

The Future of Airports

A Vision of 2040 and 2070

Topic No. 1: The World in 2040 and 2070

White Paper

ENAC Alumni – Airport Think Tank

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Foreword



In February 2019, ENAC Alumni – the alumni association of the National University of Civil Aviation (ENAC) – organized a day of discussion and education on the current and future challenges in air transportation: **The State of the Air (“Les Etats de l’Air”)**. This event, held at the headquarter of the French General Directorate for Civil Aviation (DGAC), was part of a broader effort to fulfill some of our primary missions toward our 24,000 members: to maintain their knowledge up to date, to provide them platforms where to express and exchange ideas, and to promote excellence in aviation & space.

In addition to master classes on Airports, Aircraft and Systems, Design & Certification, Airline Operations, Air Traffic Management, Aircraft Maintenance, Pilots & Flight Operations, Safety & Compliance, and Entrepreneurship, **the State of the Air** featured a series of roundtables bringing together key leaders of the industry in the sectors of air transportation, tourism and general aviation who presented their vision of the future.

Following the large success of the State of the Air, and considering the dedication and expertise of our alumni, it has been decided to take the momentum and invite our think tanks to launch projects on the future of aviation. These think tanks reflect the diversity and excellence of our alumni community: air traffic management, airline operations, airports, digital innovation, and sustainable development.

The Airport Think Tank chaired by Gaël Le Bris is one of the most active of our research groups. The Future of Airports is an important study that brings a significant value added to help us foresee future challenges and prepare our industry for the changes to come. The participants of The Future of Airports have provided remarkable work. The output of the working sessions and the research findings are being released as white papers and other practice-ready materials that will be shared and brought to decision makers and leaders of both the public and private sectors worldwide. I am confident that the outcome of this Think Tank will be a huge move forward for the promotion and recognition of the ENAC Alumni.

Marc Houalla, President of ENAC Alumni

Introduction



From March 2019 to April 2020, the Airport Think Tank of ENAC Alumni conducted a research project on the long-term future of the airport industry: “The Future of Airports”. The project involved thought aviation leaders from diverse backgrounds and affiliations who looked at the trends and potentially disruptive changes, emerging transformational innovations, their impact on practice and their challenges for air transportation, and the needs in research, education and policies for anticipating and facilitating these changes.

The future of airports cannot be envisioned without considering the future of our societies. At the 2040 and 2070 horizons of our study, we will count more fellow human beings than ever. Overall, we will be wealthier and more educated, and have a longer life expectancy. However, we will all face increased impacts from climate change that will put pressure on resources and communities, and might increase inequalities. We will have different social expectations. How can aviation address these new paradigms and continue to provide mobility?

First and foremost, we shall never forget that safety always comes first. As we are making air transportation increasingly automated and connected, we shall remember that our top priority must be to safeguard life, health, and property, and to promote the public welfare.

Human-induced climate change is the most formidable threat to our civilization. Transportation must become greener if we want to sustain the development of our societies without degrading our well-being and endangering public health at a horizon increasingly visible. Aviation shall keep pioneering green policies.

As aviation professionals, we are on the front line to tackle the fundamental issues arising and still continue to interconnect people and move freight. Aviation shall remain a world of opportunities and “create and preserve friendship and understanding among the nations and peoples of the world” as stated in the Convention of Chicago of 1947.

By 2040 and 2070, it is likely that unforeseeable groundbreaking technological innovations, scientific discoveries, and social and political changes will occur and deeply impact our world. When reading these pages, remember that we conducted our work and prepared these materials with our eyes of 2019.

We are all part of this future, and we can make a difference individually if we make ethical and sustainable decisions. Aviator and writer Antoine de Saint-Exupéry said that when it comes to the future, “it is not about foreseeing it, but about making it possible”. Let’s make a bright aviation future possible together.

Gaël Le Bris, Chair of the Airport Think Tank of ENAC Alumni

Topic No. 1: The World in 2040 and 2070

A More Populated World: Adding 3 to 6 Billion People by 2070

Per the United Nations, the current human population is more than 7.7 billion. This number will grow around 9 billion in 2040, and then 10.5 billion in 2070. While the demography of the more developed regions will be nearly stagnant and perhaps even starting to shrink by the mid-century, most of the worldwide population growth will occur in Asia and Africa. Africa will observe the highest growth rates and will account for 26% of humankind in 2070. Nigeria, currently with the world’s 7th largest population, is projected to surpass the United States and become the third most populated country before 2050.¹

These trends will dramatically modify the long-term balance of power and the face of the world. They might also change aviation worldwide. While the population will continue growing tremendously over the coming decades, living conditions in the emerging and underdeveloped regions will improve. According to the World Data Lab, half of humanity is now part of the middle class – defined as the households spending between \$11 and \$110 per day per person on a 2011 purchasing power parity basis.²

There is a strong correlation between wealth and air travel demand.^{3,4} The global air traffic is expected to sustain a long-term growth to 2040 and beyond.⁵ To address this demand, new airports and route networks are needed. The new Istanbul Airport (IST) and Beijing Daxing International Airport (PKX) opened in 2019 and are intended to ultimately accommodate 100 to 200 million passengers per year. Last year, the Civil Aviation Administration of China declared aiming to add 216 airports by 2035.⁶

In the meantime, legacy hubs in North America and Western Europe such as Chicago-O’Hare (ORD), Dallas-Fort Worth (DFW), Paris-Charles de Gaulle (CDG) and London-Heathrow (LHR) will be opening new terminal complexes. Various legacy hubs will reach their maximum capacity sooner rather than later with increasing difficulty for expansion projects due to resistance in financing and environmental concerns. For direct intercontinental flights, they will face the competition of the Middle East airports still strategically located between Asia, Africa, and the Western hemisphere.

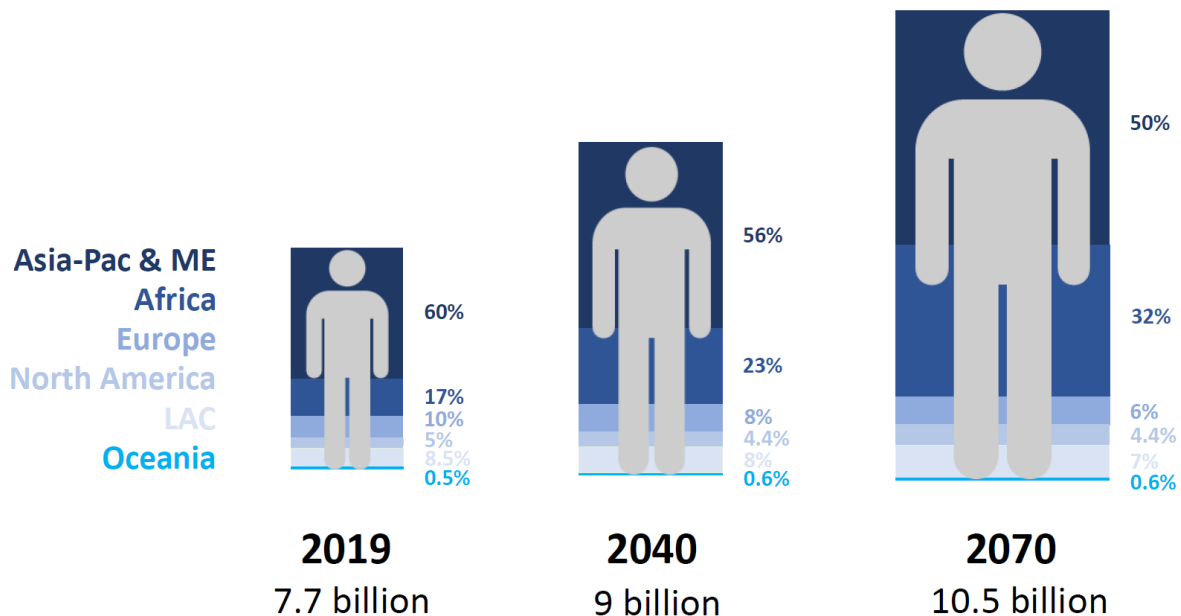


Figure 1-1 - 2019-2070 Evolution of the Worldwide Population

Asia-Pac & ME: Asia, Pacific, and Middle East. LAC: Latin America and Caribbean.

Source: World Population Prospects: The 2019 Revision (Median-Variant Prospect). United Nations, 2019

A Wealthier, More Democratic Society Open to the World

Civil wars are on the rise.⁷ They deeply impact the communities and infrastructure, and force populations to move. Conflicts and overall security in several regions severely prevent the development of air service, isolating these countries further and depriving them of economic opportunities.⁸

Paradoxically, our world is becoming freer and more democratic overall – facilitating the emergence of more stable, open and inclusive societies. Since the beginning of the 20th century, the proportion of humans living in democracies have constantly grown. The last colonial administrations were repealed at the end of the years 1970. Interstate conflicts that have ravaged communities all around the world for most of human history are now on the verge of extinction.⁸

Regional integration and inter-regional agreements have been strengthening peace and mutual prosperity, and removed some international barriers to commercial aviation as well. Open sky agreements between countries combined with the liberalization of air transportation nationwide have benefited the industry and the customers by increasing the offer and lowering airfares. After Europe^b, Africa and Southeast Asia are on their way to become the next common aviation markets. The Single African Air Transport Market (SAATM) under the umbrella of the African Union should be operational by 2023. Completion of the ASEAN Single Aviation Market (ASEAN-SAM) is still struggling with opposition from members to grant third, fourth and fifth freedoms of the air to other member states.⁹

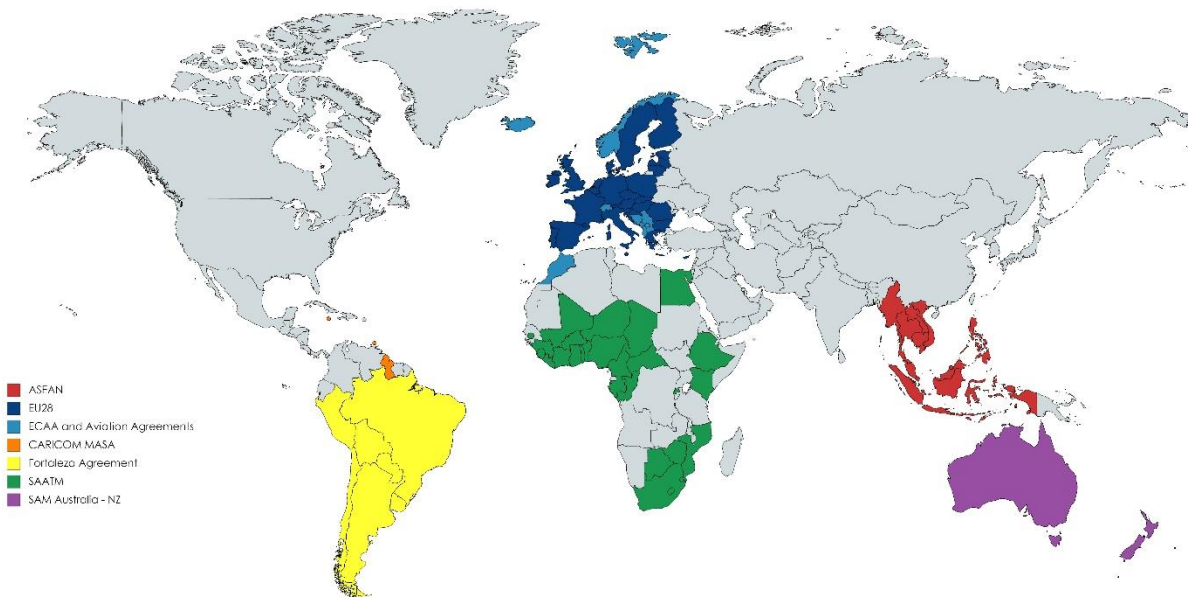


Figure 1-2 - Existing and Emerging Single Aviation Markets
Urban Civilization and Local Communities

The “last frontier” to the competition is the limitations on foreign ownership and control (O&C) of domestic air carriers. In most countries – including the U.S. and E.U., foreign entities cannot control more than 49% of a domestic air carrier. Airlines such as AirAsia and FastJet are getting around current restrictions in Southeast Asia and Africa respectively by creating affiliates under the same branding in different countries, in partnership with local investors, creating a de facto liberalization. In 2019, Brazil

^a While the U.S. is a top trade partner and origin of foreign tourists for Kenya, further development was limited due to the absence of direct flights. Delta Air Lines briefly operated direct flights before suspending operations over security concerns. Kenya Airways started flying to JFK in 2018.

^b The European Common Aviation Area (ECAA) allows any airline incorporated in a member state to operate between two airports within the Area – a key to the success of pan-European air carriers such as EasyJet and Ryanair.

repealed limitations on foreign O&C.¹⁰ The same week, Grupo Globalia (Air Europa) applied to operate domestic flights in Brazil.¹¹ Norwegian Air – already operating domestic flights in neighboring Argentina and international flights to Brazil – has expressed interest. Further liberalization could offer new air service opportunities for countries with weak national air carriers – but also the prospect of further concentration of the offer with mega-mergers between European, North American and Asian air carriers.

About 55% of the worldwide population already lives in urban areas. This percentage will grow to 68% in 2050. In the United States where 82% of the population is already urban today, 11 “megaregions” of higher urban density might appear by 2050¹². By the end of the century, the 5 most populated metropolitan areas will be in Africa and India each one with over 55 million inhabitants¹³ – only one is part of the top 5 today. The growth of megalopolis will create challenges in mobility but also give birth to new aviation megacities. Emerging mobility such as autonomous vehicles, new underground transportation modes, and urban air mobility (UAM) are promising answers to the question of connecting these airports to their metropolitan area. The large footprint of megacities and the congestion on the ground might promote multi-airport systems and secondary airports.

At the same time, smaller and rural communities will still represent a significant population, and some of them might revive or grow with citizens and workers looking for another way of life and a lower cost of living. The dissemination of information and intelligence technologies, autonomous modes of transportation, and new production processes could fill part of the gap in attractiveness of these communities with enhancing accessibility to goods and services, and their connection to the world as well. The market share of regional airlines and commuters has grown over the past decade. Local airports will continue to play a vital role in connecting smaller communities and regional hubs to the world. Point-to-point flights between regional cities will also play an important role in the future, complementary to one of the major hubs and helping to economically and socially develop some regions.

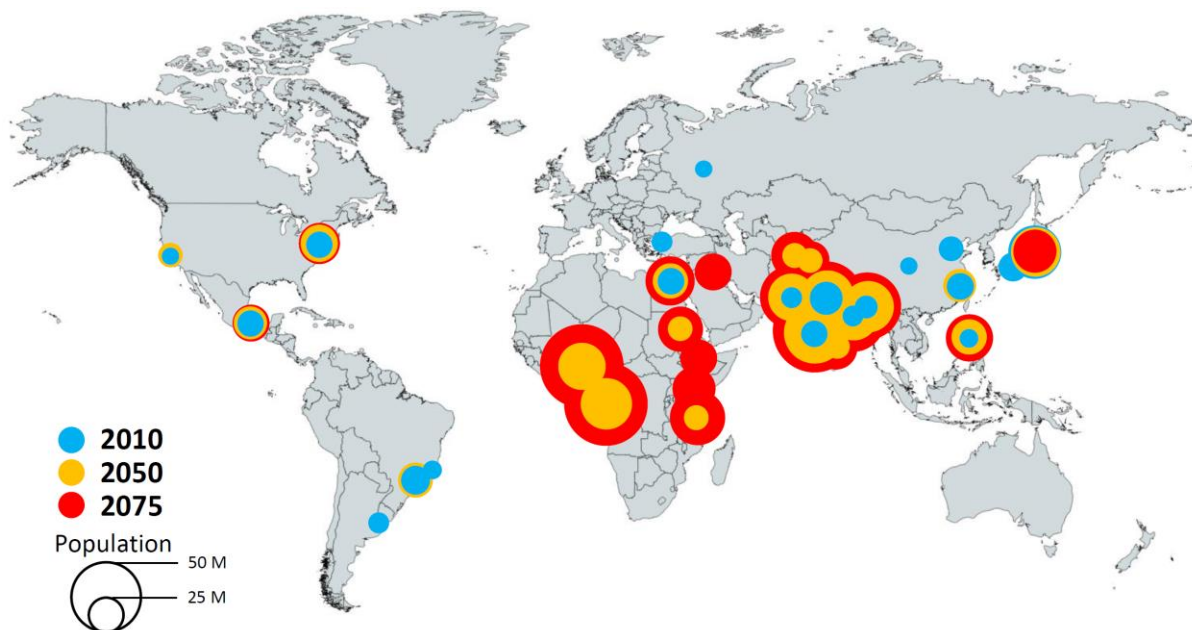


Figure 1-3 - 20 Largest Metropolitan Areas from 2010 to 2075

Source: Hoornweg, D. & Pope, K. Population predictions of the 101 largest cities in the 21st century. Global Cities Institute, 2014

The megacities of the emerging world do not want to be considered as the low-cost manufacture and the landfill of the world anymore. Indonesia, Malaysia, and the Philippines are refusing deliveries of western trash.¹⁴ The P.R. of China has been encouraging economic development in higher technologies. Wages are increasing in developing countries. Carbon taxes on transportation are in discussion. Producing on the other side of the world is not as profitable as it was. At the same time, workers of western nations ask for relocating production and jobs. A growing number of consumers buy locally and call for a circular economy. The *relocalization* of the production of goods and its decentralization to more local sites fostered with a revolution in tooling and industrial processes (e.g. 3D printing) can deeply impact the flows of freight worldwide – including air cargo.

Climate Change

The correlation between human industrial activities and global warming has been widely documented since the years 1960. The Intergovernmental Panel on Climate Change (IPCC) of the United Nations stated in October 2018 that “limiting global warming to 1.5°C would require rapid, far-reaching and unprecedented changes in all aspects of society”.¹⁵ Current policies and effective actions all around the world are mostly behind the goals¹⁶ set in 2015 during the United Nations Framework Convention on Climate Change – also known as the Paris Agreement¹⁷. It is likely that significant impacts on ecosystems, human health, and well-being will occur over the coming decades – some of them are already happening.

While the best warming is the one that we do not generate, airports (and the world) will have to adapt in order to emit less, but also to be more resilient facing the consequences of climate change.¹⁸ Consequences will vary depending on geography and will range from coastal airports more often threatened by flooding hazard to inland facilities impacted by higher temperatures penalizing aircraft payload. Additionally, climate change can already be observed by means of an increase in extreme weather events^{19,20} accompanied by disruptive effects for en route and airport turnaround processes. These changes will impact many aspects, if not all, of airport management and operations, increase both capital expenditures and operating costs, and result in more frequent adverse weather conditions.²¹

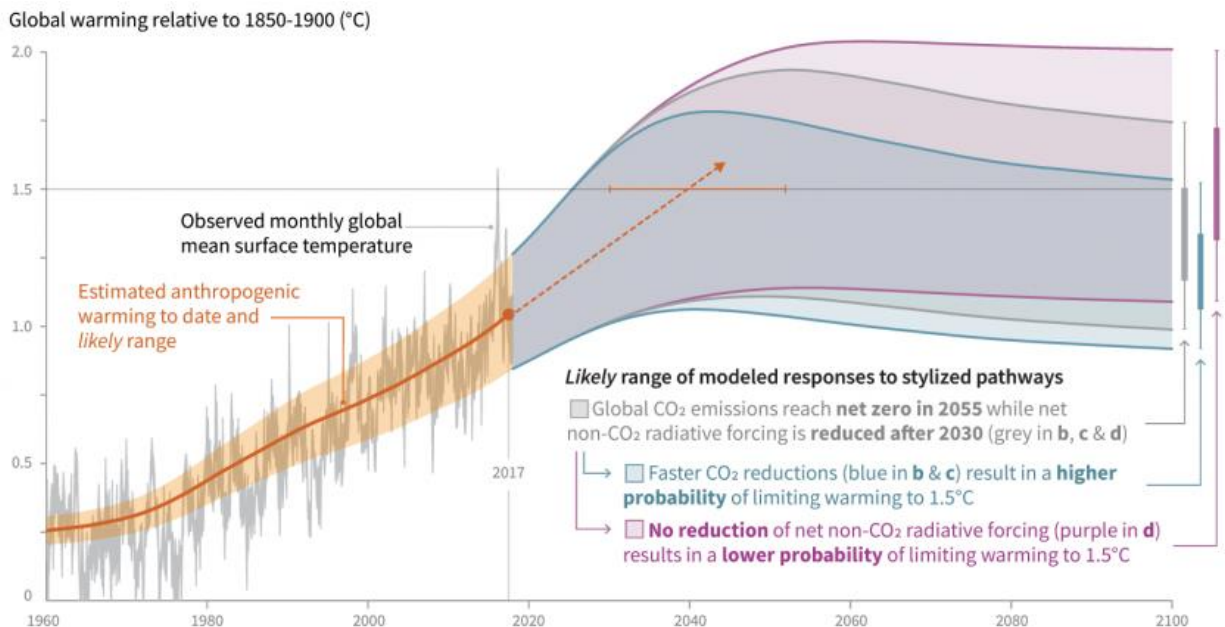


Figure 1-4 - Observed global temperature change and modeled responses to stylized anthropogenic emission and forcing pathways

Source: Summary for Policymakers, Global Warming of 1.5°C, IPCC, United Nations, 2018

Facing the most challenging threat of human history, airports and the aviation industry in general will continue their unprecedented effort to lower their environmental footprint. Accounting for 2% of greenhouse gas emissions, the aviation industry commits to an average improvement in fuel efficiency of 1.5% per year from 2009 to 2020, to a carbon-neutral growth from 2020^c, and to a reduction in net aviation CO₂ emissions of 50% by 2050 relative to 2005 levels. Today, nearly 50 airports are certified carbon neutral per the ACI World Airport Carbon Accreditation program²². Several airports go beyond and have aggressive plans toward more direct carbon emission reduction – sometimes in line with broader local or national policies. In June 2019 at the ACI Europe Annual Congress & General Assembly, the airport trade body unveiled a Resolution formally committing the European airport industry to become net-zero for carbon emissions by 2050, at the latest. Still, a “plane-bashing” movement has developed in Europe supported by lawmakers advocating for banning short-haul flights. Our industry must change, but we shall do more by educating citizens and deciders on what aviation accounts for, what it brings to society, and what it is doing for contributing to the global effort.

Generational Bridge or Generational Gap?

We live longer than ever. Life expectancy is improving worldwide. Fertility rates are decreasing. The population will continue to include a growing number of 60+ members – they will be 2 billion by 2050, healthier and wealthier than their forefathers. It will require societies to think differently, be always more inclusive, and design our world – including transportation – accordingly. Japan leads the way in this domain with a population aging earlier than any other country – more than a third of Japanese are 60-year-old or beyond.

At least half of the generations of passengers of the years 2040 and 2070 are already born. While the 60-year-olds of 2040 grew in a period of relative prosperity and optimism, the 30-to-50-year-olds will have spent their childhood in the post-9/11 era, the Great Depression and the aftermath of the COVID-19 crisis. How will that affect social psychology? Are we going to observe a generational shock?

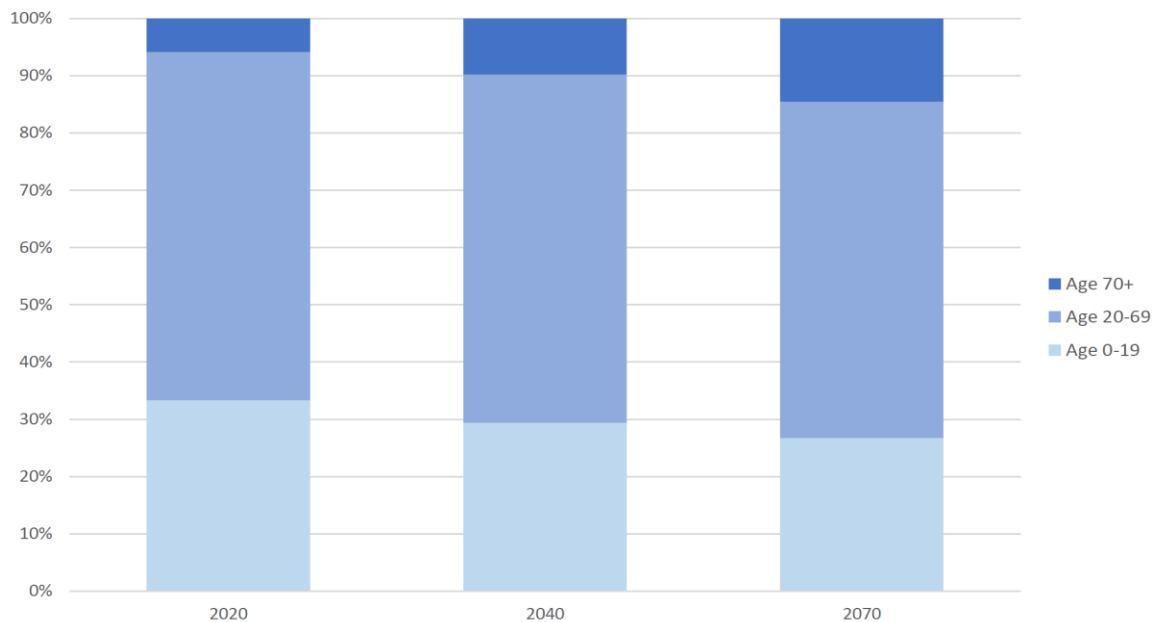


Figure 1-5 - Projection of Age Distribution from 2020 to 2070

Source: World Population Prospects: The 2019 Revision (Median-Variant Prospect). United Nations, 2019

^c This objective considers compensation mechanisms such as ICAO’s Carbon Offsetting & Reduction Scheme for Intl. Aviation (CORSIA).

Children born after 2000 grew up with new technologies. Hyperconnected, the communities of 2040, and furthermore 2070 will not have the same notion of time and space. Adults spend about 6 hours every day in front of an electronic device – half of it on their mobile phones, about the same with a computer. 50 years ago, the news used to take days to reach out to the world and they were dispensed by source considered as authoritative. Acquiring knowledge required to pursue a degree or find a library with adequate books of reference. Paper-based-only bureaucratic processes were taking weeks and months. Information provided by institutional media was curated and verified by professional journalists.

Today, internet users have instant access to more materials than they can ever read in their entire life. Lectures from the best experts are available online for free. At the same time, information is instantaneous – but less often verified. Fake news is spreading – and sometimes spread out on purpose. Waiting in a line is not acceptable anymore. Passengers want immediate achievement of their personal expectations. Full transparency of fares and rules, simplicity and instantaneity of processes, dematerialization, and automation of bureaucracy, no waiting line at all anywhere, personalization of the airport experience at any step are among emerging expectations of passengers that the industry shall satisfy. At the same time, surveys show that 55+ passengers want to keep human interaction in the loop²³.

A Brighter Future Ahead Shall Not Make Us Forget Present Responsibilities and Coming Challenges

Over the decade 2010, oppressed communities showed exceptional resilience and resolution. They do not hesitate anymore to take the streets to topple dictators confiscating democracy. At the same time, in most of the developed and developing world, various movements seem to rebuke the model of liberal democracy built over the 20th century and winner of the Cold War. While 2019 is observing low-unemployment in the Western world, many of its citizens ask for more social justice and transparency, and protest over nation-specific issues as well. They challenge and doubt institutions that promised to deliver freedom and progress for all after the post-Cold War democratization. In a recent survey in South America, less than 25% of respondents declared being satisfied with democracy in their country, and less than 50% of them prefer democracy to other forms of government – the lowest rates since 1995.²⁴

Some want a more participatory democracy – or at least a better representation of their aspirations. Others do not want to be the forgotten of the unprecedented improvements our society is experiencing. Some call for more social and environmental justice while others seem to proclaim a new world of individualism. The fear of others competes with those of extinction. While the world is getting better overall, they remind us of all the paradoxes that we need to address at this beginning of the new millennium.

To keep “flying with us” the best experience on Earth and provide to humanity safe, efficient, and reliable air transportation infrastructure, the airport industry and its stakeholders shall adapt to future challenges and address in a sustainable way the expectations of the passengers, the neighbors, and the citizens.

Appendix 1-1 - Effects of the COVID-19 Crisis on the Aviation Industry

The COVID-19 pandemic led to a brutal and unprecedented decline in air traffic that has grounded a large part of the worldwide fleet of airliners. This crisis is challenging the aviation industry and its people. While many countries are considering or are implementing economic relief measures to help air carriers and airports, it is also important to remember that the broader aviation community – including ground handlers, fixed-base operators, etc. – is being deeply impacted and should benefit from this assistance as well. Some countries have considered supporting the aviation industry entirely. In the United States, for instance, the \$2 trillion relief CARES Act²⁵ includes a \$10 billion increase to the Airport Improvement Program (AIP) with \$100 million specifically allocated to general aviation facilities. Provisions for tax relief are included for general aviation operators and direct loans and loan guarantees for repair stations.

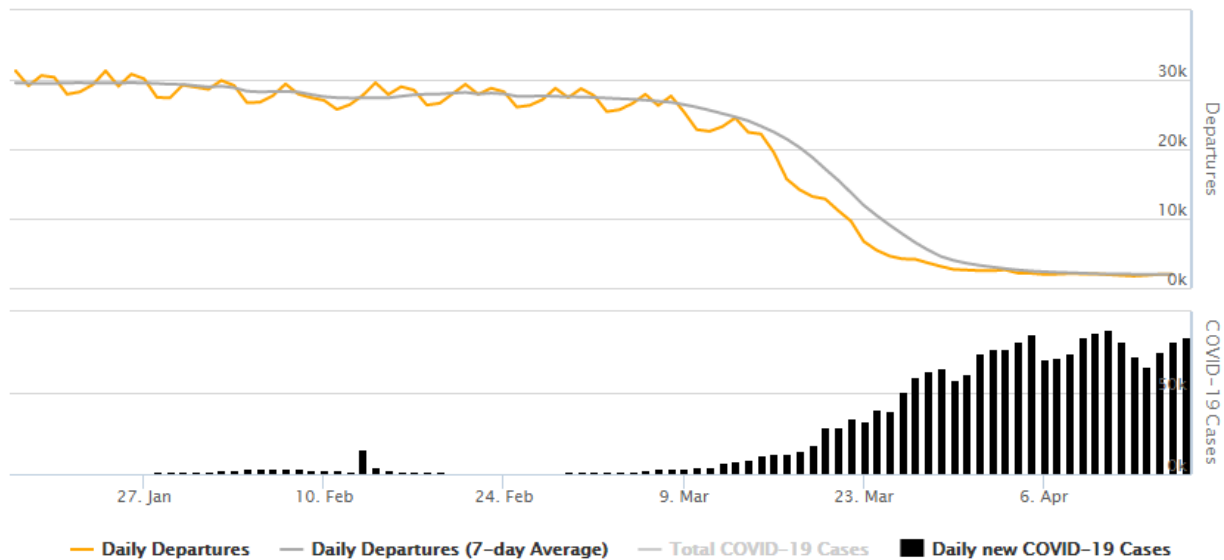


Figure A1-1 - Daily Number of Departures and COVID-19 Cases Worldwide from January to April 2020

Source: ICAO Global COVID-19 Airport Status on April 18, 2020

These bills and measures are critical to temporarily help the industry, but they will not completely offset the impact of the crisis. The effects of this pandemic on air transportation are still uncertain and they will depend on its duration, its severity, and the policies that will be undertaken locally and globally to support aviation and get back to regular operations. In addition, other factors might slow down the demand deep into 2021 and beyond. Without a vaccine, air travelers may reconsider some of their trips – especially the most fragile populations. Even with a vaccine or a cure, the prolongation of the current situation could drive longer-term changes in social behavior. For instance, remote work and web-meetings might further replace face-to-face interactions, decreasing the demand for business-related travels.

Just like 20 years ago after 9/11, we could see a restructuring of part of our industry. Airports should closely follow the choices being made by their air carriers and coordinate with them as far as practicable. Some airlines have already announced they will expedite evolutions of their fleet such as Lufthansa with the phase out of a significant part of their widebody aircraft. Air carriers will leave this crisis financially weakened. Some of them will get bankrupt (e.g., U.K. regional airline FlyBe). This will

affect airports and their relationship with their airlines. Smaller airports might be the most impacted as air carriers will focus on the most profitable markets when resuming passenger operations.

We shall not forget that air transportation has already shown an exceptional long-term resilience to short-term shocks. Once the travel restrictions are lifted, air travel will gain momentum again. The path to recovery might be steep, but the road is straight. Its unique ability to move people and goods at high speed on long distances makes it vital for our societies and our economies. However, some conditions are required to facilitate the recovery. First, aviation must ensure passenger safety. Similar to after 9/11, new procedures might be warranted at airports to screen people and make sure they do not carry the virus. COVID-19 shows that monitoring the temperature is not enough as this procedure does not detect asymptomatic carriers. New tests might be able to provide results within 15 minutes which could make them good candidates to integrate the passenger journey at the airport – at least for international flights. Even after a vaccine is found, protocols for checking passengers' health might be warranted to learn from this crisis and limit future outbreaks.

The second condition is that airports might need financial assistance in order to maintain their infrastructure and conduct the necessary development projects to meet the future demand. While the traffic decrease might be temporary, the impact of COVID-19 on airports' cash availability could last longer. The need for investment in capacity and level of service that were identified before the COVID-19 will still be here once the traffic recovers. Also, a slowdown in capital improvement programs will impact contractors and the broader ecosystem of airport construction projects. The United States has already dramatically increased its Airport Improvement Program (AIP) and lifted the need for airport operators to provide part of the funding. Brazil and Canada are waiving rents and other concession fees due to the federal government. Other mechanisms such as government loans could be needed to temporarily support the modernization and development of airport facilities.

In the meantime, many aviation facilities are partially closing or seeing a significant drop in their activity – including general aviation airports. This will be momentary. To make the best of a bad situation, this is an opportunity to perform maintenance and construction activities that would be impacting the traffic otherwise, as long as these operations can be funded and are compatible with the local orders and movement restrictions, national recommendations, and industry practices^{26, 27}. While most of the commercial service airports around the world now have some arrangements for the temporary parking of overflow aircraft, this storage shall be organized to preserve airfield assets.²⁸ Finally, this forced slowdown can be utilized for reflecting on current and longer-term policies – including sustainable airport initiatives and innovation roadmaps.

Through these difficult times, it is important that all the stakeholders work together and help each other. This is not the first time that aviation has gone through strong turbulences. With our exceptional resilience, if we stay united, and if we learn from this crisis to mitigate the impact of future pandemics, we will prevail, adapt, and leave this crisis stronger and more resilient than ever.

Abbreviations

AAI	Airports Authority of India
AAJ	Airport Authority of Jamaica
A-CDM	Airport Collaborative Decision Making
ACSA	Airports Company South Africa
ADAC	Abu Dhabi Airport Company
ADM	Aéroports de Montréal
ADR	Aeroporti di Roma
AENA	Aeropuertos Españoles y Navegación Aérea
AFIS	Aerodrome Flight Information Service
AI	Artificial Intelligence
ANN	Artificial Neural Network
APOC	Airport Operations Center
ASEAN-SAM	ASEAN Single Aviation Market
ASUR	Grupo Aeroportuario del Sureste, S.A.B. de C.V.
ATL	Hartsfield-Jackson Atlanta International Airport
ATM	Air Traffic Management
BCB	Body Cavity Bomb
BKG	Branson Airport
BNDES	Banco Nacional de Desenvolvimento Econômico e Social
CAAC	Civil Aviation Administration of China
CAG	Changi Airport Group
CAH	Capital Airport Holding
CDG	Paris-Charles de Gaulle Airport
CDM	Collaborative Decision Making
CNS	Communication, Navigation and Surveillance
COVID-19	Coronavirus Disease 2019
DAC	Dubai Airports Company
DAESP	Departamento Aeroviário do Estado de São Paulo
DFW	Dallas-Fort Worth International Airport
DOK	Donetsk Airport
DOU	Diário Oficial da União
ECAA	European Common Aviation Area
EGSA	Etablissement de Gestion de Services Aéroportuaires
EHCAAN	Egyptian Holding Company for Airports and Air Navigation
EMI	Electromagnetic Impulse
ENAC	Ecole Nationale de l'Aviation Civile
ENANA-EP	Empresa Nacional de Exploração de Aeroportos e Navegação Aérea E.P.
ERAU	Embry-Riddle Aeronautical University
FIT	Florida Institute of Technology
GACA	General Authority of Civil Aviation
GANP	Global Air Navigation Plan
GASeP	Global Aviation Security Plan
GMF	Global Market Forecast
GMR Group	Grandhi Mallikarjuna Rao Group
GTAA	Greater Toronto Airport Authority
HCC	Hub Control Center

IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
Infraero	Empresa Brasileira de Infraestrutura Aeroportuária
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IST	Istanbul Airport
KUL	Kuala Lumpur International Airport
LAWA	Los Angeles Airport World
LGP	LaGuardia Gateway Partners
LHR	London-Heathrow
MANPAD	Man-Portable Air-Defense System
MDAD	Miami-Dade Aviation Department
MIA	Miami International Airport
ML	Machine Learning
MRS	Marseille-Provence International Airport
MWAA	Metropolitan Washington Airports Authority
NEXTT	New Experience Travel Technologies
NFC	Near-Field Communication
O&C	Ownership & Control
OCC	Operations Control Center
OER	Örnsköldsvik Airport
ONDA	Office National Des Aéroports
ORD	Chicago-O'Hare International Airport
ORY	Paris-Orly International Airport
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PKX	Beijing Daxing International Airport
RPA	Regional Plan Association
RTC	Remote Tower Center
rTWR	Remote Tower
RVA	Régie des Voies Aériennes de la République Démocratique du Congo
SAAS	San Antonio Airport System
SAATM	Single African Air Transport Market
SAT	San Antonio International
SDL	Sundsvall–Timrå Airport
SFB	Orlando Sanford International Airport
SIIED	Surgically Implanted Improvised Explosive Device
SIN	Singapore-Changi International Airport
SJU	San Juan Luis Muñoz Marín International Airport
SWIM	System Wide Information Management
TAM	Total Airport Management
TIP	Tripoli International Airport
TNC	Transportation Network Companies
TRT	Turnaround Time
UAM	Urban Air Mobility
UATM	Urban Air Traffic Management

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