territories and populations will enable them to devise more effective coping and mitigation solutions.

The SCO is therefore a project that must federate the energies of all nations. France, as the project's initiator through CNES, must continue to lead the way in creating a world benchmark hub in local modelling of climate change, attracting the best and brightest research scientists and engineers and leveraging its leading research bodies, laboratories and industry, notably the increasing number of start-ups emerging in this domain.

MAKE OUR PLANET GREAT AGAIN

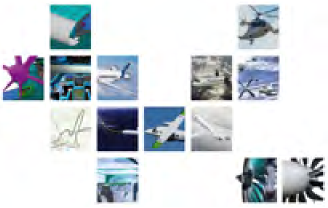
To make this project a success, we will need to devote the resources to match our ambitions. From a human resources perspective, we must exploit and develop the pool of world-renowned expertise currently available in France, continue to attract the best talents through the Make Our Planet Great Again initiative and get this fabric to mesh with and tap into all of the capabilities out there. From a material resources standpoint, we must overcome the obstacles encountered in finding, accessing and processing data, by deploying leading-edge digital technologies on a large scale.

The SCO will therefore be foundational for the world of research and will work closely with an ecosystem developed by particularly dynamic private initiatives in France in these domains. Many research laboratories and scientists are already working on these disciplines. The aim now is to scale up these efforts to obtain data covering large territories, using increased computing power able to deliver the performance required to handle large amounts of data.

SPACE FOR EARTH

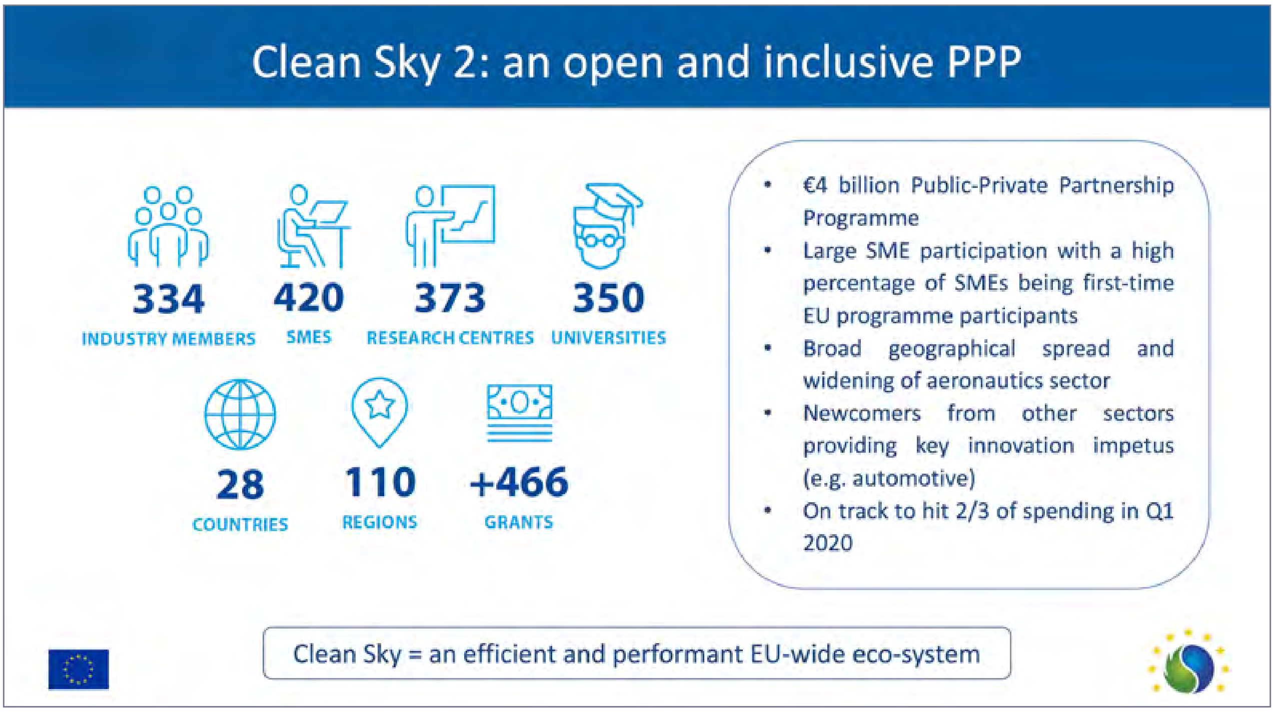
In particular, artificial intelligence, used massively by these systems, algorithms and the extraction and generation of new data will be a new source of wealth. The national material and human components of the SCO will therefore be critical to ensure that France remains a leading player in this international programme. To this end, the SCO will be able to build from the national artificial intelligence plan announced by President Macron, of which it will be destined to become the climate change component.

So, as you can see, space is coming back to Earth. Only analyses and views from space give us the information we need to propose climate-resilience actions to decision-makers at world, national, regional and local levels. Such actions will be made possible by combining our data with in-situ analyses and local data, and will enhance our ability to explain climate change, to convince people that it is real and to spawn a new planet-wide awareness. We have before us one of the biggest challenges ever faced by humankind—not to go to the Moon or Mars, not to venture ever deeper into our Universe, but to preserve our planet for future generations. With the SCO, CNES is ready for this Green New Deal!

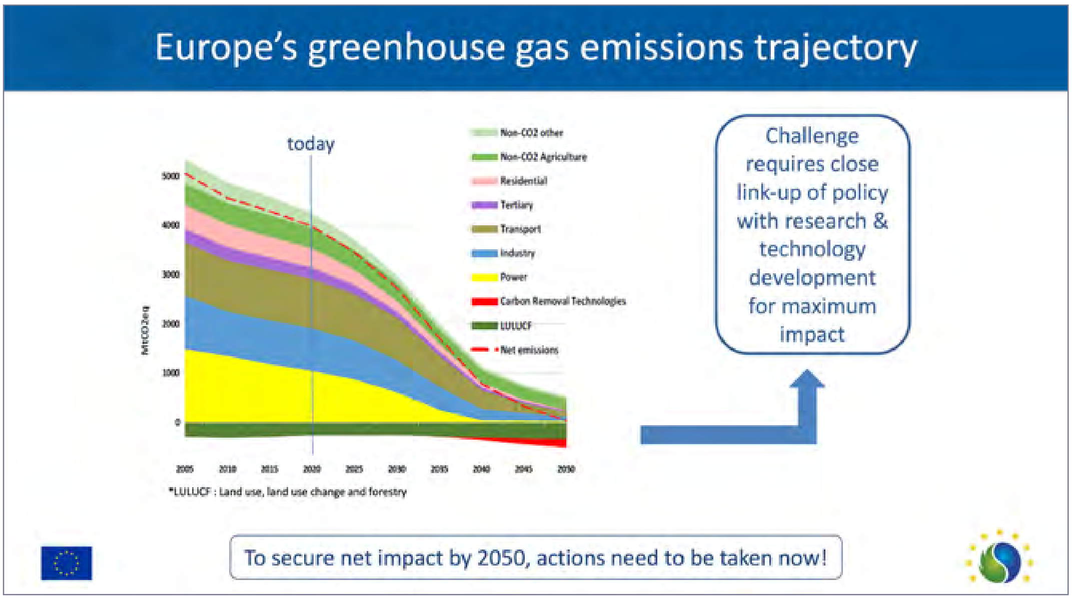


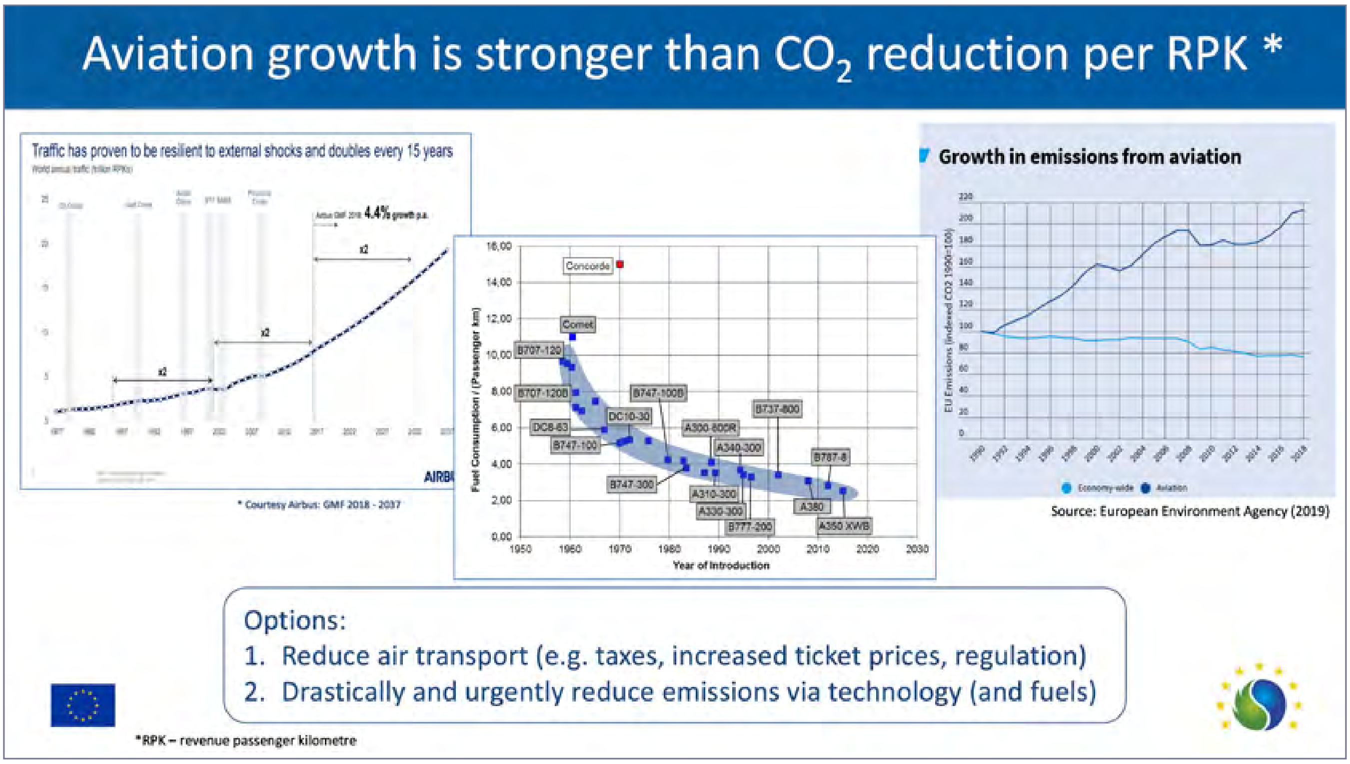
CLEAN SKY TOWARDS CLIMATE-NEUTRAL

By Axel Krein, Executive Director, Clean Sky JU

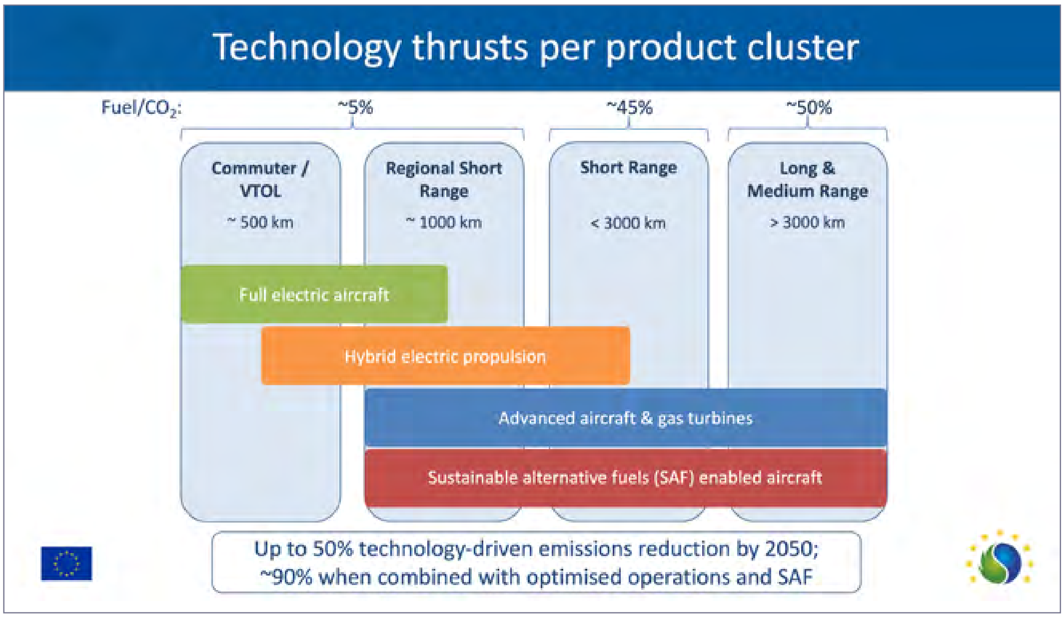


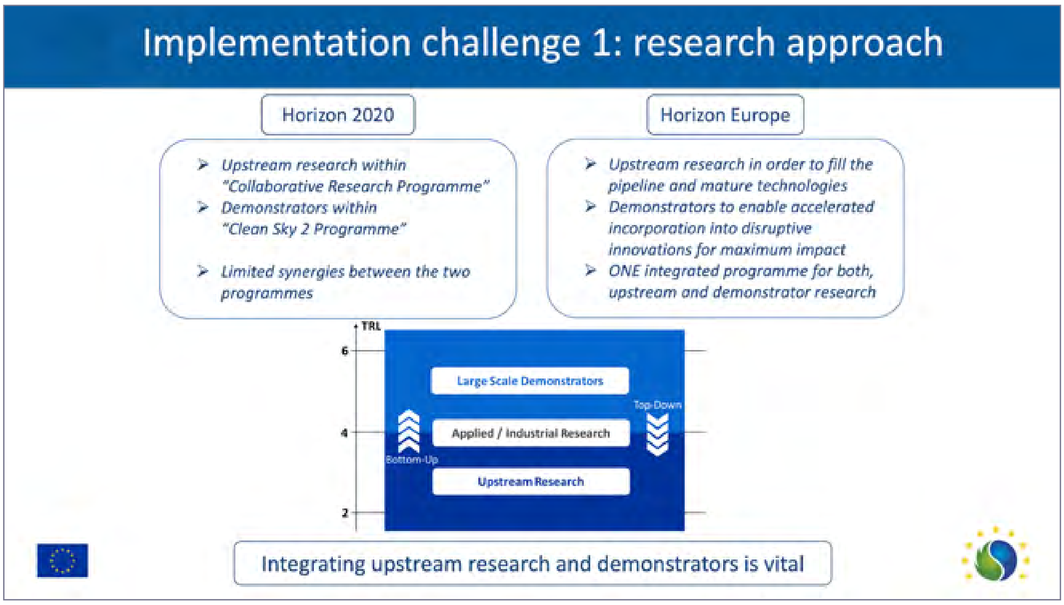

Important gains are being made, but this is not enough!
Clean Sky 2 Environmental Objectives
-CO2
-20% TO -30%
-NOx
-20% TO -30%
-20% TO -30%
vs. best aircraft in 2014
PARIS2015
COP21·CMP11
ATAG
IATA
EUROPE'S GREEN DEAL
Our vision: Climate neutral Europe by 2050
icct
The Green Deal: climate neutrality and EU competitiveness

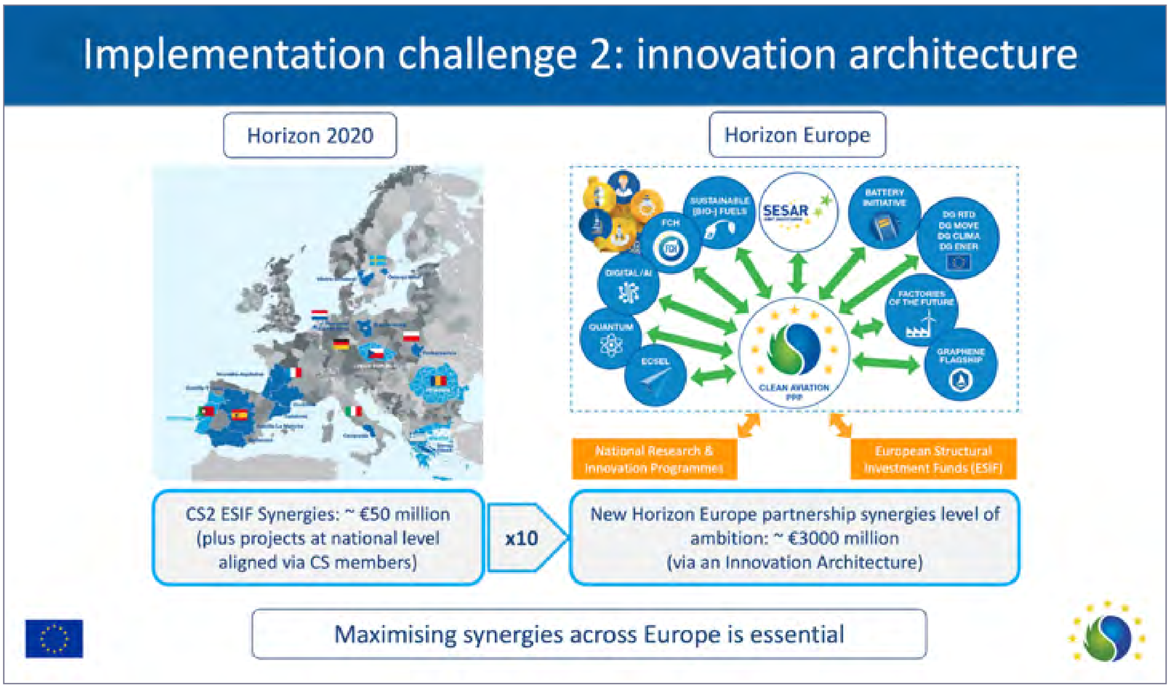

Europe's greenhouse gas emissions trajectory
today
Non-CO2 other
Non-CO2 Agriculture
Residential
Tertiary
Transport
Industry
Power
Carbon Removal Technologies
LULUCF
Net emissions
MtCO2eq
*LULUCF : Land use, land use change and forestry
Challenge requires close link-up of policy with research & technology development for maximum impact
To secure net impact by 2050, actions need to be taken now!

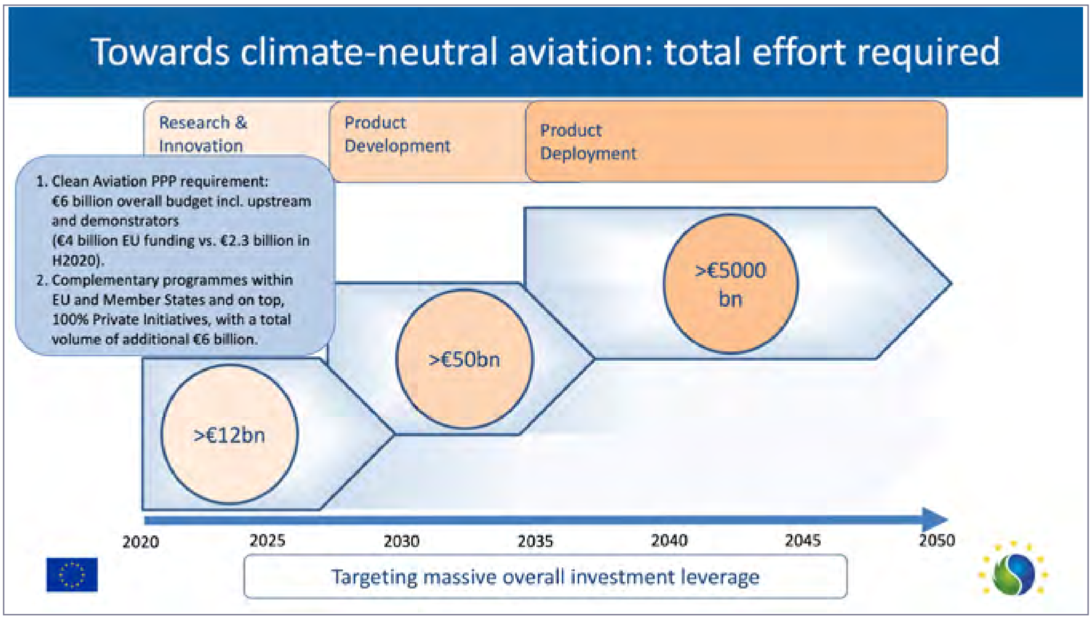

Aviation growth is stronger than CO2 reduction per RPK *
Traffic has proven to be resilient to external shocks and doubles every 15 years
4.4% growth p.a.
x2
x2
x2
* Courtesy Airbus: GMF 2018 - 2037
Fuel Consumption / (Passenger km)
Year of Introduction
Concorde
Comet
B707-120
B707-120B
B747-100B
B737-800
DC8-63
DC10-30
A300-600R
B747-100
A340-300
B787-8
B747-300
A310-300
A380
A330-300
B777-200
A350 XWB
Growth in emissions from aviation
EU Emissions (indexed CO2 1990=100)
Economy-wide
Aviation
Source: European Environment Agency (2019)
Options:
1. Reduce air transport (e.g. taxes, increased ticket prices, regulation)
2. Drastically and urgently reduce emissions via technology (and fuels)
*RPK – revenue passenger kilometre


Private stakeholder's Shared Vision and Commitment
for the proposed Clean Aviation Partnership
ACITURRI
AERnnova
AIRBUS
Avio Aero
CIRA
DASSAULT AVIATION
DLR
evektor
EASA
easn
EREA
Fraunhofer
INCAS
KU LEUVEN
LEONARDO
LIEBHERR
Lufthansa Technik
MTU Aero Engines
nlr
ONERA
PEGASUS
PIAGGIO AEROSPACE
PIPISTREL
SAAB
SAFRAN
THALES
TU Delft
United Technologies Research Center
UNIVERSIDAD POLITÉCNICA DE MADRID
UNIVERSITY OF PATRAS
Universität Stuttgart
Germany
A Shared Vision: climate-neutral aviation by 2050


Technology thrusts per product cluster
Fuel/CO2:
~5%
~45%
~50%
Commuter / VTOL
~ 500 km
Regional Short Range
~ 1000 km
Short Range
< 3000 km
Long & Medium Range
> 3000 km
Full electric aircraft
Hybrid electric propulsion
Advanced aircraft & gas turbines
Sustainable alternative fuels (SAF) enabled aircraft
Up to 50% technology-driven emissions reduction by 2050;
~90% when combined with optimised operations and SAF


Implementation challenge 1: research approach
Horizon 2020
Upstream research within "Collaborative Research Programme"
Demonstrators within "Clean Sky 2 Programme"
Limited synergies between the two programmes
Horizon Europe
Upstream research in order to fill the pipeline and mature technologies
Demonstrators to enable accelerated incorporation into disruptive innovations for maximum impact
ONE integrated programme for both, upstream and demonstrator research
TRL
6
4
2
Large Scale Demonstrators
Top-Down
Applied / Industrial Research
Bottom-Up
Upstream Research
Integrating upstream research and demonstrators is vital


Implementation challenge 2: innovation architecture
Horizon 2020
Horizon Europe
SUSTAINABLE (BIO-) FUELS
SESAR
BATTERY INITIATIVE
DG RTD
DG MOVE
DG CLIMA
DG ENER
FCH
DIGITAL / AI
FACTORIES OF THE FUTURE
QUANTUM
ECSEL
CLEAN AVIATION PPP
GRAPHENE FLAGSHIP
National Research & Innovation Programmes
European Structural Investment Funds (ESIF)
CS2 ESIF Synergies: ~ €50 million (plus projects at national level aligned via CS members)
x10
New Horizon Europe partnership synergies level of ambition: ~ €3000 million (via an Innovation Architecture)
Maximising synergies across Europe is essential

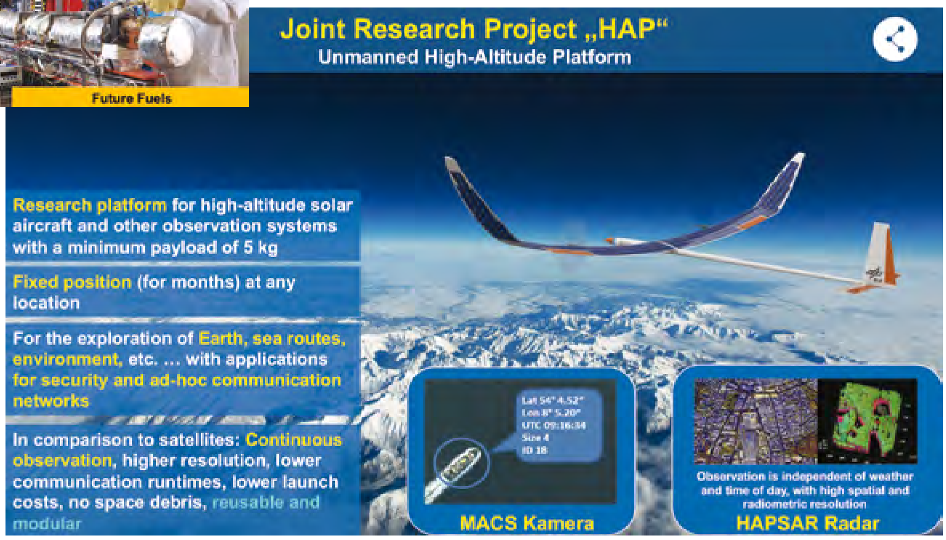

Towards climate-neutral aviation: total effort required
Research & Innovation
Product Development
Product Deployment
1. Clean Aviation PPP requirement: €6 billion overall budget incl. upstream and demonstrators (€4 billion EU funding vs. €2.3 billion in H2020).
2. Complementary programmes within EU and Member States and on top, 100% Private Initiatives, with a total volume of additional €6 billion.
>€12bn
>€50bn
>€5000 bn
2020
2025
2030
2035
2040
2045
2050
Targeting massive overall investment leverage


Outlook on Horizon Europe: Clean Aviation Partnership
• European Commission priorities for 2021-2027 (e.g. Green Deal)
• Clear and extremely ambitious sector-wide commitment to achieve a climate-neutral aviation in 2050, while ensuring EU's competitiveness
• Revolution in technology development and its fast and widespread deployment is mandatory
• A PPP ensures teaming and brings research and policy together → impact
• Impact will assure European aviation is fit for the future and a global leader
• Effective regulations and an appropriate financial framework will enable synergies, setting global standards and secure EU's industrial strategy
Courtesy DLR
Courtesy ONERA
Courtesy TU Delft / NLR

COMMON AERONAUTICS-SPACE TECHNOLOGIES AT GERMAN AEROSPACE CENTRE DLR

By Prof. Dr Pascale Ehrenfreund, Chair of DLR Executive Board

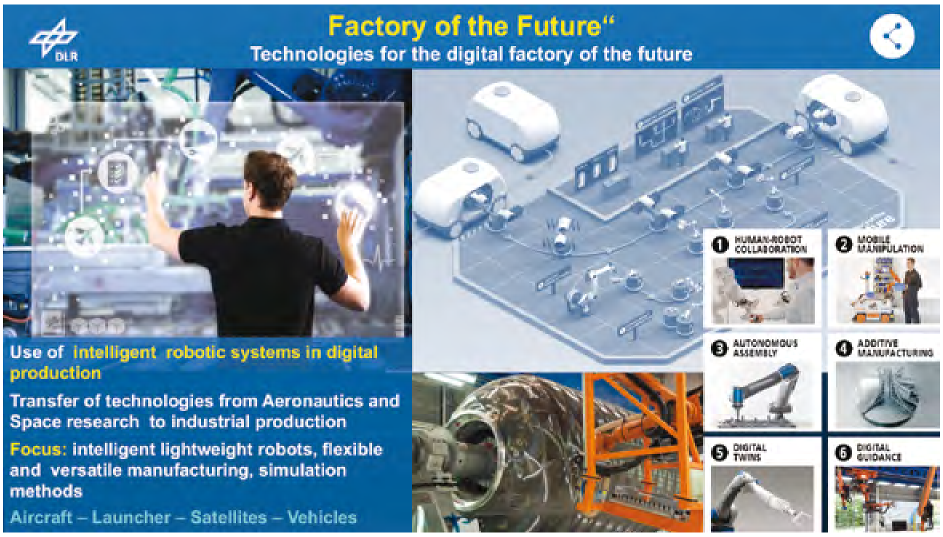

High-Altitude Platform
Global Connectivity via Satellite
DLR-wide cross-sectional joint research projects
DLR
Condition Monitoring
Future Fuels


Joint Research Project „HAP"
Unmanned High-Altitude Platform
Research platform for high-altitude solar aircraft and other observation systems with a minimum payload of 5 kg
Fixed position (for months) at any location
For the exploration of Earth, sea routes, environment, etc. … with applications for security and ad-hoc communication networks
In comparison to satellites: Continuous observation, higher resolution, lower communication runtimes, lower launch costs, no space debris, reusable and modular
MACS Kamera
Observation is independent of weather and time of day, with high spatial and radiometric resolution
HAPSAR Radar

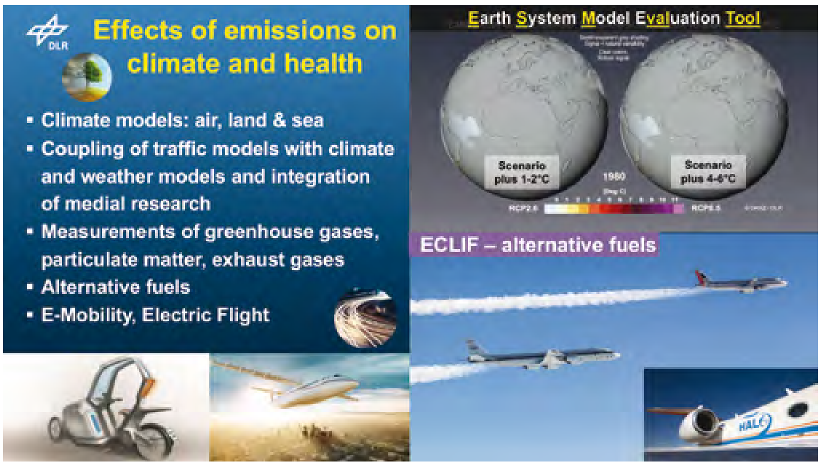

DLR
Joint Research Project „Global Connectivity via Satellite"
Research and Development of high-speed Internet Connection via satellite
Optical Feeder-Links
Reliable, cost-effective and rapidly deployable solution, to supplement optical fibre and mobile communications, through optical communication
Strengthening the basis of the digital economy and society through intelligent mobility
Increased connectivity for underserved areas and mobile carriers (trains, ships and aircraft)
Advantages include an almost unlimited spectrum and fewer regulatory obstacles
RF User Links with multi beam-antennae


DLR
Joint Research Project „Condition Monitoring "
Monitoring of Safety-relevant Structures
"Digital Twin in Operation"
Integration of DLR competencies through the topic of condition monitoring, from sensor technology to data evaluation
Bundling of the individual technologies in assessable and application-relevant condition monitoring scenarios
Scheduled application scenarios: Aircraft, spacecraft, traffic infrastructure, buildings and structures
Sensors
Data Analysis
Evaluation


Joint Research Project „Future Fuels“
DLR-wide research on synthetic fuels
E-Fuels
Solar Fuels
Biomass Based Fuels
Sustainable sources of energy for the mobility and energy sector: energy transition and climate change
Climate neutral, efficient, economical production and emission free usage
Application for cars, trains, ships, aircraft, launchers, power-heat coupling, peak load power plants
Focus: liquid hydrocarbons green fuels for space


Factory of the Future“
Technologies for the digital factory of the future
Use of intelligent robotic systems in digital production
Transfer of technologies from Aeronautics and Space research to industrial production
Focus: intelligent lightweight robots, flexible and versatile manufacturing, simulation methods
Aircraft – Launcher – Satellites – Vehicles
1 HUMAN-ROBOT COLLABORATION
2 MOBILE MANIPULATION
3 AUTONOMOUS ASSEMBLY
4 ADDITIVE MANUFACTURING
5 DIGITAL TWINS
6 DIGITAL GUIDANCE


DLR is expanding and evolving….
Many new institutes and test facilities were installed 2016-2020
The increasing interdisciplinary competences and methods like virtual system achitectures and artificial intelligence, …
and the coupling of the physical and virtual research & testing capacities
„digital thread“, „digital twin“, (e.g. aircraft, satellite, …)
are/will be used DLR-wide for common aeronautics and space technologies


Effects of emissions on climate and health
Climate models: air, land & sea
Coupling of traffic models with climate and weather models and integration of medial research
Measurements of greenhouse gases, particulate matter, exhaust gases
Alternative fuels
E-Mobility, Electric Flight
Earth System Model Evaluation Tool
Scenario plus 1-2°C
Scenario plus 4-6°C
1960
ECLIF – alternative fuels


TANDEM
Global Products: New perspectives of our planet
Demography
Global Urban Footprint
TanDEM-X Global DEM
TANDEM
FOREST/NON-FOREST MAP
DLR


Gulfstream G550
Business Jet
Altitude: 15 km
Reach: 8.000 km
Velocity : 1.054 km/h
DLR
CoMet
CO2 and
Methan Mission
Climate models
Monitoring of regional greenhouse gas fluxes
DLR
cnes
DFG


National Test Center for Unmanned
Aerial Systems: Airport Cochstedt
DLR
Zero Emission
Aviation
IStar
O
C
H

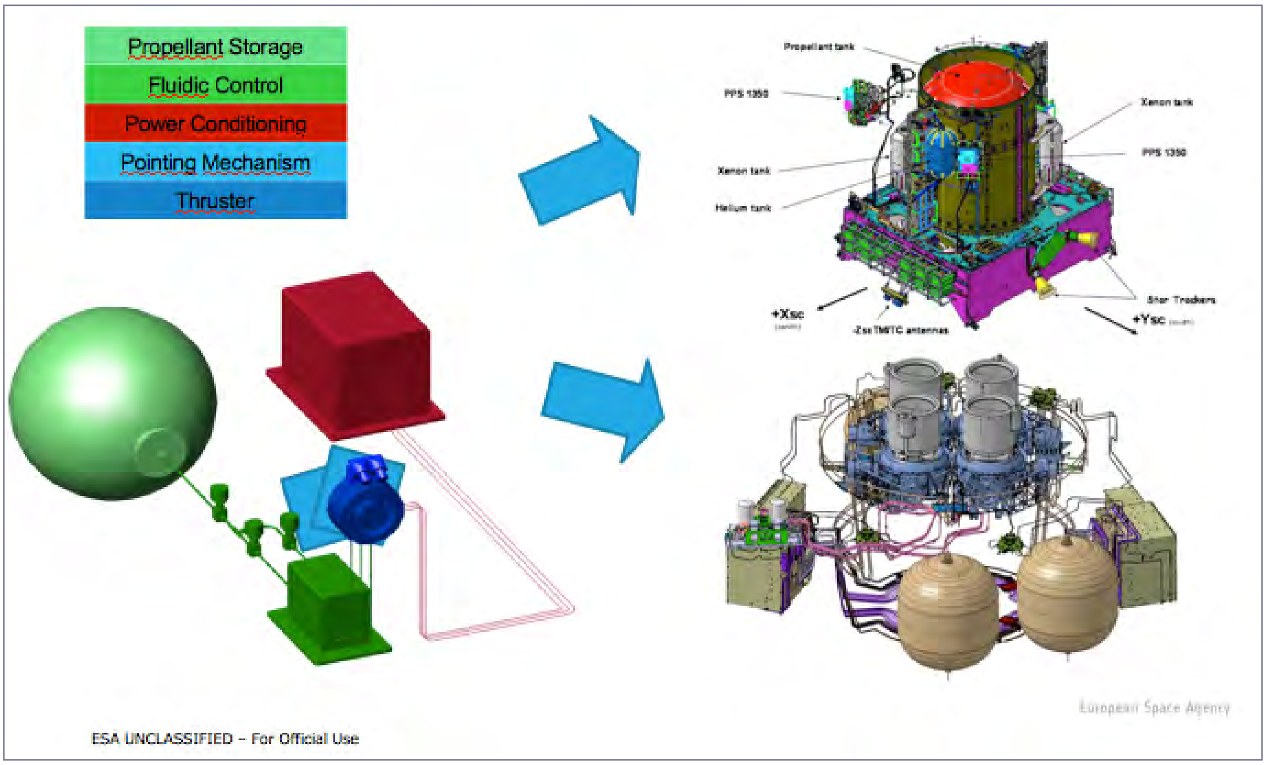

DLR
Research for sustainable, networked and automated Mobility
Urban mobility
Intermodal Transport
Quantum Technologies
Guidance and
Position Monitoring
Sector Coupling
Energy & Transport
Unmanned
Aircraft
Autonomous
Driving
Improved GNSS services


DLR
SDGs@DLR
UNDP
High Tech
Support for
Humanitarian Aid
Flight Test
Projects & Partners
WORLD BANK GROUP
United Nations
giz
TECHNOLOGY
FACILITATION MECHANISM
SUSTAINABLE
DEVELOPMENT
GOALS


DLR
For the tasks of the future
in the aerospace industry
partnership is needed ....
▪ Noticeable change processes influence the aerospace industry
▪ Partnership between research and industry
▪ In times of digitization and Industry 4.0, successful collaboration is less and less based on rigid disciplinary or industry boundaries
▪ It is more important than ever to work on future challenges together and to combine forces..

ELECTRIC PROPULSION SYSTEMS AT THE EUROPEAN SPACE AGENCY

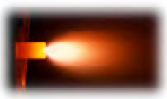
By J.A. Gonzalez del Amo, Head of the Electrical Propulsion Section, ESA/ESTEC



INTRODUCTION: ELECTRIC PROPULSION

- In general, Electric Propulsion (EP) encompasses any propulsion technology in which electricity is used to produce thrust.
- Electrical energy is used to ionize the propellant (gas, liquid, solid) and accelerate the resulting ions/plasma to very high exhaust velocities (10-40km/s)
- Electric Propulsion is very fuel efficient, but much lower thrust levels achievable than for chemical propulsion.
- Depending on the process used to accelerate the propellant, electric propulsion thrusters fall into three main categories.

- **Electrothermal**
  - **Resistojets***
  - **Arcjets***



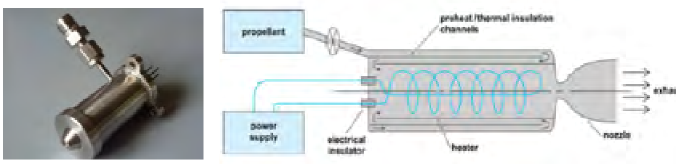
- **Electrostatic**
  - **Gridded Ion Engines (GIE)***
  - Colloid
  - Field Emission Electric Propulsion (FEEP)

- **Electromagnetic**
  - **Hall Effect Thruster (HET)***
  - **High Efficiency Multistage Plasma Thruster (HEMPT)***
  - Pulsed Plasma Thrusters
  - Magneto Plasma Dynamic Thrusters

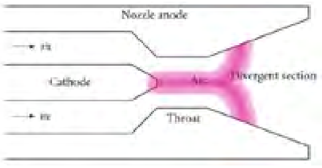
***Applicable for GEO satellite propulsion**

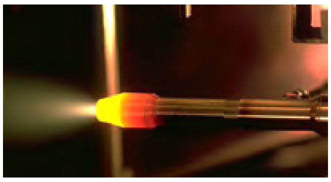
ELECTROTHERMAL THRUSTERS: RESISTOJETS / ARCJETS

Resistojets are electrothermal devices in which the propellant is heated by passing through a resistively heated chamber or over a resistively heated element before entering a downstream nozzle.
The increase in exhaust velocity is due to the thermal heating of the propellant, which limits the specific impulse to low levels (<500 s).
Resistojets are relatively simple devices and can be used as auxiliary propulsion on satellites.



The amount of energy added to the flow in a resistojet is limited by the maximum working temperature of the heating element.
In an Arcjet thruster, an electrical discharge (arc) is generated within the flow between a cathode and anode. This imparts additional energy to the propellant flow, and therefore, higher specific impulse is achievable compared to resistojets. Electrostatic Thrusters:
Gridded Ion Engines (GIE)

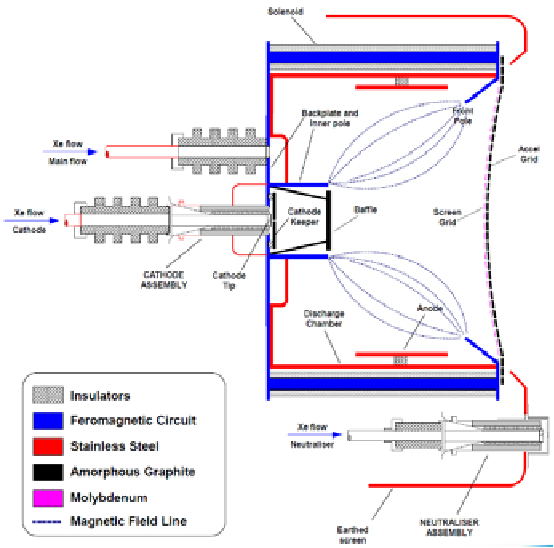


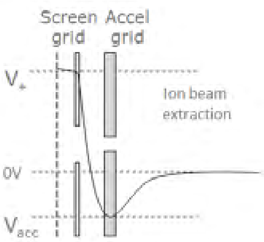


ELECTROSTATIC THRUSTERS:
GRIDDED ION ENGINES (GIE)

Gridded Ion Engines comprise three main processes:

- Generation of a plasma discharge via ionization of propellant by electron bombardment.
- Extraction of ions and subsequent acceleration to very high velocities across potentials of few kV applied between multi-aperture grids (electrodes).
- Space-charge neutralization of the ion beam using an external electron source (cathode)





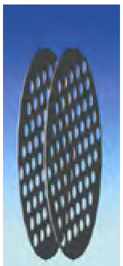
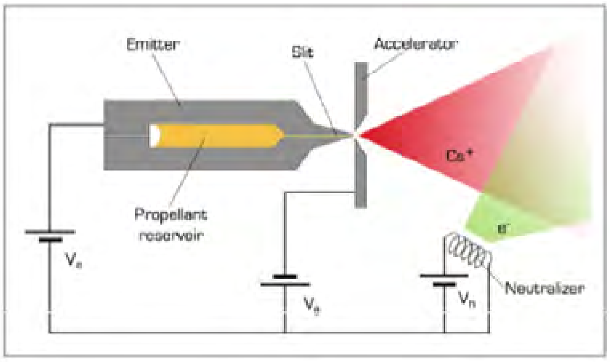


Image: QinetiQ

ELECTROSTATIC THRUSTERS:
FIELD EMISSION ELECTRIC PROPULSION (FEEP)

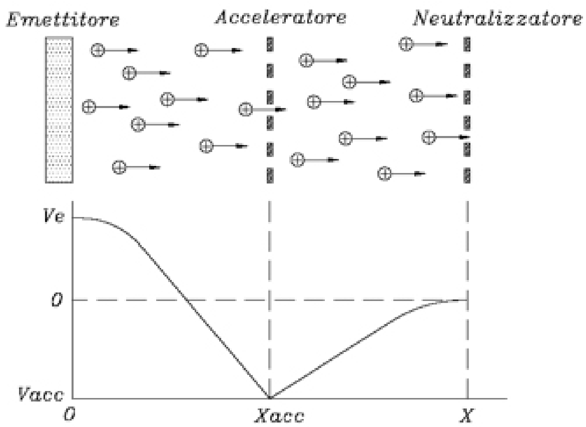
FEEP is an electrostatic type thruster:

- thrust is generated by ions accelerated by electric fields at high exhaust velocities;
- electrons need to be emitted downstream in the same quantity for charge balancing.



$$qV_e \; ? \; \frac{1}{2} M v_e^2 \; ? \; v_e \; ? \; \sqrt{\frac{2qV_e}{M}}$$

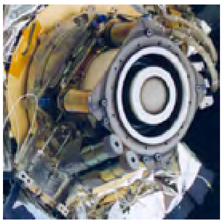
$$\dot{m}_i \; ? \; \frac{M I_b}{q} \qquad I_b \; ? \; I_e \; ? \; I_a$$

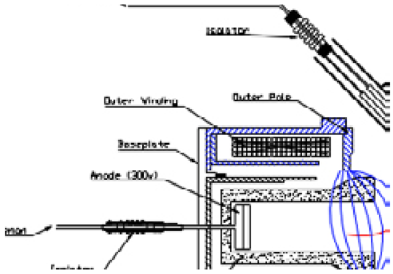


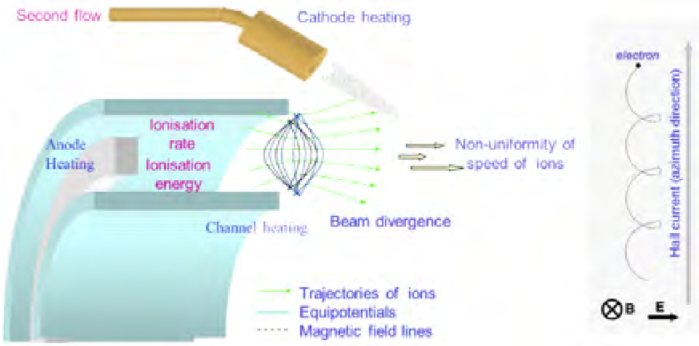
ELECTROMAGNETIC THRUSTERS:
HALL EFFECT THRUSTER (HET)

- Neutral gas supplied to hollow cathode and fed through anode at base of discharge chamber.
- Potential difference applied between cathode and anode.
- Electromagnets generate radial magnetic field in discharge channel.
- Electrons are magnetized; follow field lines and enter discharge channel towards anode.
- E x B field causes azimuthal drift of electrons around axis of thruster circulating hall current.
- As neutrals diffuse into discharge channel, they are ionized by high energy electrons.

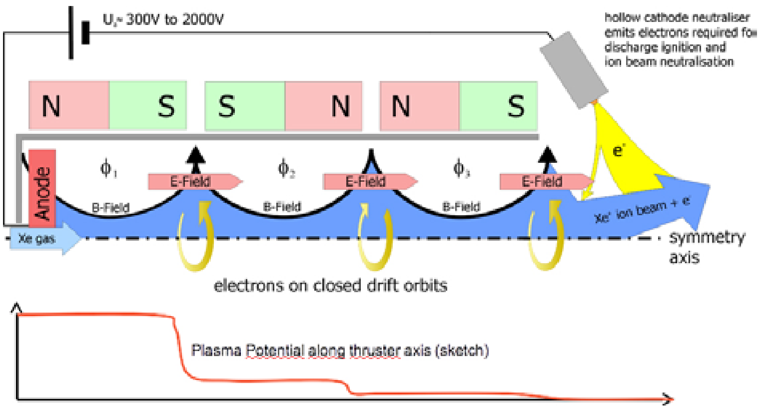
- The more massive ions are not magnetized and are accelerated out of the discharge channel by the electric field.
- Equivalent number of electrons emitted by cathode space charge neutral plasma plume







ELECTROMAGNETIC THRUSTERS: HIGH EFFICIENCY MULTISTAGE PLASMA THRUSTER (HEMPT)



Commercial Spacecraft, ESA initiatives,

1. ESA **Artemis** satellite using 4 ion engines (2 RIT and 2 UK-10) has paved the way for the use of electric propulsion in telecommunication spacecraft.

2. Astrium with several spacecraft launched (4 **Inmarsat**, 1 **Intelsat and 1 Yasat** satellites, ...) and many more satellites in construction has the most important experience in Europe in integration of Electric Propulsion Systems.

3. Astrium and Thales have demonstrated their capability to integrate this technology in GEO satellites. The ESA

Alphasat spacecraft will use PPS1350 for NSSK operations. Alphabus evolution will also consider Electric propulsion for future missions.

4. **Small GEO** satellite has 4 Hall Effect thrusters, SPT-100,

5. NEOSAT and ELECTRA will have EP for station keeping and ORBIT RAISING manoeuvres. FULL EP SPACECRAFT (PPS5000). Astrium and Thales will use the HET technology in Eurostar and Spacebus platforms.

TELECOMMUNICATION APPLICATIONS FUTURE ARCHITECTURES

The use of Electric Propulsion in the telecommunication space market is essential to improve the position of the European space sector. The announcement of Boeing in 2012 on the procurement of 4 telecommunication spacecraft (platform 702SP) , offered for only 125 million dollars each including launch, thanks to the use of electric propulsion for both NSSK and orbit raising from GTO to GEO, has been noted by European operators and primes. The launch of the first 2 spacecraft took place on the 1 March 2015. AsianSat has already ask for another extra-satellite.

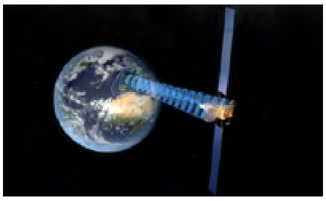
ESA is now fully involved in the preparation of several telecommunication programmes (NeoSat, Electra) that will make use of electric propulsion for all the key maneuvers, paving the way for the commercial use of all-electric platforms by the primes Astrium, Thales and OHB Systems.

Eutelsat and SES have bought in the last years several spacecraft using electric propulsion as main system for orbit raising and station keeping operations.

Boeing has selected the Falcon 9 for the launch of these spacecraft. Current and future European launchers will need to be capable to optimise their performances, interfaces and operations to offer the best launch options to new all-electric platforms.

FULL-EP PLATFORMS FOR EOR & STK

HET-based subsystems are currently the preferred choice by European Primes for full-EP telecomm platforms (higher Thrust-to-Power ratio offering reduced EOR duration)



However other architectures selected by non-European Primes (for example, Boeing 702SP platform used XIPS (GIE); Boeing have also recently selected PPS5000 for a commercial program and are developing a RIT-2X subsystem jointly with ArianeGroup).
NEOSAT (ARTES-14) successful sales of Eurostar NEO and Spacebus NEO
Electra (ARTES-33) targeting small-GEO platforms

TELECOMMUNICATION APPLICATIONS EXISTING PLATFORMS

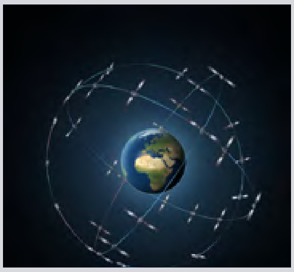
With the exception of ESA's ARTEMIS platform all European commercial platforms utilize Hall Effect Thruster Technology.

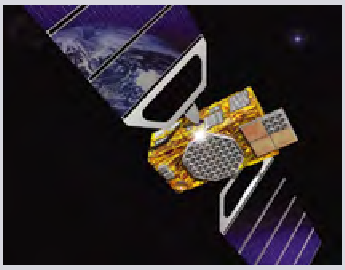
NAVIGATION – GALILEO 2ND GENERATION (G2G)

ESA is preparing the future replacement of GALILEO constellation and is targeting the possibility to increase the Galileo Payload capability without impacting the launch costs (and possibly reducing them).
The increase in payload capability could be achieved by changing the launch injection strategy and by using Electric Propulsion to transfer the satellite from the injection orbit to the target operational orbit.

The use of the Electric Propulsion system might allow to use small launchers such as VEGA or place more spacecraft in the current SOYUZ and Ariane 5 launchers.

GIE and HET subsystems are currently considered for the transfer by the selected Primes of Phase A/B1.





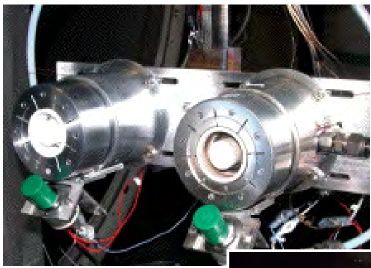
COMMERCIAL SPACECRAFT: CONSTELLATIONS

Space X: ~4000 spacecraft using mini-HET
OneWeb: > 700 spacecraft may also use electric propulsion
Others (Leosat, etc.)

Constellations will use propulsion to perform;
- orbit acquisition, maintenance and de-orbiting from low earth orbit (around 600 -1000km)

Platform	Prime Contractor	Status	Platform Mass Range (tonnes)	Platform Power Range (kW)	EP Function	EP Thruster	EP Thruster Type
ARTEMIS	Thales Alenia Space-Italy	Flight Proven	3.0	3.0	NSSK (OR during recovery)	2 X UK-10 (T5) 2 X RIT-10	GIE
Eurostar E3000	Astrium	Flight Proven	4.5 - 6.0	9 - 16	NSSK	4 X SPT-100	HET
Spacebus	Thales Alenia Space	Flight Ready			NSSK	4 X PPS-1350G	HET
AlphaBus	Astrium / Thales	Flight Proven	6.0 - 6.5	12 - 18	NSSK	4 X PPS-1350G	HET
AlphaBus Extension	Astrium / Thales	Flight Proven	<8.4	12-22	NSSK, Orbit Topping	4 X PPS-1350G 4 X PPS-1350G OPTION T-6	HET/GIE
SGEO	OHB	PFM 2014	3.2	6.5	NSSK, EWSK, Momentum Management	8 X SPT-100 Or 8 X HEMPT	HET
NEOSAT	Airbus/Thales	Under development	3-6	15- 25	NSSK, Orbit Raising	4XPPS5000	HET
ELECTRA	OHB	Under Development	3.2	7	NSSK, Orbit Raising	4XPPS5000	HET

Satellites
- ~ 200 kg with powers for propulsion ~ 200 W.
- Mini-HET is one of the most interesting options.
- Spacecraft cost around 500 000 $
- the propulsion system (thruster ~15 000 $ and electronics ~25 000 $)


MINI-HET


MINI-ION ENGINE

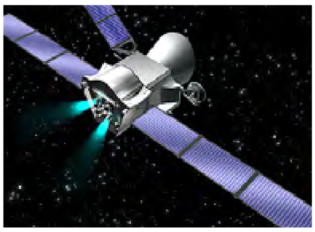

HEMPT

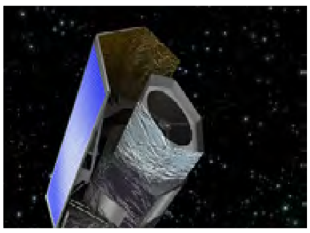
SCIENCE & EARTH OBSERVATION
GOCE: 'FERRARI OF SPACE' MISSION COMPLETE


GOCE


Smart-1


NGGM


Bepi-Colombo


Euclid


LISA

GOCE: 'FERRARI OF SPACE' MISSION COMPLETE

After nearly tripling its planned lifetime, the Gravity field and steady-state Ocean Circulation Explorer – GOCE – has completed its mission in October 2013
In mid-October, the mission came to a natural end when it ran out of fuel and the satellite began its descent towards Earth from a height of about 224 km.

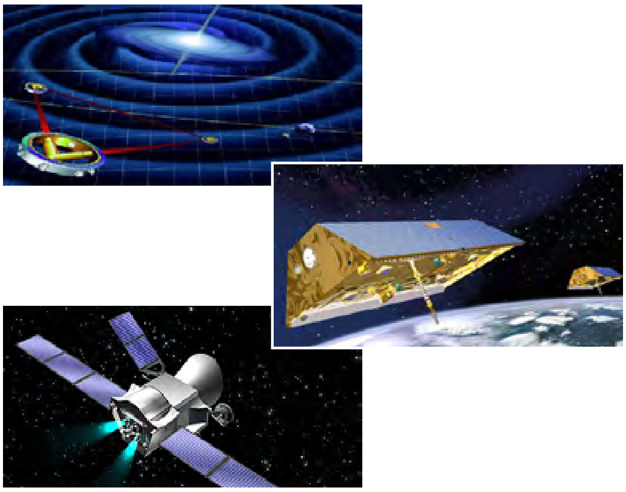
AIR-BREATHING ELECTRIC PROPULSION: HISTORY ESA DEVELOPMENTS

- In 2007, an high level ESA-CDF feasibility study concluded that to compensate the drag of a spacecraft operating at altitudes as lower as 180 km, a ram-EP concept, could be a feasible solution. As such lift-times can become far longer than with conventional electric thrusters today.
- In 2010, under TRP contract, two test campaigns were carried out on Snecma's PPS1350 Hall Thruster and on RIT-10 ion engine for performance characterization with atmospheric propellants:
  - HET and RIT technologies are compatible with N2/O2 mixture, which is of interest for RAM-EP applications in LEO (200-250 km).
  - The thruster lifetime and lifetime prediction are strongly affected by corrosion/erosion phenomena. However, with the appropriate choice of materials, the lifetime can still be in the 1000-10000 hours range.

SCIENCE & EARTH OBSERVATION

Future Needs
- Next Generation Gravity Missions, NGGM, will require Mini-ion Engines and micro-field emission thrusters to provide drag compensation and formation control.

• LISA class missions will require micro thrusters for ultra-fine formation control. Mini-ion engines, cold gas and field emission engines are the main candidates.
• Future asteroid, rendezvous or planetary missions will require high ISP thrusters for cruise to the target object.
• Remote sensing and science missions using formation flying will need electric propulsion for formation control.



• Small constellations such as **ICEYE** are going to use the FOTEC-ENPULSION field emission thrusters (FEEP) IFM Nano to keep the constellation in orbit and de-orbit all the satellites when the life is finished. This thrusters are already flying since beginning of 2018.

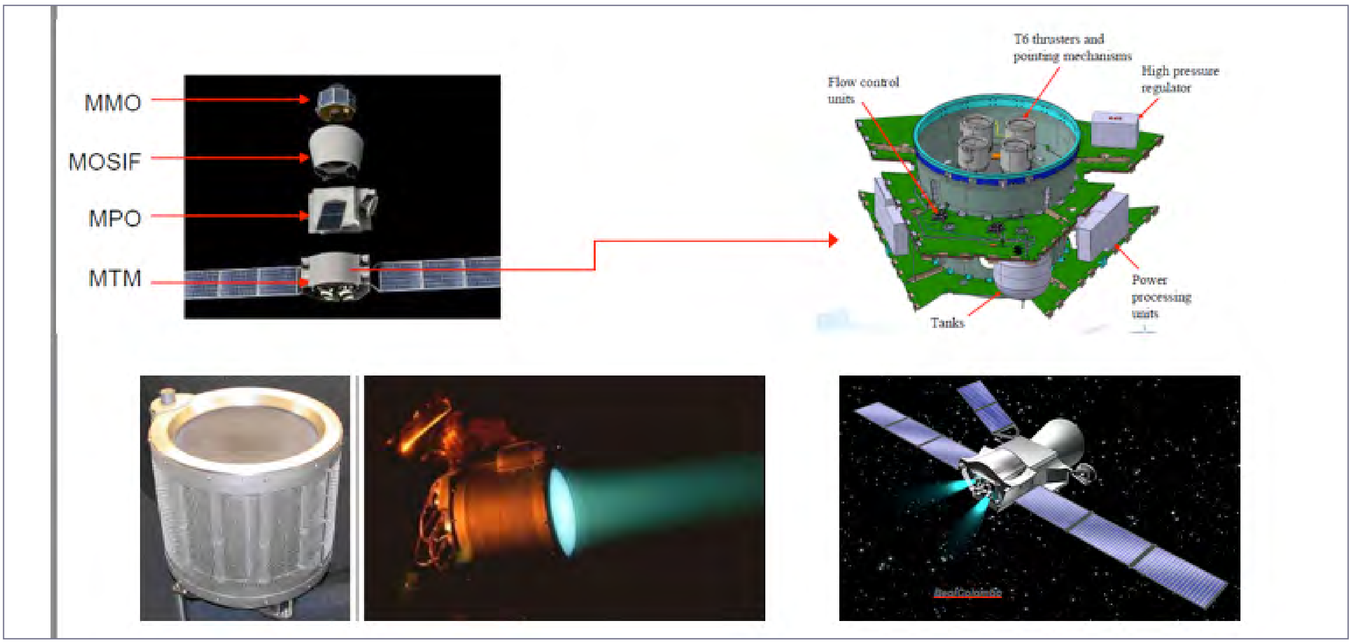
Required on-going & future developments
• Mini-ion engines system and micro-field emission thrusters are in development to satisfy the needs of future gravity missions and other science missions such as **NGGM and LISA.**

• Mini-hall thrusters system are in development to satisfy the needs of future mini/micro-satellites to perform SK and disposal maneuvers in **constellations**.

• Micropropulsion for **Nanosatellites** and microsatellites (NEW MARKET)

• **Large Electric Propulsion Systems** must be developed to meet the needs of future asteroid or planetary exploration missions. Cargo missions to Mars will also make a good use of these systems. Space Tugs (NEW MARKET)

BEPI COLOMBO MISSION TO MERCURY



SCIENCE AND EARTH OBSERVATION ELECTRICAL PROPULSION DEVELOPMENTS AND CHALLENGES

Where are we today?

• Electric propulsion has taken us to the Moon (**SMART-1**) and is allowing us to measure the Earth's gravitational field with unprecedented accuracy (**GOCE**).
• Electric propulsion is planned to take us to the planet Mercury (**BepiColombo**)

SPACE TUGS

Space Tugs are currently under discussion at all three European LSIs. Electric propulsion is considered as one of the key technologies for Space Tugs due to the relatively low propellant consumption compared to chemical propulsion. At the moment four different use cases are foreseen for Space Tugs:

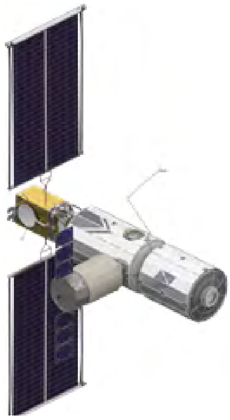
• GEO Servicing
• LEO/MEO Debris Removal (Mega constellations, SSO debris removal)

- LEO/MEO to GEO tugging (for telecommunication satellites, 60 kW tug would be required)
- Moon cargo delivery (high Isp operation would be of interest)

A clear need has been identified for the development of high power (~15 kW-20kW), long lifetime Hall effect thrusters in the frame of discussions concerning future Space Tugs.

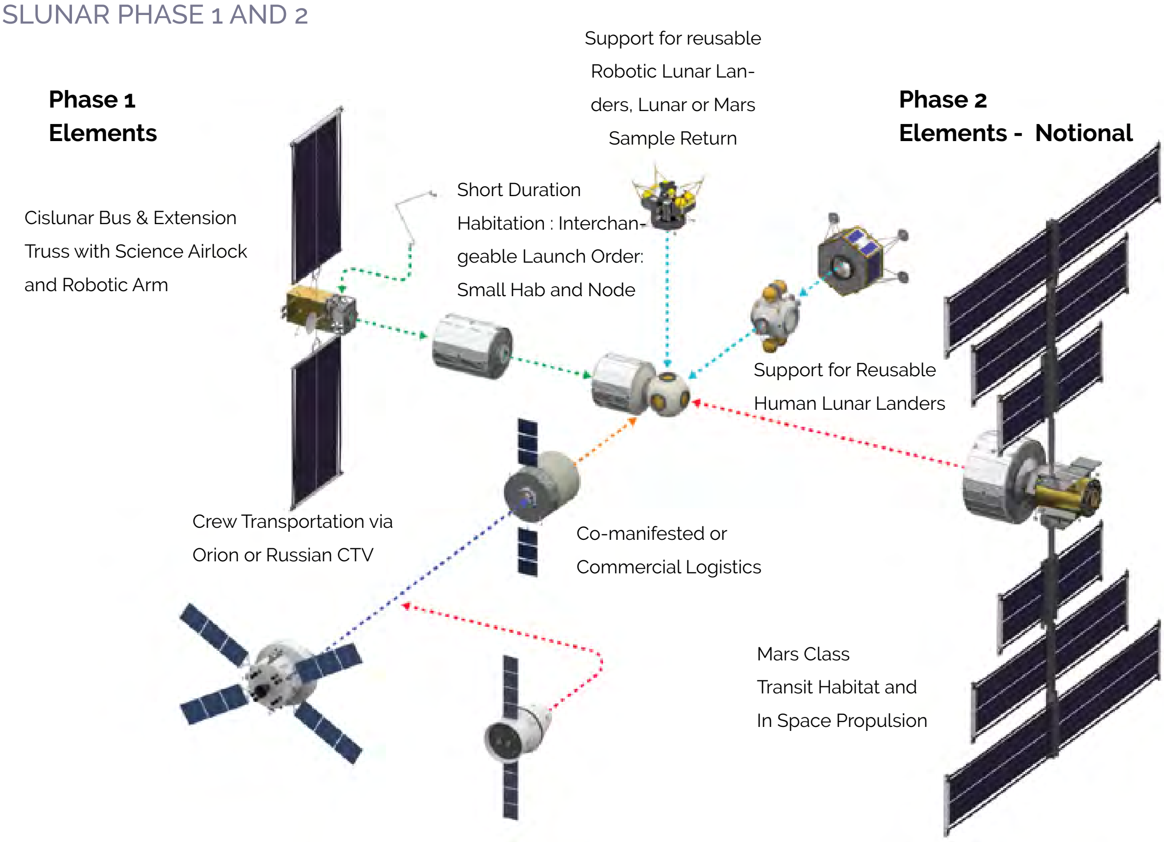
Several meetings have been performed to identify possible commonalities in terms of technology development between Space Tug applications and e.Deorbit.

PERSPECTIVE FOR CISLUNAR INFRASTRUCTURE



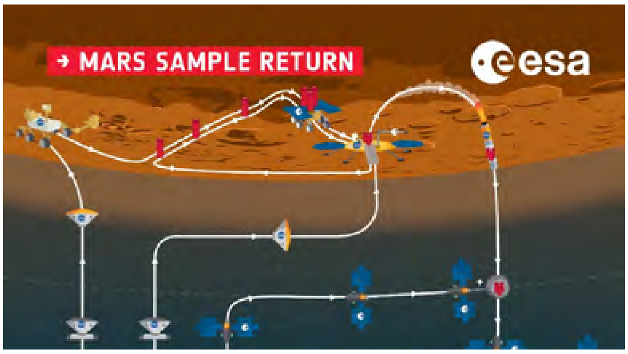
- ESA and the ISS Partners are discussing plans for beyond LEO activities, considering a small man-tended infrastructure in Cis-Lunar orbit, known as evolvable Deep Space Habitat or Cis-Lunar Transfer Habitat (CTH).
- This is the first enabling step to a sustainable access to the Moon surface and will be assembled and serviced using excess launch mass capability of NASA's SLS/Orion.
- During Phase 1 (2023-2026) such an infrastructure shall support up to 90 days of crewed operations and robotics surface missions.
- During Phase 2 (2026-2030) it shall support up to 300 days of crewed operations and Moon robotics and crewed surface missions. Then part of the CTH may go to a crewed trip to Mars.
- Phase 2 will see the arrival of a larger habitation module and resource/propulsion service module.

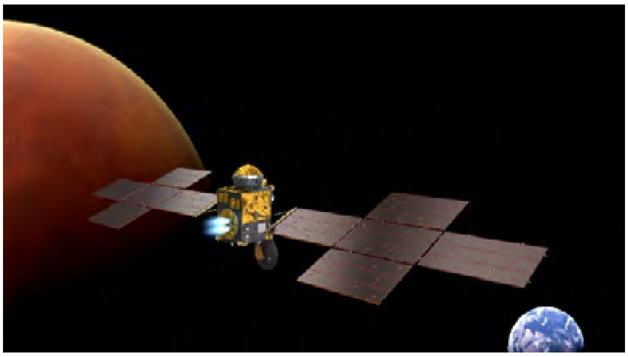
CISLUNAR PHASE 1 AND 2



EXPLORATION: POTENTIAL NEAR-TERM FUTURE APPLICATIONS

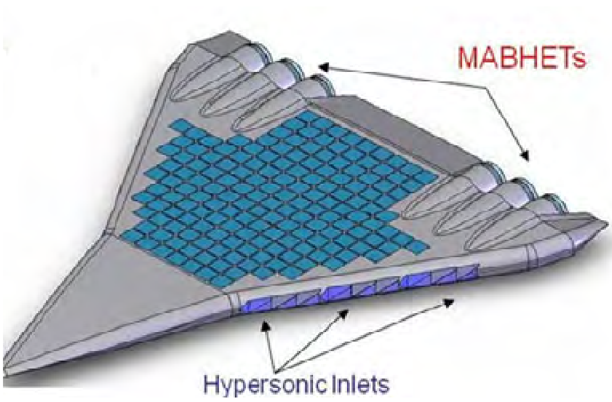
Mars Sample Return would represent a cornerstone in the exploration of the Solar System. The MSR overall architecture is based on three different missions as an international effort.
ESA is leading industrial studies for the Earth Return Orbiter (ERO) mission.
Solar Electric Propulsion (SEP) is considered for cruise phases (transfers) and orbit lowering/raising at Mars.





EXPLORATION: POTENTIAL FAR-TERM FUTURE APPLICATIONS – RAM-EP

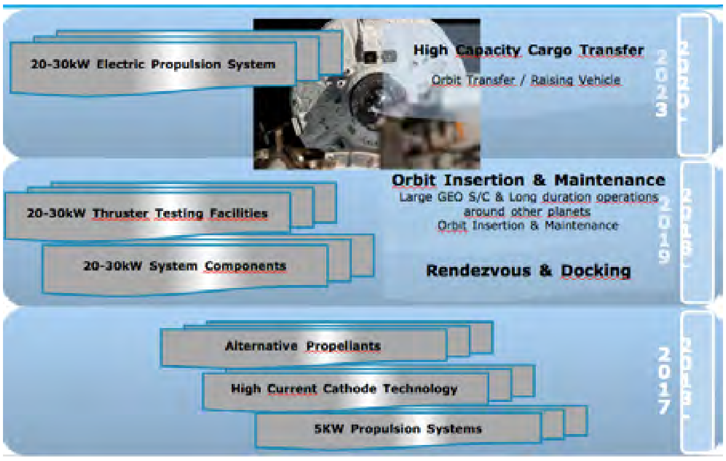
Concept studies by Busek / NASA Glenn:
(K. Hohman, V. Hruby, H. Kamhawi)



Solar Electric Power Orbiting Spacecraft that ingests Mars Atmosphere, ionizes a fraction of that gas and accelerates the ions to high velocity.
Mars atmosphere is thin and composed mainly of CO_2.
- The altitudes of interest are 120-180km due to drag and power requirements.
- The orbital velocity is around 3.4km/s.
- Solar Flux is about 584 W/m2 (Earth ~1350 W/m²) .

EXPLORATION: APPLICATION AREA: ADVANCED PROPULSION (PRIORITY FOR SPACE COUNCIL)

Technology Subject: Electric Propulsion for High Capacity Cargo Transfer



FUTURE DEVELOPMENTS

HALL EFFECT THRUSTER: Extension of lifetime via magnetic confinement and double operation point (higher thrust during orbit raising and higher specific impulse during NSSK). TELECOMMUNICATION, Navigation and Science and Exploration missions will benefit from these developments. Power levels around 5 kW or higher. System activities, cost reduction and industrial production issues should be assessed.

ION ENGINE: Reduction of the power to thrust ratio via the cusp design . TELECOMMUNICATION, Navigation and Science and Exploration missions will benefit from these developments. Power levels around 5 kW or higher. System activities, cost reduction and industrial production issues should be assessed.

HEMPT: High power HEMPT with high lifetime and different operation points to adapt the thruster output t the power of the solar array of the spacecraft. TELECOMMUNICATION, Navigation and Science and Exploration missions will benefit from these developments. System activities, cost reduction and industrial production issues should be assessed.

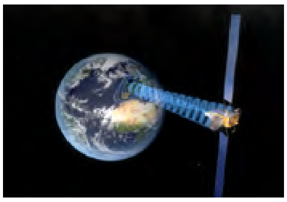
Mini-ion engines, FEEPs and mini-Hall effect thrusters will be used for science and Earth observation missions. Thrust levels from micro-Newtons to some milli-Newtons. Lifetime will be a special issue to be assessed.

Testing facilities: The utilisation of High power engines will pose strong requirements in acceptance testing facilities. The standardisation of testing methods will also be required to reduce cost and risk of these developments.

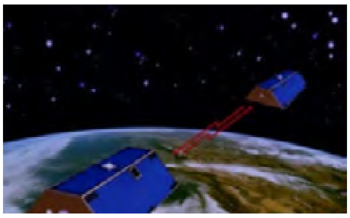
New High Power Electric Propulsion Concepts evaluation (Helicon Antenna Thruster, Electron Cyclotron Resonance thruster, MPD, E-Imapct thruster, etc.).
MICROPROPULSION and VERY HIGH POWER EP

CURRENT AND FUTURE ESA MISSIONS WITH EP

Neosat

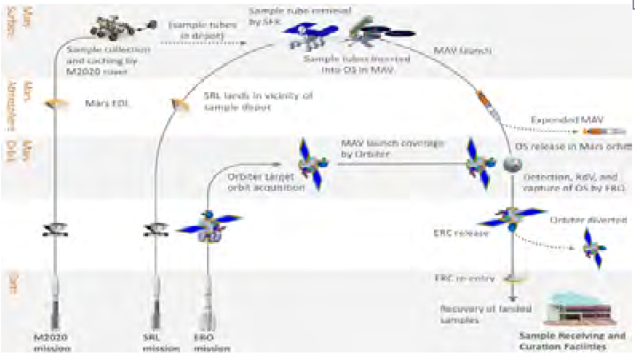


Electra

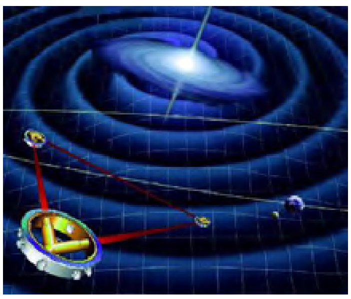


NGGM

Navigation



Exploration (Cislunar, Mars, Sample Return)



LISA

EPIC: H2020 SRC FOR ELECTRIC PROPULSION

- Electric propulsion has been identified by European actors as a Strategic Technology for improving the European competitiveness in different space areas.
- **The European Commission (EC)** has set up the "In-space Electrical Propulsion and Station-Keeping" Strategic Research Cluster (SRC) in Horizon 2020 with the goal of enabling major advances in Electric Propulsion for in-space operations and transportation, in order to contribute to guarantee the leadership of European capabilities in electric propulsion at world level within the 2020-2030 timeframe.
- The SRCs will be implemented through a system of grants connected among them and consisting of:
  1)"Programme Support Activity" (PSA): The main role of this PSA is to elaborate a roadmap and implementation plan for the whole SRC and provide advice to the EC on the calls for operational grants.
  2) Operational grants: In future work programmes (2016 and 2020), and on the basis of this SRC roadmap and the PSA advice for the calls, the Commission is expected to publish calls for "operational grants" as research and innovation grants (100%) and/or innovation grants (70%).

CAPABILITIES IN EUROPE

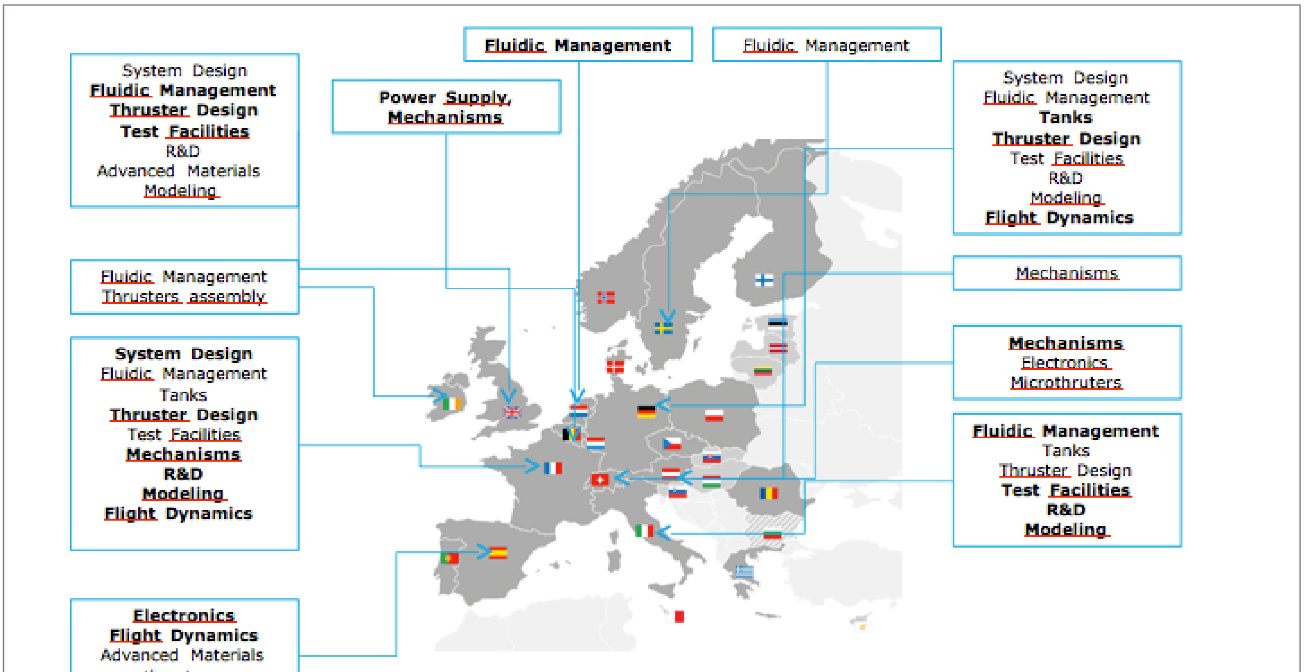
see illustration page 30

CAPABILITIES IN ESA
ESA PROPULSION LABORATORY

- ESA Propulsion Laboratory (EPL) located in ESTEC, The Netherlands.

- Provide test services to the Propulsion and Aerothermodynamics division of the European Space Agency, which is responsible for the technical support to ESA projects and the R&D activities in the areas of chemical propulsion, electric and advanced propulsion, and aerothermodynamics.

CAPABILITIES IN EUROPE



Coverage of EP technologies in Europe

EPL ACTIVITIES

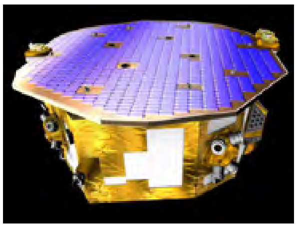
Support to ESA projects
- Independent performance assessments
- Quick answers to specific questions

Support to R&D Activities
- Technology assessment for ESA R&D programs
- Explorative internal R&D work on new technologies
- International scientific/technical cooperation
- Patent exploitation

Support to European Aerospace Industry
- Reference for standardization of testing methods and tools
- Joint testing for cross verification of performance

CAPABILITIES IN ESA
ESA PROPULSION LABORATORY

EPL today provides independent assessment on EP thrusters & propulsion components performances.
Tests are mainly focussed on low power EP propulsion and cold-gas system and space propulsion subsystems. Future improvements are aiming at enabling measurement of thrust and thrust noise in µN regime for science and earth observation application (NGO, Euclid, NGGM) and at characterising mid-high power thrusters for science, navigation and telecommunication applications (>2kW).
Planning and execution of performance characterization of electric thrusters (HET, GIE, FEEP, Resistojets), cold gas thrusters & propulsion components.
Design, manufacturing and validation of diagnostics (thrust balances, data acquisition systems, beam probes) in collaboration with European industries/research centers.




- ISO 17025 certification of thrust, mass flow and electrical power:
- Force: 1 μN – 500 mN
- Mass flow: 1 μg/s – 300 mg/s
- Power: 1 mW – 2 kW

ESA STRATEGY

- **Consolidation of the current European products** (Hall effect thrusters, ion engines, field emission thrusters, HEMPT, MPD, etc.). In this process the qualification of the European products is one of the main activities together with the European autonomy in components. ESA aims to have full European systems where not only the thruster is European but also components such as pressure regulators, feeding systems, neutralizers, etc.
- **Utilization of the current flight data** (Artemis, Smart-1, GOCE, Inmarsat 4F, Intelsat 10, Astra 1K, Alphabus, Small GEO, etc.) to validate the models that will be used by the spacecraft designers in the future.
- **Standardization of engineering processes and testing facilities** employed in the design, manufacturing and qualification of the current electric propulsion systems.
- **New electric propulson systems:** higher and lower power (space tugs, nanosatellites ...). **MICROTHRUSTERS and VERY HIGH POWER EP**

TECHNOLOGY CHALLENGES

Microthruster development and measurement of microthrust levels are very challenging. **Micropropulsion Systems for Nanosats.**

High power thrusters (5kW, 15-20kW) capable of operating at high specific impulse with a low power to thrust ratio (orbit raising and interplanetary transfer). Double operation mode for telecommunications and Space Tugs.

Qualification through long lifetime testing such as Bepi Colombo.

EP Cost reduction exercise at system level specially for Constellations, in particular for de-orbiting.

Spacecraft thruster possible interactions.

Flight opportunities, Bepi Colombo, Neosat, Electra, NGGM, ICEYE...

CONCLUSION

Telecommunication market will be able to make an immediate use of these EP technologies for on obit control and full or partial transfer. 5kW engines with low power to thrust ratio and high specific impulse will be very important. Dual mode and long lifetimes will be important.
Navigation, Science (interplanetary missions) and Exploration (the Moon, Asteroids and Mars) will require EP systems.

Mini- ion engines, FEEPs, mini-Halls, electrosprays with capability to fulfil stringent Science and Earth Observation requirements (LISA, NGGM, Euclid, microsatellites etc.). MICROPROPULSION FOR NANOSATELLITES will be a new market. Constellations such as ICEYE are flying mini-satellites with EP thrusters (FOTEC-ENPULSION).

Very High Power Electric Propulsion for Exploration and Space Tugs. 10-20 kW engines will have to be developed. Constellations of satellites may make use of EP systems at very low prices due among several reasons to the large quantities. Low power engines for constellations.

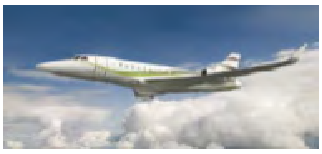
ESA, Space Agencies and Industry have participated to the EPIC proposal within the European Community Horizon 2020 programme. ESA has been the coordinator of this proposal. EPIC is the winner of the H2020 programme and work is ongoing.

GREEN BIZJET TECHNOLOGICAL DEVELOPMENTS WITHIN AERONAUTICAL RESEARCH PROGRAMMES

By Bruno STOUFFLET, Chief Technology Officer - DASSAULT AVIATION ,
Vice-Chairman of Conseil pour la Recherche Aéronautique Civile (CORAC)

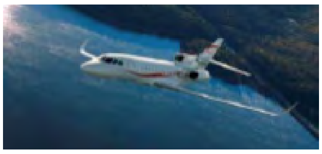
1. CONTEXT

THE FALCON FAMILY



FALCON 2000S 3,350 NM – Twin-jet

FALCON 2000LXS 4,000 NM - Twin-jet



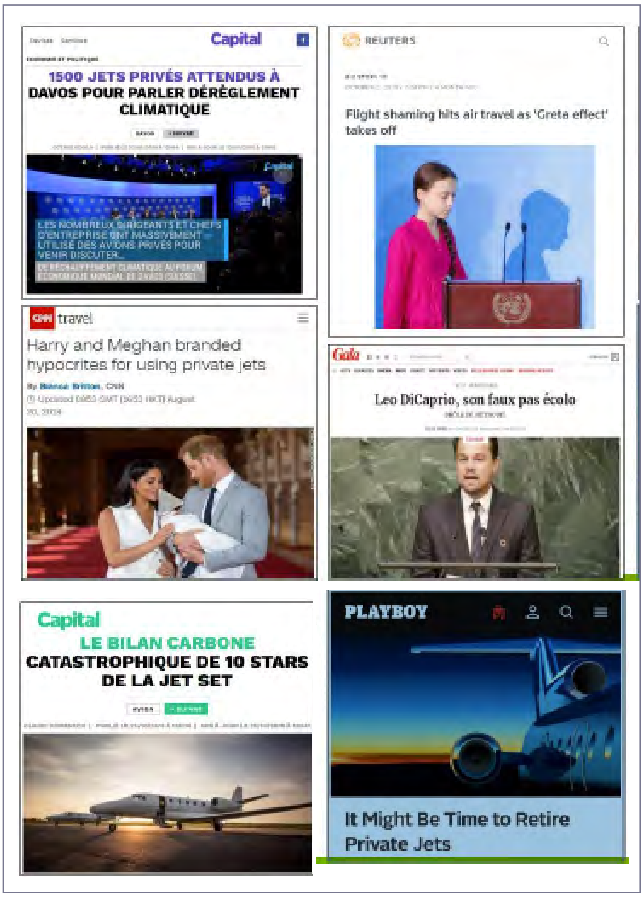
FALCON 900LX 4,750 NM - Trijet

FALCON 6X 5,500 NM - Twin-jet

FALCON 7X 5,950 NM - Trijet

FALCON 8X 6,450 NM - Trijet

SOCIETAL PRESSURE IS INCREASING

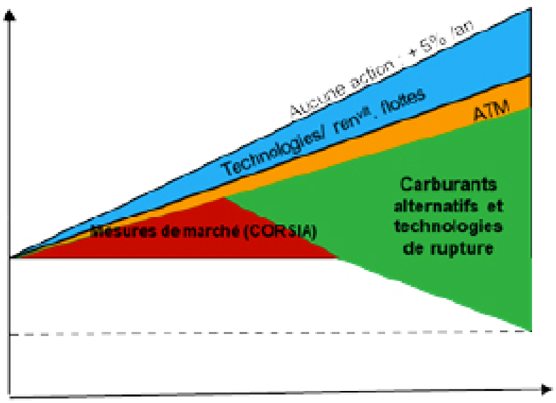


AIR TRANSPORT COMMITMENTS

The present answer of air transport lies on ICAO commitments and on IATA objectives (compatible with Paris agreements) position on Horizon 2020 Interim Evaluation as well as on European Innovation Council (EIC), by Dr Uwe Möller, EREA Secretary.

The 2050 objectives means a 90% more efficient fleet than the one of 2005
Sustainable alternative jet fuels : deployment is extremely limited : <0,01%

Incremental innovation & cycle duration for renewal (20 years) : ~1,5% annual gain in energy efficiency



2. BUSINESS AVIATION

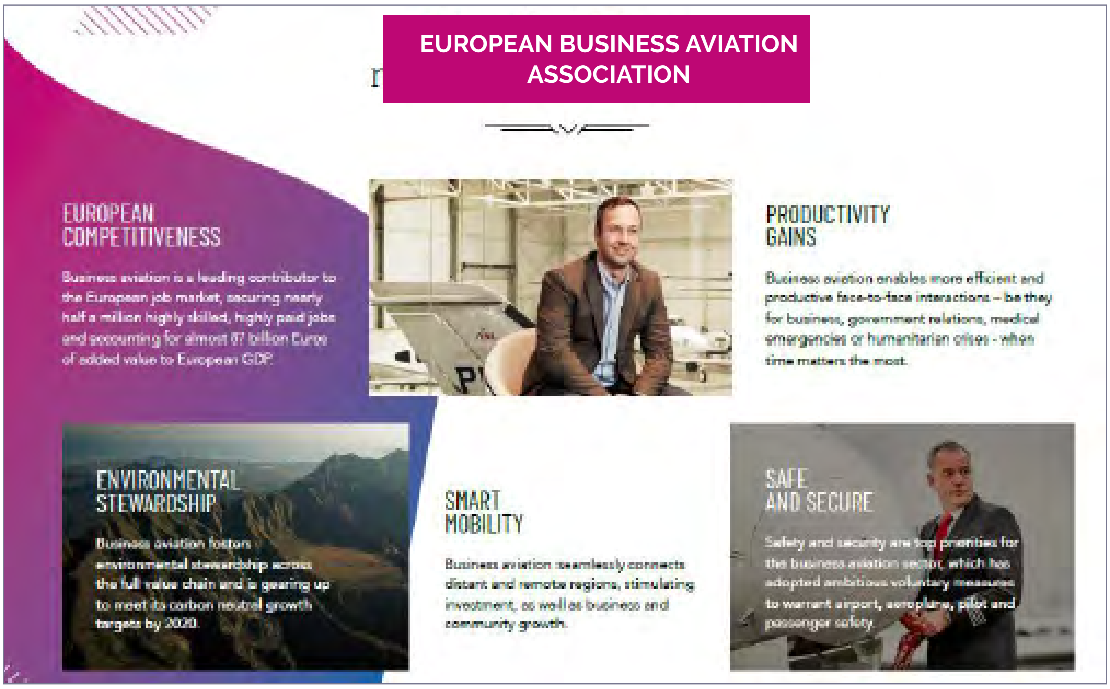
BUSINESS AVIATION OPERATIONS SPECIFICITIES

FLEXIBILITY
• On demand operations on short notice
• Ability to take off as soon as the passengers are there

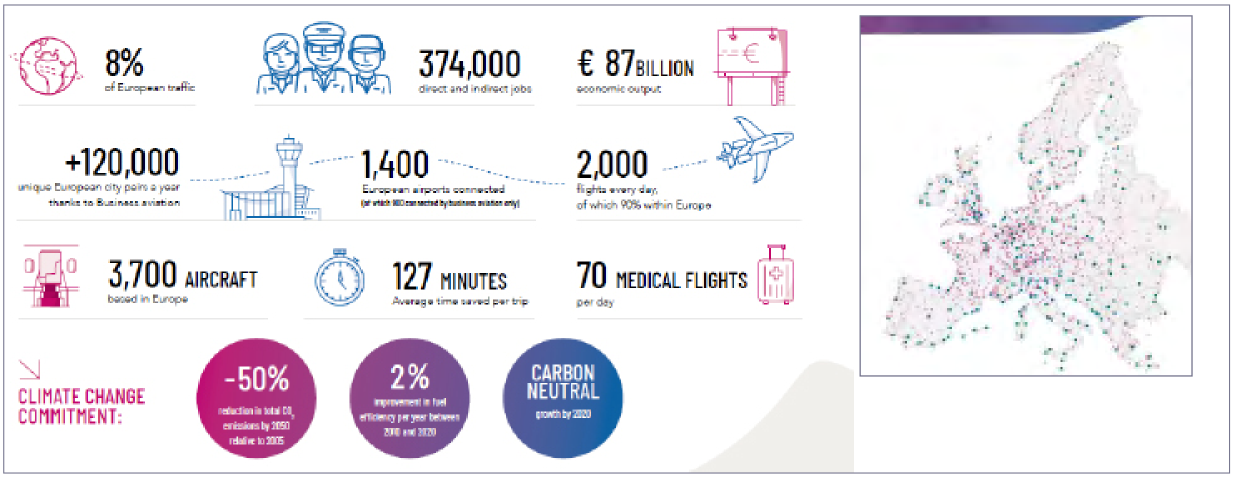
DIVERSITY
• Ability to access the whole range of airports (from main to small ones) Compliant with local noise regulations (airports close to residential areas) Worldwide operations

EFFICIENCY OF THE OPERATIONS
Ability to perform efficient missions (operate at flight levels over the airline traffic)

WHAT DOES BUSINESS AVIATION BRING?



EUROPEAN BUSINESS AVIATION : FACTS & FIGURES



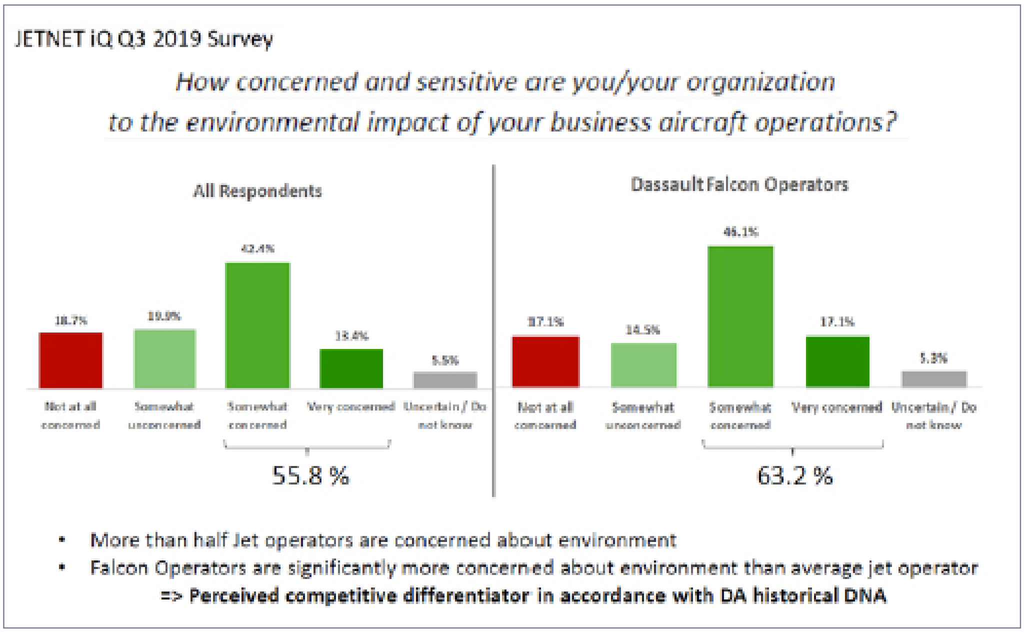
BUSINESS AVIATION : FACTS & FIGURES

Business aviation produces around **0.04%** of global anthropic carbon emissions

In the span of just eight years, the number of business airplanes has nearly doubled

From VistaJet

BUSINESS JET OPERATORS



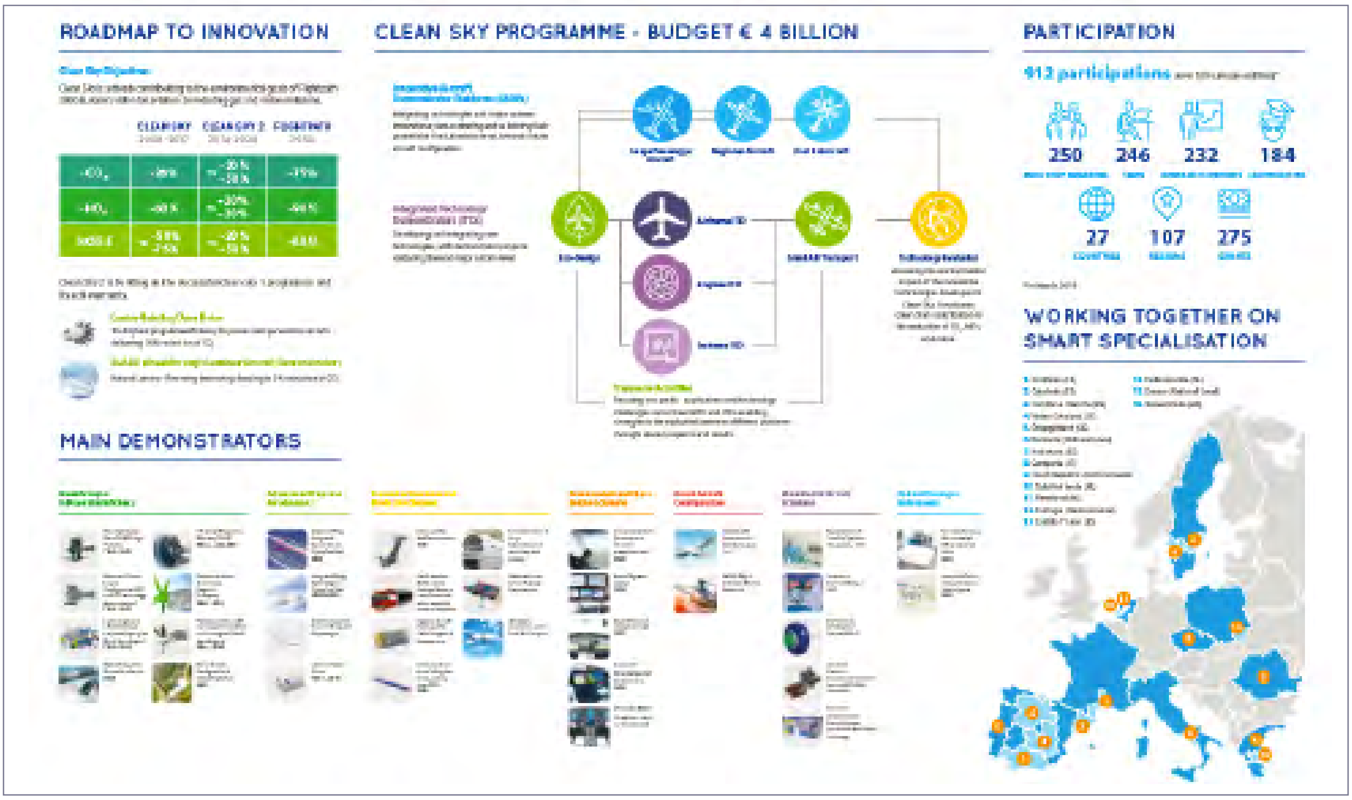
HOW THE BUSINESS AVIATION SECTOR CAN ACHIEVE CARBON NEUTRALITY?

Both GAMA and IBAC are encouraging the industry to focus on four pathways

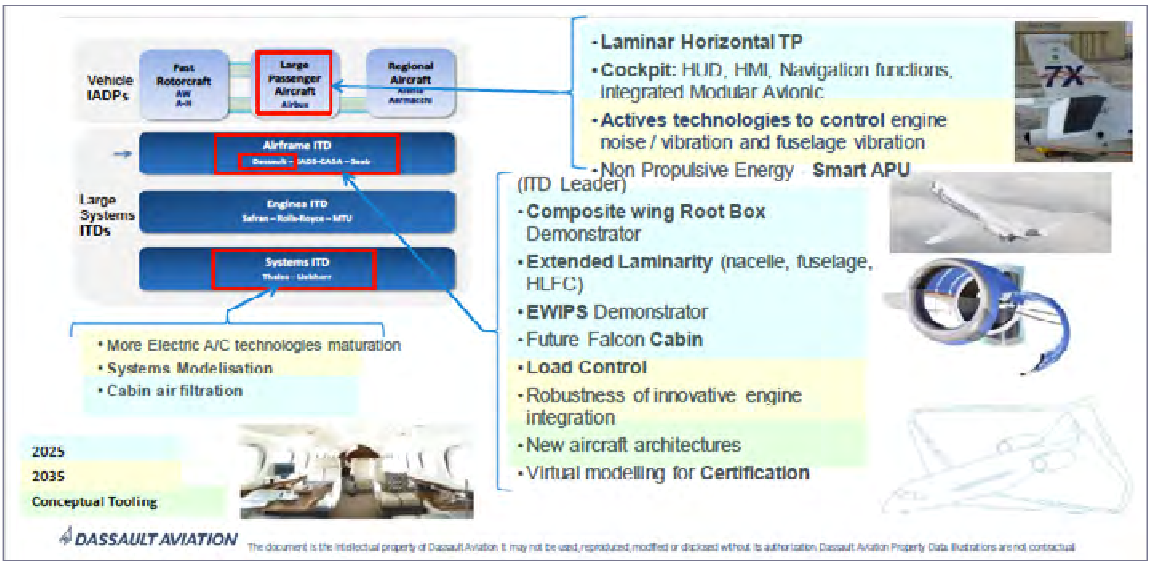
- More efficient operations
- Infrastructure improvements
- Market-based measures
- The use of new technology, including the development of alternative aircraft fuels (SAJF)
- Several SAJF demonstrations have taken place since 2018
- Several business aircraft manufacturers have cleared to fuel the airplanes with SAJF meeting the ASTM D16555-19 standard for a blend with Jet A/A1 up to 50%

3. CONCERTED RESEARCH INITIATIVES

EUROPEAN RESEARCH PROGRAM: CLEAN SKY

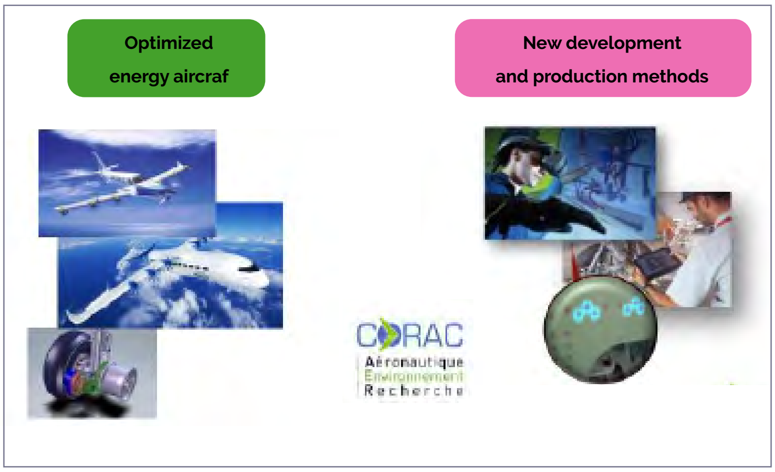


AN OVERVIEW OF DASSAULT AVIATION ACTIVITIES IN CLEAN SKY 2



FRENCH RESEARCH INITIATIVE: LE CONSEIL POUR LA RECHERCHE AÉRONAUTIQUE CIVILE (CORAC)

- Created in 2008
- Based on the European ACARE model by gathering all the stakeholders of national air transport
- Establishing a technological road-map articulating national and European implementation
- Ensuring consistency of research and innovation efforts, especially towards environmental and sustainable growth objectives
- Promoting collaborative research and demonstration projects
- Synchronizing and focusing of the whole sector
- Conducting cooperative studies with academic research



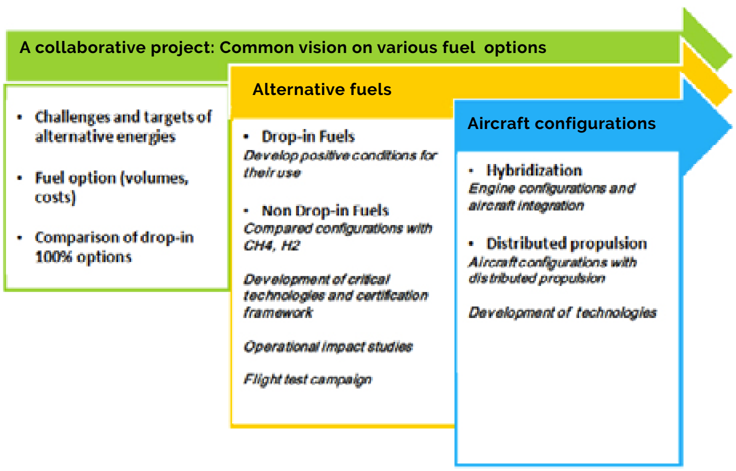
FRENCH RESEARCH INITIATIVE CORAC: THREE MAJOR PATHS

- **Three major paths carrying the objectives of the aviation sector for 5 years**
- **Federative effort of each stakeholder**
- **Structuration of collaborative projects**

Autonomous and connected aircraft

FRENCH RESEARCH INITIATIVE CORAC

Have at the year 2027 the technological bricks needed to design a decarbonized aircraft



FRENCH RESEARCH INITIATIVE CORAC: GREEN GROWTH COMMITMENTS

- **French ministries and 5 companies (Air France, Airbus, Safran, Total and Suez) have launched studies in 2017 related to aviation biofuels covering**
- Resources
- Transformation and production processes
- Distribution
- Public policy
- Economical viability

- **A comprehensive deployment trajectory has been recently issued**
- Ambition to incorporate 2% in 2025 and 5% in 2030
- Long-term objective of 50% in 2050

4. TECHNOLOGICAL CHALLENGES FOR BUSINESS JETS IN DASSAULT AVIATION

DEVELOPMENTS PARTICIPATING AT THE ENVIRONMENTAL FOOTPRINT REDUCTION

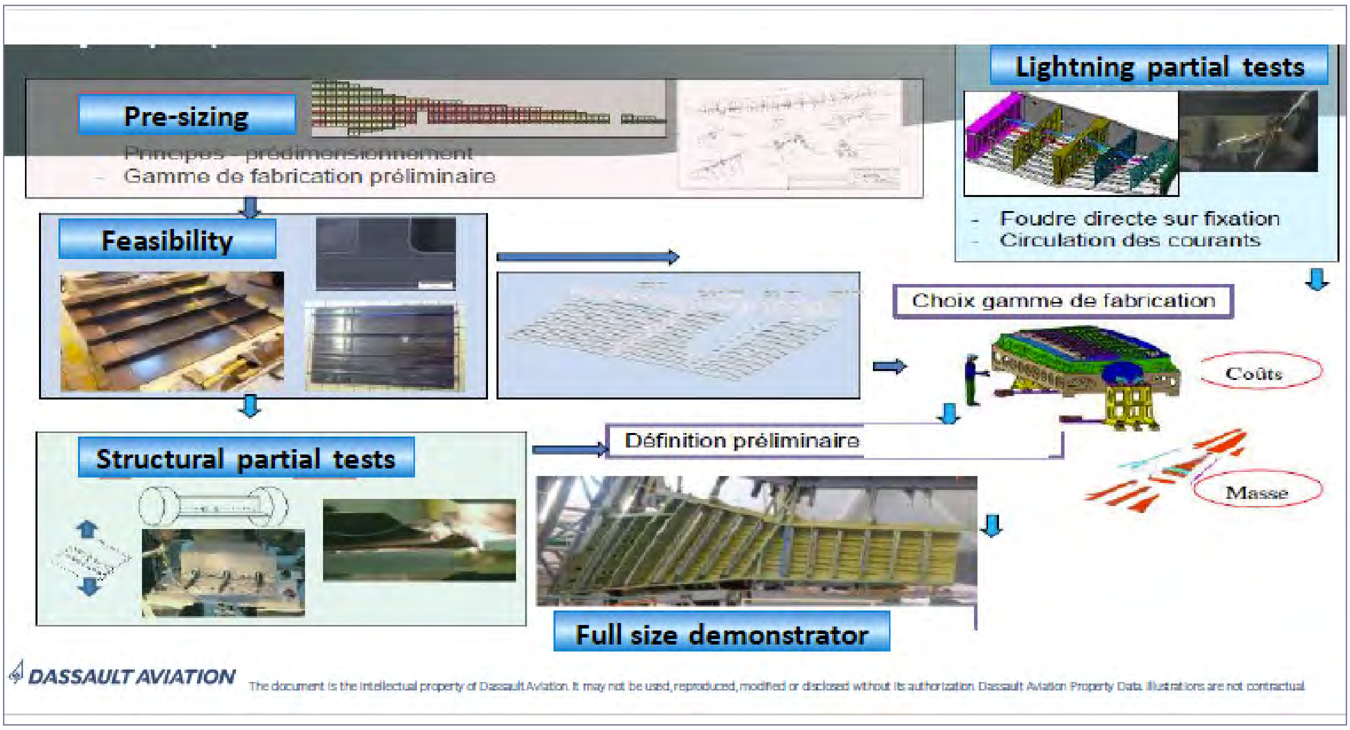
BUSINESS JET SPECIFIC DEVELOPMENTS

Emission reduction
- Weight reduction: Introduction of composite materials for large dimension structures
- Preparation and mission management « Low CO_2 » oriented for Falcons
- More electrical systems (ice protection):

External noise reduction :
- Novel configurations, inlet treatment, aerodynamic noise reduction
- **Optimized procedures for Falcons**
- Ground noise reduction (APU, ECS)

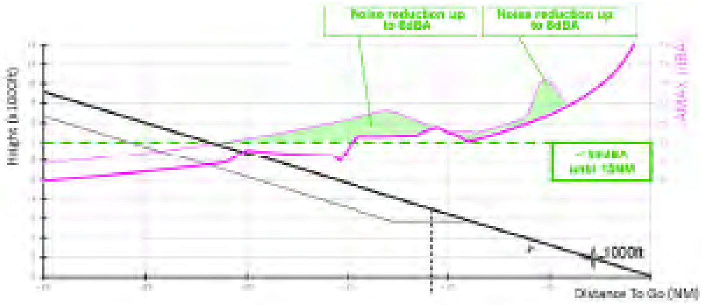
COLLABORATIVE DEVELOPMENTS
- **Laminarity for drag reduction – Participation to Airbus BLADE demonstrator**
- Weight saving by load and vibration control
- Preparation to future Air Traffic Management and Control (SESAR 2020)
- Sustainable Aviation Jet Fuel
- Eco-design
- REACH compliant processes
- Fuel consumption reduction / weight benefit: optimized energy management, electrical de-icing solutions

WEIGHT REDUCTION: THE ROAD-MAP TOWARDS COMPOSITE STRUCTURE



EXTERNAL NOISE : CURRENT CONTINUOUS DESCENT OPERATION (CDO)

Bizjets operational flexibility (steep approach capability, advanced avionics) allow to fly efficient approaches providing significant noise reduction on ground.

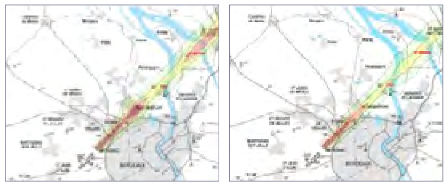


Falcon 7X Crew Operational Documentation includes a specific CDO that provides :

- **25%** reduction in noise contour areas;
- Up to **6dBA** reduction on intermediate approach and **8dBA** reduction on final approach.

This procedure is designed following ICAO recommendations:

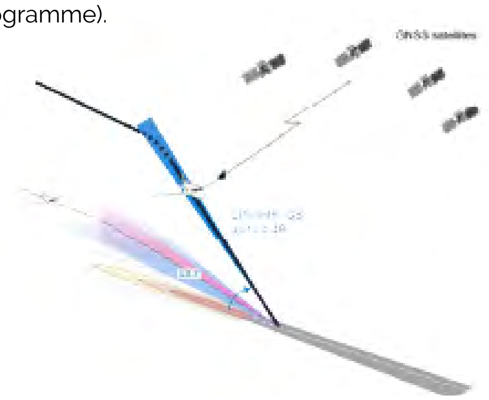
-3° flight path angle, anticipated deceleration, landing configuration stabilized around 3000 ft.



NON-CDO **CDO**

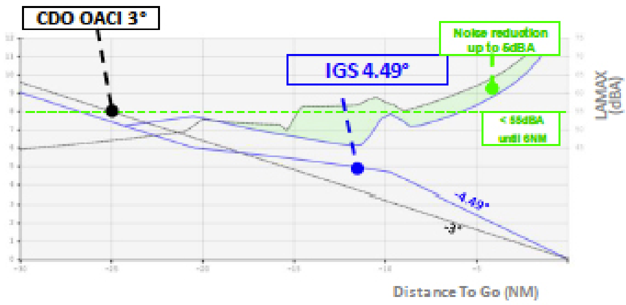
EXTERNAL NOISE : SBAS ENHANCED ARRIVAL PROCEDURES FOR FALCON

To further reduce the noise disturbance in the airports vicinity, Dassault contributes to the deployment of Enhanced Arrival Procedures (EAP) supported by advanced GNSS navigation technologies (SESAR Work Programme).



A reduction in noise up to 5dBA may be achieved using LPV with Increased Glide Slope (IGS) up to 4.49° instead of the common worldwide 3° glide slope.

All in-production Falcon aircraft are LPV capable and will benefit from these EAPs.

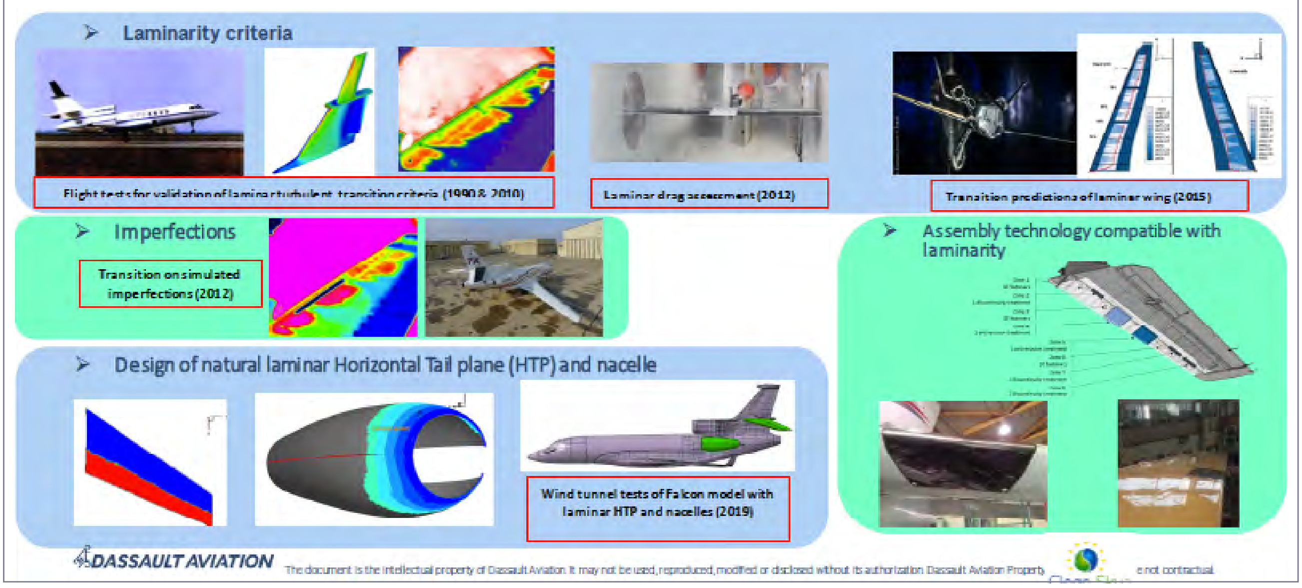


SBAS : Satellite-Based Augmentation System

LPV: Localizer Performance with Vertical guidance (GNSS)

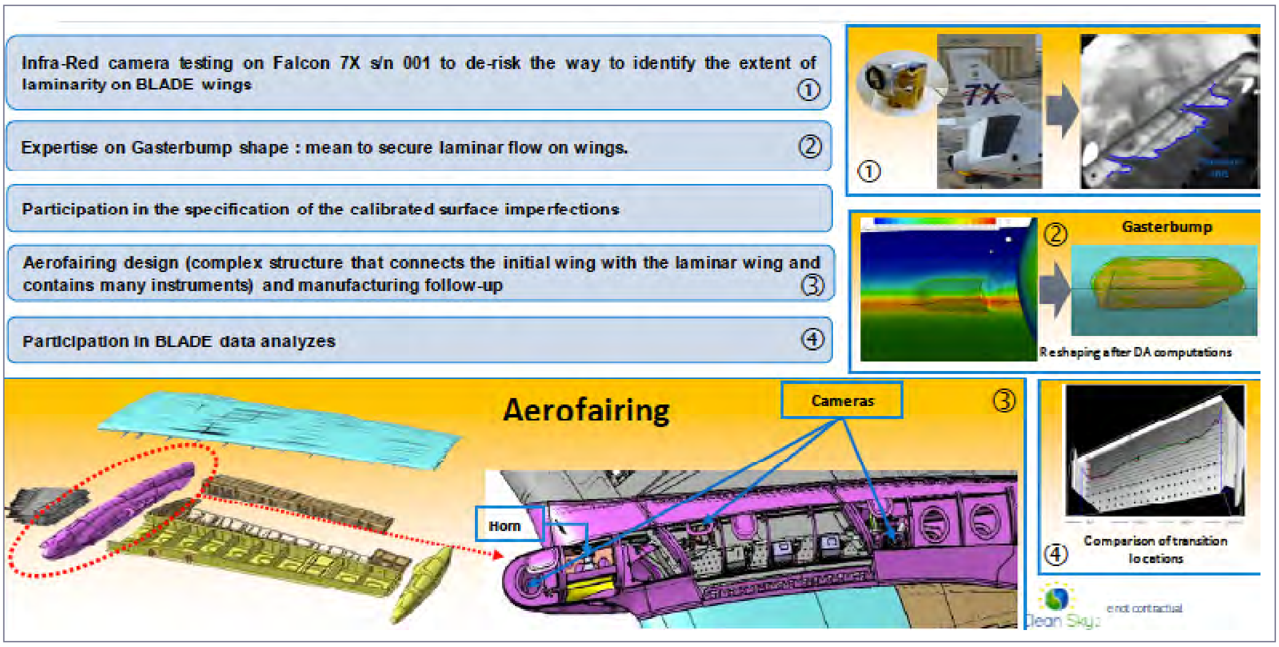
LAMINARITY FOR BIZJETS

> Roadmap Laminarity for Dassault Aviation. The BLADE project contributes to this roadmap



THE AIRBUS BLADE DEMONSTRATOR

DASSAULT AVIATION CONTRIBUTION TO BLADE



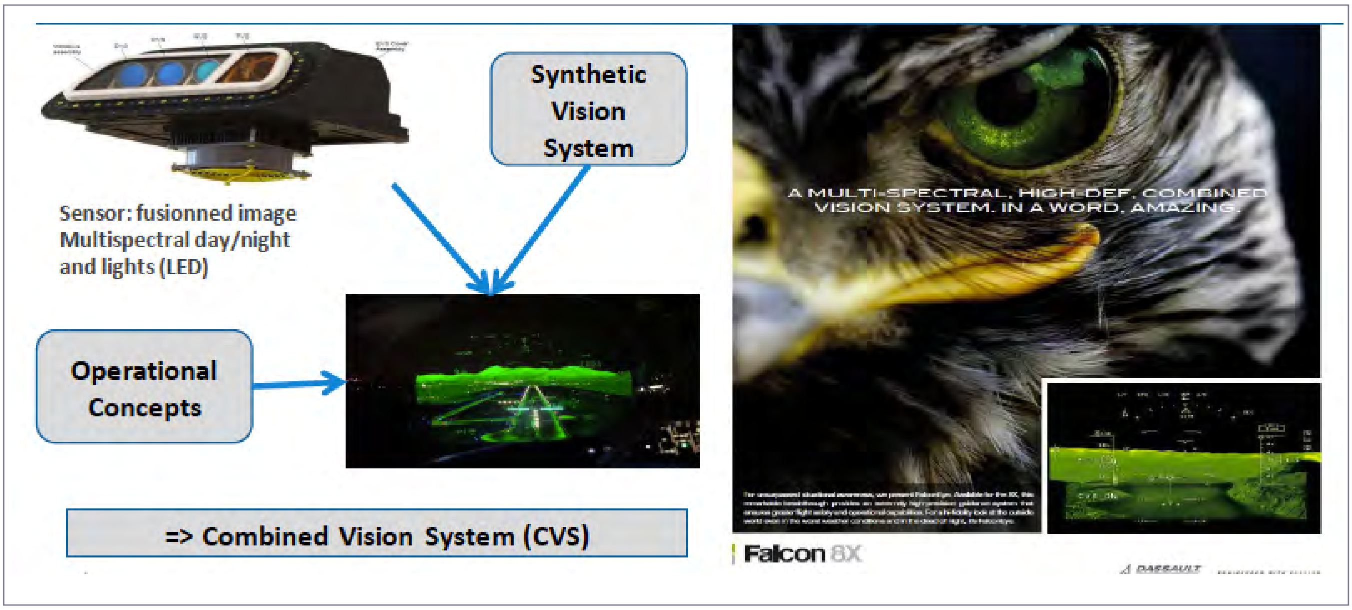
5. PERSPECTIVES

THE TOMORROW DISRUPTIONS

- **Sustainable aviation**
  - Carbon neutrality and low-noise operations considering the specificities of business jetsoperations
- **Operational flexibility**
  - Low visibility landings on non-equipped airfields, ground operations with automatic detectionof obstacles
- **More autonomous aircraft**
  - Human as supervisor of integrated systems (one acting pilot in cruise)
- **Networked aircraft**
  - Connectivity and distributed architecture, ground-flight continuity (aircraft as acommunication relay, mutualized weather forecast, runway friction monitoring)
- **Enhanced services**
  - Generalized data analysis

INCREASE THE OPERATIONAL FLEXIBILITY

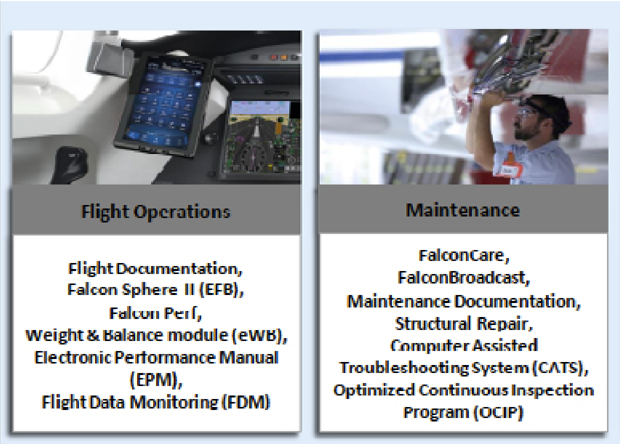
FalconEye is the first head up display to combine synthetic, database-driven terrain mapping and enhanced thermal and low-light camera images at the same time



THE EXPANSION OF SERVICES

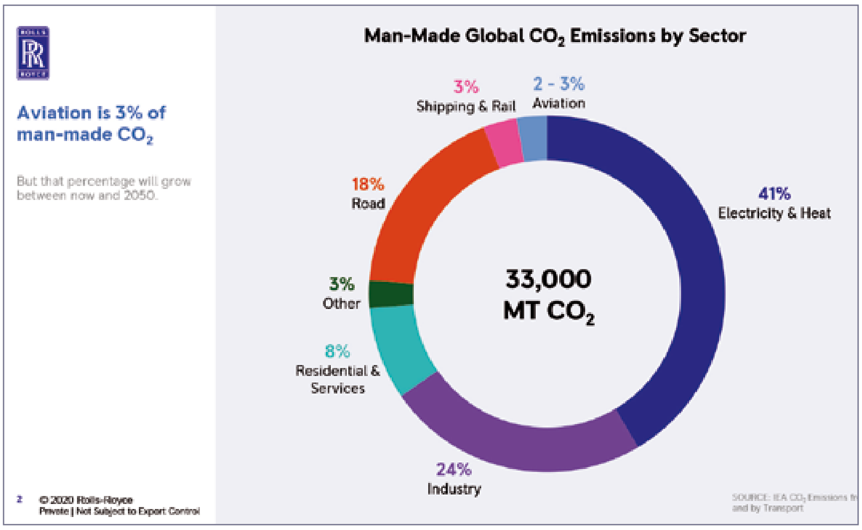
Make the most of customer Falcon

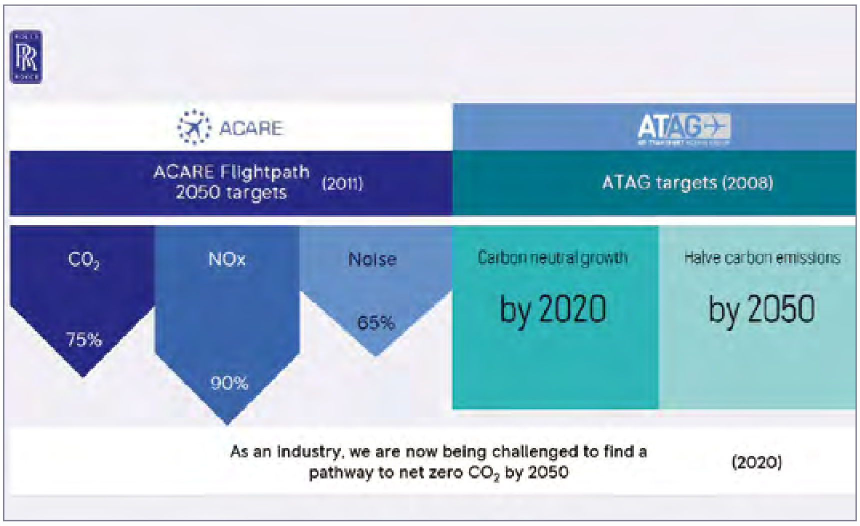
Inspired by customer needs and expectations, a suite of innovative products and services has been designed to help them maintain and enhance the value of their Falcon by maximizing the safety, dispatchability, efficiency, and performance of the aircraft.

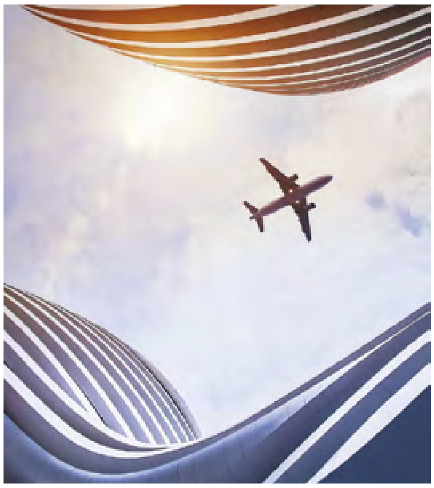


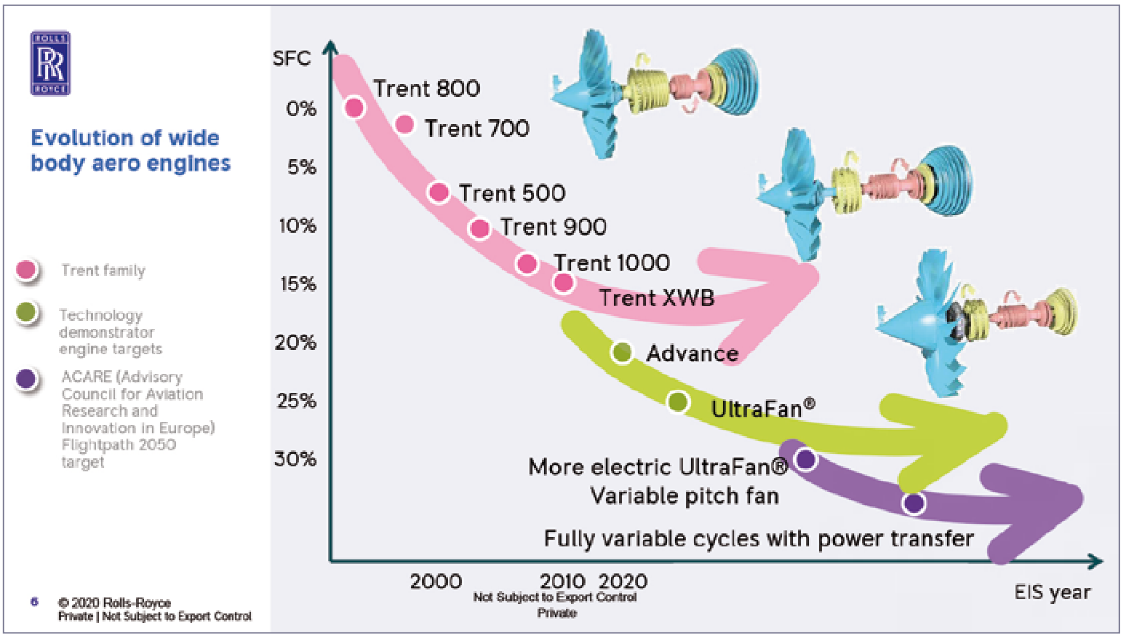
AEROSPACE SUSTAINABILITY & ELECTRIFICATION

By Paul Stein, Rolls-Royce Chief Technology Officer








Evolution of wide body aero engines
Trent family
Technology demonstrator engine targets
ACARE (Advisory Council for Aviation Research and Innovation in Europe) Flightpath 2050 target
SFC
0%
5%
10%
15%
20%
25%
30%
Trent 800
Trent 700
Trent 500
Trent 900
Trent 1000
Trent XWB
Advance
UltraFan®
More electric UltraFan®
Variable pitch fan
Fully variable cycles with power transfer
2000
2010
2020
EIS year
6
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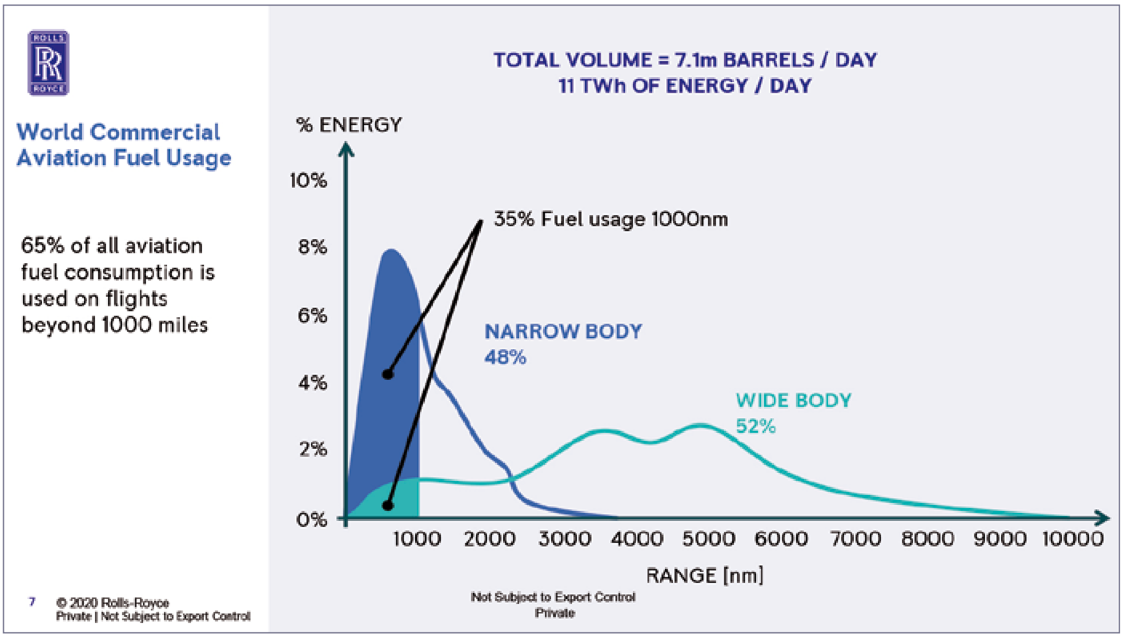
World Commercial Aviation Fuel Usage
65% of all aviation fuel consumption is used on flights beyond 1000 miles
TOTAL VOLUME = 7.1m BARRELS / DAY
11 TWh OF ENERGY / DAY
% ENERGY
10%
8%
6%
4%
2%
0%
35% Fuel usage 1000nm
NARROW BODY
48%
WIDE BODY
52%
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
RANGE [nm]
7
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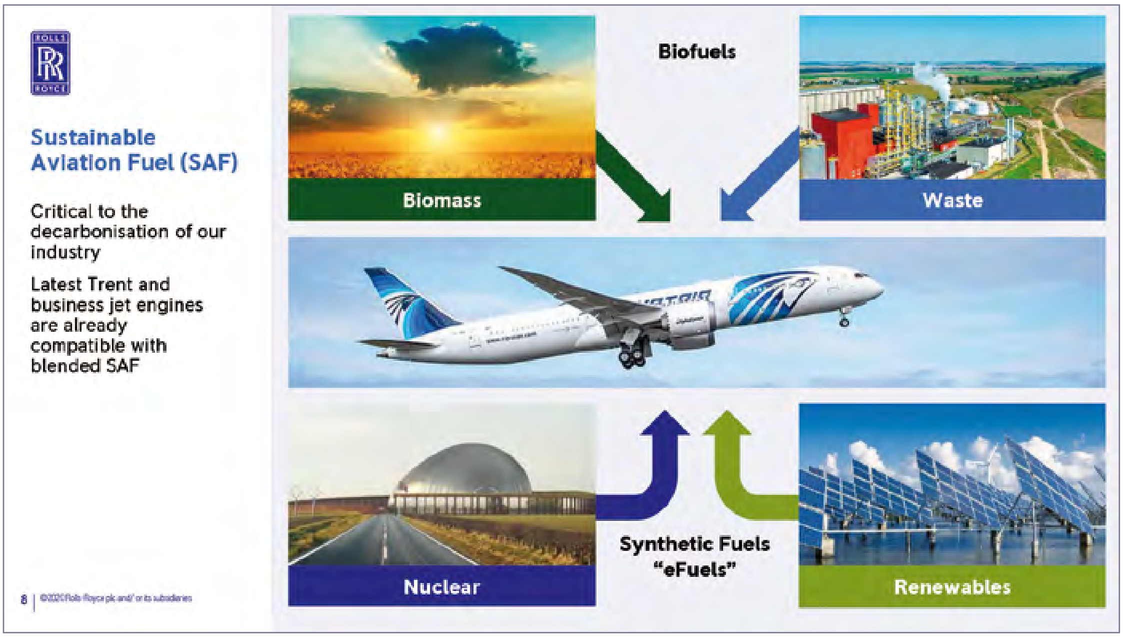
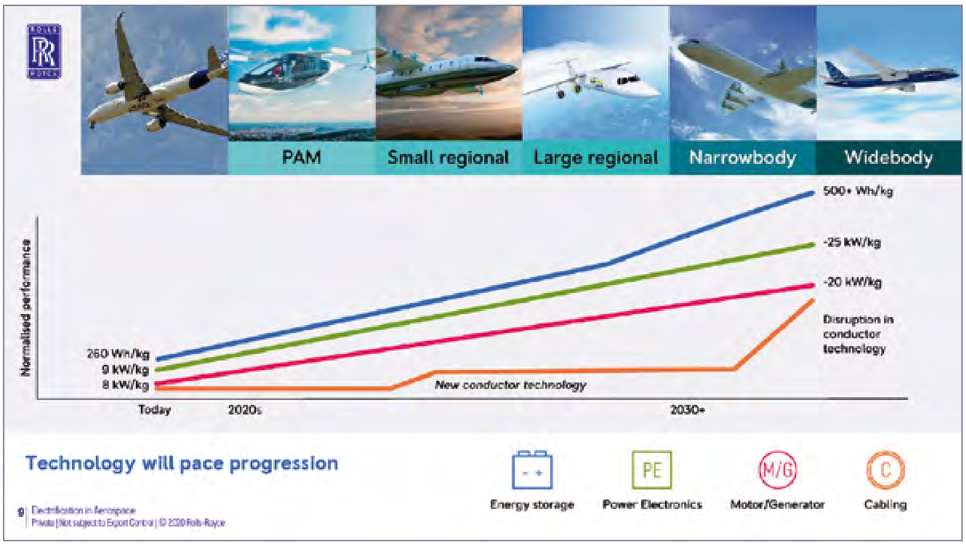

Sustainable Aviation Fuel (SAF)
Critical to the decarbonisation of our industry
Latest Trent and business jet engines are already compatible with blended SAF
Biofuels
Biomass
Waste
Nuclear
Synthetic Fuels
"eFuels"
Renewables
8


PAM
Small regional
Large regional
Narrowbody
Widebody
Normalised performance
500+ Wh/kg
~25 kW/kg
~20 kW/kg
Disruption in conductor technology
260 Wh/kg
9 kW/kg
8 kW/kg
New conductor technology
Today
2020s
2030+
Technology will pace progression
Energy storage
Power Electronics
Motor/Generator
Cabling


Electrification of Aviation
EVTOL
REGIONAL HYBRID
MoM & WIDE BODY
2025
2030
2040


eVTOLs and UAM
Electric vertical take-off and landing (EVTOL)
Urban Air Mobility (UAM)
Realistic near-term applications based on hybrid-electric and all-electric technologies
Personal transport, public transport, logistics, air ambulance, police and military applications
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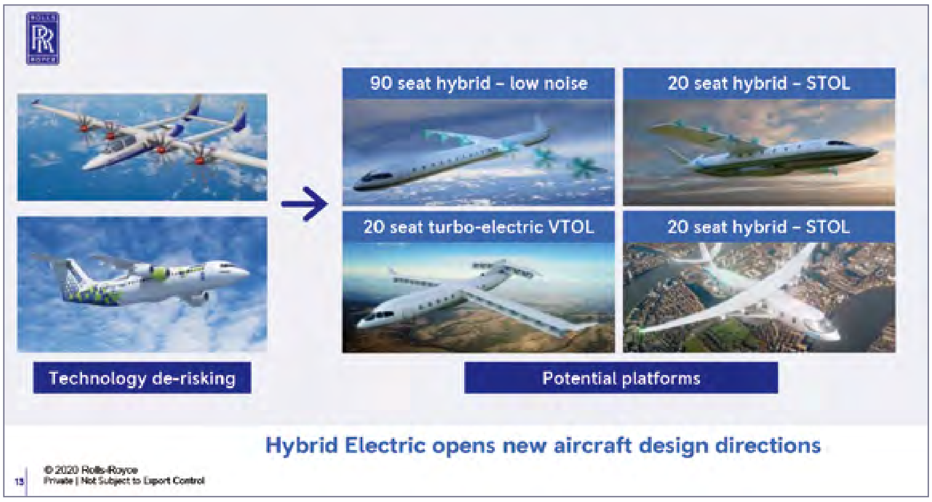
E-Fan X
Developing the world's most powerful flying generator
A serial hybrid architecture designed to demonstrate that the fundamental challenges of hybrid-electric propulsion at this scale can be overcome
A building block towards hybrid electric commercial aircraft at the scale of today's single aisle family and beyond
A hybrid electric demonstrator vehicle (Avro RJ100)
Integrating a 2MW Electric Propulsion Unit (EPU), a 2.5MW AE2100-based power generation system and a 2MW battery
Scheduled to fly in
2021
In partnership with:
Airbus
ATI UK
Clean Sky 2


90 seat hybrid – low noise
20 seat hybrid – STOL
20 seat turbo-electric VTOL
20 seat hybrid – STOL
Technology de-risking
Potential platforms
Hybrid Electric opens new aircraft design directions
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CLEAN AVIATION IN HORIZON EUROPE

By Hervé Martin, DG Research and Innovation European Commission

In the next 10-15 minutes, I will try to give you an overview of the present political landscape **and how this affects aviation R&I**. You know very well that we have a **new Commission**, which has **clear political priorities**. Member States have endorsed these priorities and Environmental protection has a central role. But let's start from the beginning.

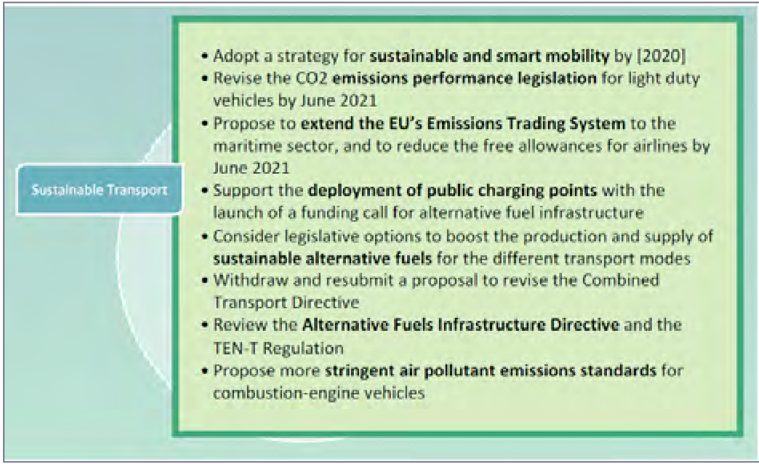
The people of Europe made their voice heard in record numbers at last year's European elections. They also presented Europe's institutions and leaders with a clear task to be **bold and resolute in tackling our generational challenges**.
Throughout the next year and the decade ahead, our Union has a unique opportunity to lead the transition to a **fair, climate-neutral, digital Europe**.
This twin ecological and digital transition will affect us all: every country, every region, every person.
It will cut across every part of our **society and economy**. But for it to be successful, it must **be just and inclusive for all.**

The European Commission Work Programme 2020 was released a month ago.
It is focused around the **six headline ambitions set out in President von der Leyen's Political Guidelines**.
It also reflects the main priorities for the European Parliament and those in the European Council's Strategic Agenda for 2019-2024.
The **first two priorities** (the European Green Deal and the digital Europe) have direct implications for **Transport and Energy R&I.**
You may download the Commission WP 2020 and the sub-priorities below the 6 political priorities.

I have seen that some of you have made reference, in your presentations, to the European Green Deal. The most **pressing challenge, responsibility and opportunity for Europe** is keeping **our planet and people healthy.**

This is the defining task of our times.

The European Green Deal is that response. **It will drive us forward to climate neutrality by 2050 and at the same time focus on adaptation.**

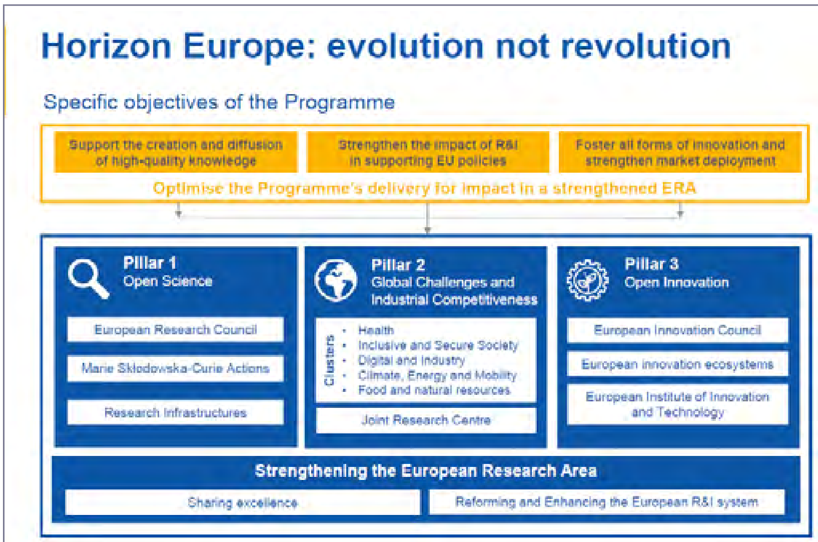


We do not have the time today to go through to all the building blocks of the Green Deal.
I will make a stop in the action for Sustainable Transport.
I will mention two actions that are planned for the Q4 of this year:

- **Strategy for sustainable and smart mobility** (non-legislative, Q4 2020)
- **ReFuelEU Aviation - Sustainable Aviation Fuels** (legislative, incl. Impact assessment, Q4 2020)

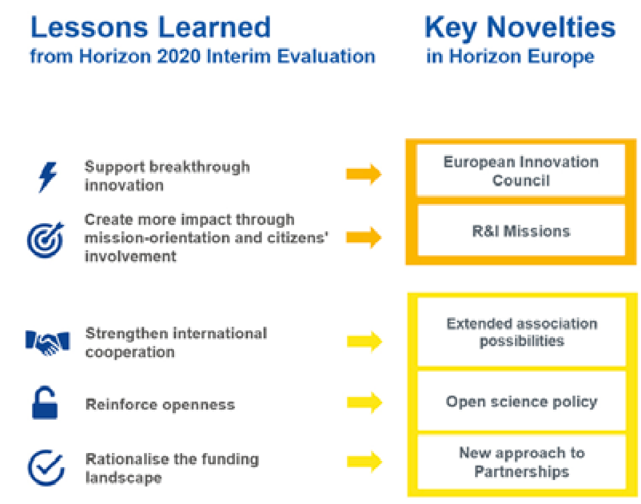
We all know that **challenges of aviation are closely interdependent**. I will not lecture you on the trade-offs between competitiveness and fuel consumption (which directly translates to CO_2 emissions).
We are also well-aware of the international character of aviation – not only as transport mode but also as supply chain and ecosystem.

Which also reminds me to thank all the international participants from the US, CANADA, Russia, Japan, China for their participation.
My clear message is that we have to **timely align our forces in precompetitive R&I as well as product development** in order to globally succeed to the global challenges.



Focus on:

3 – pillar structure – full innovation chain – non-sectorial approach for low-medium TRL
Synergies between the 3 pillars / missions / partnerships

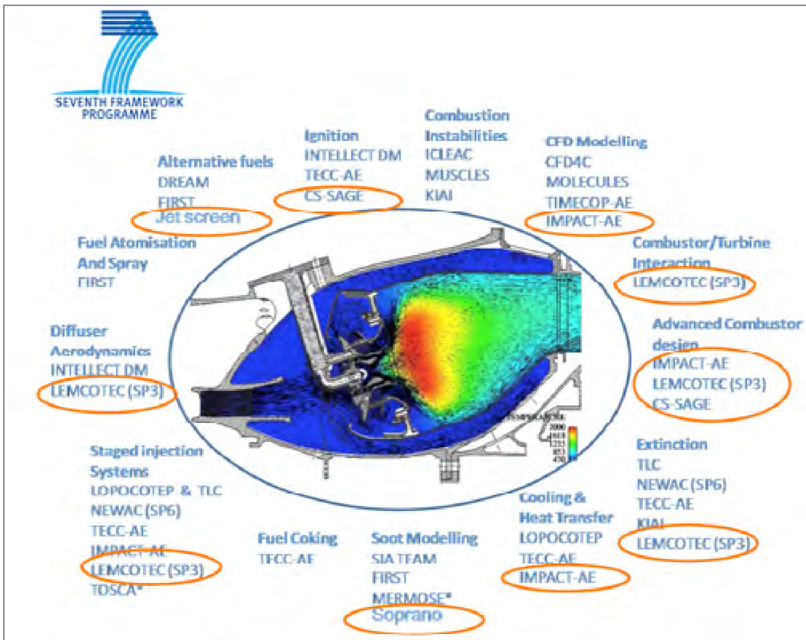


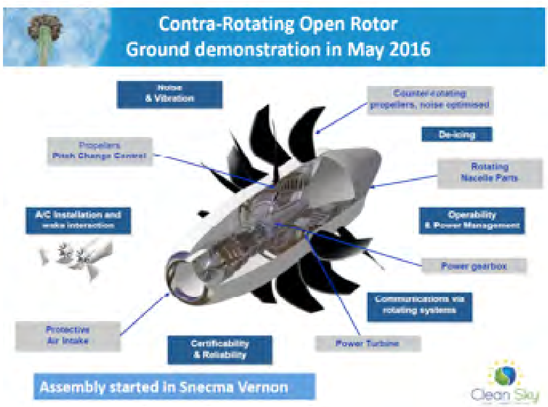
5 key building blocks of Horizon Europe.

Regarding partnerships:

1. They should be aligned to the main political priorities – that's why Clean Aviation will be different from Clean Sky where the financial crisis led to more competitiveness than greening impact.

2. We are working on the best governance modalities towards a more optimum Partnerships that share resources and focus to what is really necessary for their success.



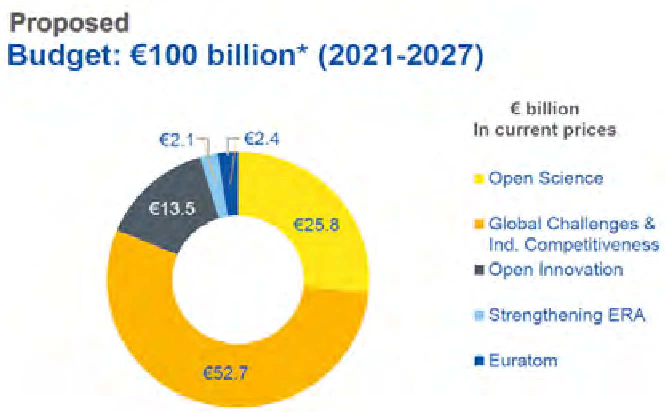


We acknowledge the excellent job done in the 30 years of European aviation R&I program – including the 10 yeas Clean Sky.

We are proud of the alignment and contribution of 100s of Level 1 and Level 2 projects to Clean Sky demonstrators.

We do very well with synergies between different Levels of Aviation programs – the stakeholders are the same.

Of course the Commission together with MS and stakeholders will pay even more attention on that – to do even better. As Horizon Europe by design is not going to be sectorial, **synergies between clusters and partnerships is important.**



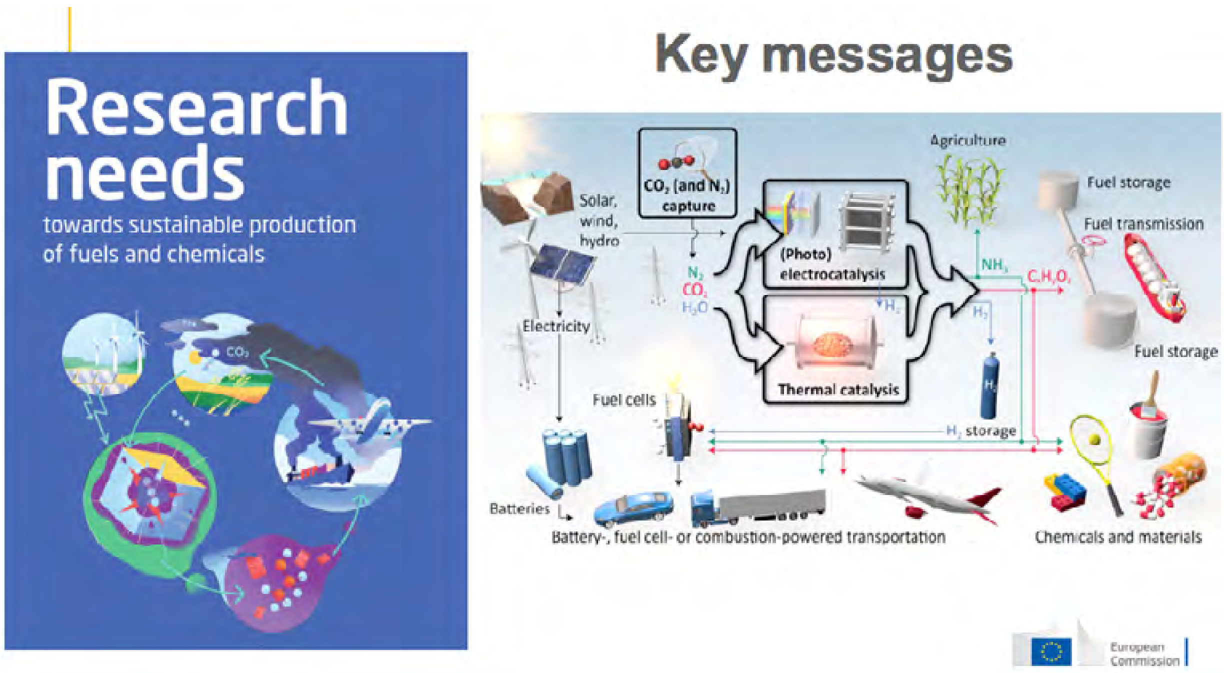
This is the proposed budget – negotiations for the whole MFF are underway – as you may read from the news.

BREXIT and other uncertainties tend to reduce the proposed budget.

My DG, JEP had extensive talks with MS to show the impact of R&I.

We hope to a successful outcome.

However our cluster is overpopulated.



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My DG, JEP had extensive talks with MS to show the impact of R&I.
We hope to a successful outcome.

Clean Aviation
Key demonstrators
Energy efficiency
Hybridization
Digitalization
Integrated approach

Invest in key integrated demonstrators – that as Bruno Stoufflet said – that will provide the technological bricks needed to design a decarbonized aircraft by the end of this decade.

Thank you for your hospitality AEC2020 brought Europe and our International Partners much closer. Merci Bordeaux!

ROUND TABLE ONE

FROM RESEARCH TO FLIGHT, BRINDGING THE DEATH VALLEY

Philippe Landiech who is department head for architecture, validation and integration at CNES French Space Agency, moderated a round-table on the following topics: "From research to flight: bridging the death valley". He and his guests Philippe Beaumier from French ONERA, Sergey Chernyshev from Russian TsAGI, Jean-François Brouckaert from the European CleanSky, Hervé Gilibert from ArianeGroup and Rafaël Bureo-Dacal from the European Space Agency discussed about how first rely on a set of innovative ideas, then be able to mature them and conditions to include them in a constrained development plan. Benefits from modern digital tools but also from hybrid approaches were identified. Help from public funding through In Flight or In Orbit demonstration programs was highlighted.Undertaking.

ROUND TABLE TWO

ELECTRIC HYBRID PROPULSION

Prof. Rolf Henke, who is the member of the DLR Executive Board for Aeronautics research, moderated a round-table discussion on electric and hybrid flying. He and his guests discussed the role of global players and start-ups in aerospace research and development as well as the challenges of integrating electric aircrafts into the existing air transport system. One of the key questions was about the contribution of stakeholders such as airlines and airports towards the implementation of electric flying in the future. The discussion therefore included topics such as ground support, ATC, logistics and noise reduction.

DLR Executive Board member Prof. Rolf Henke (right) speaks at the Aerospace Europe Conference 2020 in Bordeaux about the perspectives and challenges of electric and hybrid electric flying with (from left to right) Jean Brice Dumont, Executive Vice President Engineering, Airbus, Stéphane Cueille, CTO Safran, Mike Benzakein, Assistant Vice President for Aerospace and Aviation Research University Ohio State.
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BULLETIN
AEROSPACE
EUROPE

AMONG UPCOMING AEROSPACE EVENTS

2020

Due to the current outbreak of coronavirus Covid-19, many events are cancelled or postponed. The here below calendar is intentionally and exceptionally limited to the nearest events.

MAY

13-17 May – ILA – **ILA Berlin 2020** – https://www.ila-berlin-de/en - CANCELLED -

25-27 May – Elektropribor – **27th Saint Petersburg International Conference on Integrated Navigation Systems –** Saint Petersburg (Russia) – www.elektropribor.spb.ru/en/conferences/142

26-28 May – EBAA – **EBACE2020** – https://ebace.aero/2020/- CANCELLED -

27-29 May – EUROMECH – **17th European Mechanics of Materials Conference –** Madrid (Spain) – https://euromech.org/

JUNE

03-04 June – FSF – **8th Annual Safety Forum –** Airport Surface Risk - Brussels (Belgium) – EUROCONTROL/HQ – https://flightsafety.org/events/ - CANCELLED -

08-12 June – GICAT – **EUROSATORY 2020 –** SALON MONDIAL DE DEFENSE ET SECURITE TERRESTRES ET AEROPORTEES – Paris (France) – Parc des expositions Paris Nord Villepinte – www.eurosatory.com

09-10 June – RAeS – **The Past, Present and Future Simulation Technology, Training and Regulatory Challenges –** London (UK) – RAeS/HQ – www.aerosociety.com/events/

09-12 June – CANSO – **CANSO Global ATM Summit 2020 and 24th AGM** – Baku (Azerbaidjan) – JW Marriott Absheron – hosted by AZANS – https://www.canso.org/ - events@canso.org

15-19 June – AIAA – **AIAA Aviation Forum and exposition** – Reno, Nevada (USA) – Reno –Sparks Convention Center – https://www.aiaa.org/events

16-18 June – ACI-Europe – **30th ACI EUROPE Annual Assembly** – Geneva (Switzerland) – InterContinental Geneva – www.aci-europe-events.com

19-21 June – ICCIA **– ICCIA2020 – 5th International Conference on Computational Intelligence and Applications** – Beijing (China) – Beijing Technology and Business University – www.ccia.org – iccia@zhconf.ac.cn

21-26 June – ESA **– 11th ESA Conference on GNC –** Sopot (Poland) – https://atpi.eventsair.com/ POSTPONED TO 8 – 13 NOVEMBER

22-23 June – IATA **– 76th IATA Annual General Meeting – Annual General Meeting (AGM) and World Air Transport Summit 2020 –** Amsterdam (NL) – Hosted by KLM Royal Dutch Airlines (TBC) – https://www.iata.org/en/events/agm

22-25 June – FAA/EASA **– 2020 FAA-EASA International Aviation Safety Conference –** Washington D.C. (USA) – JW Marriot – https://www.easa.europa.eu/

23-26 June – ICNPAA **– ICNPAA 2020 – Mathematical Problems in Engineering, Aerospace and Sciences –** Prague (Czech Republic) – www.icnpaa.com

25-26 June – Council of EU/EDA **– European Defence Cooperation Conference – New Opportunities for an Enhanced European Defence Industry –** Zagreb (Croatia) – Hotel Westin – Izidora Krsnjavog, 1 – https://www.eda.europa.eu/info-hub/events/

29 June - **03** July – ESA – **#SPACE2CONNECT2020 – First edition of Space to Connect Conference – Innovation, not only in satellites but also in the down – to Earth business applications of space** – Noordwijk (NL) – ESA/ESTEC – https://atpi.eventsair.com/

JULY

19-24 July – ECCOMAS – **ECCOMAS Congress 2020 – Jointly organized with the 14th World Congress on Computational Mechanicse** – Paris (France) – www.eccomas.org/lin-de/en - POSTPONED -

20-25 July – Farnborough – **Farnborough International Airshow 2020** – Farnborough (UK - Show Centre, ETPS Rd – Farnborough GU14 6FD – https://www.farnboroughairshow.com/ - CANCELLED -

28-30 July – RAeS – **Applied Aerodynamics Conference 2020 –** Bristol (UK) – www.aerosociety.com/events/