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ENVIRONMENT

Innovation and Technology in Airport Sustainability

ECO AIRPORT TOOLKIT
2023

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1. INTRODUCTION

Around the world airports are quickly moving into the space of entrepreneurs, establishing centers for innovation and collaboration, and bringing together science and tech experts, product developers, and start-up companies to test the latest ideas in everything from cybersecurity, passenger experience, and sustainability. Sustainable aviation is an industry focus, and "thousands of start-ups and new units within companies are pouring resources into technologies that have made flying green their objective."[1] ICAO recently adopted a long-term aspirational goal (LTAG) for aviation to make rapid carbon emission reductions in the sector, and many States have programs to meet the United Nations Sustainable Development Goals (UN SDGs).History shows these goals will most likely be met through innovation and technologies.

The desire to 'green aviation' has merged with an entrepreneurial spirit, and a drive to expand business and revenue and to create a movement around innovation and technology in aviation. Airports are leading the way, offering up their facilities as places to test and refine the latest concepts and products. The goals of this e-publication, in line with ICAO's Strategy on Innovation,[2] are to raise awareness of innovation and promote its potential benefits among States, industry partners and the aviation community at large.

Ensuring long-term sustainability and reaching net-zero carbon emissions by 2050 requires developing solutions that reconcile economic, social, and environmental goals. The industry is steering in this direction through an innovative approach. This paper gives examples and case studies of how airports have embraced innovation around the world.

[1] https://www.theguardian.com/world/2023/apr/06/will-flying-ever-be-green-aviation-electric-planes-evtol
[2]https://www.icao.int/innovation/PublishingImages/Pages/default/ICAO%20Sec%20Strategy%20Innovation%20WEB%20V2.pdf

2.   A NEW BUSINESS MODEL

Defining innovation and technology

Innovation is the introduction of new things, ideas, concepts, or ways of doing something that is ahead of current thinking and forward-looking (ICAO, 2022). It includes identifying, developing, and deploying more efficient and effective (e.g., innovative) solutions that enhance the aviation ecosystem, including approaches and processes to airport systems. According to Harvard Business School, for an idea to be innovative it not only has to be novel, but also useful- offering potential for viable solutions to a certain challenge (Boyles, 2022).

Technology is defined by the Oxford dictionary as the application of scientific knowledge for practical purposes, especially in industry.[3] It usually involves machinery and equipment developed or engineered to solve problems. Installation of a new on-site incinerator that converts waste to energy is an example of technology helping to reduce environmental impacts.

Innovations can be categorised around 4Ps: product, process, position, and paradigm (Figure 1 below).
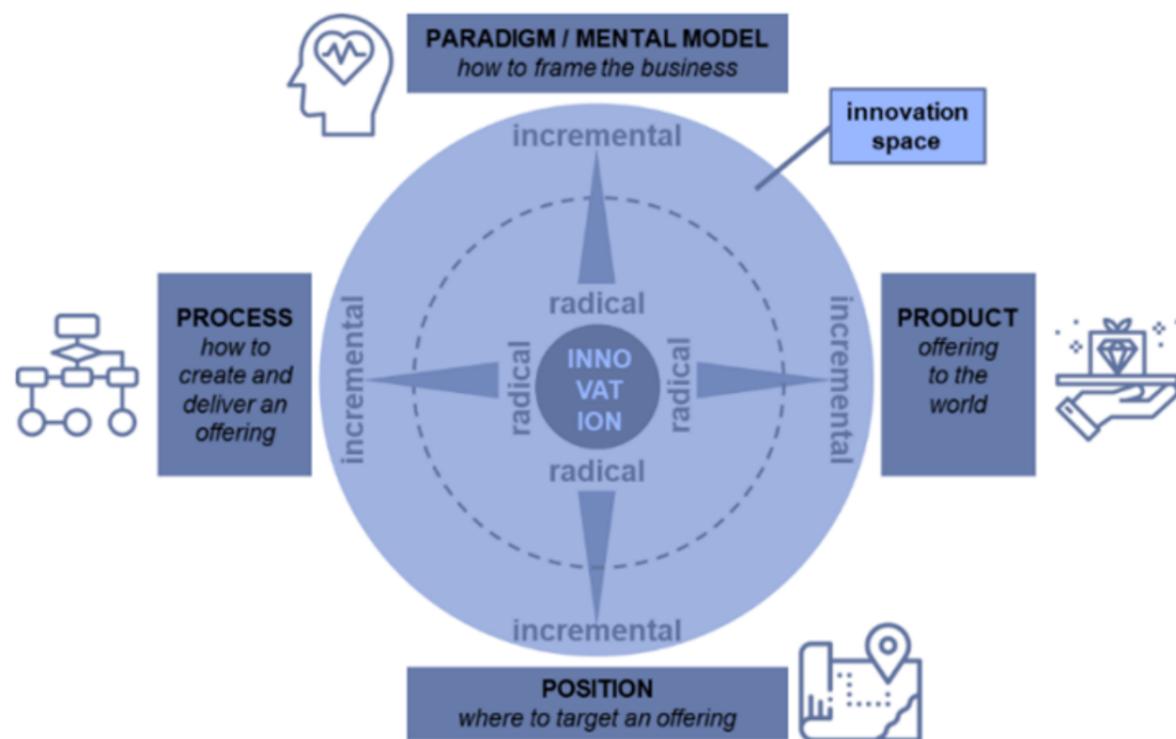
Figure 1. Dimensions of innovation. Source: Innovation at Airports in North America.

All of these must come together to be successful. Innovation can encompass many different dimensions of airport business and organizational management, and can include incremental improvements in processes and operations, or transformations of more radical nature.

Product development typically requires capital investment and time. Partnerships with local universities and businesses can encourage development and facilitate the commercial scale production process, including the right positioning, as well as boost regional economies surrounding airports.

> **Examples**
>
> **Doncaster Sheffield Airport**
> **Partnership for development of a high-value innovation cluster**
>
> Doncaster Sheffield Airport, in partnership with Peel L&P and the University of Sheffield plans to develop a cutting-edge research and development cluster, where areas such as sustainability, training, innovation and research would come together to deploy technology enabling solutions benefiting the industry[4]. The initiative aims to also tackle the issue of skills and attracting and developing talent locally- all contributing to unlocking of economic benefits and development in the region.

> **Examples**
>
> **Kansai Airports (KIX)**
> **Demonstration with Kobe University to save air-conditioning energy and boost infection control**
>
> Kansai Airports teamed up with Kobe University to conduct a demonstration experiment of the air-conditioning system for energy savings and infection control in Terminal 2 at Kansai International Airport (KIX). The joint demonstration project, commissioned by the Ministry of the Environment, is aimed at reducing carbon emissions and improving infection control measures through advanced air conditioning technologies that use AI and other innovative solutions.

In addition, introducing small changes and improvements to existing products or services gradually can hold a big potential for sustainability outcomes and added value for organisations such as airports. It also allows to reduce risk and capital for innovations that may require more radical changes. Technology plays a key role in incremental innovations and facilitates such improvements. Airports implementing energy efficiency measures, are a good example of such innovations.

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[3] https://languages.oup.com/google-dictionary-en/

[4]New partnership could help unlock economic potential of Sheffield City Region's GatewayEast development | News | The University of Sheffield

Innovation and Technology as Opportunity

New is sometimes better, but airport innovation is much more than just the development of novel products. Innovation is a culture, or lifestyle philosophy. In business terms, it is a forceful business model, centered around change, where an airport acts like a start-up company, testing new things and learning from them.

Airports may have different reasons to seek such a business model, but most would like to expand capacity, grow their business, and find new revenue streams, while reducing to the maximum possible their negative impacts on the environment and surrounding communities.

As such, many innovations in technology and process are around renewable energy, waste reduction, water management, and conversion to electric or autonomous vehicles, but also efficiency. The growth in autonomous technology has transformed food delivery and cleaning equipment within the terminal, as well as how tugs move aircraft on the airfield.

Examples

Hamad International Airport (DOH)
AI for environment

Incubated at Qatar Science Technology Park and launched at Hamad International Airport, the AI-driven EMMA (Environmental and Movement Monitoring for Airports) Systems reduces costs and emissions by enhancing efficiency, through its Airport Collaborative Decision Making (A-CDM) approach and platform.[5] Currently operating at four airports between Europe and the Middle East, EMMA addresses the revenue losses, unnecessary delays, and large environmental footprint rooted in inefficient communication among airports, airlines, air traffic controllers, and ground handlers by collecting input from each stakeholder and providing real-time access to interpreted, uniform data to connected users. Because EMMA's AI platform brings order to the many data streams, it also allows for predictability and forecasting where there was once uncertainty and, at times, chaos. [6]

The innovation approach is synonymous with learning and collaboration and lends itself well to partnerships with local technology sector and universities. To capitalize on this, many airports have established what they call 'innovation hubs' or 'living labs,' opening up their facilities like a campus to explore options to improve the airport experience. Some of the names in this area include San Diego International (SAN) in the United States, Munich International Airport (MUC) in Germany, and Singapore Changi Airport (SIN).[7]

Innovation Hub Concept

The 'hub' concept simply means the airport can be a focus for the activities involved in advancing ideas into usable technologies, through a multi-step process to test and assess performance of products before market entry:

- Proof of concept: a testing phase to see if the new technology does what it is intended to do. Proof of concepts will likely include data collection and metrics from the trials, especially when there are operational considerations.

- Scale-up: if successful, the next step for a test product is to consider how to scale up the technology to meet market needs. For small businesses, these steps can be challenging.

The airport campus offers a controlled space to conduct real-world trials. The airport is like a city with buildings, electrical systems, emergency services, transportation routes, etc., that provides an excellent setting for product trials.

Examples

Cincinnati/Northern Kentucky International Airport (CVG)
A place for testing new technologies

The region is one of the top ranked cities for startups, with multiple universities nearby. "The airport's local venture connections have leveraged a broader network of talent and tech ranging from Silicon Valley to South Korea. Its accelerated approach, appetite for pilot testing and successful product developments have led to what can be referred to as CVG's "living laboratory" on a city scale."[8]
CVG has had success with trials for new sensor technology on their automated train system and has now deployed the sensors in numerous other applications at the airport. Other projects include autonomous ground support equipment, custom LED fixtures, and curb-to-flight passenger flow management.The partnerships involved have provided partner companies with a living test venue, while the airport has improved customer experience while getting in on patents and licensing of new products.

Examples

Munich Airport (MUC)
Bus fuel conversion

In collaboration with start-up company CM Fluids converted its bus from diesel-powered to fuelled by liquid methane (picture below). The project has been honoured with the German Gas Industry's Innovation Award.

[5] https://wired.me/technology/revolutionizing-airport-operations-with-ai/.
[6] https://emma.aero/
[7] https://www.airport-technology.com/features/airport-innovation-hub-technology/

[8] How CVG Airport has become an innovation laboratory driving the Cincinnati region's economic success - The Business Journals Partners (bizjournals.com)

Given the increasing importance of the Innovation Hubs at airports, the final section/appendix of this publication outlines some of the most advanced examples in this area in the form of case studies. They include explanation of the approach of airports to such concepts, their organization and management, as well as sustainability projects as part of their work.

Environmental Challenges and Innovation- a global commitment

Airport environmental management plans often include goals to reduce energy consumption and costs, increase efficiency, lower emissions, monitor water quality, and other processes. This is where innovation and environmental concerns intersect, and new ways to operate must be identified. Innovation is a way to approach some of the most challenging issues facing sustainability, and it can have several co-benefits for an airport's communities served by airports as well.

With the amount of change happening in the industry, as well as required to facilitate progress on the journey to sustainability, innovation efforts are also emphasized on the international level. ICAO has been actively involved in facilitation of dialogue and progress between industry and States for example through work undertaken by its Small Group on Innovation. In addition, and emphasizing commitment to innovation on global level, ICAO, in September 2022, hosted an Innovation Fair with the theme of 'Innovation for Enhanced Resilience in International Civil Aviation.'[9] In the midst of the COVID-19 pandemic, the seminar covered crisis mitigation and recovery, with a focus on innovation to build back better and underscore how international civil aviation is an enabler of global prosperity and interconnectivity. It also highlighted the importance of innovation in sustainability, including green air traffic management operations, resilience, and adaptation.

Climate Resilience

Resilience to climate changes is a top priority in airport planning, and one of the most persistent challenges. Climate resilience can take many forms, and may include energy use, elevating infrastructure, cybersecurity, and much more. Innovation communities around the globe are investigating various resilience measures, one of which is hardening the energy supply against potential disruptions, through microgrids and renewable energy systems, for example.

> **Examples**
>
> **Pittsburgh International Airport (PIT)**
> **Microgrids**
>
> PIT has taken the step to establish its own microgrid[10]. A microgrid is an independent electricity system that can operate self-sufficiently, or in parallel with the utility grid. PIT's microgrid consists of five natural gas-fueled generators and nearly 10,000 solar panels, capable of producing more than 20 megawatts of electricity[11]. "The airport's current peak demand is approximately 14 megawatts." The system services the airfield, terminals, hotel, and fuel facilities, and offers a more efficient, sustainable and resilient source of energy.

Energy reliability is only one of the many elements of resilience, and as each airport's risks are unique, resilience will continue to be an area of innovation and research for years to come.

Robotic, autonomous, and unmanned vehicles

This is another large area of innovation, where for example, airports have run trials of robotic systems to load passenger bags into bins to be transported to aircraft. Looking at this through an environmental lens, the Mototok green pushback tractor is one of such vehicles being used to push A320 family aircraft out of the gate and onto the taxiway at Madrid and Barcelona airports.[12]

The device is electric, eliminating CO2 from the operation, and can push back 28 aircraft before needing recharge. Although these are not fully autonomous – an operator controls the pushback device using a handheld remote – this could soon change.

In addition, the talk around unmanned vehicles and Advanced Air Mobility (AAM) also continues to grow as new prototype aircraft are unveiled and tests conducted. Many of these are electric vertical take-off and landing (eVTOL) aircraft with electric rotor propulsion. If projections for the quick adoption of eVTOLs hold true, they will put even more demands on airport electrical systems. Indeed, the entrepreneurs are looking at how best to design 'droneports' with new tech to support rapid charging and other needs of this emerging new class or aircraft.

Alternative Propulsion Technologies

Just as automobiles are going electric, there is also great demand to move aircraft to electric propulsion. Replacing non-renewable hydrocarbon fuels with renewable electricity eliminates soot and emissions, but there is much research needed to make this viable for passengers. Current passenger jet aircraft can move hundreds of people and their bags over thousands of miles. Because of batteries' weight, this is not possible for electric aircraft at the moment, but innovation and technology may in time provide advances in this field.

> **Examples**
>
> **Eindhoven Airport (EIN), Rotterdam The Hague Airport (RTM),**
> **Groningen Airport Eelde (GRQ)**
>
> Power Up Living Lab for Electric Flight
> In the Netherlands, a group of three airports has established the Power Up Living Lab for Electric Flight.[13] Supported by Royal Schiphol Group, the consortium of Eindhoven Airport (EIN), Rotterdam The Hague Airport (RTM) and Groningen Airport Eelde (GRQ), seeks to answer what is required at an airport to make electric flight possible.[14]
> "The aim is to first experiment with 4-seater to 9-seater aircraft in the Netherlands, and eventually to build a dense European network and to operate with larger aircraft." They are looking for partners "in the field of battery technology, electric aircraft engines and charging systems, and possibilities in the field of hydrogen technology and infrastructure."

[9] https://www.icao.int/Meetings/InnovationFair2022/Pages/default.aspx
[10] https://www.forbes.com/sites/danielmarkind/2021/08/04/will-pittsburgh-international-airports-microgrid-show-how-america-can-build-infrastructure/?sh=442ac26a7a48
[11] https://flypittsburgh.com/acaa-corporate/newsroom/news-releases/pittsburgh-international-airport-goes-live-with-first-of-its-kind-microgrid-powering-entire-facility-with-natural-gas-and-solar-energy/

[12] https://simpleflying.com/iberia-driverless-pushback-tugs/
[13] https://www.schiphol.nl/en/schiphol-group/blog/living-lab-for-electric-flight/
[14] https://news.schiphol.com/airports-in-the-netherlands-will-start-with-electric-flying

Another renewable source of energy possible for aviation's decarbonization is green hydrogen. With the new aircraft designs being explored, airports have been actively preparing for the new types of operations and, in some instances, actively driving partnerships exploring opportunities for the implementation of new technologies at their premises. Others, such as for example Kansai International Airport in Japan have invested in hydrogen stations enabling fuelling with hydrogen for both ordinary cars and forklift trucks in cargo hangars.

Examples

Edmonton International Airport (YEG)
Airport City Sustainability Campus

Within its established Airport City Sustainability Campus ecosystem, YEG has been a testbed for emerging hydrogen technologies. By signing agreements with global players in the space, YEG is using its grounds for exploring and trailing various initiatives, including zero-emission flights, hydrogen fueling stations and operations with hydrogen fuelled vehicles, as well as drone wildlife management, at the same time delivering benefits for the local economies.

Co-Benefits to New Tech

New technologies can have direct and measurable environmental benefits. But the innovation approach can also have beneficial effects to less tangible aspects of airport operation such as community and stakeholder relations.Community engagement may not seem like a key area for innovation, yet it is essential to overall airport health.Airport customers and stakeholders increasingly demand that facilities be as sustainable as possible. Airports work hard to build relationships with their communities, and there is a clear social component to environmental stewardship that includes being a good corporate neighbor to customers, stakeholders, and residents.

Airport community engagement works on many levels; it can help to understand passenger needs, inform decisions for selecting the right technologies or implementing innovative processes, and educate the public as to the advantages of certain innovations and emerging technologies.

Community involvement is achieved by strengthening the means for information exchange, providing open access to quality data, and sharing possible changes in airport scenarios, and airports are looking for innovative ways to communicate with their stakeholders. In 2016, CAEP (ICAO's Committee for Aviation Environmental Protection) published a circular, Community Engagement for Aviation Environmental Management (ICAO, 2016). This publication presents several core lessons to be applied to community engagement. The circular views the use of technology, audiovisual aids, computer graphics and social media as key when engaging a broad constituency. When people have insight into how a system works, they are more understanding of change. New tools have been developed that allow the creation of digital spaces, and these have enhanced exchange of knowledge and ideas to strengthen participatory planning processes for airports.

In addition to dealing with stakeholders, airports rely on their staff to function.[1] Promoting innovation and technology can improve airport competitiveness on the job market and promote employee engagement.Airports that establish innovation hubs can harness the local workforce talent in pursuit of economic growth. It also improves attractiveness of the airport sector to the next generation of skilled workforce, thereby helping to close the labor gap.

3. FACTORS TO CONSIDER WHEN APPROACHING INNOVATION AND TECHNOLOGY

Safety Management

With all the benefits and co-benefits of innovation, why would anyone resist? While innovation is needed to address new challenges, safety is always primary when making any changes at an airport. Regardless of environmental improvements, a new system or technology must be carefully studied so that it can be safely integrated into airport operations.

An airport owner/operator considering an innovation program should first consider how much authority it has to run tests and trials of new technologies or processes. Special agreement with insurance companies may also be needed.This is especially true if testing airfield technologies such as autonomous vehicles. Any introduction of a new technology to the airfield should apply a safety management system approach. Autonomous vehicles come with unique considerations for safety, reliability, energy source, etc. In one case, the airport established an Autonomous Protocol Board, where the Board carefully considers applications for autonomous vehicle trials to ensure safe operations.

Testing new products or services must also be done at the right scale and scope to collect data, assess effectiveness, and learn from the trial. There are actions that could never be tested at a large commercial airport but may be a fine option for a small rural general aviation airport.

Examples

Kirkwall Airport
The Sustainable Aviation Test Environment (SATE)

"SATE demonstrates emerging technologies along with real-world 'use cases' that highlight the environmental, social and economic contribution sustainable aviation can make. SATE takes a holistic approach that covers the development of new sustainable ecosystems, aircraft, airspace, operations, ground infrastructure, skills development, energy and fuels... the project has seen pioneering sustainable aviation technology demonstration flights delivered..."[15]

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[15] https://www.hial.co.uk/homepage/21/sustainable-aviation-test-environment

Brand reputation

Airport owners must also consider their brand or image. Innovation is generally seen as positive, with connotations of collaboration, learning, and progress that can boost image and public relations. That said, brands are built and cultivated over years and are often driven by community interests. Opening an innovation lab must align within the existing outreach plan and other airport initiatives.

4. LEADING, ORGANIZING, AND MANAGING INNOVATION

The effectiveness of innovation processes depends fundamentally on the organizational context in which they take place; in other words, to be effective, innovation processes must be correctly 'organized' (Phillips, 2013, p.482)

To what extent an airport, or any organization, is able to benefit from innovation depends on how well it is managed. The benefits of innovations, such as improved performance, enhanced competitiveness and environmental outcomes, better employment and quality of life, are well established. However, for these benefits to materialize, a level of collaboration and flexibility across team and organizational boundaries of the airport, is required.

In addition, airports can look for inspiration from other organizations that actively create structures, practices and processes supportive of innovations. Creating roles such as Chief Innovation Officers, Innovation Managers or Innovation Boards, or establishing rewards and incentives for innovations linked to sustainability and environment could enable obtaining long-term advantage (Dodgson, Gann & Phillips, 2013).

Recognizing the role innovation plays in the future of airports operations and to drive progress towards sectoral decarbonization, ACI Europe created Eco-Innovation Award, rewarding airports for environmental excellence and achievement. The award is presented in association with Airport Carbon Accreditation and in 2022[16], winner airports included Bristol Airport and iGA Istanbul Grand Airport. The UK's project was the Low Emission Turnaround trial with easyJet as part of Bristol's Strategic Sustainability Partnership. The objective was "to show carbon savings can be achieved without compromising operational efficiency" and was a notable starting point, given the challenge of reducing scope 3 emissions.

Turkish Airport on the other hand submitted a project of IoT technology as a tool in managing and optimizing processes and decision-making. Environmental co-benefits included the real-time data referring to airport-wide sustainability.

The concepts and goals of innovation have become so important for aviation that institutions have made efforts to encourage and lead the process. ICAO has established Innovation Officers to coordinate with governments, academia, and aviation stakeholders to encourage "collaboration and sharing of experience in relation to innovation (ICAO, 2022, p.3.)". Airports such as CVG have hired Chief Innovation Officers to explore and advance 'what's new and next for the benefit of our passengers, airport campus, and global industry.'[17]

"During the 40th Session of the ICAO Assembly, in 2019, countries adopted a resolution on innovation in aviation, recognizing the significant potential of current cutting-edge aeronautical and scientific developments to dramatically improve air transport environmental sustainability, in addition to aviation safety, efficiency, security, facilitation, and economic development."[18]

For sustainability especially, it is helpful to share useful innovations quickly. The quicker a new technology is deployed into industry, the quicker the benefits are realized. Several tools can be deployed to foster innovation in an organization, such as creative problem solving or design thinking approaches (Boyles, 2022).

In addition, on both regional and national levels, the research agenda on aviation innovation and environment has been expanding. For example, in Europe, hOListic Green Airport (OLGA) is a Horizon 2020 project with the aim to develop innovative and environmentally driven solutions that focus not only on emissions, but also on biodiversity preservation, air quality improvements and waste management. The project brings together multiple airports from the entire European region, as well as technology providers, academics, regulators, and associations to demonstrate the impact of the environmental innovations. Airports engagement in such programs allows to not only share cutting-edge knowledge, but also actively shape development and testing of new products and process with lower impact on the environment.

5. ON THE HORIZON

Throughout this document, we have explored how innovation and technology can play a great role in the advancement of airport sustainability. The figure below describes well how they may bring positive outcome for airports and their ecosystems.

Figure 2. The "why" of innovation & technology for airport sustainability- summary.

[16] Airports Council International Europe | ACI EUROPE - Media (aci-europe.org)
[17] https://www.cvgairport.com/innovation
[18] See: https://unitingaviation.com/news/general-interest/highlighting-air-transport-innovation-on-international-civil-aviation-day/?utm_source=International+Civil+Aviation+Organization&utm_campaign=0f61fa8e78-Newsletter+-+UnitingAviation&utm_medium=email&utm_term=0_bf5ba6bf53-0f61fa8e78-342654541&goal=0_bf5ba6bf53-0f61fa8e78-342654541&mc_cid=0f61fa8e78&mc_eid=f8d620875d

We can see that innovation has already been used to enhance revenue, improve community relations, and lower environmental impacts of aviation, and there are many big questions that remain to be addressed – rendering airports more suitable for electric aircraft, facilitating the availability and use of sustainable aviation fuels (SAF), anticipating hydrogen uses in aviation, and preparing for AAM. Considerable research will be needed to reach these goals, and maybe some other exciting discoveries will be made along the way.

While innovating can initially seem daunting, the results can not only bring several benefits as mentioned in this paper, but also ultimately decide on organizational success.

The aim of this publication was to synthesize some of the most relevant examples in the space of innovation and technology at airports, as well as provide deeper view into Innovation Hubs at airports, which are outlined in the Appendix.

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7. APPENDIX A: Case Studies

I- Pittsburgh International Airport

The Pittsburgh Innovation accelerator is working with many organisations and business to test innovation technologies in a live airport environment. The program has four key areas of focus but the most successful has been SustainX, which allows the airport to test sustainability innovations across the campus. The focus has been on energy transition, waste reductions, and improved environmental experiences throughout.

xBridge is Pittsburgh International Airport's proving ground for technologies and startups that solve for needs in today's airport and industry as well as tests and incubates strategic technologies that could be deployed in the future. The proof-of-concept and pilot site showcases new technologies in a real-world operating environment. The xBridge is designed to capitalize on and grow the region's powerful tech economy right at the airport for the aviation industry and beyond. xBridge has partnered with firms ranging from global Fortune 500 companies to local start-ups for projects that have tackled air purification, deployed robotic floor scrubbers and applied artificial intelligence to security wait times.

xBridge aims to test new technologies for airports and airlines to drive innovation and lower costs. This is done through a number of mechanisms, among them by offering opportunities to startup companies to test/demo/build their technologies at the airport as a means to advance their business while simultaneously giving the airport and its staff to understand the value proposition of the technology and determine whether/how to integrate it into ongoing operations.

xBridge pitches working with the airport as accessing an untapped startup resource for real-world testing and pilots, in a $100B airport industry that has nearly every major industry represented (operations, transportation, logistics, food and bev, energy, retail, HR, etc.). xBridge also acts as a "translator" for startups culture that may have trouble naturally accessing the aviation industry. For the airport, the value of this arrangement lies in being able to test and evaluate unlikely solutions from unlikely sources, and quickly deploying discreet solutions for discreet that allow for many small, quick wins with the occasional game-changing intervention.

The xBridge evaluation and approval process has five major steps:

1. Pipeline. The xBridge team, through its network of VCs, accelerator and, universities, sources deals for potential deployment at PIT.
2. Proposition. Opportunities are evaluated internally by the xBridge team, then by a technical team, and finally by a cross-functional team representing all of the different departments.
3. Proof of Concept. Opportunities that make it through this process are offered a paid Proof of Concept in which the goal is to prove the technology works in the airport operating environment. At the end of a Proof of Concept the opportunity is evaluated by the cross-functional team where a business unit can put forward a business use case to test the technology in a pilot.
4. Pilot. Opportunities conduct a pilot that proves a business use case. These are dependent on interest and buy-in from a business unit.
5. Production. Upon completion of a pilot, the opportunity is handed off to the business unit to evaluate the opportunity and determine whether/how to incorporate it into ongoing airport operations.

We can see that innovation has already been used to enhance revenue, improve community relations, and lower environmental impacts of aviation, and there are many big questions that remain to be addressed – rendering airports more suitable for electric aircraft, facilitating the availability and use of sustainable aviation fuels (SAF), anticipating hydrogen uses in aviation, and preparing for AAM. Considerable research will be needed to reach these goals, and maybe some other exciting discoveries will be made along the way.

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This model allows PIT to experience and consider technologies that may not be known to the aviation industry – in many cases the startups are not targeting the aviation industry either. This allows for beneficial instances in which PIT can bring a new opportunity to the industry that may not have previously existed. These projects are in addition to all of the enterprise-level technology and innovation initiatives being undertaken by the airport; this program of xBridge takes advantage of a gap in the industry's relationship to innovation, as well as takes advantage of the Pittsburgh region's leading status in robotics and AI, among other fields.

Within xBridge, two relevant environment/sustainability projects of note include:

- AlgenAir. A startup company that manufactures and sells a consumer product that provides the oxygenation capacity of approx. 50 houseplants through the culture and maintenance of living algae. The company is targeting commercial environments for the growth and scaling of its business. In partnership with PIT, AlgenAir produced and installed a 100-gallon commercial alpha prototype of its system. AlgenAir is using the installation as a use case and demonstration of its technology at scale; PIT is evaluating the product for deployment in its new terminal.

- Ecotone Renewables. A self-powered and net-negative food waste digester system, Ecotone uses AI computer vision and robotics to sort waste streams and uses anaerobic digestion to turn food waste into a revenue-generating fertilizer. Ecotone will be testing two of its units at PIT, using the airport's waste stream to understand how different food waste "recipes" impact the quality of fertilizer. Ecotone is expected to divert 400 – 1,000lbs of food waste per week once fully implemented.

Photo 1. Innovation at PIT. Source: Pittsburgh International Airport.

II- Aeroporti di Roma

Wouldn't it be fantastic if we could test the most relevant innovations for our sector right in the heart of an airport, and be at the forefront of evolving passengers' experience and operational needs? This was Aeroporti di Roma's first thought when they decided to launch the **Innovation Hub** at Fiumicino airport and be the first airport operator in Europe to bring startups inside a working terminal.

The idea of building this 650 sqm's facility – aimed at identifying and supporting innovative solutions to redefine the industry's paradigms, while also creating new business opportunities – is part of Aeroporti di Roma's wider strategy to fully integrate innovation in any aspect of the business.

Three main pillars are at the basis of ADR's innovation operating model, which started to be implemented in September 2020 with the purpose to define an intervention plan and a mature, consistent design pipeline, capable of intercepting national and European Union resources and policy objectives.

First of all, ADR understood the importance to spread the culture of innovation and at all levels within the Group: thus, we defined a **new organizational model**, with the establishment of an "Innovation Committee" composed by the top management, which designs the strategies, establishes goals and priorities, and evaluates the projects presented by the **Innovation Cabin Crew** – i.e., ADR's internal "corporate accelerator" for the management of the innovation processes, in charge of enhancing the know-how developed in the various company areas, triggering ideas in the initial phase and contributing to the implementation phase of the initiatives.

Then, ADR developed an **Open Innovation** system by engaging startups in different ways, with projects including Hackathons organized in partnerships with universities, the creation and growth of the above-mentioned Hub Vertical Incubator, global Call 4 ideas to select startups, as well as Corporate Venture Capital (CVC).

Photo 2. ADR Innovation Hub. Source: Aeroporti di Roma

ADR launched its first Call 4 Ideas at the end of 2021, attracting interest from approximately 530 startups from all over the world and reviewing almost 100 applications of startups offering solutions in the fields of **airport operations**, improving **punctuality**, **data-driven** systems, process **automation**, **energy efficiency**, passengers' **digital experience**, and **omnichannel** commerce.

A second Call for Ideas followed one year later, bringing in some more innovations, such as the inclusion – from an ESG perspective – of incentive evaluation criteria for Diversity & Inclusion, taking into consideration both the measures adopted by start-ups with respect to issues such as gender equality and inclusion, as well as the results concretely achieved – e.g., as the relevance of the female and youth component in terms of company participation.

None of the above could have been done without the development of an international **ecosystem of partnerships**, i.e., the third pillar of our strategy.

Not solely did ADR promote our Call for Ideas and design the acceleration program with partners including **Plug and Play Tech Center** and **PWC**, but also supported – together with AENA – the creation of the network **Airports for Innovation (A4I)**, to bring together the expertise of international airports and share best practices on how to handle efficiently the digital and green transition.

So far, the A4I network is composed by ADR, AENA, Athens International Airport, Aeroports de la Cote d'Azur, Vancouver Airport Authority and Dallas Fort Worth International Airport.

To support the growth of the start-ups operating inside the Innovation Hub and start CVC's activities, we created a new SPV, **ADR Ventures**. This is the first initiative of its kind in the air transport sector in Italy, aimed at financing the development of projects in areas with an elevate innovation potential; in synergy with the airport's operational and strategic needs, ADR Ventures will operate as an engine for the development of youth entrepreneurship, ensuring support for the most virtuous and prospective start-ups, accompanying them in the integration with the business and in the management of investment processes, accelerating the process of the business growth and the commercialisation of the innovative solution devised.

Through this SPV, we aim at adding an additional milestone in our path aimed at fostering an integrated plan to redesign the industry's paradigms… designing the most advanced airport of the future.

Photo 3. ADR Innovation Hub. Source: Aeroporti di Roma

III- Groupe ADP

ADP's innovation approach, now mature after 5 years of existence, is at the service of the Pioneers 2025 strategic roadmap and the decarbonization of its activities. It is focuses on: The industrialization of experiments, whether they are focused on the passenger experience, operations, infrastructures or our employees, internationalization of this approach through territorial ecosystems (around ADP's platforms in the world), as well as exploration of new territories (VTOL, airships, spaceports, etc.), while pursuing a hybrid investment model (direct and indirect), guaranteeing a diversified sectoral and geographical scope.

ADP's innovation approach is based on 4 pillars:

OPEN

OPEN is the acculturation system for ADP Group employees and stakeholders. The dissemination of the culture of innovation within the company requires a well thought-out offer on the current themes that are specific to the company in order to meet its challenges.

The OPEN system is reflected in the existence of a place dedicated to innovation. The Innovation Hub is a 400 m² space located in the heart of the ADP Group's headquarters at Paris-Charles de Gaulle. This atypical space hosts various events as well as a technology showroom. It is also a work space open to the world. To date, the Innovation Hub has welcomed more than 35,000 people since its opening in 2017.

CONNECT

CONNECT is the experimental program of the Innovation approach. It enables the testing and deployment of innovative solutions at the various ADP Group platforms.

The deployment of smart and sustainable mobility, the optimization of airport operations, the search for new services contributing to better hospitality, new and cleaner energies, the instrumentation of ADP's infrastructures, the preservation of the environment and the transformation of the employee experience are priority topics for the CONNECT division.

Through the CONNECT pillar, ADP is setting up experiments to test new low-carbon mobility solutions on its platforms. That includes for example testing On-Demand Mobility for the transport of passengers and employees in order to reduce the number of kilometers covered, and therefore the carbon footprint, while maintaining a high level of service quality for users.

Testing of solutions to better control energy consumption in the terminals (air conditioning, ventilation, heating) by knowing and optimizing in real time the actual comfort of passengers is also undertaken.

Finally, ADP aims to limit our impact on the biodiversity of our platforms by using artificial intelligence to map and automatically monitor our biodiversity.

RE.INVENT

RE.INVENT is developing new solutions to optimize the link between the city and the airport, movement and connectivity within the airport and movement within the terminals. Today, projects such as flying cabs and autonomous vehicles are projected into the mobility of the airport city of tomorrow.

Also called AAM (Advanced Air Mobility), ADP envisions a safe and efficient air transportation system that will use automated electric aircraft to transport people and goods in low altitude airspace in urban, suburban, rural and regional contexts.

INVEST

INVEST is the ADP Group's investment program in start-ups and innovation-related funds. The strategy adopted is based on:

The continuity of the CONNECT program by financing companies that have already experimented with the ADP Group,
A strategic perspective by investing in companies with a link to the business lines. Based on the trust placed in the founding team, the challenge is to provide financing for long-term development,
A logic of providing expertise by providing the knowledge and skills necessary for development: business support, business development, recruitment, accounting, technical experts, etc.

Investing indirectly in external funds
The ADP Group's indirect investment in external funds is a complementary mechanism. It provides access to a broader range of multi-sector intelligence. Active participation in an innovation ecosystem (funds, corporate invest) is a gain for the ADP Group and creates synergy between the various players in the network (corporate, partners, etc.)

A budget is dedicated to the innovation process and is distributed among the clusters according to the types of investments planned and the projects envisaged.

Figure 4. ADP Innovation Hub. Source: Groupe ADP

ADP is also a partner for "Corporate Mobility and Intermodality" category in European Start up Prize for Mobility, focusing on solutions which support the shift to cleaner home-to-work trips, allowing the transition towards a cleaner corporate fleet and helping fleet managers in managing zero emission vehicles, amongst others.

IV- Vancouver International Airport

YVR has a long history of fostering innovation and entrepreneurship in the aviation industry, constantly striving to bring cutting-edge technologies to airports worldwide to improve the experiences of passengers, employees, and surrounding communities. To further support the development of sustainable technologies in British Columbia's tech industry, YVR established its Innovation Hub, led by VP of Innovation and CIO Lynette DuJohn. Under her guidance, the team facilitates collaboration and connection among innovators, entrepreneurs, and made-in-BC businesses to encourage growth and connectivity in the province's tech and sustainability economy. With the Innovation Hub's ongoing support, YVR is well positioned to lead the way in sustainable airport operations and inspire positive change throughout the industry.

As the post-pandemic travel landscape continues to evolve, YVR recognizes the need for digital transformation in airports and has taken a lead role in this area. The airport introduced the industry's first-to the commercial market Digital Twin, a digital platform that uses 2D and 3D visualizations to provide employees with a comprehensive view of YVR's extensive data sets. The Digital Twin Platform enables training, optimization, future planning, simulation, testing, and more, resulting in data-driven decision-making and enhanced collaboration across the operation. YVR continues to develop new use cases for the airport's Digital Twin platform, prioritizing work that delivers more capabilities to airside operations by enabling an 'intelligent airfield,' an immersive and situationally aware tool using our high-definition 3D exterior model. This work is laying the foundation to use the Digital Twin platform for simulation purposes, supporting climate initiatives and the airside rehabilitation projects by running what-if scenarios to mitigate risks of delivering our new three-year airside program. This innovative technology, developed in partnership with Unity, the world's leading platform for creating and operating real-time 3D content, and Vancouver-based GeoSim Cities, experts in large-scale precision 3D modelling, is already supporting YVR's operational goals.

As with any new technology, successful adoption can be a challenge. However, YVR's Innovation Hub has established a rigorous testing process to ensure that its technologies are readily adopted by airport employees. Building on a history of innovation, YVR employees are already primed to embrace the new technologies produced by the Innovation Hub. The Digital Twin Platform is a prime example of this success, with over 100 airport employees (and quickly growing) currently using it daily to support their decision-making processes. By prioritizing adoption rates, YVR is ensuring that its innovative technologies have a meaningful impact on the airport's operations and the experiences of its passengers.

YVR is boldly pursuing a greener and more resilient future and have committed to eliminating emissions from its operations, becoming net-zero by 2030. At the helm of this work is YVR's dynamic Climate and Environment team. As the first airport in Canada to commit to the ambitious goal of net zero by 2030, YVR's Climate and Environment team are delivering on a roadmap aimed to guide the airport's operation to its net zero target.

In support of the Climate and Environment team, YVR's Innovation Hub is playing an integral role in driving the airport's net-zero carbon emissions goal by looking at the roadmap through an innovation lens.

Importantly, as the airport advances towards this ambitious goal, it acknowledges that over 95% of Sea Island emissions are related to aircraft movements, traffic, and non-Airport Authority buildings, which are outside the immediate scope of its net-zero commitment. Nevertheless, YVR is uniquely positioned to drive emissions reductions beyond its direct operations (i.e., Scope 3 emissions) and support the decarbonization of aviation as a whole.

To achieve this goal, YVR's Innovation Hub is exploring new technologies that have potential to make a real difference in advancing the roadmap. As an example, the Innovation team has developed a GHG calculation model and baseline measurement to visually track, measure and analyze GHG data within the airport's Digital Twin Platform. By working with its carrier partners, YVR will soon be helping them to reduce their emissions, by providing key data and additional insights that will impact their emissions reduction on day-to-day operations and future planning. These efforts are critical to achieving the International Air Transport Association's ambitious emissions reduction goals for the aviation industry.

The GHG tracking model is still in its early days and YVR's Innovation Hub is currently in the process of partnering with carrier partners to test and trial this new technology. In the coming year, challenges, successes and a general understanding of the viability and value of the product will become clear.

YVR's commitment to sustainability extends beyond its direct operations and into the wider community. The airport's Innovation Hub has partnered with the Jobs, Economic Development and Innovation Ministry to support made-in-BC companies in developing and selling clean-tech solutions that address industry challenges. Projects that are in the works as part of this partnership will be announced in the coming months – stay tuned!

YVR's Innovation Hub is actively creating real-world opportunities for post secondary students to learn, collaborate and apply their industry-driven ideas within the innovation environment at YVR through an MOU with BCIT. By way of this partnership, BCIT students worked with the airport's Climate and Environment team to create a digital solution to monitor the water quality at outfall stations on Sea Island in real-time, automating a manual and time-consuming process.

YVR also partnered with a local innovative company, Intuitive AI, that developed a self-sorting waste bin that uses artificial intelligence (AI) to ensure that waste is disposed of in the most eco-friendly and sustainable way at the airport. Named Oscar, the technology uses a combination of robotics, machine learning and computer vision to detect and accurately route disposed items into the correct waste category.

YVR has found a winning formula for promoting sustainability through innovation: linking it with the community. By developing approaches that not only reduce the airport's environmental impact, but also foster economic growth and job creation in British Columbia, YVR generates a ripple effect of benefits for the region. This strategy aligns sustainability with local needs and aspirations, delivering practical and tangible benefits to the community while promoting a greener, more resilient future.

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