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WEBINAR REPORT

Defence and New Sustainable Technologies in the Aviation Sector

May 24th, 2024

ABOUT THE EVENT

Webinar: "Defence and New Sustainable Technologies in the Aviation Sector". Held on May 24th, 2024. Available at the Sovereignty and Climate Center's YouTube channel.

The event is part of the Webinar Series "Climate, Sustainability, and Defence", held in partnership with the NETZMIL Project (Loughborough University, United Kingdom) and the Training Center on Defence Economics and Force Development (NCAD/ESD).

Participants

Amanda Duarte Gondim. Amanda is a lecturer in chemistry at the Federal University of Rio Grande do Norte and is the coordinator of the Laboratory of Biofuels, Primary Processing and Environmental Analyses of NUPPRAR (LABPROBIO). She holds a B.Sc, an M.Sc and a PhD in Chemistry. Amanda also coordinates the Brazilian Network of Biokerosene and Renewable Hydrocarbons (RBQAV), the ANP Human Resources Programme (PRH-ANP -37.1). She is a consultant on the Technical Board of the SENAI Institute for Renewable Energy Innovation (ISI-ER). She is also an expert in Environmental Chemistry at the Rio Grande do Norte Public Ministry and leads research projects on oil residue valuation, biodiesel production, water quality, environmental contamination, renewable hydrocarbon and hydrogen, focussing on biokerosene and green diesel.

José Luis Gonçalves de Almeida. Graduated in Chemical Engineering (UFRJ - 1979), Master's in Chemical Engineering (Coppe UFRJ - 1983) and PhD in Catalysis (Université Claude Bernard, Lyon, France, 1995), Advanced Business Management Program - Instituto Internacional San Telmo, Spain – 2007 and, Specialization in Data Sciences and Big Data (UFBA - 2020). Full Member of the Academy of Sciences of Bahia. Fluent in English, French, and Spanish, with intermediate-level knowledge of German. Responsible for the Research Area at Cepsa Química for 8 years (Spain) and General Director of DETEN Química S.A. for 12 years, he has experience in project management and direct supervision of technical personnel (R&D). He is currently an Executive Manager at SENAI Cimatec as Executive Manager, responsible for Petrochemical Refining, Energy Efficiency, Pulp and Paper, Environment and Safety. José Luis is responsible for the Decarbonization and Low Carbon H2 projects in the Chemistry area and the H2V Atlas for the State of Bahia.

Andrew Sweeney. Squadron Leader Andrew Sweeney has over a decade of experience as an aerospace engineer in the defence aviation sector. Currently, he is the leader of the Royal Air Force's sustainable aviation strategy. He created the blueprint for the Defence Aviation Net Zero Strategy, which outlines the pathway to achieve the RAF's aspirational Net Zero 2020 goal. Since its release, he has been developing the programme to deliver this vision, working in partnership with stakeholders from defence, industry, academia, and the wider government. In addition to previous experience in engineering-focused roles, Andrew was selected for a Chief of the Air Staff's Fellowship, attending the University of Cambridge to study an MPhil in Engineering for Sustainable Development in 2021, with a project entitled "Assessing the Vulnerability in Net Zero Aviation Strategies to Inform Military Decarbonisation Pathways".

Tiago Sousa Pereira. Dr Tiago de Sousa Pereira is the Director of ANAC (Brazilian Civil Aviation Agency), also occupying the position of Acting President-Director. Before joining the board of Directors, he was responsible for several Departments at the same agency, distinguished by the Airport concessions' conduction and for the definition of Anac's governance model, which awards the Agency for good governance practices. Dr Tiago also worked for the Central Bank of Brazil and the Ministry of Planning, Development and Management. He is a career civil servant, a government executive of the Ministry of Management and Public Services Innovation, and a lecturer of Economics and Regulation at the Brazilian Institute of Development, Teaching and Research (IDP). He also has a PhD in Economics from the University of Brasília (UnB).

Duncan Depledge. Dr. Duncan Depledge is Lecturer of Geopolitics and Security in the School of Social Sciences & Humanities and the Principal Investigator of the NETZMIL Project at Loughborough University, United Kingdom. Duncan has a Ph.D. from Royal Holloway, University of London, an MPhil in Geographical Research from the University of Cambridge, an MA in Political Theory from the University of Sheffield and a BA (Hons) in History from the University of Sheffield. His current work tackles the implications of climate change and the global energy transition for the future character of military operations and war. His research is funded by the Economic and Social Research Council. Duncan is also a Senior Research Associate of the Climate Change & In(security) Project, based from the University of Oxford and an Associate Fellow of the Royal United Services Institute, as well as a member of the Advisory Council of the All-Party Parliamentary Group for the Polar Regions. He is the author of Britain and the Arctic (Palgrave, 2018).

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Introduction

Previous reports on the series presented paths for decarbonising the Armed Forces, suggesting a strategy for the defence industry to incorporate sustainable technologies as one of the core principles to retain the sector's capabilities. This discussion, in and of itself a complex and multifaceted one, involves Defence's actions on different fronts, as well as an alignment between the various federal sectors to achieve these objectives.

Thus, the reports addressed the intersection between climate change, sustainable innovation, and national defence, emphasising energy transition and cross-sectoral collaboration. They analysed how restricting government action in the sectors of environment and climate can compromise the cultural transformation necessary to face the global climate crisis, highlighting the relevance of integrating the defence sector in this process. Notably, they examined the defence industry's role in the UK and Brazil, emphasising the common challenge of adapting to the demands for decarbonisation and sustainability while appreciating their distinct industrial landscapes. Additionally, the documents stressed that international cooperation and coordination between the public and private sectors are fundamental to promoting technological innovation and ensuring national security in a sustainable manner.

From this perspective, during the "Climate, Sustainability, and Defence" Webinar Series, the Sovereignty and Climate Centre, in partnership with the Brazilian Defence College and Loughborough University, supported by Instituto Clima e Sociedade (Climate and Society Institute) and the Brazilian Association of Defence and Security Materials Industries (ABIMDE), focused on discussing the role of national defence, highlighting the urgency of energy transition considering the armed forces, as well as military operation adaptation in light of climate catastrophes.

Closing this first set of discussions, the topic of the Series' fourth and last webinar was "Defence and New Sustainable Technologies in the Aviation Sector." The following experts participated in the event: Andrew Sweeney, Strategy Leader in Sustainable Aviation for the Royal Air Force; Dr Amanda Duarte Gondim, Coordinator of the Brazilian Network of Biokerosene and Sustainable Hydrocarbons for Aviation (RBQAV); Dr José Luis Gonçalves de Almeida, Executive Manager of SENAI CIMATEC (the Integrated Manufacture and Technology Centre at the National Industrial Learning Service); and Dr Tiago Sousa Pereira, Director of the Brazilian National Civil Aviation Agency (ANAC). The moderation was performed by Dr Duncan Depledge, Principal Investigator in the NETZMIL Project and Senior Lecturer of Geopolitics and International Relations at Loughborough University.

This report summarises the webinar's discussions, which focused on decarbonisation and incorporating new sustainable technologies in the Aviation Industry. Part of the discussions, for instance, touched on the challenges of developing alternative fuels that emit less CO2 than traditional fossil fuels, technological innovations that increase efficiency in fuel consumption and reduce emissions, and aircraft that use less or no fossil fuels.

KEYWORDS
Sustainable Aviation Fuel; Aviation Sector; Innovation; Sustainability.

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WEBINAR REPORT

Defence and New Sustainable Technologies in the Aviation Sector

1. The Development of Alternatives to Fossil Fuels in Brazil

"Right now, unfortunately, Brazil does not yet have SAF (Sustainable Aviation Fuel) production. Some projects have been announced, even to begin the construction of biorefineries. Still, none of them is effectively up and running," stated Dr Amanda Gondim, Lecturer of Oil Chemistry at Rio Grande do Norte Federal University and Coordinator of the Laboratory for Primary Processing of Biofuels and Environmental Analyses.

Although Brazil does not yet produce SAF, Amanda stressed that decarbonisation is a priority for the government. According to her, the country has already advanced significantly in using renewable fuels, achieving the milestone of 50% renewable liquid fuels in the national energy matrix, surpassing many other countries. Additionally, in terms of prospects, there are promising projects for the construction of national biorefineries, and the country has an abundance of biomass due to its extensive territory and advanced agricultural development.

From her perspective, Brazil has great potential to advance in the use of technologies such as HEFA (Hydroprocessed Esters and Fatty Acids), which uses vegetable oils, and ATJ (Alcohol-to-Jet), which uses Brazil's abundant ethanol production. Apart from these attributes, the hydroelectric infrastructure and the expansion of wind and solar energy potentials show Brazil's capability to become a great producer of renewable energy.

However, Amanda emphasised that although the scenario is positive and offers plenty of opportunities for Brazil to grow and transform its energy matrix, the aviation and maritime sectors face significant challenges. This is mainly due to the high costs of replacing the existing infrastructure with technologies more suited to decarbonisation.

An analytical table is presented as follows, with the main topics addressed by Dr Amanda Gondim, such as the importance of an integrated and collaborative approach to face the challenges of sustainable aviation in Brazil. Among her proposals, technological and economic improvements and promoting policies and partnerships that drive the transition to renewable fuels in the aviation sector are particularly highlighted.

Table 1. Strategies and Challenges for Implementing Sustainable Technologies in Aviation.

CHALLENGES	APPROACHES	SOLUTIONS
Technological Maturity	**HEFA:** High TRL[1], need to reduce catalyst costs and use of local hydrogen. **ATJ:** Intermediate TRL (7-8), requires continuous investment in R&D.	**HEFA:** Improving economic efficiency through reduced costs and use of local hydrogen. **ATJ:** Increasing technological maturity and efficiency for commercial viability

1. Technology Readiness Levels (TRL) correspond to metrics that assess the maturity of a technology, ranging from TRL 1 (basic principles observed) up to TRL 9 (actual system proven in operation).

Economy of Scale	Production in small biorefineries is economically challenging, resulting in high costs.	**Scale of biorefineries:** Incentivising the construction of biorefineries on a larger scale plays a crucial role in reducing production costs and providing economic viability to biofuels and other derivatives. **Regionalised Development:** Using specific local resources to optimise biofuels production.
International Cooperation	Global norms are essential for interoperability and safety in the global aviation sector.	**International Partnerships:** Participating actively in international fora and coalitions to accelerate the harmonised development of sustainable norms and technologies.
Decarbonisation of Aviation	High energy density and long life cycle of aircraft pose significant challenges.	**Defence Actions:** Tests and research to implement SAF. **Logistics:** Studies to optimise operational and energy efficiency in aviation.
Brazilian Legislation	A mandatory model seeks to integrate biofuels into Brazil's energy matrix.	**Sustainable Legislative Strategy:** Approval of laws incentivising the industrialisation of SAF and other biofuels for the sustainable development of the energy sector and the reduction of carbon emissions.

In sum, Dr Amanda Gondim believes implementing sustainable technologies in the aviation sector requires coordinated action at the national level, especially with an approach for regionalised production of SAF in small biorefineries in Brazil. She argued that the production of biomass and other renewable energy sources in the country should consider regional vocations and available resources, promoting decentralisation of production to increase efficiency and competitiveness in the sector.

In this regard, Defence is responsible for testing and implementing the technologies necessary for decarbonisation. Gondim argued that Defence could accelerate the adoption of biofuels by promoting tests and contributing to the logistic efficiency of production. Still, it would face specific challenges concerning excessive costs and the need for adequate infrastructure. She stressed that the development of these technologies needs to align with long-term strategies, ensuring that Defence may contribute significantly to the energy transition.

Another point worthy of mention is coordination at an international level, through international cooperation and information sharing, to speed up progress and achieve the countries' decarbonisation objectives.

2. The Future of Aviation: Challenges, Approaches, and Solutions for a Sustainable Industry in Brazil

In the face of the growing demand for sustainable alternatives to implement energy transition, Dr José Luis Gonçalves de Almeida, Executive Director of Senai CIMATEC, argued in favour of a window of opportunity for developing an alternative market to fossil fuels in Brazilian aviation. As an expert in decarbonisation projects focusing on low-carbon hydrogen, Almeida argued that the industry is increasingly aware of the importance of investing in sustainable technologies and reducing greenhouse gas emissions and that this signifies a moment of transition and growth for the sector.

However, in addition to SAF production, there are challenges with repercussions in technical and financial issues associated not only with the production of alternative fuel but also with developing alternative technologies that must be associated with the sector's transformation. The manufacture of aircraft that are able to operate on SAF and the electrification of planes exemplify those issues. He also emphasised that international cooperation and the use of biomass are essential for the technological advances needed to transform the aviation industry.

Among the points José Luis highlighted were the challenges faced by the industry, the approaches adopted to overcome them, and the paths to face such challenges. The following table synthesises the main topics of his presentation.

Table 2: Moving Towards Sustainable Aviation: Obstacles, Strategies, and Paths to Decarbonisation

CHALLENGES	APPROACHES	SOLUTIONS
Reducing CO2 emissions from aviation	The urgent need to reduce aviation's environmental impact due to high emissions of CO2 and other pollutants.	Investment in technologies such as aircraft electrification, hydrogen for small and medium-sized aircraft, and SAF for large aircraft.
Technical and financial obstacles to SAF production	High production cost, need for large-scale production, and safe mixture with Jet A1, following the ASTM 4054 standard.	Continuous development of SAF based on vegetable oils and other renewable sources, use of existing infrastructure, and compliance with sustainability criteria.
Challenges in electrifying aircraft	Limited viability for different-sized aircraft, emphasising small sizes due to battery capacity and range limitations.	Focus on small aircraft electrification, use of hydrogen for medium-sized aircraft, and SAF for large aircraft.
Adapting conventional planes to new fuels	Aircraft in operation for many years have specifications that limit the reduction of aromatics and naphtenes.	Improving the composition of Jet A1, increasing SAF concentration, and exploring international cooperation for technological development.
Need for international cooperation	Technological research and innovation are more efficient with global collaboration.	Fostering national and international partnerships to accelerate technological development and advances in alternative fuels.

In sum, Dr José Luis Gonçalves de Almeida proposed strategies to create a long-term plan for the Brazilian aviation industry. His recommendations range from national SAF production to investment in producing aircraft that operate on sustainable fuels. Although SAF is a drop-in technology, which means it can be used in aircraft originally designed to operate on fossil fuels without significant modifications to their infrastructure or engines, developing aircraft designed specifically for SAF use may further increase sustainability and competitiveness in future aviation. The development of new generations of aircraft optimised to use SAF by design would thus lead to increased energy efficiency and reduced emissions. Therefore, SAF use is not conditioned to a complete replacement of the existing fleet but to an expansion of production and the economic viability of fuel.

Lastly, the practical implementation of the measures suggested by Dr José Luis requires a combination of technological innovation and investment in research and development, government incentives, and regulatory policies, as well as encompassing cooperation between national and international actors to ensure aviation's transition to more sustainable fuels.

3. Prospects for ANAC: Challenges and Opportunities in the Implementation of Sustainable Technologies in Brazilian Aviation

According to Dr Tiago Sousa Pereira, Director of ANAC, Brazil's greatest challenge is reducing carbon emissions in the sector without compromising the popularity of air travel with increased costs. Tiago, who is currently the agency's acting President-Director, spoke about the challenges and opportunities ANAC faces to implement and certify new technologies, as well as about Brazil's participation in international regulatory agencies such as the Internacional Civil Aviation Organisation (ICAO), where the country works actively in certifying fuels and defining decarbonisation targets.

He emphasised that accelerating the approval of sustainable practices and processes requires international cooperation and the participation of experts from industry and academia in the discussions. According to him, ANAC's main concern is ensuring equitable decarbonisation targets reflect environmental problems in Brazil and South America. Tiago concluded by highlighting the role of the defence sector as an incubator for new technologies that can later be transferred to the civilian sector, helping popularise and reduce costs for renewable energy technologies in aviation. The following table sets out the main topics in Tiago's contribution:

Table 3. Sustainable Initiatives in Aviation: Challenges and Prospects for ANAC

CHALLENGES	APPROACHES	SOLUTIONS
Sustainability in aviation	Balancing the need for energy transition in aviation with no increased costs for final customers.	Implementing mechanisms to use sustainable technologies without significant increases in costs for the sector.
Technical and regulatory challenges	Developing technologies have still not achieved the necessary scale and have not been fully approved.	Collaborating with experts to speed up certification processes and develop regulations that meet local needs.
Regulatory incentives and mechanisms	Need for mechanisms that stimulate the decarbonisation of aviation in the short, medium, and long term.	Implementing the Carbon Offsetting and Reduction Scheme for International Aviation for carbon offsetting, reducing emissions through SAF use, and promoting financing through BNDES and international initiatives such as ICAO's Finvest Hub.

In sum, Tiago outlined the complex task ANAC faces in integrating new sustainable technologies into Brazilian aviation. He emphasised the need to make air transport more accessible and sustainable, especially considering Brazil's economic and geographic specificities. By actively participating in international discussions at ICAO and seeking close cooperation between academia, the energy industry, and defence, ANAC is working to speed up the certification and implementation of sustainable aviation fuels. Additionally, Tiago highlighted the importance of regulatory mechanisms and financial incentives, both on the national and international levels, to foster SAF development and production, promoting the sector's decarbonisation without compromising its expansion and accessibility.

4. Leading the Future of Aviation in the UK: The RAF's Sustainable Strategy for 2040

Andrew Sweeney, former Squadron Leader at the UK's RAF, presented an encompassing view of how the Royal Air Force (RAF) is addressing sustainability while maintaining its operational efficiency. He highlighted the ambitious target of achieving carbon neutrality by 2040, a decade before the UK government's 2050 target. As a result of this advancement, the RAF, in collaboration with civilian, academic, and industrial partners, was able to influence policy and technology development. Thus, the five pillars of RAF's strategy were rethinking the provision of capabilities, increasing operational efficiency, switching to sustainable fuels, exploring zero-carbon propulsion, and combating emissions of greenhouse gases other than CO2.

Andrew also emphasised the significant challenges faced by the UK, such as the need to increase SAF production and the importance of an international collaborative approach to avoid harmful behaviour and ensure energy security. As a sure purchaser of SAF, RAF gave investors confidence to increase production. He highlighted the need to diversify energy stocks and global collaboration to handle operational and climate problems. The RAF's target for 2040 is to lead and accelerate the energy transition in the civilian and military aviation sectors. The following table presents the main topics discussed by Andrew:

Table 4. RAF's Strategies for Sustainability and Operational Effectiveness

CHALLENGES	APPROACHES	SOLUTIONS
Maintaining Operational Effectiveness	The need to maintain operational efficiency while reducing emissions, without compromising defence capabilities.	Implementing emerging technologies, such as synthetic training, fleet renewal, and retrofitting existing aircraft.

Energy Transition	Dependence on global supply chains and the need to transition to SAF.	Partnerships for SAF research and integration, exploration of zero-carbon propulsion, and studies on the impact of non-CO2 emissions.
SAF Production Capacity	Despite technological advances and growing interest, SAF production capacity is insufficient.	Using RAF as a guaranteed purchaser increases investor confidence and stimulates the SAF production capacity.
International Cooperation	Need for alignment and cooperation between countries and air forces to avoid behaviours that undermine sustainability efforts.	Establishment of global collaboration initiatives such as the Global Air Force Climate Change Collaboration to share knowledge and strategies.

In sum, Andrew Sweeney presented a vision transcending a mere adequation to the decarbonisation targets already established by the UK government, thus proposing an ambitious strategy to face climate challenges in the defence sector, which serves as an example of how military aviation can be a protagonist in the energy transition. His discourse reveals a scenario in which — even in the face of significant obstacles, such as limited SAF production capacity and dependence on emerging technologies — the RAF has been able to plot a possible and pragmatic path towards sustainability. Sweeny's contribution also describes a future in which decarbonisation is not only viable but also essential to ensure competitiveness and global security, suggesting that even the most challenging sectors can make substantial advances towards decarbonisation.

5. Opportunities and Recommendations for the Brazilian Aviation Sector

Implementing sustainable technologies in Brazilian aviation requires an integrated approach that includes developing alternative fuels, using renewable resources, and international cooperation. First, it is worth considering that Brazil can be a leader in SAF exports; however, there is a long way to go to exploit that potential. For this, it is necessary to consider biorefinery projects, the availability of biomass, and the existing energy infrastructure. Strategic partnerships and continuous investment are essential to overcome the economic and technological challenges, allowing aviation to advance sustainably without compromising operational efficiency or significantly increasing consumer costs.

Thus, some points might be considered for the sector's advances:

Table 6. Opportunities and Strategic Actions for Brazil

OPPORTUNITIES	DESCRIPTION	IMPLEMENTATION
Investment in Technologies (Aircraft Electrification, Hydrogen, and SAF)	With increased pressure on the aviation industry to reduce its carbon emissions and adopt more sustainable practices, alternatives arise focused on three main areas: aircraft electrification, specific to small-sized aircraft; hydrogen, ideal for medium-sized aircraft; and sustainable aviation fuels (SAF), more adequate for large aircraft. These existing technologies are a path for the transition into a more ecological aviation.	**1. Aircraft Electrification:** Stimulating research into high energy density batteries, promoting pilot projects, and supporting start-ups focused on electric propulsion technologies. Establishing centres for testing and certifying new technologies. **2. Hydrogen for Medium-Sized Aircraft:** Although hydrogen has the potential to reduce emissions, in addition to high energy density, it faces significant restrictions in the aviation sector, especially in complex operational contexts, such as defence aviation. Besides logistics challenges, such as the impossibility of aerial refuelling, hydrogen poses a safety risk due to its volatile nature in diverse operational conditions. Considering this, the recommendation would be to focus on research to overcome such barriers, seeking to develop safe technologies for storage and distribution in specific situations. Additionally, it would be essential to implement pilot programmes that explored the use of hydrogen in more controlled conditions, less susceptible to operational risks, such as regional routes, before large-scale adoption. **3. SAF for Large Aircraft:** Supporting the development of sustainable aviation fuels using renewable raw materials. For this, it is recommended that subsidies be provided for constructing SAF production plants, tax incentives for companies using SAF, and clear rules for mixing and using SAF.

Development of biofuels in scale	To produce biofuels with high Technological Readiness Levels (TRL), it is necessary to consider a combination of technological, economic, and operational strategies. Strategic partnerships with universities, research centres, and the private sector as well as continuous government support through public policies and economic incentives, are crucial. These actions may help reduce costs and promote biofuels' commercial viability such as HEFA and ATJ in Brazil.	**1. Local Research and Development:** Investing in R&D in Brazilian universities and research centres to develop cheaper and more efficient catalysts. Brazil has a strong academia and many renowned universities that can contribute significantly. Additionally, using the capabilities of research centres such as Embrapa to develop ATJ technologies. **2. Hydrogen Production with Renewable Energies:** (a) Using Brazil's potential for renewable energies, such as solar and wind power, for local green hydrogen production. Brazil has a significant capacity for producing clean energy that can be used for water electrolysis. (b) Synergy with the Biogas Industry, integrating hydrogen production with the growing biogas industry in Brazil, using agricultural and urban waste. **3. Optimisation of Production Processes:** Using the experience of Brazil's biofuels sector (like ethanol) to optimise HEFA production processes. **4. Improvement of economic efficiency:** (a) Increasing production capacity to make use of economies of scale, similarly to what has been done with ethanol in Brazil. (b) Government Incentives: Using Brazilian government incentive programmes and subsidies, such as RenovaBio, to reduce operational and capital costs. (c) Financing Programmes: Using public and private financing programmes to invest in expansion and modernisation of production.
Regionalised Development of Biorefineries	One way to reduce the operational cost of these elements is to drive the use of biofuels and their production in a decentralised manner, benefitting from the specificities and resources of each region, thus promoting economic and environmental sustainability.	**1. Regional development:** Stimulating local economic development with regional resources, creating opportunities for rural communities and strengthening the local economy. **2. Agricultural sustainability:** Minimising the carbon footprint by reducing dependence on fossil fuels and incentivising sustainable agricultural practices in biofuel production. **3. Improved logistics:** Reduces costs and the carbon footprint associated with transporting fuels, promoting production closer to consumer centres.
Increase in technological maturity through the Defence Industry	Using the defence sector as an incubator to test and validate new sustainable energy technologies that could scale up to the civilian sector.	**1. Viability Planning and Analysis:** Defining the project's objectives, necessary resources, schedule, and budget. **2. Developing Partnerships:** Forming consortia with universities, research centres, biotechnology companies, and government agencies. **3. Research and Development:** Investing in R&D projects to develop HEFA and ATJ technologies. **4. Pilot Tests:** Implementing pilot tests in military units, monitoring performance and collecting data for validation. **5. Scaling:** Transferring validated technologies to the civilian sector, promoting large-scale adoption of advanced biofuels.
Adaptation of conventional aircraft to new fuels	Adapting the existing infrastructure to advanced aviation biofuels requires a coordinated approach that includes technical assessment, modification of equipment, capacity-building, and logistical improvements.	**1. Aircraft:** Technical assessment to ensure compatibility with aircraft systems for using advanced biofuels. **2. Compatibility Analysis:** Performing a detailed analysis of the compatibility of biofuels with the technical specifications of existing aircraft. This includes assessing the effects of biofuels on engine performance, maintenance, and component service life. **3. Engine Modification:** Implementing engine modifications, if necessary, to ensure they can operate with mixtures richer in SAF. This may include adjustments to combustion systems, fuel injection, and thermal management. **4. Certification and Homologation:** Working with civil aviation authorities (such as ANAC) to certify and homologate aircraft modifications and use of advanced biofuels.
International Cooperation	Technological research and innovations are more efficient with global collaboration.	Fostering international partnerships to accelerate technological development and advances in alternative fuels. Making use of Brazil's potential for SAF production.

6. Conclusion

As the transformation of aviation becomes an unquestionable reality to maintain operational capability in civil and military aviation, it is evident that the path ahead is both challenging and promising. This duality presents itself as a great window of opportunity for Brazil; however, this demands significant effort in aligning strategic planning, the necessary innovations, and the existing potential in the country.

To that end, this report presents a comprehensive view of challenges and prospects for the decarbonisation of aviation, as discussed during the webinar "Defence and New Sustainable Technologies in the Aviation Sector." Each expert addressed not only the seriousness of the problem but also the different paths for development and collaboration necessary to consider a strategic plan for Brazilian aviation.

It is imperative to emphasise that there is no single path; thus, the solution to this problem is not limited to investing in the defence industry and focusing on a single area. Aircraft electrification with alternative fuels and hydrogen comprise viable solutions. However, the transition demands that governments, industry, academia, and international organisations collaborate with one another. To overcome technical and financial challenges, accelerate the certification of new technologies, and ensure safety and interoperability in the sector, different fronts must undertake a joint approach.

Another factor worthy of mention is that, despite the recognition that Defence can act as an important testing ground for emerging technologies, facilitating their transfer to the civilian sector, this dynamic has been changing in the last few years. Historically, there have been moments when Defence has led technological innovation, with the civilian sector trailing behind. However, currently — and especially in the development of green technologies — this is no longer the observed trend, be it in Brazil or other parts of the world. Thus, with a larger-scale production capacity and access to resources, the civilian sector has been leading this movement. The role of Defence, although still relevant, is a supportive role in the process of experimentation of these new developing technologies, and in ensuring that specific defence operational requirements are taken into account. In the Brazilian context, although defence is an important part of the research and development ecosystem, protagonism in green innovation has been led by the civilian sector, with a collaborative and integrated approach between both proving essential.

Lastly, it is imperative to highlight that Brazil's abundance of biomass places it as a potential leader in SAF production. The establishment of biorefineries and a regionalised approach to the production of biofuels are strategic actions that may place the country at the centre of sustainable aviation. Such a scenario might forge a future in which Brazilian aviation not only connects worlds but may also drive a new era of technological efficiency and socio-environmental accountability.

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