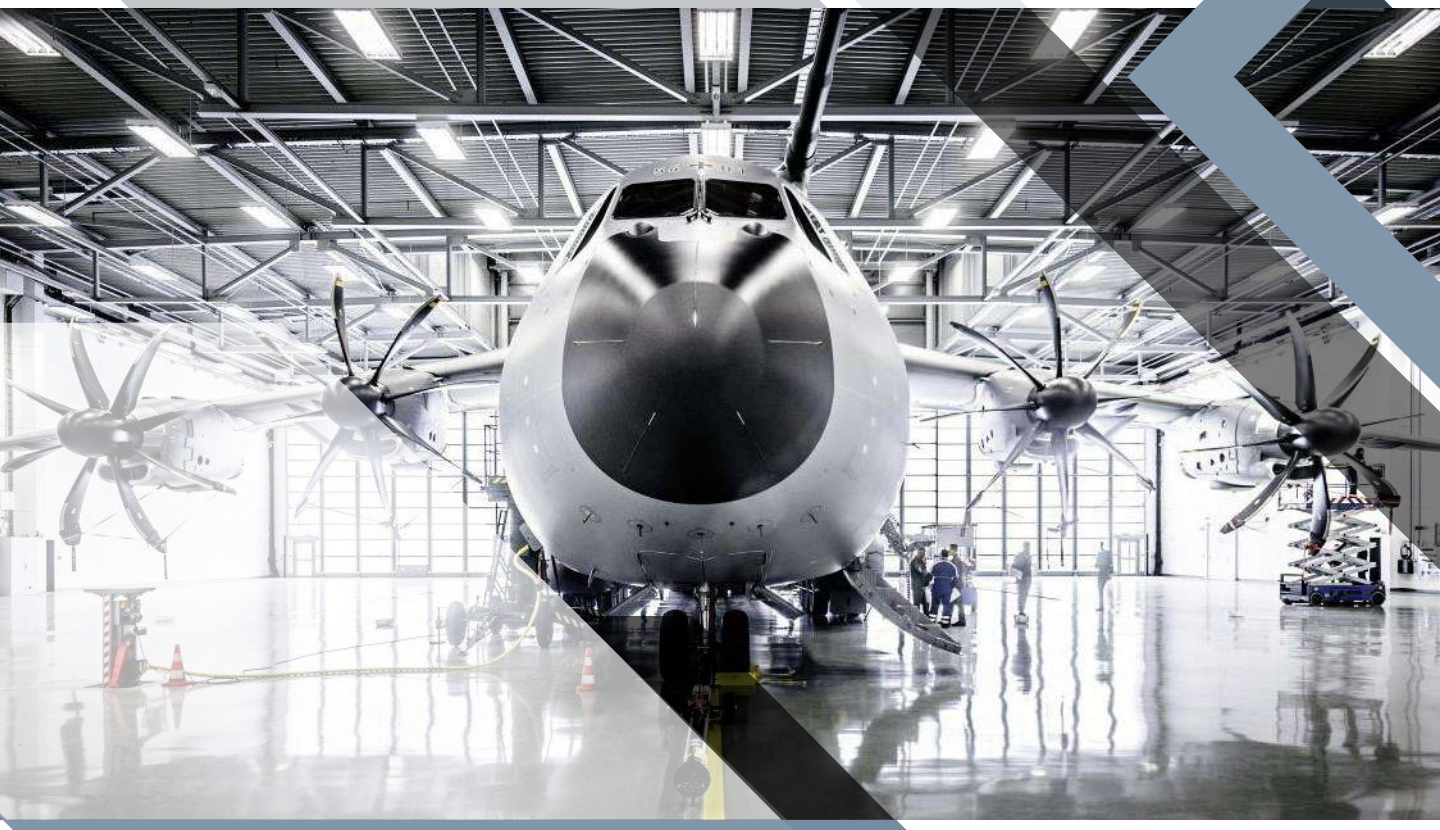
DABICO
airport solutions



THE FUTURE OF AIRPORTS

May 2022

Siva Anand
Director, Global System Solutions & PCA Management
Dabico Airport Solutions

Radu Dolghi
Vice President Services
Product Manager Services
Dabico Airport Solutions

Juergen Strommer
Chief Executive Officer
Dabico Airport Solutions

Nidhi Arora
Vice President
Fernweh Group

CONTENTS

Executive Summary

The airport industry, a significant contributor to the global economy, is going through a major transformation as it prepares for a post-pandemic recovery. To meet the challenges ahead, airport management will seek to develop an airport of the future—one that is sustainable, digitally enabled, and prepared to deliver a seamless experience to those who visit or work at it.

The transformation taking place has four major drivers. First, customers, society, investors, and governments are clamoring for greater environmental sustainability. At the same time, airports, like other employers, are encountering workforce shortages, which in part contribute to the attractiveness of investing in automation. The passengers who use airports are another driver of change as they press for travel experiences that are seamless and safe. And airport infrastructure is increasingly inadequate for meeting all these demands, especially as passenger traffic is on the increase.

These transformation drivers are propelling major shifts in several design and operational elements of airports. To meet the demands for sustainability, airports are becoming greener, with eco-friendly ground handling, efficient ground service operations, sustainable aviation fuel (SAF) infrastructure for fuel-efficient aircraft, on-site renewable energy generation, and energy management systems throughout the airport. To address labor shortages while improving efficiency and customer experience, airports are turning to automation such as robotic terminals, autonomous vehicles, and considering use of drones. To make the travel experience more seamless, airports are investing in contactless technologies, AI, data analytics, and cloud computing. And they are investing in infrastructure upgrades to build large terminals designed to flexibly adjust to new uses with more green spaces and better ventilation.

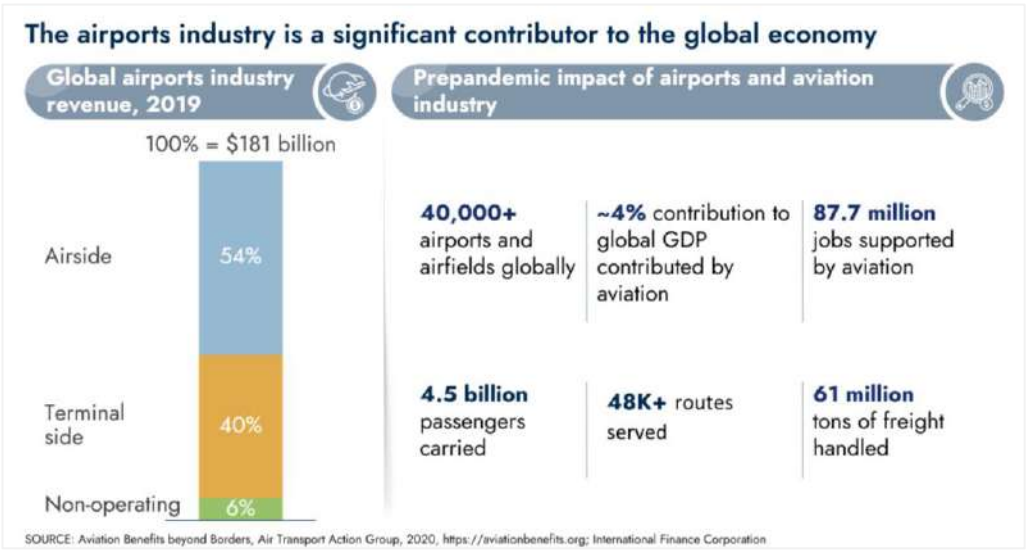
Multiple stakeholders within the aviation ecosystem have a role to play in this digital, sustainable transformation. They include airport administration and project teams, government, airlines, ground handling service providers, and ground service equipment OEMs. Among all these categories of stakeholders, we find some that are acting early and have initiatives under way.

As the stakeholders gear up to play their part in shaping the digital, sustainable future of airports, five building blocks need to fall in place for accelerating the transformation. These are end-to-end stakeholder engagement, regulations and policies in place, availability and integration of technology, adequate financing for infrastructure projects, and sustained market dynamics to provide a context for favorable returns on investment

Introduction

The airport industry is a significant contributor to the global economy. Looking at the most recent year before the COVID-19 pandemic, more than 40,000 airports around the world were carrying 4.5 billion passengers and handling 61 million tons of freight and generated $181 billion in revenue in 2019.[1] The global aviation sector overall—including airlines, airports, and the related ecosystem—contributed about 4 percent of global GDP and supported 87.7 million jobs (Exhibit 1).

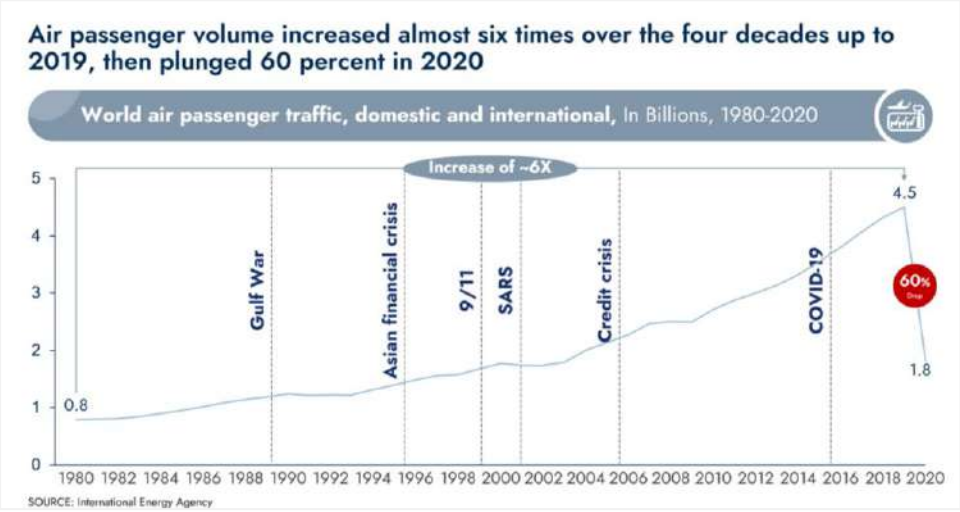
Exhibit 1



It is well known that airlines suffered when COVID-19 spread around the world, but this is expected to be a short-term, though significant, setback. Between 1980 and 2019, domestic and international air passenger traffic grew by six times, from 0.8 billion to 4.5 billion per year (Exhibit 2).[2] In 2020, global airport traffic plummeted by 60 percent. The Middle East and Africa were hit hardest, posting declines of 76 percent and 69 percent, respectively, but no region was left unscathed.

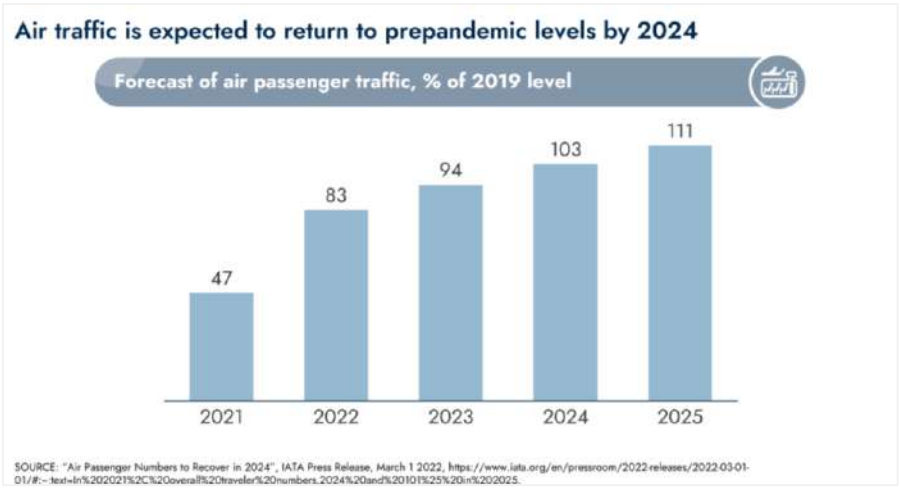
[1] *Aviation Benefits beyond Borders, Air Transport Action Group, 2020, https://aviationbenefits.org.*
[2] *World air passenger traffic evolution, 1980-2020, International Energy Agency, https://www.iea.org/.*

Exhibit 2



After a difficult 2020–21, air traffic quickly began to recover as vaccination rates rose and governments eased travel restrictions. Air traffic is expected to reach 83 percent of 2019 levels in 2022 (Exhibit 3). Growth is expected to continue, surpassing 2019 levels in 2024 and continuing to rise through 2025, reaching 111 percent of 2019 levels.[3]

Exhibit 3



As the airport industry prepares for this post-pandemic recovery, it is experiencing a transformation in response to major forces already shaping the aviation industry. These forces are necessitating a rethinking of airport design and operational elements in order to prepare for success in the future. The airport of the future will improve the travel experience for passengers even as it makes operations more sustainable for airports and airlines alike. This report describes the role different stakeholders within the aviation ecosystem must play in shaping the sustainable and digital airport of the future. Success also depends on a confluence of several other conditions.

The following chapters will take a more in-depth look at these topics.

[3] *"Air Passenger Numbers to Recover in 2024", IATA Press Release, March 1 2022, https://www.iata.org/en/pressroom/2022-releases/2022-03-01-01/#:~:text=In%202021%2C%20overall%20traveler%20numbers,2024%20and%20101%25%20in%202025.*

CHAPTER 01

Forces Shaping the Airport Industry

DABICO airport solutions

Forces Shaping the Airport Industry

While gearing up for a recovery in the transportation sector, the airport industry finds itself riding a wave of transformation necessitated by four factors in its environment: increased focus on environmental sustainability, increasing demand for automation due to workforce shortages, rising passenger expectations related to seamless and safe travel, and demands on infrastructure. While the pandemic slowed business for the airport industry, it actually intensified these forces of change. For example, focus on sustainability increased as people saw that reduced travel mitigated carbon emissions, and pandemic-related health checks contributed to pressure on airport infrastructure. Thus, the travel slowdown of 2020 contributed to rather than delayed the need to transform.

Increasing Focus on Sustainability

Environmental sustainability is not a new topic for the aviation industry, including airports. International agencies have launched several important initiatives for many years now (Exhibit 4).[4]

Exhibit 4

[4] *"Airport Sustainability: Global Trends and S4GA Impact," S4GA, November 27, 2020, https://solutions4ga.com; Katherine Preston, "Sustainability Initiatives Helping Airports Address Climate Change," **International Airport Review**, September 28, 2015, https://www.internationalairportreview.com.*

- In 2007, the International Civil Aviation Organization (ICAO) launched its Environmental Protection Program to create transparency and progress on reducing the environmental impact of aviation. As part of the program, policies and practices related to environmental protection have been updated every three years.

- ·In 2008, a partnership of the Airports Council International (ACI) World and international aviation stakeholders (airlines and manufacturers) formed the Airport Transport Action Group to develop goals for carbon-neutral growth beginning in 2020 and a 50 percent reduction in net greenhouse gas (GHG) emissions relative to 2005 levels by 2050.

- ·In 2009, ACI Europe launched the Airport Carbon Accreditation Program, a global carbon management certification program that independently assesses and recognizes airports' efforts to manage and reduce their carbon emissions.

- ·In 2012, the US Federal Aviation Administration (FAA) published its Aviation Environmental and Energy Policy Statement to identify and reaffirm its commitment to environmental protection that allows sustained aviation growth. FAA's programs and airport sustainability plans help airports integrate sustainability into airport planning.

- In 2016, the ICAO adopted the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to cap net aviation emissions of CO2 by 2050 relative to 2005 levels.

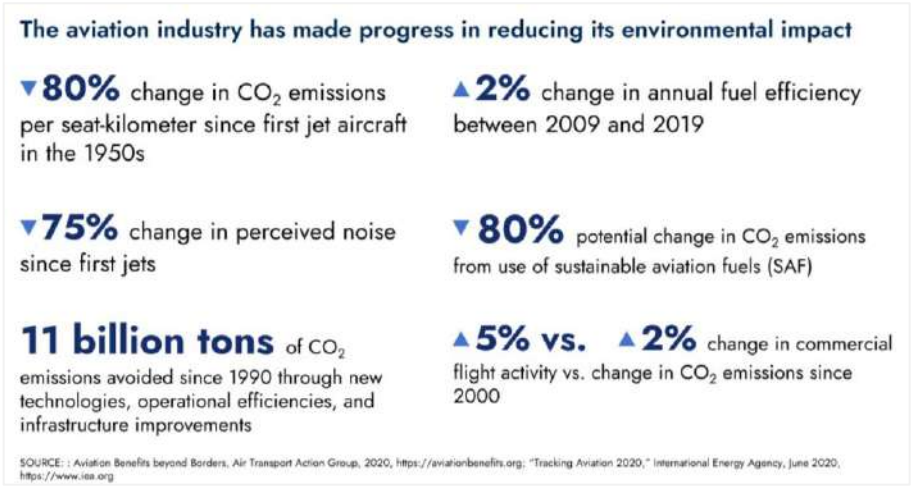
Such initiatives have only continued to accelerate as air transport business is in the public eye like never before especially with the exposure of environmental issues in the global media (Paris Agreement of 2015, Amazon rainforest fires of 2020, occasional hot summer days in the UK, Greta Thunberg sailing the Atlantic in 2019, etc.)

Now multiple airports around the world are also making attempts to go green[5]:

- Boston Logan International Airport, World's first air terminal to win a Leadership in Energy and Environmental Design accreditation, has incorporated multiple smart and sustainable building elements in its design. The terminal features roofing and pavement surfaces designed to reflect heat from the building. The low-flow bathroom fixtures help to save water. In addition, a fleet of 6ft tall wind turbines installed on top of the airport's offices generate around 3% of the energy required for its operations
- Zurich Airport has made a concerted effort to reduce carbon emissions by approximately 30% since 1991. The major enablers include the photovoltaic systems fitted on the roves of aircraft docks and car parks and the underground energy piles that are used to heat and cool its terminals. In addition to green energy, the airport has also focused on reducing water consumption through domestic wastewater treatment, rainwater usage for toilets, and recycling of water from de-icing operations.
- Delhi International Airport, is working towards becoming a "net zero carbon emission airport" by 2030, was recognized as a green airport by ACI-Asia in 2021 for its sustainability initiatives. The airport's green infrastructure includes a departure lounge lit completely by sunlight during the day, 1,200 energy-efficient LCD screens, 300 rainwater harvesting stations and storm drains. Ground operations are powered by electric vehicles and the use of TaxiBot has helped in reducing around 532 tonnes of carbon at the airport.

As a result of such efforts, the industry has in the past made progress in reducing environmental impact (Exhibit 5). In particular, improved fuel efficiency has contributed to a dramatic fall in the amount of carbon dioxide emissions per seat-kilometer. Improvements in infrastructure and operational efficiencies also have contributed to slowing growth in carbon emissions.

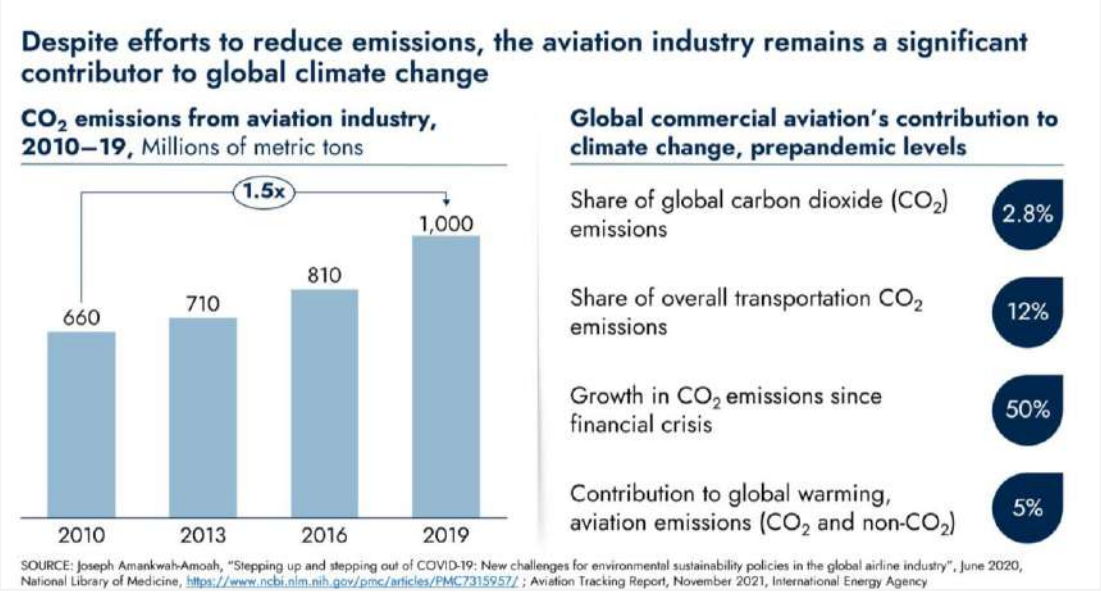
Exhibit 5



[5] *"Airport Sustainability: Global Trends and S4GA Impact," S4GA, November 27, 2020, https://solutions4ga.com; Katherine Preston, "Sustainability Initiatives Helping Airports Address Climate Change," **International Airport Review,** September 28, 2015, https://www.internationalairportreview.com; Joe Baker, "The World's Most Environmentally Friendly Airports," **Airport Technology**, updated January 30, 2020, https://www.airport-technology.com.*

Despite this, the industry is still under scrutiny because it remains a major contributor to climate change. Aviation accounts for 2 percent of global CO_2 emissions, and the industry is responsible for around 5 percent of global warming (Exhibit 6). According to a forecast by the ICAO, carbon emissions will grow by an additional 300 to 700 percent by 2050 if no effective measures are taken to minimize carbon footprints.[6] Such an increase in emissions, will trap more heat in the atmosphere, thereby causing earth's temperatures to rise further.

Exhibit 6



The COVID-19 pandemic drew additional attention to sustainability, as societies witnessed the decline in emission levels when passenger volumes plunged. In this way, the pandemic highlighted aviation's impact on climate change, thereby increasing the need to focus on sustainability as passenger volumes recover. Climate activists who welcomed the empty skies as global CO_2 emissions from aviation fell by one-third from 2019 to 2020 now demand green practices as air traffic is set to rise. The reductions in noise and air pollution during the lockdowns inspired governments and policy makers around the world to roll out new legislation aimed at curbing aviation-related pollution. The increasing need to focus on sustainability is far from over.

[6]*Charlotte Edmond, "If Airlines Were a Country They'd Be One of the World's Top 10 Greenhouse Gas Emitters," World Economic Forum, July 26, 2019, https://www.weforum.org.*

Rising Automation due to Workforce Shortages

The long-running challenge of finding and retaining human resources is another trend that became more difficult during the pandemic. The rapid drop-off in travel caused airports around the world to reduce payrolls with furloughs and layoffs. In March 2020, for example, Philadelphia Airport in the United States eliminated more than 500 positions, mostly subcontractors handling responsibilities such as baggage handling and cabin cleaning. That May, Canada's Vancouver Airport laid off about one-fourth of its staff. The same month, Dnata—Emirates Group's airport services subsidiary—laid off and placed thousands of employees on unpaid leave including at Dubai's second airport, Al Maktoum. Such measures extended into 2021 as passenger traffic resumed only gradually.

Although the pandemic conditions have eased, the challenge of workforce planning has not; it has merely shifted to coping with a labor market in which many workers are nervous about returning to busy and crowded places like airports and are demanding higher pay and greater flexibility. Airports have struggled to bring employees back to work, especially as workers find job options in less exposed environments or even retire early to avoid the risk of exposure to the latest variant. Other difficulties include a lack of skilled workers who are trained in the new safety and security measures at airports and nations' border closures, which made it impossible for airports to tap international talent. Meanwhile, employees demand higher pay, more flexible work hours, and remote work—all of which are challenging to accommodate in the airport industry.

As more and more passengers take to the skies, understaffed airports have contributed to travel disruptions. Flights are delayed and canceled more often, and anxious travelers grow impatient and worried as they stand in long lines at airport restaurants and shops. Experts predict airports of the future will adjust, restructuring work to be handled by smaller workforces, with robots, drones, and autonomous vehicles becoming a key component of day-to-day operations. Already, Hong Kong International Airport uses self-driving robots to clean public areas and restrooms, and Canada's Winnipeg International Airport uses autonomous snowplows.

Passenger Preferences for Seamless and Safe Travel

According to the IATA Global Passenger Survey in 2019, passengers wanted airlines and airports to enable innovation and improve their handling of travel disruptions to facilitate a seamless journey. For example, during air travel, key touchpoints include boarding the aircraft, changing planes at a transfer airport, and flying with multiple carriers. When boarding, passengers appreciate efficient queuing process at the boarding gate, not needing a coach or bus to get to the aircraft, and availability of overhead space for carry-on luggage. At the transfer airport, they want to avoid going through security again and picking up and reclaiming baggage. They also appreciate receiving notifications on a smart device about baggage transfer. When flying with multiple carriers, a seamless journey includes receiving boarding passes for all flights at initial check-in and complete knowledge of which airline to contact in case of an issue during the journey.

While a seamless journey was top of mind for passengers well before the COVID-19 pandemic, the pandemic, which brought health checks that increased airport processing times[7], intensified this attitude. Prior to COVID-19, passengers spent an average of one and a half hours in travel processes for every journey—including for check-in, security, border control, customs, and baggage claims. Early in the pandemic, although travel volumes had fallen to about 30 percent of pre-COVID-19 levels, the hour and a half ballooned to three hours during peak time. Reasons included slower check-in and border control due to the requirement to check travel health credentials.

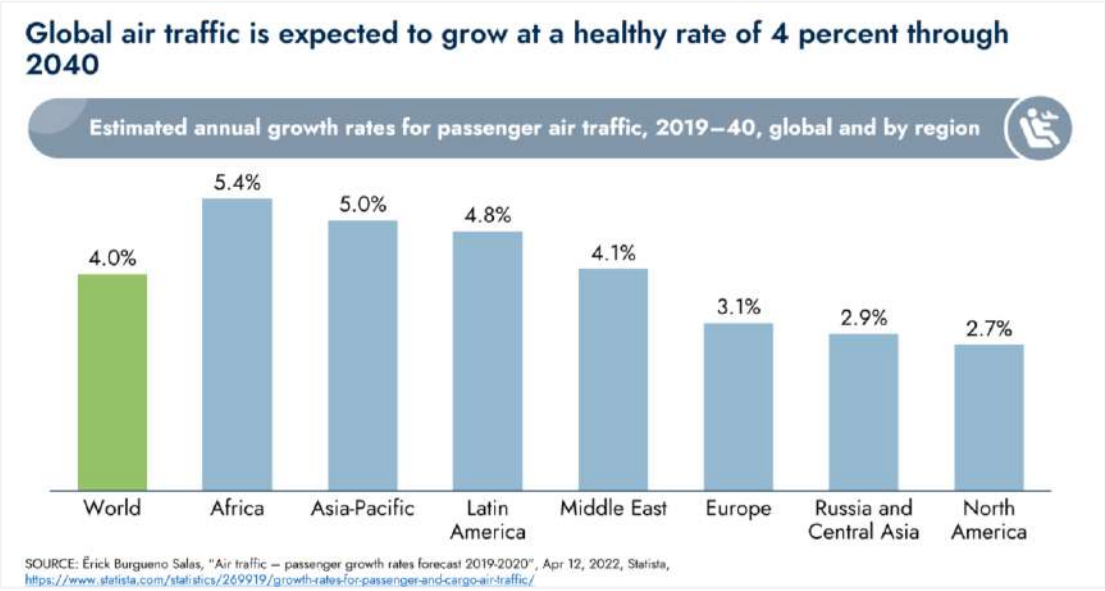
Weary and stressed passengers now demand smoother, faster processes. Generally, this means increased digitization at airports, resulting in an additional benefit: more personal control over the journey, using smartphones for check-ins, baggage tracking, and travel notifications. Passengers also demand seamless security enabled by biometrics and more contactless technology like self-service kiosks and remote thermal screening to ensure health and safety. Estimates suggest that without such digitization-driven process improvements, time spent on airport processes is likely to get even longer as more travelers return, perhaps reaching 5.5 hours per trip at 75 percent of pre-COVID-19 traffic levels and eight hours per trip at pre-COVID-19 traffic levels.

[7] *"Digitilization needed for smooth restart,"* ***IATA Pressroom****, May 26, 2021, https://www.iata.org/en/pressroom/pr/2021-05-26-02/*

Demands on Capacity

Global air traffic is expected to grow briskly, at 4 percent per year between 2019 and 2040, in response to the "democratization" of air travel, the emergence of a large middle class in the Asia-Pacific region, and low-cost travel options in Europe and North America (Exhibit 7). This makes airports' already-taxed infrastructure wholly inadequate for the future. For example, while global air cargo demand increased by 6.9 percent in 2021 relative to 2019, capacity in 2021 was 10.9 percent below 2019 capacity.[8] With global air passenger traffic expected to surpass 10 billion by 2040, according to ACI-World, airport infrastructure around the world needs to be upgraded to avoid the risk of losing 10,500 jobs and $346 million in GDP for every million passengers not accommodated.

Exhibit 7



The COVID-19 pandemic intensified the problem by forcing airports to pause many infrastructure projects. As the pandemic devastated airport finances, airport infrastructure projects around the world got delayed. European airports cut their infrastructure spending by 25 percent or more in 2020 relative to 2019. Within the United States, projects with budgets of tens of billions of dollars were delayed or cancelled due to the pandemic-driven recession.[9]

The inadequate infrastructure and pandemic-driven backlog of infrastructure projects will trigger $1.2 trillion to $1.5 trillion in infrastructure spending through 2030.[10] Asia is likely to take the lead on spending for airport infrastructure, with Europe and North America being next in terms of spending levels.

[8]*Rebecca Jeffrey, "IATA: Strong 2021 Air Cargo Demand with Constrained Capacity," **Air Cargo News**, January 25, 2022, https://www.aircargonews.net.*

[9]***Building the Runway to Economic Growth**, ACI-NA 2021 Infrastructure Report, Airports Council International (ACI) North America, March 2021, https://airportscouncil.org.*

[10]*"Airport Infrastructure," International Air Transport Association, https://www.iata.org, accessed May 12, 2022.*

CHAPTER 02

How Airports Are Responding

DABICO airport solutions

How Airports Are Responding

These transformation drivers are propelling major shifts in several design and operational elements of airports. Airports are improving the sustainability of their operations, meeting customer demand through automation, and investing in advanced infrastructure.

Sustainable Operations

As noted in the previous section, the aviation industry has responded to concern about sustainability by establishing sustainability goals. The industry as a whole aims to achieve net-zero carbon emissions by 2050 and has set targets for increasing production of sustainable aviation fuels. The airport industry took center stage at COP26's Climate Action Hub, reaffirming their global commitment to net-zero carbon emissions by 2050. Europe's airports, which in 2019 committed to a goal of net-zero CO_2 airport emissions by 2050, followed up with a global net zero 2050 commitment in 2021. As a consequence of these measures, it is anticipated that 94 European airports will achieve net-zero carbon emissions by 2030.[11]

Ways to improve the sustainability of operations at airports include eco-friendly ground handling, efficient ground operations to reduce congestion and improve aircraft turnaround times, thereby reducing fuel usage, on-site renewable energy generation, infrastructure for sustainable aviation fuels, and better energy management. One airport that is leading in such efforts is the world's first solar airport, India's Cochin International Airport. It has a solar power plant that produces 50,000 to 60,000 kilowatt-hours of electricity per day to be consumed for all its operational functions. Stockholm's Arlanda Airport in 2009 became the first European airport to achieve carbon neutrality. To save electricity, it uses a biofuel system to heat its terminals, hangar, and airfield buildings. Low-power LED lighting and several other measures allowed Arlanda to cut energy use by almost a third in the period from 2005 to 2012.[12]

[11] *Stephenson Harwood, "Cleaning Up the Skies; the Commitments Made by the Aviation Industry Surrounding COP26," news release, November 15, 2021, https://www.shlegal.com.*

[12] *"Airport Sustainability: Global Trends and S4GA Impact," S4GA, November 27, 2020, https://solutions4ga.com; Joe Baker, "The World's Most Environmentally Friendly Airports," **Airport Technology**, updated January 30, 2020, https://www.airport-technology.com.*

Eco-friendly Ground Handling

Eco-friendly ground handling operations involves switching from diesel-powered vehicles to electric, hybrid, or gas-powered vehicles for facilitating airside services, including runway and apron maintenance, ground handling—for example, towing, fueling, pushback tugs, catering trucks, baggage vehicles, deicing vehicles, and passenger shuttles. Such vehicles make less noise and do not emit GHGs. Success with eco-friendly ground-handling depends upon adequate EV infrastructure and distribution management technology.[13] Charging points should be strategically placed for usability and convenience based on knowledge of the specific airport ground service operations, including staff habits. Efficient and reliable power distribution and electrical distribution management tools can support e-charging while ensuring that passengers have an undisrupted and on-time travel experience. Real-time monitoring and control of power system status enable rapid identification of abnormal temperature, insulation faults, or power disturbances.

Another way to make ground handling more eco-friendly is to gain access to reliable green electricity sources like microgrids for e-charging. New York City's JFK Airport has included microgrid technology in the redevelopment of its Terminal One. The microgrid always provides JFK with access to reliable source of energy. In addition of electric reliability, the airport can integrate renewable sources like wind and solar power into the microgrid, thereby contributing to its goal of reaching 100% renewable energy usage within this decade. By using microgrids, the airport also has the flexibility to use the least expensive energy choice and cost effectively balance the grid during peak periods.

Electric-powered ground handling equipment is increasingly being used at several airports and help to reduce emissions. Dabico's latest offering, the 400Hz-eGPU is a step forward towards emission free power at airports (Photo 1). This new Dabico 400Hz-eGPU charges faster, lasts longer and works smarter.

Photo 1

Dabico's 400Hz battery-powered ground power unit for aircraft. *Photo owner: Dabico Airport Solutions*

[13] *Valerie Layan, "The Important Role of Ground Support Equipment in the Race toward Airport Sustainability," Schneider Electric blog, November 16, 2020, https://blog.se.com.*

At Changi Airport in Singapore, electric baggage tractors on the airside saved 627 tons of CO_2 emissions. To encourage their adoption, 26 common-use charging points eliminate the need for ground handlers' dedicated electric chargers; this also reduces costs and saves space (Photo 2). The airport has a fully electric fleet at one terminal and plans to convert a majority of diesel-powered ground service equipment (GSE) to electric by 2030.

Photo 2

Electric baggage trucks being charged at Singapore's Changi Airport. *Photo owner: Changi Airport Group*

Efficient and Safe Ground Service Operations

To attain efficient and safe ground service operations, multiple airports around the world are increasingly using fixed in-ground pit systems and integrated services for power, heating/ cooling (pre-conditioned air, or PCA), fueling, water, and sewage for ground servicing of the aircrafts. Such in-ground pit systems are one of the two types of fixed electrical ground support equipment (GSE)—the other being above ground systems and offers many advantages over both mobile GSE and fixed above ground systems. Relative to mobile GSE that are typically diesel powered, the electrical in-ground pit systems offer an eco-friendlier option. Another benefit includes enhanced safety of operations. Both mobile GSEs and above ground systems have many hoses cables that are exposed, thereby increasing risk of accidents. Above ground systems when mounted on passenger boarding bridges (PBB),

also put additional load on the PBB and add to the risk profile of the apron (Photo 3). In comparison, in an in-ground pit system, with all the equipment being in-ground (Exhibit 8), housed inside pits, no exposed excess hoses and cables are above-the-ground, and apron congestion is reduced, thereby limiting incidences of apron accidents. Such in-ground pit systems also keep the PBB free of any equipment.

Photo 3

PBB mounted systems adding additional load on the PBB. Photo owner: Dabico Airport Solutions

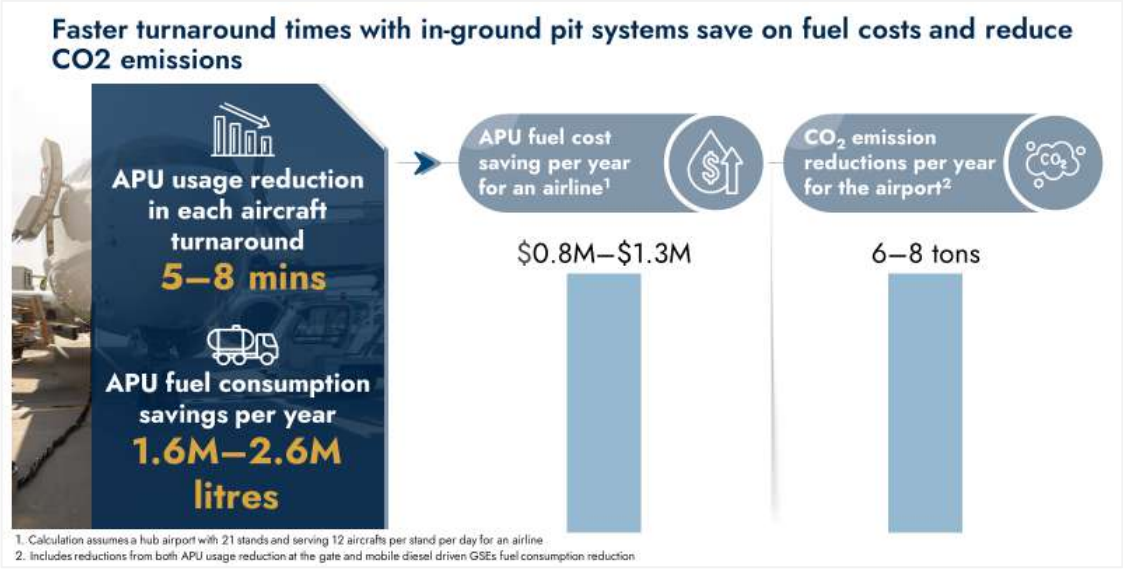
Exhibit 8

In-ground fixed systems at Oman and Dubai airports.

The most significant advantage of in-ground pit systems and solutions is the enhanced speed of operations of the services and reduced usage of auxiliary power units (APUs). With PBB mounted systems, an aircraft can be serviced only after PBB connection is established while in case of mobile GSE, the services can start only once the equipment is brought close to the aircraft. In contrast, with in-ground pit systems, integrated services like pre-conditioned air (PCA), ground power unit (GPU), potable water, etc., are available quickly with connections available close to the aircraft. This improves aircraft servicing turnaround time between chock on and chock off and allows less usage of APUs. When APU is turned off, aircraft noise levels and carbon emissions are reduced. In addition, lower APU usage is also cost-effective for aircraft as it reduces fuel consumption.

In terms of speed of operations and faster turnaround times with the in-ground fixed systems, our estimates suggest that with connections close to the aircraft, these systems enable servicing in less than three minutes from chock-on and saving five to eight minutes of APU usage in each turnaround. The reduction of APU operation reduces fuel usage, potentially saving as much as $1.3 million per year for an airline and also reduces CO_2 emissions for the airport (Exhibit 9).

Exhibit 9



Additional advantages of in-ground pit systems also include reduction of operational expenditure for airport operators due to longer lifetime and less wear and tear than PBB mounted systems and APU maintenance cost savings to airlines due to reduced APU running hours.

Onsite Renewable-Energy Generation

A significant way for airports to go green is by meeting their energy needs with on-site electricity generation from renewable sources. An airport can generate and store renewable energy on site with distributed energy resources (solar or wind power and battery storage) to meet its energy needs through on-site generation as much as possible.

At San Francisco Airport, the energy used comes from a combination of on-site solar power, the San Francisco Public Utilities Commission's hydroelectric Hetch Hetchy Power System (which is GHG emissions free), and solar photovoltaic (PV) installations in several locations across the campus (Exhibit 10). This system offers a combined rated capacity of nearly 4,000 kilowatts, delivering 4.9 million kilowatt-hours of renewable electricity per year. Several new solar PV and energy storage projects proposed for the airport are expected to save 94 million kilo-British thermal units (Btu) a year—enough power for 10,000 long-haul flights or 1,130 typical single-family homes per year—at a one-time cost of $194 million. SFO considers the solar PV project to be the most significant component of its zero net energy commitment.

Exhibit 10 **SFO is reducing GHG emissions with on-site renewable energy generation**

SOURCE: Zero Net Energy at SFO, 2020 Executive Summary Report

SAF Infrastructure

Airports are also looking to support the use of sustainable aviation fuel (SAF) in aircraft. However, to do this, they need to redesign or repurpose existing fuel transportation, storage (fuel depots, tanks, or farms), and distribution (underground pipeline) systems and set up quality control systems to meet Jet A1 aviation quality fuel requirements. Blending and storage infrastructure at airports also helps enable SAF usage.

Energy Management

Energy management is a key focus for airports as they look to find ways that improve energy efficiency with airport-wide control systems. Measures include upgrading all new and replacement lighting as LEDs and installing advanced building management systems to monitor, schedule, and control the use of HVAC, chilled water systems, and boilers. To reduce consumption, airports can also enable sub-metering of all users and airport tenants to improve monitoring, create transparency on usage patterns, and introduce behavioral shifts as needed. In addition, airports can also more efficiently manage the brightness of the lights both in the airfield and terminal with motion detectors.

Automation

Automation technologies relevant for the airport of the future include robots, autonomous vehicles, and drones. These are applicable both in terminals and on the airfield.

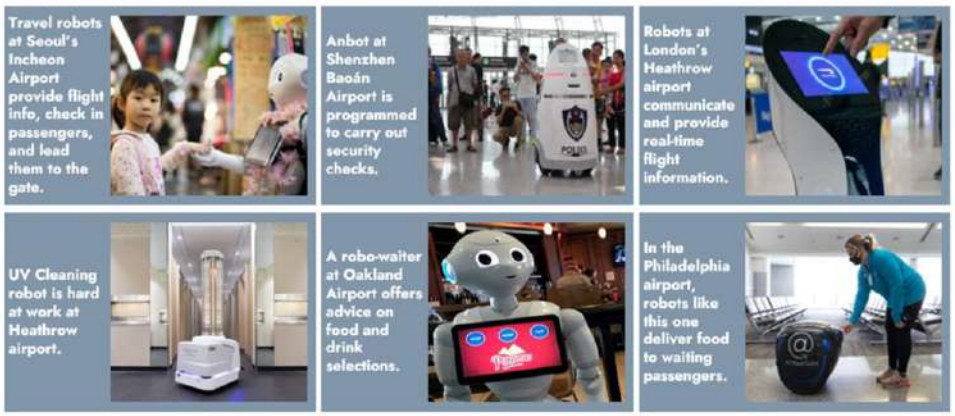
Robotics

Robots are in use at many airports for a variety of individual use cases (Exhibit 11). Applications of robotics in terminals include food and beverage services, baggage tagging and drop, cleaning and sanitization, and health checks. Airfield applications include baggage loading, aircraft refueling, and aircraft inspection prior to takeoff.

Hong Kong International Airport uses self-driving robots to clean public areas and restrooms, while Heathrow Airport uses cleaning robots around terminals and lounges to disinfect areas using UV light. Anbot at Shenzhen Baoán Airport is programmed to carry out security checks. In California, the Oakland Airport has robot waiters that can offer advice on food and drink selections. At Seoul's Incheon Airport, friendly looking travel robots deliver flight information, handle check-in, and lead passengers to their gate.

Exhibit 11

Robots in terminals have many uses for improving the passenger experience.



SOURCE: Bill Read, "The Rise of the airport robots", August 15, 2017, https://www.aerosociety.com/news/rise-of-the-airport-robots/; Frankie Youd, "Robot workforce: Airports are developing robot workers to tirelessly serve passengers", https://airport.nridigital.com/air_may21/robot_airport_workers; Tim Hornyak, "Meet the robots that may be coming to an airport near you", Jan 12, 2020, https://www.cnbc.com/2020/01/10/meet-the-robots-that-may-be-coming-to-an-airport-near-you.html

In the future, airports will use them for end-to-end passenger journey at terminals. Robotic terminals can provide faster check-ins, better security, and enhanced passenger experience. Robots can enable faster food and beverage services, assistance with queries, personal porter services, and better management of tasks like cleaning and maintenance.

Autonomous Vehicles

Autonomous vehicles can transform airside operations with AI-driven baggage delivery and loading on the aircraft, efficient jet bridges, deicing and snow-clearing operations, and driverless shuttles and maintenance vehicles. Applications in terminals include baggage handling and detection of security breaches. Airfield applications include jet bridges, passenger shuttles, deicing and snow clearing, baggage and food transportation, and maintenance vehicles. Winnipeg International Airport in Canada uses autonomous snowplows, Austin-Bergstrom International Airport uses autonomous people movement systems, and San Francisco International Airport is studying use of an autonomous aircraft-towing vehicle.

Despite the pandemic, Royal Schiphol Group continues its investment in innovation, technology, and new solutions to create smart, future-proof ground handling processes (Exhibit 12). The company plans to operate fully autonomous and sustainable airports by 2050. So far, Royal Schiphol has identified initiatives and themes for an autonomous airside and is working on a road map for 2050. The company is adopting a stage-gated approach to research, which involves experimentation prior to piloting and rollout of the transformation. It is testing an autonomous baggage tractor with KLM Royal Dutch Airlines' ground handling department, and with a large ecosystem of partners, it is exploring the feasibility of sustainable taxiing with an autonomous tow vehicle.

Exhibit 12

Royal Schipol Group envisions that by 2050, airports will combine autonomous equipment and artificial intelligence to deliver operational excellence.

SOURCE: Future Travel Experience, "Royal Schiphol Group building a roadmap towards a "fully autonomous airside operation" in 2050", March 2021, https://www.futuretravelexperience.com/2021/03/royal-schiphol-group-building-a-roadmap-towards-a-fully-autonomous-airside-operation-in-2050/

Royal Schiphol is employing a three-track approach that combines hardware, AI, and process transformation. The hardware is focused on robotics, autonomous assets, and vehicles. AI will be used for real-time data insights, adaptive routing, and integral planning and forecasting. The complete transformation of airside aims to achieve no delays and disruptions, along with higher levels of safety and sustainability.[14]

[14] *"Royal Schiphol Group Building a Roadmap towards a 'Fully Autonomous Airside Operation' in 2050,"* ***Future Travel Experience****, March 2021, https://www.futuretravelexperience.com.*

Drones

Drones can be integrated into operational routines for inspections on runways, taxiways and aprons, pavement surface monitoring, inspection of entire airport will improve access to inaccessible areas, reduce runway occupancy time and reduce GHG emissions from use of vehicles for inspection. In terminals, drones could be used for facility inspection. On the airway, drones could be used for taxiway and runway inspections, security inspections, and deliveries of supplies and repair parts. Edmonton International Airport (EIA) is using drone deliveries in partnership with Drone Delivery Canada.

Seamless and Safe Travel

Integrated and connected passenger journeys can be enabled by contactless technologies, artificial intelligence (AI), data analytics, and cloud technology to deliver safe and seamless experience. The passengers of the future will be expecting increased use of technology and digitization to improve travel experiences.

To achieve this, airports should redefine their services in terms of seamless passenger flows that connect the steps involved (check-in, security, boarding) and transform them into one uniform process. Techniques include mobile check-in or self check-in, self-printing of baggage tags and baggage drop, and use of the same biometric data for facial recognition that allows passengers to proceed through check-in, security, and boarding gates. Cloud technology can enable a platform that is shared by airports, airlines, and government; this could house passengers' personal data envelope and facilitate identification checks at different points. Artificial intelligence and machine-learning (AI/ML) algorithms could generate risk profiles of passengers and trigger enhanced security checks as needed with remote screening technologies (for example, remote image analysis, diverting suspect bags to recheck points for secondary examinations). This flow enables a fast and safe experience with no personnel contact points at the airport terminal.

For safe travel, passengers prefer that airports use more and more contactless technologies, such as self-service ticket and baggage tag printing. In addition, contactless temperature checks and infection detection could be available to passengers using self-service kiosks and remote thermal screening to become part of passenger journey. Real-time monitoring technologies along with predictive analytics can ensure appropriate distancing between passengers at key points across the airport. Such measures can ensure safety and hygiene standards; they also speed up processes.

An important consideration with these applications of digitization is the protection of data privacy, especially regarding matters of personal health. Airports need to establish standards for data privacy protection; they should be included as key requirements in the design of IT systems that support seamless passenger flows. Privacy by design principles should be integrated from the start to comply with standards and be prepared for any future additions to the system, be they new partners (more airlines) or features (e.g., mobile enrolment, retail, pre-clearance).

Finally, airports at the cutting edge of technology will investigate applications of technologies such as Internet of Things sensors and AI algorithms. Besides use of mobile apps and self check-in kiosks, airports might leverage IoT sensors such as LIDAR sensor, 3D stereoscopic sensors, proximity sensors, and video cameras at the airport to analyze physical distancing, as well as crowd planning and management. AI techniques could infer the amount of data collected each day and this could also help generate meaningful insights to enhance security and passenger experience.

Infrastructure Upgrades

With recovery slowly taking shape, airport infrastructure upgrade projects would need to restart and accelerate. Projects are already under way (see sidebar, "Airports Prepare for Future Demand").

Airports for Future Demand

Multiple airport infrastructure upgrade projects are already under way.[15] At Los Angeles World Airports, for example, Renovations to Terminal 6 began in July 2021. Project to feature a complete overhaul of gate areas and lounges along with the boarding bridges. Improvements to also feature a way to connect Terminals 5 and 6 in the future to the airport's planned people mover system. The project will cost about $230 million, a small piece of the $14.5 billion being put into a capital improvement project at the airport. Also part of the overall improvement project are overhauls of flight areas for fuel lines and redoing apron paving and upgrades to Customs and Border Protection areas and Transportation Security Administration screening checkpoints. Work expected to continue into 2023.

At Qatar's Hamad International Airport, Started in early 2021, phase 2 expansion to prepare for FIFA World Cup 2022 involves increasing airport capacity to 53Mn+ passengers by 2022, linking of concourses D and E, and constructing 11,720 sqm of landscaped retail and food and beverage space. As part of the expansion, the airport also acquired and implemented the latest technologies to optimize for safety, including the use of disinfectant robots, advanced thermal screening helmets, and UV disinfection tunnels for checked-in passenger luggage. Expansion is expected to be completed by September 2022.[16]

In Q3 2021, GMR Group announced that it would invest USD 840 million in Hyderabad International Airport to expand its aerodrome capacity to 34 million passengers by 2024. The expansion project will include an increase in passenger terminal area to over 3.8 lakh square meters, 149 check-in counters, 26 security screening machines, 44 emigration counters and 44 immigration counters. The first phase of the project is expected to be completed in Q2 2022.[17]

[15]*Matthew Thibault, "10 Airports Gear Up for Increased Travel with Expansion, Renovation," **Construction Dive**, August 17, 2021, https://www.constructiondive.com.*

[16]*Pratap John, "HIA expansion one month ahead of schedule; completion by Sep 2022: Al-Baker," **Gulf Times**, November 11, 2021, https://www.gulf-times.com.*

[17]*Saurabh Sinha, "First phase of Hyderabad airport expansion to complete soon," **The Times of India**, April 5, 2022, https://timesofindia.indiatimes.com/.*

IATA forecasts that airports will spend $1.2 trillion to $1.5 trillion on global airport infrastructure development up to 2030. Geographically, APAC is likely to be the leader in infrastructure investments both for greenfield airports and for modernization and expansion of existing airports. Europe and North America are likely to be next but mostly to maintain existing terminals and retrofit infrastructure. Infrastructure upgrades are important on both the terminal side and the airside, including ground handling. Such upgrades can deliver benefits related to public health and environmental protection, as well as use technology that meets passengers' demand for seamless travel experiences.

Terminal Side

Large and adaptive terminals should be designed to flexibly adjust to new uses, such as social distancing, increased security screening, and health screening areas. Also important are more green spaces and better ventilation. The terminal side of future airports will include large, airy, and adaptable spaces (Photo 5) to ensure health and well-being of passengers and different uses of space as needed and more real estate for cargo operations given surge in demand from e-commerce. Being large and spacious means space for fresh air; space to implement new technology for touchless check-ins, security screening, and health checks; and space for increased automation expected with robotic terminals. Besides being well ventilated, airports will feature more green areas, including large windows and ceilings for better circulation and quality of air, as well as space dedicated to outdoor gardens in between terminal buildings. Spaces will be flexible and adaptable to new uses such as pandemic-related policies (e.g., distance between travelers, lounges with outdoor seating).

Besides meeting passenger demands, successful airports will be powered with renewable energy sources (on-site + offsite generation) with efficient LED lighting and building management systems installed for energy management.

Photo 4

Passengers will feel safer and more welcome in large, airy spaces with greenery and good ventilation. *Photo owner: Gensler + HDR in association with luis vidal + architects; Source: Julie Strupp, "5 ways COVID-19 has changed airport design and construction", Feb 1, 2022, Construction Dive*

The Pittsburgh airport's modernization centers on health, technology, and environment. Its new 700,000 square-foot terminal is a $1.4 billion project expected to be completed in 2025, making it the first terminal in the United States to be built from scratch after COVID-19 struck. The focus is to be on public health and technology, with new facilities prioritizing social distancing, clean air ventilation, and outdoor spaces. Modernization upgrades will allow for a new and improved passenger experience.

Its contributions to public health include clean air technology in the form of ventilation systems, large areas to allow for social distancing, and a 90,000-square-foot outdoor terrace area and elevated three-tier structure with natural wood ceiling and multilevel glass windows to allow in as much natural light as possible. It delivers environmental benefits from a terminal powered by a microgrid fueled by 10,000 solar panels and five natural-gas generators. During construction, a minimum of 75 percent of waste produced, including concrete, is to be recycled or reused where possible. Finally, the airport's use of technology to streamline and consolidate passenger processing operations including ticketing, security checkpoints, and baggage claim—aim to reduce passenger travel and processing time by 50 percent from drop-off to airside.

Airside and Ground Handling

For airside and ground handling, the following infrastructure upgrades will deliver significant benefits:

- EV charging infrastructure: Optimal airside EV charging units will facilitate transition to electric ground handling vehicles.
- Digital, sustainable, and efficient aprons: Digital technology (e.g., surveillance systems) can share real-time information on flight status and turnaround times. Efficiency and sustainability can come from new and efficient lighting systems, provision for modern in-ground ground handling services (power, fueling, sewage, water, etc.), and pavement markings with smart coating materials.
- Enhanced cargo infrastructure: Real estate should cater to increased demand for cargo services, e.g., warehouses for goods for consumers across the destinations, facilities to store temperature and time-sensitive goods like pharmaceuticals, hotels and restaurants for individuals handling cargo.
- Airfield: Use of efficient lighting systems (LED lights, smart systems for usage detection) will reduce energy costs. In addition, in the airfield, airports need to focus on automating aircraft and ground vehicle detection and foreign objects and debris detection.

An example of modern airside cargo infrastructure is the temperature-controlled pharma cold chain at Singapore's Changi Airport.[18] Launched in November 2020, Changi Airport's pharma cold chain facilities include a temperature-controlled container used at airside to ensure an unbroken cold chain when transporting cargo from aircraft to cold storage facilities. Known as cool dollies, these containers allow for temperature-controlled storage in the range of –18°C up to 25°C (–0.4°F to 77°F). The dollies have a secure structure with alarms on opening and closing and sends alerts if the temperature shifts from the allowable ranges. They are autonomous and eco-friendly with solar-panel linings.

[18]*Mikaela Fernandez, "dnata Launches Singapore's First Fully Integrated Cold Chain for Pharma Shipping," **Pharma-Mon** (AKCP blog), November 27, 2020, https://pharma-mon.com.*

CHAPTER 03

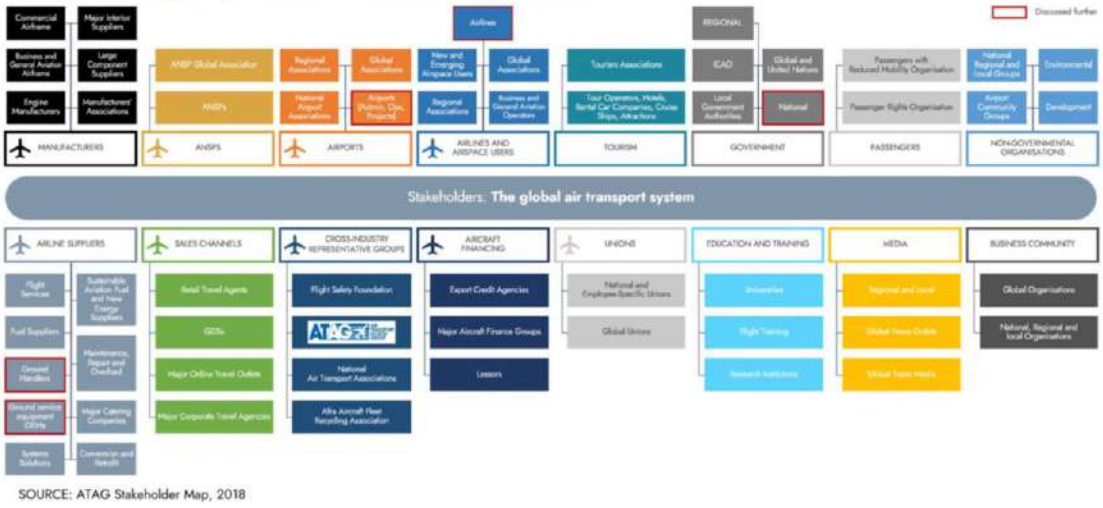
The Role of Stakeholders

DABICO airport solutions

The Role of Stakeholders

Enabling the transformation of airports described in the previous section involves important roles for each stakeholder in the aviation industry. As Exhibit 13 shows, the aviation industry contains a tremendous number of stakeholders, so this report will focus on a few key players: airports, governments, airport project teams, airlines, ground handlers, and ground service equipment OEMs. As we will describe, each of these already has several actions "in flight."

Exhibit 13 **The aviation ecosystem involves many different stakeholders, each with a role to play in a digital, sustainable transformation**



SOURCE: ATAG Stakeholder Map, 2018

Airports

Airports are already working toward goals on environmental sustainability and the IT infrastructure that can meet passenger demands.

On the environment, as noted in chapters 1 and 2, the second ACI Europe Aviation Sustainability Summit committed to net zero carbon emissions by 2050. At the summit, 235 airports across Europe made the commitment, and 90 are on their way to achieving this emissions goal by 2030.

In support of this goal, airports are collaborating with airlines to map fuel infrastructure upgrades (blending and storage) required at airports for sustainable aviation fuels (SAF).

Also, airports are adopting Airports Council International's ESG reporting framework to communicate progress on sustainability initiatives. This also helps respond to growing and varied requests from investors. DFW has been releasing its ESG report every year since 2016; it tracks and communicates results and achievements on ESG initiatives.

Finally, airports are investing in secure yet agile IT infrastructure that can support passenger journeys that are seamless—that is, efficient, fast, safe, and traveler friendly. Airports are continuously examining the role of IT in their transformation journey. A 2020 Airport IT Trends Survey conducted by ACI confirmed a commitment to investments in new technologies: 94 percent of airports said they are planning R&D in cybersecurity by 2023, 90 percent in cloud services, and 87 percent in business intelligence.

National Governments

Governments, especially at the national level, also have an important role in promoting safe, sustainable, and efficient air transport. For example, they can establish "green" financing for the aviation sector—that is, loans tied to sustainability initiatives and targets. The Dutch government's proposed €2 billion to €4 billion support package for KLM requires the state-owned carrier to contribute to sustainability initiatives, including the reduction of night flights and cutting CO_2 emissions in line with CORSIA.

Governments also can mandate that airlines and ground handling companies use energy-efficient equipment. The Civil Aviation Ministry of India mandated airlines and ground handling companies phase out airport equipment older than 12 years and switch to electric or fuel-efficient variant by May 2022.

Combining carrots with sticks, governments can provide benefits for energy efficiency, such as tax credits tied to reductions in petroleum-based fuel consumption or adoption of sustainable aviation fuels (SAF). The current US administration has been continuing to push for tax credits for SAF, with the aim of reducing aviation emissions by 20 percent by increasing SAF production to at least three billion gallons by 2030.

In addition, governments can also issue advisory to minimize environmental impacts. For example, in 2011, Director General of Civil Aviation (DGCA) in India, set guidelines for airport operators to restrict the use of APUs by aircrafts when parked at gate and switch to ground power units.

Airport Project Teams

Airport project teams can orchestrate the engagement of all stakeholders early in airport design, planning for inputs, and seeking alignment on key elements such as the following:

- Green terminals offering large airy spaces, green outdoor areas, excellent ventilation
- Space for on-site renewable-energy generation
- Apron design conducive for delivering services to aircraft such as power, preconditioned air (PCA), fuel, water and other wet services through in-ground or underground systems facilitated by pit systems such as hatch or pop up
- Airside infrastructure for e-charging of EVs and hybrid ground handling vehicles

San Francisco International Airport frontloaded coordination with stakeholders by formalizing a stakeholder engagement process (SEP). The SEP allowed project teams to gather early input and collaborate on developing a project design with all stakeholders during the planning and programming phase.

Airlines

Airlines contribute to airports' sustainable future by embracing advances in aircraft and fuels. An important step is to replace old fleet and collaborate with aircraft OEMs to transition to more fuel-efficient aircraft models.

With regard to fuel, airlines can collaborate with SAF production companies to find ways to reduce costs of such fuels, making them more affordable. They also should explore how they can ramp up their use of biofuels and operate eco-friendly flights. In June 2019, United Airlines operated the most eco-friendly flight, using a 30/70 blend of 30 percent low-carbon, sustainable aviation fuel provided by Boston-based World Energy and 70 percent traditional jet fuel.

Ground Handlers

Ground handlers can make a significant difference to airport operations by upgrading vehicles and service equipment. Where possible, they should investigate upgrades of ground handling vehicles (for MRO needs, towage, parking, and passenger and baggage transport) to electric models. At the same time, eco-driving training for drivers can reduce fuel consumption in daily driving. Baltic Ground Services (BGS) Group has been introducing more electric vehicles to their fleet and also has focused on driver training to reduce fuel consumption by nearly 5 percent daily.

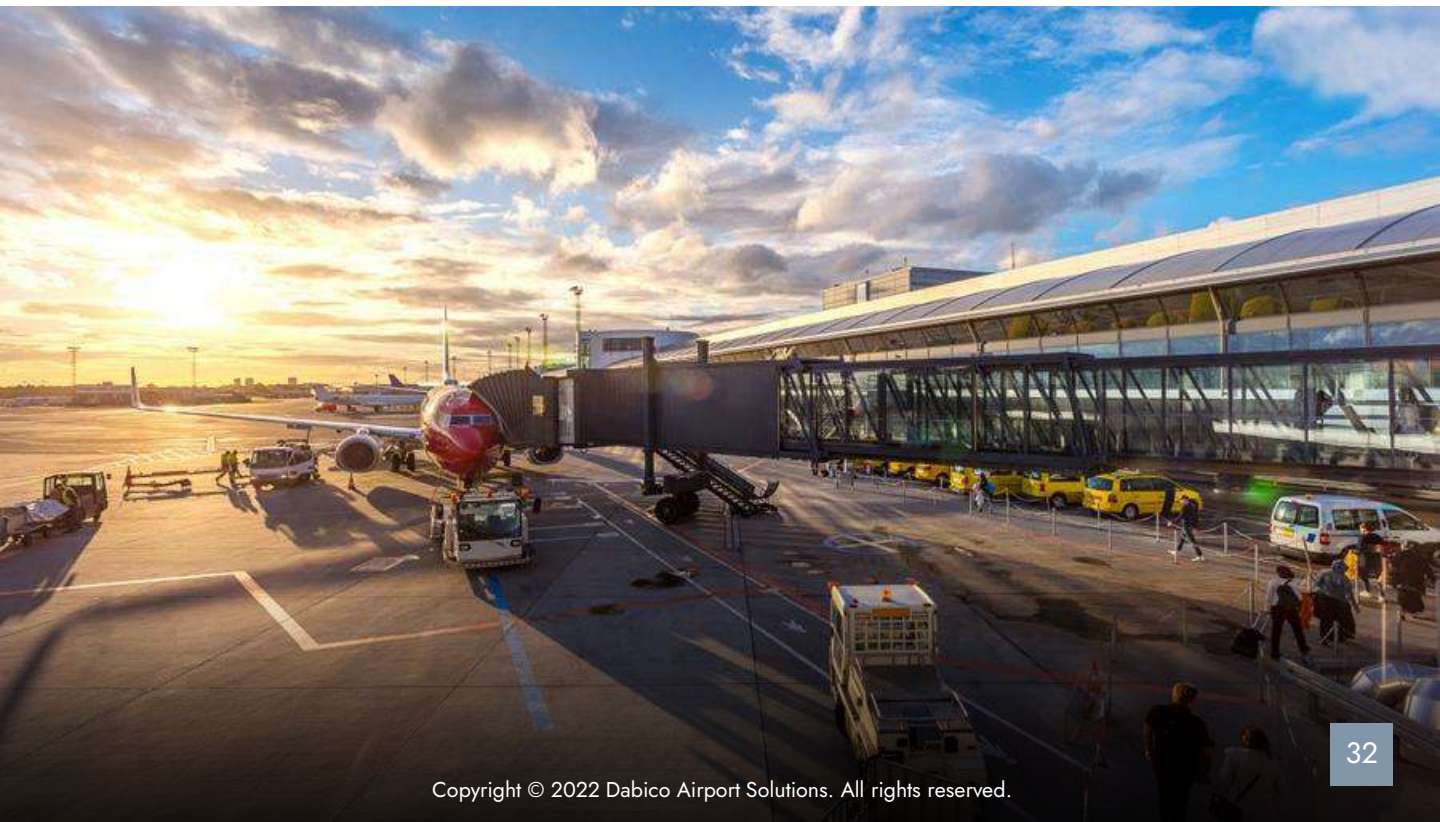
Ground handlers can also procure efficient state-of-the-art ground service equipment for powering, refueling, water, and sewage. Such equipment can help reduce APU usage and allow safe operations at the apron and fast turnaround of aircrafts, as described in chapter 2.

Ground Service Equipment OEMs

Ground service equipment OEMs contribute to the airport of the future by developing more efficient and ergonomic equipment. They should explore transitioning from fuel-powered equipment to eGSE models. For example, Dabico Airport Solutions recently launched a 400Hz battery-powered ground power unit for aircraft at the Dubai Airport Show (May17-19, 2022), the Dabico 400Hz-eGPU. The system reduces operating costs compared to conventional diesel-powered units and makes dramatic reductions in terms of emissions and noise, thereby decreasing environmental impact and improving health outcomes of those working in and around airports. In addition, the integrated solution also includes a 400Hz Jet Cable Friend that makes it safer and easier for personnel to access jet cables from in-ground chambers and connect to aircraft.

OEMs also should focus on efficiency and ergonomics of fixed ground service equipment (GSE). Dabico's in-ground pop-up pit-based PCA/GPU systems feature connections close to the aircraft with no hoses or cables on apron. This reduces congestion at the apron and personnel required. Such systems, already in use at many airports around the world, among them Dubai, Bahrain, and Oman International Airports, improve safety, reduce APU usage and enable faster turnaround times.

Finally, OEMs can introduce IoT-enabled equipment and service offerings for real-time tracking and monitoring of the equipment and its operational performance. This capability leads to optimum use of GSEs and reduces aircraft idle time at the airport.



CHAPTER 04

Conditions for Success

DABICO airport solutions

Conditions for Success

Achieving the sustainable, seamless, digitized airport of the future will require that several conditions be met (Exhibit 14). These involve the cooperation of participants throughout the aviation ecosystem, including various stakeholders.

Exhibit 14

End-to-End Stakeholder Engagement

Stakeholder engagement in transformation is essential. All stakeholders must be actively involved and aligned right from the start to enable this digital, sustainable transformation. Elements of digitization and sustainability need to be incorporated end-to-end in design, planning, and development phases.

Regulations and Policies in Place

International agencies, such as ICAO, IATA, and ACI, can assist governments by collaborating on designing and enforcing cost-effective environmental regulations and policies.

Government aid and support can further facilitate the development of sustainable technology. Examples include investments in SAF production and renewable energy-based power plants for aircraft.

Availability and Integration of Technology

Technologies that must be readily available include seamless and contactless technologies such as biometric recognition algorithms, remote imaging for security, and self-service kiosks for health screening.

Besides the technologies themselves, the airport of the future will require the know-how for integration of technologies into airport processes while ensuring data protection and privacy.

Adequate Financing for Infrastructure

Installing and upgrading infrastructure requires access to adequate levels of financing through private investors, governments, international agencies, and other sources.

Those seeking and providing this financing should ensure that infrastructure projects allocate a sizable portion of their spending to digital transformation.

Sustained Market Dynamics

As discussed at the beginning of this report, industry experts project that air passenger traffic will continue its recovery and reach pre-pandemic levels in two to three years. Following that, brisk growth over the next two decades would provide the right economic climate for favorable returns on investments.

The last 18 months have shown encouraging signs on recovery for demand for air travel, as well as continued expectations for fast-moving supply chains that include air freight when time is of the essence. Airports make all this possible. At the same time, investors and the public demand energy conservation, and passengers demand seamless travel experiences. A transformation is essential to meeting the variety of stakeholder demands digitally and sustainably. That transformation will be multifaceted. It will require visionary leadership, technological insight, and dedicated management, but with these, it is well within the industry's grasp.

Disclaimer

This document and any related materials are confidential and may not be distributed or reproduced (in whole or in part) in any form without written permission. By accepting or accessing this document or any related materials you agree to be bound by the limitations and conditions set out herein and will be taken to have represented, warranted and undertaken that you have read and agree to comply with the contents of this disclaimer including, without limitation, the obligation to keep information contained in this document and any related materials confidential.

This presentation is provided for informational purposes only. Nothing in this presentation constitutes or shall be construed as investment advice or a recommendation to proceed or not to proceed with any proposed investment, acquisition, sale, or transaction. The information in this document does not purport to be comprehensive and has not been independently verified. No reliance may be placed for any purposes whatsoever on the information contained in this document or related materials or in the completeness of such information.

Certain statements included in this presentation are forward looking statements for purposes of the safe harbor provisions under the United States Private Securities Litigation Reform Act of 1995. Forward looking statements are indicated by words that predict or indicate future events or trends. These forward-looking statements include, but are not limited to, statements regarding airport industry transformation, shifts in design and operational elements of airports, air traffic growth, future sustainability of the airport industry, and investments in information technology and research and development by airports. These statements are based on various assumptions and on the current expectations and are not predictions of actual performance. These forward-looking statements are provided for illustrative purposes only and are not intended to serve as a guarantee, assurance, prediction or definitive statement of fact or probability. These forward-looking statements are subject to risks and uncertainties.

While this document has been prepared in good faith, it does not constitute a representation, warranty or undertaking, express or implied, with respect to the information or opinions contained in it and no responsibility or liability is accepted as to the accuracy, completeness or reasonableness of such information or opinions or any other written or oral information made available to any party or its advisers.

Without prejudice to the foregoing, we do not accept any liability whatsoever for any loss howsoever arising, directly or indirectly, from use of this document and/or related materials or their contents or otherwise arising in connection therewith. The information set out herein and in any related materials is subject to updating, completion, revision, verification and amendment, and such information may change materially. We are under no obligation to provide the recipient with access to any additional information or to update this document or any related materials or to correct any inaccuracies in it which may become apparent.

All statements of opinion and/or belief contained in this document and all views expressed represent our own assessment and interpretation of information available as at the date of this document.

DABICO
airport solutions