WHITE PAPER / **UTILIZING AI IN AIRPORT DESIGN**

TRANSFORMING THE FUTURE OF AIRPORTS WITH ARTIFICIAL INTELLIGENCE, MACHINE LEARNING AND GENERATIVE DESIGN

BY Nathan Sims

Increased passenger capacities are fueling the need for airport expansion. Whether airports and airlines can keep pace to match forecasted growth remains to be seen. Artificial intelligence, machine learning, additive manufacturing and generative design may hold the answer.

In 2012, the International Air Transport Association (IATA) conducted its very first passenger survey to learn about the behaviors and preferences passengers linked to their travel journeys and experiences. The study identified passengers' desires for technologies that support push notifications of flight disruptions or changes, more in-flight entertainment, bag tracking and smoother customs and security processes.

These findings led to the first generation of airline and airport mobile applications, which offered many of these features and functions. In 2017 alone, U.S. airlines invested $20 billion in customer experience enhancements. Many airlines, for example, now allow passengers to track bags in near real-time through their mobile apps. Managed inclusion programs such as TSA Precheck, Global Entry and Clear pre-vet subscribing travelers, resulting in less stringent security screening measures and a much faster security clearing process.

Despite these technological improvements, recent IATA surveys find that passenger perceptions of their travel experiences have not changed appreciably. Passengers have become particularly more sensitive to the value of time. The FAA reported flight delays cost the U.S. economy $26.6 billion in 2017, including almost $15 billion attributed to lost passenger time.

Passengers' appreciation for timesaving solutions represents an extraordinary opportunity for airlines and airports. As such, developing more efficient ways to process passengers and bags is key to unlocking more meaningful and pleasant travel experiences.

But passengers are not the only beneficiaries of greater processing efficiency. With more time on their hands, passengers will have the incentive to explore everything that airports have to offer. Time is money, and when passengers have more time, they spend more money in airport retail outlets. Timesaving technologies further benefit airports by enabling them to better utilize facilities. By providing some of the additional capacity needed to meet projected growth, they allow airports to delay or downsize expansion plans in some cases, while also stretching the boundaries of traditional design approaches.

PREPARING FOR THE NEXT-GENERATION AIRPORT

Developing technologies that optimize existing airport facilities is important, given that funding constraints continue to slow many capital development programs aimed at expanding capacity. Technologies that support safety, security and customer experiences are also of great value to the risk-averse aviation industry, which simply cannot afford to cut any corner in these areas. Aviation industry leaders have begun turning to artificial intelligence (AI) and, more specifically, machine learning (ML) to find cost-effective solutions for keeping pace with rapid rates of passenger growth.

AI is a broad field, and because of this, definitions vary widely based on application. ML is a subset of AI that analyzes vast amounts of data to produce data models that recognize patterns, predict outcomes or generate recommended actions. Tools that apply ML are computed tomography to improve threat detection and biometrics to decrease processing time for matching modalities like faces or fingerprints. As demand grows, however, the industry needs to expand the use of AI to include facility and process design.

The application of these and other technologies will grow more urgent as the aviation industry contemplates the next generation of airports and how they might be scaled to serve future generations, allowing designers to create solutions today that are large enough and smart enough to accommodate the needs of airline passengers tomorrow and beyond.

But doing so will require members of the aviation industry to work collaboratively on technology or process changes — or both — that improve the efficiency of existing facilities. Airports are highly complex environments where technologies and processes are tied together and shared by multiple entities. When something goes wrong, the impacts can cascade throughout an airport or across the aviation system. But when technology intercedes to, for example, lower the lost bag rate or speed security screening, everyone wins.

DOUBLING UP

To go one step further, consider the value that digital twin technology can bring to airport design and operations.

A digital twin is a digital 3D replica of a physical asset, system or process — such as an airport. Built from massive, cumulative, real-time data, a digital twin simulates its real-world counterpart in a live setting, creating an evolving digital profile of its historical and current behavior. Using powerful analytics, machine learning and artificial intelligence, a two-way flow of information is created. The real-world asset sends live performance data to its digital twin for evaluation and, if action is needed, the digital twin responds with feedback or changes to optimize performance.

A digital twin, in other words, can be used to measure, monitor or model how people interact with each other and the space around them.

An airline, for example, may want to improve seat comfort or in-flight entertainment quality without increasing an aircraft's weight or reducing its seating capacity. As loads increase, it becomes more challenging to meet these goals. New planes generally have better passenger-facing technology, but new cabin configurations also include more seating, resulting in less space per passenger. Digital twin technology can be used to monitor seat comfort and overall in-flight experience quality. Sensors can be used to collect passenger telemetry data, check for seat needs and monitor health events, tailoring the flight experience for each passenger. If someone has a health emergency, flight operations staff can be notified of health data, allowing them to respond without delay. Likewise, airports are brimming with practicable use cases like dynamic tinting glass, indoor mapping, energy optimization and advanced asset management. Virtually, any connected, physical asset within the airport can produce a digital twin.

All airport spaces — from parking lots to terminals to runways — can use similarly embedded technology to create digital twins that enable smarter utilization and greater efficiency.

OPPORTUNITIES FOR ADDITIVE MANUFACTURING

Additive manufacturing — also known as 3D printing — is expected to impact many industries in the coming years, and the aviation industry is no exception. While traditional manufacturing involves carving or shaping a product from a larger block of material, additive manufacturing "grows" products by printing one wafer-thin layer at a time.

Additive manufacturing has the potential to radically change how aircraft and airport facility components are built. For example, it makes it possible to create complex structures that would be very difficult or impossible to manufacture using traditional methods. Additive manufacturing can result in strong, but lightweight aircraft — features of great value in an industry where weight reduction can lower fuel costs and extend service life.

Additive manufacturing also facilitates faster prototyping, fosters design creativity and enables engineers to test performance before production. Because it creates less waste than traditional approaches, its use is more sustainable. Its ability to reproduce obsolete or out-or-production parts means that it adds to the resiliency of an airport or airline by extending the useful life of aircraft or other assets.

GENERATIVE DESIGN AS A GAME CHANGER

The airports of the future can also expect to benefit from generative designs that apply nature's evolutionary approach to garnering new ideas.

Generative design requires a completely different design process than the one used today. Traditional airport design, for example, begins by defining an owner's requirements for an expansion or improvement project. Designers evaluate these requirements, perform site surveys, collect existing conditions drawings, hold design charrettes and develop design criteria — all to kick off the design process. Significant resources may be invested to generate just three or four conceptual designs using these criteria. Once the preferred concept is selected, design commences.

The generative design approach is much more streamlined than the traditional approach. Generative design begins with collecting information on the owner's design goals, criteria and parameters on everything from materials and manufacturing methods to cost constraints. That data is then fed into AI software, which produces dozens — potentially hundreds — of possible design solutions. Members of the design team may discover designs they never thought possible because of cognitive biases or blind spots.

GENERATIVE DESIGN IN ACTION

Recently, Airbus has taken this approach to develop new partitions for their active A320 aircraft. Doing so has allowed the airlines who use the aircraft to save fuel every time they fly.

Designers assessed that this new partition had to meet several design parameters: It would need to be lighter than the current partition; strong enough to anchor seats for two flight attendants; have a cutout to pass wide items in and out of the cabin; be no more than an inch thick; and attach to the plane's airframe in just four places. Generative design was then used to develop this new, so-called "bionic partition."

On a project like this, the human-led design team provides peer review by ranking and providing feedback to its machine-based collaborators. Models evolve as the machines learn human preferences. Engineers and designers essentially serve as mentors to the machines, using their time and talent in new and different kinds of problem-solving. Owners, meanwhile, save time and money while knowing that nearly every possible option is and was considered.

TECHNOLOGIES NEEDED TO STAVE OFF COMPETITION

Commercial air travel has been relatively protected from outside competitive threats for the past century — but that is about to change.

As the skies become more crowded, the risk of losing customers to other forms of transportation is growing. Bullet trains, hyperloops, ride-hailing services and other alternative forms of travel pose a real threat to domestic air travel. Consumers are becoming more educated about their alternatives, and substandard service experiences and late arrivals to important life events will dissuade some from boarding a plane. Commercial aviation often fails to appeal to people with the resources to charter a plane or fly privately.

Airlines, in other words, simply cannot afford to take past customer loyalty for granted.

Architecture and engineering firms need to see the many ways AI applies to improve aviation industry performance. It will be needed not only to support the design of future airport terminals, but also to implant technologies and tools that enhance operational resiliency, expand capacity and enrich the customer experience.

Our job now is to start utilizing it, and learning when and how to apply it. The goal is to develop machine learning models geared to the facilities and systems we design and construct, and technologies like generative design must be top of mind as we embark on the AI frontier.

BIOGRAPHY

NATHAN SIMS, MBA, is an airport IT and special systems project manager at Burns & McDonnell. With more than a decade of experience in the air transportation industry, he creatively transforms operational processes with the use of emerging technologies. His experience as a project and business development manager gives him extensive knowledge in supplying value-added automated material handling solutions and delivering and operating ramp technology such as baggage handling and baggage reconciliation systems.

ABOUT BURNS & McDONNELL

Burns & McDonnell is a family of companies bringing together an unmatched team of engineers, construction professionals, architects, planners, technologists and scientists to design and build our critical infrastructure. With an integrated construction and design mindset, we offer full-service capabilities with offices, globally. Founded in 1898, Burns & McDonnell is a 100% employee-owned company and proud to be on *Fortune*'s list of 100 Best Companies to Work For. For more information, visit **burnsmcd.com**.

08991-TFA-0820