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Evolving International Organisations and Fragmentation of International Law: Through the Lens of the ICAO's Emissions Regulation Practices

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Abstract:
This article explores the evolving competence of the International Civil Aviation Organization (ICAO), with particular focus on the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). It specifically addresses the fragmentation of environmental regulation within international air law, as exemplified by regional initiatives such as the European Union (EU) Emissions Trading System (ETS). Despite extensive policy and academic discourse on the regulatory relationship between these two mechanisms, there remains a significant gap in research concerning the implications of regulatory fragmentation and the growing role of ICAO. By analysing these two interconnected developments within the framework of international air law, this article argues that States can enhance global institutional cooperation to address the tensions between the EU ETS and CORSIA. Potential responses include the establishment of coordination mechanisms between ICAO and regional organisations. The conclusions may contribute to a reassessment of ICAO's role in the evolving landscape of international air law.

1. Introduction

1.1. Fragmentation of International Law

The fragmentation of international law poses a challenge to the coherence and effectiveness of the global legal order.[1] The United Nations International Law Commission (ILC) has addressed this issue, recognising fragmentation's dual nature.[2] While fragmentation carries the risk of conflicting and incompatible rules, principles, and institutional practices, it also reflects the expansion of international legal activities aimed at addressing emerging global challenges.[3] As the ILC has noted, legal fragmentation is 'an ephemeral reflection of a more fundamental, multi-dimensional fragmentation of global society itself'.[4]

Multiple factors have contributed to the fragmentation of international law. Firstly, the rapid globalisation has necessitated specialised regulatory responses to complex problems such as climate change, biodiversity loss, and aviation emissions.[5] Secondly, divergent State interests have led individual States to pursue their objectives through forums most aligned with their positions, thereby exacerbating the fragmentation of governance frameworks. Thirdly, the structure of international governance enables the formation of autonomous treaty regimes, each with its own organised framework.[6]

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1 Matthew Craven, 'Unity, Diversity and the Fragmentation of International Law' (2003) 14 FYBIL 5.
2 ILC, 'Fragmentation of international law: Difficulties arising from the diversification and expansion of international law' (UN Doc A/CN.4/L.682, 2006).
3 *Ibid.*
4 Aleksandar Dedinec et al., 'Towards post-2020 climate change regime: Analyses of various mitigation scenarios and contributions for Macedonia' (2016) 94 Energy 124; see also Bruno Simma and Pulkowski Dirk, 'Of planets and the universe: Self-contained regimes in international law' (2006) 17(3) EJIL 503.
5 Maryna Medvedieva et al., 'Fragmentation and Synergies in International Climate Change Regime' (2018) 21 J Legal Ethical & Regul Isses 1.
6 Karen Scott, 'International Environmental Governance: Managing Fragmentation through Institutional Connection' (2011) 12 Melb J Int'l L 177.

1.2. The Case of International Air Law and the Structure of this Article

The imperative to mitigate global climate change has brought increased attention to the environmental impacts of international civil aviation. As a rapidly expanding sector and a notable source of greenhouse gas (GHG) emissions, aviation requires robust international regulation.[7] In response to evolving global norms, advancing scientific knowledge, and legal mandates such as Article 2(2) of the Kyoto Protocol, ICAO has progressively expanded its environmental mandate, culminating in the adoption of CORSIA – a global market-based measure intended to achieve carbon-neutral growth.[8]

Alongside ICAO's multilateral efforts, influential regional actors – most notably the EU – have introduced their own, often more ambitious, regulatory measures, such as the inclusion of aviation in the EU ETS.[9] While such regional initiatives may promote innovation and higher environmental standards, their coexistence with ICAO's global framework illustrates the broader phenomenon of the fragmentation of international law.[10]

Fragmentation in the context of international aviation emissions involves several interrelated dimensions. The vertical dimension refers to potential conflicts between universal and regional legal rules, especially when regional approaches exempt States from general principles or impose obligations on those that have not consented.[11] This tension between regional and global regulatory approaches is exemplified by the relationship between the EU ETS and the ICAO CORSIA in the regulation of aviation emissions.[12] The horizontal dimension refers to the development of 'self-contained regimes', such as trade law, environmental law, human rights law, and climate change law, each functioning with relative autonomy and distinct institutional frameworks.[13] This dimension underscores the complexity of aligning international aviation with environmental regulation and points to a range of associated legal challenges.

Several key questions emerge: how can ICAO's evolving role as an international organisation facilitate cooperation among States in addressing contemporary challenges and mitigating the negative impacts of fragmented international law? What are the legitimate limits to the expansion of international organisations' mandates? Which mechanisms can effectively manage the resulting tensions between global efforts and regional regulatory autonomy? This article addresses these questions by first examining ICAO's role in environmental regulation in Section 2, outlining its evolution from a safety-orientated organisation to one engaged in emissions regulation through CORSIA. Section 3 analyses the

7 ICAO, 'ICAO Environmental Report 2010. Aviation and Climate Change' <https://www.icao.int/icao/en/env2010/environmentreport 2010.pdf> accessed 11 July 2025.

8 Annex 16 to the Convention on International Civil Aviation: Environmental Protection, Volume IV – CORSIA (2nd edn ICAO 2023).

9 Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community (hereinafter Directive 2008/101/EC).

10 In fact, examples of dynamic evolution of emission regulation in the context of international aviation are not limited to the EU ETS. Since 1 July 2025, the Swedish government has abolished its aviation tax since it was a drag on Swedish economic competitiveness while making no positive environmental impact. See IATA, 'IATA Welcomes Abolition of Swedish Aviation Tax' <https://www.iata.org/en/pressroom/2024-releases/2024-09-03-02/> accessed 11 July 2025. In addition, the International Air Transport Association (IATA) has launched the Sustainable Aviation Fuel (SAF) Registry to enable a global market for SAF that will accelerate the transition to net zero emissions by 2050. See IATA, 'SAF Registry Goes Live' <https://www.iata.org/en/pressroom/2025-releases/2025-04-03-01/> accessed 11 July 2025. In the context of regulating aviation emissions, therefore, different industrial stakeholders have been making efforts to explore the way forward. Though this can help identify the feasible ways for an economically-sustainable regulatory framework, it leads to fragmentation of aviation emissions regulation, which can negatively impact the civil aviation industry as a global and transnational industry.

11 *See* International Law Commission, *supra* note 2.

12 Fragmentation by its very nature arises from the tension between the EU's climate ambitions and the slower multilateral progress within ICAO. The design of CORSIA reflects compromises necessary to achieve broad international participation, resulting in a less stringent baseline and reliance on offsetting, which the EU considers potentially insufficient. Therefore, the EU's decision to include aviation in its ETS exemplified how regional actors may pursue expeditious approaches when multilateral processes are perceived as inadequate to address urgent environmental challenges.
Janina Scheelhaase et al., 'EU ETS Versus CORSIA – A Critical Assessment of Two Approaches to Limit Air Transport's CO_2 Emissions by Market-based Measures' (2018) 67 JATM 55 and 58.

13 Sébastien Duyck, 'Promoting the principles of the Aarhus convention in international forums: The case of the UN climate change regime' (2015) 24(2) RECIEL 123; *see also* Farhana Yamin and Joanna Depledge, *The international climate change regime: A guide to rules, institutions and procedures* (CUP 2004).

fragmentation of international air law, with a focus on the EU ETS as a regional initiative and its interaction with CORSIA. Section 4 investigates the tension between ICAO's expanding competence and legal fragmentation, and proposes coordination mechanisms to reduce this fragmentation. The article concludes by offering insights into how global governance objectives can be balanced with regional regulatory initiatives in the field of international aviation emissions.

2. The Role of ICAO in Environmental Regulation

2.1. The Mandate of ICAO: The Chicago Convention (1944) as the Starting Point

The Convention on International Civil Aviation (Chicago Convention (1944)) was established in recognition of the need for a coordinated approach to civil aviation in the post-war world, aiming to 'create and preserve friendship and understanding among the nations and peoples of the world'.[14] This landmark agreement set out the foundational principles for international air services and led to the establishment of the specialised agency responsible for its implementation, namely ICAO.[15] The preamble of the Chicago Convention (1944) explicitly highlights the objective of developing international civil aviation 'in a safe and orderly manner',[16] a principle further reinforced by Article 44, which outlines ICAO's primary aims and objectives. Article 44 mandates that ICAO shall 'insure the safe and orderly growth of international civil aviation throughout the world', 'meet the needs of the peoples of the world for safe, regular, efficient, and economical air transport', and 'promote safety of flight in international air navigation'.[17] ICAO's focus is aviation safety, although its broader mandate also includes the planning and development of international air transport.

The promotion of aviation safety has primarily been achieved through the development and continual revision of a comprehensive set of international Standards and Recommended Practices (SARPs), as outlined in the Annexes to the Convention. Article 37 of the Chicago Convention (1944) obliges each Contracting State to:

> 'collaborate in securing the highest practicable degree of uniformity in regulations, standards, procedures, and organisation in relation to aircraft, personnel, airways, and auxiliary services in all matters in which such uniformity will facilitate and improve air navigation'.[18]

To achieve this uniformity, ICAO has developed approximately 12,000 SARPs, organised into 19 Annexes and six Procedures for Air Navigation (PANS) to the Convention.[19]

ICAO's safety mandate has evolved considerably since its establishment. Initially centred on rebuilding international civil aviation after the Second World War,[20] ICAO's approach to safety has since become more proactive and comprehensive. Although standard-setting remains central to ICAO's safety role, the organisation has complemented this with monitoring and strategic planning mechanisms. In the 1990s, ICAO introduced the Universal Safety Oversight Audit Programme (USOAP) to systematically assess Member States' compliance with safety standards. This audit system has since evolved from a voluntary initiative into a mandatory, comprehensive evaluation covering all safety-related Annexes, substantially improving transparency and accountability in global aviation safety oversight.[21] The Global Aviation Safety Plan (GASP)

14 The Convention on International Civil Aviation (adopted 7 December 1944) (hereinafter Chicago Convention (1944)), preamble.
15 Chicago Convention (1944), *supra* note 14, art. 43.
16 *Ibid*, preamble.
17 *Ibid*, art. 44(a), (d), and (h).
18 *Ibid*, art. 37.
19 ICAO, 'How ICAO Develops Standards' <https://www.icao.int/about-icao/AirNavigationCommission/Pages/how-icao-develops-standards.aspx> accessed 11 July 2025.
20 Adrianus D. Groenewege, *Compendium of International Civil Aviation (2nd edn)* (IADC 1998/1999)
21 ICAO, 'The Universal Safety Oversight Audit Programme (USOAP) continuous monitoring approach' (2010) Resolution A37-5 (hereinafter ICAO Resolution A37-5); *see also* ICAO, 'Application of a continuous monitoring approach for the ICAO Universal Safety Oversight Audit Programme (USOAP) beyond 2010' (2007) Resolution A36-4 (hereinafter ICAO Resolution A36-4); *see also* ICAO, 'Transition to a comprehensive systems approach for audits in the ICAO Universal Safety Oversight Audit Programme (USOAP)' (2004) Resolution A35-6 (hereinafter ICAO Resolution

further exemplifies this evolution, offering a strategic framework for the continuous enhancement of aviation safety worldwide.[22]

2.2. Aviation Emissions and the Kyoto Protocol

The environmental impact of international aviation has grown increasingly significant as the sector has expanded. Numerous studies have identified international aviation as a major contributor to global GHG emissions. Research cited by the Intergovernmental Panel on Climate Change (IPCC) estimated that international aviation accounted for roughly 2% of global CO_2 emissions in 1992, with projected annual growth of about 3% between 1990 and 2015.[23] Without intervention, the environmental impact of international aviation was expected to increase by at least 1-2% annually.[24] This trajectory stands in stark contrast to the progress achieved by many other sectors in reducing their environmental footprint.[25]

The issue of how to address GHG emissions from international transport has remained contentious within the United Nations Framework Convention on Climate Change (UNFCCC) process for decades. In 1996, the Subsidiary Body for Scientific and Technological Advice (SBSTA) of the UNFCCC identified five options to serve as a basis for further work on allocation methodologies.[26] However, progress was impeded by political considerations. States facing substantial emissions from bunker fuels under the proposed methodologies viewed themselves as disadvantaged in achieving broader GHG mitigation efforts.[27] This political impasse on the allocation issue necessitated an alternative approach.

A compromise was reached through Article 2(2) of the Kyoto Protocol,[28] which mandates industrialised States to 'pursue limitation or reduction of emissions of GHGs not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organisation and the International Maritime Organisation, respectively'.[29] This provision effectively delegated responsibility for international aviation emissions to ICAO and for international shipping emissions to the International Maritime Organization (IMO).

In response to its expanded environmental mandate, ICAO established formal cooperation with the IPCC and the UNFCCC, and provided technical assistance to the SBSTA on methodologies for collecting and reporting GHG emissions at the national level.[30] ICAO has pursued a multi-faceted approach to addressing aviation emissions. This approach includes technological innovations, operational improvements, and market-based mechanisms. Operational measures – outlined in ICAO Circular 303 – focus on air traffic management to enhance fuel efficiency and reduce unnecessary fuel

A35-6); *see also* ICAO, 'Establishment of an ICAO universal safety oversight audit programme' (1998) Resolution A32-11 (hereinafter ICAO Resolution A32-11); *see also* ICAO, 'Continuation and expansion of the ICAO Universal Safety Oversight Audit Programme' (2001) Resolution A33-8 (hereinafter ICAO Resolution A33-8); *see also* ICAO, 'Resolving deficiencies identified by the Universal Safety Oversight Audit Programme and encouraging quality assurance for technical cooperation projects' (2001) Resolution A33-9 (hereinafter ICAO Resolution A33-9); *see also* ICAO, 'Report of the DGCA Conference on a Global Strategy for Safety Oversight' Doc 9707; *see also* ICAO, 'Oversight Audit Manual' Doc 9735; *see also* ICAO, 'Safety Oversight Manual' Doc 9734.

22 ICAO, 'Non-disclosure of certain accident and incident records' (2010) Resolution A37-2 (hereinafter ICAO Resolution A37-2); see also ICAO, 'Protecting information from safety data collection and processing systems in order to improve aviation safety' (2010) Resolution A37-3 (hereinafter ICAO Resolution A37-3); see also ICAO, 'ICAO Global Aviation Safety Plan (GASP)' (2001) Resolution A33-16 (hereinafter ICAO Resolution A33-16).

23 IPCC, *Aviation and the Global Atmosphere: A Special Report of IPCC Working Groups I and III* (CUP 1999).

24 IMO, *Study of Greenhouse Gas Emissions from Ships* (2000); *see also* WBGU, *Charging the Use of Global Commons* (Policy Paper 2, 2002); *see also* UNFCCC, 'Emissions resulting from fuel used for international transportation: activities of IMO on prevention of air pollution from ships' (Information by the IMO Secretariat, SBSTA 16, 2002).

25 Victoria William, Robert B. Noland and Ralf Toumi, 'Air transport cruise altitude restrictions to minimize contrail formation' (2003) 3(3) Climate Policy 207.

26 Sebastian Oberthür and Hermann E. Ott, *The Kyoto Protocol. International Climate Policy for the 21st Century* (Springer 1999) 111–112; *see also* Sven Bode et al., 'Climate policy: analysis of ecological technical and economic implications for international maritime transport' (2002) 4 Int. J. Mar. Econ 170–173.

27 *See* Oberthür and Ott, *supra* note 26, 111–113.

28 Kyoto Protocol to the United Nations Framework Convention on Climate Change (adopted 11 December 1997) (hereinafter Kyoto Protocol).

29 Kyoto Protocol, *supra* note 28, art. 2(2).

30 ICAO, 'ICAO Engine Exhaust Emissions Data Bank' Doc 9646.

consumption.[31] These technical and operational approaches build upon ICAO's established expertise in international standard-setting.

A key milestone in ICAO's expanding environmental mandate was reached during the 37th Session of the ICAO Assembly in 2010. The Assembly adopted a resolution setting global aspirational goals for international aviation: an average annual fuel efficiency improvement of 2% until 2020 and a continued target of 2% per annum from 2021 to 2050, based on fuel consumption per revenue tonne kilometre performed.[32] This resolution marked the first major decision on aviation emissions since the conclusion of the Kyoto Protocol. It was reaffirmed at the 38th Session of the ICAO Assembly in 2013,[33] underscoring ICAO's ongoing commitment to its environmental responsibilities.

The evolution of ICAO's environmental mandate illustrates the capacity of international institutions to adapt to emerging global challenges while preserving their foundational roles. It further illustrates how specialised technical agencies can support efforts to address issues like climate change, complementing the broader environmental governance frameworks.

2.3. CORSIA: A Promising Future?

The aviation sector is poised for further exponential growth, indicating that air travel demand could double by 2040.[34] This anticipated expansion heightens the urgency of addressing the environmental impacts linked to the sector's continued development. CORSIA constitutes a landmark initiative aimed at mitigating the environmental impact of the aviation sector's rapid growth. It was formally introduced at the 39th Session ICAO Assembly in 2016,[35] as a global market-based measure intended to complement ICAO's broader 'basket of measures' for environmental protection.[36] CORSIA and its associated SARPs were subsequently codified as Annex 16, Volume IV to the Chicago Convention (1944),[37] following the earlier volumes addressing aircraft noise (Volume I), engine emissions affecting local air quality (Volume II), and CO_2 standards (Volume III).

CORSIA is a comprehensive framework comprising a series of interrelated documents. Its foundational structure is set out in Assembly Resolution A41-22. Detailed implementation procedures are outlined in Annex 16, Volume IV to the Convention and in the accompanying Environmental Technical Manual (ETM), Volume IV, specifically titled 'Procedures for demonstrating compliance with the Carbon Offsetting and Reduction Scheme for International Aviation'. To support the practical application of Annex 16, Volume IV, and define specific procedural and operational elements, ICAO has also approved and published 14 supplementary documents.[38]

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31 ICAO, 'Operational Opportunities to Minimize Fuel Use and Reduce Emissions' Doc 10013; *see also* ICAO, 'Consolidated statement of continuing ICAO policies and practices related to environmental protection' (2004) Resolution A35-5 (hereinafter ICAO Resolution A35-5), Appendix H, Operating Clause 2(d).

32 ICAO, 'Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change' (2010) Resolution A37-19 (hereinafter ICAO Resolution A37-19), paras 4-6.

33 ICAO, 'Consolidated statement of continuing ICAO policies and practices related to environmental protection – Climate change' (2013) Resolution A38-18 (hereinafter ICAO Resolution A38-18), paras 5-7.

34 IATA, 'Global Outlook for Air Transport – June 2023' <https://www.iata.org/en/iata-repository/publications/economic-reports/global-outlook-for-air-transport----june-2023/> accessed 11 July 2025.

35 Uwe M. Erling, 'International Aviation Emissions Under International Civil Aviation Organization's Global Market Based Measure: Ready for Offsetting?' (2017) 42(1) ASL 6; *see also* Ruwantissa Abeyratne, 'Climate Justice and COP21 – The Aviation Perspective' (2016) 65(2) ZLW 192; *see also* Francesco Gaspari, 'Aviation and Environmental Protection after the 2015 Paris Agreement: From Regulatory Unilateralism Toward International Cooperation' (2016) 15(2) Issues in Aviation Law and Policy.

36 ICAO, 'ICAO Submission to SBSTA50' <https://www.icao.int/environmental-protection/Documents/SBSTA50%20ICAO%20submission_Final.pdf> accessed 11 July 2025.

37 *See* ICAO, Annex 16 Volume IV, *supra* note 8.

38 ICAO, 'Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)' <https://www.icao.int/environmental-protection/CORSIA/pages/default.aspx.> accessed 11 July 2025.

The primary objective of CORSIA is to achieve carbon-neutral growth in international aviation from 2020 onwards.[39] This is pursued through a mechanism requiring aircraft operators to offset any emissions exceeding a baseline level by purchasing and cancelling emissions units from the global carbon market.[40] These units correspond to certified emissions reductions achieved in other sectors or regions, thereby creating financial incentives for aviation stakeholders to reduce their environmental impact while enabling continued industry growth.[41]

CORSIA should be implemented through a phased approach. The pilot phase spans from 2021 to 2023, followed by the first phase from 2024 to 2026 – both operating on a voluntary basis with 125 Member States participating as of 2023,[42] including 18 of the top 20 emitting States. Participating States include European States, the United States, Canada, China, Japan, Singapore, Mexico, Australia, New Zealand, and Turkey, reflecting broad international commitment to the programme. The second phase, commencing in 2027 and running though 2035, mandates participation for all eligible States.[43] States are exempt if their individual share of international aviation activity in Revenue Tonne Kilometres (RTKs) is below 0.5% of the global total in 2018 or if they are not among the group of States collectively responsible for 90% of total RTKs.[44]

The scope of the scheme is expressly limited to international flights, excluding domestic aviation, humanitarian operations, medical evacuations, firefighting activities, military flights, and operations involving aircraft with a maximum certificated take-off mass of 5,700 kg or less.[45] This targeted approach reflects practical constraints and the jurisdictional complexities inherent in regulating international aviation.

A core component of CORSIA is its Monitoring, Reporting, and Verification (MRV) framework, which became operational on January 1, 2019. Under this framework, operators are required to monitor and report emissions from eligible international routes. Member States are responsible for compiling and submitting the data to ICAO, which then calculates the corresponding offsetting obligations.[46]

The COVID-19 pandemic necessitated substantial adjustments to the design features of CORSIA. The scheme originally intended to use the average emissions from 2019 and 2020 as its baseline.[47] However, the unprecedented decline in aviation activity in 2020 would have resulted in an artificially low baseline, thereby inflating future offsetting obligations as the industry recovered. In response to this exceptional situation, the ICAO Assembly adopted Resolution A41-22,[48] setting 2019 emissions as the baseline for the pilot phase and 85% of 2019 emissions for subsequent phases up to 2035.[49]

The governance of CORSIA includes a periodic review mechanism, under which the ICAO Council is mandated to assess

39 ICAO, 'Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection – Global Market-based Measure (MBM) Scheme' (2016) Resolution A39-3 (hereinafter ICAO Resolution A39-3), para 5.

40 *See* ICAO, Annex 16 Volume IV, *supra* note 8, pt. II ch. 4 s. 4.2.2; *see also* ICAO, 'CORSIA Emissions Unit Eligibility Criteria' <https://www.icao.int/environmental protection/CORSIA/Documents/ICAO_Document_09.pdf> accessed 11 July 2025.

41 ICAO Environment, Air Transport Bureau, 'An introduction to market-based measures (MBMs)' <https://www.icao.int/Meetings/EnvironmentalWorkshops/Documents/2015-Warsaw/6_1_An-introduction-to-market-based-measures-MBMs.pdf> accessed 11 July 2025.

42 ICAO, 'CORSIA FAQs – December 2022' <https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_FAQs_Dec 2022.pdf> accessed 11 July 2025.

43 ICAO Resolution A39-3, *supra* note 39; *see also* ICAO, Annex 16 Volume IV, *supra* note 8, App.1 s. 3.1.1.

44 *See* ICAO, Annex 16 Volume IV, *supra* note 8.

45 *See* ICAO, Annex 16 Volume IV, *supra* note 8; *see also* IATA, 'CORSIA Handbook' <https://www.iata.org/contentassets/fb745460050c48089597a3ef1b9fe7a8/corsia-handbook.pdf> accessed 11 July 2025.

46 *See* ICAO, *supra* note 36.

47 ICAO, 'Guidance for Verification Bodies on Remote Verification of CORSIA Emissions Reports' <https://www.icao.int/environmental-protection/CORSIA/Documents/Guidance%20remote%20verification%20(VBs).pdf> accessed 11 July 2025.

48 ICAO, 'Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection – Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)' (2022) Resolution A41-22 (hereinafter ICAO Resolution A41-22).

49 *See* ICAO, Annex 16 Volume IV, *supra* note 8.

the scheme's implementation every three years.[50] The first review, conducted in 2022, resulted in the aforementioned adjustment to the emissions baseline, with the next review scheduled for 2025. This adaptive approach ensures that CORSIA remains responsive to emerging challenges and evolving circumstances within the aviation sector.

3. Fragmented Environmental Regulation in International Aviation: The EU ETS

3.1. Defining the EU ETS

The EU ETS is among the EU's most significant and contested climate policy instruments, introduced to mitigate the increasing environmental impacts of civil aviation. Established in 2005 under Directive 2003/87/EC, the scheme initially applied to stationary installations in sectors including power generation, iron and steel production, oil refining, and cement manufacturing.[51] Aviation was included in the EU ETS due to the sector's rapid expansion and growing environmental footprint. Although aviation accounts for only approximately 3% of GHG emissions, it is the fastest-growing contributor to climate change. The sector has grown by 4.3% annually within the EU, with global projections estimating continued growth at approximately 5% per year.[52] Despite gains in aircraft fuel efficiency, these improvements have not offset overall industry growth,[53] leading to rising absolute emissions that risk undermining reductions achieved in other sectors.

The inclusion of aviation in the EU ETS also occurred against a backdrop of limited international progress under ICAO. Article 2(2) of the Kyoto Protocol explicitly mandates that aviation emissions should be addressed through ICAO.[54] However, ICAO's triennial meetings often resulted in few binding commitments to reduce emissions. In response to this regulatory gap and growing climate urgency, the EU adopted Directive 2008/101/EC, extending the EU ETS to cover aviation from 1 January 2012.[55]

The EU ETS functions as a 'cap-and-trade' system, setting gradually decreasing limits on GHG emissions while creating a market for tradable allowances.[56] For aviation, the initial cap in 2012 was set at 97% of the baseline emissions (calculated as the average of 2004-2006 emissions), decreasing to 95% for the period from 2013 to 2020.[57] Aircraft operators receive free carbon allowances based on a benchmarking system that incentivises efficiency. Of the total allowances, 82% are distributed for free, 15% are auctioned, and 3% are reserved for new entrants and rapidly growing airlines.[58] Operators exceeding their allocated allowances must purchase additional units on the carbon market or incur fines of €100 per tonne of CO_2 emitted. Enforcement measures may include operational bans.[59] Allowance prices are set at primary auctions according to supply and demand, with a minimum transaction size of approximately 500 tonnes of CO_2.[60]

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50 ICAO Resolution A41-22, supra note 48, para 9(g).

51 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC (hereinafter Directive 2003/87/EC); *see also* Decision 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

52 *See* ICAO, *supra* note 7.

53 Stefan Gossling and Paul Upham, 'Introduction: Aviation and Climate Change in Context' in Stefan Gossling and Paul Upham (eds), *Climate Change and Aviation: Issues, Challenges and Solutions* (Earthscan 2009) 1, 4.

54 Kyoto Protocol, *supra* note 28, art. 2(2).

55 Directive 2008/101/EC, *supra* note 9.

56 *Ibid*.

57 Jane A. Leggett, Bart Elias and Daniel T. Shedd, *Aviation and the European Union's Emission Trading Scheme* (CRS 2012); *see also* Linda Meleo, Consuelo R. Nava and Cesare Pozzi, 'Aviation and the costs of the european emission trading scheme: the case of Italy' (2016) 88 Energy Policy 138-147; *see also* Directive 2008/101/EC, *supra* note 9.

58 EC, 'Structural reform of the EU ETS' <http://ec.europa.eu/clima/policies/ets/reform/index_en.htm> accessed 11 July 2025; *see also* EC, 'Carbon Market Report 2017' <http://ec.europa.eu/clima/policies/strategies/progress/docs/com_2015_576_annex_1_en.pdf> accessed 11 July 2025.

59 Directive 2008/101/EC, *supra* note 9.

60 Rong-Gang Cong and Yi-Ming Wei, 'Experimental comparison of impact of auction format on carbon allowance market' (2012) 16(6) Renewable and Sustainable Energy Reviews 4148-4156; *see also* EC, 'Impact Assessment' <http://ec.europa.eu/clima/policies/transport/aviation/docs/swd_2013_430_en.pdf> accessed 11 July 2025.

The MRV is also a core element of the EU ETS, designed to ensure transparency and regulatory compliance. To simplify administration, each aircraft operator is overseen by a single EU Member State, designated as the competent authority, usually either the State that issued the operator's licence or the one associated with the highest emissions during the base period.[61]

To reduce compliance costs and enhance flexibility, the EU ETS allows operators to bank unused allowances, borrow against future allocations, and trade allowances with one another. The scheme also permits limited use of international offset credits via the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JI).[62] This market-based mechanism incentivises emissions reductions through operational and technological improvements, particularly when allowance prices are high enough to influence behaviour.

The EU currently utilises several policy instruments to address aviation-related emissions. In addition to the EU ETS, several Member States impose taxes on aviation activities. Although not directly linked to fuel consumption, these taxes aim to reduce flight frequency and prompt a modal shift towards less carbon-intensive transport modes, such as rail.[63] The EU has also introduced Sustainable Aviation Fuel (SAF) blending mandates, obliging airlines to use a defined proportion of lower-carbon on intra-EU flights.[64]

3.2. Compatibility of the EU ETS with CORSIA

The EU ETS and CORSIA both seek to reduce aviation's net climate impact but employ distinct mechanisms with notable differences as follows.

Firstly, the EU ETS operates as a cap-and-trade system, requiring operators to buy emission permits for emissions exceeding a cap set at 95% of average historical emissions from 2004 to 2006.[65] Emissions below this threshold are covered by allowances largely allocated free of charge by European States. In contrast, CORSIA functions as an offsetting scheme without an emissions cap, obliging operators to offset emissions growth after 2020 by purchasing carbon credits representing CO_2 reductions elsewhere.[66] This structural difference reflects divergent philosophies: the EU ETS sets an absolute emissions ceiling with planned reductions, whereas CORSIA seeks only to stabilise emissions at 2020 levels without enforcing reductions. Regarding geographical scope, the EU ETS covers flights within the European Economic Area (EEA) and departures to Switzerland and the United Kingdom,[67] while CORSIA targets international aviation emissions between participating States, excluding all domestic flights. The two schemes also differ in ambition: the ETS shows intensive ambition for the achievement of the EU's climate-neutrality goals through a declining cap,[68] creating pressure on allowance supply and driving up carbon prices. CORSIA uses a less stringent baseline, requiring offsets only for emissions above 2019-2020 levels.[69] But in theory, both schemes could achieve comparable environmental outcomes, as the key factor is whether emissions are capped directly or compensated by reductions elsewhere when exceeding a baseline.

61 *See* EC, *supra* note 58.
62 Julien Chevallier, *Econometric Analysis of Carbon Markets (1st edn)* (Springer 2012).
63 Marten Ovaere and Stef Proost, 'Cost-effective reduction of fossil energy use in the European transport sector: an assessment of the Fit for 55 Package' (2022) 168 Energy Policy 6.
64 *Ibid*.
65 *See* Linda Meleo, *supra* note 57; *see also* Young Dae Ko, Young Jae Jang and Dae Young Kim, 'Strategic airline operation considering the carbon constrained air transport industry' 2017 (62) JATM 5.
66 ICAO Resolution A39-3, *supra* note 39.
67 Directive (EU) 2023/958 of the European Parliament and of the Council of 10 May 2023 amending Directive 2023/87/EC as regards aviation's contribution to the Union's economy-wide emissions reduction target and the appropriate implementation of a global market-based measure (hereinafter Directive (EU) 2023/958), Recital (30).
68 Directive 2003/87/EC, *supra* note 51, art. 1.
69 ICAO, 'COVID-19 Impacts and 2022 CORSIA Periodic Review' <https://www.icao.int/environmental-protection/CORSIA/Pages/CORSIA-and-COVID-19.aspx> accessed 11 July 2025.

Secondly, in terms of offsetting costs, the EU ETS carbon prices reached approximately €80 per tonne of CO_2 in 2022, whereas CORSIA credits averaged around €3.20 per tonne.[70] Furthermore, CORSIA allows a wide range of offsetting methods, including project activities approved by the Technical Advisory Board and the use of Verified Carbon Units,[71] which may be obtained through specialised offset providers or carbon brokers.[72] In this respect, CORSIA provides operators with greater flexibility than the EU ETS, as the operators under the former may invest in offset projects, often where such credits are more cost-effective.

Thirdly, the EU ETS enforces stricter emissions monitoring standards than CORSIA. Directive 2003/87/EU sets out the monitoring requirements applicable to entities covered by the ETS. It mandates the use of default IPCC emission factors for emissions monitoring.[73] Under CORSIA SARPs, operators may estimate emissions using either the Fuel Use Monitoring Method or the ICAO CORSIA CO_2 Estimation and Reporting Tool.[74] The EU ETS prescribes a fixed emission factor of 3.16 (t CO_2/t fuel) per tonne of jet kerosene (Jet A1 or Jet A),[75] whereas CORSIA SARPs permit either 3.16 (kg CO_2/kg fuel) for Jet-A fuel/Jet-A1 fuel or 3.10 (in kg CO_2/kg fuel) for AvGas or Jet-B fuel.[76] By mandating a single emission factor of 3.16 (in kg CO_2/kg fuel), the EU ETS actually imposes extra emissions relative to CORSIA for fuels because 3.16 is numerically larger than 3.10 per kg fuel for CO_2 emissions.

Fourthly, in terms of reporting obligations, the EU ETS requires emissions reporting for flights departing from or arriving at aerodromes within the EEA,[77] which may include data on flights between third countries.[78] However, the CORSIA SARPs require operators to submit emissions data to the State to which they are attributed. Consequently, an operator conducting flights between two third States is not required to report emissions to the EU.[79]

Lastly, the environmental effectiveness of both schemes continues to be evaluated, with particular scrutiny directed at the implementation of CORSIA. Although CORSIA's geographical scope is broader, covering around 35.7% of global aviation CO_2 emissions in 2021, with projections rising to 52% by 2027 as BRIC States and others with significant aviation activities join,[80] the environmental integrity of its offset mechanisms remains contested. Key concerns include the additionality of offset projects – i.e., whether they deliver genuine emissions reductions that would not have occurred otherwise – and the robustness of MRV processes. A study by Cames et al. (2016) found that only 7% of potential Certified Emissions Reduction (CER) credits had a high likelihood of ensuring additionality and accurate measurement, while 73% had a low likelihood.[81] These findings imply that CORSIA's reported emission reductions may significantly exceed the scheme's actual environmental benefits. Furthermore, CORSIA's offset-based model requires verification not only at the airline level but also at the mechanism, programme, and project levels, which may increase transaction costs and complicate oversight, in contrast to the EU ETS's more centralised verification framework.[82]

These differences underscore the difficulties in aligning regional and global frameworks for regulating aviation emissions. The EU's more ambitious stance reflects its commitment to achieving climate neutrality by 2050 and reducing GHG

70 Ricardo analysis and Carbon Market Watch, 'EU ETS vs CORSIA: Which Better Navigates the Turbulence of the Climate Crisis?' <https://carbonmarketwatch.org/publications/eu-ets-vs-corsia-which-better-navigates-the-turbulence-of-the-climate-crisis/> accessed 11 July 2025.
71 Verra, 'The VCS under CORSIA' <https://verra.org/programs/verified-carbon-standard/vcs-under-corsia/> accessed 11 July 2025.
72 IATA, *The IATA CORSIA Handbook* 5.
73 Directive 2003/87/EC, *supra* note 51, art. 14(2), Annex IV, Part B.
74 Chicago Convention (1944), *supra* note 14, Standard 2.2.1 of Annex 16.
75 Directive 2003/87/EC, *supra* note 51, Annex IV, Part B.
76 Chicago Convention (1944), *supra* note 14, Standard 2.2.3.3 of Annex 16
77 Directive 2003/87/EC, *supra* note 51, arts. 3 and 11(a).
78 *Ibid*, arts. 14(6)(b)(i) and 11(a).
79 Chicago Convention (1944), *supra* note 14, Standard 2.3.1.1 of Annex 16.
80 Sven Maertens et al., 'Options to Continue the EU ETS for Aviation in a CORSIA-World' (2019) 11 Sustainability 5703.
81 Martin Cames et al., *How Additional is the Clean Development Mechanism? Analysis of the Application of Current Tools and Proposed Alternatives* (Öko-Institut 2016).
82 *See* Sven Maertens et al., *supra* note 80.

emissions by 55% by 2030 relative to 1990 levels. CORSIA, developed through consensus within ICAO, represents a compromise designed to accommodate the differing levels of ambition and capacity among ICAO's Member States.

3.3. The Way Forward

The EU ETS was initially applied to all flights arriving at or departing from EU aerodromes,[83] including emissions from aircraft overflying the high seas and non-EU territories – an approach often described as 'full-scope' implementation. This expansive extraterritorial scope triggered significant international backlash, especially from major aviation powers such as the United States, China, and India. They argued that the EU has no legal authority under international law to regulate emissions beyond its airspace without the consent of affected States.[84] This opposition took several forms, including legislative countermeasures – such as the US legislation prohibiting its airlines from participating in the scheme[85] – and economic retaliation, exemplified by China's reported suspension of Airbus orders.

Ongoing international resistance prompted the EU to adopt a 'stop-the-clock' policy in 2013, temporarily restricting the ETS's scope to intra-European flights.[86] The derogation, originally set to expire on December 31, 2016, was subsequently extended. Following the adoption of CORSIA in 2016, the EU amended its ETS through Regulation (EU) 2017/2392 to align with the global scheme. It continued applying the ETS to intra-EU flights while recognising CORSIA Eligible Units and introducing measures to prevent double-counting risks for aircraft operators.[87] Moreover, recital 25 to Directive 2003/87/EU states that:

> '*The Commission will, in particular, consider policies and measures at Community level in order that the transport sector makes a substantial contribution to the Community and its Member States meeting their climate change obligations under the Kyoto Protocol.*'[88]

This demonstrates that the EU ETS is not a closed system but is open to revision and improvement, particularly concerning the transport sector. Recent developments, however, suggest that the EU intends to further reinforce its regulatory approach. The EU's 'Fit for 55' package, introduced in 2021, proposes amendments to the EU ETS for aviation as part of a broader strategy to achieve climate neutrality by 2050.[89] Furthermore, Directive (EU) 2023/958 sets a potential deadline for CORSIA, stipulating that if the ICAO Assembly fails to align CORSIA with the Paris Agreement targets by December 31, 2025, the European Commission should propose extending the EU ETS to include extraterritorial flights to and from third countries starting in 2027.[90] Similarly, if CORSIA participants account for less than 70% of international aviation emissions, the Commission may consider the same extension.[91]

Addressing competitive distortion represents a complex challenge for the future development of the EU ETS. Under the current 'reduced-scope' regime, flights routed through non-EEA hubs benefit from substantial competitive advantages

83 Directive 2003/87/EC, *supra* note 51, Annex I.
84 Robert Malina et al., 'The impact of the European Union emissions trading scheme on US aviation' (2012) 19 Journal of Air Transport Managment 36-41; *see also* 'India Leads Group of 26 Nations Against EU Aviation Emissions Levy', *Bridges Weekly Trade News Digest* (5 October 2011), vol 15, no 33.
85 European Union Emissions Trading Prohibition Act of 2011.
86 Decision No 377/2013/EU of the European Parliament and of the Council of 24 April 2013 derogating temporarily from Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community [2013] OJ L113/1.
87 Parliament and Council Regulation (EU) 2017/2392 of 13 December 2017 amending Directive 2003/87/EC to continue current limitations of scope for aviation activities and to prepare to implement a global market-based measure from 2021 [2017] OJ L350/7, preamble; *see also* Directive (EU) 2023/958, *supra* note 67, Recital (4), (15) and (17).
88 Directive 2003/87/EC, *supra* note 51, Recital (25).
89 European Council and the Council of the EU, 'Fit for 55' <https://www.consilium.europa.eu/en/policies/green-deal/fit-for-55/#:~:text=for%2055%20package%3F-,What%20is%20the%20Fit%20for%2055%20package%3F,Council%20and%20the%20European%20Parliament> accessed 11 July 2025.
90 Directive (EU) 2023/958, *supra* note 67.
91 *Ibid*, Recital (30).

compared to those routed through EEA hubs, due to less stringent regulatory requirements.[92] For example, a Milan-Moscow-Bangkok route remains entirely unregulated until Russia joins CORSIA in 2027, whereas a Milan-Munich-Bangkok route incurs EU ETS compliance costs on the Milan-Munich leg. Likewise, a Milan-Dubai-Bangkok routing is subject only to CORSIA's less stringent requirements. These regulatory inconsistencies create economic incentives that may undermine environmental goals by promoting more carbon-intensive routing choices. If the EU were to reintroduce 'full-scope' implementation, competitive distortions would persist but take a different form – routes via nearby non-EEA hubs would become increasingly advantageous. For instance, a Paris-Istanbul-Phuket route would subject only the shorter Paris-Istanbul segment to the EU ETS, while the longer Istanbul-Phuket segment would fall under CORSIA's less demanding framework. Conversely, a Paris-Bangkok-Phuket routing would incur the EU ETS costs on the entire Paris-Bangkok segment. Developing a balanced approach that minimises competitive distortions while maximising environmental benefits remains a critical policy challenge.

Another notable advancement in the EU's approach is the inclusion of non-CO_2 emissions, which are not covered under CORSIA. Scientific evidence increasingly shows that aviation's climate impact extends beyond CO_2 emissions, involving other pollutants with significant warming effects.[93] Notably, nitrogen oxides (NOx) emitted by aircraft engines lead to the formation of tropospheric ozone, resulting in positive radiative forcing and exacerbating global warming.[94] The 2024 ICAO Symposium on Non-CO_2 Aviation Emissions reflected increasing international recognition of this concern.

The European Commission has assumed a leading role in tackling non-CO_2 emissions from aviation. Article 14(5) of Directive 2003/87/EC, as amended by Directive (EU) 2023/958, mandates that aircraft operators submit annual reports on their non-CO_2 emissions from January 1, 2025.[95] The Commission must develop an MRV framework for non-CO_2 effects by August 31, 2024,[96] and begin submitting annual implementation reports on the application of this framework from 2026. By December 31, 2027, the Commission is to submit a report and, if necessary, a legislative proposal to mitigate non-CO_2 emissions by expanding the scope of the EU ETS.[97]

These developments reflect a strategy of conditional multilateralism by the EU – a readiness to engage in global solutions while preserving the option to adopt more ambitious regional measures should international efforts prove inadequate.

4. The Evolving Role of ICAO: Behind and Beyond the Environmental Regulation

4.1. ICAO and Fragmented Environmental Regulation

One major consequence of fragmented environmental regulation is that it directly undermines the global harmonisation efforts promoted by ICAO. Article 2(2) of the Kyoto Protocol calls upon relevant Parties to address international aviation emissions through ICAO.[98] Furthermore, paragraph 18 of ICAO Resolution A41-22 affirms that CORSIA is the sole global market-based measure (MBM) applicable to CO_2 emissions from international aviation.[99] ICAO Resolution A39-3 also explicitly identifies CORSIA as the preferred single instrument for regulating international aviation emissions, in contrast to a patchwork of individual States' and regional MBMs.[100] In this context, the EU ETS, functioning as an independent regional MBM alongside CORSIA, inevitably fragments the intended unified approach.

92 Janina Scheelhaase, Sven Maertens and Wolfgang Grimme, 'Options for improving the EU Emissions Trading Scheme (EU ETS) for aviation' (2021) 59 Transportation Research Procedia 200.
93 Joyce Penner et al., *Summary for Policymakers: Aviation and the Global Atmosphere, Prepared in Collaboration with the Scientific Assessment Panel to the Montreal Protocol on Substances that Deplete the Ozone Layer* (CUP 1999) 8.
94 David Stevenson et al., 'Radiative Forcing from Aircraft NOx Emissions: Mechanisms and Seasonal Dependence' (2004) 109 JGR 1 and 13.
95 Directive (EU) 2023/958, *supra* note 67, art. 14(5).
96 *Ibid*, art. 1(7).
97 *Ibid,* art. 14(5).
98 Kyoto Protocol, *supra* note 28, art. 2(2).
99 ICAO Resolution A41-22, *supra* note 48, para. 18.
100 ICAO Resolution A39-3, *supra* note 39, preamble and para. 19; *see also* ICAO Resolution A38-18, *supra* note 33, preamble.

While practical adjustments have been introduced to reduce direct overlap and avoid double regulation for the time being, fundamental incompatibilities remain in terms of design, ambition, and legal interpretation. For instance, the EU ETS, even in its reduced form applying solely to intra-EEA international flights, still contravenes the provisions of CORSIA. This is because, according to ICAO Resolution A39-3, international flights – defined as those departing from one country and landing in another – should be exclusively governed by CORSIA.[101] Moreover, the EU has explicitly reserved the right to reinstate broader coverage under the ETS should CORSIA prove inadequate. Additionally, the ICAO adopted CORSIA with the aim of ensuring its sound application across all regions of the world. The term 'Sound' in this context connotes 'thorough';[102] thus, 'sound application of the CORSIA' implies comprehensive and meticulous implementation, ensuring that no State or region is excluded. Therefore, the concurrent application of both schemes to international flights results in impermissible double counting of emissions[103] and undermines the globally 'sound application' of CORSIA.

This regulatory duality creates uncertainty for both States and non-State actors regarding their legal obligations and rights under international law, while also complicating the compliance landscape for the aviation industry. Airlines operating across multiple jurisdictions bear the burden of navigating two distinct systems with divergent mechanics, scopes, MRV requirements, and compliance units. This increases administrative costs and operational complexity, in stark contrast to the predictability and efficiency expected from a unified global standard such as CORSIA. Systemically, the coexistence of potentially conflicting regional and global regimes may also undermine the credibility, coherence, and ultimately the authority of international law.[104] When international legal obligations appear contradictory or incoherent, compliance may decline as actors struggle to meet conflicting demands or exploit normative gaps between regimes. Moreover, if States or regions can easily opt out of, or create parallel alternatives to, globally agreed standards, the normative force and legitimacy of multilateral institutions such as ICAO are significantly compromised.

The EU's initial attempt to apply the ETS extraterritorially also underscored how regulatory fragmentation affects fundamental principles of jurisdiction and State sovereignty. Although curtailed by the 'stop-the-clock' decision following strong international opposition, this episode illustrated how regional fragmentation can provoke significant diplomatic friction and challenge established norms of international air law – particularly those concerning sovereignty over airspace under the Chicago Convention (1944) framework.[105] The legality of unilateral environmental measures with extraterritorial effects remains highly contentious. While the Court of Justice of the European Union upheld the EU ETS, the 'effects doctrine' invoked to justify extraterritorial regulation pushes the boundaries of traditional jurisdictional concepts.

From an economic perspective, as noted above, divergent environmental standards and compliance costs between the EU ETS and CORSIA can create competitive distortions among airlines operating on different routes or based in different regions.[106] This may give rise to concerns about 'carbon leakage', whereby emissions are shifted rather than genuinely reduced, placing operators at a competitive disadvantage.

The case of the EU ETS exemplifies the complex relationship between regional fragmentation and multilateralism. While the EU's unilateral action arguably served as a catalyst, exerting pressure that helped spur the development of CORSIA within ICAO, it also simultaneously challenged the integrity of the established multilateral process. Though unilateral State action is not uncommon in international law and actually a legitimate manifestation of individual States' sovereignty,

101 ICAO Resolution A39-3, *supra* note 39, para. 5.
102 Noah Webster, *The Merrian Webster Dictionary* (11th edn, Merriam-Webster, Inc.) 686.
103 ICAO Resolution A39-3, *supra* note 39, preamble; *see also* the Chicago Convention (1944), *supra* note 14, Standard 3.4.2 of Annex 16.
104 Gerhard Hafner, 'Pros and Cons Ensuing from Fragmentation of International Law' (2004) 25 MJIL 849, 856; *see also* Andreas Fischer-Lescano and Gunther Teubner, 'Regime-Collisions: The Vain Search for Legal Unity in the Fragmentation of Global Law' (2004) 25 MJIL 999; *see also* Christian Leathley, 'An Institutional Hierarchy to Combat the Fragmentation of International Law: Has the ILC Missed an Opportunity?' (2007) 40 JILP 259.
105 Chicago Convention (1944), *supra* note 14, art. 1.
106 *See* section 3.3 of this article.

it becomes problematic when such action affects the interests of other States.[107] In the context of aviation emissions regulation, the EU ETS thus presented a conclusive extraterritorial component impermissible under international law.[108]

This highlights the dual potential of fragmentation: while it may stimulate innovation and global action, it also risks undermining consensus-based governance structures if not carefully managed through sustained dialogue and coordination between regional and global actors.

4.2. Coordinating Mechanisms to Mitigate Fragmentation

As Karen Scott observes, the primary challenge for international environmental lawyers and policymakers is not necessarily to eliminate fragmentation – often an inevitable consequence of an increasingly diverse international legal order – but to manage its associated risks effectively while maximising its potential benefits.[109] This, in turn, requires the development and implementation of coordinating mechanisms aimed at fostering coherence, ensuring a level playing field, and encouraging synergistic interactions between global and regional regulatory frameworks.

4.2.1. Gradual convergence of ICAO guidelines and regional legislation

Achieving a more harmonised global approach to aviation emissions requires sustained efforts towards the gradual convergence of ICAO's global guidelines, particularly CORSIA SARPs, and regional legislation such as the EU ETS. As discussed above, the evolving relationship between the EU ETS and CORSIA illustrates how initial regulatory divergence can progressively give way to coordinated approaches through deliberate mechanisms of convergence.[110] Global standards can guide regional action, while successful regional innovations may, in turn, influence the development of the global framework.

A critical area for convergence lies in the technical and operational dimensions of emissions regulation, especially concerning MRV systems. Divergences in MRV methodologies between the EU ETS and CORSIA impose considerable administrative burdens on aircraft operators subject to both regimes and risk generating inconsistencies in emissions data.[111] To ease these burdens for the EU airlines, the European Commission has aligned the existing EU ETS MRV framework with CORSIA implementation requirements.[112] This allows European airlines to rely largely on their existing MRV processes to comply with both regimes. However, non-EEA airlines that operate flights within the EEA must navigate two separate regulatory regimes. They would need to report their CORSIA emissions to their national authorities and their intra-European emissions under the EU ETS to the relevant EU authority. A more practical and harmonised solution could involve fully integrating the CORSIA MRV into the EU ETS, thereby streamlining compliance processes and reducing administrative duplication.

The quality and environmental integrity of eligible emissions units constitute another key area for potential convergence. As an offsetting scheme, CORSIA depends significantly on the credibility of carbon credits derived from diverse projects. Concerns regarding the 'additionality' and actual emission reduction potential of various offset types are well documented.[113] The EU, through its more stringent cap-and-trade system, has gained experience in safeguarding the environmental integrity of compliance units. ICAO could enhance the eligibility criteria for CORSIA offsets by incorporating

107 Richard B. Bilder, 'The Role of Unilateral State Action in Preventing International Environmental Injury' (1981) 14(1) VNJTL 51.
108 Alejandro José Piera Valdés, *Greenhouse Gas Emissions from International Aviation: Legal and Policy Challenges* (EIP 2015) 223.
109 Richard S. Mbatu, 'Domestic and international forest regime nexus in Cameroon: An assessment of the effectiveness of REDD+policy design strategy in the context of the climate change regime' (2015) 52 FPE 48; *see also* Karen Scott, *supra* note 6.
110 *See* section 3.3 of this article.
111 *See* Sven Maertens et al., *supra* note 80.
112 *See* Martin Cames et al., *supra* note 81.
113 Carbon Market Watch, 'Additionality & Baselines' <https://carbonmarketwatch.org/2012/05/30/additionality-and-baselines/> accessed 11 July 2025; *see also* Jörgen Larsson et al., 'International and national climate policies for aviation: a review' (2019) 19 Climate Policy 787.

lessons learnt from regional experiences and established best practices. At the same time, regional actors such as the EU could contribute by encouraging their carriers participating in CORSIA to use only high-quality offsets that meet strict additionality and sustainability criteria.[114] This approach could enhance CORSIA's environmental effectiveness, even if its structural baseline remains less ambitious than some stakeholders would prefer.

The EU's conditional approach to the future scope of its ETS acts as a significant, albeit contested, driver of regulatory convergence. The continuation of the EU's 'stop-the-clock' measure is explicitly tied to the perceived effectiveness and global uptake of CORSIA, with provisions in place to reintroduce a full-scope ETS should CORSIA prove insufficient.[115] This conditionality provides a strong incentive for ICAO and its Member States to enhance CORSIA, both in terms of environmental ambition and practical implementation. Strengthening CORSIA in this manner could foster closer alignment between its objectives and outcomes and the EU's climate ambitions for aviation, thereby diminishing the perceived necessity for a separate regional system.

Regional leadership in emerging regulatory areas, such as the EU's initiative to develop MRV frameworks for non-CO_2 climate impacts of aviation, can ultimately facilitate global regulatory convergence. Although ICAO currently concentrates on CO_2 emissions through CORSIA, scientific understanding of the non-CO_2 climate impacts of aviation is steadily advancing. The EU's practical experience in designing and applying MRV systems for non-CO_2 effects may yield valuable data, methodologies, and insights that inform future ICAO deliberations and support the eventual establishment of global standards or guidance in this domain.

Achieving regulatory convergence presents several challenges. A key structural challenge lies in the fundamental difference between the EU ETS and CORSIA. Full alignment of these fundamentally different mechanisms may be difficult to achieve. Consequently, convergence is more likely to occur gradually and iteratively, concentrating on specific technical components and common objectives rather than aiming for full integration of the two systems.

4.2.2. Cooperation mechanisms between ICAO and regional organisations

Beyond the convergence of specific rules and standards, effectively addressing regulatory fragmentation requires robust institutional cooperation between ICAO, as the global standard-setting body for international aviation, and regional actors such as the EU that implement substantial aviation policies.

Both formal and informal dialogues are essential to fostering such cooperation. Regular consultations, information exchange, and reciprocal participation in relevant technical bodies and policy development processes promote mutual understanding and enable the early detection of potential conflicts or areas for alignment. The EU-ICAO Memorandum of Cooperation (MoC) of March 29, 2012 established a structured framework for engagement through the Joint Committee.[116] Co-chaired by the EU Commissioner for Transport and the ICAO Secretary-General, the Committee holds regular high-level meetings to assess annual progress and define future cooperation priorities. The adoption of Annex IV to the MoC in 2024 further reinforced this dialogue structure by introducing quarterly technical-level liaison meetings, which enable real-time coordination of capacity-building initiatives and information exchange through dedicated platforms.[117] This formalised dialogue system allows for the early identification of potential conflicts in areas such as environmental protection, aviation safety, and security. Additionally, the Joint Committee's conflict resolution

114 *See* Janina Scheelhaase, *supra* note 92, 199.
115 *See* section 3.3 of this article.
116 Memorandum of Cooperation between the European Union and the International Civil Aviation Organisation, arts. 7(1) and 7(3).
117 Draft Decision of the EU-ICAO Joint Committee on the adoption of an Annex IV, on capacity building, technical assistance and implementation support, to the Memorandum of Cooperation between the European Union and the International Civil Aviation Organisation providing a framework for enhanced cooperation (Doc 10316/24); *see also* Annex IV to the MoC: Capacity Building, Technical Assistance and Implementation Support (Doc 185889/EU XXVII. GP).

mandate, as reinforced by Commission Decision 2022/220,[118] provides mechanisms for addressing technical standards divergence, funding arrangements, and project prioritisation. This reduces the risk of global governance fragmentation while enhancing complementarity between EU regulations and ICAO SARPs.

Mutual recognition frameworks represent an additional strategy for managing parallel compliance regimes. The EU's recognition of equivalent compliance with specific CORSIA requirements for ETS purposes helps reduce administrative burdens on aviation operators. This approach is analogous to the mutual recognition of seafarer qualifications under IMO standards and corresponding EU directives.[119]

ICAO's function as a global platform is essential for facilitating multilateral cooperation. By offering a forum for the exchange of regional approaches, dissemination of best practices, and consensus-building around shared principles, ICAO can help avert the proliferation of uncoordinated and potentially conflicting regional measures, thereby mitigating the risk of a regulatory 'patchwork'.

The concept of 'synergy', understood as the interaction or cooperation of two or more organisations to produce a combined effect greater than the sum of their individual contributions, is particularly pertinent in this context.[120] With regard to aviation emissions, synergy may be realised if ICAO and the EU coordinate their efforts to ensure that CORSIA and the EU ETS jointly advance global climate objectives more than they would in isolation or in conflict. For instance, the EU could strategically design its ETS to offset CORSIA's limitations – by applying a higher carbon price to intra-EEA flights or promoting the use of high-quality offsets – thus strengthening the overall environmental impact. ICAO's global scope and consensus-based legitimacy offer a foundational floor for universal standards, while regional bodies such as the EU can set more ambitious ceilings to stimulate innovation and raise environmental ambition. This 'division of labour' approach capitalises on the comparative strengths of global and regional institutions while reducing the potential for regulatory conflict.[121]

4.3. Beyond the Environmental Regulation: A Second Look at the Role of ICAO

The preceding analysis of the risks posed by regulatory fragmentation underscores a compelling functional imperative for established international organisations, such as ICAO, to adapt and potentially expand their competencies in order to remain relevant and effectively respond to emerging global challenges – most notably, the environmental impact of aviation. The establishment of CORSIA may be interpreted as a direct response by ICAO and its Member States to the pressures of fragmentation, intended to reaffirm a harmonised global approach to aviation emissions. Nevertheless, any expansion of an international organisation's functions or authority must be firmly rooted in the established principles of international law in order to be regarded as both legitimate and sustainable.

4.3.1. General international law

The assessment of an international organisation's powers begins with the principle of the conferred powers. Under this principle, organisations such as ICAO possess only those powers expressly granted by Member States, primarily through their constituent instruments.[122] According to Article 1 of the Relationship Agreement between the United Nations and

118 Commission Decision (EU) 2022/220 of 15 February 2022 on the position to be taken by the European Union in the Joint Committee established under the Memorandum of Cooperation between the European Union and the International Civil Aviation Organization providing a framework for enhanced cooperation, on the adoption of a Working Arrangement regarding the cooperation in the area of accident and incident reporting in civil aviation, and appointing a chairperson of the European Union in the Joint Committee [2022] OJ L 37.

119 Directive 2005/45/EC of the European Parliament and of the Council of 7 September 2005 on the mutual recognition of seafarers' certificates issued by the Member States and amending Directive 2001/25/EC.

120 Gregory Rose, *Compliance mechanisms under selected multilateral environmental agreements* (Earthprint 2007) 22.

121 Harro Van-Asselt, Sindico Francesco and Michael A. Mehling, 'Global climate change and the fragmentation of international law' (2008) 30 Law and Policy 424.

122 Henry G. Schermers and Niels M. Blokker, *International Institutional Law: Unity Within Diversity (5th edition)* (MNP 2011) 157.

the International Civil Aviation Organization, ICAO must pursue its objectives within the framework of its foundational legal instrument, namely the Chicago Convention (1944).[123] Consequently, any assessment of ICAO's competence to develop and implement measures such as CORSIA must begin with the Chicago Convention (1944) in order to determine the specific powers conferred upon the organisation.

The law of international organisations has long recognised that the powers explicitly enumerated in a constituent treaty may not be exhaustive. The evolving nature of international affairs necessitates a degree of organisational adaptability. This need is legally addressed through the doctrine of implied powers. Originating in US constitutional practice[124] and subsequently adopted into international law through the jurisprudence of the Permanent Court of International Justice (PCIJ) and International Court of Justice (ICJ),[125] the doctrine of implied powers recognises that international organisations may possess powers not expressly stated but conferred 'by necessary implication as being essential to the performance of their duties' and the fulfilment of their purposes. This doctrine is strictly constrained by the requirement of necessity. Any implied power must be genuinely indispensable for the effective exercise of explicitly conferred functions or the attainment of the organisation's objectives.[126] Furthermore, such power must be logically derived from, and consistent with, the organisation's express powers and purposes, without fundamentally altering its institutional mandate. This teleological interpretation implies that if addressing aviation emissions is deemed essential to achieving ICAO's broader objectives as articulated in the Chicago Convention (1944), then the competence to develop such a scheme could plausibly be regarded as implied.

The principles of treaty interpretation, as codified in the Vienna Convention on the Law of Treaties (VCLT), provide the legal framework for this assessment. Article 31(1) of the VCLT requires that treaties be interpreted in good faith, in accordance with the ordinary meaning of their terms and in light of the treaty's object.[127] In the context of ICAO, Article 44 of the Chicago Convention (1944) sets out the organisation's aims and objectives, including developing the principles and techniques of international air navigation and fostering the planning and development of international air transport so as to, inter alia, 'meet the needs of the peoples of the world for safe, regular, efficient, and economical air transport'.[128] Although environmental protection is not expressly listed as a primary objective in Article 44, a dynamic or teleological interpretation could support the view that ensuring the sustainable development of international air transport, which includes mitigation of its adverse environmental impacts, has become essential to securing the long-term viability of 'safe, regular, efficient, and economical' services in the context of contemporary challenges such as climate change and regulatory fragmentation. Moreover, the Preamble to the Chicago Convention (1944), which emphasises the development of international civil aviation 'in a safe and orderly manner',[129] may also be interpreted to address environmental sustainability concerns which, although not foreseen in 1944, have become integral to the future of global aviation.

In addition to powers implied from its constituent instrument, the competence of an international organisation may also be explicitly affirmed through subsequent legal instruments adopted after its establishment.[130] A notable example is the *ad hoc* attribution of governmental powers upon the United Nations through the 1991 Paris Peace Accords concerning Cambodia. Article 2(2) of the Kyoto Protocol provided an explicit mandate, designating ICAO as the

123 Agreement between the United Nations and the International Civil Aviation Organization (adopted 1 October 1947), art. 1.
124 *McCulloch v. Maryland*, 17 U.S. 316 (1819).
125 *Reparation for Injuries Suffered in the Service of the United Nations (Advisory Opinion)*, [1949] ICJ Rep 174 (hereinafter *Reparation for Injuries*); *see also Effect of Awards of Compensation Made by the United Nations Administrative Tribunal (Advisory Opinion)*, [1954] ICJ Rep 47; *see also Legality of the Threat or Use of Nuclear Weapons (Advisory Opinion)*, [1996] ICJ Rep 226.
126 *See Reparation for Injuries*, *supra* note 125, dissenting opinion, Judge Hackworth.
127 The Vienna Convention on the Law of Treaties (adopted 23 May 1969) (hereinafter VCLT), art. 31(1).
128 Chicago Convention (1944), *supra* note 14, art. 44(d).
129 *Ibid*, preamble.
130 Dan Sarooshi, *International Organisations and Their Exercise of Sovereign Powers* (OUP 2005) 26-27.

appropriate international body for addressing the environmental impact of international aviation emissions.[131] However, this delegation of authority raises questions regarding its continued legal relevance, given that the Kyoto Protocol expired in 2020 and was succeeded by the Paris Agreement. Nevertheless, as previously discussed, ICAO's mandate in the field of environmental management is not confined to the Kyoto Protocol but may be grounded in the Preamble and Article 44 of the Chicago Convention (1944). Irrespective of the Kyoto Protocol's current status, ICAO has taken proactive steps by implementing CORSIA, thereby demonstrating its substantive commitment to the reduction of aviation-related emissions.

Besides the explicit mandate regarding emissions regulation, which was included in the Kyoto Protocol,[132] another supporting evidence of ICAO's legislative power in this field lies in the difficulties and challenges of introducing amendments to the Chicago Convention (1944). Article 94 of the Convention provides that '[a]ny proposed amendment to this Convention must be approved by a two-thirds vote of the Assembly and shall then come into force in respect of States which have ratified such amendment when ratified by the number of contracting States specified by the Assembly'.[133] The ICAO experience illustrates that none of the amendments adopted since 1947 is in force for all ICAO contracting States because of the requirement laid down in Article 94.[134] Another serious problem is that the amendments can thus require an inordinately long time to come into force.[135] The amendments introducing Article 3bis took fourteen years to come into force; and he new Article 93bis took nearly the same period of time.[136]

In this connection, one of the most notable trends in ICAO's rulemaking is the diminishing significance of international air treaties compared to SARPs.[137] Compared to international treaties, the ICAO SARPs – as softer instruments – have several advantages. SARPs may be continually upgraded and refined as situations demand.[138] They not only apply almost universally but are largely formulated by experts from ICAO's technical committees rather than by State representatives.[139] Leading the movement to underpin globalisation with universally compatible rules and minimum standards of practice, standard setting, accompanied by recommended guidelines, appears to be the optimal technique.

4.3.2. The legislative history of the Chicago Convention (1944) and the establishment of ICAO

Resort to supplementary means of interpretation under Article 32 of the VCLT, including preparatory work of the treaty and the circumstances of its conclusion, offers valuable contextual insight.[140] The Chicago Conference, convened in 1944, primarily aimed to establish technical uniformity and safety standards in response to the protectionist tendencies of States in the aftermath of the Second World War.[141] At the time, environmental protection was not included on the agenda, as the environmental impacts of aviation were minimal and climate change was not recognised as a global concern.

131 Kyoto Protocol, *supra* note 28, art. 2(2).
132 *Ibid*.
133 Chicago Convention (1944), *supra* note 14, art. 94.
134 Michael Milde, *International Air Law and ICAO (3rd edn)* (EIP 2016) 29.
135 Michael Milde, 'The Chicago Convention – Are Major Amendments Necessary or Desirable 50 Years Later?' (1994) XIX(1) AASL 407.
136 *See* Michael Milde, *supra* note 134.
137 Brinsmead, Simon Winston, 'Rulemaking in ICAO, the ILO and the IMF: The Rise of Standards' (2007) NIE.
138 For example, following the events of 11 September 2001, ICAO took steps amend the SARP contained in Annex 17 to the Chicago Convention (1944) which dealt with airline security, extending its reach to domestic airlines. Further amendments were introduced in 2006, requiring airports to screen all baggage, establish security restricted areas, and conduct appropriate evaluation and training of security personnel. ICAO also passed resolutions condemning the use of civilian aircraft as weapons of mass destruction.
139 Although in formal terms the power to adopt SARPS rests with the ICAO Council, the task in practice is largely undertaken by the Air Navigation Commission (for SARPS relating to air navigation) and by the Air Transport Committee (for SARPS dealing with the facilitation of international air transport). Contracting States are consulted at two stages of the process: they may participate in divisional meetings and conferences; and draft SARPS must be submitted to the Contracting States for their comments after they have been reviewed by the Air Navigation Commission or the Air Transport Committee. Contracting States are only required to comply with SARPS to the 'highest practicable degree', as noted by Article 37 of the Chicago Convention (1944). Article 38 of the Chicago Convention (1944) sets out the procedure by which Contracting Parties must notify ICAO of the degree to which they have found it practicable to implement a particular SARP, by 'notification...of the differences between its own practice and that established by the international standard'. Together, these articles emphasise the voluntary nature of SARPS compliance.
140 VCLT, *supra* note 127, art. 32.
141 Pablo Mendes de Leon and Niall Buissing, *Behind and Beyond the Chicago Convention* (Kluwer Law International B.V. 2019) 294.

The Convention's omission of environmental matters does not indicate an intentional exclusion but rather reflects the historical constraints on the drafters' foresight. Although the drafters addressed the immediate post-war priorities, the wording of key provisions used in key provisions might be interpreted as sufficiently general to allow for adaptation to new challenges unforeseen in 1944. The phrase 'needs of the peoples' is inherently dynamic and must be interpreted in light of contemporary circumstances, rather than being fixed to its meaning in the 1944 context. As affirmed by the ICJ, international instruments must be interpreted and applied 'within the framework of the entire legal system prevailing at the time of the interpretation'.[142] Such interpretive flexibility is also embodied in Article 37 of the Convention, which empowers ICAO to adopt international SARPs across a broad spectrum of aviation issues to achieve 'the highest practicable degree of uniformity'.[143] It may be argued that, although the drafters did not foresee environmental regulation as a specific task, they intended to create an organisation capable of evolving to ensure the long-term 'safe and orderly development' of international aviation – an objective that today arguably encompasses the sector's environmental sustainability.

While the *travaux préparatoires* offer insight into the original intent of the drafters, Article 31(3)(b) of the VCLT underscores the interpretative importance of subsequent practice that establishes the agreement of the Parties concerning the treaty's meaning.[144] Beginning with early initiatives on aircraft noise in the 1960s, followed by the creation of the Committee on Aviation Environmental Protection (CAEP) and culminating in the adoption of CORSIA SARPs within Annex 16 to the Chicago Convention (1944), ICAO has gradually and consistently incorporated environmental considerations into its agenda.[145] This trajectory may be regarded as evidence of a shared understanding among the Parties that mitigation of environmental impacts now legitimately falls within the ICAO's sphere of competence and is essential to achieving its overarching objectives in the modern context.

5. Conclusion

The governance of international aviation's environmental impact reflects a fundamental tension between globally coordinated approaches led by institutions such as ICAO and more ambitious regional initiatives, such as the EU ETS. This article confirms the legitimate legal basis for ICAO's expanded environmental competence, grounded in doctrines such as implied powers and evolutive treaty interpretation. At the same time, the EU ETS illustrates how regional measures can contribute to the fragmentation of the legal landscape. They may further create normative tensions, jurisdictional conflicts, and compliance challenges that undermine the coherence of international air law. Addressing this requires transcending the global-regional dichotomy and adopting a strategy of proactive coordination to effectively manage fragmentation. Incremental convergence in technical domains and strengthened institutional cooperation between ICAO and regional actors is essential to promote complementarity and reduce the risk of conflict. Ultimately, navigating the development of institutional competence and the challenge of fragmentation in international air law, ICAO moves beyond the 80th anniversary of the Chicago Convention (1944), demanding a commitment to manage any patchwork of international air law. This can foster coherence and synergy, aiming to secure a sustainable future for aviation within a stable international legal order, while offering broader lessons for other domains of global governance.

142 *See Legality of the Threat or Use of Nuclear Weapons, supra* note 125.
143 Chicago Convention (1944), *supra* note 14, art. 37.
144 VCLT, *supra* note 127, art. 31(3)(b).
145 ICAO, 'Consolidated statement of continuing ICAO policies and practices related to environmental protection – General provisions, noise and local air quality' (2022) Resolution A41-20; *see also* ICAO Resolution A37-19, *supra* note 32; *see also* ICAO Resolution A38-18, *supra* note 33; *see also* ICAO Resolution A39-3, *supra* note 39; *see also* ICAO Resolution A41-22, *supra* note 48.

The uncertainties of ground-level emission estimates at airports, from an operational and interdisciplinary-to-transdisciplinary standpoint

*Francesco D'Amico**

Abstract

Air quality issues are of remarkable interest due to the relevant number of people affected; in the case of ground-level aviation emissions many inventories exist but several degrees of uncertainty, mostly related to the intrinsic variability of aircraft operations and environmental factors, can be highlighted. Via an interdisciplinary-to-transdisciplinary approach accounting for various disciplines, such as Atmospheric Physics, Earth Sciences and Aeronautical procedures, this research paper provides a new insight on the above mentioned uncertainties and calls for more attention be focused on airport air quality measurements and evaluations.

Introduction

Air quality-related issues are at times *en pair* with the major issue of climate change, which has effectively become a core aspect of politics, policies, society, and economics. Though climate altering agents such as carbon dioxide (CO_2) and methane (CH_4) are distinct from *sensu stricto* pollutants hazardous for humans, both topics are now of concern. Moreso, climate-altering agents such as CO_2 and CH_4 do pose a safety hazard the moment the increase in temperatures also affects safety in contexts such as workplaces and cities, potentially resulting in more annual deaths attributable to heat waves. Airplanes are generally regarded as relevant sources of emissions, though they only account for about 3.1% of anthropogenic fossil fuel combustion CO_2 emissions on a global scale, according to an estimate on 2019 traffic by the International Energy Agency (IEA), released in 2022.[1] Aviation-related CO_2 emissions are of popular concern mostly due to the high emission-to-passenger ratio compared to other means of transportation, such as railway systems, as well as the perception of air travel of some sort of "luxury" service, especially when it comes to short routes. In the era of social media, it is not uncommon to see VIPs and other popular figures being criticized for the frequency by which they rely on air transportation instead of its "greener" alternatives.

For many reasons, airports are generally subject to monitoring campaigns meant to assess the extent of emissions, especially on a ground-level basis. The International Civil Aviation Organization (ICAO) has in fact issued the Airport Air Quality Manual[2], a key official document meant to address the issue and provide details on how such monitoring efforts are performed. This manual will be referenced many times in this research paper as AAQM.

As evidenced by the AAQM document, air quality concerns are integrated into a much wider context of increasing pressure on the world of aviation due to its environmental impact. The pressure includes, but is not limited to, issues such as aviation noise and the need to reduce aviation-related emissions via the introduction of Sustainable Aviation Fuel (SAF), as well as the effective banning of short air routes which can be replaced by trains and comparable transportation services. Such bans are already in effect in several countries, and even more countries are expected to join them soon; however, the bureaucratic measures of influencing the free market via bans have met their intrinsic contradictions during the Covid-19 pandemic, when airlines were forced to operate nearly empty flights because doing so would have ensured the legal preservation of slots. This example, though referred to a rather unique scenario, still highlights very well the odds of dealing with bureaucracy when it comes to the aviation market. Yet still, with the *datum* and premise

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1 International Energy Agency (IEA) (2022). *Aviation*.

2 International Civil Aviation Organization (ICAO) (2020). Doc 9889, *Airport Air Quality Manual*. ICAO, Montreal.

of environmental concerns and comparable issues, aviation is a key tool for the economy and its efficiency is particularly remarkable in long-haul routes, where even the best alternatives would require travel times one or two orders of magnitude greater than those ensured by commercial aircraft, if not more. Aviation is therefore meant to stay, improve and adapt, and its persistence goes with a reasonable tradeoff between its conspicuous advantages and its drawbacks, with air pollution being one of them.[3]

Airports tend to vary a lot in terms of age: some have been built very recently, others will be built in the future, and a significant fraction of them are historical as they have been serving their respective cities for nearly a century, ever since the early days of commercial aviation. This clearly indicates that urbanization increase in developing and developed countries may imply a geographic "annexation" of airports into urban and suburban areas as they grow, and ICAO itself reports that the airports themselves may also drive such urbanization processes around them. In addition to this, as air traffic has been on a nearly constant rise for decades, the exposure of urban areas to ground-level emissions related to aviation, as well as noise, has also increased. Notable urban areas, hereby not mentioned for the sake of conciseness, have experienced – and are still experiencing – active protests (in the form of sit-ins, petitions, political pressures, *etc*.) against their local airports that oftentimes result into growing social pressure towards a different management of the airports themselves, or even their closure in favor of airports located elsewhere. The geographic proximity of growing urban areas around airports is a driving factor of major restrictions, such as enforced airport closure times, specific maneuvers that need to be performed upon take-off, *etc*. In purely aeronautical terms, among the keys to noise abatement are the early retraction of flaps, steeper climb profiles and reduced thrust take-offs, though obviously they cannot be employed at all times, and do not nullify noises completely.

As a strategic infrastructural system, an airport shows multiple sources of emissions, ranging from the aircraft themselves to Ground Service Equipment (GSE), vehicular traffic and airport terminal building-related emissions. According to the AAQM, regulations on these sources may vary considerably depending on the country or state, thus adding more degrees of variability in a market that is perhaps among the most homogeneous ever seen on Earth (aircraft essentially operate in the exact same ways all over the world). That said, there are international standards on aircraft emissions, and new lines of aircraft such as the Boeing B737 MAX series and Airbus A320 family NEO variants set the fundamentals of their market on lower fuel consumption and, as direct consequence, lower emissions per passenger carried. The focus on low consumption is such that it has gained priority over reducing travel times – in the case of the MAX series, Bowed Rotor Motoring (BRM) lengthens the engine startup sequence by several minutes, and consequently results into longer travel times as well as higher chances of delays. However, this is deemed a necessary tradeoff as the reduced fuel consumption (and costs) are more valuable than mere minutes of travel time being gained.

Speaking or air quality and emission concerns as seen across the globe, it is worth noting that regulations not only may vary in terms of actual thresholds, but also show an intrinsic variability in terms of which compounds are more likely to be subject to said regulations, and the restrictions that come with them: in the case of nitrogen oxides in the atmosphere, which are one of the products of aviation-related emissions, there are two different takes reported between the United States of America and the European Union. US regulations are apparently focused on NO_x releases and their effects on increased tropospheric ozone (O_3) levels, while European countries seem more likely to focus their regulations on NO_2. In the fields Atmospheric Physics and Chemistry, in fact, several proximity indicators of sources (broad estimates on the distance between detection points and emission areas) are based on NO_x/NO_2 and O_3 ratios, as well as correction methods such as those suggested by Steinbacher et al. (2007).[4]

3 Grobler, C.; Wolfe, P.J.; Dasadhikari, K.; Dedoussi, I.C.; Allroggen, F.; Speth, R.L.; Eastham, S.D.; Agarwal, A.; Staples, M.D.; Sabnis, J.; Barrett, S.R.H. (2018). *Marginal climate and air quality costs of aviation emissions*. Environmental Research Letters 14, 114031.

4 Steinbacher, M.; Zellweger, C.; Schwarzenbach, B.; Bugmann, S.; Buchmann, B.; Ordóñez, C.; Prevot, A.S.H.; Hueglin, C. (2007). *Nitrogen oxide measurements at rural sites in Switzerland: Bias of conventional measurement techniques*. Journal of Geophysical Research 112(D11): 307.

The World Health Organization (WHO) also has its own take on the issue, in the form of actual guidelines released globally. Speaking of NO_2, the hourly guideline for this compound is 200 µg/m^3 (micrograms per cubic meter), while regional guidelines are in the 75-400 µg/m^3 range, as highlighted by the AAQM. WHO guidelines also address particulate matter equal or smaller than 10 microns, the so called "PM^{10}" category of particulates: the WHO has set a guideline value of 50 µg/m^3 while regulators across the world operate in the 50-150 µg/m^3 range. Surprisingly, the AAQM highlights one regulation gap in global guidelines, which is one of the key aspects of this research paper: in the case of O_3, the WHO reportedly has no hourly or daily guideline, though it has defined an 8-hour guideline of 100 µg/m^3 while regulators across the world are in the 100-160 µg/m^3 range. This is indeed a remarkable example of a major entity in the context of health policies and health hazards not providing a reasonable hourly value around which local regulators can build their own restrictions and guidelines.

With respect to the main engine emission standards issued by ICAO, which are also highlighted in the AAQM, they are applied for certification at various scales from the national to multi-national level and aimed at turbofan/turbojet engines capable of more than 26.7 kN (kilonewton) of thrust, but even according to the AAQM itself they are not applied to turboprops, turboshafts, piston engines, or Auxiliary Power Units (APU) installed on aircraft. What's remarkable about the standards mentioned above is that they set the fundament for the broader assessments of air quality: in fact, these standards are based on the uninstalled engine performance as measured against a LTO (landing and take-off) cycle up to a threshold of 3000 ft AGL (feet Above Ground Level), equivalent to 915 meters AGL. The ICAO standards are indeed based on uninstalled engine performance measured against an idealized landing and take-off (LTO) cycle up to 915 m (3 000 ft) above ground level (AGL). It is also recognized by ICAO itself than even though these values are widely used, notable variations driven by environmental- and operational-specific situations do occur, and regulators and encouraged to work on more accurate assessments. The fact that even ICAO itself would provide a generic recommendation on how to go beyond standardized values, and the fact that national regulators may then issue various thresholds despite aviation being a market known for operating in the same way across the globe, is itself another evidence pointing in the direction of subtle gaps in this field (though, from a legal standpoint, national regulations are legitimately recognized by both international and national laws and this paper doesn't question their applicability).

After these remarks, an enormous gap in assessments addressing these thresholds could be assumed, but it is not actually the case: by its very nature as an international market, aviation does have many regulations deemed applicable on a global basis, such as the standards developed in the context of the Committee on Aviation Environmental Protection (CAEP) which were later implemented by the ICAO Council. Following the first regulation on emissions issued by ICAO in 1981, relevant updates have been released over the years: CAEP/2, in 1993; CAEP/4, in 1999; CAEP/6, in 2005; CAEP/8, in 2011. It is worth noting that the release of new CAEP issues has accelerated over time, perhaps as result of more pressure – of both social and political nature – on environmental issues. As stated before, the global reference is a LTO cycle up to 915 meters, equal to 3000 feet (from now on, 915m/3000ft) in altitude above the ground level of the runway. The engine standards focus on CO (carbon monoxide), HC (hydrocarbons) and the already mentioned NO_x as compounds of concern; this will be better described in the second section of the paper. CO is known as a byproduct of combustion in a number of anthropic activities, and the same principle is applied to hydrocarbons, though many of them vary a lot in terms of nature and characteristics.

Of particular importance are regulatory restrictions that became more and more strict over time. In the case of NO_x, it is reported that between 1981 and recent years, emission standards were constrained by approximately 50% (regulations introduced, for instance, by the CAEP of 1993, 1996, 1999, 2005, and 2011 gradually increased these restrictions, and nothing has gone in the opposite direction). These restrictions – which took place step by step, accounting for the time and tests required to certify newly produced engines – were also largely driven by technological breakthroughs allowing

reduced NO_x outputs, though the actual interaction of released compounds in the atmosphere and other pollutants or agents of climate change poses several side-challenged which will be addressed later in the paper.

Aircraft aside, vehicles operating at airports, such as the GSE mentioned before as well as many other vehicles serving a variety of purposes, are also now subject to a number of restrictions based on the category they fall into. The two broader families used for this very purpose group vehicles by "duty" (heavy or light, also called off-road and on-road, respectively). It is reported that certain GSE are classified as "non-road mobile machinery", depending on whether their use involves roads or not. In addition to vehicles that are specifically developed and built for aircraft assistance, a variety of regular vehicles such as fire trucks also operate in the environment of an airport and are subject to standard regulations on emissions generally applied on a nation-wide scale.

Overall, aviation operates in an international scenario where procedures applicable on a global scale in terms of pure air traffic management oftentimes combine with heterogeneous regulations on emissions, which evolve in a dynamic context and are subject to changes over time. However, the issue of air quality (which does not necessarily match that of pure emissions) underlines a number of major uncertainties this paper is set to address in the next section.

Evaluation

The AAQM provides a full list of categories by which airport emissions are grouped, each representing a specific operational scenario as well as a number of subcategories.

The categories are:

1a) Aircraft main engine;
1b) Auxiliary Power Unit (APU);

2a) Ground Support Equipment (GSE);
2b) Airside air traffic of vehicles such as cargo loaders;
2c) Aircraft refueling, in the form of evaporation through fuel tanks/vents, trucks, and pipeline systems;
2d) De-icing and anti-icing substances during the winter season, in particular during snowstorms;

3a) Sources related to the main airport infrastructures, such as cooling and heating plants;
3b) Emergency power generators, such as those ensuring that runway lights can operate even in the case of power shortages;
3c) Activities and facilities related to the maintenance of aircraft, such as engine test beds, and washing;
3d) Activities focused on the maintenance of airport facilities and equipment;
3e) The storage, handling and distribution of fuel;
3f) Construction activities connected to the development of an airport;
3g) Activities related to fire training with various types of fuel;
3h) Surface de-icing, this time applied to the infrastructure, with a focus on access roads;

4a) Vehicle traffic linked to the airport as a whole, accounting for curbsides, drive-ups, parking lots, *etc*. Though it is believed by the author that any estimate on these emission categories is grossly challenged by uncertainties, this paper will address the issues related to specific disciplines and their fields.

In the simplest scenario, a given airport has one runway (intended as an actual linear infrastructure) which in turn has two bearings, identified by QFU (Magnetic bearing of the runway in use). The bearing identifies the orientation of the runway, RWY from now on, with respect to the magnetic north pole, divided by a factor of 10 (*e.g.*, 30 for 300 °N); the two headings have a 180° difference from each other. Other, more articulated scenarios with parallel runways having the same orientation would introduce the identifiers L and R (Left and Right, respectively) to differentiate them, but these examples are now ignored for the sake of conciseness. Airport runways are not built at random, as they are the result of studies on local wind circulation meant to ensure the safety of air traffic on the principle by which both take-offs and landings need to be performed against the wind: this leads to a very important assumption by which the local influence of emissions is distinct from contributions to the global output. In fact, local emissions (intended as those affecting the airport workforce and nearby suburbs) should take in consideration wind speed and direction, while 100% of the emission output does however add up to total atmospheric global budget and pollution levels. Moreso, this should at least indicate that emission outputs related to take-off and landing maneuvers are concentrated on an axis that is coincident with the runway in use, plus a buffer zone accounting for high pollutant concentration levels, which would then be reduced as the distance from the axis increases: it does not seem the case, however, of the main state of the art on the literature of the field, as classifications are performed on a per radius basis that – for example – attributes the label of "near-airport" range category to everything located in a 10-kilometer radius from the airport itself, a range deemed of particular attention in terms of health hazards, as reported by both Carslaw et al. (2006)[5] and Carslaw & Beevers (2013).[6] In fact, many annual deaths caused by a number of diseases linked to air pollution are attributable to people either living or spending working hours within this radius.

The core issue is that wind circulation, broadly characterized by the key parameters of wind speed (WS) and wind direction (WD), does influence the transport of pollutants on local to large scales. Models such as NOAA's (National Oceanic and Atmospheric Administration) HYSPLIT[7] (Hybrid Single-Particle Lagrangian Integrated Trajectory) allow to backtrack – or even make short-term future predictions – based on these wind parameters and are frequently used to monitor the distribution of pollutants that follow major events, such as large wildfires. The introduction of WS and WD (plus their intrinsic variability over time, linked to synoptic atmospheric circulation), even if fully integrated with air traffic below 915m/3000ft, does pose new challenges in the correct estimation of local pollutants caused by aircraft: one rather uncommon exception, though worth a mention due to its implications, is the Circle-To-Land procedure by which an aircraft would approach a given airport for landing, then perform a short turn (normally a left turn, according to the Rules of the Air), reach the other side of the aerodrome and land on the opposite RWY. Such a landing pattern completely invalidates any local scale pollution distribution model, as the sources of emission throughout the entire maneuver (hereby intended as points in space, the engine exhausts) follow a completely different path, and at different altitudes/orientations, each with different WS/WD parameters (especially the former, which is notoriously dependent on altitude). Moreso, at the time of writing there is no tangible evidence that such landing procedures are tracked and a recorded in a nation-wide or international database, open to researchers and their institutions, up to a point that could be used to provide reasonable pollution estimates on a local scale. Even the emission estimate on an absolute scale, in this case, is challenged by different flight times (a Circle-To-Land maneuver and a standard landing are likely to be performed with different timing and fuel consumption settings). As said before, the Circle-To-Land scenario may be regarded as a rare circumstance, but it is worth noting that training procedures performed by military airplanes of various air forces operating at commercial airports follow a similar pattern several times in a row during each training session and the exercises themselves frequently involve large airplanes with remarkable emission outputs. These odds

5 Carslaw, D.C.; Beevers, S.D.; Ropkins, K.; Bell, M.C. (2006). *Detecting and quantifying aircraft and other on-airport contributions to ambient nitrogen oxides in the vicinity of a large international airport*. Atmospheric Environment 40, issue 28, pgs. 5424-5434.

6 Carslaw, D.C. & Beevers, S.D. (2013). *Characterising and understanding emission sources using bivariate polar plots and k-means clustering*. Environmental Modelling & Software 40, pgs. 325-329.

7 Stein, A.F.; Draxler, R.R; Rolph, G.D.; Stunder, B.J.B.; Cohen, M.D.; Ngan, F. (2015). *NOAA's HYSPLIT atmospheric transport and dispersion modeling system*. Bulletin of the American Meteorological Society 96, pgs. 2059-2077.

may be considered an example of "Missing information" as intended by the AAQM: inventories not fully integrated with air traffic control, local civil aviation authority records and precise meteorological stations would systematically fail to account for these non-standard maneuvers.

In addition to the challenges posed by local pollution and emission estimates, even the accounting of released compounds itself is challenged by intrinsic degrees of uncertainties: at the time of writing, in fact, there are no comprehensive and detailed data on specific methane releases by aircraft that could be used to provide adequate assessments. Methane (CH_4), though not a pollutant *per se*, is a potent GHG (greenhouse gas) due to its global warming potential (GWP) exceeding that of CO_2 by nearly two orders of magnitude over the time period of two decades and is nearly 30 times higher over the course of a century;[8] despite this, methane levels in the atmosphere are about 200 times lower than those of CO_2, thus making carbon dioxide the biggest threat to climate (this compound also tends to persist in the atmosphere for longer periods of time, potentially one millennium, and that is why it is currently the focus of social, political and economic debates). Unlike carbon dioxide however, methane has showed degrees of variability (both in terms of global growth rates and carbon isotope fractionation, the latter being a characteristic that will be described later on in this section) which have a now confirmed influence on social sciences such as Sociology and Psychology, as evidenced by an earlier study[9] analyzing the side-effects of a complex compound when it comes to climate change communication and its numerous implications for present day society.

Prior to the analysis of engine emissions, in this context is deemed relevant to make a number of references to the Covid-19 pandemic and the consequent collapse of commercial aviation that followed, in particular with respect to the complexity of atmospheric chemistry it allowed to highlight. Globally, the disruption of aircraft operations resulted in notable atmospheric NO_x reductions which are well documented, and totally compromised long term predictions on worldwide air traffic growth, such as the environmental trends to 2050 by Fleming & de Lepinay (2019)[10] issued just one year prior to the pandemic. It is worth noting that research on the effects of aviation on climate change showed spatial variations depending on where operations occur, so the net effects may change locally; several uncertainties in estimations have been highlighted as well.[11] Air traffic reductions related to the Covid-19 outbreak are perhaps the most documented reduction of human activities during that period, as the others would be subject to gross uncertainties; therefore, airports may be considered a good environmental indicator for the major lockdowns that took place all over the world. Recent models created by Lee et al. (2021)[12] reported baseline values for methane radiative forcing sensitivity to aviation NO_x emissions, a result that was converted by Stevenson et al. (2022)[13] to a sensitivity of methane to a pulse change in aviation NO_x emissions of 1.12 ppb (parts per billion) $(CH_4)/Tg(NO_2)yr^{-1}$. These estimates indicate a tangible influence of NO_x emissions dropping to CH_4 levels, in accordance with past research from over a decade before. The broad effects of NO_x are such that recent research proposed a reduction of these emissions as more favorable compared to a slight increase in CO_2 emissions, a result that is hereby showed to demonstrate how the driving mechanisms of climate change and atmospheric pollution oftentimes rely on an intricate set of interactions between

8 Myhre, G.; Shindell, D.; Bréon, F.M.; Collins, W.; Fuglestvedt, J.; Huang, J.; Koch, D.; Lamarque, J.F.; Lee, D.; Mendoza, B.; Nakajima, T.; Robock, A.; Stephens, G.; Takemura, T.; Zhan, H. (2013). *Anthropogenic and Natural Radiative Forcing*. In: Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York.

9 D'Amico, F. (2023). *The "methane problem" as an ongoing challenge to climate change communication and understanding. When data estimate uncertainties become a social uncertainty*. Rivista internazionale di sociologia giuridica e diritti umani vol. 6, pgs. 81-96.

10 Fleming, G. & de Lepinay, I. (2019). *Environmental Trends in Aviation to 2050*. In: ICAO Environmental Report, 2019 Destination Green the Next Chapter. International Civil Aviation Organization. ICAO, Montreal.

11 Holmes, C.D.; Tang, Q.; Prather, M.J. (2011). *Uncertainties in climate assessment for the case of aviation NO*. Proceedings of the National Academy of Sciences 108 (27), pgs. 10997-11002.

12 Lee, D.S.; Fahey, D.W.; Skowron, A.; Allen, M.R.; Burkhardt, U.; Chen, Q.; Doherty, S.J.; Freeman, S.; Forster, P.M.; Fuglestvedt, J.; Gettelman, A.; DeLeón, R.R.; Lim, L.L.; Lund, M.T.; Millar, R.J.; Owen, B.; Penner, J.E.; Pitari, G.; Prather, M.J.; Sausen, R.; Wilcox, L.J. (2021). *The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018*. Atmospheric Environment 244, 117834.

13 Stevenson, D.S.; Derwent, R.G.; Wild, O.; Collins, W.J. (2022). *COVID-19 lockdown emission reductions have the potential to explain over half of the coincident increase in global atmospheric methane*. Atmospheric Chemistry and Physics 22, 14243–14252.

compounds, and the release (or increase) of certain emissions should not be regarded as an independent parameter. The climate altering balance tradeoff proposed by this research could eventually spark new advances in the development of sustainable fuels.

Speaking of methane, aircraft engines are confirmed to release certain quantities of this compound during idle, taxi, take-off, approach, and cruise phases, and its role in climate change is considerable, as remarked by Lee et al. (2009)[14] and other research groups. In general, with all released compounds considered, the climate change potential of aircraft is also related to side effects such as contrails, as reported by Burkhardt et al. (2010)[15] and others. Research on such impact has been performed in areas where domestic traffic is very heavy, such as the United States of America. Research on the local impact of air traffic on the environment is generally focused on LTO cycles, in accordance with the AAQM, while research on broader effects of air traffic also considers cruise phases.[16] In Europe, the currently available databases issued by regulators such as EASA[17] on air transportation safety and environmental impact use "HC" as a generic parameter for released hydrocarbons that includes, but is not limited to, methane. The parameters used by EASA provide information on the grams (g) of HC released per kilogram (kg) of fuel during different phases based on an Emission Index (EI), and they do so on a per-engine basis; for instance, a HC EI Idle (g/kg) of 4.6 for the CFM56-5B7/P engine, which is now out of production, indicates an emission of 4.6 grams of hydrocarbons per kilogram of fuel consumed when the engine is set to idle, a condition typical of the engine startup sequence, which normally lasts several minutes and precedes the taxi procedure, as well as holdings on ground due to nearby aircraft movements. Directives on airport air quality do specify "NMHC" (Non-methane Hydrocarbons) as released pollutants, but they're not quantified in EASA reports on engine outputs, thus making methane impossible to factor out by subtracting NHMC from HC data.

That said, before addressing into the detail the odds of several emission estimate uncertainties with respect to engine outputs, it is worth explaining what the main AAQM (and, consequently, ICAO) directives on engine emissions are based on in terms of computations. As per the referenced document, these emissions depend on three key parameters, which are Time-In-Mode (TIM), the Emission Index (EI) already mentioned before, and fuel flow through the main engine. Extra parameters include fleet sizes and types, as well as the number of operated aircraft movements, which both propagate the low-end values to higher scales, depending on traffic intensity. TIM is essentially the time period in minutes that satisfies the specific conditions by which the engines are operating at a given setting. The EI, as stated before, provides a value representing the mass of pollutant that is released per unit mass of fuel burned, classified by compound or category of compounds (NO_x, CO, and HC – note again how hydrocarbons are grouped into one category). A multiplication between the mode-specific EI and TIM-specific fuel flow results into the estimation of units of grams of pollutant per LTO. Consequently, modal emissions for a given aircraft *plus* engine combination are equal to TIM multiplicated by the amount of fuel used at a given power level, which is then multiplied by the EI (also at the related level), and the number of engines on the aircraft, which is generally equal to two. Inventories based on these methodology approaches are grouped by levels of detail and range from "simple" to "sophisticated", with "advanced" being the intermediate tier. "Hybrid" models combining characteristics of more than one approach exist, though the AAQM warns on a *caveat* when it comes to relying on such models.

Speaking of the accuracy of these estimates, a precise calculation of HC values emitted by aircraft movements and related activities would be nearly impossible to achieve: HC values are engine, not aircraft specific, and even in the context of

14 Lee, D.S.; Fahey, D.; Forster, P.M.; Newton, P.J.; Wit, R.C.N.; Lim, L.L.; Owen, B.; Sausen, R. (2009). *Aviation and global climate change in the 21st century*. Atmospheric Environment 43, pgs. 3520–3537.

15 Burkhardt, U.; Kärcher, B.; Schumann, U. (2010). *Global Modelling of the contrail and contrail cirrus climate impact*. Bulletin of the American Meteorological Society 91, pgs. 479–484.

16 Yim, S.H.L.; Lee, G.L.; Lee, I.H.; Allroggen, F.; Ashok, A.; Caiazzo, F.; Eastham, S.D.; Malina, R.; Barrett, S.R.H. (2015). *Global, regional and local health impacts of civil aviation emissions*. Environmental Research Letters 10, no. 3, 034001.

17 European Aviation Safety Agency (EASA) (2023). ICAO Aircraft Engine Emissions Databank (06/2023).

the same commercial operator, aircraft of the same type such as the Airbus A320 may have different engines mounted on them, so the analysis may have to be performed on a per-airplane basis, and precise registrations or tail numbers of aircraft are no longer available in the records after a given amount of time, normally set at two years by at least some regulators. Even if they were available, these estimations would not take into account the emissions caused by ground equipment and vehicles which rely on regular fuel whose combustion does release quantities of methane (*e.g.*, Ground Power Unit or GPU, Air Starter Unit or ASU, Air Conditioning Unit or ACU), which themselves are various in nature depending on the aircraft's technical conditions during transit (*e.g.*, a faulty Auxiliary Power Unit or APU would require the GPU and ASU be employed), airline, cargo loads (*e.g.*, cargo on commercial aircraft requires extra personnel and equipment for unloading/loading), aircraft type (*e.g.*, turboprop planes like the Bombardier Dash Q-400 require the GPU be connected during the first phase of engine start), PRM figures (Passengers with Reduced Mobility who require *ad hoc* equipment and vehicles for disembarkation and boarding), logistics and infrastructure (*e.g.*, remote stands require personnel and passengers be transferred via ground vehicles, instead of walking) and so on. As per the AAQM, these would all qualify as "Missing information" on local emissions: the absence of a precise log on these activities, as well as their integration with meteorological data, would lead to these emissions being ignored by inventories.

In purely operational terms, records do not provide precise information on the duration of engine running periods on ground, as on-block and off-block times may diverge from them depending on airline-specific operating procedures, technical issues, and operational ACARS (Aircraft Communication Addressing and Reporting System) devices. In this study, it is concluded that an extremely accurate estimation of emissions from aircraft, ground equipment and vehicles is not possible.

A case could be made that the integration of airports with advanced air quality and emission monitoring instruments, placed at key locations to cover most of the traffic or at least the most notable influence of local traffic, could at least overcome the reported uncertainties via quantitative data. Such monitoring efforts could indeed provide relevant information should certain thresholds be crossed for hours, but even in this case the uncertainties would be gross: unless the airport is built far away from its respective city, pollution levels would be affected by nearby industrial and urban activities, and even in the case of airports located far from urban/industrial areas, any spike detected at a given moment may not be necessarily connected to air traffic (wildfire and landfill emissions result into notable peaks, just to report two examples).[18] A possible solution would be an integrated monitoring system accounting for carbon isotopes, relying on the VPDB standard (Vienna Pee Dee Belemnite,[19] the shell of a Late Cretaceous belemnite cephalopod) to detect deviations from the 0‰ (*per mille*) value of both CH_4 and CO_2, the so defined $\delta^{13}CH_4$ and $\delta^{13}CO_2$ (delta carbon-13) parameters. However, not only are these instruments very expensive to implement – even the main atmospheric monitoring stations lack a total coverage of carbon isotope data on the atmosphere, so the extension of said network to airports would be a challenge under several points of view – but any detection at an airport would have to be reanalyzed and validated in order to consider observed $\delta^{13}CO_2$ and $\delta^{13}CH_4$ values attributable to natural processes, as well as anthropic processes distinct from aircraft emissions. A possible solution would be the integration of ^{14}C (carbon-14) measurements as an indicator of fossil versus present-day sources:[20] due to its radiogenic nature, ^{14}C tends to decay over the course of thousands of years, up to the point where it becomes nearly impossible to detect (this normally occurs after the equivalent of ten half-times, which are equivalent to approximately 57300 years – modern technology fails at detecting ^{14}C past this threshold). Fossil fuels, which are much older than that (their age is in the range of several dozen millions of years, at times hundreds of millions of years) are depleted in ^{14}C; with adequate analysis, it's therefore possible to distinguish CO_2 peaks derived,

18 Akagi, S.K.; Yokelson, R.J.; Wiedinmyer, C.; Alvarado, M.J.; Reid, J.S.; Karl, T.; Crounse, J.D.; Wennberg, P.O. (2011). *Emission factors for open and domestic biomass burning for use in atmospheric models*. Atmospheric Chemistry and Physics 11, issue 9, pgs. 4039–4072..

19 Craig, H. (1957). *Isotopic standards for carbon and oxygen and correction factors for mass-spectrometric analysis of carbon dioxide*. Geochimica et Cosmochimica Acta 12, issues 1–2, pgs. 133-149.

20 Zhang, G.; Liu, J.; Li, J.; Li, P.; Wei, N.; Xu, B. (2021). *Radiocarbon isotope technique as a powerful tool in tracking anthropogenic emissions of carbonaceous air pollutants and greenhouse gases: A review*. Fundamental Research 1, issue 3, pgs. 306-316.

for instance, from a wildfire affecting modern plants from the CO_2 released by aviation emissions, which relies on fuel totally depleted in ^{14}C. A continuous, integrated analysis accounting for all three main carbon isotope compounds would provide strategic details, except it's not impossible to implement with present-day technologies: standard $\delta^{13}CO_2$ measurements are still in their implementation phase throughout international networks of atmospheric monitoring, and ^{14}C evaluations require samples be collected and sent to laboratories for precise analyses, thus making a coordinated and instantaneous integration between the two methods all but impossible at this point. In addition to that, the AAQM does not include any mention of carbon isotopes as tools to differentiate emission sources around airports as guidelines for air quality indicators, and the broader academic research is lacking with respect to that, so standards and guidelines may have to be developed first. At the time of writing, in fact, not a single comprehensive study on a notable-scale employment of such standards with respect to ground-level aviation emissions has been reported.

If these extra technologies were to be implemented one day, depending on operating costs, human resources and instrument availability, they could mitigate "Error estimations" as intended by the AAQM when it comes to emission inventories. According to the document, these errors are divided into the subcategories of Measured, Calculated, and Estimated: the efficient integration of advanced atmospheric analyses, combined with meteorological and ATC data, could not only mitigate errors affecting inventories but could also provide insights and tools meant to improve the inventories themselves. For instance, in one hypothetical scenario by which the local CO_2 inventory levels at a given airport operating under regular conditions are systematically underestimated by ≈150ppm compared to observed values, research efforts could then be redirected to the estimation *vs.* observation anomaly and perhaps pinpoint the gap or error leading to that difference. That, in turn, could be used to upgrade the algorithm not only on a local scale, but also globally should the air traffic and environmental settings at that airport be somewhat relatable to other conditions elsewhere.

Restrictions on the accuracy of atmospheric measurements at airports may be overcome by the actual need behind the measurements themselves. In fact, it is recognized that continuous (or sporadic) measurements could be the result of a legal requirement at various levels, asking for an assessment of atmospheric pollution in a given area (this principle is applicable to various contexts other than airports – see core industrial areas, for example). Other reasons leading to more accurate measurements could have "voluntary" baselines as the driving factor behind them, in the form of airport authorities willing to perform more detailed analyses, or public concern over pollution levels in a given area (again, this may be applicable to a number of scenarios unrelated to aviation) that result into the central government funding these measurements. In an ideal scenario, these measurements would be performed globally, with standardized procedures, and their accuracy/frequency could be adjusted depending on the intensity of local air traffic (*e.g.*, busy airports may have to be monitored at a higher rate), as well as precise local meteorological conditions (*e.g.*, weak local wind circulation may lead to the accumulation of pollutants and, consequently, the need for continuous or more frequent evaluations), as well as the overall urban setting (*e.g.*, distance to, and population density of, urban centers). In addition to these procedures, which need to be discussed on a global scale, regulating factors such as the maximum amount of data gaps (*e.g.*, caused by lack of reports or unrepaired instruments) allowed before a sanction takes place, as well as precise legal requirements on the accuracy of reported data, need to be implemented. An integrated and well-regulated international network would then be beneficial for all authorities and countries involved, especially in terms of source apportionment (SA), a key tool by which emission sources can be detected. Right now, SA seems poorly developed in the context of atmospheric measurements at airports, for the reasons stated above.

Despite the gaps in source apportionment (SA) methodology, the AAQM however acknowledges the complexity of monitoring aviation-related emissions in geographic contexts where other emission sources are present: it is recognized, in fact, that the airport inventory – intended, by the AAQM, as a local scale source emission estimate – might constitute a "small percentage to the overall area emissions inventory". The same document also reports that railway systems and trains, though considered part of local emission sources due to their infrastructural relevance (sometimes, train

stations are perfectly integrated into airports, so the two sources coexist and each one of them has a direct influence on the other), are not covered by the document itself. This, combined with the odds of precise carbon compound analysis in atmosphere mentioned before, significantly contributes to the degrees of uncertainty that form up the core of this research paper.

Conclusions and perspectives

Via an integrated approach accounting for multiple fields of research and expertise, this research paper addressed the issue of airport air quality and the various uncertainties affecting estimates on levels ranging from local to global. In fact, via an *excursus* on global guidelines on the matter as well as their development over the course of the past few decades, where concerns over atmospheric pollutions have grown remarkably, plus the description of atmospheric measurement methods that are as of today not applied – or are applied sporadically – to air quality measurements at airports, the paper highlights the major key aspects of these uncertainties. In fact, environmental factors and local wind circulation are of remarkable interest when it comes to mounting pollution levels. Moreso, several aspects regulating air traffic on ground and at low altitudes, each adding up to the uncertainties of aviation-related emissions, are also reported. The erroneous concept by which the issues of air quality and aviation-related emissions, which are intertwined but not identical, is also addressed. The paper calls for a better integration of multiple disciplines, including – but not limited to – Atmospheric Physics/Chemistry, Aviation and Earth Sciences, as the key towards future estimates on the contribution of aviation to local-to-global pollution and emission levels. Some of the above mentioned integrations would require technological breakthroughs in the form of more cost-efficient and common carbon isotope detectors, while other aspects of the integration would require a higher amount of data on the management of aircraft on-ground be collected and collectively computed to optimize estimates. Finally, a coordinated effort on an international scale could share data and provide relevant insights on how to improve models, via a continuous trial and error methodology.

Regulatory Innovations from Hong Kong's Low-Altitude Economy (LAE) Governance

Zhiyu Xiang[*] *Luping Zhang*[**]

Introduction

Under aviation law, Low Altitude Economy (LAE) refers to economic activities in airspace below 1,000 meters, presenting a wide array of application scenarios including rescues, surveys, and delivery of goods and passengers. Formulating a management system for LAE will help drive development in areas such as telecommunication technologies, AI, and the digital industry, unlocking the low-altitude airspace as a new production factor for our economy.[1]

General aviation (GA) covers a wide range of civil aviation activities other than military, police, customs, anti-smuggling flights, and public air transport. It includes helicopters, electric vertical take-off and landing (eVTOL) aircraft, as well as agricultural aircraft and distribution drones, and LAE is part of it.[2]

China's State Council perceived the LAE as a strategic emerging industry and an impulse that prompts economic growth in 2010. By integrating cutting-edge technologies such as manned and unmanned aerial vehicles (UAVs), low-altitude activities encourage technological innovation and attract investment. As the core hub of the Guangdong-Hong Kong-Macao Greater Bay Area, Hong Kong's legal framework balances technological advancements and industrial innovations in the LAE under the "One Country, Two Systems" policy and regional coordination needs.[3] Based on the Civil Aviation Ordinance (Cap. 448) and the Small Unmanned Aircraft Order (Cap. 448G), Hong Kong has established a dual-track framework integrating traditional regulations with an innovative regulatory sandbox project. For emerging applications like drone delivery and eVTOL passenger transport, the "Regulatory Sandbox" mechanism allows enterprises to conduct innovative trials, such as beyond-visual-line-of-sight (BVLOS) operations and payload capacity tests in designated airspaces. This approach collects data to inform legislative updates. For instance, the first 38 pilot projects launched in 2025 cover logistics and emergency response, with companies like SF Express and Meituan providing an empirical basis for optimizing exemptions under the Small Unmanned Aircraft Order.

This article initiates its analysis by examining Hong Kong's existing policy and legal framework governing the LAE and investigating its current governance system. Subsequently, it summarizes the Hong Kong SAR's unique governance innovations within LAE policymaking. Finally, the paper proposes actionable pathways for refining Hong Kong's LAE legal regime through a comparative analysis with parallel initiatives in Mainland China.

1. Defining LAE

1.1. Background of LAE

The concept of an LAE in China dates back to 2010, when the State Council and the Central Military Commission jointly issued the Opinions of the State Council and the Central Military Commission on Deepening the Reform of China's

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1 Hong Kong Special Administrative Region Government, The Chief Executive's 2024 Policy Address [EB/OL]. https://www.policyaddress.gov.hk/2024/en/p81.html, 2024.

2 Liu, Shuang, Mingming Liu. *Research on the Security Risk Governance Roadmap in Low-Altitude Economic Field Based on the Economic Externality Theory*, Engineering Proceedings, 2024.

3 The "one country, two systems" policy means that under the premise of one China, Hong Kong, Macao and Taiwan maintain their existing system of capitalism for a prolonged period of time as special administrative regions, while socialism is the prevailing system of the mainland. Internationally, however, the PRC alone represents China.

Low-altitude Airspace Management (2010). This policy proposed opening airspace below 1,000 meters for general aviation activities and initiating regional classification pilots. In 2021, the National Comprehensive Three-Dimensional Transportation Network Plan (2021) formally recognized the LAE as a strategic emerging industry, elevating it to national priority. In 2024, China's Central Government incorporated LAE into the Government Work Report (2024) for the first time.[4]

China first proposed the concept of the LAE, but similar industry models existed abroad much earlier. The global development of the LAE has gone through two main stages. The first stage was early exploration, that is, from the 18th century to 2006, focusing on low-altitude tourism and experimental industrial and agricultural applications. The second stage was standardized development, that is, from 2006 to 2020, and was marked by the gradual introduction of regulatory frameworks. After 2021, driven by worsening ground traffic congestion, advancements in low-altitude aircraft technology, and improved legal systems, new applications such as air taxis and drone delivery have expanded the potential of the LAE. These developments are accelerating its transition into widespread practical use. Currently, the global LAE industry is in a phase of widespread adoption, with economies worldwide focused on exploring and diversifying application scenarios. [5]

The United States leverages its competitive market-driven general aviation foundation to seize early opportunities in low-altitude economic development. As a global leader in this field, it operates over 5,000 general aviation airports and maintains a fleet of more than 200,000 registered aircraft. The sector employs over 800,000 pilots and contributes over 0.5% to the national GDP.[6] Market forces drive innovation across industries such as agricultural plant protection, logistics, energy, and defense. Companies like Joby Aviation, Wisk Aero, and cc lead in developing drone technologies. The Federal Aviation Administration (FAA) continuously updates regulations to ensure safe and sustainable growth, solidifying U.S. leadership in the sector.[7]

Japan promotes its LAE through coordinated government planning, corporate engagement, and technological innovation. The government has implemented policies to expand drone usage across industries, with a major focus on introducing flying cars during the 2025 Osaka World Expo. Companies such as Honda and Toyota collaborate with research institutions like the Japan Aerospace Exploration Agency (JAXA) to develop drones and eVTOL aircraft for human transport. [8] Current applications span logistics delivery, crop monitoring, and disaster response operations. New use cases are emerging, including offshore oil rig maintenance, helicopter services for port operations, and cross-border air mobility solutions.

The European Union emphasizes diverse applications in its LAE strategy. Focus areas include airport operations, air traffic management, airspace coordination, and aviation infrastructure. Germany leads the EU with a social-market model that balances industrial and logistics needs with strict regulations. The country simplifies drone registration processes, invests in technology, and supports companies like Volocopter and Lilium to advance innovations such as air taxis and manned aerial vehicles. Strict airspace laws ensure safety while accelerating commercial adoption in urban mobility and specialized use cases.[9]

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4 Mingming Liu, Liu Shuang. *Comparative Study on the Legal Supervision System of Low-Altitude Aircraft in China and Europe Based on Key Risks*, Engineering Proceedings, 2024.

5 Zhang Xiaolan, Huang Weirong. *Development of low-altitude economy: Global trend, China's current situation, and promotion measures*, Economic Review, 2024.

6 Federal Aviation Administration (FAA). 2024 Active Civil Airmen Statistics [EB/OL]. https://www.faa.gov/data_research/aviation_data_statistics/civil_airmen_statistics.

7 Federal Aviation Administration (FAA). FAA Regulations [EB/OL]. https://www.faa.gov/regulations_policies/faa_regulations.

8 空の移動革命に向けた官民協議会. "空飛ぶクルマ"の実現に向けたロードマップを取りまとめました[EB/OL]. https://www.meti.go.jp/policy/mono_info_service/mono/robot/181220uamroadmap.html.

9 EASA. Urban air mobility (UAM)[EB/OL]. https://www.easa.europa.eu/en/domains/drones-air-mobility/drones-air-mobility-landscape/urban-air-mobility-uam.

The above-mentioned developments in global LAE highlight varied strategic approaches, with technological innovation, regulatory agility, and cross-sector collaboration shaping the race for low-altitude economic leadership.

1.2. Development of LAE in Hong Kong

The Government of Hong Kong Special Administrative Region established the Working Group on Developing Low-altitude Economy ("WG"), which formulates development strategies and inter-departmental action plans, starting with projects on low-altitude applications. Based on the Basic Law of the Hong Kong Special Administrative Region of the People's Republic of China and relevant regulations, the WG will designate specific enterprises for such purposes, draw up regulations and design the institutional set-up, and study and map out plans to develop the required infrastructure and networks.[10] The measures focus on:

- **Exploring low-altitude flying application scenarios:** The WG prioritizes systematic exploration of scenarios through pilot projects (LAE Regulatory Sandbox) and cooperates with enterprises to test and deploy drones for delivery, surveys, building maintenance, aerial photography, performances, search, rescue, and explore other possibilities;

- **Policy adjustment:** The WG plans to loosen drone weight and loading limits and BVLOS restrictions, encourage market research and investment, conduct technological experiments, and develop aerial tours;

- **Intensify bond with the Mainland:** The Authorities of Hong Kong and the Mainland will explore the joint establishment of low-altitude cross-boundary air routes, immigration and customs clearance arrangements, and supporting infrastructure; and

- **Improve low-altitude infrastructure:** A highly effective, intelligent, and digitalized low-altitude infrastructure system is necessary for the real-time management of networks of low-altitude activities in the long run. The WG committed to commencing technical studies and planning support facilities for low-altitude activities, a communications network, an air route network, management of low-altitude flying activities, and so on to lay the foundation for the LAE.

In short, the measures of the WG are designed to draw up a comprehensive regulatory framework and institutional architecture that systematizes low-altitude applications through pilot projects in key domains like delivery and infrastructure inspection. This approach covers phased experimentation, policy adaptation, regional synergy, and foundational digitization to create an end-to-end ecosystem for sustainable LAE development.

2. Overall Legal Framework of Hong Kong's LAE

Hong Kong's current legal framework for LAE primarily comprises administrative and legislative components. Administratively, the government adopts a top-down approach by establishing task forces and project teams with specific mandates. These entities collaborate with industry stakeholders, research institutions, and academic organizations to advance multi-domain initiatives, including airworthiness certification, safety regulation, supporting legislation, and cross-border cooperation.[11]

10 *Supra* note 1.

11 Legislative Council of the Hong Kong Special Administrative Region. Promoting low-altitude economy in Shenzhen and the United States. [EB/OL]. Promoting low-altitude economy in Shenzhen and the United States.

Legislatively, the legal system for LAE operates within the constitutional framework of the Basic Law and is further structured by specialized legislation such as the Civil Aviation Ordinance (Cap. 448), supplemented by dynamic regulatory instruments and cross-border coordination mechanisms. The legal instruments establish legal safeguards for LAE activities, ensuring compliance and risk mitigation. In practice, it updates obsolete legal provisions and continuously refines laws and regulations to adapt to emerging societal needs, thereby maintaining alignment with technological advancements and operational realities. This framework ensures both regulatory agility and legal certainty, positioning Hong Kong as a hub for safe and innovative LAE development.

2.1. Legal System of Hong Kong's LAE

2.1.1. Basic Law

The Basic Law of the Hong Kong Special Administrative Region provides fundamental guarantees for developing Hong Kong's legal framework for its LAE. All local regulations must align with the Basic Law. Articles 128 to 135 of the Basic Law explicitly grant Hong Kong a high degree of autonomy in civil aviation affairs, including the authority to formulate local aviation regulations, manage airspace resources, and engage in international civil aviation affairs. Specifically, Article 130 empowers Hong Kong to independently establish aircraft registration and airworthiness standards, which legitimizes provisions such as graded categorization and mandatory insurance requirements under the Small Unmanned Aircraft Order (Cap. 448G).[12]

Moreover, under the "*one country, two systems*" policy, the Basic Law establishes a constitutional foundation for legal coordination between Hong Kong and the mainland. For instance, through the Agreement for the tripartite collaboration on the development of air space in the Guangdong-Hong Kong-Macao Greater Bay Area (2019), Hong Kong and mainland authorities have created a cross-border interoperability mechanism for drone airworthiness certification. This allows Category B drones (7–25 kg) certified in Hong Kong to operate directly within the Greater Bay Area airspace. The legal validity of such mechanisms stems from the Basic Law's role in harmonizing Hong Kong-Central Government relations, ensuring that cross-border cooperation in low-altitude economic initiatives adheres to national strategies while respecting Hong Kong's unique local context.

By addressing systemic legal design challenges, the Basic Law provides constitutional safeguards for the long-term development of Hong Kong's LAE. It ensures alignment with technological innovation and regional integration goals while upholding legal authority and stability.

2.1.2. Civil Aviation Ordinance (Cap. 448)

The Civil Aviation Ordinance (Cap. 448) serves as the core foundational legislation within Hong Kong's civil aviation legal framework. While it does not directly regulate specific scenarios of the LAE, it provides structural and principled support through its delegated legislative framework and overarching provisions.

Section 2A: This clause translates ICAO rules into Hong Kong's domestic law, empowering the Chief Executive in Council to enact necessary or expedient subsidiary regulations. Its objectives include implementing the Chicago Convention, enforcing International Standards and Recommended Practices (SARPs) established by ICAO (including its annexes and amendments), and regulating air navigation through detailed technical oversight of aircraft operations, airspace management, and airport operations.[13]

12 The Basic Law of the Hong Kong Special Administrative Region of the People's Republic of China, art. 130.
13 Civil Aviation Ordinance (Cap. 448), art. 2A.

Section 12(2): This subsection embodies flexibility in supplementary provisions and executive directives. It clarifies that regulations or orders may include "incidental and supplementary provisions", granting the Chief Executive authority to issue context-specific directives tailored to practical needs.[14]

Section 12(3): This provision establishes the legal validity of directives issued under regulations or orders. It ensures that references to regulations or orders inherently include their associated directives (where contextually appropriate), thereby granting enforcement agencies operational flexibility and reflecting a dynamic legislative approach adaptable to evolving technological and industrial demands.[15]

By integrating international compliance, technical precision, and adaptive governance, the Civil Aviation Ordinance provides a robust yet agile legal foundation for Hong Kong's LAE, balancing regulatory authority with innovation-driven growth.

2.1.3. Small Unmanned Aircraft Order (Cap. 448G)

The Small Unmanned Aircraft (SUA) Order is a subsidiary regulation enacted under Chapter 448 of the Hong Kong Civil Aviation Ordinance by the Hong Kong government to harness the vast application potential of drones while safeguarding aviation and public safety. This regulation establishes a comprehensive governance framework for small unmanned aircraft. The Civil Aviation Department of Hong Kong (HK CAD) defines drones as *"power-driven aircraft weighing 25 kg or below which are operated without any pilot onboard, which include drones, model aircraft (fixed wing or helicopters), etc."*[16]

The core provisions of the Order include categorization and classification management, operational restrictions and safety requirements, and registration and accountability mechanisms. Drones are classified into three categories (A1, A2, and B) based on weight, with corresponding rules and limitations on registration exemptions, flight altitude, speed, insurance, and operator training. Detailed regulations are also stipulated for restricted flying zones, flight conditions, technical compliance, drone registration, and operator qualifications.[17] Under the new regulatory regime following the commencement of the SUA Order on 1 June 2022, SUA operations are regulated under a risk-based approach. Based on the weight of the SUA and the operational risk level, SUA operations of different risk levels are subject to the corresponding regulatory requirements. These requirements include registration and labelling of SUA, registration of remote pilots, training and assessment, equipment, operating requirements and insurance. While SUA operations of 250g or below are, in general, subject to operating requirements only, prior permission from HK CAD will be required for advanced operations involving higher risk.

The SUA Order fills gaps in traditional aviation regulations, providing a compliance pathway for applications such as drone logistics, inspections, and emergency rescue operations. It aligns with international standards to ensure Hong Kong's rules remain globally compatible and facilitate cross-border collaboration. To advance LAE pilot projects, the Order periodically launches initiatives allowing enterprises to conduct technical trials in designated airspaces with exemptions from specific clauses. Additionally, it defines offenses related to SUA operations, classifying dangerous drone activities as criminal acts. This enforcement approach is stricter than mainland China's model, which primarily relies on administrative penalties.

14 *Ibid.*, art. 12(2).
15 *Ibid.*, art. 12(3).
16 Civil Aviation Department of Hong Kong. Overview of the Small Unmanned Aircraft (SUA) Order [EB/OL]. https://www.cad.gov.hk/english/sua.html.
17 Small Unmanned Aircraft Order (Cap. 448G), art. 2.

In summary, the Small Unmanned Aircraft Order balances flight safety and industrial innovation, constructing a legal framework for the LAE through three pillars: categorized regulation, criminal deterrence, and sandbox innovation. Its dynamic revision mechanisms and cross-border collaboration practices not only reinforce Hong Kong's status as an international aviation hub but also establish a Hong Kong paradigm for global LAE legislation.

2.2. Administrative Measures Regarding LAE

2.2.4. LAE Regulatory Sandbox ("Sandbox")[18]

The Low-altitude Economy Regulatory Sandbox ("sandbox") is an application of the regulatory sandbox concept in the LAE sector. A regulatory sandbox is a novel regulatory tool that originated in the fintech sector in the UK. In November 2015, the UK Financial Conduct Authority (FCA) released a report proposing the feasibility of implementing a regulatory sandbox for fintech innovation. By April 2016, the FCA formalized its sandbox framework, outlining entry criteria and application procedures. The first batch of 24 companies began testing in November 2016, with multiple application rounds following. Since August 2021, the UK has adopted a permanent application system.[19]

Initially designed to address fintech regulatory challenges, this approach has been widely adopted globally and extended to emerging technologies like public health and energy. As an experimental governance method, the sandbox balances technological advancement with risk control. It creates a "safe place" where companies can test innovative products and services under relaxed regulations without penalties for legal incompatibility, while consumer rights remain protected through dedicated risk prevention measures.

The regulatory sandbox has evolved into a global tool for testing emerging technologies while managing risks. This experimental governance method creates a "safe space" where companies can trial innovative products under relaxed rules without legal penalties, provided consumer protections remain intact. Applied to the LAE, the sandbox framework allows controlled testing of drone operations in designated airspaces, focusing on airspace management, infrastructure design, and safety standards like collision avoidance and system resilience. It enables real-world trials with monitored conditions to support adaptive policy development for aviation safety and cross-border collaboration, such as testing customs protocols and scalable technologies. The model reduces industry costs through practical data collection and user feedback while promoting regional regulatory alignment and globally compatible solutions, as seen in Hong Kong's cargo drone trials and cross-border logistics networks. The table below shows part of the first batch of the regulatory sandbox pilot projects.

18 Transport and Logistics Bureau. Low-altitude Economy Regulatory Sandbox ("Sandbox") [EB/OL]. https://www.tlb.gov.hk/eng/highlights/transport/low-altitude.html.

19 Emily Leckenby, Dalia Dawoud, Jacoline Bouvy, Páll Jónsson. *The Sandbox Approach and its Potential for Use in Health Technology Assessment: A Literature Review*. Applied Health Economics and Health Policy, 2021.

Table 1- Part of the First batch of the Regulatory Sandbox Pilot Projects

	Applicant	Details
1.	**5G nuMultiMedia Limited**	Collaborating with DAMODA UAV (HK) Company Limited
2.	**Aerovision Technology Limited**	Collaborating with i. China Merchants Godown, Wharf, & Transportation Co., Ltd; ii. Hong Kong Polytechnic University; iii. Flight Pro Drone Solutions; iv. HK Model Engineering Club
3.	**Alpha AI Technology Limited**	One application in collaboration with i. HKT Limited; ii. U Resonance Limited; iii. Hong Kong Cyberport Management Company Limited; iv. Hong Kong Science & Technology Parks Corporation; v. Auki Labs Limited; vi. Ricoh Hong Kong Limited is selected.
4.	**China Mobile Hong Kong Company Limited**	Two applications. One application is in collaboration with i. Hospital Authority (Princess Margaret Hospital/ Tseung Kwan O Hospital); ii. Greater Bay Area Low Altitude Economy Alliance iii. 杭州送吧物流科技有限公司; iv. Esri China (Hong Kong) Limited; v. The University of Hong Kong One application is in collaboration with i. Auxiliary Medical Service; ii. Greater Bay Area Low Altitude Economy Alliance; iii. 杭州送吧物流科技有限公司; iv. Esri China (Hong Kong) Limited
5.	**Civil Engineering and Development Department**	-
6.	**CLP Power Hong Kong**	-
7.	**Correctional Services Department**	Collaborating with Electrical and Mechanical Services Department
8.	**DAMODA UAV (HK) Company Limited**	Collaborating with Shenzhen DAMODA Intelligent Control Technology Co., Ltd.

2.2.5. Working Group on Low-altitude Economy ("WG") as an Institutional Support20

In the 2024 Policy Address, the Chief Executive announced the establishment of the Working Group on Developing Low-altitude Economy ("WG") to formulate strategic frameworks and inter-departmental action plans for advancing Hong Kong's LAE. Under the WG, a Project Facilitation Task Force ("TF") has been established to address technical challenges associated with LAE implementation, with a specific focus on managing the LAE Regulatory Sandbox ("Sandbox") initiatives. Led by the Deputy Financial Secretary, the TF's mandates encompass four priority areas: developing comprehensive strategies for LAE growth; coordinating pilot projects such as drone logistics and cross-border applications; advancing regulatory reforms including revisions to flight restrictions and payload standards; and aligning infrastructure development such as vertiport construction and communication network upgrades with emerging technological trends. Additionally, the TF oversees regional collaboration efforts to integrate airspace management systems with the Greater Bay Area while promoting research and development in critical fields including hydrogen-powered drones and intelligent navigation systems.

3. Challenges and Experience from Hong Kong's LAE Governance

Hong Kong's pursuit of an LAE reflects a strategic effort to integrate emerging technologies like drones and eVTOL vehicles into its urban fabric. This initiative combines governance innovation with practical challenges, shaped by the city's unique geopolitical context and high-density environment. Below is an analysis structured into governance experiences and persistent obstacles, drawing from recent policy experiments and implementation barriers.

3.1. Challenges in Hong Kong's LAE Development

3.1.1. Cross-Border Coordination Complexities

As a densely populated and highly urbanized international metropolis, Hong Kong faces major challenges in planning flight routes and managing airspace. First, its close proximity to Shenzhen and Macao (two regions with separate administrative systems) requires creating cross-border regulations, industry standards, and approval processes for low-altitude operations from the ground up. This demands extensive coordination. Differences in airspace classification rules, such as definitions of Class G and Class W airspace, and conflicting approval processes between Hong Kong's Small Unmanned Aircraft Order and mainland China's Operational Safety Management Rules for Civil Unmanned Aircraft have slowed progress in streamlining cross-border logistics routes.

Second, the lack of unified global standards for Advanced Air Mobility (AAM) systems under frameworks like ICAO, IATA, and the Civil Aviation Administration of China (CAAC) has further complicated coordination. While ICAO formed the AAM Study Group in 2023 to advance standardization, key rules for communication, navigation, surveillance, and airspace management remain fragmented across regional pilots.[21] For instance, Hong Kong's Class A "Visual Flight Zones" allow unrestricted flight below 120 meters, while Shenzhen's Class W "Dedicated Drone Airspace" mandates route approvals, leading to overlapping jurisdictions in shared airspace.

Divergent airspace rules also risk legal conflicts. In 2019, launching cross-border helicopter routes by Heli-Eastern required coordination with over ten agencies, including the PLA Air Force Joint Staff Department, CAAC, Shenzhen Municipal Government, Hong Kong Chief Executive's Office, Civil Aviation Department, customs, immigration authorities, and

20 Transport and Logistics Bureau. Working Group on Developing Low-altitude Economy [EB/OL]. https://www.tlb.gov.hk/eng/boards/transport/lowaltitude/index.html.

21 Raza Waleed, Justus Renkhoff. *Advanced Air Mobility: Innovations, Applications, Challenges, and Future Potential*, Journal of Air Transportation, 2025.

airports. This underscores the bureaucratic complexity of cross-border operations.[22]

3.1.2. Regulatory Gaps in Noise Pollution Control

Hong Kong's current legal framework lacks localized noise decibel thresholds tailored to low-altitude operations. While the Environmental Protection Department (EPD) classifies noise pollution into four categories, with aircraft noise regulated by the HK CAD, the existing rules focus primarily on mitigating noise impacts near airports. This narrow scope overlooks potential disturbances caused by drones in residential areas beyond airport vicinities.

To be specific, locally designed rules, such as noise control thresholds under its Civil Aviation (Aircraft Noise) Ordinance (Cap. 312) and Civil Aviation (Aircraft Noise) (Certification) Regulations (Cap. 312A), currently adopt generalized ICAO Annex 16 standards. These rules do not address the city's unique challenges, such as noise reflection from high-rise buildings and crowded residential areas. Additionally, there are no specific laws to regulate noise from small drones. Existing regulations focus only on traditional aircraft, leaving unmanaged drone noise in urban areas.

For example, eVTOL operations generating over 80 decibels during takeoff and landing, a level comparable to heavy truck traffic, risk triggering public backlash in neighborhoods. Yet no tiered restrictions or adaptive zoning exist to address this issue. Without tailored solutions, such regulatory misalignment could stifle innovation while failing to protect urban livability.[23]

3.2. Hong Kong's Governance Experience in LAE

Hong Kong has pioneered a series of governance experiments to navigate the complexities of LAE development, leveraging its "one country, two systems" framework and common law tradition to balance regulatory innovation with institutional stability. These experiments exemplify a hybrid governance model that integrates strategic agility, cross-border interoperability, and public-private co-creation.

3.2.3. Regulatory Sandbox as an Innovative Pilot Project

The LAE Regulatory Sandbox, administered by the Working Group on Developing Low-altitude Economy ("WG"), serves as a cornerstone of Hong Kong's experimental governance. By granting temporary exemptions under the Air Transport (Air Service Licences) Regulations (Cap. 448A), the sandbox allows firms to test disruptive technologies, such as BVLOS drone logistics and urban air mobility (UAM) corridors, in real-world scenarios. For instance, the 2025 pilot project led by SF Express trialed cargo drones between Hong Kong's Cyberport and St. John Hospital, bypassing conventional aviation rules through a "data-for-compliance" mechanism. Operators submitted real-time noise profiles and collision-avoidance logs, which directly informed revisions to the Small Unmanned Aircraft Order (Cap. 448G), expanding weight limits and refining nighttime flight protocols. This iterative process transforms regulatory uncertainty into evidence-based policy-making, positioning Hong Kong as a testbed for global AAM standards.

Unlike other regulatory sandboxes, which rely on policy adjustments, this sandbox operates as temporary legislation. This legal approach addresses the strict, inflexible regulations governing low-altitude aircraft in most jurisdictions, where regulators lack discretionary power. By balancing technological innovation with risk control, this framework meets the needs of LAE development and accelerates the commercialization of aircraft.

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22 Heli-Eastern. 粤港跨境直升机航线开通，东部通航获得中国001号跨境飞行许可[EB/OL]. https://www.szdbth.com/gongsiyaowen/121.html, 2019.

23 Luo Can. *The Civil Unmanned Aerial Vehicle (UAV) Law of China: A Comparative Study of the Mainland, Hong Kong, and Macao*, The Regulation of Automated and Autonomous Transport, Cham: Springer International Publishing, 2023.

The Regulatory Sandbox serves as a dynamic policy incubator and risk mitigation tool. It bridges gaps between static regulations and rapid technological advancements by providing empirical data to refine laws like the Small Unmanned Aircraft Order (Cap. 448G). For instance, flight data on multi-drone operations or GNSS stability in Hong Kong's dense urban environment directly informs updates to technical standards and operational limits. Additionally, the sandbox validates cross-border protocols, ensuring alignment with the Agreement for the tripartite collaboration on the development of air space in the Guangdong-Hong Kong-Macao Greater Bay Area (2019) and addressing jurisdictional complexities.

By testing emergency response measures and infrastructure compatibility, it strengthens legal safeguards while fostering innovation. This mechanism not only enhances regulatory agility but also positions Hong Kong as a global model for balancing safety and technological progress in LAE governance.

3.2.4. The Experience from Shenzhen's Legislation

Shenzhen is China's first city to systematically govern its LAE through specialized regulations. Unlike most regions in the country that still rely on policies, Shenzhen enacted the Regulations of Shenzhen Special Economic Zone on Promoting Low-altitude Economy (2024). This regulation transforms policy goals into legally binding obligations, creating a two-way framework where policies and regulations reinforce each other. Shenzhen's pioneering experience in constructing a policy-legal synergy mechanism offers critical insights for Hong Kong's LAE governance.[24] This model ensures that sectoral priorities such as industrial coordination mechanisms, enterprise cultivation, and infrastructure digitization are translated into actionable legal obligations.

The Shenzhen Regulation mandates municipal authorities to collaborate with air traffic management agencies in constructing a unified digital platform for low-altitude flight management. This system operationalizes the strategic goals outlined in Shenzhen's earlier policy documents. By 2023, the city had already developed over 20 national and industry standards for low-altitude manufacturing and airspace management, which the 2024 Regulation subsequently institutionalized. Furthermore, while prior policies emphasized financial support for research and development, the Regulation legally compels district governments to allocate funding for standard-setting and experimental verification platforms. This approach embeds policy continuity into law, offering Hong Kong a replicable model to ensure long-term stability through codified fiscal and technical commitments.

For Hong Kong, Shenzhen's experience underscores three actionable strategies: First, with regard to legislative-policy alignment, by mirroring Shenzhen's dual-track model, Hong Kong should synchronize its LAE Promotion Act with administrative guidelines like the Guangdong-Hong Kong Low-Altitude Data Corridor Initiative, ensuring policy flexibility is anchored by legal accountability.

Second, to integrate data governance, the Hong Kong government may adopt Shenzhen's practice of linking municipal digital platforms with national regulatory systems. Hong Kong's proposed Joint Low-Altitude Rules Laboratory could serve as a nexus for translating sandbox-tested technical parameters into ICAO-aligned airworthiness standards.

Third is the harmonization of cross-border standards. Leverage Shenzhen's success in setting more than 20 national standards to develop Hong Kong-specific technical norms, while ensuring compatibility with mainland China's General Aviation Equipment Innovation Application Implementation Plan (2024–2030).

24 Shenzhen Municipal People's Government. Regulations of Shenzhen Special Economic Zone on Promoting Low-altitude Economy [EB/OL]. Shenzhen Municipal Justice Bureau. https://sf.sz.gov.cn/ztzl/yhyshj/yhyshjzcwjywyb/content/post_12080330.html, 2025.

3.2.3 Meituan's UAV Certification

In April 2025, Meituan's fourth-generation self-developed drone passed the Civil Aviation Administration of China (CAAC) review, securing China's first nationwide Remotely Piloted Aircraft Systems Air Operator Certificate (RPAS AOC) for low-altitude logistics.[25] This certification allows the company to operate commercial drone services across all regions of China, including urban, mountainous, and island areas. The AOC grants three core privileges: autonomous route planning below 120 meters without individual approvals, 24/7 operations using AI-powered obstacle avoidance systems for night flights, and real-time compliance monitoring via integration with the National Low-Altitude Regulatory Platform.

Meituan's achievement demonstrates how legal frameworks can adapt to technological innovation. For Hong Kong, this milestone emphasizes the need to align its common law flexibility with mainland China's regulatory scale to build a collaborative governance model for low-altitude economies. Three lessons are critical for Hong Kong's legal development:

Firstly, scholars propose enacting a LAE Promotion Act to consolidate Hong Kong's fragmented regulations, currently spread across multiple laws like the Civil Aviation Ordinance (Cap. 448).[26] A unified law would clarify strategic priorities and improve regulatory coherence.

Secondly, Meituan's integration with mainland regulatory platforms highlights the necessity for data interoperability between Hong Kong and Shenzhen. Creating a Guangdong-Hong Kong Low-Altitude Data Corridor could streamline compliance checks and reduce approval redundancies.

Lastly, Meituan's success supports using regulatory sandboxes to test localized adaptations of proven technologies, such as AI obstacle avoidance systems and drones with 83 km/h cruising speeds. Hong Kong's proposed Joint Low-Altitude Rules Laboratory could accelerate such adaptations, ensuring global competitiveness while addressing local needs.

Conclusion

Hong Kong's low-altitude economy is deeply rooted in its unique legal framework, which strategically blends regulatory rigor with adaptive innovation. At its core lies a multilayered system anchored by the Small Unmanned Aircraft Order, which governs drone operations, while a regulatory sandbox enables real-world testing of advanced technologies like hydrogen-powered drones and cross-border logistics. Building on this foundation, Hong Kong collaborates with mainland authorities through initiatives such as the Agreement for the tripartite collaboration on the development of air space in the Guangdong-Hong Kong-Macao Greater Bay Area (2019), harmonizing airspace management across jurisdictions. This structure not only preserves the city's common law traditions but also demonstrates remarkable flexibility in adapting to rapid technological advancements, ensuring alignment with global standards while fostering localized experimentation.

The legal system's strengths are amplified by its common law heritage, which allows courts to address emerging challenges from liability disputes to data privacy concerns through dynamic case law rather than rigid statutes. For instance, precedents in aviation and logistics law provide clarity for drone-related insurance claims, reducing compliance burdens for businesses. Equally critical is Hong Kong's proactive engagement in shaping international norms, as seen in its participation in ICAO's regulatory drafting and the integration of EU airworthiness standards into local laws. Moreover, the "one country, two systems" policy enables innovative cross-border governance models, such as the Shenzhen-Hong

25 Meituan. 美团无人机香港首飞！翻山跨海的配送难题有了新解法[EB/OL]. https://mp.weixin.qq.com/s/xkpytfI1jCjvOGmW_6csnw, 2025.
26 Wang Xueying, Gao Guozhu, Gu Lilan, Su Dan. *Research on the legal system to promote the development of low-altitude economy in China*, Information and Communications Technology and Policy, 2024.

Kong Loop Area pilot, where shared data and blended policies create a testing ground for regional integration. These features collectively position Hong Kong as a bridge between global standards and localized innovation.

Looking ahead, Hong Kong must prioritize comprehensive legislation, such as a dedicated Low-Altitude Economy Promotion Act, to unify fragmented regulations and address gaps in airspace rights and infrastructure planning. Simultaneously, advancing technical leadership through partnerships with bodies like ISO could establish Hong Kong-developed standards for smart air traffic control and anti-drone systems as global benchmarks. Equally vital is strengthening risk governance through mandatory insurance frameworks and blockchain-based flight data systems, alongside community-focused policies to ensure public trust. By balancing regulatory foresight with technological agility, Hong Kong can transition from a “super connector” to a global rule-setter, offering scalable solutions for low-altitude governance while reinforcing its role as a hub for sustainable urban innovation.

Competition Concerns Under the Single African Air Transport Market

William Kiema *

Abstract

This paper examines the challenges and prospects of competition regimes in the African air transport industry. The paper contextualises competition law and policy within the African air transport industry and interrogates the major competition concerns in the African air transport industry. The paper subsequently analyses the effectiveness of the normative and institutional framework underpinning competition in the African air transport industry, focusing on Annex 5 to the Yamoussoukro Decision titled 'Regulations on Competition in Air Transport Services within Africa'. The paper interrogates the challenges and prospects of competition regulation under Annex 5, within the context of the absence of a global aviation competition framework, fragmented regional regimes and under-enforced domestic competition laws in Africa. The paper maps out the regional and continental priorities to address competition concerns in air transport and argues that the successful realisation of the Single African Air Transport Market largely depends on an appropriate implementation approach for the Annex.

1. Introduction

The aviation industry presents a unique challenge to competition authorities due to its complex economic characteristics.[1] Oligopolistic market structures often characterise the industry, posing a significant challenge to applying general competition rules.[2] While these challenges manifest differently depending on the regulatory and market context, common issues such as limited market entry, airline alliances, and state intervention complicate competition enforcement globally. Unlike other sectors where lower barriers to entry foster competition, aviation involves substantial fixed costs related to fleet acquisition, maintenance, and access to critical infrastructure such as airports and air traffic control systems.[3] This naturally leads to market concentration, with a few dominant players controlling significant shares.[4] The industry is also characterised by significant economies of scale and reliance on strategic national and international routes, all of which distinguish it from other sectors.[5] The global nature of the aviation industry, involving international air transport agreements, Bilateral Air Service Agreements (BASAs), further complicates the regulatory landscape.[6] In addition to these market-specific challenges, the aviation sector is deeply intertwined with public interest considerations. Governments frequently intervene in the market in pursuit of non-market objectives such as the protection of national carriers, connectivity to remote regions, state prestige, growth of trade routes, and other priorities that extend beyond pure economic efficiency.[7] Most competition regulations focus on economic efficiency and consumer welfare and may not fully capture these broader policy objectives, potentially leading to conflicts between national interests and competition rules.[8]

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1 Zhou W, 'Competition and Development in the Aviation Industry: An Analysis of Strategic Adaptability and Challenges' (2024) <http://www.theseus.fi/handle/10024/855814> accessed 24 July 2025.

2 Doganis R, *Flying Off Course: Airline Economics and Marketing* (5th edn, Routledge 2019).

3 Paelo A and Vilakazi T, 'Barriers to Entry for Low Cost Carriers in the South African Airline Industry: Competitive Dynamics and the Entry, Expansion and Exit of 1time Airline' (Social Science Research Network, 1 September 2016) <https://papers.ssrn.com/abstract=2926806> accessed 24 July 2025\

4 Ibid.

5 Vasigh B, Fleming K and Tacker T, *Introduction to Air Transport Economics: From Theory to Applications* (3rd edn, Routledge 2018)

6 Dieter Schmitt and Volker Gollnick, 'The Regulatory Framework of the Air Transportation System' [2015] Air Transport System 73.

7 Ibid.

8 Decker C, *Modern Economic Regulation: An Introduction to Theory and Practice* (Cambridge University Press 2023)

In Africa, the challenge for competition authorities is exacerbated by the dominance of state-owned legacy carriers that operate in a labyrinth of BASAs, which are relics of a bygone era.[9] These agreements, rooted in a protectionist and state-centric era of aviation, often limit market access, restrict competition, and favour national carriers, making them increasingly incompatible with contemporary liberalisation efforts.[10] These regulatory conditions dictate route access, frequency, and capacity, stifling competition and innovation. Consequently, market concentration on domestic and international routes remains high, further compounded by protectionist policies and competition-distorting subsidies to pursue non-market objectives.[11] Peculiar economic and regulatory features also define competition in the aviation industry. Markets in the aviation industry are conceptualised in terms of routes categorised as domestic or international for short-haul and long-haul traffic.[12] The air transport industry manifests both economies of scope and scale. The demand size and cost structure of the routes, coupled with distinct regulatory regimes in the different types of routes, give rise to different market features that result in diverse competition issues. In intra-African routes, market concentration remains high and stable for a considerable duration.[13] Over time market concentration has grown, with the top 15 African carriers providing 69.0% of the total international service in 2008 compared to 81.9 % in 2018.[14]

Ten airlines account for over 90 per cent of the fleet size in Africa and a majority of the international passenger traffic.[15] There is also a high concentration on the domestic route, with one operator controlling more than 50 per cent of the market in most States. However, some markets, such as South Africa and Kenya, are outliers with the emergence of low-cost carriers. In 2019, 97 airlines based in Africa offered the least seat capacity and the fewest fleets in the world's regions.[16] The top four carriers in Africa are wholly state-owned, and four in the top ten were based in South Africa.[17] Although Africa is home to 17.89 % of the world's population, the continent contributes only 2 – 4 per cent of the global air service market[18]. In contrast, a staggering 80 per cent of the continent's air traffic is dominated by non-African airlines.[19] The underdeveloped state of air transport in Africa makes air travel winding and expensive, subjecting passengers to convoluted flight itineraries that sometimes involve travelling through different states to access other parts of the continent.[20] For example, a passenger flying from Algeria to Cameroon may go through Istanbul, spending 24 hours on the flight with three separate take-offs and landings.[21] Conversely, a direct flight from London to Athens takes three and a half hours, covering the same distance (Algeria to Cameroon), and is 80% cheaper.[22] Limited competition is one of the

9 Mercy Wambui Kamau, 'Melting Down the Borders to Reach the Frontiers" the Impact of the Yamoussoukro Decision on the Liberalisation of Air Transport in Africa' (PhD Thesis, University of Nairobi 2014) <http://erepository.uonbi.ac.ke/handle/11295/75728> accessed 23 September 2024.

10 Tshetu TN, Luke R and Walters J, 'The Role of African Airlines in Air Transport Liberalisation' (2023) 17 Journal of Transport and Supply Chain Management 13 <https://jtscm.co.za/index.php/jtscm/article/view/925> accessed 24 July 2025.

11 Joseph Amankwah-Amoah and Yaw A Debrah, '*The Evolution of Alliances in the Global Airline Industry: A Review of the African Experience*' (2010) 53 Thunderbird International Business Review 37.

12 Rosemary-Jane Luke, *Determinants of Passenger Choice in the Domestic Airline Industry in South Africa* (University of Johannesburg (South Africa) 2015) <https://search.proquest.com/openview/ae0b629ec7ea7142b1f305142331a883/1?pq-origsite=gscholar&cbl=2026366&diss=y&casa_token=xQ-80SXGD8gAAAAA:Wq5eHpvheuor8SteRFstNIZt2gyBYn1eDJ7lpDBdUWUroKkii-8jXC2-H_BUOUnOr79G6TB8Cg> accessed 23 September 2024.

13 ICAO, 'Aviation Infrastructure for Africa Gap Analysis' (2019) 121 <https://www.icao.int/ESAF/Documents/meetings/2019/Aviation%20Infrastructure%20For%20Africa%20GAP%20Analysis%202019/GAP_%20Airlines.pdf> accessed 23 September 2024.

14 African Development Bank, 'Liberalization of Air Transport in Africa: 2019's Status and Way Forward' (2019) 295 <https://cisp.cachefly.net/assets/articles/attachments/93511_afdb_esw_final_report_market_access_2019_and_way_forward.pdf> accessed 23 September 2024.

15 ICAO (n 14).

16 World Bank, *The COVID-19 Pandemic and African Aviation: Policy Note* (World Bank 2022) 5.

17 *Ibid* 35.

18 African Union, 'Single African Air Transport Market Flying Agenda 2063: The SATTM Handbook' <http://196.41.38.241/bitstream/handle/11671/1997/SAATM%20Handbook_5.pdf?sequence=1&isAllowed=y> accessed 4 September 2024.

19 Joseph Amankwah-Amoah, 'Why Are So Many African Companies Uncompetitive on the Global Stage? Insights from the Global Airline Industry' in Ifedapo Adeleye and Mark Esposito (eds), *Africa's Competitiveness in the Global Economy* (Springer International Publishing 2018) <http://link.springer.com/10.1007/978-3-319-67014-0_8> accessed 30 September 2024.

20 Vivica Brown, 'The Road to Yamoussoukro' (2017) 1 JCULP 229 <https://heinonline.org/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/jculp1&section=18> accessed 30 September 2024.

21 R Kuuchi, 'Africa's Potential Is Sky High – and the Airline Industry Is Key' (*World Economic Forum*, 11 May 2016) <https://www.weforum.org/agenda/2016/05/africa-s-potential-is-sky-high-and-the-airline-industry-is-key/> accessed 10 August 2024.

22 *Ibid.*

plausible explanations for the state of affairs in the industry. Other factors are high taxes and charges, underdeveloped aviation infrastructure, poor safety standards, lack of prioritisation of aviation, and discriminatory and protectionist practices among the African States.[23]

Cognisant of the constraints imposed by the restrictive BASAs, 44 African States adopted the Yamoussoukro Decision (YD) in 1999, which sought to liberalise and introduce competition on the intra-African routes. Although the YD became binding in 2002, its implementation lulled due to an overlap of a multiplicity of factors, including the absence of a robust competition regime to support a liberalised market.[24] To reinvigorate the implementation of the YD at the continental level and create a single aviation market for Africa, the African Union (AU) in 2018 adopted the Single African Air Transport Market (SAATM) initiative, as one of the flagship projects under the AU Agenda 2063.[25] The adoption of the SAATM initiative was accompanied by enacting the pending regulatory texts of the YD, such as Annex 5to the Yamoussoukro Decision titled 'Regulations on Competition in Air Transport Services within Africa'.[26]

2. Competition concerns in the aviation industry in Africa

There are five major competition concerns in Africa that the air transport industry has to navigate in the application of Annex 5 to the YD and other competition regulatory regimes. These include the restrictive environment of Bilateral Air Service Agreements (BASAs), competition-distorting subsidies, price wars, the emergence of horizontal cooperative arrangements, and air transport's cross-border nature.

The *first* concern is that of restrictive BASAs, which are known to mount barriers to entry and expansion on the international routes. BASAs regulate pertinent aspects of air transport such as frequencies, number of designated airlines, licensing of operators, capacity, fares, and critical facilities at airports such as landing slots, ground handling services, and fuel. The intricate web of BASAs among African States, in contrast with more liberal open-skies agreements with external partners like the United States, Europe, and Middle Eastern States, points to a legacy of protectionist policies on the continent.[27] Protectionism had its genesis in the early 1960s when air transport in Africa began burgeoning, and most of the newly independent African States created government-owned and subsidised airlines.[28] To eliminate competition, governments implemented measures that politicised the aviation sector and discriminatory practices favouring non-African airlines.[29]

As a result of the restrictive BASAs, the African air transport market is highly regulated, dampening the air traffic growth.[30] The interference stifles the space for competitive and cost-efficient airline management strategies, exposing the airlines to bankruptcy and financial distress. This leads to the *second* competition concern of perpetual State support for national carriers through subsidies and financial bailouts. State support also takes the form of preferential treatment in airports regarding airport fees and access to airport slots or support on competitive routes to defray the cost incurred in pursuing non-market objectives.[31] Africa has 17 State-owned airlines, including Ethiopian Airlines (Ethiopia), EgyptAir (Egypt), Air Algérie (Algeria), Air Burkina (Burkina Faso), LAM Mozambique (Mozambique), Royal Air Maroc (Morocco), RwandAir (Rwanda), Air Côte d'Ivoire (Ivory Coast), Air Tanzania (Tanzania), and TAAG Angola Airlines (Angola) which have histori-

23 Ibid.
24 Amankwah-Amoah (n 20).
25 Kamau (n 10).
26 AFCAC, 'SAATM_FAQs' <https://www.afcac.org/saatm_faqs/> accessed 4 September 2024.
27 Brown (n 21) 232.
28 Charles E Schlumberger, *Open Skies for Africa: Implementing the Yamoussoukro Decision* (World Bank Publications 2010).
29 Ibid.
30 Ibid.
31 Kiema W, 'Management of Competition in the Single African Air Transport Market; Prospects and Challenges' (2025) 50 Air and Space Law <https://testcdn.kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals\AILA\AILA2025025.pdf> accessed 24 July 2025.

cally remained monopolies even in liberalised markets.[32] These airlines have dominated the African skies, as evidenced by the fact that the top four airlines in Africa are 100 % state-owned.[33] The success attained by the State-owned airlines in Africa is artificially attained through State support and other competition-distorting practices such as loyalty schemes and preferential access to profitable international routes. As a result of these practices, State-owned airlines can engage in exclusionary strategies by providing a portfolio of effective benefits such as loyalty rebates.

The *third* competition concern for airlines in Africa is the issue of price wars during seasons of decreased demand or entry of new players and excess capacity on the route. Airline economics in Africa are susceptible to price wars embodied by predatory behaviour by the dominant State carrier to mount barriers to new entry and protect its market share.[34]

The *fourth* competition concern for airlines is the recent global trends of the emergence of horizontal cooperative arrangements that include interlining, code-sharing, alliance membership, and merger-like integration.[35] Cooperative arrangements are used by airlines to circumvent legal and economic barriers and have the advantages of improving connectivity and enhancing consumer experience.[36] However, in most situations, specifically in Africa, the competition authorities have either failed to enforce competition laws effectively against potentially anti-competitive airline behaviour or could not do so.[37] The regulatory gaps allow dominant carriers to entrench their market positions under the guise of cooperation. Cooperative arrangements also enable airlines to cut costs by leveraging the increased economies of scale and scope.[38] Conversely, cooperative arrangements enable the airline to reduce competition by participating in potentially competition-distorting practices such as coordinating flight schedules, reciprocal frequent flier programs, exchange of information on fares, discounts, and sales, cooperation in marketing, and joint bids for government and corporate contracts.[39] Some of the activities under cooperative arrangements, such as route division, fare coordination, and coordination of fuel surcharges, amount to cartel behaviour.

The *fifth* competition concern for airlines is the transboundary nature of the industry. Airlines in Africa have to grapple with the cross-border nature of air transport, which brings about the risk of different enforcement actions for the same conduct because several competition authorities are operating in different competition policy regimes on key aspects such as the power to investigate state-owned enterprises and the basis for assessment.[40] For example, the COMESA Competition Commission and a national competition authority such as the Competition Authority of Kenya (CAK) may scrutinise an airline alliance or fare coordination agreement, each of which may apply different assessment and investigative procedures.[41] Even in regions with harmonised competition policy, divergences in remedial actions are bound to exist.[42] Having identified the main competition concerns on the continent, the next section interrogates the effectiveness of the existing legal and institutional framework in dealing with the concerns.

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32 African Business, 'African State Airlines: Necessity or Folly?' (*African Business*, 20 June 2018) <https://african.business/2018/06/economy/african-state-airlines-necessity-or-folly> accessed 24 July 2025; AFRAA, 'Annual Report' (2017) <https://www.afraa.org/wp-content/uploads/2023/02/%E2%80%A2AR_2017-AW%E2%88%9A.pdf> accessed 24 July 2025.

33 World Bank (n 17) 5.

34 Eyden Samunderu, 'The Deregulation of Air Transport: An International Perspective' in Eyden Samunderu, *The Economic Effects of Air Transport Market Liberalisation* (Springer Nature Switzerland 2024); Eyden Samunderu, 'Air Transport Regulation: A Perspective on Africa's Regulatory Framework' in Eyden Samunderu, *African Air Transport Management* (Springer International Publishing 2023).

35 Africa Competition Forum, 'ACF Cross Country Study on Airlines' (Africa Competition Forum 2020) <http://192.168.10.53/handle/123456789/282> accessed 8 August 2024; Roxana Matei, 'Teaming up for Success' <https://www.academia.edu/download/50575435/Teaming_up_for_success_Why_global_airline_alliances_make_sense._Or_not.pdf> accessed 23 September 2024.

36 Africa Competition Forum (n 36).

37 'Competition Law in Air Transport', in Ruwantissa Abeyratne, *Competition and Investment in Air Transport* (Springer International Publishing 2016) <http://link.springer.com/10.1007/978-3-319-24372-6_10> accessed 24 July 2025.

38 Matei (n 36).

39 Africa Competition Forum (n 36).

40 Tabisa N Tshetu, Rose Luke and Jackie Walters, 'The Role of African Airlines in Air Transport Liberalisation' (2023) 17 Journal of Transport and Supply Chain Management 13 <https://jtscm.co.za/index.php/jtscm/article/view/925> accessed 23 September 2024.

41 William Kiema, 'Management of Competition in the Single African Air Transport Market; Prospects and Challenges' (2025) 50 Air and Space Law <https://testcdn.kluwerlawonline.com/api/Product/CitationPDFURL?file=Journals\AILA\AILA2025025.pdf> accessed 24 July 2025; Brenda Pamela Mey, 'Competition Law in Kenya' 1 <https://www.torrossa.com/en/resources/an/5392072> accessed 24 July 2025.

42 World Bank, *Navigating Beyond COVID-19: Airline Recovery and Regulatory Reform Opportunities in Southern Africa* (World Bank 2022).

3. Legal and Institutional Framework for Competition in Africa

Several international, regional, and national legal regimes and institutions exist to deal with these competition concerns.

3.1. International Legal and Institutional Framework

The international legal and institutional framework is the globalised framework that addresses competition concerns worldwide. The International Civil Aviation Organisation (ICAO) and the International Air Transport Association (IATA) are the two major institutions whose remit has implications for competition in the air transport industry.

3.1.1. The Chicago Convention and the International Civil Aviation Organisation

The Convention on International Civil Aviation, widely known as the Chicago Convention, has significantly shaped global aviation since its inception in 1944.[43] The Chicago Convention is based on a compromise that blends different national interests to bring consistency to international aviation regulation.[44] Rooted in the aftermath of World War II, the Convention emerged as a testament to the imperative of global cooperation in the face of technological advancements.[45] However, beneath the veneer of unity lay divergent visions of competition and regulation. At the Conference, the US advocated for a multilateral granting of the five freedoms based on a free market philosophy. The exchange of traffic rights would be relatively unrestricted, and capacities, frequencies, and market forces would determine fares.[46] At the end of the spectrum, Great Britain advocated for an orderly market development in an effort to protect its vast and strategic colonial airspaces.[47]

The divergence of approaches between the US and Great Britain was a result of pragmatic and ideological concerns.[48] Whereas the Western European industries were hitherto enduring the ravages of the war, the American industrial sector largely remained unscathed by the war.[49] Free trade in the aviation sector would grant US carriers a monopoly on major international routes, an outcome that was not only economically undesirable but also unpalatable, given the prevailing view of national airlines as embodiments of state prestige.[50] Another factor that informed Great Britain's position was the economic thinking of the day, which advocated for central control of critical industrial sectors such as steel, coal, and air transport.[51] These sectors were considered too integral to the state's well-being and as indispensable public utilities that were too critical to be subjected to the vagaries of free trade.[52] The view of airlines as public utilities led to massive government subsidisation and overt regulation in the aviation industry.[53] The negotiation process leading to the Chicago Convention reflected these contrasting perspectives, culminating in a Convention devoid of a comprehensive economic regulatory schema.[54]

One of the critical functions of the Chicago Convention is that it serves as a charter for ICAO, a specialised agency of the United Nations (UN) that is charged with 'developing the principles and techniques of international air navigation and

43 Margaret Arblaster, 'Governance of Air Traffic Management' [2018] Air Traffic Management Economics, Regulation and Governance 39.
44 Brian F Havel and Gabriel S Sanchez, *The Principles and Practice of International Aviation Law* (Cambridge University Press 2014).
45 Daniel Gorman, 'SDG 17 – The History of Global Partnerships and International Cooperation' in Martin Gutmann and Daniel Gorman (eds), *Before the UN Sustainable Development Goals: A Historical Companion* (Oxford University Press 2022) <https://doi.org/10.1093/oso/9780192848758.003.0018> accessed 24 July 2025; Jeffrey Klang, 'Celebrating the Chicago Convention's 75th Anniversary' (2019) 32.
46 Martin Dresner, 'US Bilateral Air Transport Policy', *Liberalization in Aviation* (Routledge 2013).
47 S Truxal, 'Airspace Sovereignty in the Chicago Regime: A Reality Check' in P Mendes de Leon and N Buissing (eds) (Kluwer Law International 2019) <https://lrus.wolterskluwer.com/store/product/behind-and-beyond-the-chicago-convention-the-evolution-of-aerial-sovereignty/> accessed 24 July 2025.
48 Paul Stephen Dempsey and Ram S Jakhu (eds), *Routledge Handbook of Public Aviation Law* (Routledge 2017) 252.
49 Michael Milde, *International Air Law and ICAO: Third Edition* (Eleven International Publishing 2016).
50 Havel and Sanchez (n 46).
51 Ibid.
52 David Corbett, *Politics and the Airlines* (Routledge 2023).
53 Ibid.
54 Peter Adams, 'Aerodrome Certification for Small and Emerging Airports: Is It an Issue?' (2015) 9 Journal of Airport Management 239 <https://www.ingentaconnect.com/content/hsp/cam/2015/00000009/00000003/art00006> accessed 30 September 2024.

fostering the planning and development of international air transport.' The ICAO has aims and objectives but not a mandate or responsibility.[55] Although ICAO has the authority to develop principles and technical standards for air transport by adopting Annexes to the Chicago Convention, its role is limited to promoting, rather than enforcing, the growth and development of international air transport.[56] The term foster (meaning promoting or encouraging)deprives ICAO of its leadership role in the development of air transport, reducing its responsibility to mere development of guidance.[57] Despite its broad mandate, ICAO's role in regulating competition within the aviation sector is limited. The organisation's primary focus remains on safety, security, and air navigation, leaving competition regulation to individual member states.[58]

The success of ICAO as one of the UN's largest and most successful specialised agencies is attributed to its exemplary technical and safety functions, and not its economic objectives.[59] 'ICAO's authority in the economic field is highly circumscribed. 'ICAO's guidelines on competition, while influential, are non-binding, and its authority in economic matters is circumscribed by the language of Article 44, which lacks mandatory enforcement mechanisms.[60] The only objectives that have economic implications are Article 44(d) 'meet the needs of the people of the world for safe, regular, efficient and economical air transport, " 44(e) 'Prevent economic waste caused by unreasonable competition)." 44(f) 'ensure that the rights of contracting State are fully respected, and every contracting State has a fair opportunity to operate international airlines." These objectives are nevertheless hortatory and are not specified by ICAO in binding standards.[61]
ICAO is, therefore, powerless in the economic regulation and liberalisation fields, with the stewardship of this role left to the Member States.[62]

3.1.2. The International Air Transport Association

Established in 1945, IATA stands as a global trade association, representing the diverse interests of over 300 airlines.[63] Central to its mandate is promoting safe, efficient, and sustainable air transportation while concurrently addressing the multifaceted economic and competitive challenges inherent in the industry.[64] Within the realm of competition, IATA assumes a multifaceted role, serving both as an advocate and arbiter.[65] Through its vigorous advocacy efforts, IATA endeavours to foster a regulatory environment conducive to healthy competition.[66] This entails advocating for policies that stimulate market liberalisation and eliminate barriers to entry, thereby cultivating an atmosphere where innovation and consumer choice can thrive. Moreover, IATA functions as a catalyst for collaboration among its member airlines, providing a platform for robust discussions on competition-related issues and facilitating the exchange of best practices in regulatory compliance.[67]

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55 Ruwantissa Abeyratne, 'Can ICAO Make Laws or Deliver Judgments?' in Ruwantissa Abeyratne (ed), *Rulemaking in Air Transport: A Deconstructive Analysis* (Springer International Publishing 2016) <https://doi.org/10.1007/978-3-319-44657-8_2> accessed 24 July 2025; Ludwig Weber, 'International Civil Aviation Organization (ICAO)' 1 <https://www.torrossa.com/it/resources/an/5629138> accessed 24 July 2025.

56 Vincent Correia, '20: The Role of ICAO in the Regulation of International Air Transport' (2025) <https://www.elgaronline.com/edcollchap/book/9781035315987/chapter20.xml> accessed 24 July 2025.

57 Ibid.

58 Mate Gergely, 'Fair Competition in International Air Transport' (2020) 45 Air and Space Law <https://kluwerlawonline.com/journalarticle/Air+and+Space+Law/45.1/AILA2020001> accessed 30 September 2024.

59 Ruwantissa Abeyratne, 'Should ICAO Have a Role as an Economic Regulator of Air Transport' (2014) 27 Air & Space Law. 8.

60 Filippo De Florio, *Airworthiness: An Introduction to Aircraft Certification and Operations* (Butterworth-Heinemann 2016).

61 Abeyratne (n 57).

62 Havel and Sanchez (n 46) 57.

63 Palgrave Macmillan, 'International Air Transport Association (IATA)' in Palgrave Macmillan (ed), *The Statesman's Yearbook* (Palgrave Macmillan UK 2016) <http://link.springer.com/10.1007/978-1-349-68398-7_32> accessed 30 September 2024.

64 Ibid.

65 Lasantha Hettiarachchi, 'International Air Transport Association (IATA): Structure and Legitimacy of Its Quasi International Regulatory Power' [2020] International Air Transport Association (IATA) 1<https://www.torrossa.com/gs/resourceProxy?an=5486510&publisher=FZT015> accessed 30 September 2024.

66 Havel and Sanchez (n 45).

67 IATA, 'Facilitation Policy' (2024) <https://www.iata.org/en/programs/passenger/passenger-facilitation/facilitation-policy/> accessed 30 September 2024.

However, IATA's prominent role has not been without its fair share of controversy.[68] Critics have voiced concerns regarding its influence and transparency, particularly given its dominance by major airlines.[69] This dominance raises apprehensions that IATA's advocacy efforts may not consistently align with the interests of smaller carriers or consumers.[70] Furthermore, questions have been raised regarding the transparency of IATA's decision-making processes, particularly concerning establishing industry standards and negotiating bilateral agreements.

Further, the accusations made by the defunct Civil Aeronautics Board against the IATA that it was a cartel that regulated prices, routes and schedules in the interests of carriers tarnished its reputation.[71] The accusations primarily revolved around purported involvement in price-fixing collusive activities, which significantly affected IATA's credibility and standing within the US market.[72] Historical justifications for IATA's authority have also come under scrutiny in the contemporary context, prompting questions about the relevance of past practices to current tariff coordination efforts.[73] This scrutiny is particularly pronounced in regions where IATA operates without significant oversight.

3.2. Regional Efforts

Given ICAO's limited enforcement capabilities and the credibility issues surrounding IATA, African stakeholders have pursued alternative avenues to ensure fair competition in the aviation industry. Regional organisations in Africa have provided a more robust and context-specific regulatory framework for competition regulation in Africa.

3.2.1. Yamoussoukro Decision and Annex 5

Article 7 of the YD provides that 'State Parties shall ensure fair opportunity on a non-discriminatory basis for the designated African airline to effectively compete in providing air transport services within their respective territory.' Although Article 7 is the main provision in the YD that governs competition, this provision lacks clear definitions or rules regarding fair and unfair competition, leaving room for ambiguity and potential exploitation. More specifically, the Article has been found grossly inadequate because it does not prohibit malpractices by the continental aviation hegemonies.[74] The situation has been inimical to the liberalisation of the intra-African air transport market, resulting from the well-founded fears of small airlines whose survival is threatened by the vagaries of unregulated competition.

Additionally, Article 9.5 of the YD bestows upon the Executing Agency the responsibility to enforce competition rules and regulations to guarantee fair and equal opportunity to all eligible airlines and enhance healthy competition. It was only in 2007 that the African Ministers Conference empowered AFCAC to take on the responsibility of Executing Agency for implementing the Yamoussoukro Decision, tasking it with overseeing, among other things, competition in the aviation sector. This late establishment significantly delayed the implementation of the YD's objectives. Arguably, Article 7 of the YD on competition was otiose in the absence of an Executing Agency to administer the competition regulations. To fill

68 Carole Shifrin, 'IATA Struggles For Survival As Cartel Role Is Diminished' *Washington Post* (8 April 1979) <https://www.washingtonpost.com/archive/business/1979/04/08/iata-struggles-for-survival-as-cartel-role-is-diminished/2cbb554d-9ce2-471c-bc21-12bc40edfd24/> accessed 30 September 2024.

69 Lasantha Hettiarachchi, *The Quasi-Regulatory Regime of the International Air Transport Association (IATA) and Its Impact upon the Airline Industry and the Consumer* (McGill University (Canada) 2019) <https://search.proquest.com/openview/f9f79e867bcb6a94231b12fb26e9ccfa/1?pq-origsite=gscholar&cbl=44156> accessed 30 September 2024.

70 Mohammed Almuqati, 'Critical Analyzed Information of International Air Transport Association (Divulgation Paper)' (2021) 34 Nexo Revista Científica 1065 <https://camjol.info/index.php/NEXO/article/view/11630> accessed 30 September 2024.

71 Lasantha Hettiarachchi, 'International Air Transport Association (IATA) : Structure and Legitimacy of Its Quasi International Regulatory Power' 1 <https://www.torrossa.com/en/resources/an/5486510> accessed 24 July 2025.

72 Ibid.

73 RD Peterson, 'The CAB'S Struggle to Establish Price and Route Rivalry in World Air Transport' (1990) 49 The American Journal of Economics and Sociology 65 <https://onlinelibrary.wiley.com/doi/10.1111/j.1536-7150.1990.tb02261.x> accessed 30 September 2024; Hettiarachchi, *The Quasi-Regulatory Regime of the International Air Transport Association (IATA) and Its Impact upon the Airline Industry and the Consumer* (n 71).

74 ICAO, 'Background to experiences of liberalisation in Africa' 2003 available at *https://www.icao.int/sustainability/CaseStudies/StatesReplies/AfricaBackground_En.pdf*

the lacuna, three Regional Economic Communities (RECs), the Common Market for Eastern and Southern Africa (COMESA), East African Community (EAC), and Southern African Development Community (SADC), drafted joint competition regulations to apply in their respective regions.

The COMESA-EAC -SADC regulations served as a foundation for Annex5 titled Regulations on Competition in Air Transport Services within Africa.[76] The Annex establishes a comprehensive framework to promote free and fair competition within the African air transport sector. It defines various terms and concepts crucial to understanding its scope and application. Notably, it acknowledged AFCAC as the Executing Agency tasked with overseeing the implementation of the regulations.[77]

Article 3 of the Regulations explicitly prohibits anti-competitive practices, agreements, and decisions. These include price-fixing, market division, discriminatory practices, and abuse of dominant positions by airlines. Such practices are deemed illegal and subject to penalties.[78] The regulations incorporate safeguard measures to address concerns about adverse economic impacts on Member States. These allow for the temporary imposition of measures to mitigate negative effects on competition.[79]

The Regulations outlined in Annex 5 to the Yamoussoukro Decision provide a comprehensive framework for the regulation of competition in air transport services within Africa.[80] Central to the effective implementation of these regulations is the role of the AFCAC, which has been described as the Executing Agency and is tasked with supervising and implementing the regulations, addressing complaints, and ensuring compliance.[81]

The role of the AFCAC, as delineated in Article 8 of the regulations, encompasses several key functions aimed at promoting transparency, increasing public awareness, and enforcing compliance with competition rules in the air transport sector.[82] Firstly, AFCAC is responsible for implementing measures to enhance transparency in the sector, ensuring that relevant information is readily available to stakeholders. This transparency is essential for fostering competition and preventing anti-competitive practices. Additionally, AFCAC plays a crucial role in developing public awareness of the regulations, ensuring that stakeholders, including airlines, associations, and consumers, understand their rights and obligations under the regulatory framework.[83] This awareness-building effort is essential for promoting compliance and fostering a culture of competition within the air transport industry.

Another important function of AFCAC is investigating and evaluating alleged violations of the regulations. The above function involves examining complaints lodged by stakeholders and conducting thorough investigations to determine whether anti-competitive practices have occurred.[84] By addressing complaints and enforcing compliance, AFCAC is mandated to maintain a level playing field in the air transport sector and protect the interests of consumers and competitors alike.[85]

76 African Union, 'Study on Competition Rules, Dispute Settlement Mechanism and Consumer Protection' (2014) <https://au.int/sites/default/files/newsevents/workingdocuments/29736-wd-yamoussoukro_decision_-_regulatory_framework-en.pdf> accessed 30 September 2024.
77 Ibid, Article 17.
78 Ibid, Article 3.
79 Ibid, Article 7
80 African Union, 'The First Ordinary Session of the African Union Specialized Technical Committee on Transport, Transcontinental and Interregional Infrastructure, Energy and Tourism' (2017) <https://au.int/sites/default/files/documents/32186-doc-edtd_realigd_competition_regulations.pdf> accessed 8 March 2024.
81 Africa Union, Annex 5 to the Yamoussoukro Decision: Regulations on Competition in Air Transport Services within Africa (2017) <https://africanlii.org/akn/aa-au/act/reg/2017/regulations-on-competition-in-air-transport-services-within-africa/eng@2017-03-17> accessed 8 March 2024.
82 Annex 5, Yamoussoukro Decision, 2017, Article 7.
83 Ibid.
84 Ibid.
85 Eunice A Dobby, 'The Role of Civil Aviation in Promoting International Trade in Africa: A Case Study of Kenya Aviation Industry' (PhD Thesis, University of Nairobi 2021) <http://erepository.uonbi.ac.ke/handle/11295/161504> accessed 24 September 2024; Samunderu, 'Air Transport Regulation' (n 36).

Furthermore, the AFCAC is empowered to grant, refuse, or revoke exemptions under Article 7 of the regulations.[86] This authority allows the Agency to assess the impact of certain practices on competition and determine whether exemptions are warranted in specific circumstances. By exercising this power, AFCAC can ensure that exemptions are granted judiciously and in accordance with the objectives of the regulatory framework. Overall, the role of AFCAC is multifaceted and critical to the effective implementation of competition regulations in the air transport sector.

Through its various functions, AFCAC is empowered to promote transparency, enforce compliance, and protect competition, thereby fostering a competitive and efficient air transport market in Africa. However, the Agency's effectiveness ultimately depends on its capacity to carry out its mandate effectively, including adequate resources, expertise, and institutional support. In this context, the inefficacy of the current continental institutional framework overseeing African aviation competition becomes apparent. AFCAC is characterised by its extensive mandate and a deficiency with limited tools and mechanisms to address anti-competitive practices effectively.[87] The lack of political will from States RECs further complicates matters, hindering AFCAC's efforts to promote fair competition in the air transport sector.88 AFCAC also has a multitude of responsibilities beyond competition regulation, which may detract from its ability to focus adequately on this critical aspect of its mandate. Despite being designated as the Executing Agency for the Yamoussoukro Decision and tasked with supervising and implementing competition regulations, AFCAC is also responsible for various other functions, including promoting safety, security, and efficiency in civil aviation across the continent.[89] This broad mandate leads to a lack of specialisation and expertise in competition law and enforcement, potentially hindering AFCAC's effectiveness in comprehensively addressing competition issues.

Furthermore, AFCAC's effectiveness in regulating competition is hampered by inadequate funding and resources.[90] Without adequate funding, AFCAC may lack the necessary resources to conduct thorough investigations, enforce compliance, and implement measures to promote competition effectively. Moreover, the lack of authoritative enforcement powers undermines AFCAC's ability to ensure compliance with competition regulations. While AFCAC is empowered to grant exemptions and investigate alleged violations, its authority lacks the same weight as regulatory bodies with stronger enforcement mechanisms.[91] Without the ability to impose significant penalties or sanctions for non-compliance, AFCAC's effectiveness in deterring anti-competitive behaviour is limited.

The absence of a robust legal framework leaves AFCAC with limited tools and mechanisms to address anti-competitive practices effectively.[92] Without clear guidelines and procedures for investigating complaints, assessing market concentration, and imposing sanctions, AFCAC's ability to enforce competition regulations is undermined. Moreover, the lack of political will from States and RECs poses a significant obstacle to AFCAC's effectiveness in regulating competition.[93] While AFCAC is tasked with implementing the YD and promoting competition in the air transport sector, its efforts are hindered by member states' reluctance or resistance to adopt and enforce competition regulations. Without strong support and cooperation from member states, AFCAC struggles to overcome regulatory barriers and ensure a level playing

86 Ibid.
87 African Development Fund, 'Institutional Support to the African Civil Aviation Commission (AFCAC) for the Implementation of the Single African Air transport Market (SAATM)' (2020).
88 Ibid.
89 African Union. *Decision Relating to the Implementation of the Yamoussoukro Declaration Concerning the Liberalisation of Access to Air Transport Markets in Africa* (Yamoussoukro Decision). African Union, 1999.
90 African Development Fund, 'Institutional Support To The African Civil Aviation Commission (Afcac) For The Implementation of The Single African Air Transport Market (SAATM)' (2020).
91 AFCAC, 'AFCAC – Transforming African Aviation' <https://www.afcac.org/> accessed 23 September 2024.
92 Samunderu, (n 35).
93 Dobby (n 87); Margaret N Munene, 'Liberalization of Air Transport in Africa: Case of Kenya's Air Transport' (PhD Thesis, University of Nairobi 2012) <http://erepository.uonbi.ac.ke/handle/11295/73535> accessed 5 September 2024.

field for all airlines operating within Africa.[94]

Many Regional Economic Communities (RECs) within Africa, such as the Common Market for Eastern and Southern Africa (COMESA), the East African Community (EAC), and the Economic Community of West African States (ECOWAS), have already established regulatory bodies and developed legal frameworks on competition and consumer protection.[95] This fragmentation of regulatory authority and duplication of efforts leads to inconsistencies in competition regulation across different regions, undermining the effectiveness of AFCAC's regulatory framework. Inconsistent enforcement practices and divergent regulatory standards create loopholes for anti-competitive behaviour and weaken AFCAC's ability to promote fair competition.

3.3. Regional Economic Communities and How They Address Competition

The adoption of the Yamoussoukro Decision was not accompanied by the requisite zeal to implement it.[96] As earlier discussed, Article 9(4) of the YD provided for the establishment of the Executing Agency to supervise and manage the continent's liberalised air transport industry. The Executing Agency was also expected to formulate appropriate rules and regulations to ensure fair competition and consumer protection in the liberalised intra-African air transport market.[97] Although the Executing Agency was to be established as soon as possible, no concrete measures were taken to this effect, leaving the continental implementation of the YD in the doldrums for seven years.[98] As a corollary of the long period of absence of the Executing Agency, the RECs stepped in to implement the YD within their respective regions.[99]
Although the stepping in by the RECs was a step in the right direction in filling the gap, it led to the proliferation of Regional Competition Regimes (RCRs) with varied approaches to competition enforcement. The overlapping membership of African states in different RECs also resulted in the challenge of the "spaghetti bowl" of competing normative frameworks.[100] The myriad overlapping regulations from different RECs led to inconsistent enforcement and regulatory confusion.[101]

Three RECs, COMESA, EAC, and SADC, decided to collaborate in implementing the YD in 2001 to deal with the challenge of overlapping competition regulations in the aviation industry. The three RECs came up with sector specific competition regulations tailored to manage the aviation sector effectively with legal provisions governing competition sourced from various treaties, including the COMESA Treaty, the SADC Protocol on Transport, Communications, and Meteorology, and the EAC Treaty.[102] This harmonisation effort resulted in the adoption of common draft regulations by a joint ministerial meeting comprising representatives from COMESA, EAC, and SADC responsible for civil aviation.[103] During a Tripartite Summit held in October 2008, the COMESA, EAC, and SADC adopted the Joint Competition Authority (JCA) on Air Trans-

94 Munene (n 95).
95 Stephen M Magu, 'Introduction—Africa's Regional Economic Communities (RECs)' in Stephen M Magu (ed), *Towards Pan-Africanism: Africa's Cooperation through Regional Economic Communities (RECs), Ubuntu and Communitarianism* (Springer Nature 2023) <https://doi.org/10.1007/978-981-19-8944-5_1> accessed 24 July 2025; Marco Massoni, 'Integration Dynamics between the African Union (AU) and the Regional Economic Communities (RECs) in Light of a Newly Oriented Euro-African Geopolitics', *Africa-Europe Relationships* (Routledge 2020).\\uc0\\u8216{}Integration Dynamics between the African Union (AU
96 Schlumberger (n 29).
97 Art 9.6. African Union. Decision Relating to the Implementation of the Yamoussoukro Declaration Concerning the Liberalisation of Access to Air Transport Markets in Africa (Yamoussoukro Decision). African Union, 1999.
98 African Union 'Study on competition rules, dispute settlement mechanism and consumer protection' op cit note 648.
99 Ibid.
100 Temilola Adetona, 'Competition and the AfCFTA: Building a Framework for Competition Regulation under the Free Trade Regime' [2021] LL. B Thesis, University of Lagos 110 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3925384> accessed 30 September 2024.
101 Korea Development Institute, *Case Studies on the Regulatory Challenges Raised by Innovation and the Regulatory Responses* (OECD Publishing 2021); Edward Donelan, *Regulatory Governance: Policy Making, Legislative Drafting and Law Reform* (Springer International Publishing 2022) <https://link.springer.com/10.1007/978-3-030-96351-4> accessed 23 September 2024.
102 Tsitsi Effie Mutambara, 'Regional Transport Challenges within the Southern African Development Community and Their Implications for Economic Integration and Development' (2009) 27 Journal of Contemporary African Studies 501 <http://www.tandfonline.com/doi/abs/10.1080/02589000903399488> accessed 30 September 2024.
103 African Union, 'The Development and Implementation of Competition Regulations in Eastern and Southern Africa.' (2005).

port Liberalisation and established competition regulations that would facilitate the implementation of the YD among them.[104] The COMESA - EAC - SADC regulations would later serve as a foundation for the continent-wide competition regulations adopted in 2014 as Annex 5.

The establishment of the JCA, comprising members from each region, underscores the commitment to monitoring and ensuring compliance with the regulations.[105] This body is tasked with increasing transparency in the air transport sector, developing public awareness of the regulations, and overseeing the implementation of the Yamoussoukro Decision and associated regulations. These collaborative efforts and regulatory measures aim to create a level playing field and promote healthy competition in the aviation industry across the regions, ultimately benefiting passengers, businesses, and economies.

The prevalence of regional cooperation in regulating competitive activities in Africa underscores the continent's collective approach to addressing shared challenges and fostering socio-economic development.[106] This collaborative ethos extends beyond bilateral and multilateral levels, permeating into the realm of competition regulation, as evidenced by the establishment of multiple competition regulation regimes across various sub-regions. This communal spirit finds expression in regional legal frameworks and institutions like the African Competition Forum (ACF),[107] which promotes awareness of competition law and policy and facilitates collaboration among competition agencies across the continent.

3.4. Domestic Legislation

Africa is regarded as the last frontier in adopting competition law and policy, with more than half of the States on the continent enacting competition normative frameworks for the first time between the 1990s and 2000s.[108] There has, however, been a proliferation of competition regimes throughout Africa, with nine more African States adopting legislation in the 2010s, and as of July 2020, 41 African States, representing 76 per cent, have in place competition legislation.[109] Of the 41 States that have enacted domestic competition legislation, nine – Benin, Burundi, Comoros, Cabo Verde, the Democratic Republic of Congo, Libya, Mauritania, Mozambique, and Niger – can be said to have competition law on the books since they are yet to have an operational competition agency.[110] Thirteen African States do not have a domestic framework on competition law, although 11 of the 13 are States that belong to a regional body that has competition rules for its members.[111]

3.5. Enforcement

Most African States have limited capacity to enforce competition legislation and a weak regulatory and judicial independence tradition to hold politically connected and economically powerful companies accountable for anti-competitive behaviour.[112] The prevalence of State-owned airlines in Africa further complicates the enforcement of competition law since most legislations confer immunity to State-owned enterprises (SOEs) operating on the basis of statutory monopoly

104 Karen F Luoga, 'Air Transport Competition Law In Africa: To What Extent Is the Southern and Eastern Africa Liberalized?' <https://www.academia.edu/33395260/AIR_TRANSPORT_COMPETITION_LAW_IN_AFRICA_To_what_extent_is_the_Southern_and_Eastern_Africa_liberalized> accessed 30 September 2024.
105 JCA, 'A Framework For The Operationalisation Of The COMESA-EAC-SADC Joint Competition Authority (JCA)' (2013).
106 Adetona (n 102).
107 World Bank and African Competition Forum, 'Breaking Down Barriers: Unlocking Africa's Potential through Vigorous Competition Policy' <https://openknowledge.worldbank.org/server/api/core/bitstreams/e8d45db1-bede-5488-9f5d-909a5b3d6fd3/content> accessed 30 September 2024.
108 Vellah Kedogo Kigwiru, 'The Cooperation on Competition Policy under the African Continental Free Trade Area' (2020) 17 Manchester J. Int'l Econ. L. 98, 6 <https://heinonline.org/hol-cgi-bin/get_pdf.cgi?handle=hein.journals/mjiel17&section=11&casa_token=TWLF5CAwX_kAAAAA:e_-1DduNTLnAYNwKdF9kNkOhQiJA4_7b0yn_T62WWN-DEPhsTaK1KYN54LgCT1yZCRUIjfbcG1E> accessed 23 September 2024.
109 Tim Buthe and Vellah Kedogo Kigwiru, 'The Spread of Competition Law and Policy in Africa: A Research Agenda' [2020] African Journal of International Economic Law 36 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3901690> accessed 23 September 2024.
110 Ibid.
111 Ibid 48.
112 Ibid 67.

and which are deemed to provide public utility services and are acting in the public interest. For instance, the Botswana Competition Act exempts SOEs such as Air Botswana from the competition regulation.[113]

Even in States with mature competition policies, such as the United States and the European Union, policing compliance of State-owned airlines is a daunting task as financial penalties have proved insufficient to arrest anti-competitive practices of the airlines, which are, in most instances, insulated from market-based fiscal discipline. Financial penalties, for instance, have frequently not been enough to discourage anti-competitive behaviour, even though the EU has imposed state aid regulations and fines on national carriers like Alitalia and Lufthansa.[114]

This is largely because state-owned airlines, such as Air France-KLM (partially state-owned), are frequently insulated from market-based fiscal discipline through direct or indirect government support, making enforcement less effective in curbing distortive behaviour.[115] For example, despite the hefty fines that the South African Competition Commission has imposed on South African Airways in the past, the airline continues to be a repeat offender.[116]

In Africa, two approaches exist in the implementation of Regional Competition Regimes (RCRs): the confederate and the supranational approach. The confederate, also known as the voluntary approach, does not have binding competition law but only requires participating States to cooperate and enact domestic competition laws.[117] This model pursues a lower level of cooperation. Although it has been found to lower the obstacles of adoption and enforcement, its effectiveness largely relies on the political will of the member states, resulting in lower potential benefits.[118]

In Africa, the South African Customs Union (SACU) and SADC have adopted the confederate model and rely heavily on member states' existing domestic competition laws and policies and the collaboration among relevant national institutions to foster competitive practices within the common market.[119] In SADC and SACU, the confederate model is facilitated by the fact that all the states, apart from Lesotho, have established a competition law. Consequently, the regional market lacks a comprehensive legal architecture for competition regulation, with institutions operating under varied jurisdictions.[120] On the other hand, the supranational approach, also known as the mandatory approach, involves adopting ambitious binding obligations and entails the establishment of supranational competition regimes, akin to the European Union competition model, to oversee the compliance of regional competition law.[121] The SADC and SACU models follow a confederate approach, where competition enforcement remains largely at the national level, with coordination but no binding supranational authority.[122] On the other hand, the EU is a supranational entity with a centralised competition authority, the European Commission, that has the power to enforce uniform rules and directly sanction anti-competitive practices across member states.[123]

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113 Masedi Motswapong and Gape Kaboyakgosi, 'Implications of Regulation on Economic Diversification in Botswana' [2023] Economic Diversification in Africa: Lessons from Botswana 47.

114 S Kremer, 'Effective Enforcement of the Regulation on Safeguarding Competition in Air Transport' (25 August 2018) <https://essay.utwente.nl/76257/> accessed 24 July 2025; Frank Fichert and Ralf Vogler, '18: Governance of Airline Competition in the European Union' (2025) <https://www.elgaronline.com/edcollchap/book/9781803926988/chapter18.xml> accessed 24 July 2025.\\uc0\\u8216{}18: Governance of Airline Competition in the European Union\\uc0\\u8217{} (2025

115 Sveinn Vidar Gudmundsson, 'European Air Transport Regulation: Achievements and Future Challenges', *Airline Economics in Europe*, vol 8 (Emerald Group Publishing Limited 2019) <https://EconPapers.repec.org/RePEc:eme:aiaezz:s2212-160920190000008002> accessed 24 July 2025.

116 World Bank, *Navigating Beyond COVID-19: Airline Recovery and Regulatory Reform Opportunities in Southern Africa* (World Bank 2022) 86.

117 Kigwiru (n 110) 7.

118 Michal S Gal and Inbal Faibish Wassmer, 'Regional Agreements of Developing Jurisdictions: Unleashing the Potential', *Competition Policy and Regional Integration in Developing States* (Edward Elgar Publishing 2012) <https://www.elgaronline.com/downloadpdf/edcoll/9781781004302/9781781004302.00024.pdf> accessed 23 September 2024.

119 Adetona (n 102).

120 Ibid.

121 Kigwiru (n 110) 7.

122 Vellah Kedogo Kigwiru, 'Supranational or Cooperative? Rethinking the African Continental Free Trade Area Agreement Competition Protocol Institutional Design' (2024) 12 Journal of Antitrust Enforcement 98 <https://doi.org/10.1093/jaenfo/jnad003> accessed 24 July 2025.

123 Jurgita Malinauskaite, 'Development of EU Competition Law Enforcement from an Historical Perspective: A Call for Harmonisation from the

Critiques of the supranational approach argue that the adoption of an overly ambitious binding cooperation agreement may lead to inadequate enforcement and thereby risk damaging the reputation of both the regional and national institutions, and reduce the trust between the parties.[124] Five RECs in Africa, COMESA, EAC, West African Economic and Monetary Union(WAEMU), Economic Community of West African States (ECOWAS), and Economic and Monetary Community of Central Africa(CEMAC), have adopted the supranational approach.

The two approaches demonstrate the challenge in designing an appropriate Pan-African competition framework, with the confederate and the supranational approaches each having their strengths and weaknesses. The recommendation put forward in this paper is to adopt a 'minimum standards' model for the Competition in the African air transport market.[125] This model acknowledges Africa's unique circumstances, including the coexistence of national and sub-regional competition regulations, while aligning with the Yamoussoukro Decision's goal of preserving existing systems and institutions such as AFCAC.[126] Unlike a comprehensive supranational model akin to the European Union (EU), which could potentially undermine the autonomy of RECs and the sovereignty of individual States, or a purely confederate model that may result in inconsistency and uncertainty, the minimum standards model offers a balanced approach. Under this model, the Competition Protocol would establish a uniform base of rules governing competitive activities without supplanting existing national and sub-regional regimes.

In implementing Annex 5 to the Yamoussoukro Decision, AFCAC should identify the minimum standards for addressing anti-competitive practices, mandate compliance, and guide implementation by member states and RECs. AFCAC should also facilitate collaboration among competition authorities to ensure regulatory consistency and certainty, which is crucial for fostering investor confidence and economic growth. To ensure uniformity, there should be a mechanism for resolving conflicts between the minimum rules as contained in Annex 5 and existing competition regimes. In terms of institutional mechanisms, AFCAC should strengthen its dispute resolution mechanisms. The dispute resolution mechanism should also be established to address conflicts between member states, impose penalties, and adjudicate cross-border competition issues. The dispute resolution mechanism shall ensure accountability and uphold the integrity of the competition framework within the AfCAC.

Conclusion

Regulatory reforms to foster open and contestable markets are a fundamental prerequisite for the African aviation industry to unlock its potential. Growth inhibitors such as high fares and poor services are a consequence of constrained competition in the intra-African market. The Yamoussoukro Decision remains the most important regulatory instrument for liberalising the air transport industry in Africa. Liberalisation of air transport in Africa has demonstrated the ability to enhance competition, reduce fares, and reduce the increase in passenger traffic. However, the lack of an appropriate competition framework can stall the air transport liberalisation process due to the fear of unrestrained forces of free markets.

EU' in Jurgita Malinauskaite (ed), *Harmonisation of EU Competition Law Enforcement* (Springer International Publishing 2020) <https://doi.org/10.1007/978-3-030-30233-7_4> accessed 24 July 2025; Jurgita Malinauskaite, 'Institutional Framework of the National Competition Authorities in the Central and Eastern European Countries' in Jurgita Malinauskaite (ed), *Harmonisation of EU Competition Law Enforcement* (Springer International Publishing 2020) <https://doi.org/10.1007/978-3-030-30233-7_5> accessed 24 July 2025.

124 G Deniz Both, 'Drivers of International Cooperation in Competition Law Enforcement' (2015) 38 World Competition <https://kluwerlawonline.com/journalarticle/World+Competition/38.2/WOCO2015020> accessed 23 September 2024.

125 Kamala Dawar, George Lipmile, "Africa: Harmonising competition policy under the AfCFTA" 2020 (2) Concurrences Review, 242-250.

126 Ibid.

Air transport liberalisation conducted in the wrong way, too fast, and in the absence of an adequate competition framework can produce undesirable outcomes. With the absence of an appropriate international competition framework for the aviation industry, Annex 5 to the Yamoussoukro Decision presents the quintessential opportunity to ensure the successful implementation of the SAATM Initiative. However, the implementation of Annex 5 encounters obstacles such as regulatory fragmentation, limited political will, and inconsistent enforcement practices across African nations. A 'minimum standards' model is recommended to build effective African aviation competition regimes. This approach balances the need for regulatory consistency across the continent while preserving the autonomy of RECs and individual states.
A' minimum standards' model can enhance investor confidence, foster economic growth, and promote fair competition by establishing uniform base rules governing competitive activities and facilitating collaboration among competition authorities. Furthermore, efforts must be made to strengthen the capacity and resources of the AFCAC to enforce competition regulations and resolve disputes effectively. By addressing these challenges and implementing a robust competition regime, Africa can create a level playing field in the aviation industry, encourage innovation, and unlock the sector's potential for contributing to sustainable economic development across the continent.

Miscellaneous Material of Interest

Bold Words, Blurred Lines: A Reflective Look at the EU Space Act

Sara Dalledonne[*], *Giulia Pavesi* [**]

ESPI welcomes this initiative, considering it a significant and relevant step toward addressing the European competitiveness and innovation gap. As the legislative process unfolds, several provisions raise important questions regarding implementation, legal certainty, proportionality, and the balance of competences between EU institutions, Member States, and international actors. This Brief aims to explore the challenges and concerns that need to be addressed both in the draft, and the overall scope of the Act, identifying areas that—while outside its current remit—will nevertheless be essential to achieving its stated objectives.

In June, the Commission unveiled its legislative proposal for the EU Space Act, a regulation designed to establish a harmonised legal framework for space activities across the EU.[1] The regulation represents a clear political signal that the Union aims to play a broader and more strategic role in the space domain—backed by a mandate and funding structure similar to other critical sectors. The negotiation will be long and challenging, but while many voices will weigh in on the Act, priority should be given to European perspectives and their arguments.

Among others, one crucial concerned is represented by the cost increase. With manufacturing costs projected to rise by up to 10% and launch service providers facing increases of up to 20%, European companies will be further challenged—especially given the ongoing profitability pressures across much of the space sector. When assessing the proportionality between costs or burdens and expected benefits, it's essential to consider not only the direct financial impact, but also the perceived burden. Excessive or unclear requirements risk disincentivising innovation and entrepreneurship, particularly in a sector where agility and risk-taking are critical to growth.

In addition, as outlined in the draft, an Act's key objective is to promote innovation and foster a competitive business environment. To achieve this, it should more clearly identify areas where the EU can fully leverage its market influence and unique added value. The current approach lacks concrete measures to stimulate or develop markets for space-based services and solutions that would also justify enhanced costs for compliance by European companies. Market creation is not merely complementary—it is essential for ensuring the long-term sustainability and global competitiveness of the European space industry. A synergistic approach that aligns regulatory action with demand stimulation and technological innovation and advancement will be critical to driving meaningful growth in this sector.

Much of the Act's concrete impact remains difficult to assess in the absence of an implementing act, which will be crucial for defining operational aspects and setting the stage for standardisation. Indeed, the Act's standardisation framework has the potential to enhance the Commission's role as a leader in space standards. However, while the Commission may request European standardisation bodies to develop standards for specific technical requirements, such as light

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1 European Commission, EU Space Act: enhancing market access and space safety (EU Space Act: enhancing market access and space safety - European Commission)

and radio pollution or electronic certificates, this approach may shift some standardisation responsibilities from ESA's well-established technical domain toward a framework more closely guided by political and regulatory considerations. The upcoming international agreement between ESA and the Union presents a key opportunity to clarify roles and evolve the governance relationship between the two entities, ensuring greater coherence and complementarity.

While Europe's leadership in promoting environmental responsibility in space comes at a cost, this might also reflect a conscious choice to lead where global efforts have fallen short. In the face of limited progress at international fora, the Commission does have an opportunity to position the EU as a viable first regional and then multilateral platform for advancing responsible space governance. Indeed, the Act has the potential to influence global norms through mechanisms of equivalence, encouraging other countries to align with EU standards, as it happened in other fields of EU competence. For this influence to materialise, it would be, however, essential that it be supported by robust programmes and a competitive industrial base capable of delivering tangible market benefits.

Yet crucial, a factor in realising Europe's ambitions is the availability of adequate funding. The upcoming negotiations on the next MFF will be pivotal in determining whether sufficient resources can be secured to support the objectives outlined in the Act. Ensuring timely implementation and avoiding delays will depend on this financial commitment, as will the establishment of robust structural internal and external support mechanisms to facilitate the effective adoption of the Act's various requirements.

The true value of the Act lies not only in addressing internal market dynamics but in unlocking the EU's potential to lead globally. By shifting the focus beyond internal mechanisms to strategic industrial implementation, it can serve as a springboard to position EU industry at the forefront of emerging global services—such as ISOS—and sustainable operations. This is a chance to shape international standards, build competitive advantages, and affirm the EU's leadership in future-oriented, responsible innovation. Seizing it will strengthen the Union's industrial base and establish a resilient, sustainable, and globally influential European presence.

Book review: Regulation of Outer Space: International Space Law and the State

By Jakub Handrlica *

In 2024, Routledge and G. Giappichelli Editore published a new book, *Regulation of Outer Space: International Space Law and the State*, jointly in their Routledge-Giappichelli Studies in Law. Claudia Cinelli, Assistant Professor of International Law at the Political Sciences Department, University of Pisa, edited the book. *Regulation of Outer Space: International Space Law and the State* is being published in the framework of the research project, carried out jointly by the University of Pisa, Italy and the Massachusetts Institute of Technology, USA, under the Global Seed Fund grants. This interdisciplinary project aims to combine legal and political approaches with research on innovative space technologies. It seeks to propose regulatory strategies for policymakers, the space industry, society and the academy. Also, the reviewed book builds upon the results of some previously researched projects, analysing mutual relations between sustainability and space law, such as the research project ANTARES – Anthropocentrism and Sustainability of the Earth system and Outer Space, funded by the universities in Helsinki and Stockholm.

The reviewed book focuses on how States should regulate activities in space and explores strategies to advance responsible State behaviour to ensure sustainable use and adequate protection of space for peaceful purposes. Thus, facing the current trends of the New Space Era pressing challenges, the book analyses the features of "new space" primarily as "our common future." In this respect, the reviewed book does not represent just a contribution to the scholarship of international public law. It also contributes to a much broader discourse on the sustainability principle in law and on extraterritorial applications of law.

The reviewed publication is introduced in a note authored by Marco Ferrazzani (European Space Agency). Here, the author outlines the importance of the sustainability issue in space discourse from the viewpoint of his own Agency. He stresses that the European Space Agency has recently embarked on two parallel tracks in this field: co-developing the Zero Debris Charter with major stakeholders and supporting the implementation and integration of clean space technologies. At the end of his introduction, M. Ferrazzani stresses the importance of sustainable space exploration for future generations and urges governments to implement this approach in their policies.

The next contribution is entitled *Introductory remarks: Advancing state responsible behaviour in outer space from an interdisciplinary perspective* (authored by C. Cinelli). Here, the author deals with the challenge of reconciling the free use of space on one hand with the endeavour for sustainable use of its resources on the other. Further, C. Cinelli stresses the impact of the 1987 Brundtland report, Our Common Future, on the exploration of space, particularly on the increasing privatisation and commercialisation of space activities.

Chapter 1 is authored by Katarzyna Pogorzelska (European Commission Joint Research Centre) and bears the title *Does using satellite data for sustainable development justifies unsustainable use of outer space?*. In her contribution, the author argues that space data has become instrumental in advancing sustainable development on Earth. Thus, the Chapter addresses the question of whether the use of space data for sustainable development justifies potentially unsustainable practices in space. In her text, K. Pogorzelska points out the intensive growth of satellites operated in outer space and identifies environmental risks associated with this tendency. Her contribution concludes that the responsible use of outer space is the best guarantee of the continuous space support for terrestrial sustainability.

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Chapter 2, entitled *Sustainability and Corporate Social Responsibility (CSR) in outer space,* is authored by Elena Cirkovic (Aarhus University). Here, the author identifies an interplay between the increasing degradation of the orbital environment and the Earth system. E. Cirkovic refers to the concept of Earth's Planetary Boundaries (EPB) and applies this concept to Corporate Social Responsibility (CSR). With respect to this issue, the chapter calls for further legal interpretation of interactions between space law and other legal regimes. As E. Cirkovic correctly argues, "*there is an urgent need to provide clarity and guidance on how existing principles of international, national, regional, and transnational law, as well as public-private and hybrid interactions, apply to new and expanding activities in outer space.*"

Chapter 3 is authored by Chiara Macchi (Wageningen University) and is titled *Business, human rights and international space law: filling the gaps of corporate accountability in the 'New Space'.* In her contribution, Ch. Macchi identifies a considerable gap in the current scholarly attention to human rights and the environmental implications of the increasing engagement of private corporations in space. Consequently, the chapter examines the persisting gaps of corporate accountability under international space law and identifies risks, potentially arising from a future "space race" without adequate multilateral regulations in place. In this respect, Ch. Macchi analyses in her chapter the human rights and environmental due diligence legislations currently emerging in Europe. In this respect, the author presents her own assessment of whether these newly adopted legislations could apply to commercial activities in space.

Chapter 4 is entitled *The principle of "Common Heritage of (Hu)mankind": its implementation in the light of the law of the sea and the law of outer space.* It is authored by Anne-Sophie Martin (Institute for International Legal Studies, National Research Council in Rome). In her chapter, A. S. Martin first outlines the concept of a "common heritage of humankind", its development and its constituent elements. In this respect, the author focuses on the implementation of this concept with respect to the law of the sea and international space law. The chapter also stresses that even if the concept hasn't been fully implemented in practice, some of its components are part of customary international law. Finally, A. S. Martin argues that the concept of a "common heritage of humankind" enables commercial enterprises to behave responsibly in space and consequently, underlines the sustainability of the prospective space use.

Chapter 5 is authored by Laura Yvonne Zielenski (Holland & Knight Law Firm) and addresses *The role of arbitration in enforcing international space law for private parties.* This chapter outlines the increasing commercialisation and privatisation of space activities and their relationship to international space law. While the current instruments of international space law do provide for rights and obligations of states, the leading role in space use and exploration is currently being overtaken by private corporations. In her chapter, L. Y. Zielenski aims to analyse whether arbitration can fill this remedy gap. In the conclusion of her innovative chapter, L. Y. Zielenski argues that there are disputes which are likely to arise in the coming years that any existing consent to arbitration will not cover. In this respect, the author presents several proposals that may expand the availability of arbitration in the future.

Chapter 5 is authored by Emmanuela Maio (University of Parma). It is titled *National space laws and regulations stemming from international space law.* In her contribution, the author reflects on the boom of the new space economy and explores the role of private law in regulating commercial space activities. The author uses Italy as a case study and outlines gaps in the Italian private law with respect to the challenges of the New Space Era. In this respect, E. Maio provides an analysis of the existing draft for a prospective Italian Space Law. I believe it would be beneficial if this chapter contained more comparative material with references to other already existing national space acts, such as those of Portugal, Luxembourg, France, or the United Kingdom.

Finally, Chapter 6 is titled Nuclear power sources in outer space for peaceful purposes: an evolving legal framework. It is authored by Viviana Iavicoli (Institute for International Legal Studies, National Research Council in Rome). V. Iavicoli

first outlines an existing framework for the peaceful use of nuclear power in space. Afterwards, it poses the question of whether the current legal framework is prepared for technological advances that one may expect. Reflecting on this research question, the author identifies the main gaps in the current framework and proposes ways to overcome them. The reviewed book ends with concluding remarks, written by Katlyn M. Turner (Massachusetts Institute of Technology). Having said this, I would like to highlight that the reviewed book is beautifully designed, and the texts are well unified. Each contribution contains a list of literature at its very end, which provides the reader with an overview of the most topical sources for each topic.

The reviewed book offers a unique perspective on current developments. It can be warmly recommended to readers interested in space law, sustainability, and/or current technological developments. Also, the reviewed book should not be missing from the library at any university that offers a study programme in law with an emphasis on sustainability.

Book Review: *Elgar Concise Encyclopedia of Aviation Law*

*Ottavia Carla Bonacci**

The Elgar Concise Encyclopedia of Aviation Law, published by Edward Elgar Publishing 2023, stands out as an essential contribution to the evolving field of aviation law. The entries, edited by a panel of distinguished legal scholars and practitioners, offer an accessible yet comprehensive overview of the key concepts, principles, and challenges characterizing modern aviation regulation and governance.

Edited by two of the most distinguished academic in the field, Anna Masutti, Professor of Air Law at the University of Bologna, and Professor Pablo Mendes de Leon, Emeritus Professor of Air and Space Law at Leiden University, the *Elgar Concise Encyclopedia of Aviation Law* represents a significant addition to the scientific literature on aviation law. Notably, Professor Masutti and Professor Mendes de Leon have curated a comprehensive and accessible reference work that successfully addresses both the enduring fundamentals and the emerging complexities of aviation law.

At first glance, the development of the concept of a "concise encyclopedia" might seem challenging in a field as broad and technically complex as the aviation industry. However, this volume succeeds in delivering clear, focused entries that balance depth with readability. It is an invaluable resource not only for legal professionals but also for regulators, aviation industry players and academics seeking a reliable point of reference.

One of the main characteristics of the volume lies in its well-structured organization. The entries are arranged alphabetically, allowing for intuitive consultation. Topics range from fundamental concepts like *Airworthiness*, *Carrier Liability* and *Freedom of the Air*, to more specialized subjects such as *Flight Crew Licensing* and *Environmental Obligations*. This broad thematic coverage ensures that both foundational and emerging issues in aviation law are equally and prooerly addressed.

Particularly notable is the Encyclopedia's attention to contemporary developments. The inclusion of topics like *Cybersecurity*, *Drones (Unmanned Aircraft Systems)* and *Sustainability in Aviation* reflects the sector's rapid technological advancement and the corresponding regulatory challenges. Entries such as *Passenger Rights*, *Consumer Protection* and *State Responsibility* emphizes the growing attention on passengers' rights and State obligations in the aviation sector.

Each entry specifically provides a concise definition or description, followed by an analysis of the legal frameworks, key issues and, where relevant, references to international conventions, treaties, and case law. For example, the discussion of *Warsaw Convention* and *Montreal Convention* is particularly effective in outlining the evolution of passenger and carrier liability standards in international air law.

The volume also successfully captures the inherently international nature of aviation law. References to bodies such as the International Civil Aviation Organization (ICAO), the European Union Aviation Safety Agency (EASA) and the Federal Aviation Administration (FAA) are frequent and well-integrated. The entry on *International Aviation Law* and those concerning bilateral and multilateral treaties, including the *Chicago Convention*, help readers understand the global regulatory architecture within which national jurisdiction and legislation must be integrated.

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Another accomplishment of the Encyclopedia is its balanced treatment of public and private law dimensions. While many entries focus on state regulation and international treaties (*Slot Allocation*, *Cabotage Rights*, *Open Skies Agreements*) others delve into private law issues such as *Product Liability*, *Insurance in Aviation*, and *Employment Law in Aviation*. This dual perspective allows the reader to appreciate aviation law as a complex interplay between different legal regimes and stakeholders.

From an editorial standpoint, the writing is remarkably consistent across the entries, an impressive feat given the diverse authorship. The contributors, experts in their respective areas, manage to maintain a uniform tone that is authoritative but not overly dense, making the text approachable for readers with varying degrees of prior knowledge.

Entries are deliberately kept concise: complex debates and highly specialized subfields are introduced with references to comprehensive bibliography for further reading, allowing interested readers to deepen their understanding beyond the Encyclopedia itself.

In conclusion, the *Elgar Concise Encyclopedia of Aviation Law* is a highly recommended addition to any aviation law library. Its clarity, breadth of coverage and relevance to contemporary developments make it an indispensable tool for quick consultation, teaching, or initial research, as a well-organized and expertly curated guide through the intricate skies of aviation regulation.

Book review: SPACE ECOLOGY - FROM EARTH TO MOON AND MARS

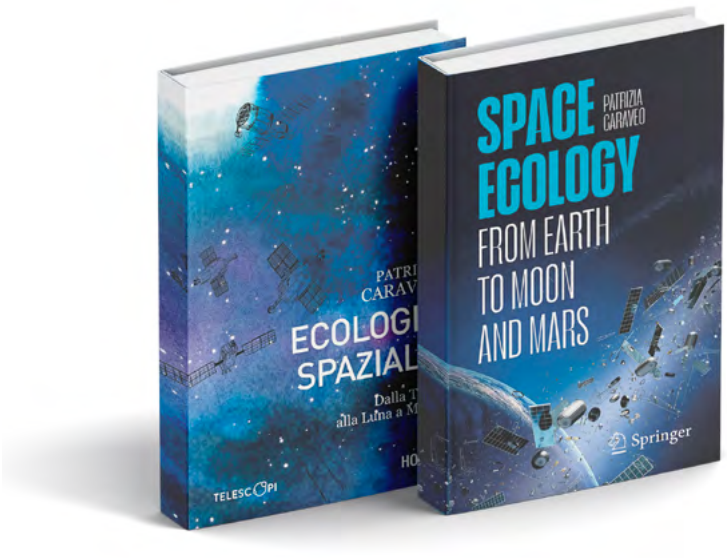
*Luisa Santoro**

SPACE ECOLOGY - FROM EARTH TO MOON AND MARS (164 pp, € 29,11) is the most recent book by astrophysicist Patrizia Caraveo, who, with unquestionable data and detailed examples, drives the reader through the exciting benefits of the space technology as well as through the risks related to the ever-increasing number of satellites that today are being launched into space, polluting and contaminating the (extremely delicate) stratosphere.

As the author explains, the space objects' census has been increasing dramatically since 2015 due to the explosion of the space economy – i.e., the expanding involvement of private companies pursuing commercial purposes in the space sector -, so that today tens of thousands of objects are orbiting above us, creating - with their intersecting routes - a dense and dangerous web that envelops our Planet, in a space that formally does not belong to anyone, since at present no globally shared rules nor binding laws exist in this regard, determining serious problems in terms of safety, sustainability and environmental protection.

This is why - Patrizia Caraveo – such situation should be addressed urgently and our "pale blue dot" – i.e. the Earth as photographed in 1990 by the Voyager 1 probe from a distance of six billion kilometres – be saved without any hesitation and delay. Because space and ecology are now closely linked: if it is true that today the space technology is fundamental for our everyday life on the Planet and beyond, since it offers (once unthinkable) services that today are crucial, measures have to be urgently taken in order to limit not only the number of in-orbit satellites but also any adverse impacts related to their lifecycle: 11.108 active satellites were registered on 2nd February 2025 and more mega-constellations are expected to join them soon, reaching the number of 100,000 satellites in orbit in the next few years just for Internet services.

And what about the enormous power associated with what has become a space monopoly? Indeed, as demonstrated by Elon Musk, a single entrepreneur - Patrizia Caraveo underlines - can presently allow or prevent customers or even countries from having access to a satellite constellation (Starlink, in this case) and, at the same time, exploit the sensitive information collected, so that we cannot but pose ourselves some questions, also considering that Elon Musk is not behaving illegally.



Finally, Patrizia Caraveo's extremely clear, competent and engaging investigation also extends to the Moon and Mars, i.e. two equally fragile ecosystems, on which the mistakes made on Earth

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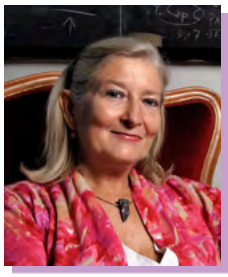
must be avoided, both in terms of uncrontrolled exploitation of their resources and biological pollution (the impact of previous missions, too, are described in the book); and to planetary defence, which means not only preventing our planet from the possible impacts of “killer asteroids” and/or other objects in space, but also addressing the issues related to the interactions between the terrestrial environment and other bodies in the solar system, including the biological dimension.

So, whether through ad-hoc space laws and regulations for the peaceful and sustainable use of outer space; collision avoidance maneuvers; measures to prevent contaminating with terrestrial organisms the celestial bodies that humans or robots will visit; or, vice versa, through measures to protect ourselves from potential contamination by samples of extra-terrestrial material, etc. (a number of proposals are described in the book), Patrizia Caraveo invites us to invert the present trend of the new space race, so as to guarantee access to space also to the living generations of the future.

SPACE ECOLOGY - FROM EARTH TO MOON AND MARS has been published by Springer since April 2025 and is available on the Springerlink platform, where it can be downloaded free of charge by anyone belonging to institutions that subscribe to the Springer service.

ECOLOGIA SPAZIALE - DALLA TERRA ALLA LUNA E MARTE (154 pp, € 17,90) has been published by Hoepli since 2024 and is available in all bookstores.



Patrizia Caraveo is an internationally renowned astrophysicist, a research director at the National Institute of Astrophysics and the President of the Italian Astronomical Society. In 2014, the Women in Aerospace Association awarded her the Outstanding Achievement Award and in 2021 she was awarded the Enrico Fermi Prize by the Italian Physical Society for her contributions to the study of neutron stars.

Events

IBA, International Bar Association Annual Conference 2025
Toronto, 2–7 November 2025

13th International - SES Workshop - Space Communication in the 3rd Millenium: Challenges, Regulation and Technology, University of Luxembourg,
Luxembourg 18 September 2025

EALA, European Air Law Association Annual Conference 2025
Vienna, 7 November 2025

Space and strategic autonomy:
the General Assembly on space, defense and cyber security held at ESA-ESRIN
Frascati-Rome, 12th September 2025

The **2025 IBA Annual Conference** will take place in **Toronto, Canada, from November 2 to 7, 2025**, bringing together legal professionals from around the world to discuss the latest issues and developments in the legal field.

The Aviation Committee will actively participate in the conference, contributing to discussions on some of the most pressing issues in aviation law. As part of the event, three dedicated aviation panels will take place. One session focuses on litigation in the aviation sector, examining the growing complexity of international disputes, from sanctions to safety issues, as well as the legal implications of using sustainable aviation fuel (SAF).

Another session is dedicated to current issues in aircraft financing and leasing, with particular attention to legal risks, repossession and enforcement under the Cape Town Convention, and the emerging role of "green leasing" linked to ESG standards.

A further session explores airport law, discussing slot allocation at congested airports, operational best practices, standardization, operators' liability, and crisis management, with reference to the Worldwide Airport Slots Guidelines.

Finally, a joint panel of the aviation law and insurance committees will address insurance products in the aviation sector, including financial leases, war risks, and other specialized coverages, offering insights into recent practices and risk management tools.

13th International SES Workshop

Luxembourg,
18 September 2025

The 13th International SES Workshop will take place on 18 September 2025 at the picturesque Château de Betzdorfin Luxembourg, organized by the Luxembourg Centre for Socio-Environmental Systems in cooperation with the Faculty of Law, Economics and Finance of the University of Luxembourg.

The central theme of this edition, "Space Communications in the 3rd Millennium: Challenges, Regulation and Technology", will provide an in-depth analysis of the most pressing issues in the field of space communications.

Discussions will focus on three key areas:

- the regulatory framework for the increasingly important Direct-to-Device (D2D) technology;
- the legal aspects of the European IRIS² constellation, designed to provide secure connectivity services; and
- the regulatory and licensing challenges related to the ground infrastructure required to operate satellite services, with particular reference to the draft EU Space Act.

This workshop will thus serve as a major international forum to explore how regulation, technological innovation, and new connectivity needs converge in shaping the future of space communications.

For more information visit HERE.

European Air Law Association (EALA)
37th Annual Conference 2025

Vienna,
7 November 2025

The European Air Law Association (EALA) has officially announced that its **2025 Annual Conference** will take place in Vienna.

This prestigious event brings together leading professionals, academics, and experts in the field of aviation law to explore the latest legal developments, challenges, and opportunities in the aviation sector.

While the exact date, venue, and agenda are yet to be confirmed, further details will be released in the coming months.

For updates, please visit the official EALA website: www.eala.aero

Space and strategic autonomy: the General Assembly on space, defense and cyber security held at ESA-ESRIN

Frascati-Rome
12th September 2025

Last week, on September 12th, the General Assembly on Defense, Space, and Cybersecurity took place at Esrin, the ESA Center in Italy dedicated to Earth Observation Programs. The event was organized by the European Parliament and the European Commission, in collaboration with the European Space Agency (ESA), in order to promote dialogue on the future of the European Union between EU and national policymakers as well as leaders from the space sector. Key participants included, among others, Andrius Kubilius, the European Commissioner for Defense and Space; Italian Ministers Adolfo Urso (Enterprises and Made in Italy), Antonio Tajani (Foreign Affairs and International Cooperation), and Matteo Piantedosi (Interior); General B. Luigi Vinciguerra, Brigadier General of Guardia di Finanza - Head of the III Operations Department, General Command; Antonella Sberna, Vice-President of the European Parliament; Claudio Casini, Head of the European Representation to Italy; Josef Aschbacher, Director General of the European Space Agency; Simonetta Cheli, Director of Earth Observation Programs and Head of ESRIN; Carlo Corazza, Head of the European Parliament Office in Italy; Admiral Giuseppe Cavo Dragone, Chairman of the NATO Military Committee; Teodoro Valente, President of the Italian Space Agency (ASI).

In an increasingly complex geopolitical context, exacerbated by unexpected challenges and tensions, during the Assembly the above institutional parties analyzed Europe's needs in key sectors such as defense, space, and cybersecurity, highlighting a common denominator, namely the need to increase coordination at the European level - as already happened with programs like Galileo, Egnos, and Copernicus, with their notable impacts in terms of innovation, industrial competitiveness, and also strategic autonomy, protection of critical infrastructures, and security.

In particular, A. Kubilius emphasized that the European Space Agency represents a trusted partner of the European Union for the design and development of space capabilities, and that further collaboration will be necessary, not only to defend our space resources, but also to use space to defend the EU. How? By improving its space capabilities in the domains of Earth observation, communications, and navigation; by enhancing the protection of its satellites from space debris, solar events, and deliberate attacks; and finally, by equipping it with a greater capacity to access space. Not surprisingly - Kubilius continued - in the proposal for the next EU multi-annual budget, the allocation for defense and space will be quintupled, up to € 131 billion. However – he underlined - such resources will not be sufficient. Therefore, European defense and European space must go hand in hand, consistently with the Draghi Report on EU Competitiveness, which emphasizes the need for greater cooperation between space and defense.

Commissioner Kubilius concluded his speech by summarizing the European space governance: the European Commission collaborates with the Member States, coordinates and submits proposals; the European Parliament approves what is submitted to it; the European Space Agency develops flagship projects and EUSPA, i.e. the Space Agency of the European Union, manages them.

Echoing Commissioner Kubilius, Joseph Aschbacher emphasized that **"ESA is the tool of its Member States"**, offering them **"an opportunity to support key security entities"**, such as, for example, the EU.

Similarly, ASI President Teodoro Valente recalled that the launch of the first satellite of the Italian Cosmo-SkyMed constellation took place in 2007 – and that today we are realising the second generation. Such national program was jointly developed by ASI and the Italian Ministry of Defense, demonstrating that Italy has been and will continue to be active in this field for a long time.

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